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ABSTRACTS

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Urban stability through integrated water-related management

STOCKHOLM WATER SYMPOSIUM

The 9th Stockholm Water Symposium

9 - 12 August 1999

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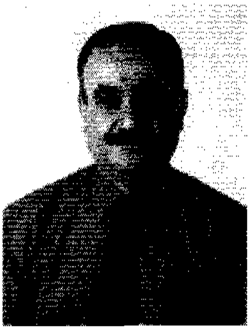

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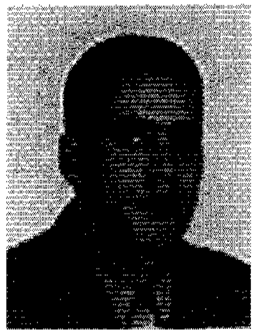

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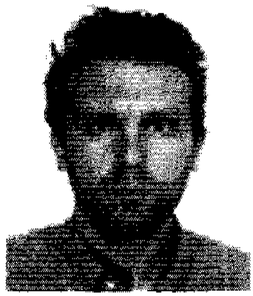

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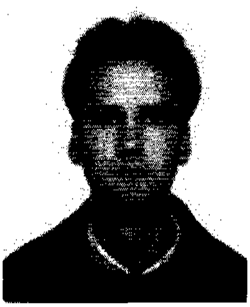

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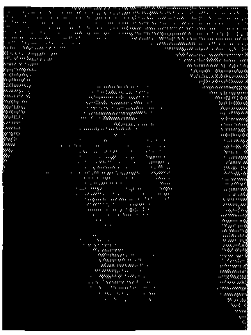

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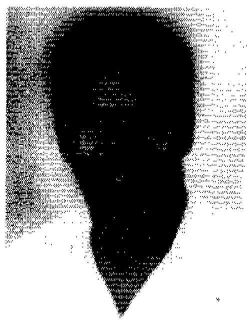

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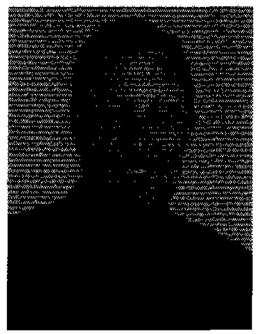

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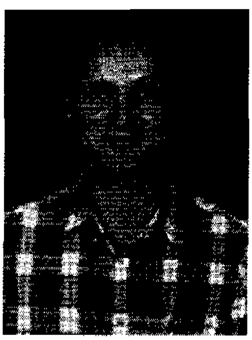

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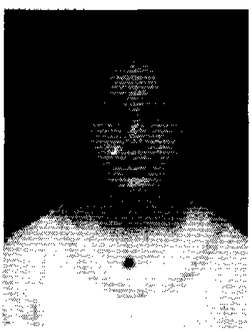

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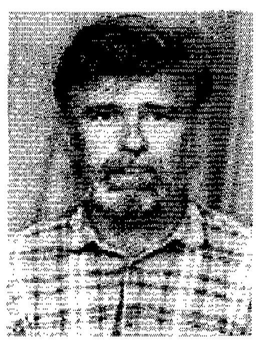

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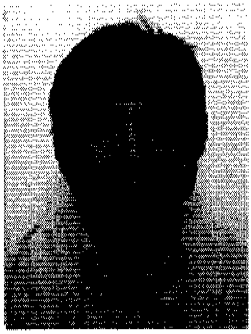

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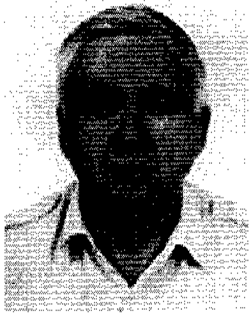

Dr B Fashchevsky, WS2

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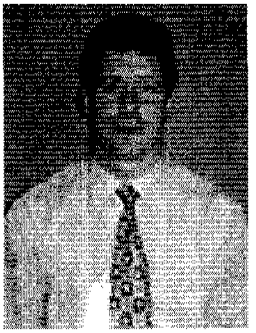

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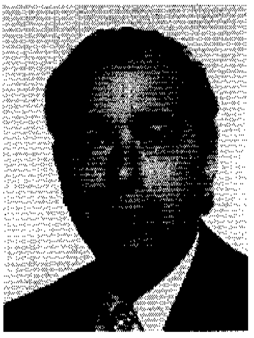

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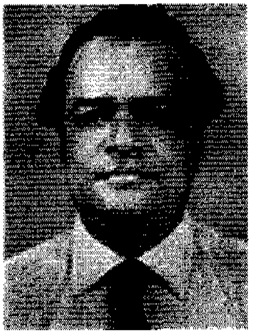

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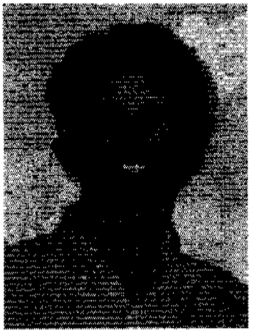

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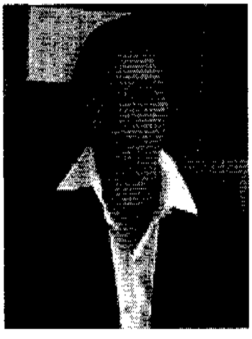

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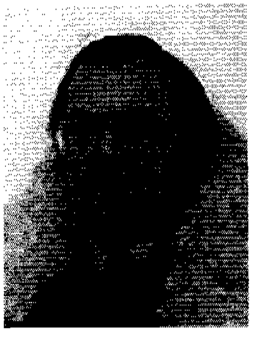
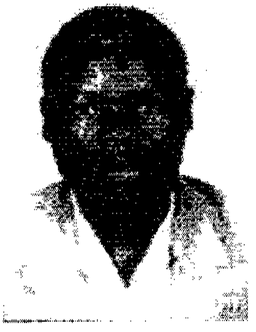
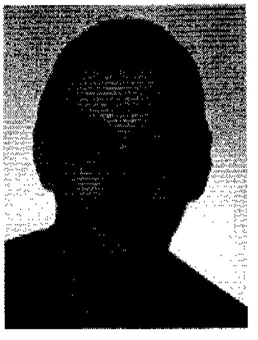


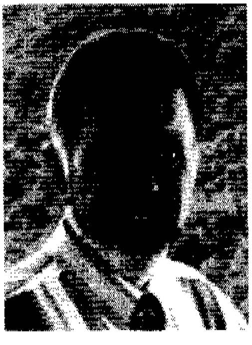
Mr C Green, WS2



Mr E Guzha, WS9



Mr T Herrmann, WS8A



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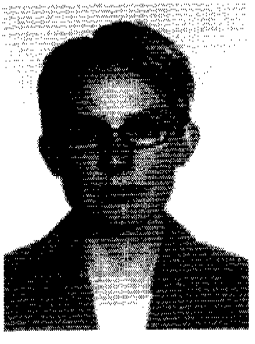

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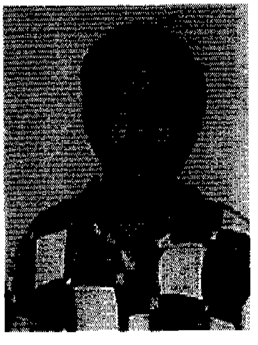

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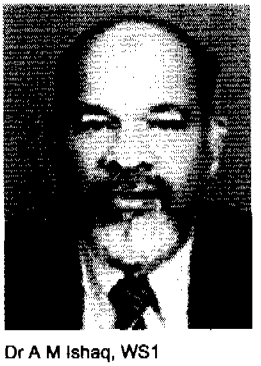

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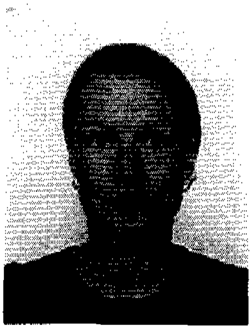

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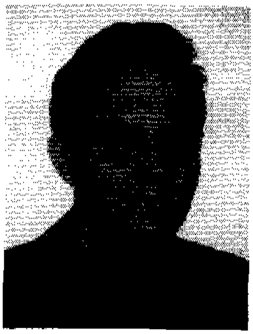

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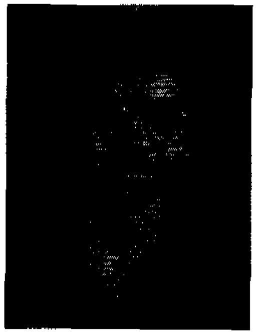

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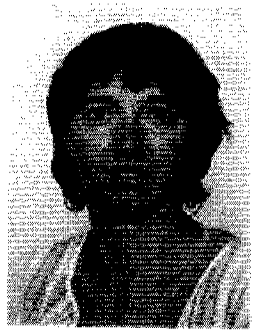

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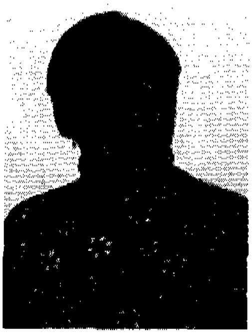

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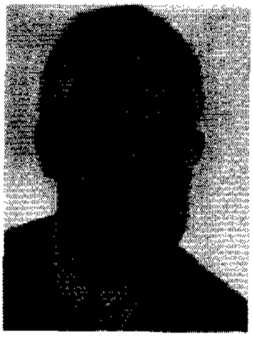

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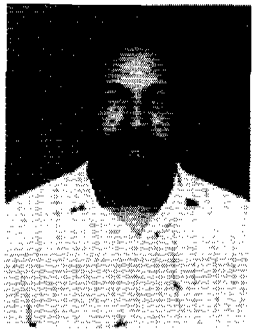

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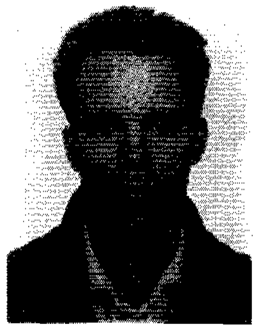

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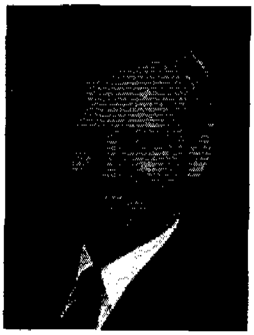

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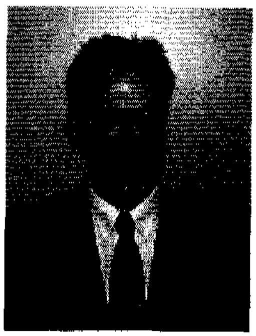

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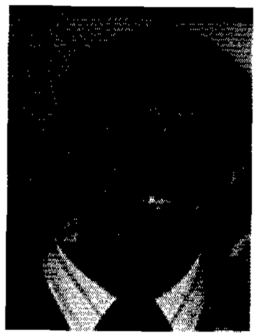

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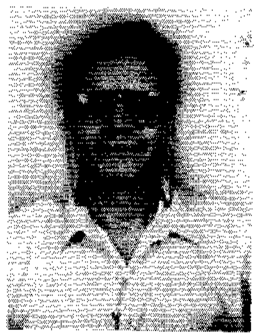

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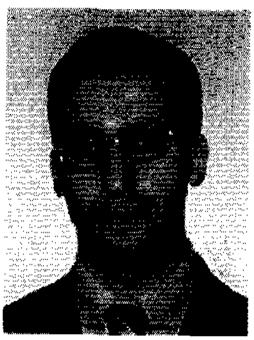

Dr E Lobina, WS6

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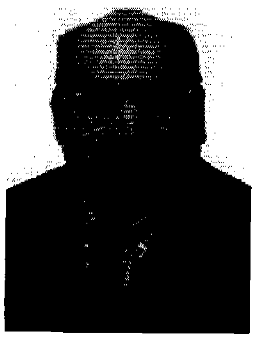
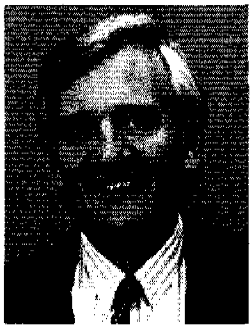


Dr A H Malik, WS6

Mr P-A Malmqvist, WS8A


Dr V Malyshev, Poster WS7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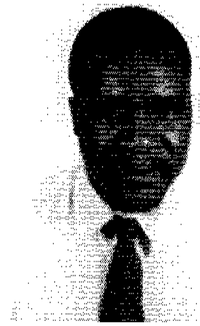
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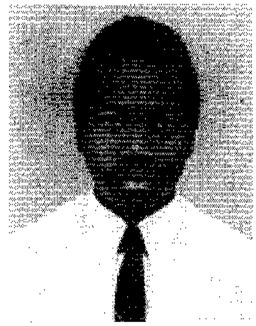
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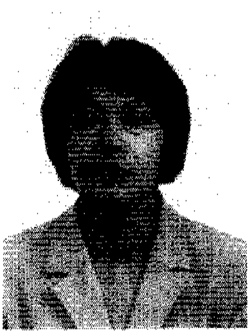
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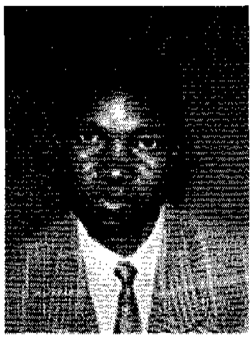
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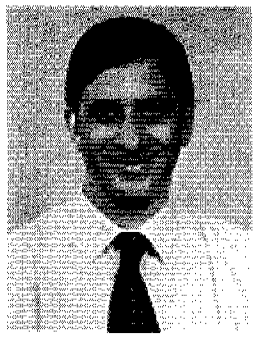
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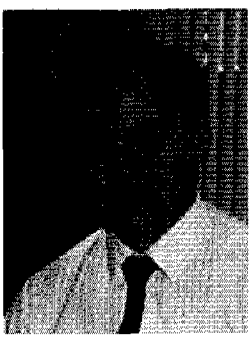
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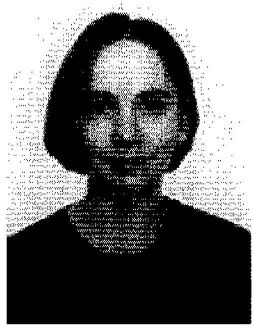
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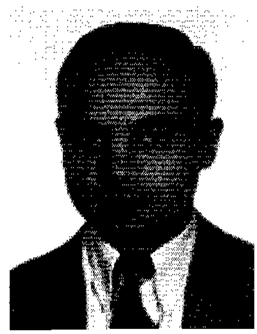
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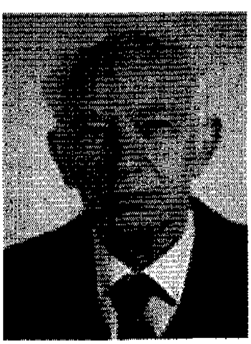
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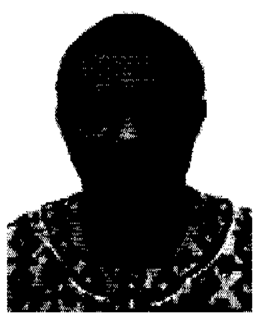
Ms A Regmi, WS3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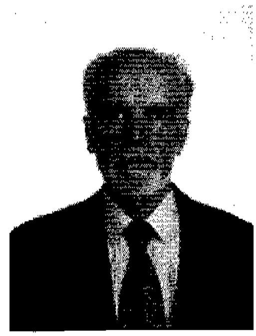
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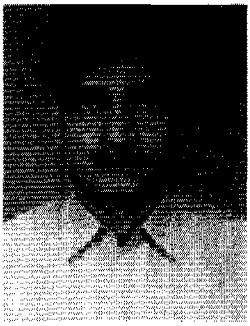

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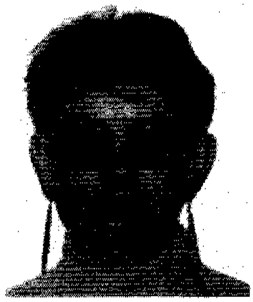
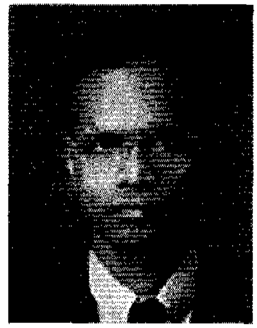
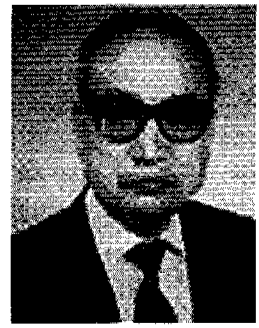


Ms B Schreiner, Invited WS4A



Mr L W Seneviratne, WS6



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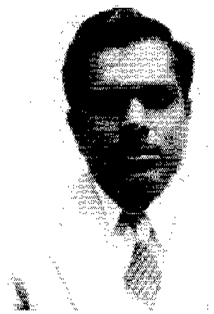
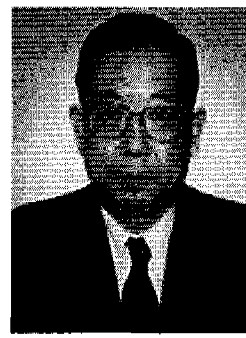
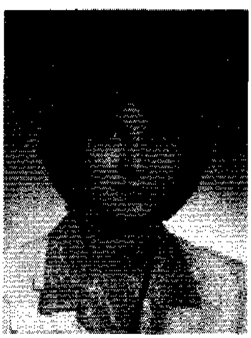


Prof M Sridhar, WS9

Prof K Takeuchi, WS5



Prof M Takezawa, Poster WS2



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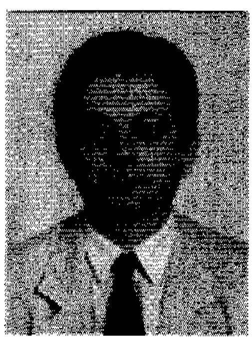
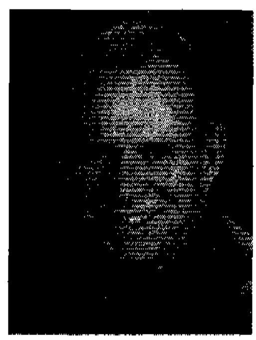


Prof C Tucci, Invited WS2



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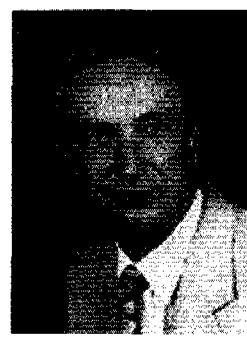
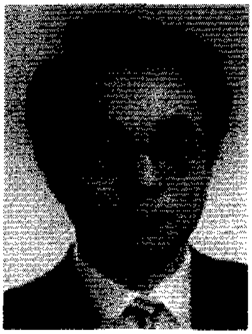


Mr B Van Der Merwe, Invited WS1



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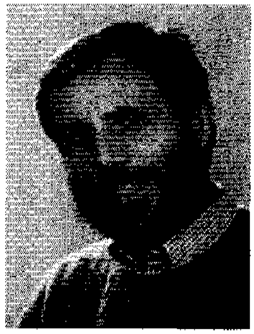

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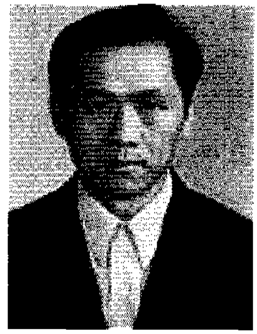

Prof Y Zheng, Invited WS7

Plenary speakers

WE ALL LIVE DOWNSTREAM: URBAN INDUSTRIAL GROWTH AND ITS IMPACT ON WATER SYSTEMS

Dr. Sunita Narain, Centre for Science and Environment, India

Abstract
Paper to be presented at 1999 Stockholm Water Symposium

It is indeed ironic that as we go into the next millenium the key challenge will be the management of the world's most basis resources - its air and water. Studies for the Southeast Asian region tell us that when the economy (GDP) of Thailand doubled during the 1980s, its total load of pollutants increased an amazing ten-fold. A study conducted for India shows that when the Indian economy doubled over the period 1975-1995, its industrial pollution load went up by four times and the vehicular pollution load by eight times.

The processes of wealth generation - through an industrial-urban model that demands the intensive use of energy and material -- will clearly put increasing pressure on natural ecosystems and generate huge amounts of pollution. Every city in the Southeast Asian world is gasping for air - from Taipei to Delhi. 'Hydrocide" - that is, murder of aquatic systems - is widespread across the region. In India, river and small streams have today been reduced to toxic drains.

It was in the post-World War II period that the world began to see what was then an unprecedented economic boom in Europe, Japan and North America. By the 1950s itself, cities from Tokyo and London to Los Angeles were choking under pollution. The Western society responded to this problem with increasing investment in pollution control. It is estimated that in the early 1970s, Japan spent over 25 per cent of all industrial investment in pollution control measures. Will countries like India have the necessary investment to clean up our environment? Or should these countries find other ways to manage progress.

In the developing world, management of rivers will demand a new partnership between the upstream and downstream users of the resource. In India, with pollution of river systems growing, residents are taking action; going to court against the upstream industrial users of their water or even downing the shutters in the town to protest against the upstream polluters. In the city of Vidisha, in central India, for instance, town-dwellers forced the industries upstream of their river to stop polluting.

The scale of the problem and its cost will demand innovative solutions. For instance, residents of Delhi need to 'think upstream'. Haryana the upstream state is witnessing both agricultural and industrial development. It is a major Green Revolution state of India and uses large quantities of pesticides. Gathering all these toxins, is the river Yamuna, the mythological daughter of Yama, the Hindu God of Death, which brings to the people of Delhi their very basis of survival --- drinking water.

The drinking water of Delhi contains these chemicals. The city does not treat the raw river water either for pesticide residues or for industrial contaminants. In fact, with higher costs of installation and running, no water treatment plant in India treats drinking water supplies for chemical contamination.

If we go further along the Yamuna we find that what Haryana does to Delhi, Delhi does the same to the cities downstream. After Delhi, the river literally turns into a sewer. The water supply agency of Agra - a city downstream of Delhi -- then simply dumps in as much chlorine as it can find, not that it would do anything to reduce chemical contaminants.

So what do we do? When it comes to something as basic as the environment -- our air, water and food -- prevention is obviously the best policy. Even industrialised countries are finding that treating polluted waters to make them safe for drinking is very expensive. It would be cheaper to persuade farmers and industries upstream to pollute less and to move towards safer pesticides and integrated pest management. Thinking through the governance of the river with its upstream and downstream users will be the key to change in the future.

THE URBAN CENTURY: THE WATER CRISIS
The Role of Industry in Conservation, Efficiency, and New Technologies

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We are ending a century which saw dramatic movement of people from rural areas to cities. Mega-cities such as Cairo, Mexico City, and Shanghai, along with "new" cities springing up throughout the Pacific rim and elsewhere, all have dramatic water needs unparalleled in modern history. Indeed, in the next century, a sustainable Global-Local Economy will depend on water for individuals and industry. Without understanding and planning, conflicts of the 21st century may well center on water access rather than oil.

THE RESPONSIBILITY OF INDUSTRY

Industry, with its understanding of **economics, technology, and applications**, has a specific opportunity and responsibility to lead the way in meeting the water crisis. In the past neither industry nor government has viewed water as a raw material with a value. It has been distributed to users without logic or understanding of its true worth. It is now essential to understand the value of water to use it efficiently, re-use it appropriately, and to apply new technologies as feasible.

For success in water use and management there must be:

- High Standards
- Measurements
- Integration of environmental needs with business & people needs
- Planning with dialogue

MEASUREMENT: LAND YIELD/WATER YIELD

It is standard practice to consider **land yield.** Agronomists and economists regularly examine

- the food yield per hectare of land;
- the raw material yield (such as bauxite) per hectare,
- the number of people sustained by a hectare of land.

It is not yet standard practice to consider **water yield**, that is,

- the amount of food grown per water unit via irrigation;
- the goods produced and food processed per water unit;
- the drinking and sanitation per water unit.

A new standard of water measurement is needed in order to move to a sustainable glocal economy, one which is of course dependent on water.

FROM MEASUREMENT TO REAL VALUE

With measurement comes the possibility of determining real value. Too long, water has been viewed as somehow "free," even though its misuse has cost dearly in disease and stunted economic development. Water *does* have a value, and with measurement and new needs, **water markets** are essential. Water markets are already in place in many parts of the world, from the American West to the United Kingdom to South America. These water markets are helping to distribute water more fairly, strengthening economies, and improving public health.

With an understanding of value, comes real opportunity to resolve current problems of water access and misuse. Industry can assist mega-cities and emerging cities by both improving the water and supply, and by strengthening the urban economies, a natural result of such water improvements.

THE RESULTS OF UNDERSTANDING VALUE: NEW EFFICIENCIES, TECHNOLOGIES, AND APPLICATIONS

With an understanding of value, there will be many changes that will affect the use of water, the efficiency of industry, and the well-being of the populace of cities and rural areas.

Energy Efficiency

There are many opportunities to save money on the energy associated with moving and treating water. These savings make industry more effective and make possible a wider distribution of affordable, clean water.

Energy efficiency in use of water has been clearly demonstrated in manufacturing and processing plants where simple, inexpensive engineering changes have dramatically saved energy and thus money.

Re-use

Conventional wisdom accepts the value and appropriateness of recycling glass, plastic, paper, and steel. There is no similar awareness of the value of recycling water. With recognition of the value of water, that awareness changes.

Industry should, and in many places is, setting the goal of cleaning water for a closed loop of water use rather than constant discharge of the "old" and depletion at the water source to obtain the "new." As the value of water becomes clearer, food processors and manufacturers are already practicing this closed loop processing.

Applications and Scalability

In the past, vast engineering projects have been the accepted approach to ensure access to water. Vast dams and redirections of rivers have been enormously expensive public works projects with short-term success and significant long term consequences.

Mega cities and emerging cities should not rely on expensive engineering projects, but should instead consider what is "doable," with identifiable results, within a realistic cost of infrastructure. A "component" implementation of water processing and distribution (that is, smaller series of treatment and movement centers) is not unlike distributed data processing as opposed to centralized data processing. It lessens expense, upkeep, and avoids system overloads and disastrous shut-downs.

PRIVATE AND PUBLIC REALITIES

When the value of water has been clarified, industry will be quick to realize the value of efficiencies of conservation, use and re-use. Public awareness, however, will depend on education and forums such as this one to prepare the way for the future. Only a true value process and a true information/education process can result in a globe with adequate water for industry and clean water for its people.

THE SUSTAINABILITY OF URBAN SANITATION: SECURING HUMAN HEALTH THROUGH INTEGRATED MANAGEMENT AND CAPACITY BUILDING

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Introduction

The sustainability of current urban sanitation is questionable, in developed and developing countries alike. Historically, sanitation has primarily been perceived as a stand-alone issue. Therefore, the ultimate health and environmental impacts of sanitation systems have not been fully considered, nor was a systems approach followed, whereby sanitation is integrated in the management of the urban water cycle as a whole.

Urban sanitation will be considered in its broadest sense - covering the management of human excreta, but also all other wastes generated through human activity in the urban environment.

Factors undermining the sustainability of urban sanitation

Inadequate human sanitation. Under these conditions, human faeces and associated pathogens, extensively contaminate drinking water, soil and the domestic environment.

Poorly planned on-site sanitation. In poor urban areas, the most common form of sanitation is pit latrines. Often, proper account is not taken of hydrogeological conditions, resulting in groundwater pollution.

Water-borne sewerage, but no treatment. Even in middle-income countries, sewage is rarely treated. This means that rivers in and around such cities are little more than open sewers. This is aesthetically degrading and creates reservoirs for cholera and other water-borne diseases.

Inadequate sewer management. Sewer breaks, blockages, heavy rains and rising water tables could force raw effluent out of sewerage pipes, creating serious health hazards.

Inadequate refuse and solid waste disposal. In many poor cities this is a growing problem. Wastes are dumped indiscriminately, often around points of public water supply. Such conditions contribute to environmental degradation, surface and groundwater pollution, and health problems through vector-borne diseases.

Complete water-borne sewerage and treatment. In many affluent cities, services provision is comprehensive, but this situation too is unsustainable, mainly for the following reasons:

- The mixing of waste streams. Clean water and human excreta are mixed with toxic chemicals and metals from industry. Sewage treatment then results in a problematic sludge and in the discharge of effluents with negative environmental and health impacts.
- Sludge handling. This is a vexing problem world-wide. Ocean discharge is unsustainable; agricultural use is bedevilled through the presence of heavy metals; landfilling leads to groundwater pollution; while incineration releases toxic chemicals into the air.
- Costs. Energy costs for pumping and treatment are enormous. Even for rich cities the maintenance of deteriorating sewers constitutes an increasingly heavy financial burden. Discharge quality standards, too, are progressively becoming more stringent, leading to substantial cost increases. The deterioration of water quality through effluent discharges also increases the cost of water treatment downstream.
- Water use. Flush toilets constitute some 40% of residential demand. Many cities are already water-stressed, and the use of water for transporting wastes is difficult to justify.
- Secondary pollution. Enrichment of the aquatic environment with nutrients, through effluent discharges, stimulates algal growth. This leads to aesthetic degradation, increased cost of potable water treatment, and the release of algal toxins.

A way forward

Can sustainability be improved, considering the massive investments and the awesome problems of developing countries in providing the unserved? Taking a long-term perspective, there can be a way forward - if two initiatives are vigorously promoted and sustained: (1) An **integrated approach** to urban water and waste management; (2) **Capacity building** to enable the widest possible adoption of the integrated approach. Success will only be possible through the collective support of the international urban water sector. A strategy for achieving this will be suggested

An integrated approach to urban water and waste management

Integrated urban water management (IUWM) should consider the collective impact of all possible water-related urban processes (of which the management of human excreta or sewage is only one) on issues such as human health; environmental protection; quality of receiving waters; urban water demand; affordability; land and water-based recreation; and stakeholder satisfaction. Individual processes should then be planned and managed in a way that the collective impact be optimised as far as possible. Due account should also be taken of the interaction of processes. The aforementioned constitutes what one could call the *technocratic dimension* of the IUWM approach. However, there is also the *human dimension* of IUWM, which is equally important. This requires stakeholder involvement and capacity building. For cities in developing countries, the *human dimension* of IUWM is particularly important. For example, hygiene education and building of managerial capacity can generate major benefits over a relatively short term.

It would also lay the foundation to more effectively attend to the *technocratic dimension* of IUWM.

The need for IUWM is increasingly recognised by agencies such as the World Bank. However, there is still a wide gap between concept and practice. IUWM initiatives thus far tended to be isolated and fragmented, thereby precluding the development of generic and proven strategies.

A collaborative international programme for IUWM

To accelerate progress, broad-based international collaboration is needed, involving a partnership of stakeholders. A strategy to achieve this, would be the launch of a **collaborative international programme for IUWM**. It should be a permanent programme, and take the form of a partnership between one or more of the international agencies and one or more of the international professional associations in the water field. The international agencies will be able to establish political recognition and support for IUWM, while the professional agencies, through their members, will provide direct links with stakeholders who are active in urban water management.

The recently established *International Water Association* (IWA) could be a potentially valuable partner in such a programme. IWA is the result of a merger between the International Association on Water Quality (IAWQ) and the International Water Services Association (IWSA). As such, IWA is the world's first major international professional association that represents stakeholders that are directly involved in all facets of urban water management.

A collaborative programme should benefit IUWM, globally, through: advocacy at political level; stimulating research and field testing; maintaining a central, Internet-accessible database; promoting networks and partnerships; and promoting capacity building in IUWM. Progress in IUWM would also promote the state of the art for integrated catchment management, as cities comprise components of major importance in any catchment.

Capacity building

The capacity to implement IUWM is still very limited as tools are not yet well developed. To accelerate capacity building, the knowledge base for IUWM needs to be expanded. The suggested programme would stimulate research and field testing, and outputs can progressively be integrated into capacity building initiatives. Some of the areas in which knowledge should be expanded, are: hygiene education; cleaner production; life cycle analysis; water demand management; water re-use; by-product recovery; low-cost wastewater treatment; sewer management; and dry and low-flush sanitation systems. Dry sanitation, in particular, deserves more attention, as the sustainability of the western model of water-based sanitation is seriously questioned. The prestige value of water-borne sewerage is so high that even the poor are prepared to pay for it. Research should, therefore, include the development of dry sanitation models for upscale market acceptance.

It would be unwise to limit capacity building only to technical tools. In the long term the water sector needs more people that are generally capable of integrative thinking in dealing with water-related problems. This offers a tremendous challenge to the academic community, but the long term benefits would be immeasurable.

The professional associations could play a key role in capacity building. The appropriate knowledge will mainly be generated by members of the associations. Thus, the associations are well positioned to identify progress made, and to facilitate training through the mobilisation of their members, many of whom are academics.

Conclusion

An invaluable resource to the global water sector that has never been fully utilised by the international agencies, is the pool of goodwill comprised by the members of professional associations. Many members have demonstrated their willingness to sacrifice time for a good cause. What is needed is a mechanism to mobilise and channel this goodwill, and a programme as suggested could provide this instrument.

URBAN FLOODS MITTIGATION DEVELOPED VS. DEVOLPOING WORLD'S PRIPRITIES

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Floods occur in nature, but urban areas can be hit badly if not properly defended against this natural disaster of human mismanagement. In urban areas, urban storm drainage as a part of the urban infrastructure and it is complementary to the system of defence against major, floods from adjacent streams. are topics which are gaining in importance in recent years. The concept of integrated catchment management, and means of underpinning the sustainability find its place in the search for the appropriate flood mitigation. It differs in developing and in the developed countries. While developing countries are mostly struggling with major floods cased by flood waves caused by remote storms raising water levels in adjacent rivers, the developed ones, although suffering from the same threat, put more emphasis on the local floods,(caused by local storms) and means of exercising the sustainability concept by introducing more source control (Ichikawa, Maksimovic 1988) in order to achieve reduction of flood risk, improvement of water quality and urban amenity and use storm water as a resource. It is argued here that the sustainability concept can be applied in developing counties as well by a prudent rehabilitation of the existing (often abandoned) conventional systems with improved functionality, relying on the preserved indigenous concepts.

The urban flood mitigation methods in developed countries combine the conventional "technology" of flood defence, with advanced method of sustainable urban drainage system. Although the methods for protection against flooding by local storms and for assessment of the effects of pollution transported by storms on receiving waters have been significantly improved during the past two decades with the introduction of computer based simulation, design, optimisation, real time control and management, there is still a big need for finding the most efficient methods for flood mitigation and for the assessment of the performance of these systems under operational conditions. In developing countries, due to lack of funding or low priority given to flood mitigation, significant improvements in reducing destruction risk can be achieved even in the extreme cases such as hurricane Mitch. Modern informatic technology provides some opportunities, but these have to be combined with the "conventional wisdom". In both developed and developing countries the awareness of the wet-weather pollution potential from diffused pollution sources has rapidly increased in recent years. The systems, which used to have a simple function of collecting storm water and conveying it to the nearest point of disposal, have gradually evolved as their role has changed and now covers two such important fields as urban flood protection and control, and pollution control and management. Additionally urban storm water can be used for improvement of urban amenities and as a precious resource. The proper solutions have to be sought in a well

balanced combination of structural and non structural measures in urban areas and in the broader river basin.
The interaction of storm drainage system with downstream municipalities and water users is strong in those cases when the drainage peak flow uses up the capacity of the river channel, so that no room left for downstream runoff. In these cases, the downstream-upstream relationships and links have to be analysed in order to either share the existing capacity or to share the costs of its enlargement. Small river basins are therefore more sensitive. Sustainability of urban drainage systems in developing countries is sought in implementation of source control measures.

In developing countries the appropriate flood mitigation in urban areas is a topic which has not been addressed appropriately. It was until recently that drinking water and sanitation (waste water systems) had an absolute priority in funding by both local and international sources. Ignoring storm runoff and local floods has often resulted in complete failure of the sanitation projects in developing countries. Because storm water reaches waste water facilities during storm events, mixture of the polluted waste water creates high health risk. It often reaches even the drinking water systems which frequently operate in an intermittent mode. Ignoring storm water often results in failure of the waste water systems. However, there are some positive changes taking place in the Urban flood mitigation can only be achieved by combination of structural and non-structural measures (Braga 1998). Sustainability concept can be applied in both developing and developed countries but there are no universal methodologies. Modern technology combined with common sense and conventional "wisdom" seem to be a promising route.
It is being realised that these systems have to be considered together. In some cases when the conventional degraded storm drainage systems are properly analysed, prudent and cheap solutions can be found for their sustainable rehabilitation (example: Klisa catchment: Novi Sad – Yugoslavia Ref 3.). A network of the almost fully degraded open ditches is proven to have a capacity to be converted into a modern sustainable urban flood mitigation system. The recipe is not universal. Modern analytical technology has to be combined with indigenous methods for a success. Other examples will be presented and discussed in the forthcoming Stockholm Water Symposium

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SUSTAINING URBAN WATER SUPPLIES: THE METROPOLITAN REGION OF SÃO PAULO, BRAZIL

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Introduction

Rapid growth of the urban population has been a general trend in most countries over the past 40 years. This fact introduced important implications for the environment. Urban domestic and industrial consumers are using larger amounts of water and, consequently depleting the available sources. At the same time, they are degrading these resources with their wastes. In 1955, 68% of the global population lived in rural areas and 32% in urban areas. In 1995 these figures were changed to 55% of the population in rural areas and 45% in urban areas. By the year 2025, the urban population will represent 59% of the global population and only 41% of the population will live in rural areas. In some areas the situation is much more critical. For instance, in Latin America and Caribbean, 70% of the population live in the cities.

Urbanization and the consequent concentration of production are an essential part of economic development. They also help in lowering unit costs for the water supply systems and for many forms of sanitation services, including here also access to health services. However, in developing countries, the rate of investments needed to provide water supply and sanitation falls behind the urban growth, leading to a situation of intense pollution due to the concentration of industrial and domestic wastes. In these countries the problem is aggravated due to the unplanned way the cities grew. Migration induced by economic difficulties lead poor populations to settle in peri urban areas with poor housing conditions and almost no urban infrastructure, creating large slum areas.

The fact is that one of the greatest challenges posed by the fast urbanization rates and rapid population growth is to guarantee safe, adequate and reliable water supply, as well as adequate sanitation conditions, to all people and permanently. Beyond difficulties of reaching a large area with reliable service, a situation that is aggravated if the urban expansion was unplanned and chaotic, it also leads to severe strain on the water resources availability and on the environment due to the increase in the water demand and pollution loads.

The challenge is augmented when megacities are considered. The paper presents a selection of water management principles that are to be adopted to surpass such obstacles and its application on the recovery of part of the water supply system of São Paulo, the Guarapirnaga reservoir.

Overcoming the challenge

Improving water management in urban areas is one of the key issues to achieve better quality of life and sustainability of the cities. Excessive use of the freshwater resources leads to scarcity and to increasing costs of developing new, distant sources, and have a considerable impact on development and economic growth. For several megacities around the world, the cost of a cubic meter provided by "the next project" can be two or three times the cost of current supplies.

The sustainability of a safe water supply system depends upon the protection of its water sources and well implemented conservation programs. Water sources are to be safeguarded against chemical and organic wastes, certainly a difficult task in densely built-up areas. The goal of protecting water sources near urban areas, and therefore guaranteeing their sustainability and lowering water production costs, is only met through integrated management. Integrated management to achieve such goal includes:

. *multisectoral approach*, which requires strengthening of management institutions at the appropriate management level and establishing intersectoral planning groups; in practical terms, this means that water supply utilities, environmental protection agencies, housing agencies and municipalities are to be integrated and to work together under the same planning framework.

. *recognition of the economic value of the water*, and the consequent water charging, as a means to guarantee funds to support the management activity, to induce water conservation, to encourage the adoption of efficient water-use practices and to ensure financial viability of new water projects.

. *local capacity building*, training personnel at all levels in the project related institutions, improving their skills in intersectoral work and community involvement.

. *community and stakeholders involvement* in water management teams, where their decision is considered in order to establish the necessary sense of ownership.

The integrated water management must include water conservation and demand management programs. Both are important elements of any strategy to make the use, allocation and distribution of water more efficient. It must also include pollution abatement programs and enforcement of pollution control legislation. All these elements will require the implementation of the principles outlined above.

Supplying water to a megacity: São Paulo Metropolitan Region

The metropolitan region of São Paulo, Brazil, demands 57 m^3/s of drinking water to supply its 16 million inhabitants. The water supply utility operates six large production systems, with nine reservoirs, tunnels, pipelines and treatment plants. The second largest system is the Guarapiranga reservoir, the case study presented in this paper. This system produces 11

m^3/s, being responsible for supplying almost 20% of the entire demand. Its watershed is located on the edge of the urban area of the city of São Paulo.

The Guarapiranga watershed suffered gradually an unplanned and disorganized occupation process over the last 30 years, due to the implementation of an industrial district nearby the reservoir. The population living within the watershed in 1997 was 622,000 inhabitants, the great majority being low income families. Urban areas occupied 15% of the total watershed area.

In 1990, algae blooms became the first nuisance observed by the water supply company. An intensive water quality degradation process was under development due to discharges of untreated domestic waste that was being dumped into the reservoir.

In 1992, water managers of the State of São Paulo decided that the Guarapiranga system was a precious water source for the city of São Paulo due to its yield and the close location. A US$ 336million seven-year project to recuperate and maintain the water quality of the reservoir then began. A World Bank loan of US$ 119 million together with a collateral investment of the State of São Paulo of US$ 217 million allowed the implementation of the project, finishing during the present year of 1999.

The project required a multisectoral approach and a coordination effort to put together four different management levels: the state government, the municipalities within the watershed, the water supply utility and a housing and development agency. The watershed committee was also involved in the decisions. Environmental sustainability of the watershed and quality of life improvement for the poor population were the two main objectives to be achieved by the project.

Five different sub-programs were developed: water supply and sanitation (US$ 94.3 million), solid waste collection and disposal (US$ 5.7 million), rehabilitation of degraded urban sites (US$ 187.1 million), environmental protection (US$ 27.7 million) and watershed management (US$ 22.4 million).These sub-programs dealt with very different topics, from the implementation of wastewater treatment plants and diversion of part of the waste, to urbanization of slums and relocation of people living in risk areas, from waste collection to environmental education and improvement of recreation areas.

Conclusion

Demand management and environmental conservation are essential to achieve success in managing urban water supplies. Therefore, water managers are to look up to projects that aim the sustainability of the water supply sources. Renewed commitment of all water managers to the implementation of the integrated management is necessary to achieve this final goal. It will not be an easy task since it will require better integration of all involved sectors and a greater attention to improving all regulatory and institutional framework in water management. It may be difficult but it is possible, and the Guarapiranga project is here to prove it.

URBAN WATER MANAGEMENT IN DEVELOPING ARID COUNTRIES

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In arid countries such as those of the Arabian Peninsula, where precipitation is low and the available water resources are limited, challenges for satisfying the growing urban water supply and sanitation are serious. Urban water demands has increased substantially especially during the last two decades due to rapid growth in population and improvement in living standards. This is coupled with extensive urban, indusrtial and economic developments. This has put enormous challenges on local water authorities to satisfy the growing demands in terms of water qualities and quantities and to expand water sanitation systems within the the available financial, technical, manpower and time constraints. With lack for proper institutional arrangements, regional and national water planning, and very low water charges; several negative impacts were experienced to various extent in some of these countries. Some of these impacts are excessive water use and wastewater production, significant water leakages, depletion and pollution of shallow and deep aquifers.

In Saudi Arabia, the average annual population growth ranges between 3% to 4%. During the last two decades, comprehensive developments have been experienced in social, construction, and industrial sectors. This is coupled with substantial improvement in standards of living especially with the increase of income from oil production. The urban population has risen from about %50 in 1970 to more than 75% of the total population in 1990. The population has increased from about 7.74 million in 1970 to 14.87 million in 1990, and to about 19 million in 1997. The population is expected to reach about 30 million in 2010, if the present growth rate continues. Consequently, the domestic water demands have increased from about 446 million m3 (MCM) in 1980 to about 1563 MCM in 1997, and it is expected to reach 3000 MCM in 2010. The jump in domestic demands for water supplies and sanitation systems have put the water authorities under extreme pressure and challenging conditions. The Muslim laws " Shari'a " is followed in all aspects of life in Saudi Arabia. The water is considered as one of the natural resources, which is the main component of the sustainability of the nation's life and security The government realized the prevailing water conditions under the arid climatic conditions and the limited water supplies to meet the rapid growth in water demands. It has introduced specialized water agencies, regulations and measures in agreement with Islamic Laws to achieve effective water demand management. This was carried out with continuous consultation with leading Islamic sholars, and specialists in water, agriculure, planning and economics. Specialized agencies were established for water production and distribution. Special regulations were introduced to manage water demands and to protect the interest of the community and its natural resources. The Ministry of Agriculture and Water (MAW) was established in 1953, and assigned the responsibility of water production to satisfy the required water demands in terms of quantities and qualities. The Saline Water

Conversion Corporation (SWCC) was established as Ministerial agency under the MAW in 1965, then as an independent corporation within the MAW in 1974, to be responsible for construction, operation and maintenance of desalination plants for drinking water production. Water and Wastewater Authority (WWA) is an independent agency under the Ministry of Rural and Municipal Affairs, to distribute the drinking water, and to collect and treat wastewater in different cities and towns of the country. Laws and regulations were developed to organize the water management issues including measures to reduce the water demands and to augment the available water resources. To meet the jump in water and sanitation demands within short and limited period of time, costly large seawater desalination plants on the Gulf and Red Sea coasts were constructed to produce the sweet drinking water with water transmission lines to deliver the domestic water to coastal and in lands major cities. Thirty five desalination plants were built to produce potable water from sea water and raw groundwater using Muli-Stage Flush System (MSF) and Reverse Osmosis (RO). Presently, Saudi Arabia is the largest desalinated water producer in the World. The annual water production has reached about 719 MCM in 1997 and the capacity will reach about 1050 MCM by 2000. The present desalination production is about 46% of the total domestic demands, and the rest is pumped groundwater from deep and shallow wells. About 97% of the houses in the country are supplied with clean drinking water. About more than US $10 billion were invested in these plants. Seawater desalination unit cost is about US $ 0.70 per cubic meter for large size desalination plant with energy priced at world prices. The plant also, generates electricity, which is supplied to the regional Power Company. A more realistic sea water desalination cost for a middle capacity plant which produces also electricity is about US $ 0.90 per cubic meter.

These water projects is heavily subsidized by the government, and the consumer pays only less than one-tenth of the actual production costs. In general, the law water charges have indirectly resulted in over-usage of domestic water, which in turn resulted in production of excessive quantities of wastewater. Due to rapid urbanization in major cities and towns, about 55% of the houses in some cities are served with municipal sewage network, and the rest is using septic tanks. This has enhanced the shallow water table formation and rise within some cities. It is estimated that about 1,000 million cubic meter (MCM) of wastewater are generated in the country in 1996, and it is expected to increase to about 1,500 MCM by the year 2000. About 41% of the generated municipal wastewater is treated, and in 1995, only about 150 MCM of the treated wastewater is recycled for irrigating agricultural crops and landscape plants and in refineries.

Legistlation and laws were developed to organize the water management issues including measures to reduce the water demands and losses and to augment the available water resources such as: 1) the introduction of leakage detection and control measures in domestic water supply networks of cities and towns to minimize water losses, 2) in 1994, water tariffs were introduced to enhance the awareness of the people with the value of water production, but still the levels of these tariffs are very low, 3) a special Fatwa (Islamic Permission by the Council of Islamic Leading Scholars) was issued to permit the reuse of wastewater effluents especially for irrigation (this Fatwa helped in the reuse of millions of cubic meters of treated domestic effluents every year for irrgation) 3) recycling of ablution wastewater in the Two Holy Mosques at Makka and Al-Medina Al-Monawwarah for toilet flushing at Two Mosques, 4) introduction of a municipal regultaion to recycle the ablution and bathing wastewater in multistory and high rise resedential buildings for toilet flushing and 4) transportation and use of highly saline water in place of desalination water from Wadi Malakan near Makka for toilet flushing in the Holy Mosque At Makka.

The industrial water demands have increased from about 56 MCM in 1980 to about 300 MCM in 1997. The growing industrial water demands are mainly satisfied from desalination plants and from the nonrenewable groundwater resources. The industrial sector produces large quantities of wastewater at plant level. To minimize industrial water demands, to maximize wastewater recycling and to protect the environment, large industrial cities were established in different parts of the Kingdom. Each city contains tens or hundreds of factories. The industrial wastewater is collected, treated and recycled within each city at plant level for industrial and landscape purposes. The Industrial cities have specifications for the quality of the collected wastewater from factories. Generally, significant quantities of the effluents are still not utilized. The uncontrolled disposal of the effluents causes negative impacts such as: shallow water table rise, water logging, and possible pollution to groundwater, marine sediments and soils. New approach called closed water cycle were introduced to industrial plants to maximize wastewater recycling, to minimize wastewater disposal, to reduce groundwater pumping and to protect the environment.

With continuous rise in urban demands for water and sanitation, the challenges for satisfying these demands are increasing. The same previous trend in construction of more costly desalination plants is difficult especially with the decline in the oil prices. The challenges can be solved by the introduction of new legislation and technologies to improve the management of urban water and sanitation supplies. Legislation has to be developed to improve the coordination of responsibilities and actions among different water agencies. Water tariffs should be increased to reflect the actual value of the water, and to enhance the awareness of public with the value of water. The introduction of strong and transparent regulatory framework to adopt different forms of water supply privatization, to reduce the costs of building, operation and maintenance of water and sanitation facilities, and to improve the level of services and billing, leakage and wastewater collection and treatment. It is also essential to use new approaches and technologies to reduce the water demands, and losses, and to enhance wastewater recycling and water conservation. Other measures should be taken to reduce the urban water demands by improving the life conditions in rural areas to reduce the movement of people to urban centers. Development of short-term and long-term water plans on regional and national levels using proper techniques for water demands forecasting is important to achieve realistic and feasible solutions to satisfy the water and sanitation demands.

THE INTERDEPENDENCE OF GROUNDWATER AND URBANISATION

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Subsurface Dimensions of Urban Development

The subsurface plays an important role in key elements of urban infrastructure development (the provision of water-supply, sanitation and drainage) (Inset A) and in the disposal of industrial effluents and solid waste. The main initial benefits perceived from such use of the subsurface environment in urban areas are given in Inset B which balances them against the long-term costs which are rarely taken into initial consideration.

Groundwater plays a fundamental role in shaping the economic and social health of urban areas in the developing world. No comprehensive statistics exist on the proportion of urban water-supply worldwide derived from groundwater, but more than 1,000 million urban dwellers in Asia and 150 million in Latin America probably depend upon well, spring and borehole sources. Due to its relatively low cost and generally high quality, groundwater has often been the preferred source for reticulated public water-supplies, and is also widely exploited for private domestic and industrial uses.

Urbanisation and industrialisation have, in turn, a profound effect on urban groundwater resources, which are inextricably linked with land-use and effluent disposal practices in a complex fashion (Inset B). For example, the subsurface plays a key role in urban wastewater disposal (because of the widespread use of unsewered sanitation) and is often also a major receptor for industrial effluents, either directly from casual disposal to the ground, or indirectly as seepage from treatment lagoons, or infiltration from surface watercourses.

Interrelated and Conflicting Processes

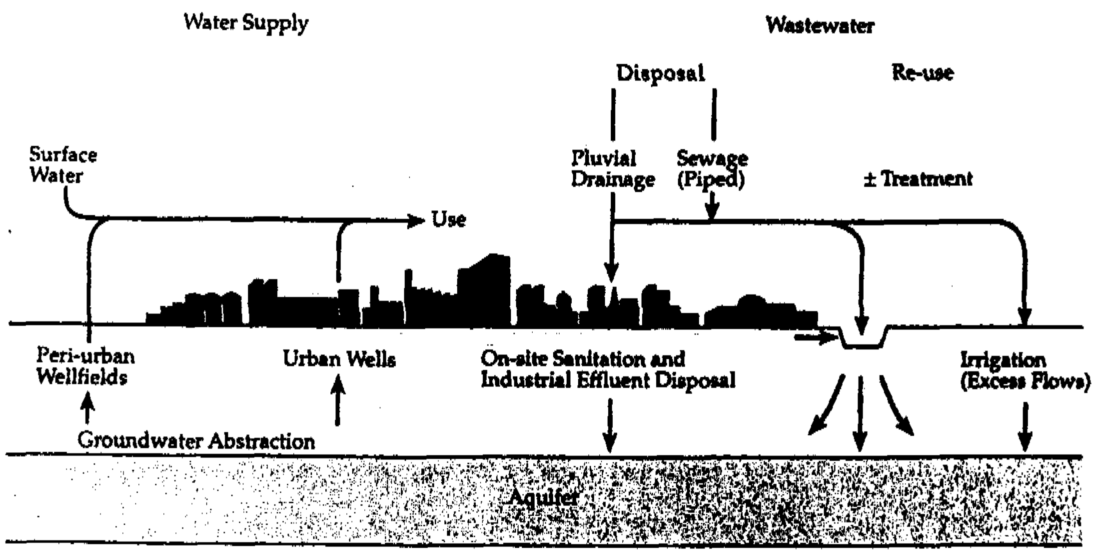
In most instances urbanisation affects the underlying groundwater system in two ways:

* by radically changing patterns and rates of aquifer recharge
* by adversely impacting the quality of groundwater.

The effect on recharge arises both from modifications of the natural infiltration system, such as surface impermeabilisation and changes in natural drainage, and from the introduction of a water service network, which is invariably associated with large volumes of water mains leakage and wastewater seepage. Urban processes can cause severe, but essentially diffuse, pollution of groundwater by nitrogen compounds, petroleum products, chlorinated hydrocarbons and other synthetic compounds, and on a more localised basis by pathogenic microorganisms.

FUNCTION OF SUBSURFACE	INITIAL BENEFITS	LONG-TERM COSTS
Water-Supply Source	• low capital cost • staged development possible • initial water quality better • private and public supply can develop separately	• excessive abstraction can lead to: - abandonment/reduced efficiency of wells - saline intrusion risk - subsidence risk
On-site Sanitation Receptor	• low-cost community-built facilities • permits rapid expansion under sanitary conditions • uses natural attenuation capacity of subsoil	• sustainability of groundwater abstraction threatened if contaminant load exceeds aquifer assimilation capacity
Pluvial Drainage Receptor	• low capital cost • conserves water resources • roof runoff provides dilution of urban contaminants	• contamination from industrial/commercial areas and major highways
Industrial Effluent/Solid Waste Disposal	• reduced manufacturing costs	• may prejudice groundwater quality • favours irresponsible attitude to waste management

INSET A: ***Balancing Initial Benefits and Long-Term Costs in the Urban Use of the Subsurface Environment***



INSET B: ***Interaction of Groundwater Supply and Wastewater Disposal in an Urban Area overlying a Shallow Aquifer***

Where groundwater abstraction is heavy and concentrated, such that it greatly exceeds average rates of local recharge, aquifer water levels may continue to decline over decades, provoking an expensive and inefficient cycle of well deepening or even premature loss of investment through abandonment of wells. Major changes in hydraulic head distribution within aquifers lead to reversal of groundwater flow directions. This reversal can induce serious water-quality deterioration and as a result of the ingress of sea water, up-coning or intrusion of other saline water, or induces leakage of polluted water from the surface. Cities located on some types of aquifer may suffer subsidence because of groundwater abstraction, causing damage to building foundations, and all piped services routed underground.

Urbanisation tends overall to increase the rate of groundwater recharge, thus if underlying aquifers are not used then groundwater levels will probably rise. In this situation, as the water-table rises towards the land surface, service tunnels and ducts may suffer structural damage or be flooded, and both hydraulic and corrosion effects on building foundations and tunnel linings can occur. In extreme cases, the water-table reaches the land surface and a health hazard may result as septic tanks malfunction and polluted water accumulates.

The effects of urban water-supply and wastewater disposal are not limited to the geographic areas occupied by the city itself. As cities expand they may even degrade their own peri-urban wellfields, either directly through in-situ sanitation and/or industrial discharges, or because of infiltration of polluted surface watercourses in downstream riparian areas.

Towards Sustainable Groundwater Management

Unless groundwater receives more proactive management and appropriate protection (in terms of both quantity and quality), there will be increased scarcity and escalating cost of urban water-supply, with potential impacts on human health. In formulating the appropriate management measures it is absolutely essential to have a clear understanding of the interdependence between the urbanisation process and groundwater resources. One important aspect is the need to take an integrated approach to the evaluation and management of both municipal and private groundwater exploitation and wastewater disposal. This rarely, if ever, has been the case to date. Serious negative consequences for all urban dwellers are likely to arise if scarce high-quality groundwater is not conserved for potable and sensitive uses.
Since cities evolve in space and time groundwater resource management measures must be flexible and reviewed regularly. Controlling incipient trends relating to imbalance of groundwater recharge or contaminant loading is much easier than dealing with more deeply-rooted problems. In some megacities, especially in the more arid regions, only partial remediation may be possible, and policies aimed at helping medium-sized cities to avoid the problems currently observed in some megacities may be the highest priority.

THE TURNING OF A SCREW

Social resource scarcity as a bottle-neck in adaptation to water scarcity
(Outline of a planned SADC research project)

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Abstract: The task of managing the process of adaptation to water scarcity essentially entails learning how to deal with: i) the conflicts encountered as a result of the natural resource scarcity itself (both international and internal conflicts about the distribution of the resource); and ii) the conflicts encountered as a result of the social resources applied to overcome the natural resource scarcity (internal conflicts, often directed at the state, and therefore a dangerous impetus for external conflict).

Countering the widely held opinion that water scarcity entails prime risks of international conflicts over shared water resources, it is argued that the risk of conflicts within countries in fact is larger, and that the risk of international conflict is derived from the necessity to avoid what is defined as second-order conflicts within countries, caused not by water scarcity itself, but by the institutional change required to adapt to water scarcity.

The paper seeks to establish some common grounds for a planned research project on this subject in the SADC region.

The purpose of the planned project is to identify, that is, discern and describe in detail, in a SADC region-specific context, how societal attempts of *adaptation* to water scarcity in fact run the risk of giving rise to mechanisms whereby the very *adaptive capacity* of societies are undermined.

The problem under investigation thus constitutes a vicious circle, hitherto neglected in research on water resources management, and urgently needed to investigate in order to identify unforeseen bottlenecks. The problem arises from a generally identified and recognized progression of the need to apply an increased amount of social resources in order to accomplish intensified adaptation to water scarcity

1. At the first level of adaptation societies attempt *supply-side management* ("get more water"), involving dam-building, pipelines, inter-regional water transfer schemes, and the drilling of boreholes to abstract groundwater. Social resources employed at this stage thus mainly are *large-scale engineering efforts.*
   Current examples in the SADC region are the Kafue Gorge and Cunene Dam projects, the Lesotho Highlands Water Project (the largest water transfer shceme in the world bringing water to South Africa's industrial heartland from the Katse Dam in Lesotho), a pipeline from the Zambezi-Chobwe to Botswana, and a pipeline from the Zambezi bringing water to Bulawayo.
   A low-tech example of supply-side management is *rain-water harvesting*, practiced in some parts of the Sahel, Eastern Africa, and the SADC region.

2. At the second level of (increased) adaptation, when further supply-side management no longer can deliver the amounts of water required by continuing population increases and desirable welfare increases, societies are forced to employ *demand-side regulation*, first by *end-use efficiency* measures ("get more use out of every drop").
   Social resources employed at this stage are institutional change, new regulatory frameworks, and economic incentives for water-saving (plus the scrapping of previous economic disincentives, such as subsidies). A current example from the SADC region is increased water pricing in Namibia.

3. At the third level of (further increased) adaptation, societies are forced to abandon the traditional goal of food self-sufficiency, and replace it by food security, that is, the ability to produce sufficient economic value in industries and cities, or by non-renewable resource abstractions, to be able to import the required amount of food. This is the second stage of *demand management*, namely so called *allocative efficiceny* ("get more value out of every drop"), entailing imports of "virtual water", that is, the amount of water required, but not available, in order to grow the food now imported instead.
   The need for social resources at this stage are particularly acute, since allocative efficiency entails enforced and large-scale social restructuring; people now have to find jobs and livelihoods in cities and industries instead of in agriculture. A current example from the region is Botswana, which explicitly has abandoned food self-sufficiency in favour of food security. A similar process, however, is going on all over the region.

*

The three stages of adaptation to water scarcity thus could be envisaged as "the turning of a screw", whereby a *first-order scarcity of the natural resource water* gives rise to a *second-order scarcity of social resources* required for successful adaptation to live with and develop under conditons of water scarcity. The image should be one of a spiral movement, oscillating between a perceived scarcity of the natural resource water, and a perceived scarcity of the social means required to adapt to the original scarcity; all the while progressing towards ever increased amounts of social resources applied to adapt to the natural resource scarcity.
At different turnings of the screw, distinctive challenges are encountered.

Challenges encountered

1. At the first turning of the screw, *the phase of large-scale engineering projects*, the problem is perceived as water scarcity, pure and simple. It is a first-order scarcity, the solution to which is mobilizing more water, that is, supply-side management. Challenges encountered are how to deal with conflicting interests *between* countries, and between groups of users and sectors *within* countries.
   i) At the *international* level the mechanism of conflict is the perceived zero-sum upstream-downstream game, giving rise to fears of "water wars" as a result of one country (most often upstream) holding other countries ransom to its own capture of water resources.
   Note, however, that this risk of conflict is relevant only as long as water policies of countries are focused on the first turning of the screw, attempting adaptation to water

scarcity solely by supply-side management. At all later stages, the pressure to "get more water" diminishes, as societies adapt to living with water scarcity.

Note also that all empirical evidence points at the risk of international conflicts in fact giving rise to *cooperation* between countries (albeit with possible tensions continuing), rather than conflict. A number of treaties and cooperative administrative bodies on shared rivers exist in the region.

ii) At the local and regional level within countries the conflict mechanisms are those described by the concept "environmental scarcity": *demand-induced scarcity* ensues from the water needs of increasing populations with justified demands for increased welfare; *supply-induced scarcity* as rivers running dry, lowered water-tables, and polluted groundwater and surface water courses; and *structural scarcity* as more powerful segments of water users confiscate a larger part of the scarce resource, resulting in the ecological and economic marginalization of the less powerful.

Conflicts may also arise between, for example, the often large number of people displaced by dam-building projects and the state (an example in the region is the Epupa Falls project in Namibia); and between frustrated and water-starved farmers in areas transversed by large-scale water transfer projects (an example is farmers in Zimbabwe along the projected Zambezi-Bulawayo pipeline), on the one hand, and the state on the other.

2. At the second turning of the screw, *the phase of institutional change*, societies attempt adaptation to water scarcity. The solution then is to save water by doing more with every drop, that is end-use efficiency. The means to do so are found by changing rules and regulations, administrative bodies, and economic incentive, that is, the institutional framework, in order to bring more water-efficient modes of usage into practice.

   Water scarcity now becomes relative, since the available amount of water depends on the social willingness and economic rationality of employing more labour and technology-intensive, but less water-consumptive modes of production. On a high-tech level examples are drip-irrigation, re-circulation of waste-water, and water-efficient appliances.

   The means whereby this more water-efficient mode of usage is brought into practice are however not without social costs. Institutional frameworks (rules and regulations, administrative bodies, and economic incentives) are always designed to facilitate a certain mode of water use, and to pave the way for a particular group of water users, be they cooperative farmers, large-scale irrigators, or parastatal hydroelectric companies.

   To change such an institutional framework is not only cumbersome and tedious; it will also infringe on the vested interests of societal segments that may have become very powerful and entrenched over time. The potential conflicts at this stage will thus occur within countries, and most likely exhibit a fault-line with the *state* (trying to impose new regulations and economic incentives) on one side, and so-called *narrow coalitions* of previously subsidized large water users on the other side.

3. At the third turning of the screw, *the phase of large-scale social restructuring,* the second stage of demand-management, *allocative efficiency*, comes into play. The problem at this phase is perceived as achieving a quantum-leap in water efficiency by

maximizing the economic return of every drop of water mobilized in society. It is a logic that, once realized, follows almost inevitably from the institutional change and new economic incentives introduced during the previous stage.

The solution, then, becomes a conscious effort to redirect water to cities and industries, yielding some 20-70 times higher economic returns to water compared to agriculture. Concurrently, a shift in food procurement strategy takes place, from food self-sufficiency, based on what a country can grow internally, to food-security, based on the degree to which a country can afford to import the food it no longer can find the resources for growing, water prime among them. It is thus a strategy of relying on virtual water.

Conflicts at this stage do not arise as much over competiton for the amount of water diverted to cities and industries, since a comparatively small proportion of the water used for agriculture will suffice for those needs. The social challenge is much more basic and has to do with agricultural expansion as such no longer being an option. Thereby the issue of livelihoods, as distinguished from just food procurements, becomes pivotal.

The challenge is enormous, since it involves creating new jobs in cities and industries to compensate not only for the stagnating or even shrinking number of jobs in agriculture, but also to do this at a time when populations in many cases still are growing rapidly, and people have justified demands for not only livelihoods, but better lives.

The conflicts likely to occur are extremely difficult to predict. In all probability they will not be directly coupled to changing water allocations, but to widespread ruptures in the social fabric, stemming from the inability to incorporate such a large and growing proportion of people into the modern sector, at the pace required by both continuing population increases and the structural change from agriculture to cities and industry. The social resources during this phase are taxed to the outmost, while the supply of social ingenuity may be severly hampered by social conflict.

WATER RIGHTS ADMINISTRATION IN DEVELOPING COUNTRIES: A PREREQUISITE FOR SATISFYING URBAN WATER NEEDS

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Introduction

Water resources development has traditionally emphasised assessing water availability rather than water use, and solving water problems by increasing supply instead of reducing demand. Due to increasing water pollution, shortages and conflicts among uses, users and geographical areas, many cities in the near future will suffer from severe water shortages if we insist on a supply-oriented approach. Therefore, more emphasis should be placed on water demand management and conservation of the quality of water sources if cities are expected to satisfy their future needs. Water demand management usually includes introducing water saving technologies and public participation as well as water rights transfers to activities that make more beneficial use of water from social, ecological and economic viewpoints. But realistic water demand management and pollution control programmes cannot be designed or implemented without a fair knowledge of who uses how much water and for what purpose, as well as who the water polluters are and what the quality of their wastewater discharge is. Moreover, users and polluters may not be willing to participate in such programmes unless they have legal certainty on their rights to abstract water and to discharge wastewater under a certain effluent standard.

This paper presents the experience of implementing aspects of a major component of water legislation, namely the granting of water abstraction and wastewater discharge permits in four developing countries. A comparative analysis of the four cases was made with the objective of offering guidelines that may help other countries establish realistic water legislation in accordance with their specific history, culture and present conditions.

Scope

The Mexican Water Law was enacted in 1992 and its regulations in 1994. It took six years to obtain information regarding most water uses and wastewater discharges in the country using an approach that trusted users to supply such information. This, along with an improvement of water quantity and quality information systems as well as enhanced public participation tools, is expected to set the stage for sustainable water resources development.

Anticipating implementation problems while drafting the South African Water Bill in 1997 and 1998 contributed both to drafting a more realistic Bill, which was enacted in

August 1998, and establishing a capacity building program to set up the water rights administration system to be implemented in phases.

In Uganda the 1995 Water Action Plan advocates a gradual and phased approach for water resources management. The Water Statute was enacted in 1995 and the Water Resources and Waste Discharge Regulations were issued in 1998. In order to implement a water rights system that the water authority is able to enforce and water users and polluters can comply with, several legal provisions to clarify and simplify the existing legislation, a user manual and a realistic effluent standard were suggested. A capacity building programme for both the public and private sectors was also suggested.

Sri Lanka is presently modernising its water policy and legislation and it is expected that the policy will be adopted in the near future and that the Act will be passed by early 2000. In the first place, this approach to designing and implementing a realistic water rights administration system consisted of anticipating implementation issues while drafting the Water Resources Act and secondly, simulating on paper the entire process to analyse applications and grant water use and wastewater discharge permits before the Water Resources Regulations are officially issued. The paper exercise is expected to contribute in establishing realistic regulations and procedures and help develop a capacity building programme.

Methodology

This paper is the outcome of a research project sponsored by FAO. It draws on the author's four years of experience as the person responsible for implementing the Mexican Water Rights System. Later as an FAO consultant, he had the opportunity to participate in the South African, Ugandan and Sri Lankan efforts to establish water right systems.

The four countries that were studied are developing countries, but with different backgrounds and at different development stages. Furthermore, the design and implementation of the water rights administration system is at a different stage in each case. The study consisted of analysing the four cases in order to identify the main implementation issues, those that have been successfully dealt with and the main drawbacks and ways of coping with them.

Results and Conclusions

Enforcement of water legislation is hindered by the fact that during the drafting stage it is usually difficult to anticipate implementation problems such as the capacity of users to comply with the law and the capacity of the water authority to apply it. Furthermore, it must be recognised that the design and implementation of water rights administration systems is a lengthy process that cannot be achieved overnight. The following recommendations were drawn from the four cases that were studied and may help other developing countries to establish more realistic water rights administration systems in accordance with their own specific history, culture and present conditions.

- Within a country each region has specific water pollution and shortage problems as well as different needs to transfer water rights. These differences must be taken into account when establishing a specific timetable for implementing a water rights administration system in each region.

- No single tool will solve water rights administration problems in any given country. A balanced combination of economic and regulatory tools as well as participation must be selected in each specific case.
- Water rights administration should be made operational by placing under the same organisational unit the granting of surface and groundwater abstraction and wastewater discharge permits.
- An operational water rights administration system will not necessarily be theoretically perfect. A more important requirement is that it can be implemented. The following recommendations are geared to implementing operational systems:
  - ✓ Laws and regulations should be as simple as possible.
  - ✓ The team in charge of drafting and implementing the system should be interdisciplinary including lawyers, economists water resources and environmental engineers.
  - ✓ Those responsible for implementation should participate in drafting the legal instruments. This will help anticipate problems in the application of the law and regulations as well as in establishing capacity building programs to facilitate implementation.
  - ✓ Quality control for the application of technical and management procedures used to recognise existing water uses and wastewater discharges and to adjudicate rights to new developers should be established in the initial implementation stages.
  - ✓ Before enactment, drafts of the proposed water law and regulations should be discussed within the implementing authority and with water-related government units, water users and stakeholders. The ownership acquired through this approach should increase the probability of successful implementation.
  - ✓ The best available information and monitoring technology should be applied, but only to the extent that the existing capacity in the country assures that such technology will be taken advantage of in a sustainable manner.
  - ✓ A phased approach should be adopted. Regulations and procedures should never go beyond the existing capacity of users and the water authority.
  - ✓ A capacity building programme should be implemented as soon as possible. If consulting firms are required to support governmental efforts, the programme should also include the private sector.

Finally, a second stage to this research project is suggested, which would involve carrying out a field evaluation of the four cases and including new case studies.

Workshop 1

Water reuse within the city

REUSE OF WATER IN WINDHOEK, NAMIBIA

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Introduction

Most of the countries within Southern Africa receive a mean annual rainfall less than the world average. The erratic rainfall, periodic droughts, relative low humidity and high temperatures have a major effect on the availability of water Apart from the direct problems of water shortage there are other implications of diminishing supplies. The cost of expanding existing water supplies, or developing new sources, is expected to increase as the limits of conventional water sources are approached. It is generally predicted that water will be one of the most important factors for socio-economic development in many growth centres in the twenty-first century.

Scope

The purpose of this paper is to review the different factors which influence water reuse, various options available for reuse in urban areas, and some examples of reuse in Windhoek, Namibia, which may serve as role models for possible implementation in other places with water stress. The progress and results with the implementation of Integrated Water Resource Management (IWRM) in Windhoek with special emphasis on water reuse are discussed.

Methodology

Integrated Water Resource Management (IWRM) is part of a holistic approach towards sustainable development and use of water resources. This involves the implementation of clear policies for the efficient use of water, for equity, economic efficiency and environmental sustainability.

Wastewater reuse through onsite reuse, dual pipe systems, water reclamation for potable use, artificial recharge of groundwater as well as Water Demand Management (WDM) form part of the integrated approach. The lowering of risk on the reuse of water will also be discussed in the case of Windhoek.

The financial costs of the different options will be evaluated over the past few years, as well as the actual saving by replacing water from conventional sources with water that does not "impinge" on primary water sources.

Future projects based on integrated bio-treatment with recovery of nutrients in wastewater will be highlighted, including the environmental and financial sustainability of such approaches.

Results and Conclusions

Reuse of wastewater is a well-established practice world-wide. In Southern Africa where permanent water stress is foreseen in many countries within the next three decades, reuse will form an important cornerstone for Integrated Water Resource Management. Considering the high population growth rate, the importance of Windhoek as an economic growth centre, the high capital investment needed to make more water available to the Central Area of Namibia and environmental aspects, water reuse and WDM is the only viable option to use existing resources more efficiently.

- Through the reclamation of water and the installation of dual reticulation for purified effluent (irrigation water for parks, sportsfields and cemeteries), the required volume from conventional surface and groundwater sources was lower in 1997 than in 1987. Over the same period the population of Windhoek approximately doubled from 105000 to 202000.

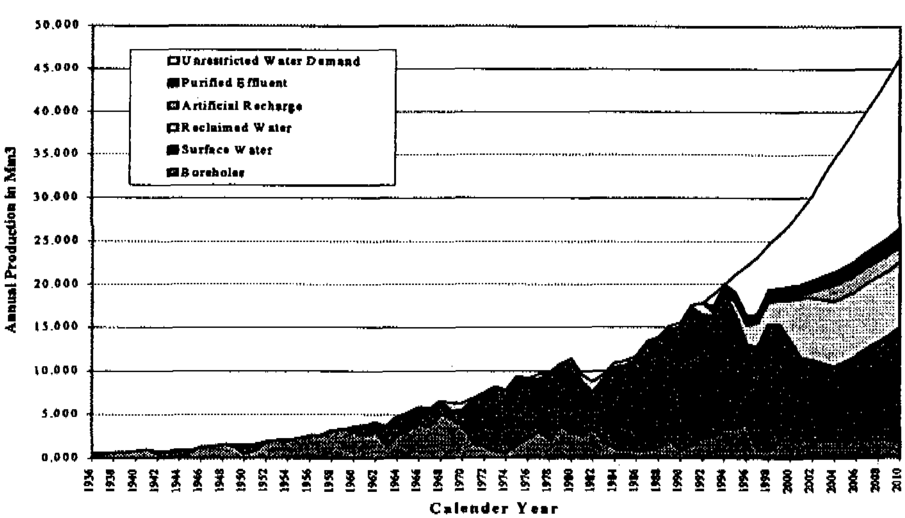
- Direct reclamation of domestic wastewater for potable reuse has been practised for more than 30 years in Windhoek. No negative health effects could be detected up to now.

- Direct artificial recharge of aquifers is beneficial lower evaporation and augment supply through "water banking" during periods of drought.

- A feasibility study on the implementation of an Integrated Bio-systems concept for the treatment of industrial wastewater shows that the total investment cost can be recovered in five years. At the same time approximately 50 fulltime job opportunities will be created.

The graph in **Figure 1** gives an indication of savings realised until the end of 1998 as well as projected savings on water demand from conventional sources until 2010.

Figure 1 Historic and Expected Water Production from Different Sources



The saving in water volumes and costs are summarised in **Table 1**

Table 1 Summary of Savings in Water Production and Savings in Cost

Method of Saving	Volume Saved in 1998 (Mm^3)	Value of annual Savings in N$ Million* (N$ 6=US$ 1)	Expected Savings in 2005 (Mm^3)	Value of Annual Savings in N$ Million*** (N$ 6 =US$ 1)
Water Reclamation	2.59	1.7	7.5	2.8
Dual Pipe System	1.22	2.0	1.6	2.5
Artificial Groundwater Recharge	0.21	0.4	2.0	3.8
Water Demand Management	5.25**	16.6 (3.5)	14.2	45.0 (9.5)

* *Values are calculated according to bulk supply cost recovery prices in 1998 i.e. N$3.17/$m^3$. Figures in brackets represent savings in operational expenditure i.e. N$0.67/m3*

** *A large percentage of this volume evaporates because of storage in open reservoirs. Real benefits will only realise with underground storage.*

*** *All cost savings in 2005 are calculated on 1998 cost recovery prices.*

Should all the reuse projects including WDM be implemented successfully, Windhoek will need only one third of the unrestricted water demand from conventional water sources in the year 2005. Water from boreholes and dams in ephemeral rivers are regarded as conventional sources.

Under normal climatic conditions further investment in bulk infrastructure in order to augment water supply to Windhoek, can be postponed with at least 10 years. **Security of water supply during extended periods of drought remains the biggest challenge.** Practical experience in Windhoek demonstrates that implementation of IWRM, is a responsible way of managing urban water supply and demand in arid regions. Implementation of IWRM (including reuse and WDM) requires commitment, comprehensive planning, clear policies, updated legislation, public participation and support for continued success. In an arid country like Namibia, with low and erratic rainfall and fragile eco-systems, water must be treated as a scarce natural resource and a precious commodity.

URBAN AQUACULTURE : WASTEWATER RECYCLING CALCUTTA CASE STUDY

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Introduction

Aquaculture played an important role in the ancient civilizations but today it has new meanning in the cities with scarcity of water or flooding and water pollution. Rapid urbanisation and modernisation of society are producing large amount of waste both solid and liquid. There will be many large cities in poorer countries in Asia and modern methods of disposal of solid and liquid waste will be very expensive and beyond the financial capacities of many municipalities. Much of these can be recycled by natural process even by the urban poor which will provide food, employment and protect environment.

The reuse of human waste in aquaculture is an ageold practice in Asia and recycling of waste water instead of conventional disposal, with natural treatment with least cost provide maximum agricultural and aquacultural benefits from the nutrients contained in the waste water.

There are examples from countries in Asia – India, China, Bangladesh, Taiwan, Thailand, Vietnam and Cambodia – recycling of waste water is gaining momentum despite threats by urban sprawl and real estate development.

Methodology : Calcutta Case Study

Calcutta has the largest recycling of wastewater in the wetland on the eastern fringe of metropolitan area. In 1959-60 the total area of recycling/wetland was 7500 ha but due to largescale conversion into paddy cultivation, vegetables fields and urban development total area is now about 2500 ha which is being reduced by encroachment and urban development. The annual yield of fish product has fallen from 30000 to 15000 tons. The fish ponds known as *bherry* are now only 120-130 in numbers.

The underground trunk sewer lines of Calcutta city are linked with 17 pumping stations all located on the eastern fringes. The trunk drain was designed to take the discharge towards a tidal river on the east. About 75% of the total waste water flow through the dry weather and storm weather flow channels. 15% is carried through canals in the north and remaining 10% through a southern canal. There were 16 drainage basins identified by the WHO study in 1959.

The Calcutta Municipal system generates about 750 million litres of waste water daily and 2500 Mt of solid waste is disposed on east Calcutta near the wetland. After separating the paper, plastics and metals, the waste is naturally composted. The natural compost is used in the production of good quality vegetables (150 mt/day) without adding any fertiliser but sometimes the nutrient rich sewage fed waste water or sludge is used. A compost plant has been set up also.

Previously mechanical treatment of waste water and release of effluent into Bidyadhari river towards the east was practiced but this expensive arrangement failed and the river became silted. The local fishermen was practicing the sewage fisheries on wetland for many years. Fish and vegetables meet about 25% of the need of the city. In southwest area a fishermen's cooperative at Mudialy has taken lease of 15 ponds, 50 ha in area from the Calcutta Port Trust and 23 million litres of waste-sewage water is treated.

The pond unit each of lagoon type (between 7 ha – 10ha) in size is to facilitate natural aeration through wind action of shallow depth, about 1.5 metre to allow sufficient sunlight to reach upto its bottom to promote growth of algae and photosynthetic oxygen is fitted usually with two sluice boxes as inlet and outlet points, for periodical sewage feed exchange from the city's nearest drainage outflow channels and canals. Using aquatic plant like water hyacinth and duckweed *(lamnae)* water is purified and it is also purified by exposure to sunlight and aeration (oxygenation) enhanced by sun and wind. Occasional use of lime achieves coagulation and floculation. The State Government declared a Recycling Zone of 12000 ha but this is being threatened by allowing various devleopment nearby.

The process is advocated in other waste water discharge areas. It was found that there are hundreds of outfall in the river Hooghly (a tributory of the Ganges) in Calcutta and it was found that to reduce pollution under the Ganga (the Ganges) action plan of the Govt. of India it would be very expensive to adopt alternative disposal or treatment. Wetlands, ponds and marshy lands have been brought under the fisheries and the State Fisheries Dept is very active. Three projects in rural fringe of metropolitan area have been taken up with the participation of local people, fishermen and the village council. Community Based Wetland Ecosystem (CBWE) has been first introduced in 1995 in Titagarh, northern industrial town in metropolitan area.

There are paddy fields in the vicinity and in lower Gangetic area. Traditionally paddy fields require much water and certain species of fish are cultivated but use of chemical fertiliser and pesticides have destroyed the species. Experiments are being carried out to produce fishes in paddy field again with natural process by using wastewater to get multiple benefits.

Potential benefits

Urban solid and liquid waste are primarily organic and regenerates the environment. The east Calcutta wetlands are keeping city's edge green and waste water treatment ponds are enriching the soil which is producing vegetables more in quantity and quality.

Waste water treatment is the primary objective, but broader aspects of aquaculture, horticulture, livestock and poultry development, agroforestry etc. are required as buffer between the urban and rural areas to prevent sprawl. Industrial employment has declined in many cities and growth of informal sector employment in aquaculture and agriculture in the wetlands in and around cities is to be encouraged.

The high productivity of these fish ponds is mainly due to rich nutrient element in waste water like nitrogen, phosphorous, potash, calcium etc and the high alkanity stimulates production in the fish food chain. There are several parameters. It generates abundant quality of algeal photosynthetic oxygen at the assured rate of 1 gm algae synthesized to produce about 1.25 gm of oxygen and thus dissolved oxygen is found to be 0 mg/1 at the inlet point to 16-20 mg/1 at the outlet zone. The biochemical oxygen demand (BOD), a critical parameter of waste water quality is 150-180 mg/1 at the inlet to about 15-32 mg/1 at the outlet. The total number of people engaged in the solid and liquid waste disposal is about 30,000.

Conclusion

Waste must be regarded not as a problem to be disposed off, but as a resource for sustainable development. Metropolitan areas should be viewed as ecological systems in which waste and resources are one and the same. Reuse, recycle, rehabilitate, repair, restore and refurbish should be the new order. The success of waste water treatment, aquaculture and agriculture development has been achieved due to the people and their link with the wetland.

While waterhyacinth removes metals and other inpurities duckweed has many uses besides wastewater purification. These also provide feed for livestock, compost and fuel. These plants draw rich nutrients from sewage especially nitrogen, and phosphorus in the process of cleaning water. There are several aquatic plants for food also.

Excess water which is clean is discharged through drain into the river. A variety of fruit trees and a variety of fishes in cleaner water can invite birds and some animals, MudialyFishermen's co-operative has developed a nature park, with deers, swans, ducks etc.

Biodiversity is being reduced due to various encroachments and human activities. Any integrated ecological approach for preservation and wise use of wetlands enhance biodiversity.

Water Reclamation and Reuse for Agriculture and Afforestation

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Introduction

Kuwait is an arid country. Hence, water resources are very scarce and a valuable commodity. Due to the fast-paced development in Kuwait over the last two decades, the demand on the water supply has increased significantly. To meet the increasing demands for water, the Kuwaiti government has set forth plans to utilize industrial and municipal wastewater for potential applications in agriculture, landscaping, and afforestation. Such plans, if successfully executed, could significantly reduce the wastewater discharges into the sea. Wastewater will be used as source of water supply for non-drinking applications.

For drinking water, the first desalination plant in Kuwait was built and commissioned in Shuwaikh in 1953, with a capacity of 4000 m^3/d of fresh water. By early 1984, four giant desalination plants had been established in Shuwaikh, Shuaiba, Doha, and Ras Al-Zour. Their total capacity is about 50000 m^3/ .

Besides the desalination plants, Kuwait has two areas with natural underground water; Rawdatan and Umm Al-Aish. Their combined capacity is about 1.5 million gallons per day; this capacity could be increased to 3.5 million gallons per day.

Present muncipal wastewater generation is about 345 000 m^3/ which is treated at three main plants; Ardiyah, Regga and Jahra. All the three plants are equipped with primary, secondary and tertiary treatment. Kuwait is currently using less than 15% of its treated wastewater in agriculture and the rest of the treated wastewater is discharged to the sea.

The major portion of the industrial wastewater is generated from the Shuaiba Industrial Area (SIA). The projected sanitary wastewater flow based on the ultimate development of the SIA was estimated at about 5000 m^3/ d, in contrast to the current flow rate of about 3000 m^3/ d. Industrial wastewater generated by the main industries is estimated at 31000 m^3/d. With the addition of the Kuwait Petroleum Company's (KPC's) Petrochemical Complex and other future projects and long-term development in the SIA, the predicted industrial wastewater flow will reach about 51,000 m^3/ d in the year 2000. A small fraction of treated sanitary wastewater is used for irrigation and the rest is discharged to the sea, whereas the treated industrial effluents are all discharged to the sea.

An area ofnine million m^2 has been chosen in the Sulaibiya district for an agricultural irrigation project. The focal point of the effluent reuse system is referred to as the Data Monitoring Centre (DMC). This is the place where all treated domestic wastewater is discharged into two 170 000 m^2 reserviors. From the DMC, the treated wastewater is transferred to several farms. Each farm contains storage reserviors and on-site pumping systems to supply the irrigation network. The farms produce a veriety of agricultural products, including animal fodder (an average of 3000 tons/month), and vegetables such as spinach, potatoes, onions, and eggplants. There is a plan to increase the agricultural area by the year 2010, which is considered as the most ambitious scheme for agriculture reuse in the Middle East. In addition a program of afforestation to cover an ultimate area of 12000 ha is planned. The purpose is to grow a variety of trees for beautification along major highways and to protect new towns. To support developmental projects, the use of treated wastewater is inevitable.

The purpose of this study is to focus on water reclamation and reuse for agriculture and afforestation. This program is aimed at growing a variety of trees for beautification. The information obtained is intended to assist planners and policy-makers for effective utilization of wastewater, which may help improve agriculture and landscape development in the country.

Scope

The concept of effluent reuse of wastewater was formulated in 1960. It was initially intended to irrigate the area surrounding the treatment plants, but this policy was abandoned because of environmental health risks. Therefore, sites were chosen in Sulaibiya instead. Even though this project was started in 1976, the landscaping activities are not being less implemented. Based on the adequate quantities of wastewater, the Kuwaiti government has set forth a plan to utilize industrial and municipal wastewater to expand the green areas of Kuwait by a national policy for improving the appearance of Kuwait through the implementation of extensive planting and irrigation.

Methodology

The available literature and information about the sources and quantities of reclaimed industrial and wastewater in Kuwait were collected from appropriate sources. Table 1 presents operational characteristics and sewage flow forecasts for the main treatment plants in Kuwait. It indicates that domestic sewage in Kuwait has high strength compared with other states. Investigations were conducted to determine current flows for both industrial and sanitary wastewater generated in S.A. Sanitary and industrial wastewater are expected to increse due to the expansion in sanitary wastewater plants and in SIA. Discharging municipal and industrial wastewater into the sea can be considered a waste of Kuwait's limited water resources. A program of wastewater reclamation and reuse is helpful in implementing of water conservation policies for beneficial uses.

Table 1. Summary of Sewage and Tertiary \Treatment in the Middle East

Country	City	Sewage Treatment			Tertiary Treatment			Reuse Application
		Process	Design Capacity (m^3/d)	Effluent Standards (BOD/SS)	Process	Design Capacity (m^3/d)	Effluent standards (BOD/SS)	
Kuwait	Kuwait	AS	342,000	20:30	RGSF&Cl_2	342,000	10:10	A, F, V
UAE	Abu Dhabi	AS	100,000	20:30	RGSF&Cl_2	100,000	10:10	MU, A
Qatar	Doha	AS	60,000	20:30	RGSF&Cl_2	81,000	10:10	MU, A
	Umm Said	EA	4,320	10:10	Cl_2	-	-	MU
	Khor	EA	728	10:10	Cl_2	-	-	MU
Saudi Arabia	Makkah		112,000	20:30	RGSF&Cl_2	112,000	10:10	MU, W, NP
					AT	90,000	Potable standards	W, NP
	Abha	EA	22,500	20:30	RGSF&Cl_2	22,500		F, A
	Qassim Province	EA	75,000	20:30	RGSF&Cl_2	75,000	10:10	
Oman	Khowair Town	EA	10,000	10:10	Cl_2	-	-	MU, A
Libya	Sebha	EA	15,000	20:30	RGSF&Cl_2	15,000	10:10	W, NP
	Yeffren	EA	1,725	20:30	Cl_2	-	10:10	W, NP
Egypt	Cairo	AS	1,000,000	30:30		-	-	RD, NP
	Cairo	AS	600,000		Cl_2			

Notes:
BOD - Biological oxygen demand
SS - Suspended solids

AS - Activated sludge
EA - Extended aeration
RGSF - Rapid gravity sand filtratior

Cl_2 - Chlorination
AT - Advanced treatment
MU - Municipal use
NP - No policy yet determined

V - Vegetables
W - Discharge to waste
RD- Discharge to river
H - Afforestation
F - Fodder

(Source : Cowan and Johnson, 1984)

Results and Conclusions

The results obtained demonstrate that the total volume of wastewater (sanitary) produced in Kuwait is estimated at 345 000 m^3/ d. However, sanitary wastewater production in the SIA is estimated to reach about 5060 m^3/ d and the current sanitary wastewater flow is about 3000 m^3/ d. Industrial wastewater generated by the SIA industry is estimated to be 31000 m^3/ d. With the addition of a new petrochemical complex and planned expansion projects, the total industrial and industrial wastewater produced will reach to 55,670 m^3/ d(sanitary and industrial).

The concept of effluent reuse has reached a level of acceptance in Kuwait as an important source for irrigation water. The treated wastewater to be used for agriculture and afforestation can be evaluated based upon the criteria . Effluent reuse is an important issue for the government of Kuwait. This program is going to expand the green areas in Kuwait by effectively utilizing this valuable water resource.

REUSING THE TREATED EFFLUENTS BY RECHARGING AQUIFERS IN SAUDI ARABIA

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Introduction

The massive urbanization that the Kingdom has undergone in the last 2 decades is reflected in the increase in the domestic demand for water. The Kingdom's sixth development plan put the water demand in 1994 for municipal and industrial purposes at 1800 million cubic meters (MCM). This is projected to grow to 2800 MCM by the year 2000. A large portion of this water returns as wastewater to the Kingdom's various wastewater treatment plants. Here, it is treated at some expense and then is discharged into the ocean or into the desert. There are at least 15 such treatment plants in the Kingdom. Of the estimated 1000 MCM of wastewater generated in the Kingdom, only 150 MCM is reused, the rest is discharged as stated before. The volume of wastewater generated is expected to grow to 1500 MCM/yr by the year 2000. This uncontrolled discharge of wastewaters in the aforementioned methods is not without consequences. It could be detrimental to the environment and could lead to degradation of groundwater quality.

Scope

Thus, it is clear that an environment friendly approach is needed to dispose treated wastewaters generated in the Kingdom. One promising technique is the controlled recharge of aquifers using wastewaters. This process of recharge also results in the removal of contaminants from the wastewaters. The recharged water could be used to supplement the current water resources of the Kingdom as it can be used for irrigation. Thus, wastewater recharge would not only provide an environment friendly means for disposal of treated wastewaters, it would also contribute to the increased reuse of wastewaters. In order to examine these possibilities, a laboratory scale study of the quality changes that take place when secondary effluent is recharged through a sand dune and a field pilot study were undertaken.

Methodology

Laboratory study

A preliminary laboratory investigation was conducted to compare the effect of chlorinated and unchlorinated effluents on clogging time and to establish a conservative estimate of the contaminant removals that can be obtained by the recharge of local effluents through a sand dune. For the latter, the study was conducted under conditions that minimised the removal of pollutants i.e. under saturated flow conditions and high effective velocity. In particular, the development of anoxic conditions was studied. In the preliminary study, a vertical circular Plexiglas column of internal diameter 0.203 m and a length of 2.41 m was used. The column had sampling ports along its length, the middle port being at a distance of 1.25 m from the bottom. For determining the spatial distribution of pressure, there were 7 piezometer ports at approximately equal spacing along its length. The flow was adjusted to ensure a slight overflow always. This experimental setup is shown in Fig. 1.

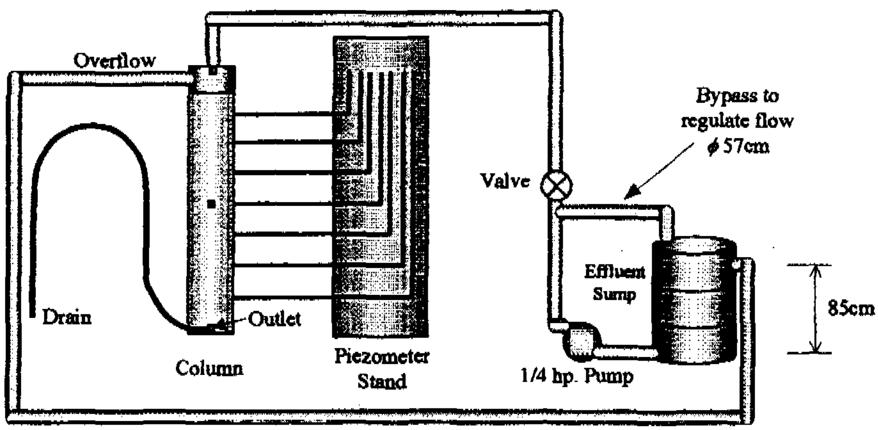

Fig. 1. Setup for preliminary studies

There were two sets of experiments in the laboratory study. The first run using unchlorinated effluent and the second run using chlorinated effluent. A summary of the quality of chlorinated and unchlorinated secondary effluents (influent for the column) in these sets of experiments are provided in Table 1.

Results show that the head loss development rate was greater when using unchlorinated effluent than that with chlorinated effluent. After 197.5 hrs of operation in PC, the head loss at all ports was less than the head loss after 190 hrs of operation for PUC. The rate of clogging is greater in the experiment using unchlorinated effluent because in the experiment using chlorinated effluent, the presence of chlorine in the water restricted the growth of bacteria and algae. The main and the most significant difference in the performance of chlorinated and unchlorinated effluents was in the development of anoxic conditions. After 197.5 hrs of operation, the DO levels still had not reached anoxic levels (DO < 2 mg/l) at both the middle and the bottom of the column when chlorinated effluent was used.

Field Study

The field recharge site comprised of: (a) sand dune and supporting embankment, (b) the pretreatment facility, and (c) instrumentation for water quality and quantity monitoring. For the construction of the sand dune, an area of 39 m × 39 m was excavated to an approximate depth of 1.6 m and was filled with sand upto the ground level. An area of 25 m × 25 m in the middle of the excavated area was chosen to be the

Table 1. Summary of results of preliminary laboratory studies

Parameter	Port No.	Depth (cm)	No. of Samples	Average Unchlorinated	Average Chlorinated
pH	Influent	0	7	7.729	7.669
	Middle	100	7	7.544	7.498
	Exit	225	7	7.387	7.422
Turbidity (NTU)	Influent	0	6	1.65	1.37
	Middle	100	6	0.417	0.44
	Exit	225	6	0.417	0.29
DO (mg/l)	Influent	0	5	6.44	6.45
	Middle	100	5	3.46	5.35
	Exit	225	5	3.12	4.7
SS (mg/l)	Influent	0	5	17.4	18.75
	Middle	100	5	11.4	14
	Exit	225	5	8.6	8
TOC (mg/l)	Influent	0	7	3.926	4.04
	Middle	100	7	3.328	2.936
	Exit	225	7	2.944	2.722
Total Coliform (MPN)	Influent	0	4	8000	115
	Middle	100	4	4550	40
	Exit	225	4	1300	30

recharging facility (dune). This area was filled upto depth of 5 m from the original ground surface (6.6 m from the water table). This dune is held in position by an embankment of a base of 7 m at the bottom tapering down to a width of approximately 2.5 m at the top. The embankment was further supported at the bottom of the embankment by a berm of width and height 2 m along its perimeter.

Summary and Conclusions

From the limited field study (9 recharge cycles) the following conclusions may be drawn:

(1) It may be possible to recharge a depth of upto 3.14 m of effluent per day in the type of sand used in this study (This is the predominant sand group found in the Eastern Province of Saudi Arabia).
(2) Also in the same sand group, recharge is possible for a period of 10 days before significant head losses are noticed.
(3) The quality of the product water is well within the standards required for recharging aquifers in Saudi Arabia.

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WATER REUSE WITHIN THE CITY MOSCOW

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Introduction

The city Moscow is in place of water short region. So, the special water supply system has been created for the Moscow. This system contains the canal Volga-Moscow and water reservoirs. A canal coveys water from Volga to Moscow river. The five special pump stations are using for this process. A canal coveys vessels from one point to another too. The length of this canal equals 128 kilometres. But, there is a problem with water supply of Moscow now. Many difference factories, mills, works have been built in Moscow. About 10^7 people are living in this city now. The Moscow's people and factories are needing water within city. In Moscow region, water renovation and reuse is an attractive alternative to high-cost transfers from far-away rivers or impounding of new water reservoirs from Volga river. So, the Rzhev water storage has not been made. Water intakes of Moscow are giving 124 m^3/c with probability 97%. But, only electrical power stations of Moscow are using 160 m^3/c. This is possible with the aid of reuse of water on Moscow's electrical power stations. So, the electrical power stations of Moscow are needing in 16 m^3/c of new water from Moscow's water supply system only! Closed systems of water circulation are extensively used for conversion to nonwaste technologies and increase the efficiency of hydrosphere protection within Moscow's city industry now.

Major findings

Moscow has some achievements in reuse of treated wastewater. The are Electrical power stations and following industries: Petroleum Chemistry, Chemistry, Ferrous Metallurgical engineering (Iron and Steel Works, Iron Foundry and Rolling Mills), Non-ferrous Metallurgical engineering, Chemistry engineering, Electrical Technical, Chemical machine building, Motor-Car, Instruments, Agricultural machine building, Wood and paper, Light-weight, Big weight machine building, Road machine building, Medical biological.

One of the important problems of water reuse systems is associated with sludge accumulation and its control because a closed system of water circulation can be effective only when the content of sludge in it does not exceed a certain admissible value. This problem can be solve with the aid of the following rule of sludge accumulation: *If the sedimentation of all particles with the sizes less then the separation size in sludge collector obeys the Stokes Law, then the relative accumulation of sludge mass in closed system of water circulation during the time of its operation cannot exceed the product of the square of the sludge collector's separation size, the shape coefficient, and the* *density and specific radius of particles entering sludge water.* This rule has been set for reuse water systems in Moscow.

In modern Moscow's conditions it is necessary to decrease expend energy in water reuse systems. There is a problem of decreasing of a work done by the filtration under water reuse within city. This last problem have been studied with the help of methods calculus of variations. A non-linear differential equation of the second order for the optimum control of Purification against disperse pollutants by filtration for the reuse water has been deduced as the result of the consideration of that problem. This equation is follows:

$$-V'\frac{\psi_v(V',V,t)}{\psi_p(V',V,t)} - \frac{1}{S}\frac{d}{dt}\left[\frac{V'}{\psi_p(V',V,t)}\right] = 0,$$

where $\psi_v(V',V,t)$ and $\psi_p(V',V,t)$ are functions that have been defined from the kinetic equation of filtration; V is the volume of filtrate; t -is time; S - is the effective cross-sectional area of the filter; V' is the dV/dt. The decision of this equation gives dependence of change of volume of water that is separated by filtration from a time. in a optimum mode of filtration. This mode ensure least significance of work that expended on process of filtration in view of effects of formation of compressed deposits of filter cake them deteriorate with time and non-linear dependence of speed of a water on a gradient of pressure. The algorithm of optimum control of filtration for the water reuse city systems has been created with the aid of this equation.

Treated wastewater are reused within city Moscow in many industries. The results of this water reuse within city Moscow have been given in the following table:

Table. **The results of water reuse within the city Moscow in different industries**

An industry within city Moscow	**A degree of water reuse %**	
	In 1987	**after 1990**
Electrical power stations	87	91
Petroleum Chemistry	83	76
Ferrous Metallurgical engineering	76	90
Non-ferrous Metallurgical engineering	79	85
Chemistry engineering	46	50
Electrical Technical	73	69
Chemical machine building	46	46
Motor-Car	57	64
Instruments engineering	41	73
Agricultural machine building	52	64
Wood and paper engineering	63	60
Light-weight	41	50
Big weight machine building	65	72
Road machine building	48	54
Medical biological	32	56

Discussion of the findings

We can see in the table that the degrees of water reuse have been increased in all Moscow's industries except Petroleum Chemistry. The decreasing of degree of water reuse in Moscow's Petroleum Chemistry has been induced the catastrophically increasing number of cars within city Moscow. A sludge and salt accumulation prevents from increasing a degree of water reuse within Moscow city. There are many filters, hydra cyclones, centrifuges, separators in Moscow's systems of water circulation within city. The theoretical achievements have been helped to find solution the problems of this work devices for improving a water reuse within city Moscow. The applied problems are stimulating the developing water science too. For examples, the two algorithms of control of sludge accumulation in closed systems of water circulation and optimum control of filtration in water reuse have been created. The realisation last algorithm allows decrease energy expended on filtration renovation water on 10 - 25 %. We see in table that there are many possibilities for increasing the degree of water reuse within Moscow's city. But, new difficult in developing of water reuse in capital of Russia was happened 17 August 1998. The citizens and factories are losing money as the result of last Russian's economic crisis. So, anybody in Moscow do not pay for water its real price now. It is preventing from increasing of water reuse within Moscow's city now. The government of Moscow city direct controls water reuse under specific conditions of last Russian's economic crisis. But, we may hope that economic mechanism will control water reuse within city Moscow in future too. It will help to find a solution of water problems within the city Moscow.

Conclusions

The reuse of treated wastewater in different industries within Moscow is developing now with the aid of same scientific achievements in theory of sludge and salt accumulation and filtration kinetic in water recycled systems. But, there is a problem of price on water works in Moscow under condition of last Russian's economic crisis. This problem prevents from increasing a degree of recirculate city water back into the Moscow's urban water supply system. Growing Moscow's city have no choice but to recycle.

Key words: water, reuse, city, Moscow, industries, renovation, recycled

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OVERVIEW TO WATER RECYCLING IN CALIFORNIA: SUCCESS STORIES

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Introduction

Water recycling, or the beneficial use of reclaimed water, involves the reuse of treated wastewater for non-potable or indirect-potable uses. Recycled water has been used as planned non-potable water supply in California for over a century, beginning in the 1880s, when raw wastewater was used to irrigate orchard crops. By the mid-1990s, nearly 600 million cubic meters of treated wastewater was being used annually for agriculture, landscape irrigation, groundwater recharge, environmental needs, and urban-based uses such as landscape irrigation and industrial processes (see Table 1).

Table 1: Use of Recycled Water in California by Category of Reuse for Survey Years

Amounts in million cubic meters

	1987	1989	1993	1995
Agricultural Irrigation	207	213	98	191
Groundwater Recharge	48	86	228	162
Landscape Irrigation	49	67	58	101
Industrial Uses	7	7	8	42
Environmental Uses	12	22	36	19
Other	5	5	45	84
Total	329	401	473	598

Cities and water districts in California are increasingly turning to recycled water as a source of supply as access to new supplies of fresh water become more constrained. In California, the State Water Resources Control Board regulates the production, conveyance, and use of recycled water through its nine Regional Water Quality Control Boards. Uses for recycled water are governed by Title 22 Wastewater Reclamation criteria in the California Code of Regulations. Title 22 allows recycled water uses, depending on the level of treatment, for agriculture irrigation, groundwater recharge, landscape irrigation, wildlife habitat enhancement, industrial use, recreational impoundments, and other miscellaneous uses.

Agencies in southern California have turned to recycled water for groundwater recharge, which not only help replenish the basin, but also provides an alternative to purchasing imported surface supplies for recharge. The County Sanitation Districts of Los Angeles County, Los Angeles County Department of Public Works, and the Water Replenishment

District of Southern California have been recharging the Central Basin groundwater aquifers with treated effluent since the 1960s. Orange County Water District has used recycled water in its seawater barrier injection operations since 1976, and the district is developing a proposal for a groundwater recharge project that will recharge more than 100 million cubic meters of recycled water annually. In Monterey County, the Monterey Regional Water Pollution Control Agency and Monterey County Water Resources Agency are cooperating in a $75 million regional water-recycling project to ultimately provide around 20 million cubic meters of water annually for nearly 5,000 hectares of farmland. This would replace groundwater pumping from a coastal aquifer that is overdrafted and suffering from seawater intrusion. The Irvine Ranch Water District in southern California has promoted broad use of recycled water for urban landscaping for nearly 30 years. The East Bay Municipal Utility District in northern California has worked with industry to develop a recycling project to serve cooling water needs for oil refinery operations. As the cost of potable supplies increases, recycled water projects will increasingly become more viable economic alternatives for stretching California's freshwater resources.

Scope

This paper provides an overview of recycled water use in California over the past two decades, illustrating the evolution of its application from individual projects for nearby users to citywide and district programs. The paper will present and identify the factors motivating reuse in California, as well as the challenges to water recycling in California. Several detailed case studies of recent water recycling projects will demonstrate how agencies are overcoming these challenges, including the West Basin Water Recycling project in southwest Los Angeles County and the South Bay Water Recycling project in Santa Clara County. Both projects provide recycled water to numerous cities.

Results and Conclusions

It is estimated that California produces 3.1 to 3.7 billion cubic meters of wastewater each year. Incidental reuse occurs all the time as wastewater is discharged into California waterways and used downstream. Planned recycling projects provide the opportunity to divert and reduce some of the discharge, as well as to provide a substitute for potable supplies, stretching current potable supplies further by better matching use with water quality needs. These projects provide water agencies with greater flexibility and reliability in managing supplies and meeting demand. Support for reuse has grown as the need for making better use of our existing supplies has grown. The past decade has seen a significant growth in the volume of water recycling taking place, as well as an expansion of uses for recycled water. As California continues to grapple with the challenges of meeting current and future water demands, water recycling has an important role to play.

The cases studies illustrate some common themes in water recycling in California. Water-recycling projects continue to be motivated both by water supply enhancement and wastewater reduction goals. Common elements to successful implementation demonstrate the importance of working with the numerous stakeholders throughout the process and bringing them in as early as possible. Successful projects spent considerable time identifying the stakeholders and working with them to address their concerns. Particular attention was paid to working with water retailers and customers to address cost and revenue concerns. Each also established different forums to communicate and coordinate with stakeholders. Education played an important role in bringing actors together, marketing services, and engendering support. It was particularly important in securing the agreement of utilities and retailers to support the incentives and in promoting water recycling among customers. Finally, projects relied on large volume users to support a more cost-effective design.

On the financial side, benefits of the recycled water projects are clear but not always easy to valuate in a purely economic fashion. Water recycling may not be the least-cost alternative in traditional economic terms, but it offers long-term economic benefits of future reliability and/or environmental benefits that other alternatives may not offer. Additionally, projects provided environmental benefits in terms of reducing wastewater flows and substituting for potable supplies. The sharing of costs continues to be difficult. Most often, the costs are borne by those undertaking the project. While the long-term benefits may be clear, they do not always accrue to the entity financing the project, nor can the organization always afford the initial capital costs. Finding partnerships can help share costs, and this is where it is particularly important to make the connection between wastewater and water supply and the benefits that accrue to both.

Overcoming traditional institutional barriers that separate wastewater and water-supply functions is important for cost-sharing reasons. Additionally, it allows for better identification of benefits and cooperative exploration of a more comprehensive alternative that can serve both wastewater and water-supply needs.

Finally, as projects seek to expand water reuse options, it becomes increasingly important that the science and regulations keep pace with identifying, verifying, and permitting the safe practice of new uses.

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Urban Water Use and Reuse: Lessons from Silicon Valley

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Introduction

The trajectory of water use in Silicon Valley over the last century has gone from minimal use with dry-land farming, to greatly increased use with irrigated farming, to use exceeding local supplies as urbanization and industrialization took over in the second half of the century. Overdraft of the groundwater resources resulted in land subsidence (up to 4 m), flooding of shoreline areas near San Francisco Bay, as well as saltwater intrusion (migrating 4 km inland), precluding the use of shallow aquifers near the Bay. Recent droughts have lead to water shortages and rationing (mandated 25% reduction in domestic water use).

Water Reuse

In addition to the importation of water to address these water supply problems, artificial recharge and direct reuse of advanced-treated wastewater contribute to solving problems of water supply, as well as addressing immediate environmental issues at the point of treated wastewater discharge. Such steps have been seen as essential to permitting continued growth in the valley. Artificial recharge is performed under the auspices of the Santa Clara Valley Water District, a public agency founded in 1928 to manage water in the valley. Through its ability to pass ordinances and levy taxes, this agency has been crucial in assuring the quantity and quality of water supplies. Artificial recharge is performed through instream recharge and through a series of percolation ponds distributed around the margin of the valley. It provides for approximately 26% of the present water supply demand.

Direct reuse of advanced-treated wastewater began in 1996. This reclaimed water is distributed through a second, non-potable water supply system. The project was initially set up to serve customers in the northern portion of the valley, but was rapidly expanded southward so that 100 km of pipeline currently exist. The current capacity of the pipeline is 2.2×10^6 m^3/d, about 34% of the peak output of the wastewater treatment plant. The principle use of the recycled water is for landscape irrigation in public parks, at golf courses, and in business parks. Additional uses include in decorative fountains, toilets, and cooling towers. Studies are being performed to determine the effect of the water reuse on groundwater quality through strategically-placed shallow and deep monitoring wells. Data to date indicate no degradation of groundwater quality in either TDS or nitrates. Any degradation that may occur is predicted to be localized and subject to dilution by mixing.

Phase II is in the planning stage, with expansion of the water recycling project through the year 2020. Uses under study are agricultural irrigation in the southern part of the county, artificial recharge through injection wells, streamflow augmentation to enhance aquatic environments, and industrial consumption including Ultra-Pure water uses at manufacturing plants. Finding customers for the recycled water is aided by a municipal ordinance that requires water users to use the recycled water for non-potable uses if there is recycled water available. The current cost to the consumer is 80% of the cost of potable water. This initiative is part of a larger regional initiative, Bay Area Regional Water Recycling Project, which seeks to maximize water reuse to assure future supply and minimize environmental degradation caused by current surface water diversions.

Effects of Industrial Contamination

Industry has also contributed to the water-supply problem by inadvertently contaminating the groundwater, a major source of supply. The county currently has more serious contamination cases (Superfund sites) than any other county in the United States. The majority of these cases resulted from failure of hazardous materials storage systems for high-technology manufacturing. Initially, large volumes of remediated groundwater were wasted to stream discharge. As awareness grew of this practice which lead to the loss of tens of thousands of cubic meters of water per day, requirements for recyling were instigated. This recylcing was performed as direct reuse of the remediated water in the manufacturing processes at the industrial plants or as indirect reuse by artificial recharge through injection wells.

In-Situ Treatment of Contamination as an Alternative

New alternative approaches to treating the contaminated groundwater in-situ rather than removing it from the aquifer have also indirectly addressed minimizing that waste of the groundwater resource. Among these approaches are the permeable, reactive barrier technologies. These utilize iron filings or solid organic substrates to promote chemical and/or biological reactions within the groundwater flow field. Some of these in-situ technologies may prove useful if they can be adapted to treat raw urban wastewater in artificial recharge ponds, allowing for percolation of wastewater with minimal pretreatment and minimal negative impacts to groundwater quality.

Conclusions

Assuring an adequate water supply and minimizing the negative consequences of groundwater overdraft require a constant updating of the water resource management approach as new demands arise. Management agencies with legal jurisdiction over the water supplies can be a crucial component of such required updating. Artificial recharge and direct reuse of treated wastewater can be important components of such an approach. In regions were groundwater has become significantly contaminated, requirements to encourage the reuse of remediated groundwater are important. Technologies developed to address these contamination problems may also prove useful in underdeveloped countries to promote the artificial recharge of wastewater with minimal pretreatment.

Workshop 1

Posters

CHARACTERISTICS AND REQUIREMENTS FOR AN URBAN WATER REUSE SUPPLY

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Introduction

In the de-pollution plan of the metropolitan area of Palermo (Sicily, about 800.000 inhabitants) it is planned the treatment of sewage (≈ 100 millions cubic meters per year) by two different biological plant ("Acqua dei Corsari" to the est, "Fondo Verde" to the west). The treated-sewage will be utilized for orchard irrigation, Oreto river supply, refilling of groundwater during the winter, and -finally- for a lot of urban uses by an appropriate distribution system independent by the town waterworks. The definition of the characteristics and requirements of this distribution system is the purpose of the present research.

Presentation

The presented research deals with methodological approach for determining the water-needs which can be covered by a treated-sewage within a big city. The approach is performed by several stages: i) the selection of users interested in treated-sewage use by performing a comparison between the user qualitative requirements and the characteristics of the treated-sewage; ii) the procedures, the investigations and the checks required for fixing the needs for each user; iii) the determination of the possible internal use for each user, allowing only in special cases further local treatment or mixing with drinkalble water. Further in the research some other fundamental aspects are presented such as: planning problems of a treated-sewage distribution system; marking of the treated-sewage for avoiding improper use; healt-problems related to treated-sewage use.

Discussion

In the first stage more than 350 "potential" users have been selected and their localization has been fixed in a planimetry. All the users have been divided in ten categories: industries (195 in town; 46 in the industrial area of Brancaccio), gardens (28), parks (2), railway users (7) cemeteries (4), military barracks (22), pubblic and private parking areas (6), forest nurseries (33), general users (15).

In the second stage three different steps have been performed. They consist in : determining the total amount of the user needs, determining their quality requirements (both divided according to the internal function), comparing these requirements with the characteristics of the treated-sewage of the "Acqua dei Corsari" plant. All these steps have been performed by on-the-spot investigations, literature data, and about 45 direct investigations.

After this selection the total number of effective users is 257, equal to the 75% of the potential users. Once the effective users have been determined for each of them the quantitative amount of treated-sewage has been determined leading to the conclusion that about five millions of cubic meters can be covered by the use of treated-sewage. It is important to emphasize that this quantity is about the 10 % of total clean consumption of drinkable water. Further, by using the treated-sewage the groundwater intake can be reduced to the 75% of the actual amount.

A first result of the investigations descrived above is formed that, for the particular case under examination, the three main applications of treated-sewage are the following: industrial use for about 50%, irrigation of urban areas, applications which can be grouped under the general term of "washings".

The localization of the effective treated-sewage users outlines on the urban area of Palermo a very simple ring network. This network is supplied at two different locations by "Acqua dei Corsari" and "Fondo Verde" plants, respectively, and its course follows the principal users while the others are supplied either transversal connections or open short branchings.

The above-described network must posses many important hydraulic characteristics: i) lack of head, reservoir and surge tanks, in order to avoid eutrophication; ii) need of head pumping station and probably along the course, due to the low level of outlet sewer of two plants; iii) limited lift in order to avoid improper uses. It is important to emphatize that the treated-sewage network must be at lower level than that of the drinkable water supply and that the pipe material must be a plastic one.

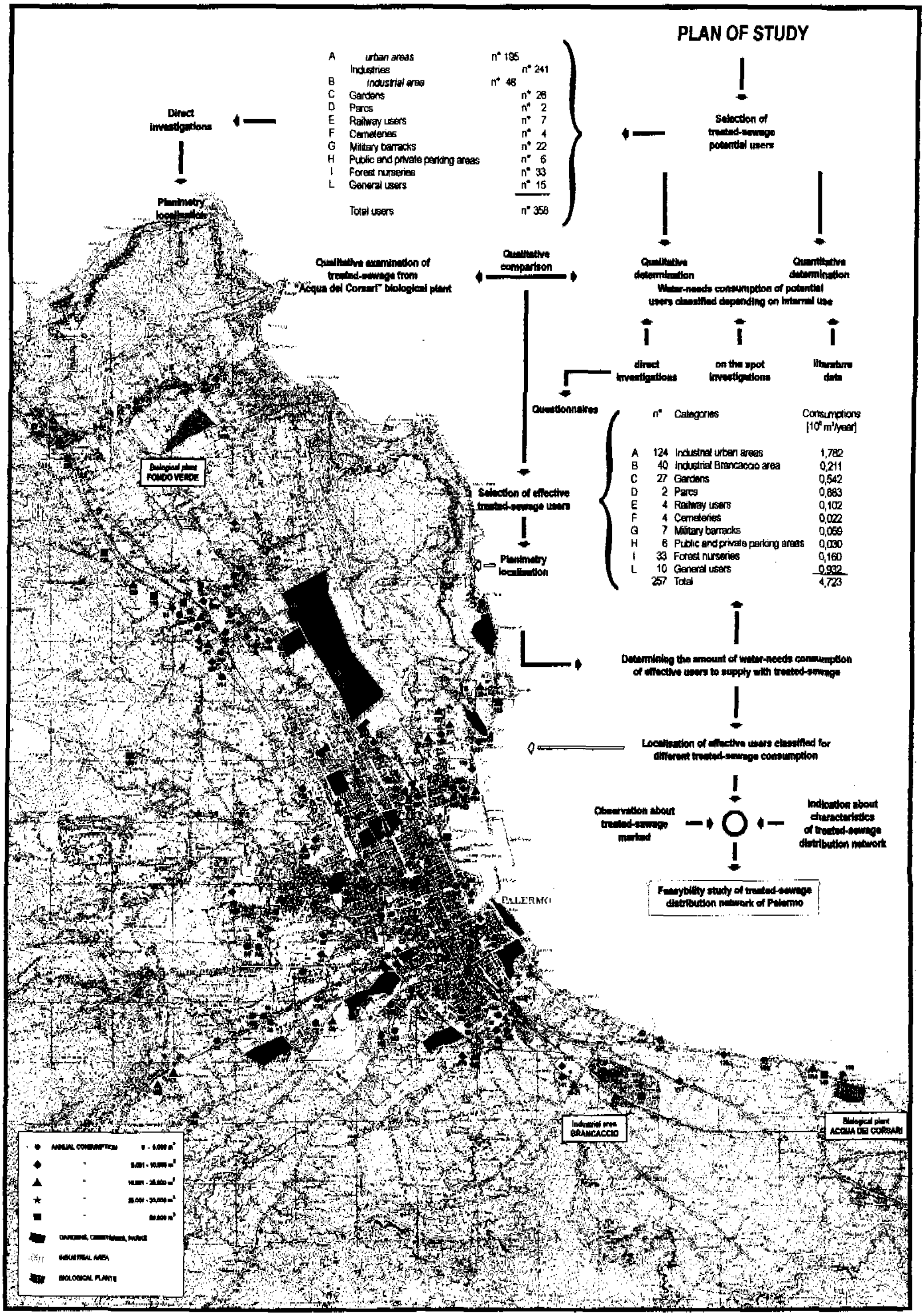
Finally, the build of this network shows a lot of higienic and sanitary problems, the most grave of which is a wrong drinkable use. In order to avoid these problems, it is thought to mark the treated-sewage with couloring and odouring additives. The latter substances must have the following qualifications: a) their use should not alter the treated-sewage characteristics; b) the marking effect should be not eliminated by the treated-sewage chimical-biological composition; c) phisical or psicological problems users should be avoid; d) these substances must be stable at the ligth and give no habit; e) they must be neither toxic nor irritating; f) they must be cheap and efficient at small concentrations.

Conclusion

The metodology showed has been defined, corrected and improved during the different steps of the study. It is the main result of the research since it is generalizable and it can be used in other urban reality, with the necessary and opportune adaptiens to the particular local conditions,.

The localization of the effective treated-sewage users outlines on the urban area of Palermo a very simple ring network. This network is supplied at two different locations by "Acqua dei Corsari" and "Fondo Verde" plants, respectively, and its course follows the principal users while the others are supplied either transversal connections or open short branchings.

The needwater results in this specific application (5 millions cubic meters per year), confirm the validity of the idea of an urban treated-sewage network, which should be further on developed and integrated with a suitable feasibility study.


PLAN OF STUDY
A urban areas n° 195
Industries n° 241
B industrial area n° 46
C Gardens n° 28
D Parcs n° 2
E Railway users n° 7
F Cemeteries n° 4
G Military barracks n° 22
H Public and private parking areas n° 6
I Forest nurseries n° 33
L General users n° 15
Total users n° 358
Direct investigations
Planimetry localisation
Selection of treated-sewage potential users
Qualitative examination of treated-sewage from "Acqua dei Corsari" biological plant
Qualitative comparison
Qualitative determination
Quantitative determination
Water-needs consumption of potential users classified depending on internal use
direct investigations
on the spot investigations
literature data
Questionnaires
n° Categories Consumptions [10⁶ m³/year]
A 124 Industrial urban areas 1,782
B 40 Industrial Brancaccio area 0,211
C 27 Gardens 0,542
D 2 Parcs 0,883
E 4 Railway users 0,102
F 4 Cemeteries 0,022
G 7 Military barracks 0,059
H 6 Public and private parking areas 0,030
I 33 Forest nurseries 0,160
L 10 General users 0,932
257 Total 4,723
Selection of effective treated-sewage users
Planimetry localisation
Determining the amount of water-needs consumption of effective users to supply with treated-sewage
Localisation of effective users classified for different treated-sewage consumption
Observation about treated-sewage market
Indication about characteristics of treated-sewage distribution network
Feasybility study of treated-sewage distribution network of Palermo
Biological plant FONDO VERDE
PALERMO
Industrial area BRANCACCIO
Biological plant ACQUA DEI CORSARI

DISINFECTION OF SECONDARY EFFLUENTS FOR IRRIGATION REUSE

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INTRODUCTION

Among the most attractive applications of reclaimed wastewater, irrigation of public parks, sports fields, golf courses and market gardening are described. These uses require an advanced treatment of wastewater, including disinfection. According to WHO's guidelines and current rules and regulations in Tunisia, faecal coliforms contents have to be lowered down to less than 10^3 or 10^2 cfu/100 ml (WHO 1989).
In Tunisia, most wastewater treatment plants are performing only secondary treatment, and in order to meet health related regulations the effluents need to be at least disinfected, but usually, secondary effluents need to be filtered prior to disinfection. Effectiveness of conventional disinfection processes, such as chlorination and ultraviolet radiation are depending on the oxidation level and SS content of the treated water. Ozonation is relatively expensive and energy consuming. The consideration of advantages and disadvantages of conventional techniques, their reliability, needs of investment and operation costs will lead to the use of less sophisticated, alternative techniques for certain facilities.
Among alternative techniques, soil aquifer treatment and infiltration percolation through sand beds have been studied in Arizona (Rice and Bouwer, 1984, Bouwer 1991), Israel (Shelef, 1991), France(Brissaud and Lesavre, 1993), Spain(Salgot and al., 1996) and Morocco (Guessab and al., 1993). Infiltration percolation plants are intermittently fed with secondary or high quality primary effluents which percolate through 1.5 to 2 m unsaturated coarse sand and are recovered by underdrains.
Infiltration-percolation facilities, microorganisms are eliminated through numerous physical, physico-chemical and biological interrelated processes, respectively mechanical filtration, adsorption and microbial degradation. Efficiency of faecal coliform removal is depending on the water detention times in the filtering medium and on the oxidation of the filtered water (Schmitt, 1989) . Detention times are related to the hydraulic load, the fractionation of water feeding and the existence of preferential pathways. The oxidation of the filtered water and the water detention time are also depending on the homogeneity of the infiltration rate.
Effluents of the Sfax town aerated pond were infiltrated through 1.5 m deep sand columns, in order to determine the performances of infiltration percolation in the polishing of secondary effluents. Elimination of total coliforms, faecal coliforms and faecal streptococcis, and their relationships with the hydraulic load and the temperature were investigated.

MATERIALS AND METHODS

The filtrating bed, 1.50 m deep, is consituted of sand packed into a column 0.16 m in diameter. The sand is taken from Oued Chaffar and has a d_{10} and a d_{50} respectively of 0.27 and 0.53 mm with a uniformity coefficient of 2.3 .
The water to be treated was sampled twice a week at the outlet of the treatment plant of Sfax .The column was fed by an automatic peristaltic pump.
The operating schedule was an alternance of 4 *days operating* -3 *days drying* phases. Influent was delivered by sequences of 10 minutes, each 3 hours. Physico-chemical and disinfection performances were assessed for daily hydraulic loads ranging between 0.10 and 0.50 m/day.
The applied water and the filtrated water were sampled twice a week and analysed for SS, COD, NTK, N-NH4 and N-NO3, total and faecal coliforms.

RESULTS

By winter time, under an hydraulic loads 0.4m/day and 0.27m/day, coliforms removal though effective, is not high enough to allow unrestricted irrigations (fig1).
When treating 0.1m/day, a 5 log units reduction of faecal coliforms is obtained on average .
During a period of relatively hot temperature conditions, better results are obtained. For hydraulic loads of 0.27m/day and 0.5m/day, there was no clue of clogging or decrease in the oxidation capability. We observed indicator reduction between 2 and 6 log units.
Hot seasons seem to be the more suitable for the renovating process, with a very high disinfection level. Since April, concentration in faecal coliforms of filtrated water is less than 10/100 ml (fig 2). Non restrictive agricultural reuse becomes then possible.

CONCLUSION

During hot seasons, from spring to fall, where the demand for irrigation water is high, oxidation is complete and the disinfection obtained through 1.5 m infiltration is high enough to allow reusing the reclaimed water for unrestricted irrigations. On the other hand, considering the low level of disinfection during winter time, unrestricted irrigation reuse could then be risky. Fortunately, by that time, the water demand is not that important.

H = 0.40 m/day

H = 0.27 m/day

H = 0.10 m/day

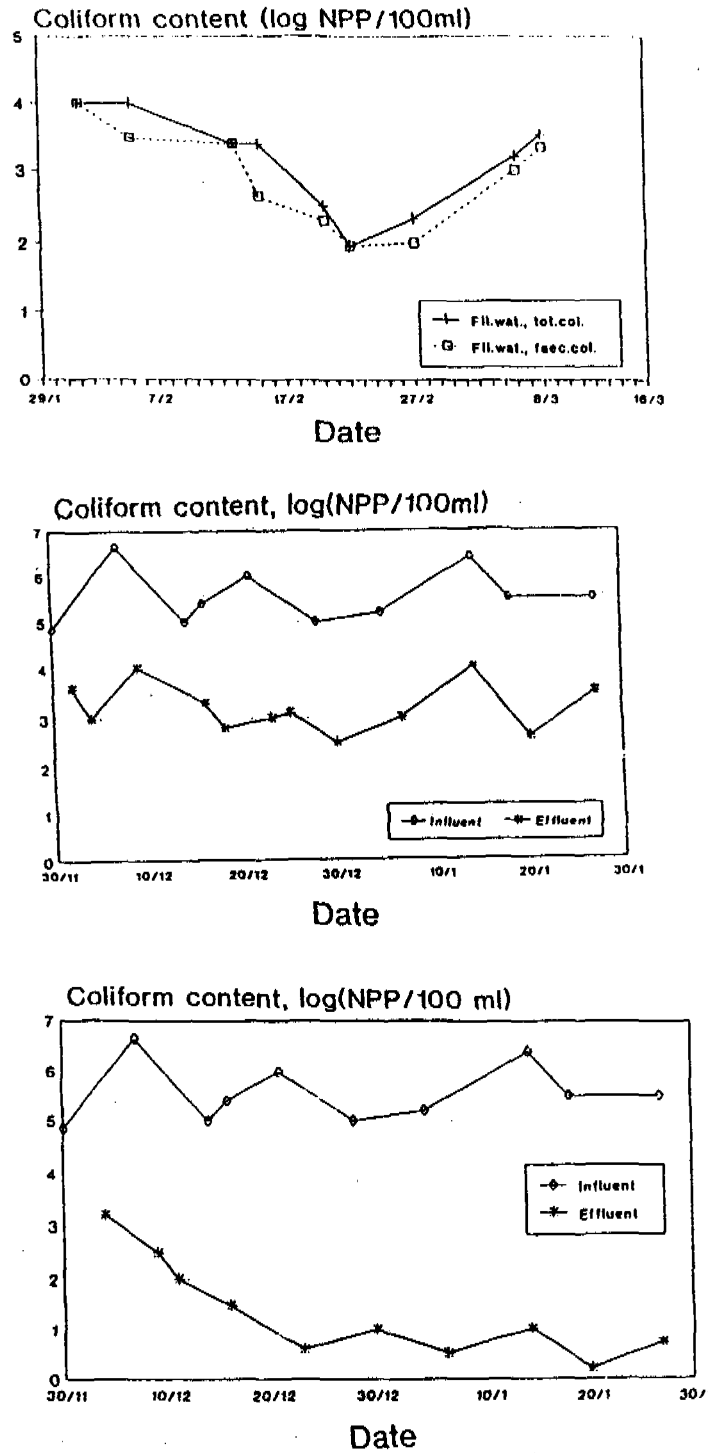
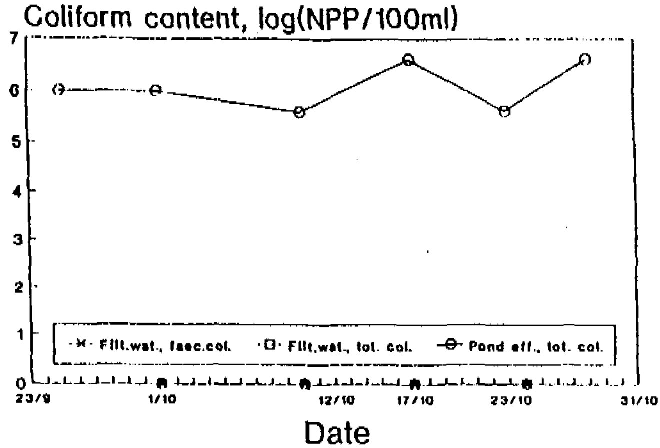


Fig.1 : Coliforms removal : Winter performances.

H = 0.27 m/day



H = 0.5 m/day

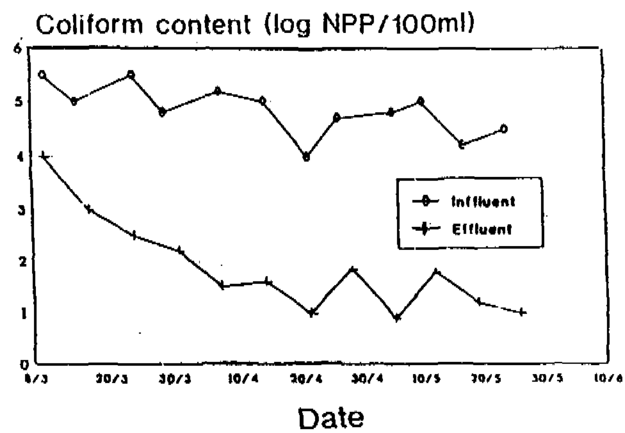


Fig.2 : Coliforms removal : Spring to fall performances.

ENTEROVIRUSES IN GROUNDWATER

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Introduction

Groundwater is a vital source of drinking water world-wide, and for many small communities it may be the only economically viable option where the cost of treating surface water is prohibitive. In Europe, reliance upon groundwater varies significantly between countries: for example Norway uses only 15% of groundwater in its drinking water supplies whereas Denmark uses groundwater in 98% of its supplies (UNEP, 1998). In the United States approximately half the population relies upon groundwater for their drinking water supply (USEPA, 1987), although there are large regional variations.

The contribution made by contaminated groundwater to the global incidence of waterborne disease cannot be assessed easily; for many countries figures for the incidence of waterborne disease are not available and the usage of groundwater is not known accurately. Where controlled epidemiological studies have been carried out, mainly in the US, untreated or inadequately treated groundwater was shown to be responsible for 51% of all waterborne disease outbreaks and 40% of all waterborne illness (Craun, 1985). During these studies the illnesses most frequently transmitted through groundwater included acute gastro-enteritis of undetermined aetiology, chemical poisonings, hepatitis A, shigellosis and viral gastro-enteritis.

Viruses are highly significant as etiological agents of water borne disease, and their presence in groundwater has been shown, by several authors, to represent a threat to human health. Although the source of many viral pathogens in groundwater may be predicted, little is known about their transport, attenuation and survival. Several groups have shown that viruses will attach to mineral surfaces in static columns and that the interaction between the mineral surface and the virus particle is influenced by pH (Loveland *et al.* 1996). These observations are important when making predictions about the transport and attenuation of viruses in groundwater; in particular they imply that transport may be affected by reversible attachment to the aquifer matrix and mobile colloids.

Colloids are suspended particles usually defined on the basis of size, the upper limit for colloidal size being 1μm. Colloids in groundwater can originate from a number of sources e.g. clay platelets, silicate particles, iron oxides. Colloidal particles provide an extensive solid-water interface and may play an important role in regulating the concentrations of many pollutants in groundwater systems. Contaminants passing through an aquifer will interact with colloidal particles and may sorb to their surfaces. This interaction could provide a mechanism for the transport of contaminants within an aquifer system, and thus affect both the total mobile contaminant load passing through an aquifer and also the contaminant travel times through the aquifer.

The lack of knowledge of virus mobility is, in part, a consequence of inefficient methods for the isolation of viruses from groundwater samples. A major difficulty faced by investigators has been the need to sample and transport large volumes of water to detect low levels of infectious virus particles, combined with poor recovery using standard methods. This feasibility study has assessed sorption-based methods for concentrating viruses from groundwaters in the field. The outlined methods were trialled in the field, initially at sites known to be contaminated with sewage through bacterial and nitrogen isotope work. The results have indicated virus occurrence/mobility in groundwaters, and virus/colloid associations.

Experimental design

A variety of adsorbent materials including oiled sodocalcic glass wool and activated carbon have been assessed in the laboratory for their ability to adsorb enteric viruses (poliovirus sabin type 1 vaccine strain, and bovine rotavirus) at a range of pH's. Optimum conditions for the adsorption and elution of enteric viruses to and from the medium have been determined.

The columns of adsorbant material have been modified for use in the field for the concentration of enteric viruses from groundwater. These virus traps consist of disposable columns packed with glass wool. The traps are designed to be positioned within a borehole in an 'on-line' system and left for a specified monitoring period to process a known sample volume. The trap is then removed from the pumping device and transported back to the laboratory for analysis. Enteric viruses are eluted from the adsorbant material and assayed using cell culture, and nucleic acid detection methodologies.

To further investigate the interaction of suspended particles and colloids with virus mobility in groundwater, groundwater samples are separated into three fractions: raw sample having both suspended particles, and colloidal particles; prefiltrate sample having only colloidal particles; and an ultrafiltrate sample having no suspended particles and no colloidal particles >1 nm. Using standard filtration methodologies, glass wool traps and prefilters, the percentage recovery of poliovirus for each method has been compared using each groundwater fraction.

Concentrated colloidal groundwater samples, and artificial colloidal particles have been assessed for their ability to adsorb viruses using Transmission Electron Microscopy.

Results and conclusions

Replicate experiments using glass wool to bind poliovirus have revealed that optimum binding occurs at pH 7 (Figure 1). Experiments comparing the efficiency of standard filtration methodologies (APHA, 1998) to glass wool have revealed that glass wool is more efficient at binding poliovirus unless the sample contains a high concentration of suspended solids.

As most natural groundwater systems are predominantly neutral, the glass wool trap will be working under optimum 'trapping' conditions in many field situations. The benefits gained from using a glass wool trap are three fold: the materials are of negligible cost, its use dispenses of the need to transport large volumes of water back to the laboratory, and virus recovery is improved. Further experiments are currently planned to investigate the association of enteric viruses with suspended particles, and the effectiveness of the glass wool trap under these situations.

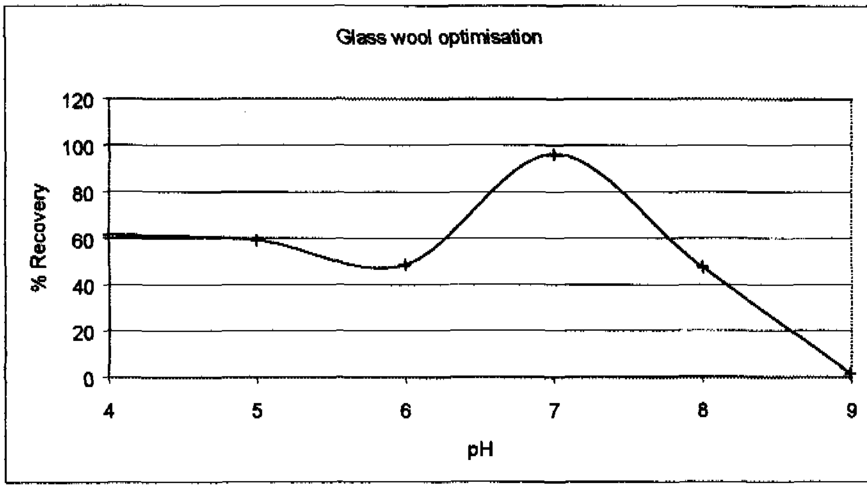

Figure 1. The effect of pH on the binding of poliovirus to glass wool. The curve represents the mean recovery from three repeats of the experiment.

Applications and benefits

The glass wool trap will allow mapping of virus distributions in groundwaters, monitoring of supply wells/springs and will assist with the study of transport mechanisms. This is important in understanding disease transmission through groundwater in developed and developing countries and allowing direct comparison to standard indicators of microbiological contamination.

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Workshop 2

Mitigation of flood hazards in urban areas

ISSUES CONCERNING FLOOD CONTROL AND URBAN DRAINAGE IN DEVELOPING COUNTRIES

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Urbanization: In 1900, only 15% of the world's population lived in cities; today, the percentage is more than 50% and the UN has forecast that between 1990 and 2025, the urban population will rise to more than 5 billion, 90% of which will be in developing countries.

In Africa and Asia, more than half of the population still lives in rural areas. In Latin America and Caribbean countries, urban population growth is from 3 to 5% a year, and in Brazil the urban population is near 80%, equal to that of North America and Europe. By the year 2000, between 30 and 35 of the world's cities are expected to have more than 10 million inhabitants (Foster, 1986). By the year 2010, the forecast is for about 60 cities with more than 5 million inhabitants, with most of these cities in developing countries.

In these cities, a high proportion of the population lives in squatter settlements (favelas in Brazil or barrios in Venezuela). More than 50% of the population of Caracas lives in such areas; in New Delhi, about 20%. Slums are built from cardboard and scrap material in hazardous areas such land liable to flooding and steep hillsides. Over the years, these settlements evolve into a more permanent form through the use of better materials, but the settlements continue to be labyrinths of small streets without any planned structures for water supply, waste disposal and drainage.

Water Issues: In 1990, 81% of the world's urban areas and 58% of rural areas had access to safe water supply; 71% of urban areas and 48% of rural areas had access to sanitation.

In the developed countries, provision of urban water supply and sanitation control are no longer a problem. For developing countries, water supply covers of about 80% and only 10% of the waste, but a billion people still do not have access to clean water. Clearly, are water supply and waste treatment are still important issues in these countries.

The large population increases within limited areas occurring in many of the world's cities aggravate water shortages. Population growth is one of the major problems in urban water resource planning. The cost of water is increasing mainly because of: (a) increased water demand through population growth; (b) degradation of water sources (aquifers and rivers) caused by waste disposal;

In 1990, 20 countries experienced water scarcity (available water per inhabitant less than 1,000 $m^3..yr^{-1}$). The World Bank has forecast that this number will increase by the year 2025 to 34, most of them in North Africa, the Middle and inside the Humid Tropics (The Economist, 1998).

In most developed countries, quantity aspects of urban drainage are no longer an issue, the emphasis nowadays being the control of urban drainage water quality. However for developing countries waste treatment is still the important issue and in urban drainage the quantitative impacts continue to be the main problem (Table 1).

Table 1 Comparison of urban water facility issues in developed and developing countries

Urban water facility	Developed	Developing
Water Supply	Solved	For some countries water shortage is the main problem
Sanitation	Solved	Only 10% is treated
Urban drainage and flood control	Quantity control solved and water quality control is a issue	Quantity control is a issue; there is no control on water quality from urban drainage.

Impact of urban development on urban drainage: The main issue in developing countries is urban development without planned drainage. Its consequences are the following:

- Population settlements on river flood plains, which increases flood damage;
- Increase in flood frequency due to basin urbanization;
- Degradation of urban areas due to erosion and sedimentation;
- Water quality impact from wash-load of urban surface and solid waste.

One of the main examples is the Tiete River flowing through the city of Sao Paulo. The valley of this river has been occupied since the beginning of the century. By increasing the river flow capacity, the Government was able to reduce the frequency of occurrence of floods for some years, so that population density increased in both the flood plain and in upstream areas. Frequency of flooding, and the magnitude of flood peak flows, increased again following urbanization, and flood damage also increased. Today, during the rainy season, there are more than five flood events per year, causing extensive damage both to private property and public infrastructure, high cost through traffic congestion, and lost income due to difficulties in mobility. The cost to date of increasing main channel capacity has been greater than US $ 1 billion.

Brazilians cities, and some others in countries within the humid tropics, have been developed according to Urban Master Plans, which usually do not consider the impact of urbanization on drainage flow. The creation of impervious areas from urban development upstream also produces effects downstream, where flooding increases. City engineering departments commonly do not have the hydrologic support to cope with this problem and engineering works - such as channels construction, pipe installation - are designed without taking potential downstream impacts into account, where built-up areas leave no space into which flow could be diverted during flood events, as a means of decreasing peak flows.

The basic concept used for stormwater drainage works design is to drain water from urban plots as quickly as possible through pipes and channels networks; but this increases the peak flow and the cost of the drainage system. There is no control of peak increase at microdrainage level, so that there is a rapid build-up of flow in larger drainage channels.

To cope with this problem, city and state administrations have developed many works involving canalization of main drainage, with pipe networks as secondary drainage. However this solution has merely transferred problems of flooding from one section of the basin to another, whilst incurring costs of canalization ranging from US$ 2 to 50 million per kilometre of channel.

As well as the failure to plann drainage networks adequately, municipalities encounter many difficulties in enforcing legislation. These difficulties are due to the following:

- *large increases in urbanisation*: most new developments within the city boundaries are not approved by the township and do not have the required stormwater and sewer networks. This arises from lack of control and law enforcement;
- *invasion of public areas*: public areas, such as planned green areas, become occupied by poor and homeless people who settle there;
- *occupation of flow conveyance areas*: during periods when no floods occur, low-lying and other areas that might be reserved for flood-water dispersal are taken for poor-quality dwellings. These areas have high potential risk for damage and loss of life.

The impact downstream of such informal urban constructions is not usually very large, but they are sited in areas of high risk since they commonly lie close to rivers where flooding is frequent, or on unstable hill-slopes with risk of landslide during the rainy season.

As well as the quantitative aspects of urban drainage, water quality is also an important issue not usually taken into account; domestic and industrial sewage is rarely treated, and polluted water aggravates the effects of flooding.

One of the major difficulties in the urban development of developing countries is to enforce legislation. To control the impact of urbanisation on drainage flows, it is necessary to create new regulations for urban developments defining, for example, a limit to peak flow resulting from new developments. But since invasion of public undeveloped areas by squatters often occurs and developments within city boundaries are made without formal administrative approval, regulation of urban development becomes exceedingly difficult

However, these difficulties should not be an excuse for not defining necessary regulations and the Drainage Master Plan. Some strategies can be followed to develop the drainage volume control:

- Sub-catchments lying within the city boundaries or close to them should be planned to allow for future development by evaluating their capacity for settlement and the limits to which they can be reasonably developed. Limits can be defined for the increases in peak flow resulting from increases in impermeable areas, and by planning public facilities such as parks with urban detention ponds to which flood-waters can be diverted. Such areas can be used to lessen the impact of high flows within cities, but they must be designated as such before they are invaded or developed by private users;
- It is possible to create a permeability index to allow for some infiltration in building plots and public space;
- Increasing public usage of designated green areas prevents invasion, thus making undesirable settlement much more difficult. In some cities, invasion of

public space has been discouraged by the use of effective barriers such as river channels, roads or railway lines.

Example: An illustration of flood control strategies is given by the plan for Curitiba (Tucci, 1996). The Metropolitan Area of Curitiba (State of Paraná, Brazil), population about 2,5 million, is developed in the Upper Iguaçu River Basin which has a drainage area of 1000 km^2 with about 25% of this area urbanised. The Iguaçu River has a large natural flood plain due to the small river conveyance resulting from the small channel section area and low slope. In the flood season, the hydrograph is damped by the storage capacity of the valley. During the past decades the regional administration ruled against occupation of the floodplain, but there were invasions and unapproved developments and occupation. In July 1983 and January 1995 two major floods occurred with severe damage. The 1995 flood had a seven- day rainfall with return period more than a 100 years (the largest in the 110 years' record). The duration of the main river hydrographs is seven days.

The usual approach would be to increase the Iguaçu river capacity to cope with the 50 or 100 year flood. But if this were done, the population would occupy the floodplain and upstream areas, increasing again the peak flow due to the lack of control on the urban drainage. In this scenario the cost of control would be very high.

The main approach to flood control was therefore taken to be the following:

- Create a storage area in Iguaçu river in the Metropolitan Area in the form of a major park (area about 20 km^2). This park is defined by a channel which creates a limit to urban settlement pressure;
- The park to be designed and implemented together with the channel construction. In addition there must be an important control of this area;
- Development of the Drainage Master Plan for the region using the strategies presented above: (i) developments of urban parks in the tributaries to hold the peak increase of the uncontrolled upstream area; (ii) regulation for the controlled area.

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MODELLING OF HEAVY METAL CONCENTRATIONS IN THE STORM-WATER RUNOFF OF URBAN ARID CATCHMENTS

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Real data from three residential urban arid catchments of varying size in Saudi Arabia were used to identify the probability distribution function that best-fit the concentration means and maxima of selected heavy metals in urban stormwater runoff, and to develop a reliable methodology for predicting the concentration means from the distinguished climate and flow features of arid areas. The selected metals are Copper "Cu", Lead "Pb", Nickel "Ni", Zinc "Zn", and Iron "Fe".

In determining the best-fit probability distribution function, a criterion was employed to obtain statistically-independent sets data for the concentration means and maxima. In each of the data sets, a constant number of 58 data values was selected by a random draw. Then different probability distribution functions were fitted to these sets of data. The probability distribution functions include the two-parameter normal distribution "N2", the two-parameter exponential distribution "EX2", the two-parameter gamma distribution "G2", the Pearson type 3 distribution "P3", the three-parameter mixed exponential distribution "MEX3", the extreme value distributions (i.e. the extreme value type 1 Gumbel distribution, the extreme value type 2 Frechet distribution, and the extreme value type 3 distribution, denoted respectively as EV1, EV2, and EV3), the two-parameter lognormal distribution "LN2", the three-parameter lognormal distribution "LN3", the log-Pearson type 3 distribution "LP3", and a mixture of two probability distributions "MIX". The maximum likelihood method was utilized to estimate the parameters of the distributions. The suitability of each probability distribution function for modeling the mean and maximum concentrations of a metal was examined by performing the Chi-square, the Kolmogorov-Smirnov, the Cramer-Von Mises, and the Anderson-Darling goodness-of-fit tests.

For the developed methodology, regression techniques were employed. Because properties of metals may vary with the grain size diameter of transported sediments, the sampled suspended sediments were separated into five divisions according to their grain size diameter "d"; namely, $d > 0.20$ mm, $0.20 \geq d > 0.06$ mm, $0.06 \geq d > 0.02$ mm, $0.02 \geq d > 0.002$ mm, and $0.002 \text{ mm} \geq d$. The suspended sediment samples within each division were further split by random selection into two groups of samples. The first group contains about 80% of the samples (called the regression group), and was used to develop regression equations, while the remaining 20% of the samples (called the verification group) were used to verify the developed equations. First, a regression equation was developed for each diameter division to relate the concentration mean of transported suspended sediment with corresponding stormwater depth and total

suspended particulate matter concentration averaged over catchment. Then, another regression equations were developed to relate for each diameter division the heavy metal concentration means with the corresponding concentration mean of the transported suspended sediment. The results have shown that:

1. The best-fitted probability distribution varies with event type (mean or maximum), but does not vary significantly with metal type in the stormwater runoff of the investigated arid catchments.
2. The event mean concentrations of metals are best modeled by a mix of two two-parameter lognormal distributions. Thus, such a mix of distributions should be adopted when accurate design or management of urban flows is required.
3. The event mean concentrations of metals are reasonably fitted by the three-parameter lognormal distribution, followed by the three-parameter log Pearson type 3 distribution and the two-parameter lognormal distribution. Thus, these distributions may be used in case of initial design or planning of urban flows.
4. A mix of two extreme value type 1 distributions best fits the event maximum concentrations of metals. Thus, This mix should be considered for modeling the maximum concentrations of heavy metals.
5. In case of small-size catchments, the extreme value type 1 distribution provides satisfactory fit to the event maximum concentrations of metals. Thus, this distribution may be adopted for such sizes of arid catchments.
6. The event mean concentrations and the event maximum concentrations of heavy metals are poorly fitted by the commonly adopted two-parameter normal distribution. Thus, this distribution should not be used for modeling either the event mean or the event maximum concentrations of metals in the runoff of arid catchments.
7. Suspended sediment concentrations in the stormwater runoff of arid residential catchments are significantly affected by the characteristics of both flash floods and duststorms over the catchments. Thus, both floods and duststorms are recommended to be considered for proper estimation of the sediments in the stormwater runoff.
8. The effect on the suspended sediment concentrations of flash flood is much more significant than that of duststorms. Thus, duststorms may be neglected for rough estimation of suspended sediments in the stormwater runoff.
9. The effect of the flash floods and duststorms on the suspended sediment increases as the grain size of the sediment decreases. Thus, it is recommended to control intensive duststorms and small grain size sediments from pervious areas for efficient control of drainage facilities.
10. The regression equations relating the concentrations of Cu, Fe, Zn, and Pb with those of suspended sediments are of reasonable accuracy. Thus, these equations may be used for design purposes.
11. The performance of the regression equations is better in the case of small grain size fractions of sediments than in the case of the large grain size fractions of sediments. Thus, these equations should be used for the estimation of metal concentrations in the stormwater runoff.
12. The regression equation relating the concentration of Ni with that of the suspended sediments provides poor results. Thus, this equation may not be used in the investigated catchments.

FLOOD MITIGATION AND POLLUTION MANAGEMENT IN COLD CLIMATE URBAN AREAS

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INTRODUCTION

The climate conditions define the framework and criteria of sustainable management of urban water resources including urban drainage. Floods mitigation and pollution management are two aspects addressed in this paper.

Cold climate conditions affect urban drainage in many ways, including changes in the hydrological cycle, generation and transport of runoff and pollutants, operation of runoff control facilities and sewage treatment plants, and disposal of runoff and pollutants. Up to 50% of the annual precipitation and the annual runoff load of the pollutants in urban areas in cold climates are stored in the snow pack. The area covered with snow is directly related to the surge-type runoff potential. The state of the snow pack during the melt period is of prime importance for the development of flooding. Transport of the urban pollutants depends on the snow characteristics as well as on snow removal and disposal activities.

Although investigations on urban hydrology under wintry conditions are plentiful, the practical contribution to flood control is moderate. Still, flooding is observed every year during snowmelt in urban environments in Scandinavia, Canada and northern USA. A lengthy operation of Combined Sewer Overflows (CSOs) during the melt periods leads to a significant pollution load on the receiving bodies.

One of the most difficult problems in dealing with flood and pollution hazards is the spatial distribution of snow packs and spatial-temporal variation in thermal inputs affecting snowmelt dynamics in both urban catchment and regional river basin. Low reliability and insufficient data on snow pack and inadequate snowmelt runoff modelling, the use of rainfall statistics based on summer rain and the rather elusive runoff coefficients are the main reasons that urban drainage systems are surcharged during common flood events. Flooding by backup through sewers occurs on a regular basis.

FLOODING POTENTIAL AND POLLUTION RISK - TWO CASE STUDIES

There are numerous examples indicating that snowmelt and rain-on-snow events give the most adverse flooding conditions. One such event on 30 March 1997 resulted in flooding in the city of Trondheim. The snow cover, which had been melting and freezing cyclically during the winter, had only a small direct contribution to the runoff volume from its melting. However, the indirect contribution was critical. Once the snow was frozen/saturated, the drainage area behaved as if it were impervious. All the subsequent rain was from then on converted to runoff without loss or detention. The increase in runoff was dramatic. A calibrated storm water runoff model was set up and runoff was analysed for a 30-year period. Whereas the rain that caused the flooding had a return period of 15 years, the return period of the flooding was 50 years (Milina, 1998).

Delayed and rapid snowmelt, coupled with several days of heavy rain during the spring of 1995 resulted in a major flooding of the Glomma-Lågen river system in Norway (catchment area 415,000 km^2). Some parts saw the worst flooding since 1789. However, studies showed that the lasting effects of the flood on the water quality were less serious than expected. Untreated wastewater from a population of 125,000, containing both nutrients and pathogenic bacteria and viruses, flowed into Lake Mjøsa. Due to the temperature stratification of the lake itself, the contaminated floodwater had less effect on the water intakes of the main towns around the lake. In all, about 400 tonnes of phosphorus, 3,800 tonnes of nitrogen and 200,000 tonnes of particulate matter from the whole catchment area were carried out into the outer Oslo fjord (Faafeng, 1995). However, there was no abnormal growth of algae in either the lake or the Oslo fjord.

PROGRESS IN FLOOD AND POLLUTION MITIGATION

One should distinguish between floods in a large river basin and local floods caused by rain and snowmelt in an urban area. The effects of urbanisation on runoff regimes and flooding risk have been studied in many urban areas in cold climate conditions. In some cases it is shown that flood events in large river basins have only been affected to a minor degree by urban development, whereas in urban areas, local flood frequency significantly increases by the progress of urbanization (Milina, 1998).

The need to mitigate storm water discharge impacts led to the development of storm water best management practices (BMPs). Cold climates present additional challenges that make some traditional BMP design criteria less effective or even unusable (Engineering Foundation Conference 'Stormwater management-Creating sustainable urban water resources for 21st century', 1997). Consequently, the runoff and pollution distribution from snowmelt and rain-on-snow events are one of the most important criteria for BMP design in cold climate conditions.

Difficulties with the operation of storm water BMPs in a cold climate include cold temperature, deep frost line, short growing season, and significant snowfall (CWP, 1997). There is still insufficient knowledge about the integration of flood and pollution reduction facilities with beneficial use of storm water in urban areas in cold climates (MISTRA Research Program: Sustainable Urban Water Systems, 1998). Further research is needed on identifying the sources of toxicity, the assessment of acute and cumulative impact caused by snowmelt toxicity as well as the selection of test organisms, exposure conditions and use of biological early warning systems (Dutka et al., 1994).

NEW COMBINED MODEL FOR WATER QUANTITY AND WATER QUALITY

The complexity, temporal and spatial variation of urban drainage processes in cold climate requires sophisticated methods of analysis. Perhaps the greatest innovations in this field include the application of integrated models to simulate water flow along with sediment and pollution generation, transport, treatment and disposal. The use of an integrated model tailored to typical cold climate conditions will lead to a better understanding of urban drainage management. Fig. 1 compares two strategies for sustainable urban water management in the city of Trondheim (Risholt et al., 1998).

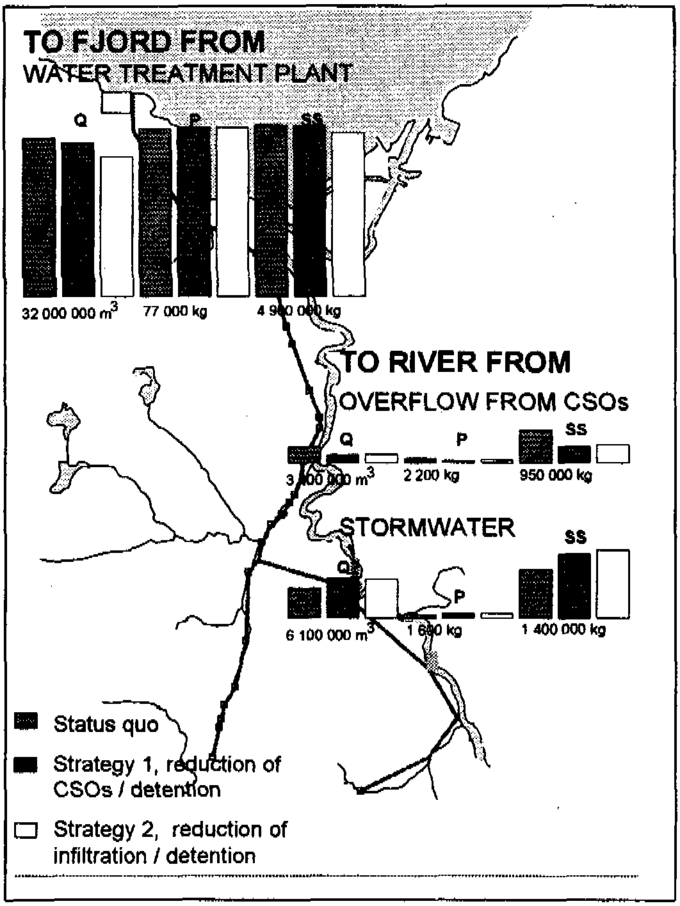

Fig. 1 Model results of present condition and two strategies for sustainable urban water management in the city of Trondhem, Norway. Annual discharges of total water volume (Q), phosphorus (P) and suspended solids (SS).

The integrated models will contribute to the evaluation of strategies against flood and pollution impacts. Effective management also requires access to the monitoring system for decision support and real time control of the transport, storage and treatment facilities. New trends include the application of models in conjunction with remote-sensing data of snow pack and rainfall (Andersson, 1998) and more accurate mathematical simulation of overland flow along with efficient routing of pressurised flow.

CONCLUSION

The paper emphasises the need for supporting a pro-active use and further development of 'urban drainage wisdom' based on hydrological processes in cold climate that are significantly different from those in temperate climates.

The monitoring system based on GIS and remote sensing data of rainfall and snow pack characteristics combined with integrated models are critical to flood forecasting, control, and pollution mitigation. Further development and modification is needed for a broader application of a range of storm water management measures referred to as best management practices in cold climates.

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EMERGING MODELS OF FLOOD HAZARD MANAGEMENT

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Complexity, diversity, dynamics: The management of water systems is characterised by *complexity* of uses and problems, a *diversity* of actors and *dynamic* change. As a consequence, it is of little use to devise generic, static, one-size-fits-all solutions.

- *rivers have multiple functions* - rivers cannot be managed solely for flood control purposes. Ecosystems have always developed around the water regime; changing that regime to mitigate floods will damage the existing ecosystems.
- *different floods present different management problems* - flash floods on small catchments; floods in large mature river systems; and localised surface water flooding each present different management problems.
- *different countries face different vulnerabilities* - the appropriate response in a country like Japan where 50% of the land area is at risk of flooding, is likely to be very different to that in, for example, those parts of the USA where both population density and economic intensity are very low.
- *both the challenge presented by floods and vulnerability to flooding are changing* - factors such as development of catchments, climate change and ground subsistence are increasing the risk; urban systems are also becoming more susceptible to flooding.

Anticipating uncertainty: Placing numbers on projects easily gives a false sense of security and control.

- *we always prepare for the last flood* - adaptation to flooding is frequently successful, providing that the next flood is like the last flood; if the next one is different, by being, for instance, more extreme, then adaptation is likely to be unsuccessful.
- *all management is about uncertainty* - there are inevitable uncertainties about the outcomes of choices; the critical form of uncertainty is 'uncertainty about what to do'. Decision uncertainty is frequently easier to resolve than outcome uncertainty.
- *somewhere soon there will be an extreme flood.*
- *it is necessary to manage all floods, not just some* - conventionally, flood management has been concerned only with mitigating floods up to some design standard event; the management of more extreme floods has been ignored.
- *it is necessary to design for failure.*
- *mitigation strategies are becoming more complex* - historically, physical solutions were grand and simple; environmentally sensitive solutions often involved a large number of localised, disparate and small scale works.

Land-water nexus: Land and water should not be managed as separate entities - they continually interact.

- *where land was under acute development pressure, rivers have been treated in the past as a waste of space* - the restriction and confinement of rivers to the minimum land take has resulted in a range of problems, not the least of which are flood problems downstream.

- *flooding and erosion are necessarily linked* - high rates of runoff usually result in flooding; they often also result in soil erosion. A joint management approach is necessary to the management of both erosion and flooding.
- *we need to work with nature rather than constrain it* - rivers are naturally adaptive, dynamic systems and seeking to restrict that dynamic change is less successfully than working with that adaptive capacity.

Managing the whole cycle: The interconnectedness of the hydrological system implies holistic water management.

- *all floods are the result of someone else's runoff* - we easily forget that floods are a symptom and not the disease. Changes in rainfall and runoff can radically increase the difficulties of managing floods downstream.
- *this implies a change to seeking to slow down floods rather than to shift them away as quickly as possible* - the less the lead time between precursor events and the onset of flooding, the greater the difficulty of coping with that flood. The new tendency is to seek to store and slow the rate of change in flood flows as far as possible.

Reassessing floodplains: The easiest option for flood protection would be to move out of flood-prone areas altogether. However, when the positional advantages of flood plains are considered, it can be quite sensible to develop a flood plain.

- *flood plains have positional advantages* - flood plains have major economic advantages for development; they are close to water, flat and usually have good soils. This attracts intensified development; conversely, they are typically also ecologically rich.
- *not all floods are a problem, some are a necessity* - in some countries, the agriculture is critically dependent on the annual flood; it is the extreme events that are the problem.
- *urban flood mitigation measures are cheap relative to the other costs of development* - compared to the infrastructure and other costs of development, flood mitigation is low-cost.
- *managed realignment, or managed retreat, options have been found to be most likely to be efficient where the land concerned is low-grade agricultural land* - managed realignment options are being considered for riverine systems as well as on the coast; low-grade agricultural land would sometimes be of higher value if it reverted to its natural state.

Limitations of cost-benefit analysis: When assessing floodplain development and flood protection, however, there is more at stake than economic value. The complexity of water uses should be reflected in more sophisticated project criteria than economic value only.

- *to those experiencing them, the stress and other intangible impacts of flooding are often worse the financial losses they experience* - the stress, disruption, anxiety and health affects of flooding are frequently both severe and long lasting; we do not have a good idea of the most effective way of alleviating these effects.
- *the purpose of project appraisal methods such as CBA is to reduce the complexity of the decision to manageable levels* - CBA and similar methods are now widely used in flood hazard management. A better understanding of the problem can help

generate better flood management options but the critical step is the generation of the set of options being considered. The 'best' option as appraised in a CBA can be no more than the best of those options considered.

- *economic analysis has both limits and unresolved problems* - the purpose of CBA is to gain a better understanding of the nature of the choice, which understanding can then inform the decision.
- *the economic objective is to maximise the efficiency of land use in the catchment; it is not to minimise flood losses* - it is misleading to look at annual national flood losses as an indicator of the effectiveness of the national flood mitigation policy.
- *short-run efficiency does not necessarily result in long-run efficiency*
- *holistic management requires holistic funding instead of narrow earmarking* - it is very difficult to achieve holistic management if the sources of funding are functionally based.

Multiple options: Responding to uncertainty requires a more sophisticated toolbox than the traditional unified structural solutions. It is equally unwise, however, to simply denounce structural mitigation measures and switch wholesale to non-structural measures.

- *flood mitigation seeks either to reduce the challenge to adaptation presented by a flood or to enhance the coping capacity of those threatened by a flood* - flood embankments, property raising and land use controls, for example, all seek to reduce the challenge presented by flooding. Flood warning, flood relief payments and counselling all seek to increase the coping capacity of flood victims.
- *flood mitigation can be either through physical means (e.g. flood embankments, flood proofing) or by changing institutional (regulatory) structures (e.g. land use control, flood warning, flood insurance)* - greater emphasis has come to be placed on institutional change in recent years as opposed to the historical reliance on physical methods. The two are not alternatives but complements.
- *institutional approaches are in themselves no more reliable than physical or structural flood mitigation strategies* - they are frequently not very reliable and appear to be least reliable where most needed. Flood warnings are least likely to be successful in small, flashy catchments; land use control is least likely to be enforced where the pressures for development are greatest.
- *a combination of challenge reducing and coping enhancing measures are likely to be required* - the challenge from all floods cannot be reduced and hence coping-enhancing measures are likely to be necessary as well as challenge-reducing approaches.

Mixed actor involvement: The burden of flood alleviation does not have to fall solely on the shoulders of central government. Increasingly, non-public actors and local-level capacities are (re)tapped.

- *an increasing range of partnership models are being adopted.*
- *local solutions can be adopted rather than seeking to apply some 'universal' solution* - to match the mitigation strategies to local flood and community conditions rather than to import the strategy adopted elsewhere.

SOME APPROACHES TO MITIGATION OF INUNDATION HAZARDS IN URBAN AREAS

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Introduction

The large development and construction of cities and towns in the different regions of the world causes of the necessity to take into account of a possible risk from floods.
In this paper an attempt has been undertaken to elaborate a united classification of inundations according to their origin.

Scope

The paper concern the problem connected with perspective development urban territories and protection their from inundation. Suggested approach allows more proper to make a choice of disposition place of urban areas.

Methodology

The study takes into analysis of the negative and positive experience of construction and development of urban areas for the last tree hundred years in different countries of the world (Russia, USA, Belarus, Italy, Brazil, Karakhstan, etc.).

Results and conclusions

The united classification of inundations according to their origin it simple form it is as follows:

1. Snow melt inundations usually occurring in spring-summer period both in the North and South hemisphere. Usually they form in the result of snow big supply and influx of intensive hot. These most typical for flat and middle-mountain rivers.

2. Glacier and perennial firn fields inundations usually occurring in summer in the result of influx intensive hot. The most typical for high mountain rivers.

3. Rain and storm inundations, formed long-term rains and heavy showers. These can happen in all seasons of the year in different regions of the world.

4. Ice-jam and frazil-jam inundations by jamming the river channel.
An ice-jam is an ice dam in the river channel, which are formed by blocking of the river cross-section by broken surface ice-flows.
Ice jams appear on the wave of the spring floods and can increase already high levels by

1-5 metres but they are quickly demolished (2-7 days) because of the heavy inflow of the maters usually these occur on the flat rivers.
A frazil-jam occur when the river channel is damned by frazil, sludge and broken surface ice. It occurs mainly in mountain rivers during the formation of surface ice in the channel turns and river parts with slow currents.
Frazil jams are formed in autumn-winter periods when the negative air temperatures grow. Such ice "dams" can be maintained in the river during 2-3 months. Upstream from this dam, "a reservoir" is created sometimes flooding the nearby communities at temperatures of -20°C — -30°C.
A sharp drop in water discharges and levels are observed downstream from so-called dam because the frazil jam has been formed against the background of depleted ground water discharge. All this leads to exposing of water intakes and stoppage of water supply to consumers.

5. On-icing inundations, which are formed by blocking of the river channels by ice-fields. On-icing inundation is an ice formation occurring as a result of freezing of water flowing through the cracks in the surface ice cover under negative temperatures. Such inundations are typical of Alaska, Eastern Siberia, Chukotka and some mountain areas.
A vivid example of such inundation in the mountain part of the West Siberia, in Altai, is Chuya River, running along the Chuya Steppe situated 1800 - 2000m. above sea level. In winter the river often freezes up forming on-surface ice with 3 - 4m. thickness and inundating of the town of Kosh-Agach.

6. Wind inundations caused by continuous winds from the same direction and affecting large stretches of reservoirs, lakes and seas. They usually cause flooding of the mouth areas.
In some places wind inundations from the sea cause great damage for example, in S.Petersburg on the Neva, Vilcovo town on the Danube, etc. In the course of the sea wind inundations in the mouth areas, the sea water intrudes and leads to salinization of floodplain and forests, causing their destruction. Freshwater hydrobionts also die from the salty water.

7. Tsunami ("waves in harbour" in Japanese) inundations are formed with long waves produced by a submarine earthquake, volcanic eruption in seas and oceans. The wave velocity reaches 800-1000 Km for hour with 100-150 Km length, 1-2 metres height. But rolling onto the shore, the wave reaches 10-15 metres height and destroys everything on its path. Tsunamis occur most often in the Pacific Ocean (over 80%) although sometimes observed in other places (the Atlantic and Indian Ocean, the Mediterranean, etc.).
The most catastrophic inundation from Tsunami in Russia was recorded in 1952 near the town of Severo-Kurilsk when three waves of 10m height rolled on the town. Most of population was killed and residential and industrial buildings were destroyed.

8. Mud-stone inundations are formed by mud-stone torrents in the mountain basins where extensive rock destruction products accumulate and much water are created in the result of intensity of glacier and snow melting, falling precipitations and together both phenomena. Suddenness is characteristic property of mud-stone inundation as well as a short period of happening of solids (10-80%). They cause great damage to cities,

highways, roads, farm lands and spawning grounds.
Mud-stone inundations have an especially important significance for cities, placed in hazards regions.
One such city is Alma-Ata which has been repeatedly exposed to mud-stone inundations.
In the spring of 1973 on the river Malaya-Almaatinka a dam 110m height was constructed for protecting the city Alma-Ata. Its volume for storage of a capacity of mud-stone inundation was estimated 6,2 million m^3.
On the 15 July 1973, the greatest mud-stone torrent occurred in the 100 years of the city's existence on the Malaya-Almaatinka river.
Its velocity was $10ms^{-1}$, height 20 metres and the total volume of transported rock fragments was about 4 million m^3.
Thus, the mud-stone reservoir saved Alma-Ata from destruction.

9. Accidental inundation caused by breakage of man-made dams as a result of bad construction, earthquakes, mud-stone torrents, sudden glacier motions, etc.
To protect a city from inundation damage the type of protection needed depends from which of 9 categories the inundation can arise.
One of the main measures is the creation of the necessary monitoring system. This system should insure of the early warning about inundation danger and for forecast of the size this phenomenon. Take into account that the most part rivers are transboundary, such systems of monitoring would be global, the similar meteorological.

Measures for reducing inundation hazard include:

1. Planning and construction of reservoir systems on the upstream river parts for detaining runoff and cutting of peak floods.

2. Planning and construction of drainage canals for transporting water away from urban areas in period of floods.

3. Planning and construction of dikes both in the river and around of urban areas.

4. Organization of the public and private insurance systems.

5. Planning and construction of new settlements should be permitted only after extensive scientific study.

6. In some regions of the upper reservoir can serve as water supply system, increasing winter discharges for preventing formation of on-icing and frazil-jam inundations, and also improving quality water in region of city through special releases in low-flow periods.

7. Improvement of storm canalization systems inside cities and towns.

8. Construction out and inside urban areas of forest-bush stripes.

THE DISASTROUS FLOOD OF 1998 AND LONG TERM MITIGATION STRATEGIES FOR DHAKA CITY

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Introduction

Dhaka City with a high growth rate of 7% per year is expected to emerge as a mega city by 2010. Dhaka is surrounded by a network of rivers – Turag on the west, Buriganga on the south, Balu on the east and Tongi Khal on the north (Figure 1). Water level in all these rivers rises in the monsoon (June-September) due to seasonal flooding and makes the city vulnerable to flood. In 1988, a major flood of 100 years return period hit the country, including the capital city Dhaka, causing enormous damages to life, property and income. During this flood about 80% of the area under Dhaka City Corporation (DCC) went under water.

Consequently, a number of studies have been carried out within the general framework of the Flood Acton Plan (FAP) that specifically addressed this issue. These reports suggested a combination of structural and non-structural measures for flood protection and mitigation. As of 1998, Phase I of the recommendations have been mostly completed that includes the Dhaka City Flood Protection Embankment along the Turag and the Buriganga rivers and improvement of internal drainage system of the city. However, the eastern part of the city still remains unprotected. Additionally, in 1998 another disastrous flood hit Dhaka which affected both protected and unprotected parts of the city. During this flood, almost all of the eastern block (118 sq km) went under water and much of the protected part (136 sq km) got inundated due to hydraulic leakage through ungated drainage pipes and culverts at various locations. As a result, city life was severely affected and the government is under serious pressure to undertake long term flood protection and mitigation measures to prevent such disaster in future.

Scope

Vulnerability of the city to floods is likely to increase in future due to the process of climate change already initiated by the Green House Effect. Experts apprehend that floods of 1988 and 1998 magnitudes may occur more frequently. With this in mind, this study has developed a set of long-term strategies for loss minimization and flood management of Dhaka City. These strategies can be used as guidelines for flood management for other cities of Bangladesh and elsewhere.

Methodology

The study has been carried out in a number of steps which include - review of existing documents on flood in Dhaka City; evaluation of current flood management practices; field visit; interview with concerned officials, key professionals, people's representatives and general public; synthesis of the long term flood protection and mitigation strategies.

Results and conclusions

Dhaka West is largely protected by the Dhaka City Protection Embankment constructed after 1988 flood. Even then, about 20% of this part of the city went under water in 1998 due to the following reasons:

- Hydraulic leakage through un-gated drainage pipes and culverts
- Untimely operation of the main drainage regulator
- Inadequate pumping from the retention storage
- Leakage through incomplete segments of the flood wall along the Buriganga River
- Lack of coordination between concerned government organizations responsible for flood control and drainage.

Dhaka East is annually flooded as this area is still largely an unprotected low lying flood plain. This area is being rapidly developed, which implies that soon flood protection has to be extended to this part of the city.

Dhaka West can be made flood free if Phase I of Dhaka Integrated Flood Protection Plan (DIFPP) is fully implemented and the shortcomings of current flood management practices identified in this study are alleviated. Flood protection of Dhaka East will require completion of the Balu River embankment as suggested in Phase II of DIFPP. This plan of Phase II has been further expanded by incorporating road and railway on the embankment and making it an economically attractive multi-objective project.

It is emphasized that attention must be given to maintaining adequate internal drainage network and retention basins. This has to be incorporated into the long run land use plan of Dhaka City. Thus both structural and nonstructural approaches have been suggested for long term flood protection and mitigation which are summarized below.

Structural measures

- Complete Phase II of DIFPP and ensure total flood protection for greater Dhaka.
- Install and operate adequate number of pumps (supported by corresponding retention ponds). Maintain these in good condition.
- Maintain all existing and future flood control structures. Reinforce weak points, provide bank protection where necessary.
- Maintain the internal drainage network in good condition. Undertake major awareness campaign to prevent indiscriminate throwing of garbage in the surface and subsurface drains of the city.
- Develop operating rules for all the regulators and establish close collaboration with the flood forecasting and warning system.

Non-structural measures

- Protect existing retention ponds in the western part of Dhaka and set aside sufficient land for retention ponds in the eastern part of Dhaka.
- Improve the current flood forecasting and warning system, provide forecast in terms of inundation as well as rise of water level for the currently unprotected Dhaka East.
- Build public awareness through local NGOs and the media on flood preparedness.
- Streamline institutional bottlenecks and assign most of the flood related responsibilities to Dhaka Water and Sewerage Authority and Bangladesh Water Development Board.
- Introduce necessary rules and regulations for proper land use in the eastern part of Dhaka.

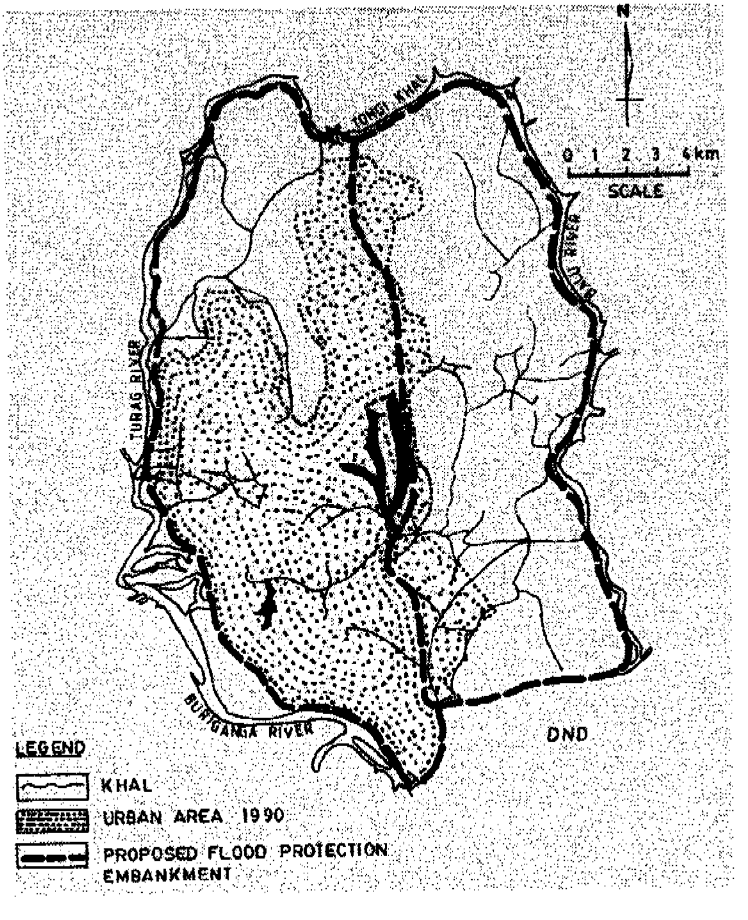

Figure 1 Dhaka City and surrounding rivers

THE FLOOD HAZARD OF THE POPULATED TERRITORIES IN THE RIVER DELTAS

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Introduction

The river mouths were of the great importance in humanity development since ancient times: favourable climate, fertile soils, abundance of the fish and wild fowl were a reason for people to settle these regions first. The location of the first delta settlements at the crossroads of the main transport ways produced the sea-ports development at the river mouths. The greatest European sea-ports are located now at the river mouths: Hamburg, Riga, Rotterdam, London, St-Peterburg, Rostov-na-Donu, etc.

In parallel with great comfort for urban population, industry and transport in big cities, situated in river deltas, also, there is the constant flood hazard in these regions. This hazard is caused by both marine and riverine factors, unlike the cities, situated only on the seashore or near the river.

Methodology

River mouths are located at the boundaries between sea and river. The marine and riverine factors interaction defines the specific hydrological regime and unique environment. Economic development causes the serious changes of the river mouths ecological balance. The negative consequences of the anthropogenic influence take place in the river mouths: the runoff value decrease and regulation, industrial and domestic pollution, reconstruction of delta streams network with the dams and channel building. Therefore investigations into the river mouths as a zone of active marine and river factors interaction accompanied with intensive economic development become of special importance.

The analyses of the delta hydrological regime enables us to determine the main factors of the delta floods (Table below).

In the deltas the main flood factors of the river origination are the spring-summer floods and flushes, emergency spills or catastrophic breaks through the dams. The sea level backwater and storm surge waves are the main factors of the sea origination. At the time of the long period sea level rise or fall we can include the sea level fluctuations as one of the marine factors. The interaction of the delta flood factors of the river and the sea origination represent the long-wave fluctuations of different periods. This interaction of the delta flood factors is unique for each river delta, therefore investigation of the role of these factors in the flood hazards in the urban deltas is very important. It is necessary to make integrated investigations of the flood factors in the river deltas of different types to devise a spectacular method of flood protection for the cities and big sea-ports.

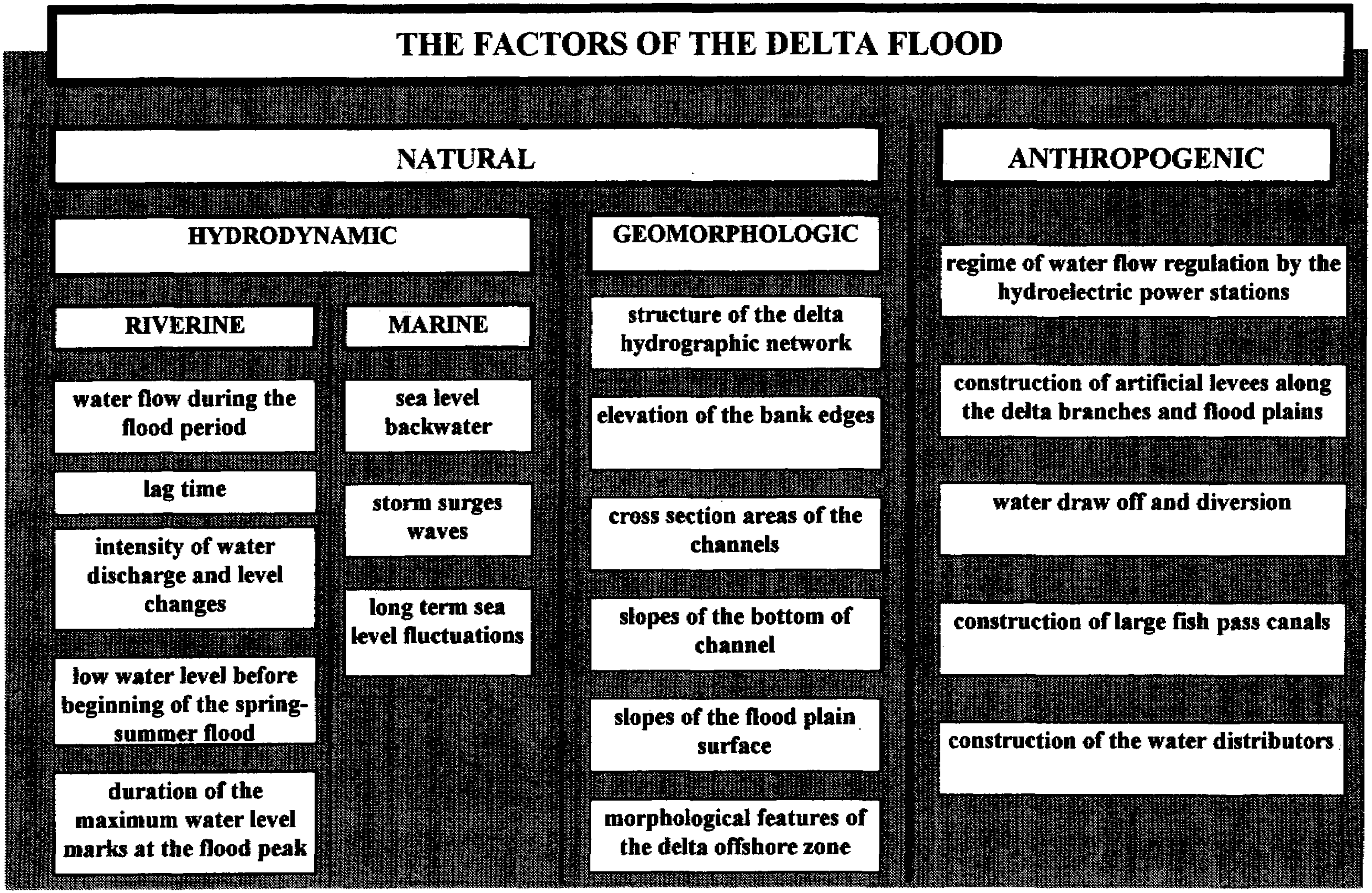
Results and Conclusions

There are more than 20 river deltas of different types along the Russian coastal line. It is unique possibility for us to estimate their flood characteristics. All deltas were divided into several groups for analyses. As an example we chose the multibranched Volga delta with great industrial and transport centre - Astrakhan, the Neva delta with the city of St.-Petersburg, the Don delta with the city of Rostov-na-Donu. Volga flows into the Caspian Sea with the variable sea level. During the last 20 years the Caspian Sea level has risen more than 2,3 m. Neva flows into the Baltic Sea and Don flows into the Azov Sea. The Neva delta and the Don delta were chosen, because these objects are prone to catastrophic storm surges.

Taking Volga delta as an example we have made the calculation and analysis of the possible inundation of the urban territory. The methodology for estimation of the inundated areas under conditions of sea level rise and flood waves transformation was developed on the basis of the Volga Delta satellite- and aerial-images analysis. This methodology enables us to estimate the storm-surges role in the lower delta inundation in 1990s and the new role of the Volga spring flood waves in the upper and middle delta inundation.

Taking Neva and Don deltas as an examples of the delta inundation by the reason of the storm surges we have made the analysis of the ways of salvaging the environment in these river mouths. The great dam in the Neva gulf, which was built some years ago, protects the city of St-Petersburg from the peaks of catastrophic storm-surge waves. But the ecological conditions in the gulf now are worse, than before the dam construction. The dam upset the water exchange between the Neva gulf and the Baltic Sea. The peaks of the spring flood waves in the Don delta were cut off after the Tsimlyanskaya dam construction. But the threat of the inundation of the Don delta and the city of Rostov-na-Donu by the reason of the storm-surge waves is retained.

On the basis of the analyses we have made the forecast for the Volga River Delta future inundation in conditions of the Caspian Sea level rise. In future it is necessary to develop the complex of the measures for the control the urban river deltas inundation, caused by different factors of the river and the sea origination.


THE FACTORS OF THE DELTA FLOOD
NATURAL
ANTHROPOGENIC
HYDRODYNAMIC
GEOMORPHOLOGIC
RIVERINE
MARINE
water flow during the flood period
lag time
intensity of water discharge and level changes
low water level before beginning of the spring-summer flood
duration of the maximum water level marks at the flood peak
sea level backwater
storm surges waves
long term sea level fluctuations
structure of the delta hydrographic network
elevation of the bank edges
cross section areas of the channels
slopes of the bottom of channel
slopes of the flood plain surface
morphological features of the delta offshore zone
regime of water flow regulation by the hydroelectric power stations
construction of artificial levees along the delta branches and flood plains
water draw off and diversion
construction of large fish pass canals
construction of the water distributors

MANAGING FLOOD HAZARD IN CHENNAI CITY, INDIA: ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT APPROACH

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THE PROBLEM PERCEPTION

Flood is a recurring problem and a recurring disaster. In cities, with highly dense populations and locations along the coast, it is a recurring hazard for large numbers. Chennai city is a case in point, where a third of its 175 km2 area, nearly half of its more than 5 million population and more than half the middle class and nearly all the lower class families live through nearly three months of battering rains, consequent floods (when cyclonic rains are in excess) and the trauma of living flood affected, polluted and health hazard areas.

This paper is about the difficulty in managing floods using conventional management practices in respect of Chennai city and the potential for using Adaptive Environmental Assessment and Management Approach. Flood in Chennai is an yearly occurrence, human-made because it could be mitigated but not mitigated at all. The people concerned about it find the means of coping with floods such as emergency relief, evacuation and storm shelter provision are only temporary and do not involve the people affected by floods in mitigation.

Cyclones hit Chennai invariably, and sometimes in chains, in the months of October-December every year. The annual frequency numbers about 12, of which 5 develop into cyclones and the maximum cyclone activity is in the period October-November. The minimum of only one cyclone occurred in 1986, while the maximum of 11 have occurred in 1976. The coefficient of variability has been of the order of 37 per cent. When cyclones strike the city, or the east coast of India, there is sure to be high rainfall (it pours cats and dogs, and for days on end sometimes). The rainfall in excess of 50 per cent causes severe flooding of the city, especially in the lowlying areas of the city where more than a third of the city's 5 million lives, often causing hardships for the poor, rendering them homeless and without proper shelter, food, and clothing. In comparison, the cyclonic disturbances on the east coast are 5-6 times more than that occur on the west coast of India.

The most appalling aspect of tropical cyclones is the storm surge. A storm surge is a temporary rise of the sea level at the coast in excess of astronomical and climatological tide. Caused mainly by strong winds, with an onshore component, and due to changes in the atmospheric pressure. Storm surge prediction is the most important component of cyclone preparedness and flood hazard management, with various statistical, empirical and numerical methods of prediction. The methods in use are such that the accuracy of prediction is hampered by the cyclone data forecast model. While short term flood hazard management plan depends on accurate cyclone forecasting, the inherent difficulties in accurate prediction due to the abnormalities in cyclone behaviour cannot be avoided in a prudent disaster management. With the errors in track prediction being still considerable, the threat models to quantify the risk of flood hazards have to be based on probability alone.

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WHAT PEOPLE THINK ABOUT FLOOD HAZARD AND MANAGEMENT

A group of 27 people from varied walks of life, brought together in a March 1998 Workshop at the University of Madras, considered Flood Hazard in Chennai city. They considered the problem to be widespread and pervasive. It is more serious a problem within the city than among the peripheral urban areas. Occurring at regular intervals, in a cyclic fashion, the hazard varies at different localities in extent and intensity and is a regular, localised problem in several areas. The participants at the workshop arrived at three major problem categories, namely, (a) Population and objectionable land use; (b) Hydrology; and Social, Political and Management aspects of the problem. The problems under each of these categories are:

Population and Objectionable Land Uses

Poulation growth, through natural increase and migration, and densification of settled inner city and peripheral areas; Encroachments on public land, slum development, and location of new slum developments in low-lying areas putting a third of the city population at risk of floods and flood-related diseases;

Densification and intensification of land uses as a response to urbanisation and industrialisation;

Lack or absence of storm water drainages, affecting approximately half the city population (about 2.5 million), living in housing in flood prone areas and former lake/tank sites; and

Among the upper class population with Rs. 50,000 to Rs. 800,000 as probable limits of family's monthly expenses (1.0 per cent of a million families) and lower classes with Rs. 1,000 to Rs. 2,000 as family's monthly expenses (22 per cent of the families in Chennai), broader development and altruistic perspectives give way to more selfish interests (award of development and industrial contracts, concessions in tariffs, for example) or more urgent concerns (food, shelter, drinking water, subsidies, handouts and income generation activities). Only the middle class with probable limits of family's monthly expenses ranging from Rs. 2,000 to Rs. 15,000 (about 40 per cent of the city families) has the time and means and also an interest arising from a 'sense of being useful and an identity with culture, prosperity and values of the country'.

In fact, only the middle class citizens of the city can focus on questions of long term strategy for flood mitigation and on alternatives to recurrence of floods (and droughts) and very low and inappropriate utilisation of land

Hydrology

Stagnation of in low-lying areas, especially in areas of above 2-4 metres in sea level, along the natural river courses such as those of the Cooum and the Adyar rivers and in the new housing areas occupying former tank beds, retardation of flood flow potential, slow flow - no flow during inter-monsoon periods, leading to health hazards; Flooding and overflowing due to clogged sewerage and storm water drains for most of their stretches and the resultant inadequate disposal of monsoon rains; and Heavy silt from sewage and storm water drainages during the floods and degradation of land, water and air along the river banks and heavy pollution becoming a health hazard prior to, during (rains) and after floods.

Social, Political and Management Aspects

Communities, citizens and government inaction, neglect and lack of political will to mitigate the recurring flood hazard in the city (as also elsewhere, for if it were solved in some place, the solution could be replicated);

Lack of multi-disciplinary approaches to the flood problem and the inability to approach flood management with integrated efforts and holistic outlook; Lack of communication and coordination among and within (social, political, and government) institutions concerned with flood control, regulation, and mitigation and with relief, rehabilitation and development;

Budget limitations and day-to-day management problems of local bodies and insufficient management and upgrading to keep up to the problem in the past leading to current crisis situation;

Lack of public awareness, knowledge (no large scientific databases of parametric variables) and cooperation due to masking by government agencies; and

Greater levels of conflict, number of stakeholders, number of overseeing agencies and failures of previous management attempts.

THE ACTORS, ACTIONS AND THE SOLUTION

The flood hazard has been seen as not an individual's problem but as a problem of four groups of actors, who might and could take part in a solution to the problem: Government and Government Agencies, CBOs and NGOs, Academic and Research Institutions and Citizens and others. The Government and its agencies face an inter-departmental (overlapping boundary) problem, in the solution of which no one agency is more important than others. The Corporation has the responsibility of the storm water drainage while the Chennai Metropolitan Development Authority has the planning of city development and mobilisation of resources, organisations and political clout. The Public Works Department is in charge of maintenance of river courses, removal of sludge and silt, plugging of outlets, ensuring free flow and the storage of floods and flushing. The CBOs and NGOs, because people at large are involved, they can speak freely on behalf of the people, and they can take on the role of 'egging on', 'encouraging' and 'challenging' people and the government and educating the public, have a special role not only in mitigation but also in the flood hazard and environmental damage assessment but also in the making of an adaptive environmental management approach to flood hazard. Adaptive environmental assessment and management is an intervention designed such that the actors and their actions are embedded in the enhanced, experiential knowledge about the flood hazard and 'people' form the key in the solution: the likelihood is internal management organisations will have more 'embeddedness' in the local solution.

STORM WATER MANAGEMENT IN A SUSTAINABLE SOCIETY

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Traditional storm water handling has mainly been emphasised to transport the water from the cities. This have been done by separate or combined sewer systems. The characteristics of storm water in urban areas are the complex mixture of different types of substances, such as heavy metals, hydrocarbons, nutrients, bacteria, substances which causes oxygen demand, suspended material and salts. The storm water may have a detrimental effect on water, soil, vegetation, animals and micro-organisms. The impact depends both on the properties of the storm water, such as concentration of pollutants, volume, flow, and temperature, and on the properties of the receiving body. Depending on the concentration of pollutants, the effects can either be acute toxic, or arise after a period of time. When the environmental impacts caused by storm water pollution where identified the interest of the storm water quality increased.

The last years the interest of ecological storm water handling has been paid more attention. Examples of ecological storm water systems are ditches, dams, brooks and wetlands. These systems may lead to several changes regarding life in the city, the economy and the environment. For example, areas of impermeable surfaces will be reduced and the green areas will increase as a consequence of ecological systems. The water is made visible for the people, and the wetlands and parks could be used for recreation. When the storm water handling is planned, the bas should be from the local situation and that small-scale system is preferred before large-scale system. The ecological methods differ for different types of area, such as city centres, residential areas and industrial areas with regard to the quality of the storm water. Clean storm water can be supplied to maintain ground water levels. It may also support vegetation which improves the climate in cities. In other words, the storm water need not be seen only as an environmental problem: it can, in many cases, be a positive factor in city planning.

Ecological systems will also affect the environment, climate, receiving water, ground and vegetation. Solutions that lead storm water to the ground and/or the ground water have already started to be questioned because unwanted unknown effects might occur. Also, the impact of storm water at waste water treatment plants is discussed in many Swedish municipalities, since the quality of the sludge is important in a sustainable society.

In the future it maybe necessary to divide the storm water into more or less polluted parts. For the less polluted water, we might use ecological methods while for the polluted water, we should use special solutions, depending on the type of pollutants. These questions are not easy to answer. There can be a number of different answers with regard to the long-term and short-term perspective. In the long time perspective the best way is to never create the pollutants i.e. to stop them at the source. In the short time perspective more knowledge is required in order to implement ecological storm water treatments.

In areas with a cold climate, the situation arising when snow falls differs from that arising when rain falls. For example, when the rain reaches the ground, it runs off directly, while the snow accumulates on the ground during the winter and becomes continuously polluted. In addition, because of the snow handling practices, large amounts of snow and pollutants are relocated.

FLOODPLAIN RESTORATION AND FLOOD PROTECTION – A CASE STUDY

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Introduction:

The need to recover and protect natural floodplains is rapidly gaining recognition in recent years. This tendency is largely enhanced by two factors. Firstly, floodplains are known to be ecologically rich, in terms of biodiversity. The mosaic structure of vegetation cover with species hardly found in other landscapes coexisting next to each other is a unique feature of floodplains. Secondly, floodplains are known to have a large potential to contribute to flood protection. The project discussed in this paper is primarily ecologically motivated with a view to contribute to nature conservation. The project area presented here is one out of six sites along the upper reach of the river *Weser* in Germany, in which a group of researchers experiment with different methods which may be employed to restore conditions and biotopes typical for natural floodplains. The aspect of flood protection in the project area is closely examined with the help of a two dimensional hydrodynamic numerical model.

Principles and Methods of restoration

The underlying principle behind the restoration efforts in all project areas is to provide minimum initial help and then leave everything in the hands of nature to decide the course of future developments rather than correcting the course of nature with a view to achieve a given landscape picture. The extent to which floodplain dynamics is established is a key factor in determining whether floodplain biotopes will be re-established or not. Consequently, most of the project sites, like "**Lake**" are within such floodplain channels, where a reasonable amount of flood energy is diverted into, setting off morphological processes common in natural floodplains. Artificial dams or dikes are absent along the banks of the river in the upper reach, making it possible for the main river channel and the rest of the floodplain to interact, from a hydrological point of view, without hindrance

Depending on the reality of each area, the diversity of interest of the different interest groups (stakeholders) and expert judgement, different methods were employed in each area. Methods used to regenerate the floodplain-typical biotopes in the project areas include: terminating agricultural use of land or switching to extensive use of agricultural land where the former is not possible, initial planting of typical floodplain trees, generation of open water bodies and exposed soil surfaces as potential pioneer growth areas in the initial succession process, through excavation.

The project area "Lake":

The project area referred to as "**Lake**" is situated in the upper reach of the river *Weser* in Germany. Under flood conditions the river branches at the upstream end diverting part of its discharge into the "natural" floodplain channel "**Lake**" adjacent to the main river bed. During moderate floods, the flow in the channel is confined to the channel bed (see fig.1), but as the discharge increases the slightly elevated parts of the plain between the riverbed and the channel

Fig.1: Arial view of the project area "Lake" during the floods of 1997 (the discharge of 660m^3/s captured in this picture has a return period of slightly less than two years)

The model:

As part of the study, a two dimensional hydro-dynamic finite element model was developed in order to assess, numerically, the effects of floods on the ecological dynamics of the area. To that effect, intensive surveying was carried out in the model area. Structures which contribute significantly to roughness, like trees etc. were accurately surveyed too. The point data from the survey was used to construct the mesh for the numerical analysis, thus increasing the accuracy of the model considerably. Elements were formed, using the survey points, and roughness coefficients assigned to them. In assigning roughness coefficients to elements, use was made of the vegetation maps which are produced yearly as part of the project. Discharge data was obtained from a gauge about two km upstream. Measuring stations installed in the model area provide water elevation data during floods. The data thus collected is used to calibrate and verify the model. Velocity measurements at known locations during two floods were also used to calibrate the model.

Model results and conclusions:

Natural floodplain channels like "Lake" are particularly effective as flood protection measure for two reasons. Firstly, they provide much retention room for flood waters by virtue of their relatively large depths which can be filled with water. Secondly, by diverting part of the peak discharge away from the main river channel, the stage of the river within the reach is reduced, thereby minimising the risk of the river bursting its banks. The flood water hence stored in the floodplain constitutes an important element of floodplain ecology. Table 1 below shows the total storage and percentage of the discharge diverted, for floods of different intensities.

By using accurate field data, the model results show that the project area has a significant storage capacity. For example, the storage within the project area, excluding the storage in the main riverbed and its banks, during a moderate flood, with a peak discharge of 660 m^3/s , shown in fig.1, amounts to more than 100.000 m^3 (one hundred thousand m^3).

Table 1: Storage and percentage of discharge diverted for floods of different intensities

Total discharge (m^3/s)	Return Period (Years)	Total Storage (million m^3 10^6)	Discharge diverted (%)
700	2 (mean)	0.18	10
940	5	0.33	20
1100	10	0.45	23
1490	50	0.63	28

The estimated storage for the whole upper reach of the *Weser* with a total length of 200km, by extension, amounts to more than 1000.000 m^3 (one million m^3).

In terms of biodiversity, it could be observed that since the inception of the project, the monotonous vegetation cover has developed into a mosaic including many rare plants on the verge of extinction. Furthermore, a mosaic of organisms typical for active floodplains has also been established side by side with the former.

To conclude, the results of the study have demonstrated that by carefully activating floodplains, instead of cutting them from the main channel, the biodiversity of floodplains could be regenerated and conserved and flood hazards minimised at the same time. Even though very simple methods were used and the overflow conditions which determine the start and mode of flow diversion into the floodplain channel remain unchanged, genuine results were achieved. The natural potential of floodplains therefore need to be further explored.

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MITIGATION OF FLOOD HAZARDS IN URBAN AREAS FLOODS AND FLOOD PRONE AREA MANAGEMENT OF COASTAL CITY: A CASE OF CHENNAI, INDIA

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The most common of the water related disasters in the coastal cities are floods. The devastating of flood producing rainfalls is generally associated with tropical cyclones/typhoons, and the coastal cities that are subjected to these hazards suffer from the destructive floods. Out of 75 largest cities in the world, nearly half are in Asia-Pacific and are more than half of these are situated on or near the coast. By the year 2000 the number of people in coastal Urban Agglomeration in the region is expected to reach nearly 480 million. In India areas undergoing rapid urbanization particularly in low lying coastal and delta areas and their environs are severely suffering from increasingly frequent flood damage due to increased flood flows or inundation. In flood control project for rivers whose basins undergoing rapid urbanization, there is need to address various problems related to land acquisition and environmental impact. There are many problems yet to be coordinated well with local land use or development in urban drainage basins. In the basin of urban rivers, especially in densely populated areas along the river reaches of those rivers, widening of rivers, which involves land acquisition, for the purpose of flood control is often impossible. All most all countries of Asia and Pacific frequently experience severe flooding.

The present paper discusses the impact of floods and flood mitigation of Chennai City. Chennai is an unplanned metropolitan coastal city with flat terrain, located in the southern part of India. The city lives from monsoon and in the recent years, the problem floods have increased manifold. The areal extent of the Chennai Urban Agglomeration is 571.93 sq. km and the population of the city between present and 2011, will increase 5.6 million to 9.5 million. There are 10.57 lakhs of households in Chennai agglomeration area with 7.47 lakhs of households constituting formal housing comprising flats, apartments and bungalows and 3.10 lakhs households constituting the informal shelter including tenements constructed by Slum clearance Board, household living in slums and pavement dwellers. The percapita income at Rs 425 per month is the lowest among the largest cities in India. The present urban development planning system relying solely on physical planning, and divorced from economic planning and infrastructure coordination has not responded to the needs of the city's growth. The waterways of Chennai consists of the city lying stretches of two natural rivers (Cooum, Adayar and Kusaithalaiyar); the drainage courses of the tanks (Otterinullah, Captain cotton canal, Mambalam-Nandanam Drain, Kodungaiyar Drain etc.) and city lying stretch of the man made Buckingham Canal. The floods and their magnitude experienced by the city waterways are the consequences of meteorological factors and rapid urbanization. The runoff from heavy precipitation and locally inadequate drainage systems during monsoon period result severe flooding in the city. The city had experienced very heavy floods during 1943, 1976 and 1985 caused heavy damage to men and properties. In Chennai city, its occurrence is more frequent during Northeast monsoon period (September, October, November, and December) causing loss of life and destruction of property. Many of the tanks have silted and have been filled up to provide urban land. The result has been heavy inundation of low-lying areas during the monsoon period. Despite heavy rainfall in this period, Chennai has chronic water shortage due to inadequate storage and percolation. The flatness of the terrain also poses difficulties in transporting sewage and other waste water. A relay system of pumping stations collects the sewage, and transports in to sewage treatment plants located in the periphery. During peak flow time, and heavy rainfall, the pumping stations overflow, causing pollution of the waterways. Water supply, sewerage, storm water, drainage and garbage collection system, which developed in 1866, have not been able to keep pace with the rapid urbanization.

The yield from all sources of surface and ground water is 293 million litres per day. The percapita water supply of 78 litres per day is the lowest for any metropolitan city in the country. Chennai Metropolitan Water supply and Drainage Board maintains the water supply system and its operations are limited to the city area covering 170 sq.km. The rest of the areas don't have good water supply system. About 15 per cent of the population, is not directly connected to the sewerage system. They live in slum areas or other older areas of the city, which are not sewered. Low cost sanitation techniques like septic tanks and public latrines have not worked efficiently, due to poor permeability of the clayey and the higher water table. Deficiencies in the sewerage system are major cause of pollution in the rivers, particularly Cooum. The World Bank has proposed a water supply and sanitation project, which includes improvements to the sewerage system and will provide services to the slums and low-lying areas. As the city has separate systems of sewerage and storm water drainage, there is interlining of storm water and sewage at a large number of locations. When flooding occurs in areas not having storm water drains, there is tampering of manhole covers and consequent inflow in to the sewage system, resulting in pollution (street surface contaminants) of the waterways.

The city faces the problems of process of rapid urbanization and overpopulation, the inability of urban services to cope with such rapid growth and consequent pollution in the watercourses, by different types of wastes. In this way waterways are polluted with various chemical, toxic and bacteriological pollutants. Floodwaters carry significant amounts of bacterial contamination and pathogenic agents. The sanitary aspect of rehabilitation must be implemented depending on the intensity of flood. As potable water and water supply are sensitive, special care should be taken to protect them from floodwater than rehabilitate them afterwords. The city generates a daily average of 1500 tons of garbage and 1500 tons of construction debris. About 30-40 per cent of this waste is uncollected and accumulates in drains and open land. In addition about 70,000 cattle and buffaloes contribute to the solid waste problem and these wastes are dumped in the sewers and result in choking of the sewers. Disposal takes place in low-lying areas without sanitary landfillings. This has potential of polluting both surface and ground water. Flies rodents and other vectors of diseases find these areas to be convenient breeding grounds.

Due to poor sanitation system, 75 per cent of water borne diseases (cholera, typhoid, amoebiasis and infectious, hepatitis), water washed diseases (scabies, skinsepsis, leprosy, dysentery etc.). Diseases caused by water related vectors (dengue fever, malaria, filariasis etc.) and diseases caused by chemical contaminants in water (through food chain-fish, milk) are found during monsoon period. The control of first three types requires ample quantities of safe water, good hygiene and proper disposal of wastes.

The important causes are, Increasing concentration of people on low lying areas particularly slums are concentrated along the waterways, encroachment of development in to flood prone areas, squatter populations occupying floodways and lack of government action due to insufficient funds, inexperience and low technical capability.

Applying the following measures can carry out coping with floods in flood prone areas of the city.

- Do nothing except to educate people how to live with, and adjust to, floods which inundate flood prone areas from time to time and warnings may be issued by authorities. It should expanding individual awareness of and knowledge about flood prone areas, improving training programs for code administrators, planners, inspectors local government personnel directly involved and ensuring that postdisaster mitigation funds are used completely and creatively.
- Use of non-structural measures includes, Zoning of the flood prone areas, Coding (how the land should be managed), Insurance (against losses from floods), Modification etc.
- Application of structural measures, includes levees, dikes and rigid walls, reservoirs
- Use in combination of structural and non-structural measures.

Various measures and methods have been discussed including, use of GIS and Remote sensing to protect the city from water related problems. In order to obtain a clear view of the necessary measures, and their timely planning and implementation, it is essential that reliable information should be available about the characteristics of the waterways, soil types, Geology, land use, water level, slope, landforms, rainfall, the possible flood waters the area in danger and its intended use, all kinds of structures and necessary rehabilitation for the area. In order to obtain all of this, the best method is the use of modern GIS technology and the forming of a GIS information system which can improve the efficiency and quality of flood prone area Planning, management and rehabilitation. The Flood Prone Area Management should result in an actual decline in the city's flood losses, including public and private property damage, injuries, and disaster relief.

Workshop 2

Posters

Severe Microclimate Effect on Floods in Kuwait: Case Study Al-Jahra Area

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Introduction

Kuwait lies at the northwestern part of the Arabian Gulf. The land surface of Kuwait is generally flat but occasionally interrupted by low hills, scarps, valleys of ephemeral streams and shallow, wide inland depressions. The altitude rises from sea level to about 300m in the southwestern part of Kuwait. It slopes gradually northeastward with an average gradient of 2m/km.

Kuwait is located in the desert zone, where there is a wide range of variations in the temperature. Two climatic seasons are recognized: a long, hot and dusty summer that extends from May to October; and a relatively short, pleasant winter that starts in November and ends in February. March and April are transitional between summer and winter. Precipitation in Kuwait is limited to the cool season from October to May. The annual average is around 115mm. Evaporation is very high; the daily mean evaporation is 6.6mm.

Kuwait faced different times of heavy rainfall events that caused severe floods during December 1934, March 1954, February 1993, March 1996, and November 1997. The last one, which had a rainfall of around 65mm in around 3 - 4 hours, caused huge damage to infrastructures and development facilities. Huge amounts of soils were eroded by runoff water.

Al-Jahra area (case study) is located 30km to the west of Kuwait City. It exists in a basin between 10 - 50m above sea level. The area is bounded to the north, west, and south by continuous ridges with heights of 100 - 145mabove sea level and to the east by Kuwait Bay.

During heavy rainfall (50mm in some years), Al-Jahra city acts as a water collector. Runoff water from the surrounding high areas flows towards its central area and outwashed sediments block roads and fill drainage systems. The amount of water accumulated in this basin caused many problems to the area, for this reason, the area was chosen for this study.

Scope

In the present study, precipitation forecasting is done using new forecast methods or development of new ones. Measures to control flash floods in Al-Jahra will be discussed.

Methodology

The case of November, 1997 flood is studied by using synoptic situation maps. The 1000 - 500 HPA thickness is the key parameter for forecasting heavy precipitation in Kuwait, from passing depressions, fronts, and local thunderstorm "Alsarayat" (a local weather phenomenon) in winter and the transitional seasons. The microclimate effect on floods cause millions of dollars of property damage and even a few deaths in Kuwait, and prompts the need for more accurate forecasts of heavy precipitation. It is one of the most difficult meteorological parameters to forecast especially the amount of rainfall for a desert region like Kuwait.

The precipitation data used in this study were daily precipitation records for November 1997, data for the synoptic, upper air analysis, and satellite pictures which were taken from the Kuwait Meteorological Department's (KMD). Analyses were used so that the parameters utilized to develop a heavy precipitation forecasting technique would be available to all forecasters for analyzing similar situations in the future.

The synoptic situation was examined for this case. Surface maps from 1200 GMT and 0000 GMT from November 10^{th}, 1997 to November 12^{th}, 1997 were examined. Upper air maps from 850 to 200 HPA were examined for temperature, wind speed and direction; dew point depression, height and instability were all put into account. Surface maps were examined for frontal positions in these three days in relation to the upper layer parameter. Other surface parameters such as pressure, temperatures, wind speed and direction etc. were examined to see if there is any relation to the heavy precipitation. All of these analyses were done to find a technique to forecast heavy precipitation event associated with fronts in similar cases in Kuwait.

Results and conclusions

Kuwait and the surrounding regions are effected by an average of four low-pressure events during November to June. They are the prime reasons in shaping the annual weather phenomena. This is indicated the observed weather patterns: 1. Severe to moderate thunderstorm during transitional and winter seasons, 2. Warm southeasterly airflow masses and winds in the winter months, and 3. Frequent duststorms.

Passing depressions through Kuwait are not restricted to a general track. North to south depressions moving from the east of the Mediterranean coasts cause light to moderate precipitation associated with cold fronts. The major track, as in the study, is the south to north depression. The synoptic comparison shows that the front, which caused the heavy precipitation on November 11^{th}, 1997, was oriented and formed locally over the center of the Arabian Peninsula. After developing and intensifying, the low pressure started move northward and its center, associated with a strong southeasterly flow, moved over Kuwait. A warm front caused almost continuous light rain started from 11:00 Am on November 10^{th}, 1997 to November 11^{th}, 1997.

The heavy precipitation which caused the flooding started when the cold front forming a squall line of a small microscale scattered heavy thunderstorm started to approach Jahra and Kuwait City at 14:00 local time, but the heaviest rainfall was between 16:00 to 18:00 local time. More than 100mm of rain accumulated in less than 3 hours and caused the flooding. In this case, from the synoptic situation the 1000 - 500 HPA thickness and the deep upper trough with cold air pool behind the cold surface front were the most important parameters, which indicated that *heavy precipitation* would occur. When a thickness ridge starts to increase as the front approaches, the forecaster in the weather center should consider warning heavy precipitation that will begin in the next 12 hours. The area which will receive the heavy precipitation is located between the thickness ridge and the down stream inflection point. In this case, we found that certain *synoptic characteristics distinguish the heavy* precipitation cases, as on November 11th, 1997.

The key parameter for the west to east oriented fronts with the low depressions forming over the Arabian Peninsula and moving south to north track was the 1000 - 500 HPA thickness ridge. A deep low pressure surface with a very humid southeasterly flow form convective cumulonimbus clouds, which will be present in the heavy precipitation cases. In this type of synoptic situation, the national weather service should issue a flash flood warning to inform the officials and the public to reduce casualties and damages.

In conclusion, strategies designed to minimize flood damage in Al-Jahra area include the building of concrete barriers around basin, and forming of paved roads. Other strategies are increasing the number of municipal sewage disposals with new designs, designing artificial channels for the flow to reach the desert or coastal areas, and increasing public awareness against future disasters.

A GIS PLANNING TOOL FOR STORMWATER BEST MANAGEMENT PRACTICES

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Abstract

Stormwater (rain and melt water runoff) is by tradition discharged directly to the recipients in open ditches and stormwater sewers, or transported together with sewage water to the wastewater treatment plants. None of these methods is acceptable in the sustainable society we try to build today. Stormwater runoff contains, e.g. nutrients (nitrogen and phosphorus), oil, persistent organic compounds and heavy metals such as zinc, lead and copper. These pollutants can cause ecotoxicological effects in the recipients. Another example of counteraction to sustainability is the contribution of metals from stormwater to the sludge in wastewater plants, a product that otherwise could be used as a fertiliser resource.

In order to improve recipient conditions, a planning tool in the form of a stormwater management plan has been developed. It employs a watershed system approach, i.e. the system boundary is natural not administrative. The management plan is developed in a GIS format with links to spreadsheet models (Excel) and databases (Access). This integrated tool may in a user friendly presentation form bring answers to the following questions:

- How are the different land uses (roads, houses, forests etc.) distributed and which areas contribute with fluxes to a specific discharge point or recipient?
- How large are the water flows generated in the sub watershed areas?
- How large are the pollutant concentrations (mg/l) in stormwater runoff from different land uses and in the discharge points to the recipients?
- What pollutant loadings (kg/year) can be expected to the recipient from each discharge point and where are the largest points of discharge located?
- Where are stormwater measures to be considered and which kind of measures are relevant due to site-specific conditions?
- What are the conditions of the recipients (nutrient and pollutant concentrations)?

The answers to these questions and the clearness provided by the GIS tool give a basis for decision making of which measures have the highest priority. The focus is on reducing pollutant loadings, but also flow compensation is considered.

A large amount of data about the watershed area is gathered in the databases of the GIS model, such as the area of each land use, precipitation data, land use specific runoff

coefficients and pollutant concentrations. The latter consist of standard values for each land use and calculated or measured concentrations in the discharge points. There is seldom a complete set of measured flow data. Complementary calculations of stormwater flows and material loadings to the recipients are carried out in the linked tables in Excel and/or Access, and with the use of this data. Both point loadings (by watercourses and sewers) and diffuse loadings (from the surrounding areas of the recipient) are estimated. There are also results from recipient sampling of lake water pollutant concentrations. There is a possibility to add new parameters or new areas. The information about the sub watershed areas and the recipients is presented in an interactive GIS map which presents discharge points, sewer systems and suggested and existing stormwater treatment facilities. The sizes of the points on the map are set in correlation to the size of the loadings. Different choices of presentation can be made from a designed menu (e.g. the choice of which pollutant to study). When pointing at a specific sub watershed area on the map presentation tables of flows, concentrations, loadings etc. are opened (Fig.1). These tables are interactive. By changing table values different scenarios can be simulated, e.g. changed land use results in changed loadings. These scenarios are visualised on the map as well as in the tables. The concentration values can be updated. Photos of existing facilities (or areas where such facilities are planned) and a digital report with descriptions of areas (Fig. 2) and facilities can also be accessed from menus and maps.

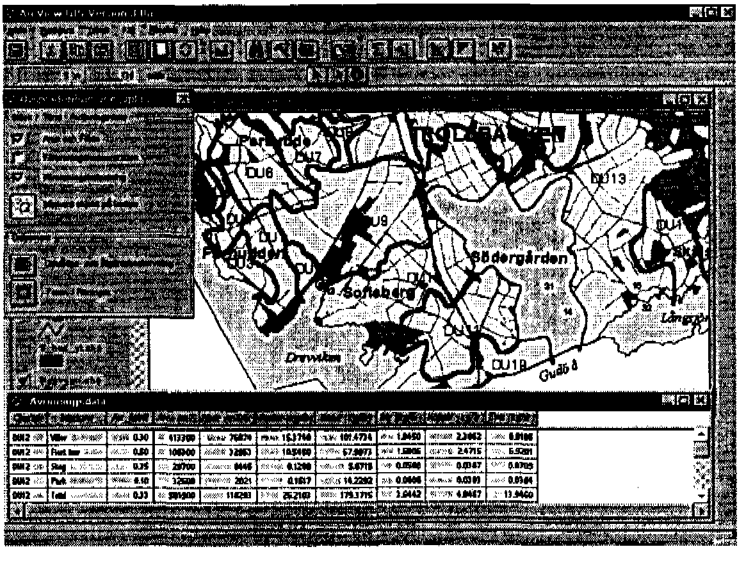

Figure 1. GIS map of Tyresö with menu (to the left) and table describing land use areas, runoff coefficients and loadings for the chosen area ("Södergården").

This stormwater management-planning tool has been implemented in two Swedish municipalities, Tyresö and Botkyrka, both outside Stockholm. To increase the flexibility and to make the model more user friendly, parts of the model has been presented in Internet (http://www.tyreso.se/kommun/forv/tekni/dagv/index.htm) and a geographical data viewer. The case studies showed that relatively high loadings of nutrients and pollutants are transported to the recipients with the stormwater and contribute to the eutrophication and reduced water quality in the recipients. With the use of the planning tool, the largest pollutant discharges in the municipalities were identified. This information, together with data on recipient conditions, gathered experience from the municipalities and in-situ studies, was needed for studying possible measures to be taken. The following measures were suggested for reducing the flow and pollutant pressure on the recipients: wet ponds, constructed wetlands, filter strips, open ditches, distribution ditches, oil separators, detention basins, floating basins at lake bays and local disposal of stormwater, e.g. infiltration facilities. As a complement to the mentioned measures, different kinds of lake restoration techniques such as sediment removal, the addition of oxygen to the bottom water or the addition of precipitation chemicals were mentioned, but only as a possible secondary step if the reduced external loadings should not prove to be enough.

Future developments of the GIS model are planned to, e.g. visualise the recipient status by implementing a classification system. Acceptable loadings and/or concentrations for discharge to the recipients are to be calculated and presented on the map. This may give indications of where limit discharge values are exceeded, i.e. where measures need to be implemented. A digital manual is to be included to simplify the use of the model and the addition of new data. Also, a tool for presenting the uncertainties of the model parameters is to be developed.

This kind of planning tool has many areas of application and by using a GIS environment the problems and solutions may be visualised as a basis for decision making. Furthermore, it provides the user with an overview picture and a better understanding of urban water management.

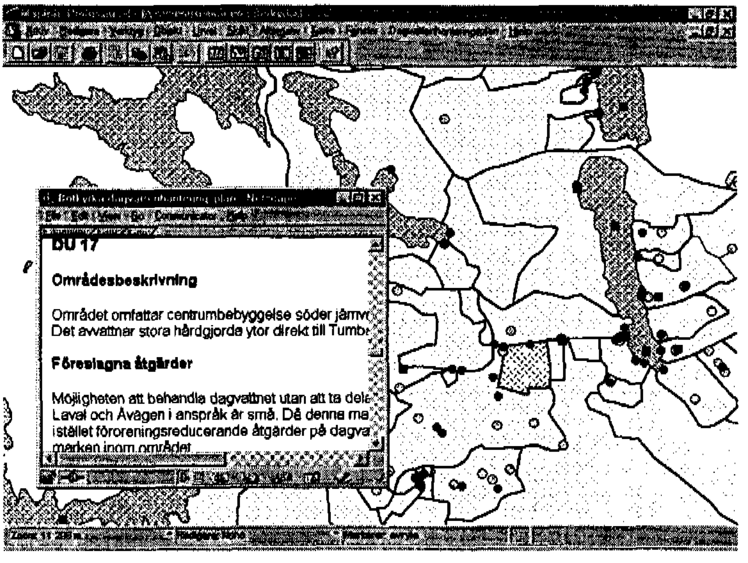

Figure 2. GIS map of watershed areas in Botkyrka. By clicking on a specific area web browser highlights a description of land uses and measures from the digital reports.

URBAN FLOOD CONTROL OF SMALL RIVERS IN TOKYO

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Introduction

Rapid urbanization has reduced the capacity to accommodate rainfall in the watershed area of small rivers in the inner Tokyo Metropolitan area. As a result, occurrences of urban flooding have become increasingly frequent and widespread. The Tokyo Metropolitan Government is presently involved in the completion of flood control facilities capable of managing rainfall of up to 50 mm/hr. However, widening rivers is extremely difficult due to difficulty involved in obtaining land adjacent to rivers. Therefore, the Tokyo Metropolitan Government decided to develop a system of underground rivers and large storage ponds to provide flood control and store water. This system is to be comprised of underground rivers constructed under arterial roads and regulated ponds located at appropriate sites along the underground rivers. These systems are expected to provide a high degree of flood control capable of handling rainfall of up to 100 mm/hr for in the 21st century.

Scope and methodology

Ten years after the end of World War Ⅱ, the Japanese economy had recovered from the damage of the war, and subsequent economic expansion continued at a rapid pace. As the economy developed, residential and commercial areas began to extend to the west of Tokyo. The urbanization of these areas resulted in the flooding problems discussed in the present paper. Changes in the runoff pattern due to the urbanization of land can generally be characterized by three factors: faster arrival time of flood runoff, magnification of peak discharge, and an increase in the total runoff volume. Urban areas are usually of great economic importance. Thus, the financial damage caused by flooding is much higher for urban areas. Changes in hydrological factors such as the effective rainfall intensity, flood arrival time, peak discharge flow, total runoff volume, and shape of the hydro-graph were evaluated in relation to changes in urbanization factors. Finally, a modified rational formula was developed that enables the time series of runoff discharge at any point in a river to be predicted to a reasonable degree of accuracy for engineering applications. The modified rational formula is characterized by following terms: hourly rainfall intensity, time of concentration, and coefficient of discharge expressed through an Urbanization Index which represents a weighted value involving the percentage of impermeable surface caused by changes in land utilization, river channel improvement and sewerage expansion. The modified rational formula enables the time series of runoff discharge to be predicted at a given point in a river when the time series of rainfall is given. The outflow discharge at any given point can be calculated if the water level at the downstream end of a river is known. The water volume stored in a reservoir can be estimated by determining the water level at key points along the inland drainage channels and sewerage system. The equation of continuity can then be used to predict the excess discharge that either floods over the dike and into inland areas or ponds, or is transferred to other drainage channels or rivers. This simple calculation method is based on a water budget. The water budget was calculated at various critical points in the river, and the program of flood control was established for three different stages of flooding: for rainfall intensities of 50 mm/hr, 75 mm/hr, and 100 mm/hr, reflecting tentative, future, and long-range goals, respectively. To complete the program, the following steps are planned. The tentative plan will be carried out through the improvement of current river channels and involves widening and deepening the river channels. The future plan consists of constructing underground rivers, handle the excess discharge, and a group of flood control ponds, to temporarily store the excess discharge. The fundamental plan reflecting long-range goals requires the construction of additional large flood storage ponds, increasing the permeability of the inland surface, and many small storage ponds at parks, undeveloped areas, and below public facilities.

Results and conclusions

The maximum total rainfall depth and the intensity of rainfall in Tokyo due to typhoon 6422 (Typhoon Kanogawa) on September, 1964 were 444.1 mm and 76.0 mm/hr, respectively. The design intensity of rainfall at that time was 25 mm/hr. As a result of inadequate control, no less than 203 persons were lost and wounded in the flood. Since then, the design intensity of rainfall has been improved to 50 mm/hr, and the improvement of rivers was planned and carried out by the Tokyo Metropolitan Government. However, the urban population of Tokyo is increasing, and as a result, the impermeable area has been expanded due to road pavement, and the volume of sewerage has been increased. In the future, the population of Tokyo is expected to increase. As a result, further improvements to river channels will be required. However, since Tokyo is limited in area and is densely populated, underground rivers and storage reservoirs have been planned and constructed as described in the present paper. Although several dams have been constructed, the construction is extremely difficult due to new environmental considerations. Underground rivers and storage reservoirs also provide a means for storing water. The conclusions are following:

(1) The characteristics of urban flood were clarified through long–term observations.

(2) The urbanization of watershed and changes in flood runoff were clarified through the investigation of impermeable areas, discharges, etc.

(3) The rational formula was modified according to long-term observation, and the modified rational formula was applied to calculations and flood control plans.

(4) A three-stage flood control plan was established for rainfall intensities of 50 mm/hr, 75 mm/hr, and 100 mm/hr for small rivers of Tokyo.

(5) Underground rivers and large storage reservoirs will provide adequate flood control as well as water storage.

Workshop 3

Interaction between urban and peri-urban water-related activities

ALTERNATIVE WATER MANAGEMENT APPROACHES TO ENSURE ENVIRONMENTALLY SOUND URBAN AND PERI-URBAN WATER-RELATED RELATIONSHIPS - CLOSING THE LINKS

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Abstract

Urban population growth, improvement of living standards, evolution of socio-economic conditions, development of industry and tourism, all these changes have increased pressure on the natural resources and water, in particular. Furthermore, they have led to withdrawal of water from the large catchment areas or aquifers, some of them non-renewable, and transfer of water over long distances, when rural population, on the other hand, may rely on local supplies. The actual demand is already outpacing available supply in several areas. Due to high population growth rates, this trend will become more pronounced in the future. Moreover, mobilisation of new water resources is technically more and more difficult and expensive. Withdrawal of water resources from water-short areas and transfer to cities may become less and less feasible in the future. New supplies to cities will require water resources reallocation, transfer over longer distances, or treatment of marginal water quality.

In the catchment areas, quality of surface and underground water resources are affected by different pollution sources. Industrial plants are usually set up without reference to any environmental concern. Most of them consume large quantities of water and generate different kinds of pollutants. Rural areas suffer from inadequate sanitation practices and systems which enhance diffuse pollution development, threatening several areas and vulnerable sites such as reservoirs. Not appropriate agricultural techniques are another source of diffuse pollution. All these conditions may impair the quality of water supplied to urban areas.

On the other hand, cities generate increased volumes of wastewater and solid wastes which require adequate treatment, reuse and discharge options to prevent health problems and environmental degradation. These liquid and solid substances produced by the city metabolism are often discharged untreated in the environment. They are causing major eutrophication threat to existing water sources. Uncontrolled and direct reuse of raw wastewater is often taking place in the vicinity of urban areas to irrigate vegetable crops sold in the urban markets. Such a practice is a major threat to public health.

At the same time, the rapid expansion of low and middle income urban areas, particularly in developing countries, due to migration from rural areas has resulted in a significant growth in informal settlement areas surrounding many major cities world-wide. Informal housing is taking place with the proliferation of scattered housing. Because of inadequate water quality and insufficient water quantity, on the one hand,

and lack of sanitation facilities or improper disposal, on the other hand, the population is exposed to water-borne and fecal diseases. Problems are exacerbated by solid wastes and stormwater drainage. In some regions, the quality of life does not meet acceptable health and social standards. This situation might create critical environmental, security and health problems. The sustainable supply of potable water and the disposal of waste (both liquid and solid) for these urban areas is now a real problem.

To face these challenges, a balanced combination of measures in the water catchment and in urban areas taking into account upstream-downstream relationships and links are needed. Macro and micro-scale approaches have to be combined. Solving problems at a small local scale require, for questions such as source control programs, the definition of national solutions. Water saving techniques and increased water use efficiency are required in all the activity sectors. Minimizing production and discharge of waste and recycling and reuse as much as possible and disposing the remainder in an environmentally sound manner will require changes in attitudes and consumption patterns. There is also a need to look for technological alternatives based on the principles of closing cycles. The end-of-pipe technology solved several problems in a first step such as elimination of water-borne diseases, eutrophication, etc, but problems need to be solved closer to the source of waste. How can we combine both end-of-pipe and source approaches? To achieve more local favorable solutions, several prerequisite conditions are required. More research should be carried out to define urban models in which material cycles are closed at affordable economic costs. Technological and non-technological solutions are required with the involvement of the communities. With urbanization growth and increased competition for natural resources and water in particular, there is a need for a holistic approach which integrates the different issues relating sustainable urban and peri-urban development and defining the best strategies and options.

In view of the above, this paper aims at suggesting alternative water management approaches to ensure environmentally sound urban and peri-urban water-related relationships.

THE ROLE OF INDIAN HYDROGEOLOGISTS IN PROVIDING DRINKING WATER FOR THE URBAN POOR

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Abstract: The influx of the rural population into urban areas in search of employment, has resulted in rapid and unplanned growth of peri-urban settlements and slums, which are not connected to the water supply network. Surface water sources are polluted and cannot be used for drinking. Ground water is also polluted due to seepage from septic tanks, peri-urban industrial effluents and irrigated farms. Hydrogeologists cannot exercise control over urban planning or the growth of slums. However, they can still help the urban poor and the slum dweller by locating proper sites for drinking water bore wells or dug wells, which would yield adequate quantity of drinking water of acceptable quality. Although the Paper is based on the Author's experience in India, the situation is similar in many developing countries.

1.0 Introduction

By the year 2015, about 50% of India's population would be living in cities and out of this, about 60% would be living in urban and peri-urban slums. Such rapid and unplanned urbanization brings with it the problems of water supply and sanitation, waste disposal, housing, traffic congestion, pollution of air, water and land, and unsafe social and cultural environment. These problems virtually bring the cities on the verge of 'sustainability', because the development policies have so far focussed only on the 'economic' growth without much regard to the urban environment, especially to the degradation of water quality.

As the quality of raw water deteriorates, water treatment becomes more and more expensive. There is no separate network for drinking water supply. The quality of 5 to 10 liters or so of drinking water per person per day is thus the same as the quality of about 100 liters of water supplied for non-potable use, in the same pipe line. The quality of drinking water, therefore, can only reach a standard that is manageable and affordable to the municipal authorities and acceptable to the citizens, who in turn are reluctant to pay higher water rates. The condition in the peri-urban slums, which are not connected to the urban water supply network, is even more deplorable. Here the slum dwellers use any type of surface water or ground water, even without knowing that it is polluted, as long as the colour, odour and taste of water is not offensive.

2.0 Urban Planning and Problems

The development plan of an urban area takes into consideration the required civic amenities for residential and industrial zones, such as the water supply, drainage, electricity, roads, schools, hospitals, parks, markets, open spaces, playgrounds, and cinema halls. Activities like acquisition of land for public purpose, reservation of land for specific use, restricting industrial growth in some areas, developing of new industrial zones, monitoring the quality of industrial effluent water, and putting a ceiling on the maximum holding of residential land per family, are initiated as a part of the urban planning process.

In practice, however, this idealized development planning scenario is marred by several factors such as, (a) the uncontrolled growth of urban population as a result of the exodus of job seekers from rural areas to urban and peri-urban areas; (b) lack of coordination between various departments involved; (c) lack of funds for providing the planned civic amenities; (d) low educational status of the majority of the elected representatives on the civic bodies and their inability to foresee and tackle civic problems; and most importantly (e) corruption at all levels. The greater the number of rules and regulations, the greater is the corruption.

As a result of this, the planned growth of cities becomes a distant dream. In real life, cities, especially the big cities are suffocating from polluted air, polluted surface water and ground water, crowded streets, packed buses and trains, traffic jams, and shrinking open spaces due to encroachments from urban and peri-urban slums.

3.0 Ground Water Resources and the Hydrogeologist

Groundwater in urban areas receives pollution from leakages in sewers, waste water and effluent lines, septic tanks, underground storage of chemicals and petroleum products, from leachates from solid waste depots and landfills, and from percolation from chemical spills, storm water drains and polluted water in rivers and streams. Industries, landfills, and dwellings with septic tanks, if located in the recharge area of the regional aquifer, often pollute the ground water flowing towards urban areas.

In order to minimize the effects of shallow percolation on bore well water in hard rock area, steel or PVC casing is provided for the first 6 m depth or upto 3 m below the top of hard rock, whichever is more. Bore wells are preferably located in the up-gradient direction from the nearby sources of pollution i.e. on a higher level than the slum areas.. Hydrogeologists working with the government departments, universities, consulting firms and NGOs , can help to solve the drinking water problem of slum dwellers or the urban poor, in the following ways:

(a) In slum area where ground water is likely to be available, bore well should be drilled with adequate length of casing pipe and a hand pump should be installed. The bore well should be about a hundred metres away from the slum area, in the up-gradient direction of ground water flow.

(b) In some cases, ground water is not likely to be available in adequate quantity, due to hard and massive nature of the underlying hard rock. Here, if there is a surface stream nearby, a dug well located in the sandy alluvium on the stream bank usually gives filtered water from the polluted surface water in the stream. The well can be regularly dosed with bleaching powder.

(c) In a few cases where ground water and surface water are both absent, the only feasible solution is to connect the municipal water line upto the slum area and provide a few public water taps. Funds, which are otherwise likely to get wasted on dry drilling or digging, can fruitfully be used, on the hydrogeologist's recommendation, for laying a pipeline.

4.0 Conclusions

(a) Geoscientists/ hydrogeologists have virtually no control over urban land use planning or the extensive growth of slums in urban and peri-urban areas. However, they should always submit technical opinions and reports when required by the planners, politicians and policy makers, hoping that some day the planning process would be modified, learning from earlier mistakes.

(b) At local level, they are certainly in a position to help the urban poor or slum dwellers by digging or drilling drinking water wells or bore wells for them at proper locations.

(c) For the long term benefits, hydrogeologists with the help of active NGOs, can educate slum dwellers about water and health; write articles in local newspapers on water pollution; and give lectures in schools about improving the urban environment.

(d)Although the paper is based on the experience in hard rock terrain in India, hydrogeologists from other developing countries may also have similar experience.

HEALTH EFFECT OF URBAN WASTEWATER REUSE IN AGRICULTURE IN A PERI-URBAN AREA OF MARRAKECH (MOROCCO)

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Introduction

The growing urbanisation in many areas of Morocco resulted in a significant increase of generated amounts of urban wastewater. Indeed, the volume of produced wastewater increased from 129 to 470 millions m^3 per year from 1970 to 1994 with an annual increase rate of 5.3%. In Marrakech water supplies are very scarce and this fact has encouraged many rural families to migrate and settle in peri-urban areas where urban wastewater is poured out. At present, raw wastewater is being used to irrigate about 3000 ha, and irrigated crops comprise trees, fodder and vegetables which are either consumed by farmer families or sold at the city markets. There is no doubt that application of urban wastewater on agricultural land has many benefits. Wastewater represents primarily a source of water and its nutrient content has been shown to have a fertiliser value for many crops and contribute to the improvement of the soil properties. However, the benefits of urban wastewater reuse may be limited by its potential health hazards associated essentially to the danger of transmission of pathogenic organisms to human beings. To date, a few epidemiological studies were conducted in the exposed peri-urban areas to evaluate the extent of the incurred risk.

An epidemiological study was carried out to determine the impact of the urban wastewater reuse in agriculture on the transmission of two protozoan infections, giardiasis and amoebiasis, to children in a peri-urban area of Marrakech. These two infections are pathogenic and recently giardiasis is being recognised as the most frequent protozoal infection and is becoming a major public health concern. An increase in the incidence of waterborne outbreaks of giardiasis is reported in many parts of the world. Yet the role sewage reuse has played in the transmission of these parasites is not established.

Scope

The paper presents results of an epidemiological study conducted on children of two peri-urban areas of Marrakech. A peri-urban area where urban raw wastewaters are poured out for more than 60 years and reused to irrigate about 3000 ha of many types of crops. In the second investigated peri-urban area fresh water is used in agriculture and it is considered as a control zone. An excess of protozoan infections (amoebiasis and giardiasis) was observed among children of the wastewater spreading area as compared to the control group. The prevalence of infection among the exposed group was higher in low aged children and in farmers children. It becomes therefore more evident that reuse of raw wastewater for agricultural purposes in peri-urban areas involves health risks for the human population.

Methodology

Our study was carried out on two children populations counting 608 individuals comprising males and females from 2 to 14 years old. The first population constitutes the exposed group (321 children), living in the wastewater spreading area of Marrakech, a peri-urban zone where urban wastewater is used for irrigation purposes. The second population is a control group, (287 children) issued from a peri–urban area with similar social living standards, in general, but surface water is used for irrigation (control zone). Data on individual exposure and on potential confounding factors (water supply, sanitation, hygiene etc...) were collected by suitable questionnaires developed and pretested prior to use. As a subject may not be declared non infected by a single stool examination because of the existence of negative phases in which no cyst is eliminated in faeces, the repetition of examinations was necessary. So, 3 samples were taken from each subject at one week intervals. A subject is considered non infected if the 3 examinations appeared negative. The study took place over an extended period (several months) working in all 2 exposure groups at the same rate. The collected stool samples were examined in the laboratory by direct microscopic examination and by microscopic examination after application of the formaline-ether concentration technique.

Results and conclusions

Results of this study showed that in the wastewater spreading area 67% of the investigated subjects were infected by *Giardia intestinalis* and/or *Entamoeba histolytica*, against 26% in the control zone. Giardiasis was observed in 39% and 20% in the exposed and control group, respectively. Amoebiasis was detected in the exposed group with a prevalence of 28% versus 6% in the control group. The Chi-square test showed that the differences observed between the exposed and control group are statistically significant ($p<0.001$).

To determine the most exposed children to parasitic infections in the wastewater spreading zone, infection rates were analysed according to sex and age. Males were infected with a level of 30% by *Entamoeba histolytica*, while 26% of females were infected. Giardiasis prevalences in males and females were 44% and 33%, respectively. Males seem to be more infected than females, but no significant difference was recorded ($p>0.05$). Among the children of the spreading area, we observed that the prevalence of the intestinal protozoa varied according to age. Giardiasis prevalence reached 47% among children of 2 to 8 years of age, versus 30% for 9 to 14 year old children. The difference is statistically significant ($p<0.001$). For amoebiasis, the respective prevalences in the two age groups were respectively 33% and 23% and there is no significant difference ($p>0.05$). Giardiasis was more frequent in children of 2 to 8 years old (46%) than those of 9 to 14 years of age (30%).

The findings of the conducted epidemiological study revealed a consistent excess prevalence of giardiasis and amoebiasis in children from the peri-urban area where urban wastewater is being used in irrigation as compared with children from a control zone using clean water for irrigation. Hence, the risk of infection rate attributable to urban wastewater reuse in agriculture is about 41% (19% for giardiasis and 22% for amoebiasis). Children of the peri-urban area receiving urban wastewater are therefore more exposed to detectable risk from parasitic protozoa than children of the control group. The recorded infections excess among children of the spreading area may be related to children activities which tend to expose them to direct contact with contamination sources (wastewater irrigation, field upkeep, harvest etc…), in addition to the role played by the consumption of contaminated agricultural products. Indeed, in the wastewater spreading area, there are fields cultivated with all kinds of vegetables (Marrow, turnip, radish, eggplant, squash...), and analysis undertaken on crop samples showed that they were contaminated by protozoan cysts.

Children of 2-8 years of age are more exposed to parasite infections because of their imprudence and non hygienic behaviour. During our visits to the wastewater spreading area we noted that younger children spend most of their time playing near irrigation canals and in irrigated fields without any precaution.

The present study has raised a situation in which urban wastewater reuse in agriculture is the main causative agent of the high protozoan infestation among the infantile population in a peri-urban area. On the other hand the uncontrolled reuse of raw wastewater in agriculture in this peri-urban area would be a real threat for urban population health as it provides the adjacent urban markets with contaminated agricultural products. The prevention of these risks can be achieved by an integrated set of measures which may include wastewater treatment, crop restriction, appropriate wastewater application techniques and human exposure control. This, would contribute to the improvement of the socio-economic and sanitary level of peri-urban populations and provide urban markets with agricultural products having a best hygienic quality.

WASTEWATER REUSE IN URBAN AGRICULTURE

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This paper describes three on-going projects funded by the *Cities Feeding Program* (CFP) of the International Development Research Centre. CFP supports applied research projects in urban agriculture (UA), to help address food-insecurity resulting from rapidly increasing urban populations in lesser developed countries (LDCs). When practiced sustainably, UA can help absorb liquid and solid wastes generated in a city. The three projects all analyze potential waste management solutions, for wastewater reuse in UA, appropriate to the local context.

Case-Studies in the West Bank

Two of the case-study projects are located in the West Bank.

The Occupied Territories are facing a grave water crisis. The current access of Palestinians to fresh water only barely meets current domestic, industrial, and agricultural demands. According to figures released by the Harvard Water Project, given current population growth and even a very low projected per capita consumption of 50 lpcd, by 2000, domestic demands alone will outstrip available access to supply. If any industry is to be developed, or agricultural output is to be maintained in Palestine, either must use recycled water. But currently only 20% of the West Bank is sewered. All rural communities and the peri-urban areas of larger cities rely on cesspits as on-site disposal systems. Cesspits are meant to retain grease and solids, and allow effluent to gradually infiltrate through the soil, which treats it. But most cesspits are overloaded which results in the soil around the tank becoming clogged with grease and suspended solids. The cesspit begins to operate like a closed tank, requiring frequent pump-out. Because pump-out can cost up to $USD 20/month, few Palestinians can afford it, so the system begins to overflow and raw sewage contaminates the soil and groundwater near the home. And even if the cesspit is pumped out, the sewage is usually dumped in the nearest wadi. So not only is the freshwater supply/capita declining due to population growth, but the remaining freshwater is under threat from uncontrolled raw wastewater discharges. Finally, food security is becoming a real problem for many Palestinians--agriculture is receiving a declining share of water, and incomes to buy food are increasingly lower due to job losses since the commencement of the *Intafada* and frequent West Bank-- Israeli border closures.

Greywater Treatment for Peri-Urban Horticulture, West Bank

This pilot-project will optimize the design of small-scale trickling filters for the treatment of greywater (all domestic wastewater discharged from the home including from the kitchen, bathroom, laundry etc, but not including wastes from the toilet). The individual home systems use local materials such as wadi gravel or wastes such as crushed plastic bottles as filter media and operate as sealed anaerobic upflow systems, to control odours and produce little sludge. The treated grey water from a properly operating system can be used safely for irrigating any products in home gardens, including raw vegetables. The project will not only reduce the amount of total waste (black and grey water) contaminating the sensitive aquifers in the West Bank, but by reusing wastewater, will help address the growing fresh water scarcity in the region. It will also help Palestinians, often affected by border closures, maintain a secure food supply.

Duckweed Treatment for Food and Fodder Production, West Bank

This project will pilot-test duckweed, a floating plant, to treat wastewater in an aquatic treatment system, in the West Bank. In the past five years, there has been growing recognition of the effectiveness of this tiny aquatic plant to treat wastewater in small, decentralized communities at much lower cost than mechanical treatment plants. Because duckweed is 40% protein by weight, and grows so quickly, it can serve as an excellent supplement to feed poultry, livestock, fish in aquaculture systems, and even as a component in salads for human consumption. An integrated system can both treat wastewater and provide income and employment opportunities for local residents who sell the produce raised on the duckweed. In addition to reducing BOD and TSS levels, duckweed efficiently reduces nitrogen and phosphorous levels in wastewater. But the operation of duckweed systems is still an art rather than a science, and while plants flourish in some locations, it is difficult even to grow the duckweed in other locations. This project will optimize various operating parameters for an integrated duckweed wastewater treatment system in the Middle East.

Case-Study in Senegal
Wastewater Treatment using Water Lettuce for Reuse in Market Gardens

The high urban growth rate in Senegal, currently five percent in Dakar, has stressed the municipal government's ability to provide services such as water supply and sanitation. Urban agriculture has spread in Dakar, in response to the growing demand for affordable food, and the scarcity of fresh water has meant that urban gardeners are increasingly irrigating their plots with raw wastewater. This practice poses a threat to public health -- in 1987, 400 residents became seriously ill during a typhoid epidemic in Dakar. An epidemiological study proved that the cause was the consumption of contaminated vegetables irrigated by insufficiently treated or raw wastewater.

This project is examining the technical and socioeconomic feasibility of using aquatic plants to treat wastewater in two peri-urban areas of Dakar, and reusing the wastewater in market gardens. It builds-upon a wastewater collection and treatment and community strengthening project organized by ENDA Tiers Monde in the communities of Castor and Rufisque. In addition to installing small-bore sewers and septic tanks, ENDA built two aquatic treatment systems, both employing *pistia stratiotes* (water lettuce). While the water lettuce did not grow in Rufisque, it is thriving in Castor, and the community is growing hot red peppers, corn, zucchini, okra, onions, and fruits such as bananas, apples, and papayas, which are sold on-site. Ornamental plants and trees are also sold. The integrated system appears to be working well. Community members, primarily women, trained by ENDA, finance, operate, and maintain the plant, and the fruit and vegetable plots.

However, no tests were conducted in the past to assess the efficiency of the treatment system, or the amount of pathogens, heavy metals, and other toxic compounds in the wastewater or the food grown in it. The institutional arrangements are not without their problems and many different crops are being grown experimentally. The project is evaluating the present system of wastewater treatment, institutional arrangements, and crop production, and seek to optimize each. The study will also identify other locations in Dakar where small-scale, low-cost aquatic treatment could be provided. It is hoped that the integrated system which protects the environment, conserves fresh water, boosts food production, and provides income and employment, can be introduced to peri-urban areas throughout Senegal, wherever appropriate, to meet the challenge of urbanization.

Conclusion

Rapid urbanization in lesser developed counties is stressing the ability of LDC cities to cope with the enormous quantities of wastes being produced, resulting in widespread contamination of land and water. In arid areas, wastewater will increasingly be the only water available to irrigate agriculture, necessary for food security in these regions. But it is clear that traditional, centralized mechanical sewage collection, treatment systems are inappropriate and unsustainable in most LDCs. Small, decentralized, waste treatment systems must be implemented, and the solutions will differ depending upon the local context.

In the West Bank, aquatic treatment plant systems, such as duckweed may be appropriate where land and secondary treatment is available, such as Jericho. In contrast, household-level, modular trickling filters are suitable in the hilly, decentralized terrain, surrounding Jerusalem. In Senegal, where land is more plentiful, small-bore sewerage and septic tanks, followed by water-lettuce treatment, may be most appropriate.

VALUES, MULTIPLE USES, AND COMPETING DEMANDS FOR WATER IN PERI-URBAN CONTEXTS

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Introduction

The fact that so many languages have an expression that "water is life" indicates the high value that this resource has in many societies. But water has many values: economic, social, religious, ecological, and political. There are also many different uses of water, including for agricultural and industrial production, human and animal consumption, physical and ritual washing, and ecosystem preservation. Each use has different values, depending on whose standpoint one takes, and what system of values is used.

As long as water was abundant relative to demands, this was not a problem. But as human populations have grown, along with per capita water consumption, competition and scarcity of water have emerged as major issues. Not only does each use take some water out, use also puts something into the water, causing water quality as well as quantity interactions between uses. This raises basic questions of how we value water across different uses and users.

Nowhere is this more apparent than in peri-urban areas, where demands for water for industrial and domestic use, and for disposal of wastes, have been increasing most rapidly. Initially, municipal water supply was treated as a technical issue of supply and waste disposal, often by a centralized authority. However, as water demands exceed the availability of water near urban centers, and as wastes created exceed the capacity of treatment plants, water shortages and quality problems have necessitated broader thinking and strategies to deal with the situation. Because many growing cities are located in basins where water supplies were already being used, especially in the peri-urban areas, increasing water supplies have often required transferring water from other users (including the environment). This, in turn, requires assessing the values of water in its different uses. This paper examines these different uses, based on a review and detailed study of multiple uses of water.

Water Uses and Values

"Drinking water" scores high on most types of valuation systems for water use. Economic studies that use willingness to pay for water show very high values for drinking water, even among the very poor. From a public health standpoint, sufficient clean water for the population has a very high payoff, and from a political standpoint, lack of sufficient clean water is often a touchpoint for unrest and dissatisfaction with the government. Even most religions reserve special status for drinking water. In Islamic societies, this may apply to animals as well as human drinking water.

Supplying "drinking water" to growing urban populations is often used as a rationale for expropriating water from other users to supply rapidly growing urban water demands. Many have even viewed the supply of potable water as the primary function of municipal supply systems. But a closer look at how water is used in municipal systems reveals that a low proportion goes to "drinking." Industrial, business and civic uses use a large proportion of municipal water. Even when we look at "domestic" water consumption, relatively little goes for drinking and cooking, except among the very poor (who often do not have access to municipal water connections). As incomes rise, so does per capita water consumption, with an increasing share of water going to lawns, swimming pools, and other types of consumption. Urban and peri-urban agriculture may also use significant amounts of water from municipal supply systems, either on small home gardens or commercial horticultural production adjoining the cities.

As cities and incomes rise, the demand for water for municpal systems has increased dramatically. Furthermore, because municipal systems generally aim to provide potable quality water, the growing pollution from industrial and sewage effluent around cities makes it increasingly difficult to meet the water demand (often phrased as "requirements") of cities from the rivers and aquifers around the cities. As a result, cities look further and further afield for their water sources.

When we go beyond drinking water, there is less consensus on which uses have the highest "value." Judging by economic measures such as willingness to pay, municipal and industrial uses often have the highest value, but when the impact of such water withdrawals and their effluents on ecosystems is taken into account, these uses may not be valued as highly. On the other hand, environmental uses that do not pay at all (free flow of rivers, and fish, wildlife, and ecosystem uses) may be held above economic values. The Public Trust Doctrine, found in most countries that with a heritage of Roman law, has been used in many contexts to protect environmental water uses and protect them from appropriation by other uses that are willing to pay more.

Where growing municipal water use cannot be met by tapping "undeveloped" or "unused" water, either because there is none available or further exploitation is blocked by environmental conservation concerns, water transfers are required--either from other basins or from other users, usually agriculture. The phenomenon of cities acquiring water from agriculture is found around the world, not only in major cities like Kathmandu, Ahmedabad, Madras, and Los Angeles, but also in smaller towns and urban centers. Water transfers may be private and ad hoc, with individual well owners pumping water into tankers to be sold in the city, or public and planned, with water districts taking water from irrigation systems through a variety of institutional means, with and without compensation to the irrigated farmers.

Transferring water from irrigation systems to municipal systems is often justified on the grounds that it is going to a "higher value use." In economic terms, irrigation systems are seen as consuming large volumes of water, and producing a relatively low value of output, especially when used for staple grains that have low and declining world prices. Even if all water in municipal systems is not assumed to be drinking water, the higher prices charged for municipal water is an indicator of the higher economic value of water in urban uses.

But this approach misses many of the uses and values of water in rural areas. Irrigation systems supply water for a range of productive and reproductive uses. For example, a recent study of Kirindi Oya irrigation system in Sri Lanka found water used not only for field crops, but also for permanent vegetation, garden horticulture, fishing, livestock, wildlife, and small enterprises (Bakker et al. 1999). Rural populations also face challenges in meeting their basic drinking water requirements, although these problems may not be as apparent or receive the same political attention as urban water demands. In Kirindi Oya, even where rural piped domestic water supply systems are available, quantities supplied are not usually enough for all domestic purposes, so people use irrigation systems for bathing, washing clothes, and even recreation. Although these uses may not consume much water and are often overlooked in water resource planning, the Kirindi Oya study shows that they can have high value for local people and their livelihoods.

At the same time, growing use of agrochemicals in irrigation systems can threaten other water uses, especially fishing, wildlife, and domestic use. Agricultural production can also be threatened by industrial effluents, either downstream of cities, in peri-urban areas, or through dispersed industrial production. Thus water quality issues are increasingly part of the valuation of water. Even discussions of water rights must now address water quality, as well as quantity aspects.

Where the opportunity arises to sell water to cities, either through formal channels such as water banks or through informal means such as pumping water to tankers to sell to urban consumers, many farmers and rural well owners have eagerly done so. Others, however, have argued that more is at stake than simple economic transactions; that water is not a regular commodity, but has a fundamental role in rural lifestyles and livelihoods. This is especially problematic where a few people participate in the decision-making and receive the benefits of water transfer, while the rest of the rural community loses out. Formal water rights for these other users may not be ascribed or recognized by the state, but interfering with them can cause protests.

Conclusion

For equitable and integrated water resource management, we need to go beyond simplistic notions to a disaggregation of the multiple uses and sources of water in urban, peri-urban, as well as rural areas. This is essential for identifying the hydrologic linkages between the sources of supply (and channels for waste disposal) of different uses and users. Recognizing the different strategies employed by different categories of people to meet their water and economic livelihood needs takes us beyond concepts of a uniform service group, to identifying differences among the various stakeholders. Instead of seeking to impose a single valuation "currency" for water, the objective can be to create processes for negotiation between different stakeholders, so that all can have input into the allocation and reallocation of water in peri-urban areas.

MANAGEMENT OF URBAN DRINKING WATER: STUDY OF INSTITUTIONAL RESPONSES TO WATER SCARCITY IN KATHMANDU

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Introduction

Providing domestic water to the expanding urban population of the developing world has emerged as a major challenge. In many urban regions the available services are poor and on the decline. Kathmandu, the capital of Nepal is a classic case where the level of service is highly deficient despite efforts made in creating domestic water supply infrastructure. The extent of the problem was evident in the city during the summer of 1999 when the capital experienced the driest season in recent decades and the residents faced immense hardships without drinking water. So bad was the situation that, irate housewives cornered the valve operator of the supply utility and slapped him for not opening valve in the sub-system that supplied water to their locality. In turn, the operator admitted that he had no knowledge that the particular locality did not receive any supply.

This simple incident is a manifestation of the institutional problems that ail the management of domestic water supply in the city and calls for in-depth non-conventional analysis of the problem. This paper makes an attempt to explore the kernel of the problem by studying institutional responses to the declining level of domestic water services in the capital. The analysis provides opportunities of looking at the problem from a variety of disciplines and possible alternative solutions.

The principal water source of Kathmandu valley is the rain-fed Bagmati River and its tributaries, which have low dry season discharge. Even during the monsoon, fluctuations are high. The floor of the valley has resulted in a geo-hydrological formation with deep aquifers with limited natural recharge characteristics. The occurrence of shallow groundwater is widespread, but its quality and quality fluctuates seasonally and varies by location.

Drinking Water Supply

Piped domestic water was introduced in Kathmandu as early as the 1880s, when the Bir Dhara system was built primarily to provide water to the Prime Minister's palace. It was also available to the ruling elite. The domestic water system introduced a new technology in a social milieu where traditional water management was the order. Water was one of the main elements of the early Lichhavi and Malla civilizations in the valley (500 AD). For its domestic water supply, the urban core had stone spouts *(dhungey dhara)* with an ingenious system of water filter and hydraulics which were locally managed.

With the advent of democratic polity in 1951, new lifestyles were disseminated more rapidly among the local inhabitants of the city. The capital became more accessible to other parts of the country when a number of highways that connected the valley to other parts of the country were completed. Improved accessibility was associated with concentration of administrative, commercial, industrial and educational activities in the valley. This, in turn, resulted in the mushrooming of settlements, garment and carpet factories and other manufacturing enterprises in the capital. To cope with the increasing municipal water needs new water systems were built.

In 1974 Nepal secured a loan from the World Bank to upgrade the municipal water system in the capital to provide safe and uninterrupted supply of water to the residents. Almost a decade later, the bank funded another initiative to tap the valley's deep groundwater aquifer. From virtually nothing, the contribution of groundwater to the city's domestic water supply had reached almost 60 percent of the total dry season supply by 1998. The groundwater extraction rate far surpasses the rate of natural recharge and thus the resource is mined from the aquifer lenses.

Despite these initiatives, the domestic water supply service is deficient both in terms of quality and quantity. Supply is intermittent, available on an average only for 3 hours in the morning and evening. Because of high losses from the transmission and distribution lines as well as wasteful use, only of 40-60 percent of the supply fed into the system is actually available for use. In several parts of the area served by the distribution system there is no supply for weeks or even months.

In the wake of deficient level of services in the urban core the state agencies have emphasized bringing more water supplies. This approach has continued ever since the first domestic water system was built more than a hundred years ago. Since the late 1980s, inter basin transfer has been recognized to be central in solving the problem of domestic water in the capital. Supported by bilateral and multilateral donors, the government of Nepal has proposed diversion of a portion of the Melamchi, which is a tributary of the Indrawati River, to the valley through a twenty-seven kilometers long tunnel.

Is the cause of deficient service solely lack of supply ? Simple analysis shows that it is not. In one day the supply systems that include the surface and ground water sources produce 107,000 m^3 of water, which is reduced to about 60,000 m^3 /day during the dry months. This quantum is supplied via 96058 service connections. Even in the dry season after accounting for systemic loss of 40 percent, 36,000 m^3 water/day would be available for distribution. The volume amounts to 374 liters of water per connection per day that could be made available. That this quantity is not available points to the fact that the problem of drinking water within the existing reticulation system of Kathmandu is not lack of supply *per se*.

Some of the possible causes of the deficiency in service could be: a) production volume lower than stated; b) higher loss; and c) a highly unbalanced distribution system. Several studies have pointed that the systemic loss would be much higher than stipulated 40 percent. The net result is that some sections of the distribution system receive better service while others do not. These are part of the managerial constraints that are at the root of the deficient quality of water supply which need to be overcome.

Study in Institutional Styles

The dominant responses to declining water supplies in Kathmandu has focused on bringing in more supplies through inter basin water transfer instead of innovations that allows allocation of water already appropriated. This is the option preferred by the state organizations and public utilities. The inter basin transfer option has technological and organizational inflexibility embedded in its design. It is highly capital intensive with a long lead time for implementation but is presented as the panacea to solve the capital's domestic water problems. There has been a tendency to disregard the fact that "management of the feasible" would generate water from within and begin improvements.

The failures of the state-led supply arrangements have forced the residents to resort to other options for water supply. Many residents in the city have connected centrifugal pumps in to the distribution main extracting water from the system, leading to overall reduction of pressure in the network. Those with land have installed hand pumps, rower pumps or dug open well as alternative sources. Private tanker water sellers are active, and use of bottled water use widespread. Hotels, industries, government offices and international agencies and commercial establishments in Kathmandu have installed deep tube-wells that tap into the valley's aquifer lowering the water level. People collect rainwater to cope with lack of drinking water even during the rainy season. Traditional stone waterspouts continue to be the source for many. Since many of the water sources are of uncertain quality, commercial establishments that offer water treatment services have emerged. The institutional response shows preference for flexible options of supply.

The third institutional response in Kathmandu is the critique of the deficient service by activists, media persons, and consumer groups. These critiques highlight the need to bring about systemic and institutional improvements to achieve a higher level of service. However, the questioning has been too infrequent, disorganized and feeble to receive enough attention, though they are recently beginning to be heard. The World Bank, which is the major actor in the Kathmandu domestic water scene had backed the inter basin transfer option of supply for more than a decade. It has changed its earlier position and is instead emphasizing improve-ment through private sector participation in managing the city's water and wastewater.

Our analysis shows how different social groups within the capital have perceived and responded to the problem of declining in domestic water quantity and quality. The analysis have categorized the response as occurring within three institutional groupings: (1) the state utility, (2) the market and (3) civil society institutions consisting of the activists, consumer groups, and media. By juxtaposing these responses the paper brings to the fore a reconceptualization of the institutional strategy and worldview as key to overcoming the challenges of urban water supplies. The analysis also highlights social, institutional and managerial constraints and that flexible options instead of a centralized hierarchic response can bring about improvements. The analysis is a starting point for instituting a more realistic approach of overcoming the challenges of domestic water supply management in urban regions. The emphasis placed in the past decades in new development or construction need to be shifted to "management of the feasible" in a context where civil society institutions creatively contest the terrain of water management and policy.

REVIVING TRADITIONAL WATER CONDUITS: ORGANIZATION OF WATER RESOURCES FOR AN URBAN ORDER

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Introduction

Over the last twenty years, population in Kathmandu has grown from *200,000* to over *600,000* just within the municipal area. By year 2017, estimates indicate the population of Kathmandu alone (excluding Bhaktapur and Patan cities) will exceed one million. As with most major towns and cities, demographic trends leading to increased urbanization have led to severe water scarcity and erratic supply for Kathmandu's urban community. Most city dwellers rely on surface and ground water through conventional water systems. The total quantity of the central water supply system, at present, is inadequate to meet the water demand in the city and its periphery.

Parallel to the existing sources, Kathmandu has an intricate and dynamic network of traditional water systems that date back to the Licchavi dynasty of the sixth century A.D. For centuries, the population of Kathmandu depended on the indigenously designed stone waterspouts known as *dhunge dhara* in Nepali and *hiti* in Newari to satisfy its water needs. Approximately 1000 stone water systems containing conduits, stone spouts, stone spigots, step wells, fountains and artificial ponds exist in the three cities of the Valley of Kathmandu. Today only 20% of the stone waterspouts are estimated to be functional. These, however, continue to serve 15% of the urban population, particularly the economically weaker sections. A number of factors have contributed to the decline of these important traditional systems.

While the causes for system decline are varied, the potential of these traditional systems to meet the increased water demand cannot be overlooked. As government agencies, bilateral and multilateral institutions explore appropriate solutions to meet the water demand, community initiatives to rehabilitate individual waterspouts demonstrate that this source can be an important complement to the central water supply system. Observation of renovated water systems in Patan and Bhakatapur reveal that use patterns and functions of waterspouts remain unaltered even in contemporary Kathmandu. In comparison to Patan and Bhakatapur, there has been very little effort in revitalizing and rehabilitating the stone waterspouts within the jurisdiction of Kathmandu municipality.

This paper focuses on the traditional stone waterspouts that fall within the municipal boundary of Kathmandu. The paper examines the chronology, elements and technology of the traditional spouts and investigates their potential to contribute to the sustainable provision of water supply within the urban area. After examining the causes and effects of the deterioration of the traditional system and the quality and quantity of water it supplies; the paper explores potential avenues for revitalization and rehabilitation of traditional stone spouts. The paper proposes that a coherent strategy be prepared to incorporate these systems as a complementary source for domestic water supply. The system can be used to create a clean and highly reliable source of water, improve the physical and visual environment, improve urban space in terms of cultural, social and aesthetic organization.

Based on observation of water use from spouts and interviews, three benefits that could be achieved by rehabilitation of the system are highlighted:

1. the utilization of traditional stone water spouts to provide complementary and in some cases alternative potable water supply in contemporary Kathmandu;
2. socio-cultural organization and historic-cultural preservation in light to urbanization and water use; and
3. the need to integrate traditional water conduit systems in the overall urban policy agenda and town plan for proper management.

If time-tested technology and strategies can provide water reuse and social stability and improve the quality of life in the urban area, it is suggested that the revitalization and rehabilitation of these water conduits contribute in resolving the dichotomy between the past and the present.

Water Scarcity and Traditional Water Organization

The traditional water conduit system consists of numerous stepwells and continuously supplies water through stone spouts that are intricately carved and adorned with stone statues representing different deities. Traditionally, this important water infrastructure was organized holistically in the overall town planning of the Valley and was ensembled symbolically in terms of space, time, community, and the scared realm. The systems functioned in organizing a cohesive urban order based on boundaries and hierarchies incorporating governance through divine, cultural, social and ecological synergy.

Population growth, immigration, dismantling of homogenous social structure and erosion of the traditional local trusts called "*guthi*" that managed the systems are the fundamental reasons for the degradation of the traditional systems. In addition, inadequate policies and non-compliance at the overall town planning and implementation process, vis-a-vis incorporation of these urban water structures have led to the neglect of water spout as a source of water supply. Ironically, faced with a situation of severe water shortage, the valley residents still rely on a few remaining functional stone spouts.

The systems also serve an important cultural purpose. The water spouts feature in civic functions and astral deities even to date and remain an inalienable component of every day life. Over the years, these traditional systems also functioned as important gathering and informal communication centers. Resthouses and sheltered public spaces in and around the water complexes served as convenient locations for social, religious and community events. Recently the Municipality of Kathmandu under the direction of the Mayor, has taken a keen interest in exploring rehabilitation and preservation opportunities of these systems.

The traditional water conduits are not dependent on the conventional systems and can provide a significant alternative water supply. Out of 103 water conduits surveyed by the Town Planning Commission of Kathmandu, 86 percent are semi-functional (with either one or two spouts dry) with an average volume of 12.4 liters of discharge per minute. However, blockage of outlet drainage pipes and stagnant water is visible in almost all the systems. The remaining sources are dry primarily due to declines in ground water levels. Microbiological analysis demonstrate that fecal coliform is prevalent in most. Despite these problems, our survey indicates that the water from the stone spouts serve multiple uses. In addition to domestic consumption, water from this source is used for ritual bathing, hygienic, commercial, industrial and irrigation purposes.

One of the main challenges facing rehabilitation of the traditional conduit system has to do with the multitude of organizations involved and their differing mandates and objectives. Currently, the Department of Archeology is responsible for the rehabilitation of the systems only to the extent of heritage preservation. The municipality has yet to accept responsibility for the management of these conduits claiming lack of access to resources. The Drinking Water Supply Board visualize the water conduit structure as a monument pertaining to the past. The Town Planning Commission under the municipality is optimistic to take a proactive role with the pending approval of the long waited local governance act. The necessity of strengthening of municipal administration in terms of authority and resource mobilization is evident. Lack of clarity and contested institutional authority at the policy and management level has led to derailing of goodwill efforts.

Conclusion

Traditional water supply facilities were once central to the cultural life of the region and remain a key part of its architectural heritage. The water conduits were traditional vehicles of various cultural and social institutions. Embracing the notion that water is needed 24 hours a day, a lot of resources are required to the ever-burgeoning population. The traditional water systems were designed to provide water 24 hours a day, with the water flowing continuously from the spouts. The constant flow also assisted in recharge of ground water. Furthermore, the systems brought the community together in a benign way. They were a meeting place for men and women and functioned as a communication and dissemination center where through interaction, joys and sorrows of everyday life were shared, problems were resolved and relationships were strengthened.

Given the current neglected condition, unhealthy environment, polluted ground and surfaces, many of the degraded systems are likely to contribute to the spread of disease, rather than serve as an alternate or even complementary source of clean water supply. At the macro-level, inclusion of these systems in the overall urban planning and development seems imperative. The water conduits constitute an outstanding feature of the urban Kathmandu. Rehabilitation, revitalization, and protection of these systems could be used not only to create a clean and highly reliable source of water, but also effectively utilize the urban space in terms of cultural, symbolic, and aesthetic organization. Such rehabilitated infrastructure could serve as an epicenter for bringing communities together to work around a common productive theme. Revitalizing the larger urban environment in which people reside is expected to positively impact their economic security, both for users of the traditional water conduits and also to those who depend on tourism.

WATER IN THE TRANSITION ZONE: ETHICS, ENVIRONMENT AND LIVELIHOOD ISSUES IN PERI-URBAN WATER MANAGEMENT. INSIGHTS FROM YEMEN, INDIA AND THE U.S.

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Introduction

Tensions over water management are increasingly evident in peri-urban areas due to the multiple roles water plays as a critical resource supporting environmental, domestic use and economic systems. As the National Research Council (1997) has documented, valuations for groundwater established through market mechanisms tend to reflect extractive not in situ values. In the case with surface water, values such as instream flows, food security, or cultural systems that depend, for example, on the structure of rural agricultural economies, tend to be poorly reflected in the market price for water in different uses, resulting in tensions. Tensions also emerge due to deeply held ethical positions regarding the role of private and public rights in water. Prophet Mohamed's saying that: "People are Partners in three (things): fire, water and grass" emphasizes the common nature of water rights and has been interpreted by some Islamic scholars as forbidding water sale whether for drinking or other uses (Al-Eryani 1995). Similar sentiments also underlie elements of common law in the West. The Public Trust Doctrine, for example, is derived from the Institutes of Justinian which states: "By the law of nature these things are common to mankind--the air, running water, the sea and consequently the shores of the sea." (Institutes of Justinian, 2.1.1). Public Trust often conflicts with equally deeply established traditions involving private water rights.

This paper examines points of tension over water use in peri-urban areas near Ta'iz and Sana'a in Yemen and compares them to similar situations in the San Luis Valley (USA) and Gujarat (India). It focuses on existing water markets and water marketing proposals as mechanisms to transfer water between agricultural and urban uses. Details of water markets are presented along with consequences of transfer activities for environmental, economic and community systems in the areas of origin. Key gaps in our understanding of transfer impacts on these interconnected systems are identified. Particular emphasis is given to: (1) the limits of scientific understanding of hydrologic systems; (2) limited understanding of environmental services; and (3) social, cultural and environmental values that are poorly reflected in market transactions. Insights are then related back to some of the underlying ethical issues that influence how different societies view communal and individual rights in water and the checks and balances on water transfers associated with different mechanisms under conditions of uncertainty.

Urban Water Transfers in Yemen

The cities of Sana'a and Ta'iz in Yemen have grown rapidly over recent decades. In both cases, the water resources available locally are extremely limited. Groundwater in shallow aquifers under Sana'a was identified several decades ago and at that time was estimated to be sufficient to meet urban needs for at least a century. Expansion of agricultural production in the Sana'a basin combined with burgeoning urban use has, however, resulted in rapid depletion. Now supplies are estimated to be sufficient for only a few more years of use. Similarly, in Ta'iz, urban water supply projects designed to tap the sub-flow in wadi-bed aquifers were originally thought to be sufficient to meet urban needs with little impact on rural residents. These aquifers are, however, now dry in lower portions of the wadi beds and rural agricultural activities dependent on them have declined dramatically.

Due to depletion of aquifers, tensions are high between rural residents and urban water supply authorities in the areas surrounding both Ta'iz and Sana'a. In contrast to tensions over official supply systems, however, informal but widely accepted water markets have spontaneously emerged as a major mechanism for urban residents to meet their domestic supply needs as the reliability of municipal water utilities declines. These water markets consist of rural farmers in peri-urban areas with transportation access selling water to transporters (tanker owners) who then either wholesale or retail the water to urban residents. Water markets of this type are wide-spread and often highly structured with different prices for different qualities of water and levels of service. Unlike water transfers through formal municipal supply systems, they are viewed as a profitable, popular and legitimate use of water by well owners in rural areas. They are also viewed as a reasonable, if in many cases expensive, mechanism for supply by many urban customers. From a governmental and, in some cases, wider social perspective, however, major questions exist regarding the water markets.

In Yemen, some Islamic scholars have interpreted Prophet Mohamed's saying that: *"People are Partners in three (things): fire, water and grass"* as emphasizing the common nature of water rights and forbidding water sale whether for drinking or other uses (Al-Eryani 1995). This prohibition makes formal recognition of water markets by the government potentially sensitive. It also strikes a deep chord in many rural and urban communities. Informal water markets may be accepted but formalizing them touches questions of rights and other deeply held values. In addition, in rural areas well owners are the primary ones to benefit from water markets. Other rural residents, particularly those whose livelihoods depend on agricultural labor, benefit little from water transfers to urban areas whether via the market or other mechanisms. This represents a large group of people whose livelihoods may be displaced if markets expand or are formalized. Overall, the emergence of water markets and increasing pressure to transform them into formal mechanisms for water allocation is raising basic questions regarding the nature of rights to "common heritage" resources such as water and the distribution of benefits and costs as those resources are reallocated to meet the needs of a changing world.

Water Transfers in India and the United States

The situation in Yemen is paralleled by similar debates over water transfers in Gujarat (India) and the San Luis Valley (Western United States). The deep alluvial aquifers of central Gujarat are heavily overdrafted. Water supplies for the major urban center of Ahmedabad have traditionally been drawn from the Sabarmati river and underlying aquifers. With water available in aquifers declining in both quantity and quality terms, Ahmedabad's growing demand is increasingly focused on the Sabarmati and on newly imported supplies from the Sardar Sarovar (Narmada) project. Both these sources of supply are being increased largely at the expense of rural populations. Increased supply through the Sabarmati is being drawn from Darhoi Dam, an irrigation project. As a result, irrigation deliveries are increasingly unreliable and the overall supply available to the rural population has declined. In the Sardar Sarovar case, development of the project is displacing large populations in both the dam submergence area and through canal construction. Environmental concerns with the project are also wide-spread.

In the San Luis valley case, major transfers have yet to occur but debates over proposed transfers north to the Denver metropolitan area and south to cities along the Rio Grande are intense. The SLV represents a remarkable example of environmentally compatible economic and cultural systems. In the SLV, irrigation return flows and associated groundwater recharge sustain a distributed network of seasonally flooded wetlands and priority natural heritage sites that are among the best in the inter-mountain west. These sites depend on patterns of water allocation. As one review concluded: "protection of the unique hydrological regime of the Valley and the maintenance of the water table will be necessary to conserve both riparian and terrestrial sites and habitats." The hydrologic regime is also central to agriculture and to the economic foundations of communities in the Valley. According to the National Research Council (NRC), irrigated agriculture: "is the basis of a traditional way of life for ethnic communities that are proud of their histories and have a high level of interest in maintaining their historic way of life despite pressures for change." Unregulated water transfers would have a major impact on both the environment and communities in the SLV. At the same time, such transfers are increasingly likely to occur. As economic conditions fluctuate, farmers are selling their water rights and, once investors have accumulated sufficient holdings there is little to stop the sale of water from the region to urban areas within Colorado.

Conclusions

All three situations outlined above involve a complex mix of technical, legal and ethical questions. On the technical level, hydrologic systems are poorly understood. As a result, the effects of transfers on water availability and environmental values in the areas of origin is often only clear in hind-sight. Determining impacts in advance is difficult, even in the "data rich" environment of the western U.S. On a legal level, debates over transfers often pit individual water use rights (whether formally recognized or traditionally accepted) against legal structures designed to protect certain sets of larger social values. In the Yemen case, these legal issues rest on Sharia'a doctrine, in the U.S. they stem from the Public Trust Doctrine and specific legislation (such as the Endangered Species and Clean Water Acts), and in India they are rooted in constitutional provisions. None of these higher level institutional frameworks comprehensively addresses the underlying ethical tensions that emerge in the case of most water transfers. These tensions have to do with the nature of private rights in resources, such as water, that represent a common heritage rather than a resource created by the individual owner. They also have to do with the dispersed and difficult to mediate impacts of water transfers on cultural, economic and environmental systems in areas of origin.

Workshop 3

Posters

WASTEWATER REUSE - THE AUSTRALIAN EXPERIENCE

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Introduction

Australia has one of the longest and most beautiful coastlines of any nation, and, Australians have an ever increasing dependence it's coastal and marine environments. Our coastal zone supports 86% of the population and much of the country's commercial and industrial activity. Australia's marine related industries such as shipping, recreational and commercial fishing, offshore petroleum and tourism are worth around $30 billion a year. The beach is a national icon and a centre for our outdoor activities, attracting millions of people each summer. However with use, comes abuse, and each year thousands of tonnes of inadequately treated sewage effluent and stormwater are discharged into estuarine and coastal waters.

Coasts and Clean Seas is an initiative under the Australian Federal Government's "Natural Heritage Trust" a $1.25 billion injection of funds for environmental projects over 5 years, initially set to finish on 1 June 2001. The goal of *Coasts and Clean Seas* is to promote partnerships between all spheres of government, industry and the community to contribute to the "protection of coastal, marine and estuarine quality". A primary focus of *Coasts and Clean Seas* is to provide financial support for projects dealing with the sustainable disposal of wastewater previously entering estuarine, coastal or marine environments.

In Tasmania, Australia's only island state, the economic importance of satisfactory water quality is paramount as the state relies heavily on tourism and primary production such as aquaculture to support its economy. The Derwent Estuary is an important recreational and scenic resource, heavily used for boating and fishing, as well as supporting the state's third largest port and several large metal and wood processing industries. It is internationally known as the finishing venue for the annual Sydney - to - Hobart Yacht Race.

Scope

The poster presentation will highlight the achievements of the *Coasts and Clean Seas* program to date by focusing on the Tasmanian experience of the program and in particular the outcomes of a project entitled "Derwent Estuary Ecological Improvements through Brighton Wastewater Reuse".

Brighton is a rural-residential municipality to the north of Hobart, in the middle to upper reaches of the Derwent Estuary, one of the largest in Tasmania. The Derwent catchment covers approximately 20% of Tasmania's land mass and supports over 40% of the state's population. The Sewage Treatment Plants at Brighton treat 2 - 3 megalitres/ day. In the past this effluent was discharged directly into the Jordan River just above its confluence with the Derwent. The *Coasts and Clean Seas* project represents the final stage of an upgrade which will result in zero effluent discharged into receiving waters. Instead, the effluent will be used to irrigate crops in areas previously dependant on limited town water supplies and for fertilisation in growing areas that rely on Australia's notoriously nutrient poor soils.

Methodology

Brighton Council operates two treatment plants to treat domestic sewage from the homes of its 12,000 residents. One is an activated sludge plant with chlorinated disinfection of effluent; the other is a lagoon system, with aerated and mulching lagoons. Assisted by *Coasts and Clean Seas* funding, the Council has established a 15 hectare tree farm with radiata pine seedlings, and irrigate them using treated sewage effluent. The trees are expected to grow at more than twice the rate of unirrigated trees, enabling thinning after 7 years and 15 years, and full commercial harvest after only 20 years. At current prices, harvest will yield timber worth close to $A 0.5 million.

Coasts and Clean Seas grants have also funded Brighton Council's construction of four pumping stations and an associated 17.5 km of pipeline with the capability of irrigating 400 hectares per year of cropland. Crops already thriving on the newly-productive land include fodder crops, crops yielding essential oils and poppies harvested for pharmaceutical extracts.

Results and Conclusions

In an acknowledgment of the negative impacts humans have made on Australia's coastline in the past and the need to develop a system of sustainable usage of our coastal resources for present and future generations, *Coasts and Clean Seas* has been running throughout Australia for the last 3 years.

To date, over $29.7 million has been spent on 93 *Coasts and Clean Seas* projects across Australia to improve coastal and estuarine water quality through the upgrading of sewage treatment facilities and the reuse of effluent. Projects have turned what was once an environmental threat into an economic advantage, with benefits for all Australians. Effluent, instead of ending up in our oceans, is now considered an asset, irrigating commercial crops and reducing demand on scarce potable water resources.

Since Hobart was established in 1803, the Derwent estuary has received the majority of the city's urban and industrial wastewater, much of it untreated or poorly treated until the 1980's/ 1990's. Despite existing degradation from these uses, it is still an important and productive ecosystem. The Derwent River and its tributaries are also an important source of municipal and industrial water supplies.

Water quality in the Derwent Estuary has improved markedly with regard to nutrients and faecal indicator bacteria as a result of the reuse of effluent previously discharged to the estuary. Brighton municipality, through the *Coasts and Clean Seas* project "Derwent Estuary Ecological Improvements through Brighton Wastewater Reuse" will achieve zero effluent discharges to all receiving waters by the year 2000 and be able to provide local farmers with a reliable, good quality irrigation water supply for agricultural and horticultural production expansion.

LIMITS OF REUSE: SALINIZATION OF SOILS AND GROUNDWATER AS CONSEQUENCES OF INTENSIVE REUSE FOR IRRIGATION

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ABSTRACT

The complete utilization of the country's (Israel) water potential (safe yield) 1800 MCMY (millions cu.m. per year) combined with wide and intensive reuse of most wastewaters 300 MCMY, reduced to minimum water outflows to the sea (see Figs. 1 and 2).

Irrigation is a "consumptive" type of water use: most of the water being "lost" by evapotraspiration, leaving the mineral salinity in soil solution and in the excess (residual) water seeping - penetrating to underlying unsaturated layers on its way to groundwater. Thus the complete use and reuse of water brings about a high rate of salt accumulation in soils, in the unsaturated zones, and eventually in groundwater. It poses a serious risk of salinization of the country's lands and aquifers.

Salinity of a city's wastewater is much higher compared with the water supplied to that city. In Israel the TDS (total dissolved salts) increment in municipal use, amounts to 500 grams per cu.m. (500 mg/l), most of it is sodium salts, the chloride increment being 150 g/cu.m. (mg/l).

Annual mass increment in TDS in municipal use countrywide amounts to 150 thousands tons. The total mass of TDS in municipal wastewater (original TDS in supplied water plus the increment in municipal use) amounts to 360 thousands tons annually, 100 thousands of them are chloride salts. Disposal of this wastewater, after appropriate treatment, to the sea directly or via streams (creeks, rivers) - as practiced in water rich countries - would purge the 360 thousands tons of salts from the system (Figs. 1 and 2).

The total accumulation of mineral salts (TDS) due to fresh water use and reclaimed wastewater use amounts to 700 thousands tons per year, including 230 thousands tons of chlorides (Fig. 3). Most of this cover the coastal aquifer and adjacent valleys - a small region (150 km x 30 km) in a small country.

Effects of salinization of soil and water are felt on time scale of tens of years. In several regions in Israel, salinization of soil has already been encountered and there is a permanent increase in water salinity at the coastal aquifer (Fig. 4). Reports of many studies indicate significant salinity increase in the unsaturated zones and at upper interface layers of the groundwater table. Also, accumulation (fixation) of specific heavy metals can be seen in soils irrigated with reclaimed wastewater. Though negative effects of heavy metals have not been felt up to now, the rate of accumulation predicts such effects in 10 to 30 years of continuing practices of such irrigation. The accumulation of salinity in general, combined with the accumulation of the specific elements, can be defined as a chemodesertification process.

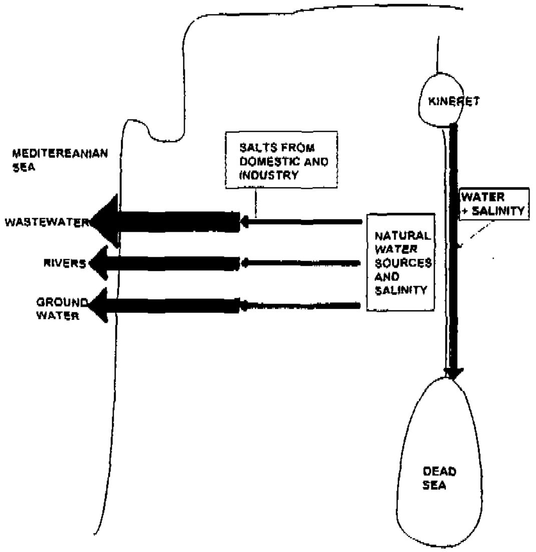
The means to minimize the above irreversible damage could include:

- Redirection of part of the reclaimed wastewater (up to 100 MCMY) for industrial use, replacing fresh water of low salinity to make it available for irrigation. The water after its industrial use, with an even higher salinity, could be easily disposed as a point source to the Mediterranean or Dead Seas which are in proximity to most large industries.

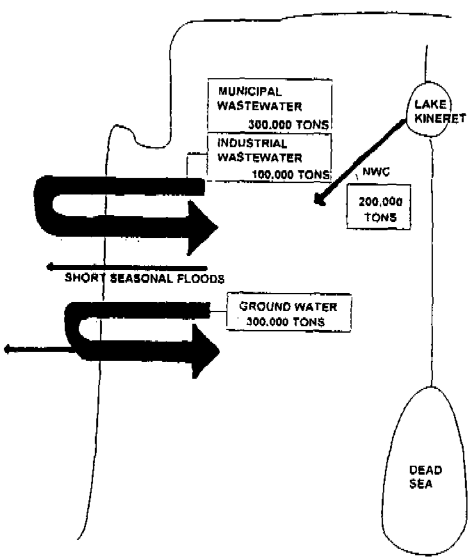
- Strict control of industrial saline (brine) discharges into municipal sewer systems.

- However, the most effective, and eventually necessary, steps will be to include partial desalination processes in the use-reuse schemes. Membrane processes for such waters (salinities much, much lower then sea or brackish waters) are expected to be feasible for future intensive "high-tech" agriculture, and for prevention of chemodesertification. The reduction of the high rate of in-land salt accumulation should be of high priority (even before sea water desalination) to prevent the deterioration of land and groundwater resources.

SCHEMATICS OF INPUT AND OUTFLOWS OF WATER AND SALTS TO THE SEA BEFORE OVERUSE OF FRESHWATER AND REUSE OF WASTEWATER



SCHEMATICS OF WATER AND WASTEWATER USE AND CLOSURE OF FLOWS TO SEA. SALINITY CONTRIBUTION IN TONS PER YEAR



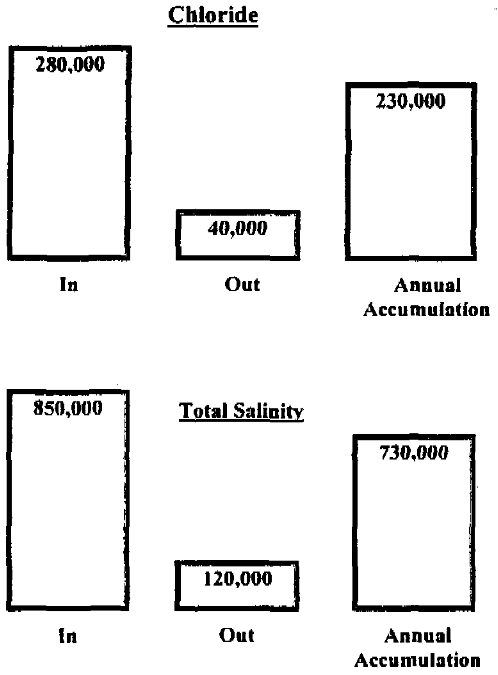
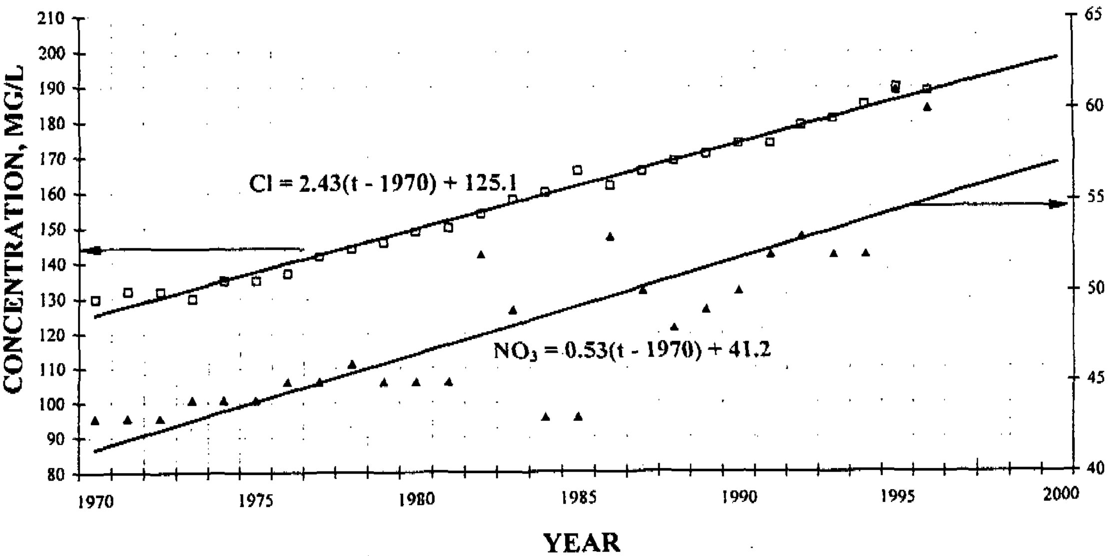


Fig. 4 RATE OF INCREASE OF CHLORIDES AND NITRATES (COASTAL AQUIFER)



WATER HARVESTING MANAGEMENT IN LARASTAN, IRAN

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Abstract

Larastan is located in Fars province in southern part of Iran with arid climate. The average precipitation in the area is around 200 millimeters which falls during late fall and winter times. The uneven spatial and temporal distribution of precipitation, high rate of evaporation, arid and semi-arid climate, evaporative geological formations such as gypsum and salt domes are the main reasons that made it impossible to maintain the surface and ground water supplies for the communities living there. Traditionally the people in this area used a system of water harvesting which called "*abanbar*", that Iranians have used for centuries. The main objective of this paper is to investigate the know-, how of this system, which works as a means of city water supply for centuries. Architectural, structural, geotechnical, hydrological, and hydraulic aspects of this system of water harvesting are discussed.

Introduction

The rate of water resource use in an area depends on the climatic conditions and the level of knowledge and technology in that area. For example, in some places one can lift groundwater by digging wells and Qanats. In other places, water is supplied from surface waters such as rivers and streams. But in some arid areas like Iran, about two-third of the country has an arid or semi-arid climate with insufficient rainfall to provide surface runoff. In the absence of enough precipitation, the level of water table is also so deep that it is not economical and feasible to obtain water by digging wells and Qanats. The quality of groundwater due to evaporative geological formations is not suitable for drinking, either. The only option left which is capable of supplying water for the community is a water harvesting system called "*abanbar*". *Abanbar* is a structure that can store the surface runoff resulting from precipitation. Unfortunately, population growth, increased water demand, problems associated with modern technology, and sanitation problems have caused *Abanbar* to deteriorate over the last several decades. It is unfortunate that these systems of water harvesting are going to be forgotten because they are not considered as effective as they used to. In this paper, in addition to a description of *Abanbars*, efforts will be made to have a more careful look at the system and its problems. Approaches will also be introduced for the solution of the existing problems with respect to *Abanbars*. In other words, the objective will be to find a way to integrate these systems into modern technologies to save the most effective means of water harvesting in desert areas. [1,2,11] The geographical distribution of *Abanbars*, are mostly in areas near the Persian Gulf, i.e. Fars and Hormozgan provinces, and in desert areas mostly in Yazd, Kashan, and Semnan. The main reasons for the construction and use of *Abanbars* can be summarized as follows:

-Shortage of water and the ensuing problems;

- Underground water resources with undesirable quality and the need to provide water with a better quality;

- Lack of surface water due to high temperature and hot climate and high rate of evaporation;
- Many limitations in water transmission, such as poor economy in the face of the necessity for having a cheap system of water harvesting;
- Use of *Abanbar* as a system for improved water quality. [3,9]

Abanbars can be categorized in three groups with regards to their applications (a) agricultural-desert *Abanbars*, (b) Urban- rural *Abanbars*, and (c) Road *Abanbars*.

Design Criteria

The main parameters to be considered in the design of *Abanbars* are as follows:

1) Population studies. Usually the volume and the number of *Abanbars* are evaluated from the population to be served, which is estimated for a design period. The per capita per day water consumption can be calculated using the statistical studies and other factors? which are discussed later.
2) Climatic conditions and the rate of precipitation.
3) Hydrologic and hydraulic design criteria.

In order to perform the hydraulic design of *abanbars*, the hydrologic design factors should initially be defined. These factors are as follows:

- Duration of rainfall
- Intensity of rainfall
- Average annual temperatures and the rate of evaporation and transpiration.
- The area of the rainwater catchment (of the *abanbar*)
- Drainage area of the rainwater catchment.
- Atmospheric humidity content. [4,5,8]

An *abanbar* is made up of a reservoir, a faucet (outlet), stairs, vent, doorway, decorative parts, related structures around the *Abanbar*, canals for collection and conveyance of rainwater to the *abanbar*, and settling chambers.

Environmental aspects

Environmental problems related to *abanbars* are considered from different viewpoint [9.4]:

- Public health,
- Physical pollution's [thermal, noise and radiation],
- Chemical pollution's [pH, gases, dissolved solids, different elements],
- Biological pollution's [bacteria, viruses, parasites, protozoa], and
- Aesthetic problems [odor, taste, color, turbidity,]

Social aspects

In Iran, the *abanbar* is an effective means of rainwater harvesting. This system of harvesting socially has the following advantages:

- Providing a cheap and easy system to meet the water demand of society,
- Decreasing the rate of immigration from the area,
- Creating positive effects on human psychology and physiology,
- Strengthening friendly relationships and group solidarity among consumers.

Economic aspects

Abanbars also play an important role in the sustainable development of the economy of the area. The water that is obtained from the desert-agricultural *abanbars* can be used to irrigate plants, providing a more promising agricultural market. This matter, besides the direct profits, has a great deal of indirect economic advantages.

On the other hand, providing potable water for the community decreases the price of water. This system of water collection is much cheaper than other expensive systems such as dams and deep wells.

Religious-political aspects

As previously mentioned, construction of mosques and other public gathering places around the *abanbars* have constructive effects on the morality of the communities.

Cultural aspects

Everything has its own specifications and these specifications are the criteria for the building of a social culture. *Abanbars* as a vital necessity nourish a culture of their own and it is obvious that, this culture will leave its own impression on the socio-cultural behavior of the people.

Concluding remarks

Abanbars are the most effective way of rainwater harvesting in some places in Iran, especially in places with very low amount of precipitation, lack of stream and river flow and lack of suitable groundwater resources. The social, cultural and economic feasibility of these systems has proved their usefulness during the past several decades. The only disadvantage with these systems is the hygiene problems associated with its use. Integrating this system of water collection into modern technologies will optimize its proper use. This integration is the one way to save *abanbar* systems as a sustainable water resource development

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Workshop 4

Water and social stability

A) Stable situations
B) Unstable situations

A) Stable situations

WATER AS AN INSTRUMENT FOR SOCIAL DEVELOPMENT IN SOUTH AFRICA

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Introduction

South Africa held its first democratic elections in 1994, emerging from a long history of colonial domination and racial segregation, which reached its culmination in the official apartheid policies of the Nationalist government (1948 – 1994).

Apartheid policies left South Africa with a great disparity in wealth[1] and access to both services and natural resources. The white minority had access to a high level of services such as water, sewerage, transport, electricity and housing, equal in most cases to the service levels of the developed world. Large sections of the black community, on the other hand, had little or no access to basic services. Only 21% of households have piped water, on 28% have sanitation facilities, and in rural areas more than 80% of poor households have no access to piped water or sanitation. Most people without basic water and sanitation services live in the rural areas (May 1998).

The lack of access to services was compounded by a lack of access to natural resources. The apartheid government had forced the black majority onto less than one quarter of the land, through a variety of legislative instruments. The most notorious of these was the 1913 Land Act, under which large numbers of black South Africans were forcibly resettled. Although the legislation governing access to water in South Africa was not, in itself, overtly racist, access to water was linked to ownership of land through the concept of riparian rights.

The black population in South Africa suffered, therefore, under a double deprivation in relation to water: lack of water services was compounded by a lack of access to water for economic purposes, including irrigated agriculture. In addition to this, South Africa suffers from high levels of unemployment, and high levels of poverty. In 1997 the unemployment rate in South Africa was 37.6% and the majority of unemployed people were black (SSA 1998).

Figures from 1998 show that lack of access to adequate maternal and child care, basic health services and a healthy environment, a lack of food security and overwhelming poverty have resulted in a national stunting rate among young children, arising from malnutrition, of 23% - 27%. Among the poorest 20% of households the rate is 38% (May 1998). Women, and women-headed households, are amongst the poorest of the poor (31% of female-headed African households are in the bottom income category in South Africa, with the figure rising to 37% in rural areas). Apartheid policies lead to a disproportionate number of women and women headed households in rural areas.

Poverty eradication and service delivery

The democratic government is committed to redressing the wrongs of the past, particularly in relation to racial and gender discrimination. It is also committed to the eradication of poverty. In relation to access to water and water services, this approach is outlined in a number of crucial policy documents, such as the Constitution (Act 108 of 1996), the Reconstruction and Development Programme, the White Paper on Water and Sanitation (DWAF, 1995), the Water Services Act (1997), the White Paper on a National Water Policy for South Africa (1997) and the National Water Act (1998). The latter has substantially altered the framework for access to bulk water. In particular, the legislation has divorced access to water from land ownership, and has removed the previous expectation of permanent rights to water. Under the National Water Act all water will be allocated through time limited licences.

The new policy and legislative tools have enabled the government to make some major inroads into changing access to water and water services in South Africa. Since 1994 the Department of Water Affairs and Forestry has brought water services to over 3 million people mainly in rural areas. At the same time, the National Water Act has given the Department of Water Affairs and Forestry the tools to make water available to previously disadvantaged communities for economic activities such as irrigated agriculture.

Impact of water on social development

The question that needs to be examined is what impact access to water can, and has had on the social development potential or actuality of the lives of poor communities.

When looking at social development one is looking at a more complex set of indicators than those attached to economic development. Social development must take cognisance of improvements to health, life expectancy, infant mortality rates, the position of women, and general education levels as well as economic development. The UNDP Human Development Index is calculated on life expectancy, education and standard of living. A deprivation index has been constructed for South Africa which takes into account 12 household indicators thought to represent critical basic capabilities which reveals that some people classed as non-poor by income measures only are actually deprived in other ways (May 1998).

The ultimate aim of social development must be to lift individuals and communities out of poverty and into a realm in which fulfillment of the individual can be achieved. Social development must also take into account the environmental sustainability of any development which takes place.

Case studies and lessons

This paper will examine several case studies from the South African post-apartheid experience, in relation to water services delivery and in relation to irrigation options for previously disadvantaged farmers. These case studies will show that the South African government has made some remarkable strides in providing water services to disadvantaged communities and to emerging farmers. The paper will also show that the social stability of urban areas is closely linked to levels of economic and social development in rural areas.

The case studies will examine whether the use of water as an instrument for social development has been optimised, and what the lessons are that should be gleaned from the South African experience.

The apartheid legacy is not easy to overcome. The restoration of land to communities may be accompanied by considerable tensions between community members as they return from a diaspora and try to rebuild a communal life style after many years of forced exile.

The political pressures of delivery may also contribute to the difficulties associated with establishing sustainable projects. At the same time, extreme poverty, illiteracy and lack of capacity require very specific and often time consuming interventions and interactions in order to ensure that the best advantage can be taken of access to water.

In many success projects the role of women in the project has been crucial to the overall success.

A number of lessons can be learned from the South African experience which, if applied, could enhance the social development potential of making water accessible to the poor.

There are requirements for improved inter-departmental planning if the full potential of water as an instrument for social development is to be realised.

If the provision of water services and bulk water supply to communities in South Africa is to play a significant role in enabling communities to break out of current poverty traps ongoing monitoring, evaluation, review and improvement of the approaches to implementing the new policies and legislation is required.

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[1] The Gini co-efficient for South Africa in 1997 was 58.4.

WATER SCARCITY AND SOCIAL ADAPTIVE CAPACITY: TOWARDS AN UNDERSTANDING OF THE SOCIAL DYNAMICS OF MANAGING WATER SCARCITY IN DEVELOPING COUNTRIES

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Introduction

There is generally a paucity of theory within the water sector that is capable of explaining and predicting what the critical elements of social stability are. It is known, for example, that there is an increase in water scarcity (Falkenmark, 1989), and that this is affecting the developing world. It can therefore be anticipated that this increased water scarcity will impact in some form or other on social stability within these developing states, but it is not known exactly where or how this will manifest itself. Existing research tends to have focussed on water as a scarce natural resource. This can be understood as being a first-order analysis of water as a resource, which can be misleading however, as it tends to take researchers in the wrong direction. A more fruitful area of research is that which focuses on the ability (or inability) of a social entity to cope with the increasing demands caused by water scarcity. This can be called a second-order scarcity (Ohlsson, 1998) of social resources, which gives a far better insight into the dynamics at work within the context of social stability/instability in developing countries.

Scope

The fact that water sector reform is widespread within the developing world at present shows that existing policies are generally inadequate. There are major gaps in knowledge regarding the social, institutional and hydropolitical dynamics of these water sector reforms. The construction of such new knowledge, specifically regarding the social dynamics at work, is likely to increasingly become of strategic significance to the governments of developing countries. This paper is therefore designed to develop a coherent theoretical framework by linking the different approaches that have been used by economists (Allan & Karshenas, 1996) and social theorists (Ohlsson, 1999) via the newly emerging instrument of water demand management (WDM). WDM strategies are likely to become increasingly important as adaptive mechanisms in future (Turton, 1999), yet the social aspects of these are still largely unknown.

Methodology

The methodology that has been developed is a new one. It starts with the theoretical concept of 'natural resource reconstruction', which is a typical first-order form of analysis. This has tentatively been shown to exist in certain water-scarce societies such as Israel, South Africa and Botswana. It then embraces the concept of 'adaptive capacity', which is a second-order form of analysis, being defined as the ability of a social entity to mobilize sufficient social resources in order to adapt to the increasing first-order water scarcity. By shifting the analysis away from the first-order water scarcity, to the second-order mechanisms used to maintain social stability, it now becomes possible to explain why certain social entities are unable to adapt to increasing water scarcity. These social entities are therefore likely to be the ones where major disruption can be expected in future. One of the methodological complexities that arise is derived from the fact that a significant component of any adaptive mechanism is normative in nature, and therefore difficult to operationalize and empirically quantify. The methodology allows a neat distinction to be made between 'water poor' states and 'water scarce' states as originally conceptualized by Feitelson (1999), by showing that water poor states with high levels of adaptive capacity need not necessarily remain water scarce states. This suggests a dynamic process of adaptation and social stability in the face of increasing water scarcity.

Results

There have been three specific results that have emerged from this research programme to date.

Firstly, the initial results have allowed for the generation of a coherent model that can be used to understand the social dynamics that are at work in developing states. It has therefore been possible to develop a significant piece of theory that can be a valuable tool for development agencies and consultants seeking to build capacity. At the theoretical level, it is now possible to show how an adaptive society is capable of mobilizing sufficient social resources with which to manage the transition from purely supply-sided solutions, through demand management approaches to the ultimate adaptive phase. Similarly, it is now possible to show how a non-adaptive society is incapable of mobilizing sufficient social resources (now defined as a second-order scarcity of social resources) with which to confront the increasing water scarcity (defined as a first-order scarcity of natural resources). It is these social entities that should be the target of development agencies, where it can be shown that efforts should be focussed on building capacity to the extent that the social resources become sustainable over time.

Secondly, the research has shown that there is a definite series of cyclical movements that can be anticipated as developing societies move from the initial supply-side dominated phase of water management, through a demand management phase and ultimately into an adaptive phase. It now becomes possible to predict, albeit tentatively at this stage, that the demand management phase needs considerably more research effort, as this is the time when developing countries need to mobilize the social resources that are necessary in order to effectively manage the transition to the adaptive phase of living with permanent water scarcity. One of the products of this research process is the development of a number of concepts and definitions, which are now less fuzzy than before, and which can be tested in other social settings. These include concepts such as 'allocative efficiency', 'productive efficiency', 'value', 'rationality' and 'return to water' etc.

Thirdly, the research has shown that a critical element in the adaptive capacities of a society facing water scarcity is WDM. This is an extremely complex issue however, often being the source of civil disobedience or social disruption. In order to achieve a deeper understanding of this critical adaptive aspect, a tentative WDM model has been constructed. This suggests that there are two distinct components to WDM. The structural component consists of intellectual capital functioning within the context of an institutional setting and can be defined as being the generation of viable alternative solutions by a technocratic elite. This component can be partially exogenous and can be assisted by foreign technical and financial support in the form of capacity building projects. The social component is the complex one however, existing endogenously, largely in the hearts and minds of the people being governed, which means that a technocratic elite cannot artificially create it. The social component has been defined as the willingness and ability of the social entity concerned to accept the technocratically generated solutions as being both reasonable and legitimate. The latter implies that the social component is highly dynamic in nature, and it is this aspect which is relevant to a deeper understanding of water within the context of either social stability or instability.

Conclusion

The development of a tentative WDM model has meant that a theory can now be developed that is capable of explaining and predicting how and why developing countries are likely to face future threats of social instability in the face of increasing water scarcity. In other words, it links the first-order scarcity of natural resources to the second-order scarcity of social resources. It shows that a critical aspect of water and social stability is the way in which a social entity responds to attempts that are being made by the government to manage water scarcity. It is these socially-induced conflicts that are likely to result from attempts to adjust to water scarcity, rather than conflict over access to fresh water, that need to be better understood. This model is now being tested in a number of social settings in order to develop a coherent database of case studies sufficient to fill the gaps in existing knowledge.

ENHANCING THE GOVERNABILITY OF URBAN WATER MANAGEMENT

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In his 'Coming Anarchy' article in *Atlantic Monthly* (1994), Robert Kaplan sketches a world of chaos, uncertainty and, most of all, increasing *ungovernability* in (inner) cities. Indeed the change of adapting to population growth (urbanisation, megacities) and a stagnant resource base can easily engender stresses that, in turn, may create severe tensions. However, while it is important to analyse the social stresses degenerating into conflict, we must check the assumptions underlying the apprehension first. Socio-cybernetics teaches us to exploit rather than fear change and complexity, while Kooiman (1997) instructs us not to ignore its opportunities in devising ways to enhance *collective urban water security*. It will be argued that integrated water management does not just concern a holistic view of (land and) water management, it involves social inclusion as well.

Stability or metastability?

In these turbulent times, present-day developments look bewildering and chaotic, even threatening from a control perspective. But if we recognise that cities are like *living systems*, we can see that they have always been in flux; maybe it is just the *rate of change* that is increasing. Living (complex adaptive) systems display a dynamic equilibrium: a degree of instability is normal and inherent in the process of constant transformation. It is therefore imprudent to try and force cities into a steady state (stability) - that would be to take the dynamics out of cities. We should not rely too much on planning, but plan for unpredictability. We need *to relax the idea of order, stability and predictability* and allow for constant change and metastability. In both human and aquatic systems, turbulence is the normal state of affairs!

The concept of *social adaptivity* addresses the flexibility and durability of social and political systems in the face of social change (Ohlsson, 1999; Pelling 1998). Adaptation requires *room* for manoeuvre - physical as well as institutional. Unfortunately, space is at a premium in most urban settings. If anything, the concentration of people and assets increases vulnerabilty to flood hazard (e.g. Parker 1994), pollution and disrupted water supply. Management models based on control and efficiency colonise this space even more.

Greater space can be created, however, by diversifying one's options. This necessitates urban authorities to develop a *flexible repertoire* of responses (Stoker 1997). The 'range of alternatives' approach (White 1974) recognises that centralisation and techno-fixes for water management, while apparently efficient, take much of the elasticity out of the system. In fact, they increase system vulnerability to large-scale failure and strategic resource manipulation. In addition to decentralisation (localised water supply and neighbourhood flood protection), one can also diversify between *types* of risk mitigation - structural as well as nonstructural risk mitigation. The benefit in all this is that it introduces redundancy to reduce dependency on a single actor and alternative.

So far, this challenge has not been seriously addressed. In the past few decades, urban authorities have tried to enhance their management capacities by outcontracting services to the private sector. As a consequence, WS&S has been privatised in many megacities (the most attractive targets for investment) around the world and public-private partnerships have promoted speedier construction of urban water supply and disposal infrastructure. But outcontracting has favoured costly and complex works rather than small and affordable ones, and where the private sector is made responsible for urban water management, it will be hard to avoid increasing social disparity, as more affluent quarters are likely to be prioritised in water supply and flood protection. Commercial insurance often is only available to the affluent, while it is sorely needed in the more vulnerable areas where the poor tend to live. This inequality and exclusion will still have to be offset by non-commercial arrangements.

Recently, *civil society* has belatedly been rediscovered as a partner in governance. In the South African countryside, bodies like the Mvula Trust are active in helping communities realise local water projects by granting microcredits. Such community-owned projects tend to be extremely successful. But in cities, horizontal ties between households and communities are generally weaker than in the countryside. Yet, while it is clear that civil society is not a homogeneous entity and it is a mistake to treat it as such (Ball 1997), it seems equally wrong to assume that the heterogeneity (diversity) of city populations necessarily causes (unmanageable degrees of) instability (Moser 1998).

Rather, diversity and flexibility of actors and alternatives are sorely needed to cope with *change* and enhance *governability*, defined as the balance between (security) *needs* and *capabilities* (Kooiman 1993). Both in the North and the South, however, governments are overloaded and find it hard to make good on raised expectations. 'Public services' in developing-country megacities struggle to meet increasing social demand for water security. Social complexity and low coherence of political society makes the capacity to act even more difficult in urban settings (Stoker 1997). However, coherence does not have to take the form of top-down planning; it can also be the result of co-ordinated tapping of existing local energies. This requires a degree of mutual trust that is as yet sorely missing in many localities.

<u>Restoring legitimacy</u>

Control-oriented models spring from an outdated interpretation of 'development'. This is all the more worrying as the 1990s have seen a conflation of 'security' and 'development' (Duffield 1998), in which development serves to strengthen struggling states and strengthen state security rather than societal security. In their control efforts, states have tended to create client bases, vertical links to the centre that substitute for solidarity links. This has tended to atomise civil society as part of an unproductive struggle for political control between public, private and civil-society sectors.

It is high time that the security focus returned to the people. To increase the two-way legitimacy of urban water management, stakeholders need to be allowed greater *control* (over their own lives and over the decision-making process) and *choice* (Bloomfield *et al* 1998). Legitimising and improving on informal WS&S and flood defence initiatives may prove a significant step in improving trust between society and state. This could be a first step in the direction of a new 'security contract' between citizens and government

- a more radical type of Local Agenda 21 outlining the rights and obligations, needs and capabilities of each sector. This requires the restoration of:

- *two-way trust* In a high-trust society, the network of mutual aid, as well as a diversity of material and immaterial risk-spreading arrangements, will be more developed. In a low-trust society people tend to withdraw from collective action, only protecting their individual homes from scarcity and flood risk. A lack of integration and co-ordination easily leads to a counterproductive scramble for resources. The most vulnerable urban residents tend to have scant access to material and immaterial political resources. On the other side of the economic spectrum, the affluent quarters (and touristic amenities) may lay a disproportionate claim on the natural resource base (resource capture). In the end, the environmental resource base bears the brunt, in turn eroding the preconditions of societal adaptivity.

- *two-way communication* From a cybernetic perspective, openness and feedback are systemic requirements. Both the technical and social performance indicators need to be continually gauged, which requires social feedback mechanisms in the form of genuine participation. People need to be consulted, informed and allowed genuine input to enable adequate feedback on current and new water projects. The security contract itself can only be kept alive by continual review and as such the terms are 'meta-stable'.

Integrated urban water management

The above seems to pose a problem in the context of integrated urban water management. Integrated management can be defined as a centralised form of management bringing together different functional and geographic administrations to achieve a more complete understanding of interdependencires and a more successful management of the system as a whole. At the same time, successful public participation requires decentralised decision-making, shifting decisions down to small geographical and functional units. Integration and public participation pull in opposite directions! (Green & Tunstall 1998).

The challenge, then, is to build an institutional infrastructure which can deliver the integrated management of water and people on the basis of co-ordination rather than control. The first thing to notice is that this easily leads to a *complex* institutional structure. In line with Ashby's Law of Requisite Variety, the complexity of water may demand a similarly intricate management system that takes the different functions and interdependencies into account. Unfortunately, this tends to translate into fragmentation in the real world, a patchwork quilt of partly overlapping jurisdictions and mandates. The complexity is in place, but as a consequence, non-co-operation can only be expected. The challenge is to create or foster kinds of 'social glue' to connect the parts into a network of resilience and promote social trust by finding the right mix of interventions, co-ordination and incentives for self-help and some sort of communication mechanism that co-ordinates the parts and provides flexibility. What is important here are the interconnections: the way constituent elements are dispersed but interlinked. The result may well look like a *network*. In the case of ITN Philippines (Manila), for example, public, private and academic actors work together in running a training programme, in a country where mandates often overlap and public institutions are mutually hostile. This seems to be the way forward.

GOVERNMENT BY CONSENT: A ROLE FOR COMMUNITY GROUPS IN THE MANAGEMENT OF HONG KONG'S ENVIRONMENT

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Introduction

Good water supply, adequate sanitation, and a tolerable, sustainable environment are especially vital to the stability of an urban community. The confidence a community places in its government depends to some extent on its perception of how effectively these essential and highly visible services are delivered. Research in Hong Kong has shown that the involvement of community stakeholders in this aspect of their government can boost the effectiveness of the services and so contribute significantly to stability and prosperity in the long term.

Any city is dependent for its life on the land and communities of its hinterland. None is more so than Hong Kong, a largely urban community of some 6.2 million people. It is a politically distinct entity in southern China, but environmentally and economically it is an integral part of the Pearl River Delta. This is a region of about 27 000 km^2, including five major cities, with a total population over 24 million. It is undergoing very rapid transformation from a former agricultural economy to an urbanized and industrialized one. Hong Kong's own economy has evolved during its recent history from an agricultural hinterland, with a modest trading city at its heart, through a period dominated by manufacturing industries, to a service economy in the 1990s.

A coincidence of events has disturbed Hong Kong and its immediate neighbours in 1998. They include an epidemic of avian influenza, a damaging outbreak of red tide, and very visible pollution of the air, caused by a combination of dust from the construction industry and smoke from motor vehicle exhausts. These incidents have focused community attention on the government's effectiveness in tackling problems of the environment.

Criteria for Effectiveness

Public sector reform in several countries has attempted to sharpen the focus on goals and performance measures, to increase the effectiveness and accountability of government agencies. An attempt to measure effectiveness in water pollution control would require multivariate criteria, to match the diversity of realistic goals that pollution control encompasses. Setting ambient water quality objectives to protect beneficial uses of a water body is a complex enough scientific problem. Agreeing on the beneficial uses, weighting priorities among them, and devising affordable programmes to attain them, add further layers of even greater political complexity. It is widely understood that most of the scientists and engineers who dominate water management institutions are less than comfortable with the social and political challenges that arise.

In the Hong Kong Environmental Protection Department, an attempt was made to devise water programme goals, and to build them into a strategic plan of action, using soft systems methodology. This is a process of enquiry that explicitly recognizes and examines the social, political and cultural aspects of a problem, as well as those that are amenable to technological analysis.

The attempt had only modest success. It was possible to devise reasonably well operationalized goals at various levels, such as the attainment of water quality objectives (a strategic goal), reductions in effluent loads of various pollutants (tactical) and the rates of inspection of industrial premises (output goals). The objective of demonstrating the programme's effectiveness was, however, thwarted by countless confounding factors including the natural variations in water quality observations and the migration of polluting industries to neighbouring jurisdictions.

There have been many other attempts to set up complex suites of rational goals to measure the effectiveness of water quality management. It is impossible to show that they have ever improved water quality.

The Role of Stakeholders

A better approach to improving the performance of water pollution control institutions shifts the focus from a scientific understanding of water quality towards meeting community aspirations. An examination of the way Hong Kong's water pollution control institutions evolved gave a fresh insight into the question.

In the latter half of the 1980s, interested members of the Hong Kong community had given strong support for a vigorous, expanding water pollution control programme. It was possible, then, to make beneficial changes in water pollution control law, even when they were not in the short term interests of some powerful members of the community in the industrial lobby. On the other hand, in the late 1990s, when the state of the environment once again emerged as an important concern, the government's Environmental Protection Department is seen as just another element of the bureaucracy. It does not enjoy community support, and it suffers frustration as it struggles to tackle a different but undiminished range of problems.

With these observations in mind, the research proceeded through a large number of interviews of scientists and officials involved in the management of water, and the examination of several hundred written opinions on the subject. The outcome was a formal definition of effectiveness. Effectiveness is behaviour that attains goals negotiated with a set of stakeholders, membership of which is also negotiated. Thus the ability to recognize and communicate with stakeholders and to understand their ethos is critically important to achieving or enhancing effectiveness in water pollution control.

A plan of action based on this definition could be in constant flux, as the composition and aspirations of dominant stakeholder groups change. It would be risky, too, for technologically oriented professionals to accept, because they might be obliged to adopt a course of action contrary to their scientific understanding of the 'correct' course. It is argued that it is, nevertheless, the best approach to improving the overall evaluation of the organization's performance.

This conception of effectiveness goes far beyond the common practice, and even more common advocacy, of stakeholder support networks, which are a common feature of river basin management institutions in several parts of the world, including France, Australia and America. Such networks are usually built on a deficit model of communication, in which a government agency holds all the knowledge and power, and expends considerable effort in 'educating' (or persuading) the public at large or special interest community groups to accept its point of view. Active resistance to political pressure based on irrational views of the environment is not uncommon. A conclusion of this research is that a water pollution control programme will be effective where there is congruence between the aspirations of its key stakeholders and the activities of the programme, and both sides should expect to modify their positions to achieve this.

It is pertinent to ask why this should be so. The findings suggest four factors in the relationship with stakeholders that can combine to increase effectiveness:

- The agreement on what is to be done (or 'congruence') creates an economy of effort, with the maximum energy directed to achieving the results that define and create effectiveness;
- Less effort is wasted in overcoming the friction of difficult relationships;
- Feelings of esteem are raised in most participants in a shared effort towards agreed goals, motivating higher individual and team performance (especially in a 'service' ethos);
- In many cases, stakeholders have an influence on the provision of resources, and some may enhance a water pollution control organization's effectiveness directly by participating in its programmes.

Conversely, stakeholder hostility, based on the perception of failure or alienation for other causes such as unresponsiveness or the suspicion of deceit, will eventually throttle the flow of resources and negate the other beneficial factors. For example, a sense of powerlessness was prevalent in Hong Kong in the early 1990s, where only 4% of people felt they could make a substantial impact on environmental problems, compared with a reported 16% world wide. This alienation has had a strong adverse influence on the resources provided for the Environmental Protection Department to do its job.

It would not be true to say that the Government of Hong Kong or its Environmental Protection Department has wholly accepted this alternative model of effectiveness for its water pollution control programmes. Nevertheless it is going some way to listening to interested community groups, and in 1999 it has constituted a series of forums to participate in developing its policy for the 21st century. It remains to be seen whether they will truly be a departure from the deficit model of the past, but it is certain that they will contribute to improving the effectiveness of water pollution control institutions, and, by reducing alienation, they will support the long term stability of the community.

GROUNDWATER OVER-EXPLOITATION – A CASE STUDY FROM NAMAKKAL DISTRICT IN SOUTH INDIA

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Introduction

India, one of the developing countries in the world, with a population close to one billion, initiated a national water supply programme almost 45 years ago. This and several billion dollars later a large population in the country is still to get safe drinking water, even to a bare minimum. A significant percentage of the population depends on groundwater as they live in habitats, which are away from surface water bodies. This over-dependence on groundwater for domestic, agricultural as well as industrial water needs has resulted in severe over-exploitation of this precious natural resource. As a consequence wells and borewells on which the populace depends have gone dry and the quality of groundwater, where available, has deteriorated. The problem of over-exploitation has reached critical levels particularly in areas underlain by hard crystalline rocks, which, to begin with are poor host rocks for groundwater.

Evaluation of historical data on groundwater shows that the water levels have steadily declined over the past decade at an alarming rate in several areas. The groundwater levels, which were around 5-6 m. below ground level in late seventies, are now to be found at levels as low as 50-60 m. The quality of groundwater is also observed to be deteriorating either due to external pollution or due to the fact that deeper sources contain more total dissolved solids as they have had more time for rock-water interaction. Shallow borewells have become unproductive leading to loss of agricultural income of several families in each village. The deterioration in groundwater quality has also led to increasing health problems.

The district of Namakkal in Tamilnadu is one such area with several over-exploited pockets in it. This paper deals with some of the hydrogeological studies carried out in the area in order to understand the complexity of the problem of groundwater over-exploitation and its effect on the rural population.

Scope

The study primarily focuses on collection of hydrogeological data from a hard rock area and analyses it in terms of present and past hydrogeological environment and projects the possible scenario for the future, so that remedial measures can be taken up. Essentially the exercise is to know the ground realities that are existing in an over-exploited zone, analyse the reasons for the over-exploitation, study the effects of the declining water-levels and yields on the socio-economic health of the people. Once the problem is understood possible measures to rectify the situation could be formulated and put into action.

Methodology

From a survey of hydrogeological data available with various organisations, the area around Puduchatiram in Namakkal district, Tamilnadu was selected for study. Details on groundwater exploitation in the area since 1982 were collected for the wells existing in the area. The details included the depth of wells, number of wells per unit area, groundwater levels over the study period, yield pattern of existing wells and changes in the yield of wells from the time of construction of wells. The geology of the area was also studied for details such as rock types, presence of intrusives, structural aspects, fracture patterns etc. The cropping pattern in the area was also studied with particular attention to the changes, if any, that have taken place over the years. This is important since the extent of availability of groundwater determines the kind of crop raised by the people. Changes in the occupation of the population was also studied in the area. The mode of obtaining domestic water supply for the population was studied in detail. The chemical quality of groundwater was also taken into consideration.

Results and Conclusions

The area of study is underlain by charnockites and granitic gneisses belonging to the Precambrian age. These rocks are well foliated with two to three sets of prominent joints. The depth of weathering varies from a few meters to as much as 30 meters. Groundwater occurs under unconfined conditions in the shallow near-surface aquifer and semi-confined conditions in the deeper fracture aquifers. However, in several zones the unconfined aquifer made up of weathered rock has been completely de-watered with the result that the wells tapping only this zone are dry. Density of borewells here is quite high, at 37 per sq. km. The depth of the borewells ranges from 90 m to 350 m, with an average depth of 165m.

In general, borewells of less than 120 m depth which were yielding at the time of construction of the well, have become unproductive due to drying up of the shallow fractures. Study of the data obtained during 1998-99 shows that the first productive zones are encountered only around 120-150 m in most of the borewells (during drilling). The yields of borewells range widely from nil to as high as 500 lpm. However analysis shows a declining trend in the yield of borewells over the period.

The dynamic groundwater levels have steadily decreased over the years. The water levels were generally about 20 m bgl in 1982, but now in most areas it is around 35 m bgl. In one borewell, the water level, which stood at 29 m bgl in 1991, had declined to 100 m in1994. Thus shallower borewells are abandoned and new, deeper wells are constructed year after year to obtain water for drinking purposes.

The problem gets serious when there are no water-bearing fractures at deeper levels in a specific locality. In such habitats, the population finds itself without domestic water supply leading to great human misery. The problem gets complicated when people in the neighbouring areas, where groundwater is still available, refuse to allow the precious commodity to be pumped to the needy village, fearing depletion of their own groundwater levels. This creates social unrest and animosity between neighbouring communities. This problem is becoming increasingly common in the study area.

The quality of ground water is also seen to be deteriorating over the years. This is particularly true in the case of total hardness, which increases with increasing well depth in many parts.

The cropping pattern, which was mainly cereals when waterlevels were at shallow depths has changed almost exclusively to cash crops such as tapioca (Marantaceae), turmeric, vegetables and sugarcane. The decline in the well yields has also resulted in reduction in cropped areas, as more and more cultivable land is left fallow for want of irrigation water. This has resulted in loss of jobs for agricultural workers.

The increasing cultivation of tapioca has led to the setting up of starch production units, which discharge effluents, leading to pollution of the already declining groundwater resources. The groundwater in the vicinity of these units is often unfit for human consumption. The study shows that there is an alarming decline in both the quality and quantity of groundwater brought about by the over-exploitation of groundwater. It is necessary that there should be an immediate control on its abstraction in order to prevent further lowering of water levels, lest a large population is deprived of potable water. Further, large numbers of recharge structures should be put up in such areas in order to facilitate artificial recharging as well as harvesting of rainwater.

THE MICE AND THE ELEPHANT: NGOS AND THE URBAN ENVIRONMENT IN DEVELOPING COUNTRIES

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Introduction

Environmental degradation is a striking feature for most cities in developing countries. Demographic change, compounded by political power structures, industrialisation and culture, pose big institutional challenges in coping with urban environments. Already today, the government and local authorities in urban centres face great difficulties in coming to grips with environmental decay and dwindling natural resources. For example, there is a widening gap between public service demands and what is actually supplied by the government, and environmental legislation is poorly implemented.

Riding on the tidal wave of doubts about state-led development, Non-Governmental Organisations (NGOs) are under way to play the role of new development wizards. The NGO-sector has been attributed a plethora of capacities from various sources, such as donors, governments and the NGO-sector itself. NGOs' role in various aspects of development ranges from more tangible comparative advantages in the field of service provision to the poor, to an ability to independently or as development partners restructure political and social life and formulate alternative pathways to sustainable development. The paper critically assesses NGO capacities in the area of sustaining urban environments and their role in restructuring local political and social life.

Scope

The paper draws evidence from the South Indian mega-city Chennai, formerly known as Madras. A single issue NGO net-work protesting urban river water pollution was studied with respect to its capacity of scaling-up NGO activities and co-directing and complementing the formation of government policies and action.

NGO capacity is dependent on organisational structures, such as linkages between leadership and membership, organisational ability to utilise external funding and voluntary work. What NGOs do or not do is also conditioned by how they relate to other actors. Net-working among NGOs is today seen as crucial for most NGOs, and getting isolated would almost be equal to be out of business. How NGOs relate to governments and bureaucracy is also an important determinant in their capacity to abate urban environmental problems. A third important determinant is the traits of the problem NGOs are set to solve.

The task facing urban environmental NGOs is how they can turn around processes of magnifying environmental problems, which emanate from structural and direct causes of lack of services, industrial pollution, people littering and defecating on the streets and so on, all complicated by poverty and unequal distribution of services and environmental burdens to parts of society. Multiple and complex origins of urban environmental degradation also suggest that environmental degradation can be battled in numerous ways by NGOs, such as educating citizens, pressurising governments and local authorities to make and enforce environmental legislation and policies and organising people to set up their own service provision system and clean up their neighbourhood and so on. In such a perspective urban environmental NGOs can chose to battle structural or direct causes or improve areas where environmental problems are manifested, or any combination of them.

Many of the urban environmental problems are connected to lack of public services and *infra-structure*. Most cities prevailing systems of environmentally related public services (e.g. water supply, sanitation and garbage collection) are connected to large-scale solutions, involving complexities of technology, division of labour, and requiring huge investments. How can NGOs complement such systems and do they have the ability to innovate and scale-up their activities?

Tentative conclusions

The results demonstrate that scaling-up of NGO activities and their role in co-directing and complementing government policies and action do not come easy. Despite clientelist linkages between NGOs and local authorities this has not been sufficient to make an impact on the polluted waterways. The basic response from local authorities has been to keep NGOs at arm's length and reject remedies made by NGOs. Difficulties of scaling-up are also found in a segmentation of the NGO-sector. First, NGOs are project-driven, attempting to carve out their own niche to recruit volunteers, get financial and moral support.. Second, an NGO-ego prevails, hindering closer cooperation. Third, big fish eats little fish. This means that smaller NGOs feel less inclined to work with the bigger.

Apart from intra and inter-organisational conditions, the paper also demonstrates that traits of polluted waterways make it difficult for NGOs, or the government for that matter, to come to grips with polluted rivers. The case of polluted rivers displays many diffused pollution sources, making it difficult to pin-point actual polluters and their contribution. Slum resettlement is at the heart of the issue, representing a hot political potato. Strong political and other slum interests prevail and many NGOs feel reluctant to challenge them, at the same time as their own links to slums are poorly developed.

The study suggests that NGOs in part have to reconsider their strategies. In sharp contrast to official rhetoric of NGO participation many NGOs are still considered to be playing at the margins, and their involvement or help is only sought when it suits the political and bureaucratic elite. The paper also suggests that scaling-up of NGO activities should be sought in widening grassroots' participation. Increased popular support of NGO activities may lead to even more precarious NGO-state relationships, however in order to make a development impact popular support would be essential.

The case of polluted rivers in Chennai suggests that NGOs are operating at a low capacity. They have neither been able to influence government policies nor build popular support. Even if the waterways were dredged and restored this would not be a viable solution. A massive attack on the roots to pollution is required. This would involve, among others, heavy investments in sanitation, water purification, pollution control and monitoring, enforcement of legislation, and slum resettlement. Obviously NGOs lack financial and personnel capacity to directly deal with polluted waterways, their roles are to educate the public and watch-dog and increase the pressure on the government.

B) Unstable situations

Workshop No. 4
From stability to instability and from instability to metastability

Abstract

Restoring urban water supply in extreme instable situations: partnerships and strategies to create the conditions for a relatively safe transition to stability.

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Abstract

In extremely unstable situations, like war or natural catastrophies, provision of safe water supply is a key component in the effort to rescue and help enhancing stability. Political embargoes have an immediate effect on technology dependent countries, as essential spare parts are difficult to procure, but also on the necessary engineering know-how to run or install the equipment, as engineers and technicians are looking for better opportunities for survival, as most of the society does. The results are increased degradation due to poor maintenance, and the efforts of the international humanitarian organizations (IHO) (NGO UN bodies, ICRC, engineers, others) can only mitigate the extent of the decay and help to restore the existing installations. The involvment of IHO and NGO's are getting more complex and their need for specific trained engineers is increasing.
In the last 10-15 years the humanitarian organizations went from emergency water supply for informal "towns", like the huge camps set up to care for the refugees leaving the different war-torn countries, to a more recent involvment in complex urban water schemes, to care for the urban trapped, like in Beirut, Aden, Baghdad, Monrovia, Sarajevo, Brazzaville, Kabul etc. The technology developed to supply camps is in these situations nc appropriate, and the IHO had to step up their competences to tackle complex installation and to work in partnership with the local water boards, who are lacking resources and a often badly affected during the conflict, to help them to cope with the most dire needs but also to rebuild or strenghten their operational capacity.

Quick decisions have to be taken to avoid disruption of the production of water. Several indicators are used to describe the severity of the situations:
- energy supply, in general electricity, which is very often the target of any military operation, but also
- the operational state of the water treatment plants, which may be damaged or looted dur the unrest, even if seldom to an irreversible extent
- essential chemicals which must be purchased, stocks to be rebuilt (this can take months)
- equipment must also be supplied, as tools are very often looted. The purchase of new equipment may take weeks or months, as they are mostly designed for a specific environme
- personnel will have to be brought together, protected and paid, sometimes at the beginning of the interventions, on a food for work basis, as food is often lacking. Only late

incentives can be provided, on a downscaled basis, linked with the progressive recovery of the financial capacity of the boards, when metering and subsequent billing can be initiated.
- tools and transportation are necessary to carry out repairs on the network which are often badly damaged.

This recovery may take years, as in Rwanda, where chemicals (1500 MT) for the whole country had to be purchased and transported to Kigali up to the end of 1995. Later, the salaries for the operators had to be made available for about six months and important programmes were launched to improve the water supply for the towns, to cope with the influx of people, but also to supply people living in the rural areas, where a third of the gravity flow schemes were out of work.
The relative importance of these indicators can be appreciated; before, during and in the aftermath of a conflict, by analyzing the production figures of the city of Brazzaville. The lack of electricity, the poor security of the staff, the need for chemicals, for a better protection of the pumping devices, to support the somehow erratic power supply, can be immediately recognized. But not all the situations are the same, and some conflicts have left the installations and the operational capacity of the water boards untouched, but without any medium- term capacity to deal with future needs.
Programmes must be implemented before the total collapse of the supply systems, as in former Yugoslavia, where essential items were delivered to almost all the waterboards since the end of 1993, to delay the general degradation of the systems. Those programs were continued when the conflict came to an end and scaled down only in 1998, one year after the Dayton agreements. The budgets involved reflected the problems and even if only repairs or improvements of existing installations are carried out, tens of millions of USD must be allocated for water and sanitation rehabilitation programmes alone. Embargoes also do affect the supply of water and create instable situations in already difficult ones. The case of Iraq is emblematic, where trained engineers and technicians left and are still leaving the premises in search for a minimum of economic security. This enhances the decay of the schemes which are left to less trained operators and has triggered a different response from the ICRC, shifting from the delivery of spare parts to a complete rehabilitation of the stations, with its own teams. This is a response to the general degradation of the "technicity" of the Iraqi society, where it is more and more difficult to find the former existing local resources.

Extreme conflictual situations are sometimes coinciding with a general decay of the urban services and may be related to lack of water and more generally to lack of resources. Water supply is seldom the unique cause of the instability, but, if not immediately addressed, more suffering will be in the pipeline, as epidemics may strike. The role of the ICRC and other IHO is to create the conditions for some sort of stability, which means, in this sector, to a quite normal access to safe water. But then, a lot remains to be done, to strengthen and improve the services in the long term. The work of the ICRC and other organizations must be supported and the role of the private sector could be more important, not only in these extreme situations, but in prevention, together with the water directorates of the concerned countries, in preparing them to maintain and restore some sort of stability, the one that water can give in its every day use.

WATER DEMAND MANAGEMENT, NATURAL RESOURCE RECONSTRUCTION AND TRADITIONAL VALUE SYSTEMS: A CASE STUDY FROM YEMEN

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Introduction

The Sa'dah Basin in Yemen is an extremely arid region, with virtually no surface water at all and very little endogenous precipitation. What water exists, is found in alluvial aquifers, which until recently, have contained significant quantities of good quality water. This could not be exploited for a number of reasons, until a turning-point arbitration was made regarding land use and water runoff rights during the mid 1970s. From that moment onwards, the aquifers have been mined to the extent that the water table is falling at an alarming rate. This practice is clearly not sustainable and it can be predicted with some confidence that, unless there is a drastic change in current patterns of water consumption, a high level of social instability is likely to occur.

Scope

This particular research project has been launched in order to give some empirical substance to a larger effort that is designed to specifically focus on the impacts of the second-order scarcities of social resources as defined by Ohlsson (1998). Particular attention has been paid to some of the more normative aspects of water use, such as notions of value and sustainability. The role of Islam within this social fabric of society is particularly relevant. To this end, any changes in the interpretation of Islamic principles are deemed to be relevant as they can be regarded as being valuable indicators of shifts in the normative order of society. In other words, it is being hypothesized that normative value systems are one of the crucial elements that maintain stability in a social entity that is facing an increased first-order scarcity of water. The role of traditional value systems and communication mediums such as poetry is being investigated, in an attempt to develop a viable water demand management (WDM) strategy that is regarded by the population as being both reasonable and legitimate.

Methodology

The methodology has involved a long-term series of field trips to the area, covering a span of 3 years. During these field trips, a number of interviews are held with key role players. These interviews are conducted in Arabic. The yield from these interviews provides a rich source of qualitative data. This is interpreted in conjunction with evidence derived from personal observation and empirical measurement. The methodology involves a high level of multidisciplinarity, with methodological tools being used from five specific fields. These fields are Islamic Studies, Geography, Political Science, Social Theory and WDM.

Results

The project is now in a position to start reporting some initial findings, which are cause for some optimism.

Firstly, the initial results have shown that the Sa'dah Basin is the locus of a deeply entrenched traditional value system. This system derives from an intermeshing of religious belief systems and tribal practices that go back many hundreds of years. Initial interpretation of data therefore suggests that where such a rich cultural heritage exists, it provides a strong foundation for the adaptation of a society to the third phase of water management - learning to live with absolute scarcity. This is extremely encouraging.

Secondly, the research has shown that there is definite evidence of a change in behavior regarding water use. There is strong evidence that resource capture is manifesting itself. Should this continue, it can introduce yet another cleavage line into what is already a deeply fractured social entity. This suggests, at least in this early stage of interpretation, that social instability can result from water scarcity. However, some encouraging evidence has been uncovered which is strongly suggestive that the affected population is countering this resource capture. The most significant evidence of this comes from a shift in the interpretation of some Islamic principles regarding water use. There is a small but growing group of *Zaydi* scholars who are starting to offer interpretations that can provide a strong normative basis for sustainable water use. In support of this, there is also evidence that certain *Sheikh's* are forbidding the sale of land as they now see that resource capture can be an undesirable end-result. Some of the tribespeople themselves are starting to resist efforts at resource capture on their own initiative by refusing to sell land (land rights and water abstraction rights are linked).

Thirdly, the research has provided some rich evidence that can be used to better understand the notion of 'value' or 'rationality' regarding water consumption. To this end, it can be tentatively said that there is no absolute notion of 'value'. In certain instances water use can be regarded as being economically irrational, but socially or politically highly rational. In other words, the value of water may be such that its use defies an all-encompassing definition. For a farmer to use scarce water for producing relatively low value citrus may be economically irrational, but politically rational as the ownership of a citrus orchard in an otherwise barren area is regarded as a symbol of wealth and prosperity. The political value of water, the social value of water and the economic value of water are thus three distinctly separate things.

Fourthly, the role of poetry has been found to be a viable way of communicating information about WDM in a culturally acceptable way. This aspect is being evaluated and new evidence will be reported, as it becomes available.

Conclusion

The Sa'dah Basin of Yemen provides an interesting example of adaptive capacity. It can be tentatively concluded that where a strong normative basis exists within a social entity, then a second-order scarcity of social resources need not necessarily be the end result. It is therefore possible to say that social instability need not necessarily result from water scarcity, provided that a strong normative value system is evident. These conclusions are tentative only, and more intensive research clearly needs to be done in order to substantiate this claim with a higher degree of certainty.

WATER PROJECTS AND POST-WAR STABILITY IN THE CITY OF LUBUMBASHI (DEMOCRATIC REPUBLIC OF CONGO)

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Introduction

Since the conflict of the earlier 1960's secession, the International Committee of the Red Cross (ICRC) has been punctually present in the country, trying to respond to the subsequent humanitarian emergencies. After the 1996-97 conflict that led to the overthrowing of the Mobutu's regime, the American Red Cross (AmCross) and the ICRC undertook a large scale urban water rehabilitation project meant to increase the production and to improve the distribution of potable water in Lubumbashi.

Located in the southern mining province of Katanga, Lubumbashi is the second largest town of the country with a population of around 1'000'000 inhabitants. Built during the colonial era, the water infrastructures were largely insufficient and did not cope with the city expansion and the population growth, leaving large sectors of the town with limited access to water, thus creating large discontent toward the responsible authorities (Water board and public administration) that sometimes triggered social unrest, particularly in the disadvantaged neighborhoods.

Scope

As social stability is intimately linked to the ability of governments to provide their populations with basic essential services, such as water and sanitation, conflicts and related damages to these infrastructures generate instability, which is expected to be partially attenuated by any intervention aiming to the resumption of an acceptable level of service.

Based on the water supply rehabilitation project completed in Lubumbashi and on the pre and post-projects studies conducted through questionnaires, this paper attempts to highlight the stabilizing role of easier access to water on the social fabric of such post-conflictual troubled societies.

Results and conclusions

The project doubled the water production of the spring catchment (from 240 m3/h to 500 m3/h) and entirely rehabilitated the city main pumping station and its equipment, increasing the production by nearly 20 % (from 1'700 m3/h to over 2'000 m3/h) as well as the pressure in the network, enabling the water to reach all districts served by the pumping station, that means the city centre and the low income southern districts, accomodating alltogether around 80% of the population.

According to the results found during the research, 75,6 % of the concerned population have seen improvements in their access to water, particularly felt in the regularity of the delivery and the increase in quantity and pressure. The positive impact on the daily life is felt in the sectors of health (63,2%), hygiene (66,2%) and living environment (55,8%) and it is expected that water borne and related diseases will decrease. It appears also that new economic activities were brought up with the additional amounts of water, such as ice making, bakeries or with the possibility to grow vegetable to be sold on the local market. 48,2 % of the people have seen a significant decrease in the time spent to collect water (corvée d'eau) and could use the spared time for other income activities.

The study showed the overall satisfaction of the population but also the willigness to pay for water, if provided regularly, and the intention of a large part of the inhabitants to be supplied through a private connection in order to gain independence from alternative supplies, considered not safe, expensive (if purchased from water vendors or neighbours) thus avoiding the burden of collection and storage.

The results of the study suggest that water can be considered as a tool promoting social stability, particularly in a context where the social fabric has been weekened by the direct consequences of a conflict.

IMPROVING HEALTH THROUGH HUMAN WASTE DISPOSAL IN FOUR DISTRICTS OF KABUL (AFGHANISTAN)

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Introduction

Afghanistan has been in conflict situation since 1979. Between 1992, Kabul, the capital, was the theatre of intense fighting and ended up more than 40% destroyed. As a consequence, important population movement took place among its estimated 1'200'000 inhabitants. Those who lived in the most affected areas moved to those which were preserved, thereby increasing their density. The sanitary infrastructure and in particular its water and sewerage networks were heavily damaged. Since then the authorities have been more and more reluctant to attribute resources to sanitary public services. Today the water network is reduced to less than 20 % of its prewar capacity and supplies to about one third of the city; only 10% of the population is connected to a sewerage network; rain water drainage is limited and refuse evacuation sporadic.

The resulting poor environmental situation is a constant threat for the health of the population. No reliable figures concerning the prevalence of diarrhoea or other waterborne diseases are available. This is due to the lack of constant monitoring and accurate population figures. However, diarrhoea is believed to be, by far, the first cause of infant mortality.

The reaction of the international community contributed to the restoration of a minimum level of sanitary conditions; constructing wells equipped with handpumps and collective septic tanks for communities; repairing and supporting the operation of water and sewerage networks for the entire city.

Scope of the ICRC environmental programme

As a part of this process, the ICRC decided to address the problem at the individual and community levels, mainly because of the lack of reliability of the authorities in charge. The programme, started in August 1996, focused mainly on the sanitation aspect, although water supply and refuse disposal is also part of it.

More than 90% of Kabul's population relies on latrines for their sanitation. The existing sewerage network concerns a very small minority. Its extension was considered in 1978 but was never implemented. Kabul latrines are elevated and constructed in such a way that the chamber receiving the night soil has a hole opening onto the street. The night soil can then either be emptied through this hole or simply flow outside and dry, or be washed by the rain. The enourmous quantity of night soil permanently flowing in the streets of Kabul remains its most obvious sanitation problem. Not only it does allow flies and other vectors to spread diseases but it also contributes to the contamination of the watershed, which happens to be very shallow in many areas of the city. Tackling night soil disposal and evacuation was therefore likely to have an impact on the prevalence and the incidence of diarrhoeal diseases.

Furthermore, helping individuals to improve their sanitation partly avoids having to rely too much on authorities, who are rarely able to assume this kind of responsability.

Results

ICRC latrines are an improvement on the existing Kabul latrines. Their design is a variation of the traditional style. This is part of a strategy to assume the participation of a large portion of the population since it disturbs fewer of the habits of the people. The capacity of the chamber is increased to reach 1 m3 with a minimum floor elevation of 1.2 m; urine is separated and directed to a soak pit in order to achieve a consistency of the night soil, which easies the evacuation; ventilation is assured through a pipe closed with a screen for fly reduction; the chamber is closed with a concrete slab and the night soil is therefore confined. These improvements can sometime be achieved for less than 25 USD without destroying the existing latrine, but in about 80% of the cases, reconstruction has to be done, and then the operation costs 80 USD. It is very important to obtain the participation of the beneficiaries in terms of materials and manpower. Every household contributes about one third of the price of the improved latrine. Since the beginning of the programme, more than **26'000 homes** have received an ICRC sponsored improved latrine, giving access to proper sanitation to more than **250'000 people**. This represent almost a quarter of the Kabul's population. By the end of 1999, the number of these latrines should reach 35'000. Four NGO implemented a similar programme in 1997 and in 1998, adding about 10'000 more latrines to this total. The area of intervention of the programme is limited to 5 of the 15 districts of Kabul. They were choosen from those most densely populated and where destitute families, often displaced, had settled. Considering that a high level of coverage of the population with access to improved latrines would prevent diarrhoea diseases, the main objective of the programme was to achieve a high level of coverage in as many streets as possible. At this stage more than one third of the streets of the working area have reached a coverage of 80 % or more.

The success of the latrine construction activity is in great part due to individual's participation, in a town where the community services have been severely disrupted. Notwidstanding, the involvement of the Municipality of Kabul was necessary to facilitate the dissemination of health messages linked with the proper use of the latrines. Different means were used such as leaflets, posters and radio broadcasting. Traditional health education is difficult to implement due to the present religious and political constraints prevailing in Afghanistan. Nevertheless efforts were made in schools to educate boys. Another aspect involving the Municipality of Kabul was night soil collection. Human night soil is traditionally used for composting and sold to the farms around Kabul as fertiliser. A large number of trucks collect the night soil in the city. This activity is very disorganised and undertaken without hygienic considerations, and often the chanbers of the latrines are left open. The Municipality has been made aware of this difficult problem and is helpful in finding solutions.

Another objective of the latrine construction activity is to train farmers in the production of safe compost from an agricultural as well as from a sanitary point of view. It appears that farmers have a tendency to prefer the use of "fresh" compost. This objective has not been implemented yet.
As a complement to the latrine construction activity, the programme financed and implemented the construction of public wells equipped with hand-pumps and of fully closed refuse containers. The area for new wells have been selected according to the needs as more

than 2'000 public wells and tap-stands are already functioning in Kabul. A sufficient number of improved latrines is a condition for the construction of a well. The maintenance of the hand-pumps is financed by the community. The refuse containers are part of a pilot project aimed to evaluate the capacity of the Municipality to assure the refuse evacuation and the motivation of the community to use the containers properly.

Expected impact

The protective effect of the latrine construction activity should be verified by a case control study whose data are currently being analysed. The data were collected in October 1998 in five mother and children health clinics around the working area of the programme. The study showed a strong protective effect from the improved latrines but accurate results are still pending.

Apart from its impact on health, two important achievements of the programme should not be neglected: on one hand, its success is very much linked to the community spirit as it encourages the resumption of solidarity with the common objective of cleaning the environment; on the other hand, promoting concerns about the sanitary conditions of every individual and its impact on the health of the community is a way to restore a kind of dignity, partly forgotten after twenty years of war.

WATER POLITICS IN THE WEST BANK AND GAZA STRIP. WHEN FOREIGN DONORS FUEL COMPETITION

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Introduction

The present water situation in West Bank and Gaza Strip offers the perfect picture of a strong society, weak state model as conceptualized by J. Migdal. The Israeli authorities have never extended full control over water access and water use in Palestinian villages, at least not over spring water and over water pumped by Palestinian wells in the same quantity as prior to 1967. The Palestinian Authority has yet to extend its control over this water. But the social control does exist. It is dispersed among a multitude of informal social institutions across the West Bank and Gaza Strip.

Scope

This paper will investigate local hydropolitical constellations in the West Bank and Gaza Strip and the manner in which foreign donors interact with them. This interaction with international actors such as development agencies has so far fuelled both dynamics at work today. One is the centripetal dynamic that draws power to the Palestinian Authority (PWA) and concentrates it in the hands of the would be Palestinian state. The opposing dynamic is centrifugal: it strengthens the water power of various village organizations and of the Israeli authorities.

Results and discussion

Two Gaza case studies will be used: the Siamat well rehabilitation carried out thanks to Canada Fund fuelled the centrifugal dynamic whereas the Lyonnaise des Eaux's work funded by the World Bank fuelled the centripetal dynamic. Two West Bank case studies will also be used: the Hebron-Bethlehem pipeline funded by USAID fuelled the centripetal dynamic whereas the Hebron pipeline funded by Germany fuelled the centrifugal dynamic. The manner in which this fuelling of opposite dynamics is exacerbating existing competitions and is hindering the process of state cosntruction will be discussed.

A typology of water actors will be drawn as well as a typology of the competitive, cooperative or exploitative relations among them. The issue of water theft will be especially examined. Water theft is responsible for more water losses in Gaza than technical reasons are. The interactions among local, national and international actors will be especially examined in the case of Dora village water theft in 1998, in Hebron district.

Emergency response to water supply shortages in Iraq with sustainable solutions

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Introduction

Today most of the Iraqi population outside the big towns of Baghdad, Mosul and Kirkuk have to live with insufficient quantities of drinking water and what they have is of low quality.

Since 1991, the drinking water situation -which relies in Iraq on highly sophisticated water treatment and pumping facilities- has been severely affected by the shortage of electricity[1], logistics, management and manpower, consumables and spare parts. Furthermore the insufficient available capacity, the ageing networks and lately the severe drought with the ensuing extremely low river levels, combined with higher pollution and salinity make the current year a particularly difficult one.

It must be assumed that even an immediate lifting of the embargo would not positively change the situation in the near future. At best, the present level of service might be maintained.

Unstable water supply and social stability

Iraq is caught in a vicious circle. Today's low level economy entails worsening public services. This results in higher health risks, and at the same time the consumer has to expend more energy to cover his needs so that his contribution to the economy diminishes. These days, the efforts that people must make just to survive are often of such magnitude that they threaten social stability.

Objectives

The primary objective is to reduce the constraints endured by the population due to the scarcity of such a crucial resource as water. Working capacities would be then better allocated into other essential social and economical sectors. Practically, maintaining a suitable level of quality in the water services for the vulnerable populations is the major operational purpose to which the ICRC efforts are dedicated. WHO's water quality standards for the consumers and efficient sewage drainage are the specific targets to reach.

Methodology and strategy

The backbone of the ICRC's strategy for emergency response in Iraq is to break the continuous spiral generated by the degradation of water services. In an environment where water is so precious, the ICRC has been addressing the most urgent needs in ways which have been adapted a lot over time. Over the past 5 years, the Water and Sanitation programme evolved from a predominantly *equipment donation programme* to a *service oriented* one. The services provided are aiming at mid-term solutions, which take into account a maximum of local constraints, while being still innovative.

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1 Due to the Gulf war and the continuous deterioration of infrastructures ever since, electrical power supply capacity dropped from 9000 MW in 1991 to 4'500 MW in 1998.

The main components of the ICRC's intervention in Iraq can be summarised as follows:

1. rehabilitation and follow-up of existing water facilities, e.g. drinking water and waste water treatment plants, boosting stations, sewage lifting stations,
2. refurbishing outdated or heavily degraded stations,
3. customised interventions, which might go as far as building a new water treatment plant.

This strategy is supported by an average yearly budget of 3.5 million USD for the ICRC water programme. This amount, albeit modest in absolute figures with regard to a 20 million population represents, in terms of purchasing power, an equivalent of between 40 and 100 million USD if spent on local products and workmanship. As a matter of fact, the local economy, which developed in isolation over the 9 years of embargo, is largely disconnected from world market realities.

The key for success is first to identify the weakest component(s) of the whole sequence then to carry out the necessary works in order not to repeat the mistakes which led to breaking this vital link(s). It appears therefore imperative to adopt a strict procedure founded on a comprehensive analysis where all 'technical' and 'human' parameters involved are considered.

Achieved results

The ICRC has rehabilitated 28 treatment plants through 1998, ensuring a capacity of 28'700 m^3/h for drinking water and 13'750 m^3/h for sewage evacuation or treatment. A total of 3.8 mio people are now benefiting from these interventions in both urban and rural centres all over Iraq.

The acceptance by the Authorities of offered services came slowly and gradually increased over the years. This change in attitude has been triggered by the oil for food programme which came into force in 1996. The latter gave the country the possibility to import equipment through other channels than the Agencies working in the field.

Once completed, the projects based on a systemic approach, increased both the yield and the reliability of the water processing chain for the end user.

Some typical ICRC interventions in Iraq are:

Interventions related to raw water supply

1. Due to exceptionally low water levels and sedimentation problems around the intake, the *Right Bank water treatment plant (capacity of 11'000 m^3/hr)* supplying the town of Mosul, 600'000 inhabitants, was almost at a standstill. The diversion of the river flow towards the intake appeared to be the only durable solution to the problem. It involved the construction of three submersible partial dams (60m long each) in the Tigris. The work was completed in only three weeks and enabled the plant to resume its normal operation.

2. *Al-Wahda (capacity of 2'800 m^3/hr)*, a smaller water plant in Baghdad, was about to completely stop its production due to the same reasons. The extension of the intake structure by 70 meters in the Tigris brought the station from near death to a new lease of life. It may now substantially contribute to cover the needs of 250'000 beneficiaries.

Pumping equipment

Because the country is flat, the water must be pumped through all the treatment process as well as through the distribution network of pipes. Thus every rehabilitation requires overhauling or replacing extensive electrical equipment such as pump-sets and control panels. The total pumping capacity installed by the ICRC from 1996 to 1999 is 21.7 MW.

Sand Filters

The sand filters are what limit the treatment capacity of the plant. Nowadays, most of the sand filters in Iraq are in a poor condition, especially in the remote stations. Lately, the ICRC has been increasingly focusing on filter rehabilitation, which comprises important under-drains repair work, and often supply of new filter media. The ICRC has rehabilitated a total filtration surface of approximately 1'200 m^2 throughout 1998.

Treatment chemicals

The chemicals involved in the purification stages in Iraqi stations are mainly chlorine and Aluminium Sulphate. In all the plants which benefit from the ICRC programme, precision dosing and control equipment are repaired or replaced if necessary.

Basrah Sewage Network

Many crucial sewage lifting stations in Basrah, the second most inhabited town of Iraq, were stopped after the Gulf war. Since 1995, the ICRC embarked on a rehabilitation programme which mainly included installation of new pumping equipment for 14 lifting stations. A total pumping capacity of 900 kW has been installed. Today the ICRC technicians are still following-up these stations. Since the sewage evacuation is fully dependent on power supply, special attention is given to the deteriorating electricity situation. Recently, the ICRC assisted the water and sewage authorities in installing 6 new generators issuing from R-986 for the sewage network, which corresponds to a total installation of 3'300 kVA of backup power.

Conclusions

Nowadays, most of the Water and Sewage treatment services in Iraq are in a very poor condition. Not only has the productivity been severely reduced, but the available capacity is more and more unpredictable. The fact that a service is available today does not mean that it will be tomorrow. Imbalance between input and deterioration continues to persist in which case, the best the ICRC and other Humanitarian Agencies working in the water and sanitation field can do right now is to stabilise the degradation.

Although specific interventions can positively affect the water and sewage services, or avoid a disaster as seen in Mosul and Basrah, one should be aware that it is very difficult to substitute for the economy of what was one of the richest oil-producing countries in the world until 1990.

The ICRC stated in 96 (cf. brochure 'Water in Iraq') *"It is important to stress that the ICRC's programme is only dealing with the tip of the iceberg. All it can do is prop up a system which really needs costly rehabilitation, proper maintenance and long-term investment"*. This remains today more evident than ever.

It would be impossible to assess the social benefits of the ICRC's Water and Sanitation achievements in Iraq. However, we believe that the risks endangering social stability have been significantly reduced, in specific locations where the water availability has been notably increased by rehabilitation of the water system.

What the ICRC has been doing over the past 4 years, that is to palliate the most problematic deficiencies in the Water and Sanitation field, has to continue but on a much larger scale, involving broad planning with all the 3 sectors.

Workshop 4

Posters

WATER RESOURCE AVAILABILITY AND SOCIAL STABILITY IN A CONTEXT OF CLIMATE CHANGE: A CASE STUDY FROM THE NIGER RIVER BASIN IN NORTH BENIN (WEST AFRICA) : AN INTEGRATED ASSESSMENT.

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SUMMARY

The study is carried out to evaluate the relationship between the evolution water resource availability and trends in climatic change in this region on the one hand, and their impact on the social stability on the other.

Because of recurrence of rainfall shortage, peasant communities have adopted new breeds and extended cotton farms, since drier conditions seems to be favourable to cotton crop, but unfavourable to sorghum which is the common food crop in this region. So on the one hand, maize and cotton become more important. On the other hand, herd migrations become longer and further toward the southern regions and along river valleys, generating social conflicts, since water resources are less abundant : rivers and rivelets dry out earlier in the dry season, pastoralists should migrate in wetlands and low grounds where farmers cultivate rice and vegetables, and even maize and sorghum, to overcome food shortage.

A tentative systemic analysis shows that, eventhough there is a steady trend of decrease in rainfall amount during these last twenty years associated with increase in temperature and larger decrease in vegetation cover extent linked with cotton farming, there is no evidence for a feedback loop between the degradation of vegetation cover and decrease in rainfall amount (KERANG Li and MAKARAU A, 1993). The survey of the spatial evolution of the classified forest of Goungoun, in the southeastern area of the town of Kandi, and of the vegetation cover of Banikoara region, has been carried out through remote sensing pictures, from 1975 to 1990 and 1992. (GUIWA,1996, BOKO and all, 1998). The regression of the vegetation cover is compared with the tendency of rainfall chronicles and with the evolution of water budget. This comparison results in a particular situation : the regression of the vegetation cover in Banikoara area is fitting with the rainfall tendency, but the classified forest of Goungoun is extending while rainfall amount is decreasing during the last thirty years. However, there is evidence for a feedback loop between pastoralist migrations and social conflicts within peasant communities, which are linked with the degradation of soil and vegetation cover. Rainfall shortage has great impact on social stability.

The outcomes of the study show that when people migrate, mainly pastoralists communities, there is a spatial transfer of social conflicts between them and farmers, because of difficulties which arise in the share of space and water resources.

Regarding the social and economic impact of the degradation of ecosystems and decrease in water resources availability, other scenarios are shaped. Each rural

community reacts according to its main economic activity, social structure (gender, relation with other communities), and relation with space and natural resources (soil property, water resources). Paradoxically, water resource shortage could result in increase in crop yield when farmers adopt new breeds which are more resistant to dry conditions. The excess of food crop yield are sold by women, and there is an improvement of gender/production relationship.

Moreover, there could be a positive feedback when pastoralists become sedentary : they help farmers in fertilizing crop fields, they cultivate food crops and even cash crops (cotton and groundnut). In general, such a situation could result in increase in crop yield, and there will be an improvement of socio-economic conditions of peasant communities.

But, there should be a threshold for mitigation strategies to overcome change in climatic parameters and water resource availability, which is not yet determined.

Key-Words : Benin, climate change, water resource, population, mitigation strategies, social stability.

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INTEGRATED APPROACH FOR REHABILITATIONS OF CANAL WATER-WAYS FOR URBAN WATER MANAGEMENT IN METROPOLITAN CITY CALCUTTA, INDIA

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Introduction

Some natural drainage systems and canals played a very important role in and around the metropolitan city of Calcutta (Lat. 22° 34' N; Long. 88° 24' E) to facilitate irrigation, transportation, drainage and sewarage, agriculture, pisciculture etc., But during the past three to four decades most of these waterways are filled-up with sediments and non-degradable wastes. Some of these are almost choked due to ill-maintenance. Almost all the canals are environmentally polluted and transformed into open sewer or wastage dumping ground. Transportation facilities along these canals had stopped several years ago thus depriving the cheapest mean of transportation and marketing of goods. Due to rapid growth of urban population coupled with incommensurate development of social facilities,this elaborate transportation network has now attained the most crucial state for environmental sustainability of the city.

Hence the present investigation has been carried out to test the feasibility of using the canals and waterways of this metropolis judiciously for the purpose of essential drainage, mass transit systems, cargo movement and improvement of theenvironmental-cum-aesthetic betterment of the city.

Case Study of a dominant Canal System

The Tolly's Nullah (28 km. in length), one major canal system in south Calcutta, has been taken into consideration for the present investigation. This Nullah has taken its birth from the original course of the Ganga known as 'Adi Ganga' which now flows as an almost dead river. This course later revived as the Tolly's Nullah played some important role in the Basic Development Plan (BDP) for the Calcutta Metropolitan District, 1966-86 formulated during 1965-66.

The Nullah was navigable enough even during the 1950s and was regularly used for cargo transportation from the seaface to the city of Calcutta. It also served the purpose of irrigation and drainage as a part of BDP. Appreciably high flood and ebb flows along the Nullah flushed the bed sediments. During spring the bore tides the water level reached heights of over 3m above the normal level.

But this situation changed stupendously with the population and pollution exposition in Calcutta during the last three decades. The Nullah bed has shallowed down with high siltation and dumping of garbage. The Nullah, by the side of the market areas, is absolutely choked into pools due to stagnation of non-degradable wastes especialy polybags. Tidal influx is very meagerly felt and this canal serves the purpose of one big sewerage drain at the present time. The canal water is stagnant, black and stinking and the bed seems to be devoid of any slope. The sediments are mostly silty with subordinate clays. Decomposition reaction in the sediments involving sulphate reaction leads to the formation of H2S in many places.

The study reveals that the response of sediments to fluid shear stress is significantly affected by their biological components. Weeds, herbs, creepers, and other bushy help trapping and binding of sediments and promote sedimentation. Organism-sediment relations also appear to be of potential value in controlling the physical properties of sediments. The degree of thixotropy is controlled by settling time, interstial water salinity and nature and composition of organic matter. Thus a pseudoplastic flow behavior os common for the sediments. All these rheological changes of cohesive sediments are based upon conditions of laminar flow in canal.

The canal mud viscosity plays a significant role in governing sedimentary processes. Viscosity variations including thixotropic effects influence sediment transport locally. Gully erosion from canal margins, particularly during the rainy seasons, dumps sediments on canal bed causing further deterioration of flow conditions.

Environmental impact assessment survey is being carried out to estimate the degree of land pollution, water pollution, pollution in water resources, public health hazards and changing socio-economic conditions of the slum communities by the side of the canal, Tolly's Nullah.

On spot survey reveals that majority of the people live in appalling unhygienic conditions in canal bank settlements with ill health and dreaded diseases. The characteristic features of this canal slum areas are substandard, dingy houses of high density, insanitary conditions, absence of basic amenities like water supply, drainage and sewarage and disposal of garbage. The collected data on physicochemical variables of soil and water of the canal (dissolved oxygen, pH, biochemical oxygen demand, organic carbon, salinity and the levels of heavy metals such as Hg, Cd, Cr, Co and Ni in the sediment) reveal a very poor and degraded ecological status.

In order to revive the health of this canal, the first step to be taken is to get back the desired depth of water so that it could be used beneficially and productively round-the-clock. For achieving this, substantial amount of dredging is urgently required together with a sustainable maintenance plan for the canal from the Government level.

Project Benefits

(a) Improved water urilization efficiency and making the very important sector of "Agriculture" to be more productive in the city
(b) Development of fisheries of the canal network
(c) Development of "progressive" forestry
(d) Improved irrigation efficiency due to canal automation and information processing network
(e) The above will drastically cut down the health hazard caused by uncleared waste and rain water in the entire area contributing to notable improvement in public health
(f) Relieving the pressure on road transport

Conclusion

There exists immense possibilities inherent in resurgence of the canals of Calcutta and the Tolly's Nullah can be restored back to a perpetually flowing water stream. A complex exercise is required for desilting and flushing operation in the canal using cost-effective and affordable technology in order to make a financially viable proposition. Canal restoration will also improve rehabilitation status of the people living on the banks of the canals.

AVOIDING COMPLETE DEGRADATION AND IMPROVING THE WATER SYSTEMS DURING THE BOSNIAN-SERBIAN WAR.

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Between 1992 and 1998, the International Committee of the Red Cross (ICRC) carried out through its Water and Habitat Unit over 4'000 projects in Bosnia-Herzegovina (BiH).The assistance provided - which ranged from the supply of water treatment chemicals and plumbing materials to the complete rehabilitation of pumping stations - covered some 470 towns and villages, addressing the needs of differents types of beneficiaries.

Although we helped schools, hospitals, displaced people centres, local Red Cross sections, etc. our most important partners were the city water boards, which received over 80 % of the total assistance provided, close to 30 millions of DM. .

The intervention in BiH can be divided in two different phases. The first one (1992-1995) was of an emergency type, consisting in the supply of equipment, spare parts, tools and chemicals, which allowed the water boards to prevent a total breakdown of their water systems.

An exemple of such an emergency assistance was the installation of 147 hand pumps in several suburbs of the town of Sarajevo in 1995. At that time, the water supply in Sarajevo was more than insufficient: all sources including the main wellfields supplying the town were on the Serbian side and both water and electricity were frequently cut. Water to the town was distributed from time to time from the gravity line of Jahorina, from two water treatment units installed out of the town and from one deep borehole located in the old city. This project was implemented in partnership with the German Red Cross and with the local authorities and was aimed to respond to the water shortage by providing technical water from the superficial aquifer, thus improving the living conditions and the security of the population, which had to collect water in a quite hazardous way.

The second phase (1996-1998) took place after the Dayton agreement and focused on the rehabilitation of water distribution networks, water treatment and pumping stations within several urban centres. These projects were launched to avoid a too drastic gap between the emergency phase and the post conflict period, with the objective to strengthens the operational capacity of the water boards and to improve the poor conditions of such systems, often due to lack of maintenance, equipment and neglect.

Workshop 5

Town planning and urban metabolism: Integrating water-waste-energy management

INDUSTRIAL SYMBIOSIS - TRADING BY-PRODUCTS

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1.0 Summery

The Industrial Symbiosis at Kalundborg, Denmark, is an environmental network that has developed during a couple of decades. Five industries and the local municipality cooperate through commercial agreements to obtain economic and environmental benefits.

The cooperation now comprises 19 part projects on reuse of water, energy and waste. All projects are based on the philosophy that one company's by-product is a valuable raw material to one - or more - of the other companies. In this way substantial amounts of resources are being saved and the annual revenues exceeds USD 15 millions.

The symbiosis industries are Asnæs Power Station, the plasterboard manufacturer Gyproc A/S, the pharmaceutical and biotechnology company Novo Nordisk, the soil remediation company, A/S Bioteknisk Jordrens and the Statoil refinery.

The cooperation has been named Industrial Symbiosis because it is based on the same principles that can be studied in natures symbiosis. Thus, the objective of the Industrial Symbiosis is to achieve economic and environmental benefits trough collaboration.

The Industrial Symbiosis in Kalundborg is often seen as an example of Industrial Ecology in practice and has reached world-wide attention as it has shown that environmental concern and business can go hand in hand.

2.0 Highlights

- Exchange of water, energy and waste between different industries.
- Reduced resource consumption and economic benefits.
- Sustainability and industrial networking.

3.0 How the different by-products are used

The different by-products exchanged between the symbiosis partners can be divided into three main categories, namely water, energy and waste.

3.1 Water

The Kalundborg district has very limited ground water resources, and the large industrial enterprises there have a big water consumption. Therefore, the enterprises participating in the Symbiosis try to reuse as much water as possible.

Previously, only municipal ground water was used by the industries, but today the groundwater has been replaced by surface water from a nearby lake, Lake Tissø.

As the water from Tissø is not an unlimited resource a lot has been done to reduce the intake of surface water. Therefore, treated waste water and cooling water are exchanged between the industries and some of these water streams are recycled in a 250.000 m^3 buffer basin. By these arrangements substantial amounts of water are being saved. Asnæs Power Station, for instance, has succeeded in cutting its annual groundwater consumption by no less than 90%.

3. 2 Energy

Six of the symbiosis projects are concerned with exchange of energy between the industries.

Asnæs Power Station delivers steam to Novo Nordisk and the Statoil refinery. Statoil receives 15% of its steam requirements while Novo Nordisk receives all of its requirements from Asnæs Power Station. Asnæs Power Station also supplies the town of Kalundborg with heat, thereby eliminating the use of 4.300 oil-fired residential furnaces. Co-generation of heat and power results in far better fuel utilization than if the two forms of energy were produced separately.

An "eternal" flare of surplus gas is part of the safety system at all refineries. At the Statoil refinery the flare has been reduced to a night-light because of internal re-use and because Asnæs Power Station use the surplus gas as fuel instead of coal and oil, when traded at a favorable price. Statoil also supplies Gyproc A/S with butane gas. There, the gas is used to fuel the furnaces for drying the wet gypsum.

A project of quite a different nature is Asnæs Fish Farm. Some of the heated cooling water from Asnæs Power Station is used by a fish farm, exploiting an increase in growth rate from the warmer water . With an annual production of 200 tons of "power station trout" Asnæs Fish Farm is performing very well.

3.3 Waste

Asnæs Power Station's flue gas desulphurisation plant (FGD), which removes sulfur dioxide from the flue gas, produces about 170,000 tonnes of gypsum a year. A part of the gypsum is sold to Gyproc A/S, which makes plasterboard products for the building industry. The gypsum from the power station is used instead of natural gypsum. It is more uniform and cleaner than natural gypsum and is therefore well suited for plasterboard production.

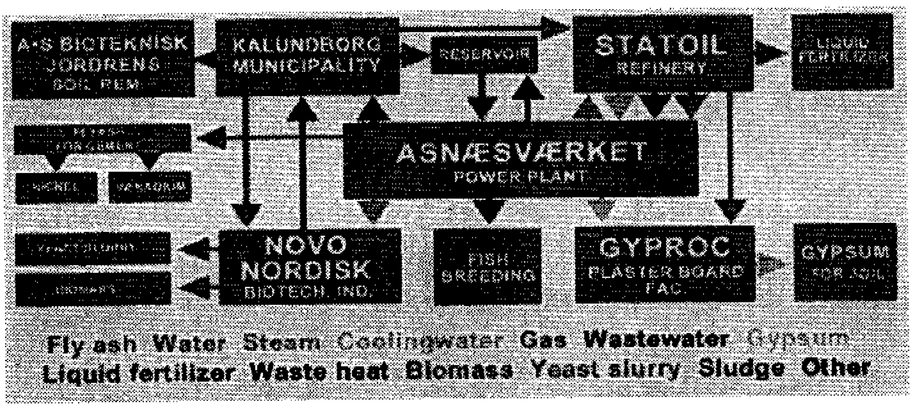
The Statoil refinery also removes sulfur dioxide (SO_2) from the flue gas, thereby reducing emissions of this substance. Pure liquid sulfur is produced as a by-product which is sold to Kemira, where it is converted to sulfuric acid.

Enzyme production at Novo Nordisk is based on fermentation of such raw materials as potato flour and corn starch. The fermentation process produces about 97.000 m^3 solid biomass (NovoGro/30) and 280.000 m^3 liquid biomass (NovoGro) every year. The biomass used to be mixed with the waste water and discharged into the sea. Today, it is piped or transported by tanker to about 600 West Zealand farmers, who use it to fertilize their fields, thereby reducing their need for commercial fertilizers.

Asnæs Power Station has an electro-filtration unit for removing ash from the flue gas. The fly ash, 70,000 tonnes a year, is used in the building industry. Most of it goes to Aalborg Portland, where it is used for cement production.

Sludge is a major residual from the public water treatment plant in Kalundborg. The sludge is utilized at A/S Bioteknisk Jordrens as a nutrient in the bioremediation process. Thereby a waste product from one process is turned into a useful remedy in another process.

4. 0 Schematic illustration of the Industrial Symbiosis



5.0 Environmental and economic aspects

The environmental strain on an area with several large industries has so far been equal to the sum of the strain of the individual industries. This means that the more industries gathered in one place, the greater the strain on the environment

This linear correlation is invalidated in the Industrial Symbiosis as residual products from one company are used as raw material in another company whereby resources are saved. In comparison, residual products of a company working independently would have to be deposited or discharged into nature and the other companies would have to purchase their raw materials elsewhere.

As indicated, the products exchanged are low economy residual products. The profit therefore partly lies in the price difference between the residual products and the raw materials and partly in the price difference between the symbiotic activity and the least expensive alternative.

The Industrial Symbiosis has so far resulted in substantial savings. Calculations show that the total investment amounts to about USD 75 millions, while the annual savings are about USD 15 millions and the savings over the 25-year period are at least USD 160 millions.

On the top of that, natural resources are saved which is valuable in itself.

6.0 An effective network model for production in the future

The main principle of the Industrial Symbiosis is to co-operate "across" the fence between different industries. There is a big potential that ought to be used, both in existing industrial areas and in new "Eco Industrial Parks". The first possibility is relevant, especially in Europe. The second possibility has been a matter of great interest in America, and also in certain countries in Asia. However little has been materialized until now, but the development will come. Industrial Symbiosis seems to provide an effective network model for cleaner production in the future.

THE RECENT HISTORY OF URBAN WASTE MANAGEMENT IN SUB SAHARAN AFRICA: THE CASE STUDY OF EMMAUS INTERNATIONAL PROJECT

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The general crisis of the eighties accelerated everywhere in sub-Saharan Africa, the government resignation in the urban waste management. This situation has brought about the creation of several associations and community corporation which aim generally at solving the problem of urban environment degradation. It is during this urban crisis period that began in Porto-Novo, capital city of the Republic of Benin, 250.000 inhatants, a new experience in urban waste management by the compost technical with the Non Governmental Organization "EMMAUS INTERNATIONAL". The waste collected is trhown on the way and treated according to an integrated approach: urban environment - economic - agriculture production.

SOME TECHNICAL DATAS

The increase of the population, the improvement of standard of living and the production have contributed to extend urban waste management in African cities and especially in Poto-Novo. Urban waste management in this city poses clearly serious health and environment problems, mainly by their composition and perceptible aspect in the urban landscape.The main infection and diseases caused by urban unhealthly in Porto-Novo can be grouped in tree distinct categories:

(i) diarrhea
(ii) parasitoses
(iii) malaria

The situation was worsened in the eighties when the municipal urban waste management services resignated and the sanitary situation deteriorated: the case of malaria has increased by 1165/year, parasitoses 9286/year and diarrhea 1938/year. The wild rubbish tips were multiplied: 5 in 1960, 11 in 1980 and 27 in 1990. Then it appears necessary to identify a new strategy to solve urban unhealthy problems in Poto-Novo. In that way, in 1989 the NGO's EMMAUS INTERNATIONAL implemented a project of collecting and valorizing the urban waste in a field about 7ha given by population in a suburbs in Porto-Novo, called TOHOUE.

THE METHODOLOGY

It consists in collecting waste by going from doors to doors with carriage on payment of 1000F cfa (about 1 dollar US) per month. The waste collected in Porto-Novo (about 20m3/day), is trhown, set to the village TOHOUE and treated according to a commercial and scientific view. The approch consists in successively developing household stamping activities, recycling non-organic waste from household (bottle, iron, bone and shell, glass...), waste water purified by macrophyte lagoonage (water hyacinth)..., and people education on these new activities. The operating procedure consists in:

(i) hand-picking of waste and recovering vegetable and animal waste for doing swath,
(ii) recovering the swath with branches,
(iii) following up the swath in controlling the temperature and humidity (65°c for a good qualirty of the compost),
(iv) watering frequently the swath and returning it out six weeks after,
(v) doing maturity and fermentation control six weeks after returning,
(vi) finally passing the compost trought a sieve and pick out the non-organic waste.

So, the compost which is obtained could be used for market-garden, maize, cassava and so on production and planting certain trees with contribute to the biologic wrestle against "the enemies of the crops" (insects).

RESULTS AND CONCLUSION

This experience from EMMAUS INTRNATIONAL, a specific example in sub saharan Africa, has rapidly proved to be the best solution of urban management, cities improving of sanitation, agriculture development and employment creation.
Today, there are more than 200 NGO's in Benin, training at TOHOUE, which collect waste in the cities in order to get job, and two majors other centers for waste treatment according to the compost technical.

In the continent, EMMAUS-TOHOUE is a curiosity and a reference as far as training is concerned in waste potentialities acoording to a commercial and scientific waste valorization in a sustainable view. This technical is not imported from industrial countries and is really adapted to Africa. It also concerns the economic operational insertion of the organic waste valorization, in one hand in waste management, in the other hand in the peri-urban agriculture production.

The EMMAUS-TOHOUE PROJECT experience is now widespread in many african countries. It is used for waste management in the Republic of cameroon, Ivory-Cost, Ghana, Togo, Mali,...and actually supported by UNDP and UE in technical and financial assistance. This experience succeeded in taking into account some factors:

(i) the people effective participation
(ii) the integrated character of the project activies
(iii) the possibility to create jobs from waste management.

KEY WORDS: Porto-Novo, urban waste, compost technical, integrated management, people participation, regional interest.

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PLANNING URBAN CO-MANAGEMENT OF WATER, SANITATION, SOLID WASTE MANAGEMENT, AND WATER-POLLUTION CONTROL IN ALTAMIRA, MEXICO

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Introduction

Rapid urbanization in the poorer nations of the world has led to large deficiencies in water supply, sewage management (sanitation), solid waste management, and water-pollution control. Three important factors contributing to water-supply and sanitation (WSS) and solid-waste management (SWM) deficiencies are: (1) the small portion of costs that are borne by the beneficiary; (2) the noncritical transfer of conventional technologies, standards, and service levels from the wealthy temperate nations to poorer, largely tropical countries; and (3) the inefficiency of the WSS and SWM systems currently in place. Important contributory causes of water pollution include the aforementioned deficiencies in sanitation and SWM, and the tendency to view sewage and other residuals as wastes rather than resources, in turn reflecting cultural and economic evaluations that impede the attainment and sustainability of a high-quality urban environment.

This paper describes the development and ongoing application of an approach to the integration and co-management of four water-related urban environmental services: water supply, sanitation, solid-waste management, and wastewater treatment. The approach consists of a set of integrated decision-making procedures to help coordinate the resources of, and share the burdens upon, the government, the community, and the private sector in providing such services in a sustainable, equitable, effective, and efficient manner. It is informed by and integrates methods from participatory planning and systems analysis, with those from the latter drawn heavily from multicriterion decision modelling (MCDM). The approach is being evaluated within a case-study framework, with applications underway in Mexico and El Salvador. Considering existing spatial variations in social, hydrological, geographic, and service-related conditions, each application will integrate issues and goals concerning WSS and SWM technology assessment, water-quality protection, sustainability of water sources, equity and consensus, system efficiency, and resource mobilization, in order to:

i) determine a broad range of feasible WSS, SWM, and sewage-treatment technologies for the urban and periurban areas in question, and define systems that integrate those technologies acceptable to all stakeholders;

ii) determine the types and amounts of finance, labor, water and energy, and other resources required for such systems; and

iii) determine the portion of each of those resources to be provided by governmental agencies (the "municipality"), the private sector, and the community.

Methodology

Although the project includes the identification of a host of multicriterion methods with which to achieve the above objectives, as well as the elaboration of a set of guidelines to select the method(s) most suitable in any given case, we here describe briefly only one such procedure, the "Hierarchical Compromise Method" (HICOMP).

Like any method, HICOMP is based on several assumptions:

Hierarchical structure

- The municipality (or utility agency) is the "central decision maker" (CDM), whose objectives pertain to the city as a whole.
- The communities, or defined zones, are "local decision makers" (LDMs), focussed on their own situation. Their concern that they be treated fairly, however, means that they will also compare their share of municipal resources with that of other communities.

Context and Relationships

- Given the disparity in service levels across communities, we assume the latter might be suspicious, and somewhat distrustful, of contributing additional resources to the municipality. They will want assurances that additional contributions they make for service improvements will apply directly to their own concerns.
- Given deficient resources, the municipality views as its main responsibility that of providing a basic level of service to each community. It may raise service levels but is not required to do so. If communities want higher levels, then this view is that they can contribute additional resources to (help) do so.

Technologies

- To protect public health, the municipality will only consider and fund WSS systems that are technically feasible--i.e., that when operated correctly will isolate pathogens from human contact.

Given these assumptions and characteristics, the procedurebegins with the utility's (CDM) formulating and solving an *initialization model* to define its *initial proposal* in terms of service objectives. The communities (LDMs) respond by specifying: (1) which service levels to fix at the levels offerred; (2) which to raise (and by how much); (3) which they'd be willing to reduce; and (4) what additional resources (over their current contributions) they'd be willing to contribute in support of their wishes. A *compromise procedure,* in the form of a multiobjective optimization model, is then invoked to produce a *compromise proposal.* If this proposal is acceptable to all parties, the procedure stops, with the service allocation and burden-sharing arrangements as specified. If the compromise is not acceptable, the procedure iterates: feedback via the four questions is once again elicited from the communities, the compromise procedure is invoked, resulting in a new compromise proposal The model itself is anticipated to be a multiobjective, multiperiod, mixed-integer program, with solution by interactive compromise programming or compromise goal programming.

The Ongoing Case Study of Altamira

The second half of this paper reports on the ongoing application to the city of Altamira, located in the northeastern Mexican state of Tamaulipas. Facing high population growth rates and large deficits in solid-waste management and sanitation, and a general lack of sewage treatment contributing to the pollution of Lake Champayan, a team of representatives from community groups, university researchers, utilities, and government agencies was formed to develop a plan utilizing the participatory MCDM approach developed earlier. With the existing situation assessed, the team is guiding the stakeholders in the use of interactive multiobjective optimization to formulate alternative WSS-SWM system options that best meet their objectives and concerns. These options include systems that variously integrate pit and pour-flush latrines, modified septic tanks, small-bore sewers, conventional sewerage, and conventional and nonconventional (e.g., stabilization ponds and wetland lagoon systems) sewage-treatment technologies, some of which include co-composting, lagoon systems, and aquaculture for fish cultivation and lake restocking.

Waste-stabilization ponds and wetland-aquaculture systems are two wastewater-treatment technologies which at present (end of May, 1999) are being studied seriously as alternatives to a conventional activated-sludge plant designed and planned a number of years ago as a wastewater solution for the entire Tampico-Madero-Altamira metropolitan region. However, now recognized as far too costly a solution, it has never been built, and, with large tracts of land available at the site, the advantages of stabilization ponds and wetland systems are becoming evident. A series of stabilization ponds would effect desired reductions in organic loadings and suspended solids as well as pathogens, before discharging into an existing wetland that drains into the nearby Gulf of Mexico. A separate set of ponds is also being contemplated just east of Altamira, to replace malfunctioning ones on the western edge of the town that currently discharge poorly treated and highly pathogenic sewage into Lake Champayan, the town's source of drinking water. The ponds' effluent would also drain into a nearby existing wetland. Both wetlands are being evaluated for aquaculture.

Although final evaluation by the various stakeholders has yet to be completed, it is clear that the procedures can strengthen government-community partnerships and facilitate resource co-management while identifying and/or formulating a number of system alternatives that (1) increase SWM and WSS service coverage, resource recovery, and employment and income-generating opportunities, and (2) reduce costs, pollution, and public health risks.

A SYSTEMS APPROACH EVALUATION OF SLUDGE MANAGEMENT STRATEGIES IN LATINAMERICA. CASE STUDY: SLUDGE MANAGEMENT IN VALPARAÍSO AND ACONCAGUA REGIONS, CHILE

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1. Background

In Latinamerica there is a growing demand for waste and wastewater handling systems in order to satisfy several demands, mainly from the point of view of health of the population. In order to evaluate correctly the different technical alternatives it is necessary to promote a knowledge transfer both at the system level and at the specific technology level.

In the 5th region, located in central Chile, with approximately 1.200.000 inhabitants, infrastructure projects are being implemented or in a planning phase in order to increase the capacity to treat and dispose sewage. The proposed installations include new or significant retrofitting of sewage treatment plants as well as sea outfalls, including mechanical and chemical treatment previous to disposal to the sea. It is expected that these installations will result in a significant sludge production.

In Sweden, a specific approach to municipal waste and wastewater systems analysis has been developed, namely the ORWARE (ORganic WAste REsearch) model (Figure 1). This model calculates material and energy flows (MFA: Material Flow Analysis) for various alternatives to organic waste handling and municipal wastewater treatment within a municipality. For evaluation, the results are translated to environmental effects using LCA-methodology (LCA: Life Cycle Assessment). The LCA-methodology is applied to compare the environmental loads of different possible alternatives to generate a product or service, and it has become a part of the ISO 14000 system, the international Standard on Environmental Management.

In order to analyse the sludge management alternatives mentioned above in a structured way, we have proposed to apply the ORWARE model, as well as relevant parts of the ISO 14000- guidelines.

This approach was presented to the international co-operation agency in Sweden, (ASDI / SAREC) which is funding the participation of the external research group during the period January 1998 - December 1999.

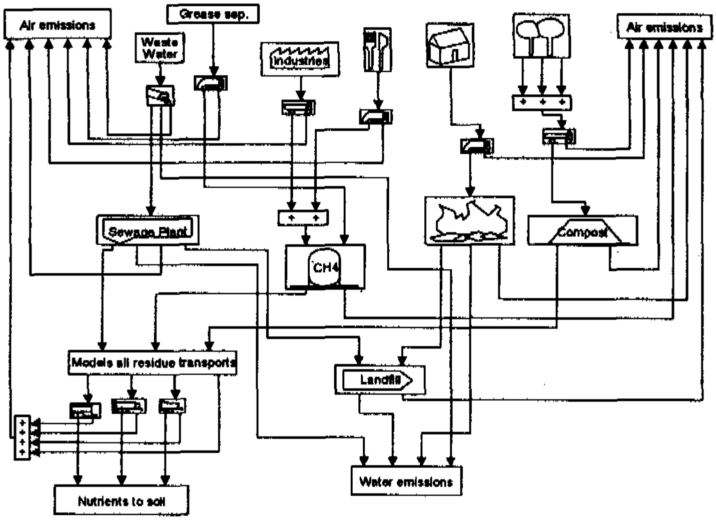

Figure 1. *The ORWARE model*

2. Objectives

The overall research project goal is to further improve the approach used in the ORWARE model to a general tool for municipal waste and wastewater management systems and to develop a methodology for evaluation of sludge management strategies which should be applicable in Latinamerica and other developing countries. Partial objectives of the present research project are:

A) Technology transfer and application of the ORWARE model for the evaluation of sludge management strategies to be applied in Loma Larga and in the Aconcagua area.

B) Technology transfer regarding sludge management technologies, including existing processes, environmental effects and costs.

C) Technology transfer regarding existing regulations on sludge management and disposal.

3. Approach

The research project is divided in two stages:

In the first stage the base-line has been established and the relevant data and documentation gathered. This included the following activities:

- Review of existing sludge management techniques and international regulations on the subject
- Review of the ORWARE model and relevant ISO 14.000- guidelines in order to assure that the data collection is correct
- Establish the relevant evaluation criteria by which the alternatives will be compared, e.g. population health, ecotoxicology, energy re-use, economy, etc.
- Characterisation of the wastewater and the sewage sludge

- Recopilation of other relevant data, e.g. location of planned wastewater treatment plants, location of landfills, estimation of price of sludge as fertiliser, etc.
- Definition the sewage and sludge management strategies to be compared.

The management alternatives chosen were for sewage chemical or biological treatment while for sludge the management alternatives were based on digestion, composting or lime stabilisation. Alternatives for final destination of the treated sludge were landfill disposal or utilisation as fertiliser in agriculture.

The environmental impact categories chosen were pathogen emissions, toxicological effects of selected heavy metals and organic compounds, energy use and generation, and emission of green house gases. Costs of management alternatives are also analysed.

The second stage, now under way, includes the implementation of the model and deduction of conclusions from the results of the model. The analysis of the results of the model will focus on:

- Comparison of the base-line alternative with other alternatives, especially regarding emissions to water.
- Comparison of sludge handling based on anaerobic digestion with sludge handling based on composting
- Indicate the limits of the ORWARE model, e.g. need for complementary study of the effects/ risks of sea disposal compared to river and lake disposal of wastewater, as well as of different beneficial uses of sludge, such as agriculture or silviculture.

4. Results

The preliminary results indicate that the base alternative, that is only mechanical treatment and sea outfall in the case of Valparaíso, has some emissions values which are rather high and may not even comply with the new standard for recipient discharge to be applied in Chile from year 2000. In the case that treatment capacity is built up either through assisted sedimentation and flotation or active sludge treatment these emissions to water are much lower and fulfill the standard. However, a higher energy use and emissions to air and soil are generated, besides the additional investment and operation costs. Eventually, the need to to build up the treatment capacity may be reduced or substituted by means of a better control at the sources, but this has not been tested in this study.

Further results of the wastewater treatment model, as well as sludge handling model will be presented at the Stockholm Water Symposium.

MODEL OF TECHNICO-ECONOMICAL ANALYSIS OF REGIONAL INTEGRATED WATER RESOURCES MANAGEMENT. APPLICATION TO THE WEST BANK CASE *(Occupied Territories of Palestine)*

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1. Introduction

This paper presents the principles of WEIRM [1], a global technico-economical model concieved for making detailed simulations of the functioning of complex water management systems at the regional scale – in the sense of drainage basins, islands, municipalities, administrative regions, or any other territorial divisions of countries.

The model simulates during one year, hour per hour, the main flows which are to be considered for global water management at this scale: *primary water* (not directly drinking) from rain, rivers, natural or artificial reservoirs (dams, aquifers); *drinking water* produced for population, firms and collectivities; *wastewater* disposals produced by population and economical activities (agriculture, industry and services); and incidentally *sea water*, from which dessalination may produce drinkable water.

2. Presentation of the model

In the *technical part of the model*, the management of these flows is described as completed by equipments whose main functions are transportation, storage, and conversions (allowing changes of quality of water) which are necessary to adapt the productions (available resources) to the consumptions by each kind of users (water demands), considering that the demands always must be satisfied. So water imports are simulated in case of insufficiency of resources, rather than shortfalls of productions. Electricity consumed by equipments are simultaneously registered, knowing that they may imply significant additionnal investments and operation costs, and so have a significative influence on the economical result. Detailed balances sheets of electricity and of each quality of water are drawn up at the end of the simulation, for one year, which will help the calculation of a global criteria for optimisation, in an other part of the model (synthesis).

The *economical part of the model* allows the calculation of the mains costs associated to the installation and functioning of all the equipments (that is investments, maintainance and operating costs), to produce other detailed financial balance sheets at the end of the simulation (year).

A *synthesis* of these results is made through the calculation of an optimization criteria, which represents the ratio between the investments which would be necessary to install all the system, and the financial benefits that one would get from managing this system during one year by selling water to the users, while paying operating costs and imports. So this criteria is homogenous to a "time of return on investments", which reveals a micro-economic view of the water resource management, but allows usefull comparisons between a large variety of technically feasible systems, and may be used to help the research of a globally opimized solution in this view of things. Other criterias may of course be used, to deal with other points of view or preoccupations – notably about environment, through the description of disposals, on which a lot of informations is also produced by the model.

[1] Water and Energy Intergated Resource Management.

So the originality of the WEIRM approach is not to put emphasis on details of the structure and functioning of the water systems at the level of the space, but :

- to rather pay attention to details concerning the management of storage systems and conversion units, through the use of a very short step-time (with hour per hour simulations), in order to evaluate precisely the capacity that each of corresponding equipments should have, according to the size of the others ;

- to include and link technical and economical analyses, which are usually separated and so become incomplete or difficult to use for helping decisions on the size of equipments and/or on the management itself ;

- to be opened and adapted to in depth analyses of problems which are directly linked to water management, such as electricity production, or environmental impacts of re-uses, generally ignored by specialized water management models.

3. Major applications and findings

This model model has been recently applied to an in-depth study of the case of Palestine (occupied territories of the west bank of the Jordan river), on which datas were collected from various sources, to evaluate the intensity of the water stress in the different economical sectors, and to discuss some technical solutions of equipment (re-uses, dessalination...), and other arrangements which could limit this stress. This study permitted to verify the aptitude of the model to help the dimensioning (optimization) of water collection, production, storage and conversion equipments for the region, as well as to examine different scenarios of evolution of the demands in long term (20 years), linked to different hypotheses on its demographic, social and economic developments.

The main issues of this application were:

- to put in evidence the difficulty of collecting reliable datas about involved people and systems, specially for what concerns their present water requirements and the perspectives of their evolution — observing that the treatment of available statistics as datas of the model leads to the reveal of avoiding important shortages of potable water in some periods of the year;

- to allow the simulation and the technico-economical evaluation of different (partial or complete) solutions to these problems, through the installation of new equipments for production more water, and/or the development of waste water collection, treatment and re-use;

- to show that the investments and operating costs implied by the electric production (required by the functioning of the water system's equipments) are always considerable, and in some cases of the same order of magnitude than the costs for water system itself;

- lastly, to define and evaluate the issues of a lot of scenarios on the long term evolutions: of the population, and of its water requirements; of the main economic activities (agriculture, industry and services); of the performances and prices of the main implied technologies (for wastewater treatments, and dessalination); of the relations (i.e. the possibilities of sharing resources and/or cooperating on some equipment projects) between the nations of this region.

Some scenarios on this application also showed that the prospects of rapidly decreasing costs of technologies for water desalination may lead to predict a hard competition, from the economic point of view, between them and the re-use solutions, to satisfy all the demands during the next two decades... However environmental considerations, introducing the necessity of taking in account indirect effects of water pollution on the long term economics, will surely give strong arguments to the re-use solutions in this competition.

Seven other applications of WEIRM on real cases (islands, municipalities, small regions...) are presently under development in the context of the european CATCHWATER project (Environment and Climate Programme of the 4th R&D), connected to other technical and economic models for completing or improving it in the corresponding fields, if suitable.

4. Discussion

After the description of the WEIRM model itself, and the presentation of the main results of its applications, the discussion will finally concern :

- the limits of the feasability and relevancy of such integrated models for helping decisions on water resources management and equipments, in various contexts ;

- the possibilities of using it in environmental studies, by developping inside it new modules concerning this aspect of the management ;

- other developments of this approach, in the sense of its generalization through its re-writing in a more powerfull simulation software called SOSIE, developped by CNRS at the end of the 80's, or in the sense of its connection to other models which will allow to integrate its results in macro-economic analyses, at the same regional scale.

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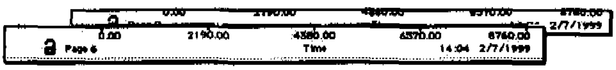
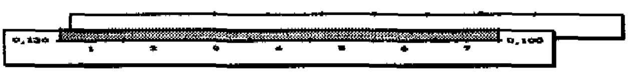
"Instrument pannel" if the WEIRM model



charge of the aquifer *(DURING THE YEAR)* Drinking water deficits



micro-economic Optimisation of the sizes of

non drinking water storage capacity of treatment of disposals

(LOCAL OPTIMIZATIONS WITHIN A DESCENT ALGORITHM, WITH DIFFERENT HYPOTHESIS ON COSTS OF EQUIPMENTS AND PRICE OF WATER)

JAPANESE PLAN FOR URBAN RESTRUCTURING USING RIVERS

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Introduction

This is a report on the recommendation made by the Sub-Committee on Rivers in Urban Communities of the River Council of Japan addressed to Minister of Construction, Japan in March 1999. Recommendation puts forward the concept of integrated urban management by revitalizing the natural function of rivers. This includes use of rivers for disaster prevention, ecological network, easily accessible waterfront, urban lifelines routes etc. It is based on various experiences of Japanese rivers in some decades.

Problems on Rivers due to Rapid Urbanization

Rapid urbanization started in 1950's created various problems in urban rivers. One was flood. Urban expansion converted green space and agricultural lands to impervious areas which made the flood concentration time shorter and the peak higher. The development of lowlands and the land subsidence by overdrafting of groundwater made urbanized areas more vulnerable to floods. The urban floods due to such changes were first experienced at Kano-gawa typhoon in 1958 and the urban flood control works started. The basic policy was the channel improvement to increase the capacity for fast drainage. Since the lack of river space in densely populated areas, the enlargement of cross section of rivers was not always possible. The river channels were then deepened and the bottom and both sides were lined by concrete or concrete blocks which eliminated most of biota from urban rivers. It was in the 1970's that such fast drainage policy was realized unable to solve the problems completely and the comprehensive flood control policy started promoting the retardation function in urban drainage.

Urbanization also depleted the urban river discharge due to increase of water intake and impermeable landcover upstream and development of sewerage downstream. Yet, since sewerage system could never catch up the rate of urbanization, a number of urban rivers were polluted and became sewerage like without biota. In 1970 the water pollution prevention act passed and in late 1970's the river water quality gradually started improving by effluent discharge control and waste water treatment.

Such deterioration of river environment together with new lifestyle introduced by the urban immigrants, the traditional festival activities with rivers such as floating lanterns disappeared and the relation between rivers and people was disintegrated in most of urban rivers.

Still worse, since the city planning and the river management belong to different authorities, i.e. municipalities and prefectures, there is a serious lack of coordination. There is no formal mechanism to directly reflect public desire to the river management. As a result, urban river works became isolated from city planning and community activities and have been directed just to serve for the flood and waste drainage. Many rivers became useless even when fires or earthquakes occurred as houses were so densely built along rivers whose water depleted and width narrowed. People cannot free to rivers even at emergency and the fire engines cannot approach nor get water from rivers any longer.

Houses are built back facing rivers and there is even no pathway that people can walk along the river. Often there is a fence along the concrete lined river to protect children to fall in. Rivers are behind the tall houses, dark and dirty. In such cases, rivers are nuisance with bad odor. All the traditional city landscape with popular and joyful water front disappeared. So did aquatic ecology. This is sometimes not just a loss of physical function of rivers but extends to deterioration of urban dwellers' soul and mind.

New Approach to Urban Planning with Rivers

The basic policy to solve those problems is to adopt and use the nature of rivers as component of urban planning rather than to keep it away or to control it to obey. In fact, there are many urban rivers in the world which serve as symbols of cities with their landscape and riparian activities. The necessary standpoints for urban planing would be:

(1) Rivers are a wide public space forming a geographical back born of urban district. Urban planning should make use of individual uniqueness of rivers such as their physical shape (width, depth, gradient etc.), flow regimes (discharge, velocity, water quality etc.) and ecology.

(2) Sound hydrological cycle in urban river basin should be maintained by conserving the retardation and infiltration capacity of the basin.

(3) Rivers should be used as a component of urban planning. A river is an urban facility like park, green space, streets etc. A river should be designed considering its continuity in landscape, utility (including flood control), environment etc. Solidarity between city managers and river managers is indispensable and public participation from the planning stage is important.

The expected utility or the role of rivers in urban areas includes the following:

(1) Rivers should serve as a buffer against fire, evacuation space, emergency transportation routes etc. They did provide water for fire engines replacing the dead hydrants as well as drinking water till water supply was recovered in the occasion of the Great Hanshin Earthquake of 1997.

(2) Rivers are the precious open space in urban area for the public to enjoy sports, recreation, ecological nature, historical and cultural interests and natural beauty.

(3) Rivers provide useful space for transportation, underground lifeline (water supply, sewerage, electricity, optic cables and other utilities) and possible use for heat pump for district air conditioning.

Concrete Measures for Implementation

The Committee report further elaborates the policies to a set of concrete measures for implementation:

Policy	Measures
Use of rivers as precious public space in urban areas	• Use of rivers as components of urban disaster prevention management providing emergency evacuation space and water source. • To make rivers part of continuous urban network of parks and green space connected by pathways along rivers. • To conserve and create natural settings by nature oriented river works and riverside woods. • To secure easy and safe access to the public including children and the elderly. • Revival of rivers once buried underground due to pollution again to open waterfront promoting the use of reclaimed water.
Utilization of unique characteristics of individual rivers	• To form attractive river landscape by coordinated buildings and river control works, wider streets facing rivers and clean water. • To make use of history, natural features and culture of the region reflected in river-related works. • To promote popular social events such as festivals, concerts, sports, cultural performance etc. in riversides. • New river-related works in concert with riverside areas, e.g. river surface extending near to riparian residence while keeping the river in public ownership. • To promote boat transport over rivers in densely populated areas for daily as well as emergency use. • The recreational use of rivers by providing walkways and water front for the people to easily see, touch and play with water. • The use of river underground for urban lifelines such as water supply, sewerage, electric cables, optical fibers as well as emergency communication lines for public as well as private use.
Development of area betterment plan using rivers	• Both prefectural government and municipalities should develop "Area betterment using rivers master plan". • Municipalities should develop "Riverside betterment projects " to realize the master plan and implement it.
Share of Roles	• Municipalities develop and implement the "Riverside betterment projects (RBP)" according to the area betterment master plans. • Local residents participate in planning of the projects to make the RBP of their own. • River administrator (Nation and Prefectures) provides necessary information to the public and municipalities and supports NPO's. • Private sector develops their private riparian buildings and space in accordance with the RBP.

Concluding Remarks

The recommendation is the authorization of many successful independent trials already exercised in various rivers in Japan. Some early cases like Tsurumi-gawa work have more than 25 years history. The institutional efforts to combine the river planning with the general urban planning are now underway in all the local governments.

Workshop 5

Posters

GREAT-ER for the Aire Basin – Application as a first level modelling tool to meet the requirements of the Water Framework Directive

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The Aire basin in Yorkshire, UK, which includes the river Calder, covers an area of over 2 000 km^2. It contains both the Yorkshire Dales National Park and densely populated and industrial areas with a long history of pollution. Major cities in the basin include Leeds, Bradford, Huddersfield, and Wakefield. This urbanisation has a major impact on the state of the local environment. At times of low flow, more than two thirds of the River Aire below Leeds consists of treated sewage effluent. [1]

The population of 1 900 000 is served by 63 major sewage treatment plants which are mainly of the trickling filter type, though activated sludge plants and some plants with tertiary treatment are also present. The dry weather flow of the Aire is 9 m^3/sec just above the confluence with the Calder, which adds another 10 m3/sec to the combined flow.

The European Surfactant Industry[2] and the Environment Agency, in co-operation with Yorkshire Water, have recently completed a three year project to develop GREAT-ER[*], a GIS model which, when supplied with the necessary hydrological and discharge data, will predict the concentrations of consumer chemicals in European rivers.[3] Hydrological, discharge, and consumer consumption data[4] have been provided for the Aire basin, for use within the GREAT-ER model.

The hydrological component of the model as applied to the Aire basin uses a digital river network on the scale of 1 to 50 000. River flows are based on the river flow predictions of the Micro-LOW FLOWS[5] model, which incorporate the impacts on flow of impounding reservoirs, surface and groundwater abstractions and consented abstractions, and consented discharges. The model provides reach-based estimates of the flow duration curve which can be used in the calculation of concentrations of chemicals at any location in the river and at any specified flow on the flow-distribution curve.

Data on the sewage treatment works infrastructure, including the population served, the type of sewage treatment provided, and effluent flow information has been supplied for the major sewage treatment works (STWs) in the Aire basin. Consumer

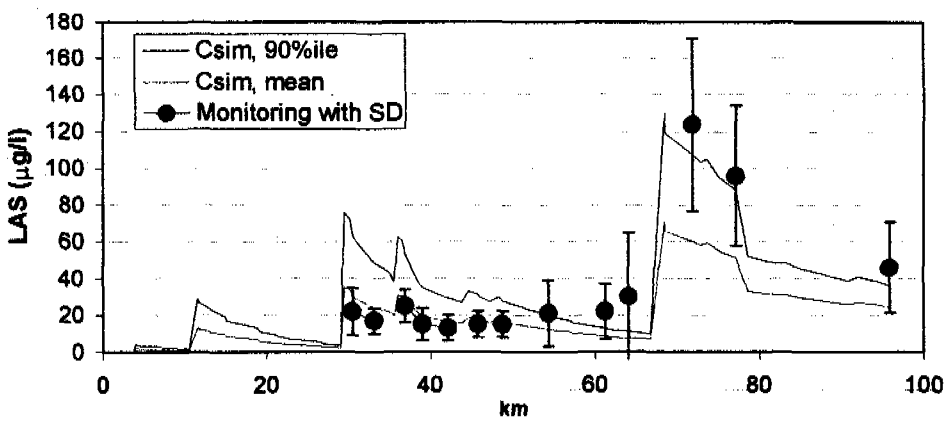
[*] Geography-referenced Regional Exposure Assessment Tool for European Rivers

consumption has been determined from local sales information, and from product data supplied by participating industries. Percentage removal based on measured data has been used to predict removal during sewage treatment. A deterministic model with a stochastic component has been used to predict in-stream removal of biodegradable components.

As an essential part of the GREAT-ER project, a validation exercise has been carried out for two chemicals, the surfactant linear alkylbenzene sulphonate (LAS), which both adsorbs and biodegrades, and the conservative chemical boron, in the Aire Basin. Over 2 000 grab samples were collected, over a period spanning almost two years, as a part of the Environment Agency river sampling programme. Effluents from the STWs were also collected, by Yorkshire Water. Analysis of water quality parameters, LAS, and boron was carried out by the Environment Agency Laboratory Service.

The results of the validation show that the predictions of mean values of both LAS and boron generally agree with the mean measured values, within one standard deviation of the measured values. The agreement is better for boron than for LAS, which undergoes specific removal processes. The few site-specific deviations can be attributed to processes not initially included in the model input, such as industrial boron input to the sewage treatment plant, or a background boron concentration of geological origin. It has also been necessary to use specific LAS removal figures for some sewage treatment works, in cases where removal was better than predicted due to the provision of tertiary treatment processes, or in some cases worse than predicted due to the presence of inhibitory effluent of known origin. As an example, the graph below shows the predicted and measured LAS concentrations in the River Aire, with distances measured downstream from Gargrave Sewage Treatment Works (STW). The model includes site-specific removal for Esholt STW (km 44), which has tertiary treatment, but does not incorporate the significantly reduced in-stream LAS removal measured downstream of Knostrop STW (km 65).

Predicted and Measured LAS Concentrations in the River Aire



The Water Framework Directive will require tools to help to predict and regulate the concentrations of chemicals in rivers. The building and calibration of operational water quality models requires collection of at least three years of monthly river sampling and effluent data. In contrast, GREAT-ER can be populated with available hydrological and effluent discharge information, and used to predict the *concentrations in rivers which can be attributed to sewage treatment works* discharges. Thus it can serve as a screening tool, to decide whether sources other than STWs should be sought for a particular site-specific concentration of concern. GREAT-ER can also provide screening information for sub-basins considered too small to warrant the building of a complex water quality model. GREAT-ER can also be used to predict concentrations of chemicals in rivers in situations in which the chemical can be measured reliably in STW effluent, but the added dilution gives measured results in rivers which are often below the analytical limit of detection.

In the UK, a project is in preparation which will extend the geographic extent of GREAT-ER to cover England and Wales, and allow variation in artificial influences to be incorporated in the model analysis protocol. Extension of GREAT-ER to other countries is actively encouraged.

The first issue of the GREAT-ER model, containing operational data for four basins in Yorkshire, one in Italy, and two in Germany, can be licensed for use by ECETOC,[6] upon request. WINDOWS NT and ARCVIEW are currently required to operate the model.

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LONG IS THE WAY TO WASTEWATER TREATMENT

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Introduction

The heading of this abstract sounds like a beginning of the popular English song. So, first of all, a fact of the long time that was necessary to substantiate, to design and to build the wastewater treatment plant for the Kaunas city, Lithuania, is emphasised. On the other hand, an image of the song helps us to pay attention to the complicated human, social and the political interrelations, that have had place in a wide sphere consisting of the initiators of the wastewater treatment; decision makers of various ranks from Kaunas up to Moscow, the capital of the former USSR; designers from the various institutions; local community containing a source of social non-stability, etc.

Scope

Kaunas is the second of the greatest cities in Lithuania (the first is Vilnius, Lithuania's capital). After the Second World War Kaunas grew rather extensively and at the end of 1980-ies it had more than 400,000 inhabitants. Various industry factories/enterprises were put into the operation, the whole infrastructure was expanded. Sewerage system was built extensively too; it served the industry, commerce and about 70% of domestic water users. The discharge of wastewater reached 300,000 m^3/d. Without any treatment this wastewater was discharged to main Lithuanian rivers Neris and Nemunas. Then it flowed to the Kursiu Marios (Curonian Lagoon) and then to the Baltic Sea, polluting everything on its way. For instance, the total nitrogen load was about 12,000 kg/day, the coliform count – more than $1x10^6$ bact/l.

It was not allowable both nationally and internationally. Lithuanian community used every possible in Soviet times way to emphasise the obvious degradation both of the Nemunas river and the Curonian Lagoon and the acute necessity of the wastewater treatment.

Lithuanian decision makers of those Soviet times understood the problem quite well and so in 1979 the first draft project of the Kaunas wastewater treatment plant was worked out. But high-ranked decision makers in Moscow did not find money for the further project development. Money was more necessary for the socialism building, for "Cold War" programmes…

The absence of the wastewater treatment plant in Kaunas, the ecological degradation of the Nemunas river was one of the main arguments against the Soviet system during our "singing revolution" in 1988-1990. When Lithuania's independence was re-established, the design of the Kaunas wastewater treatment plant got the significant acceleration. Several feasibility studies for the plant site options were carried out.

But... local inhabitants were against the wastewater treatment plant in their neighbourhood, especially those lived not far from the best plant sites. Their duality was obvious: they cried for the wastewater treatment and they cried "but not at me!". Such was that time. People had no more fear as in Soviet times; the mass media became open to every, even not serious, opinions: new-born "politicians"; Greens; used the wastewater treatment plant problem for their own popularity... The sober arguments (e.g. ours) were not listened. Such a situation in some sense caused ... the suicide of the Kaunas Vice Mayor Saulius Gricius, one of the pure-minded young politicians and Green activists. It was a sort of cold shower bath for the crowd. Moreover, Swedish specialists decisively recommended the site selected at Marvele for Kaunas wastewater treatment plant as most acceptable. They proposed their experience to work out the wastewater treatment project meeting the highest technical and ecological standards. Various social and technical measures for Marvele benefit were provided.

Then finances come from European Bank of Reconstruction and Development, from Nordic Environmental Financing Corporation, from Swedish International Development Agency (BITS at that time), Finish Ministry of Environment, from EU-Phare and Lithuanian State. The construction of the plant started in 1992. Construction process was complicated due to the lack of finances from the Lithuanian Government. Project changes due to a big decrease of Kaunas wastewater amount, caused by the industry decrease, by water price increase had to be implemented too.

Methodology

Due to the specific content of this abstract its methodology can not be described. Some its aspects can be seen from the above text.

Results and Conclusions

The main result – the first stage of the Kaunas wastewater treatment plant, namely, the mechanical wastewater treatment, is to be ready this year. It will be, without any doubt, a prominent event in the 75-year history of "Kauno vandenys", a significant step in improving an ecological situation in the Nemunas river and in the Baltic Sea.

The conclusion is that the first stage is far from being a conclusion of the work that must be done. A long way still must be gone ...

Workshop 6

Challenges to urban water management in developing countries

URBAN WATER MANAGEMENT PROBLEMS IN DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO BANGLADESH

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Introduction

The pace of urbanization in the developing world is led by Asia. Worldwide, urban population is forecast to more than double from about 2.5 billion in 1994 to about 5.1 billion in 2025. Urbanization is increasingly located in developing countries: in 1970, 50 percent of urban residents lived in these countries, these figure rose to 66 percent in 1994 and is forecast to be close to 80 percent by 2020 (United Nations 1995). United Nations 1995. *World Urbanization Prospects: 1994 Revision.* New York: United Nations.

Historically, towns and cities in Bangladesh have been few in number, and until recently, the country was largely rural. In 1961, slightly more than 5% of the population lived in the urban area. According to the 1991 census estimate, 22% of the country's population is urban. This rapid urbanization in Bangladesh, unlike in developed countries, has been occurring almost independently of any overall improvement in the socioeconomic conditions. Thus, rapid urbanization in Bangladesh, instead of being a sign of economic progress, has led to considerable urban poverty.

Current trends indicate that urbanization is inevitable and unavoidable in most developing countries, and brings substantial negative consequences. Problems occur especially when the rate of growth of the urban population is too fast and exceeds the capacity of the infrastructure to absorb and support it.

Ground Water and Surface Water

Almost all domestic water supply is derived from underground water. Groundwater, a vital source of water supply for Bangladesh generally requires no treatment. The country is almost underlain by water bearing formations at depths few meters below ground surface. Surface water sources are polluted and require treatment before domestic use. The two sources are interrelated and use of one for domestic supply or irrigation will affect water availability from the other.

The monsoon recharge to groundwater is not adequate to replenish the annual withdrawals in major City like Dhaka which is causing mining of ground water level at an annual rate of more than 1 meter. In Dhaka about 50% of water supplies demand are met at present. Surface water sources must be tapped in near future to meet the rapidly increasing urban water supply demand.

Impact of Upstream Development

As the lower riparian of the Ganges, Brahmaputra and Meghna rivers, Bangladesh occupies only 8% of the total river basin area but it is located at the point of concentration for monsoon floods generated by the runoff from Himalayas. On the other hand, during October-May lean period, it only receives the residual flow after diversion and upstream use in the dry season. Consequently, water shortage is felt all across the country and specially in the southwest region, the reduced stream flow aggravates saline water intrusion. The upstream diversion in dry season caused severe water supply problems in several major urban areas located in the southwest.

Continued development of the upstream basin will increase the disadvantages of being the lower riparian; floods are likely to increase because of deforestation of the Himalayas as well as land degradation and erosion, while agricultural growth will require even greater streamflow diversion, and this will lead to greater saline water intrusion in the coastal areas.

During the June-September monsoon, Bangladesh receives about 80% of annual precipitation, averaging 2300 mm, but varying from as little as 1200 mm in the west to over 5000 mm in the east. Runoff from adjacent riparian countries is generated by rainfall which averages 5000 mm over the Himalayas, and exceeds 10,000 mm over the Meghalaya plateau north of Sylhet. Together inflows and rainfall cause peak floods in the Ganges, Brahmaputra and Meghna Rivers in the period July-August, and on an average 22% of the country is flooded. Many urban areas including the City of Dhaka are severely affected by these monsoon floods. In the eastern regions flash floods from the surrounding hills located outside the country are a hazard in early summer and causes major damages to number of urban areas.

The problems of shortage of water supplies and floods in the urban areas of lower riparian countries are dependent on the development in the upstream, the whole river basin should be studied to resolve the urban water management issues in future.

Institutional Strengthening

Pollution of water resources, especially of drinking water, comes in many forms, from the recently detected and only partially understood phenomenon of arsenic contamination to industrial discharges from tanneries, distilleries, pulp and paper mills, textile dyeing and other chemical industries. The other points of industrial pollution are in the Karnaphulli River in Chittagong, and Pussur River in Khulna.

With the explosive rise in urbanization over the next decades, untreated sewage could easily become the most serious source of water pollution and the gravest hazard to human health. In Dhaka, the DWASA sewage system covers only one-third of the metropolitan area, and the city's lone sewage system is completely inadequate. About 70% of the Dhaka household that are not connected to sewers have sanitary latrines hooked into septic tanks, but the rest use either open latrines or none at all. Although

DOE has promulgated standards for sewage effluents, these regulations go largely unenforced.

The passage of Environment Conservation Act of 1995 has given greater power to the Department of Environment to enforce anti-pollution laws but enforcement of those are not noticeable till now. The DOE should be strengthened to prevent the deterioration of environments in congested urban areas.

Pricing Policy

DWASA is operating at a loss. DWASA have been practicing both metered and non-metered connections both for domestic and commercial/industrial connections. Water rates are low. For metered connection, the rate is Taka 3.93 (US $0.08) per 1000 litres. In order to encourage conversion from non-metered to metered connection the rates for the former are higher.
The unit water production cost has been estimated to be Taka 2.91 per 1000 litres (M3) only on the basis of recovering the O&M cost, without considering the cost recovery of capital investment, debt coverage, replacement of major components. Preliminary estimates showed that the water tariff for metered connection should be at least Taka 8.00 per 1000 litres.

People's Participation for Improved O&M

System loss (Unaccounted for water) is very high (about 50%) in DWASA distribution system. The losses are due to technical and non-technical reasons.
The technical reasons include leakage through old pipes, leakage at poorly made joints and excessive water use through non-metered connections.
Non-technical system loss is due to illegal connections, meter bypassing, manipulating the meter readings and weak and outdated billing systems.
In Bangladesh there is conventional piped sewerage system only within the jurisdiction of DWASA. And covers about 20% of the city area.
The design capacity of storm water drainage systems has reduced greatly due to dumping of garbage and polythene bags through manholes. The surface drains have been connected to the storm water drainage and sewerage systems illegally which caused severe siltation.

Participation of beneficiaries in Managing O&M activities may improve the situation greatly. It is expected that beneficiaries' participation would greatly reduce pilferage and would reduce water prices.

Conclusion

In urban areas of developing countries, similar to Bangladesh, over exploitation of ground water resources have taken place, water supplies and flooding problems have aggravated due to excessive diversion of water in the upstream. In these countries anti pollution laws are not enforced due to lack of political will and weak institutions.

Subsidies on urban water services caused serious shortage of resources and together with lack of people's participation are responsible for very poor O&M.

The proposed paper will highlight the above and other aspects of urban water management.

THE CHALLENGE OF MANAGING WATER FOR AFRICAN CITIES

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Africa is experiencing the most rapid rate of urbanization in the world. The growing number of medium and large cities in the continent face a major challenge of providing their populations with adequate water supply, with large parts of the continent facing severe water stress. African cities urgently need to put in place effective, water demand management strategies that could use the limited water resources efficiently without wastage, and widen the service coverage, particularly in the burgeoning urban low-income settlements.

A major environmental crisis is also looming large in the continent as the African cities continue to discharge ever increasing volumes of waste into freshwater bodies, threatening water quality and aquatic ecosystems. Several African cities share one or more international river basins, which present a special challenge of managing water resources in these basins, avoiding future conflicts. A business-as-usual approach to urban water resources management threatens not only the sustainability of its cities but also its precious water resources and supporting ecosystems which are closely linked to Africa's future.

The paper informs of the most comprehensive regional initiative yet to support African countries to effectively manage the growing urban water crisis and to protect the continent's threatened water resources from rising volumes of pollutants from the cities. The regional programme has been launched this year jointly by UNCHS (Habitat) and UNEP with active support from the Turner Foundation, the World Bank, the European Commission and bilateral donors.

An important focus of the programme is to put in place an effective water demand management strategy in the participating cities that could significantly improve the efficiency of urban water use and increase service coverage from existing investments. The paper highlights the key elements of the strategy which uses a mix of technical, economic and regulatory measures to demonstrate results in a relatively short time while institutionalizing measures requiring longer time span. The paper also highlights the methodology being developed for the assessment of the impact of the growing ecological footprints of large cities on the continent's water resources.

The paper also informs of the region-wide, information and awareness raising campaign for water conservation and efficient urban water use, launched by the programme, addressing policy makers, city managers and the user community.

In conclusion, the paper discusses the relevance of this approach to integrated, urban water resource management in other developing regions of the world.

ALTERNATIVE POLICIES TO WATER SUPPLY AND SEWERAGE PRIVATISATION: CASE STUDIES FROM CENTRAL AND EASTERN EUROPE AND LATIN AMERICA

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Introduction

As it was manifestly the case at the Dublin and Rio conferences in 1992, the management of water as an economic good is being promoted as a solution to the challenges facing urban water management in transition economies and developing countries. As a consequence, transnational corporations (TNCs) are enjoying significant opportunities for expansion, as policies increasingly adopted worldwide concentrate on the restructuring and privatisation of water utilities. Yet the observation of practice suggests that, especially in transition and developing countries, private sector involvement in urban water supply and sanitation is often associated with serious concerns for the public interest.

The paper is intended to contribute to the debate on the available options for local decision-makers in order to achieve an efficient and equitable use of such an essential resource. It therefore focuses on the evaluation of credible policies as an alternative to the divestiture of public assets or awarding concessions to private operators. Cross-country case studies of publicly-owned enterprises (POEs) active in the water sector and successful in, or devoted to, reconciling commercial considerations, efficiency and social purposes are presented. The case studies also highlight the ability of POEs running water utilities to carry out structural and managerial changes.

Scope

In its first section, the paper treats TNCs' activity in Central and Eastern Europe (CEE) and developing countries, with particular reference to Latin America, drawing on empirical evidence of the economic and social impact of water privatisation. In the second section, public alternatives to privatisation are evaluated. Those options vary according to the scale of restructuring undergone up to the establishment of arm's-length companies and the setting up of co-operatives.

The first case studies consider significant examples of efficient POEs in Western Europe, in particular Sweden, which testify to the credibility of alternative policies to private sector involvement. Moreover, those examples provide important lessons to developed, transitional and less developed countries alike. Such examples of successful public operation of water utilities encourage the consideration of similar experiences in CEE and Latin America, which could be more easily reproduced in other developing countries. In CEE, the cases studied include Debrecen in Hungary and Lodz in Poland. In Latin America, the impressive example of Sao Paulo in Brazil, the transformation of a public undertaking in Honduras and the activity of co-operative societies in Bolivia and Argentina are considered. The applicability of the lessons learnt to different regional contexts is finally suggested by identifying analogous experiences in other developing countries.

Methodology

The role of private sector involvement as a catalyst for investment, economic and technical efficiency, as well as rationalisation has been assessed by contrasting expectations with the observed practice. In this exercise, empirical evidence has been mainly gathered from PSIRU database.

As for the case studies of public alternatives to the privatisation of urban water systems, information obtained from the PSIRU database and the existing literature has provided the basis for further field research. In particular, data and opinions were acquired from direct sources such as the concerned POEs' management and trade unions. The choice for public alternatives is explained in the light of the observed POEs' performance, evaluated in comparison to:

a. where proposed, the rejected plans for privatisation; and
b. the experience of private management and operation in the same country or region.

Results and conclusions

In many respects, privatisation of water supply and sewerage seems to be overestimated as a factor of enhanced effectiveness as well as productive and allocative efficiency. Empirical evidence suggests that it brings distortions such as restricted competition and corruption, excess pricing leading to restricted access to water and excess profits leading to low quality standards.

The case studies presented provide important lessons for tackling the above challenges to urban water management in transitional and developing countries. Among those:

- the public management and operation of urban water systems should be taken into account more often as an alternative to privatisation;
- contrary to common belief, many POEs appear no less efficient than privatised water companies without necessarily undergoing extensive restructuring;
- POEs tend to be better at reconciling commercial considerations, efficiency gains and social purposes;
- finally, efficient public management and operation of water utilities can be observed in developed, transitional and developing countries, not only in small and medium settlements but also in large cities and even metropolis.

- ***Developed countries:*** In general, Swedish municipally-owned companies boast low operating costs and appreciable performances which exclude excess profits. Other examples of efficient public management and operation of water utilities can be found throughout Western Europe.
- ***CEE:*** In Lodz, Poland and Debrecen, Hungary local municipally-owned companies have been awarded water concessions prevailing over their private competitors in the light of the lower rates imposed as investments were assessed to encounter technical needs rather than generate excess profits. Furthermore, both companies have successfully resorted to the financial markets due to their accepted credit ratings and are thus implementing the respective investment plans.
- ***Latin America:*** The restructuring of Sabesp, the world's largest water utility serving Sao Paulo, Brazil has enhanced efficiency and effectiveness so that privatisation plans have been rejected as unnecessary. Instead of privatisation, restructuring under public ownership and management was also adopted to re-invent SANAA in Tegucigalpa, Honduras. The example of SANAA was, as a result, recognised by the United Nations as a Model Project to promote internationally. Finally, the Bolivian co-operative SAGUAPAC stands out for its record of efficiency, social equity and effectiveness, so that its example could be adopted in urban areas of other developing countries.
- ***Other developing countries:*** Other similar examples can be found elsewhere. For example, the POE of Cape Town, South Africa has undergone a participatory restructuring exercise.

EFFECTIVE INSTITUTIONS FOR URBAN WATER MANAGEMENT

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Introduction

It is widely recognized that the technological problems of urban water management are much easier to solve than the institutional problems. Building a capacity to handle the technology, and to make it effective in a sustainable way, demands attention to the political environment, organizational capabilities, legal and economic status, and the development of human potential to understand and manage all these issues and more.

The water sector has certain defining characteristics that create a unique challenge for management. These characteristics are:

- Water is a vital public good. Supplying and managing it is a social service, and almost always a natural monopoly.
- Water attracts very high political interest because of both its intrinsic importance to any community and the large capital investment needed to provide services. In many instances water services are undertaken in the public sector, and where they are in the private sector they are usually under strong political control.
- Water management in general lacks a profit motive or other market mechanism by which to measure its effectiveness. (Commercial organizations that provide services under contract to a community are a very special exceptional case.) Therefore, they have diverse goals, including *collateral goals*, such as requirements for equity, equal access, and political accountability, and *incidental goals*, such as other public works or utilities. Any of these goals may divert the organization's resources.
- Water sector organizations are dominated by technological professionals (but by no means always managed by such people). Most scientists and engineers in the profession are poorly educated in communicating with politicians and other stakeholders in their field.

Research

This presentation will describe research into effective organizations for water pollution control in 90 countries in most regions of the world. It is not very surprising that the research revealed bureaucratic organizations are less than optimally effective in delivering a service. Unfortunately, bureaucratic organizations are more likely to be found, and more likely to be tolerated, in developing countries: exactly those countries that are most in need of effective organizations to deal with the complex and numerous decisions involved in expanding sanitation systems.

Conventional capacity building efforts may exacerbate this problem. Capacity building tends to rely on a rational-comprehensive methodology, which has a strong and proper appeal for the engineering mindset. On the other hand it relies very heavily on massive data gathering exercises, falsely imputes systemicity to the real world, and produces output that is inaccessible or unhelpful to those it is intended to serve. Being promoted by organizations that are themselves bureaucratic, capacity building tends to build bureaucracy. To improve urban water management institutions, a new and more flexible paradigm for effectiveness is needed.

A survey of water pollution control institutions was conducted through the cooperation of the International Association on Water Quality. The members of its specialist group on management and institutional affairs, and other professionals involved in the management of the water sector around the world, were invited to describe the characteristics of their organizations, the specific problems they faced, and the extent to which they were effective in meeting them. Reliable responses were obtained from 130 organizations.

Findings

Using a working definition of effectiveness as 'meeting client expectations,' the survey suggested that those organizations that serve their clients best have the following characteristics:

- Flatness of structure, short chains of command, possibly with a matrix organization, and probably decentralized power
- Growing in size, or at least not shrinking
- Flexible management style, oriented to customer service and to quality of service rather than quantity
- Participative management styles, democratic rather than autocratic, inclusive and open-door rather than exclusive and technocratic
- A high degree of autonomy and a powerful, proactive approach to the political environment.

These findings are consistent with the well-known dysfunctions of bureaucracy.

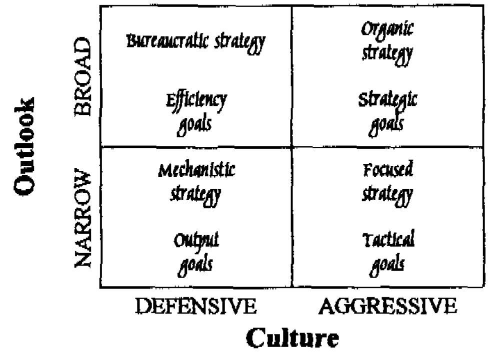
The survey also showed that the characteristics that are associated with effectiveness are most likely to occur in those countries that are more mature economically. Developing countries are much more likely to suffer from ineffective water pollution control organizations.

Further enquiry identified certain underlying features of bureaucratic organization that limit its effectiveness for water management, and revealed alternative organizational strategies that might be more effective in different circumstances. These strategies are dichotomized by having a defensive or an aggressive culture, and a broad or a narrow outlook.

Organizational strategies within a defensive culture protect members against hostility, scarcity and turbulence in the operating environment. They are characterized by a cautious, prudent, rule-bound approach. On the other hand aggressive, expansive cultures characterize organizations that seek to exploit the resources of their social environment to the maximum, even at the cost of depleting them. Bureaucratization would tend to make a culture more defensive, while empowerment would shift it to the aggressive end of the spectrum.

A narrow outlook concentrates the organization's activities on a tightly defined objective. Conversely a broad outlook allows a diversity of input to multiple processes and lacks a single-minded focus on goals. This represents cosmopolitan strategies based on affluence and stability. The difference between a broad and a narrow outlook is not one of organization size but of the diversity of inputs that are accepted. There is also likely to be a difference in the nature of control, which would be much more centralized in a narrow outlook, and more dispersed where the outlook is broader.

This reveals four strategy types: mechanistic, bureaucratic, focused and organic. They are appropriate to fundamentally different types of goals, and corresponding measures of effectiveness.



- The mechanistic strategy has a narrow outlook and a defensive culture. It is cautious, narrow and parsimonious towards stakeholders. Its effectiveness can be measured by its output: for example the number of pollution control licences issued in a unit of time.
- The bureaucratic strategy is also defensive, but has a broader outlook. Cautious, rule-bound, but diplomatic and considerate of stakeholders, it is most appropriate for dealing with routine procedures in unchanging circumstances. The effectiveness of this type of strategy should be measured by its efficiency, the amount of resources used to produce the outputs. This corresponds to the very widespread pressure on bureaucratic organizations, especially but not only those in government, to try to reduce their manpower, or to produce more output without increasing manpower.
- The focused strategy, with its narrow outlook and aggressive culture, keeps its attention on a single process. It is firm, resolute and intolerant towards stakeholders, and under very firm control. The measure of effectiveness here is the attainment of overall rational objectives: for example, reducing pollution.
- The organic strategy, is aggressive and broad in outlook, exploiting many and diverse opportunities. It is characterized by relaxed or more decentralized control. It has a positive, decisive but liberal approach, and tends to ignore rules. The effectiveness of this strategy can only be assessed on the biomorphic criteria of growth and survival. This is the best strategy for dealing with the unknown, and can be very appropriate where the priority is to build a capacity for managing water rather than dealing with a specific issue.

The choice of a strategy for urban water management in practice may well be accidentally constrained by political and organizational factors in the environment: in other words, no choice at all. However, the effectiveness of the organization can best be monitored and improved if the goals and strategies are consistent with each other and appropriate to stakeholder aspirations. Capacity building exercises need above all to recognize the validity of alternative strategies and to support those that are most relevant to local circumstances.

ENVIRONMENTAL AND SOCIAL SUSTAINABILITY OF URBAN WATER MANAGEMENT IN MEXICO

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According to the Ministry of Environment, Natural Resources and Fisheries (SEMARNAP), Mexico has witnessed an intense process of economic development during the recent decades, but this has not been matched by the needed realisation that economic development cannot be sustained over the long-term without appropriate environmental safeguards. Not surprisingly, the country now has a very deficient environmental management process. Increases in population, fragmented and inappropriate national policies, and industrial development patterns and other associated factors have promoted an irreversible urbanisation process which, due to historical, cultural and institutional reasons, has contributed to the formation of centres of dense population and economic activities. These urban centres are now facing serious environmental problems, including problems of severe water scarcities in most areas, extensive water contamination and environmental degradation due to poorly planned and managed water development projects.

Water planning and management programmes in Mexico have been developed over the years mostly in an *ad-hoc* manner. It consists of regulations regarding restrictions of groundwater use in several overexploited aquifers; water quality improvement programmes; wastewater treatment regulations and surveillance activities; aquatic weed control; and coordination agreements between users and state and Federal authorities for regional problems. However, for all practical purposes, these are examples of programmes that have neither been planned with proper technical, economic, social and environmental considerations, nor have serious attempts been made to implement adequately the programmes formulated, irrespective of their earlier well known deficiencies.

In order to meet the escalating water demands in the urban centres, the Government has almost exclusively relied on supply management and technical solutions, which have resulted in investments of hundreds of millions of dollars and the construction of major infrastructure projects for inter-basin water transfers. Long-term economic, social and environmental strategies still have to be developed to achieve more sustainable urban development and to improve the lifestyles of its millions of inhabitants.

This paper presents the main findings of the analyses of 56 Environmental Impact Statements of water projects in Mexico which were carried out by the National Water Commission (CNA). A main constraint for the sustainable urban water management in Mexico is the fact that the EISs do not provide any usable and reliable source of analysis and information for the decision-makers of any institution at any level. None of the EISs reviewed considered a holistic and integrated approach which considered potential social, economic and environmental benefits and costs of the urban water projects. In general, EISs, as currently carried out in Mexico, focus only on the "improvement in life-style" due to the implementation of the projects, which are automatically expected to happen for each and every urban water project.

Mexico has numerous environmental legislations and institutions, which indicate national concerns with environmental and the social issues. The amended Law of Ecology (LGEEPA) stresses the importance of the conservation of the environment and natural resources, including water, during the construction and operation of all projects. The reality, however, is totally different. No EIS of any water projects has ever made any serious analysis of the environmental and the social issues associated with them. Nor do the authorities legally responsible for sustainable urban water management in the country have taken their tasks seriously. For example, a main constraint of the Law of Ecology is the official evaluation process of the EIS of the water projects. The Article 35, IIIc, states that "the Ministry (of Environment) would take into consideration in the Environmental Impact Statements, ONLY the environmental implications of the projects or activities into consideration." The law does not clarify who then is responsible for the social and economic implications of the various water projects and related-activities. This is a very dangerous shortcoming, since legally, urban water projects or activities which could negatively impact upon social and/or economic issues, cannot be considered by the Ministry.

The country could significantly improve the effectiveness of both the institutional and the legal frameworks for proper environmental management of the water sector, including in the urban areas. Vertical and horizontal coordination needs to be strengthened significantly, and the division of the responsibilities between the institutions would have to be clarified. More use of economic instruments would have to be made in conjunction with the appropriate regulations. Water quantity and quality and environmental monitoring efforts need to be streamlined and strengthened, and information systems must be improved. As in many other developing countries, whatever information on pollution levels and sources is available, is withheld from public scrutiny. While there is some form of water monitoring, system needs to be improved and strengthened, and whatever information is available should be made public. Stakeholder participation to improve water resources management should be actively pursued, and not given lip service as in the case at present. Processes need to be devised and implemented through which stakeholders can participate on a regular basis.

At present, there are several alternatives which could improve the environmental management of urban water resources in Mexico. The first would be an effort by the civil society, especially the NGOs and the media, to force the Federal Government to live up to its obligations in terms of the existing environmental requirements. This has already happened in certain developing countries like India, and given some time, it may occur in Mexico. The second possibility could be certain changes in the Mexican political system, where the entire senior management of all ministries and departments are changed every six years, with the election of a new President. Thus, in late 2000, there would be a new group of top managers in CNA. If they are environmentally conscious, as they should be, the entire process could be changed radically within a very brief period. Finally, society must share the responsibilities for urban water management, especially conservation. Issues from increases in water fees, regular collection of water charges, to awareness campaigns should be seriously considered.

The biggest urban area in the country is the Mexico City Metropolitan Area (ZMCM). The Cutzamala System is the second major source of water to this area. Currently, water is being transferred from distances of 60 to 154 kms away, and pumped to a height of more than 1000 m, which requires 102 pumping stations and very significant amounts of energy. This makes the operation extremely energy-intensive and expensive. According to the EIS carried out for the expansion of the Cutzamala System (fourth stage), the total investment cost for the first three stages was $965 million (1996 prices). One of the main adverse socio-economic impacts of the Cutzamala System has been the inadequate resettlement of the affected communities, who, as of May 1999, had not received the expected compensation.

It is worth noting that the total cost of the Cutzamala System at $1300 millions (mainly construction and equipment costs) was higher than the entire national public sector investment in Mexico in 1996, in the areas of education ($700 million), health and social security ($400 million), agriculture, livestock and rural development ($105 million), tourism ($50 million), and marine sector ($60 million). Up to 1994, the Cutzamala System alone represented three times the annual infrastructure expenditure of the Ministry of Environment, Natural Resources and Fisheries for 1996, which was more than $470 million. Clearly this type of lop-sided investment to increase water supply of only one major urban centre cannot continue *ad infinitum* in the future.

The present approach to the management of the urban water supply and wastewater systems in Mexico is neither efficient nor adequate and sustainable. In order to fulfil the needs of the population in urban areas in terms of water quantity and quality, and to simultaneously maintain a proper balance between the people, natural resources, environment and health, it is necessary to develop and implement an integral management plan which should explicitly consider the interests of the different sectors as well as appropriate economic, social, technical, political, environmental and institutional factors. The importance of public consultation and involvement in preparing and implementing such plans should not be underestimated. This aspect is currently receiving primarily lip-service.

On the basis of the in-depth review carried out, it is clear that the current practices will not contribute to the sustainable development of urban water projects including proper wastewater treatment. Environmental and social issues are being ignored for the most part at present; only technical and some economic aspects are considered. Until and unless this approach changes significantly in the near future in the areas of urban water and wastewater management, the overall situation in the urban areas of Mexico is likely to deteriorate even further in the coming years.

INTEGRATED WATER RESOURCES MANAGEMENT WITH SPECIAL REFERENCE TO SUSTAINABLE GROUNDWATER DEVELOPMENT OF THE LEI-BASIN (ISLAMABAD-RAWALPINDI, NORTH PAKISTAN)

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Introduction

The following work considers ways of utilising water management low cost technologies developed in the industrialised countries and the application of local traditional appropriate technologies already available in the developing countries. This study focuses on Islamabad and Rawalpindi area, which is a drainage system of a small river called Lei-Nullah. It drains an area of about 211 km^2. About 55 % of the drainage system lies in Islamabad and the rest in Rawalpindi, and the area as a whole lies in the north-eastern part of the Pothwar Plateau, a rainfed part of the Punjab Province in North Pakistan. The two rainy seasons are the summer autumn monsoon and the winter spring rains. In the former case rain is brought by the SE wind from mid July to October and yields about 60 % of the total annual precipitation. The average precipitation in the area is about 1,220 mm, of which about 30 % (364 mm) flow off, about 56 % (684 mm) evaporate and about 14 % (172 mm) contribute to groundwater recharge. The Lei basin is recharged annually with about 36 mil. m^3 by precipitation. According to one assessments 35 mil. m^3/a flow into it from the neighbouring river Kurang. Presently total amount of about 115 mil. m^3/a is being exploited but about 70 mil. m^3/a can be taken as an average value for the sustainable groundwater development of the area, thus about 45 mil. m^3 is being over mined annually. According to one estimate, about 68 % (70 km^2) of the total unsealed infiltration area of Islamabad in the year 1981 was providing about 16 mil. m^3/a (100%) of groundwater. The remaining 30 % of the total unsealed infiltration area of Islamabad in the year 2030 will be producing only about 6 mil. m^3/a (38%) of the prognostic value of groundwater production. The partially consolidated alluvial sediments of the study area are up to 300 m thick and are the ones mainly involved in the formation of the local aquifers. The water table in Islamabad is about 10 m and in Rawalpindi about 12,5 m below the ground surface. The problems of un-scientific environmental regional planning and urbanisation, floods and droughts, aquifer over-mining and surface and groundwater contamination, improper placement of landfill sites and industry, inefficient waste treatment facilities, soil erosion are the basic environmental challenges of the areas. After the droughty year of 1994, every private groundwater exploitation has been allowed, irrespective of the effects on quality and quantity. Thus there is no longer any central groundwater control.

Till 1988 groundwater covered about 30-40 % of the total need for drinking water in the area. Yet if present trend towards urbanisation and sealing of the groundwater infiltrating surface and aquifer contamination continue, this percentage is bound to fall. The quantity and quality of surface water vary monthly and inter-annually, and the floodwater of the monsoon and winter periods carries a lot of sediments in it. The lack of sewage-treatment, landfills covering the groundwater infiltrating areas and the inadequacy of the disposal network impose a great burden on the water available, and the pollution of groundwater - especially in Rawalpindi - is ever more likely. The demographical data suggest that the need for water will grow.

Scope and Methodology

The possibilities of groundwater recharge have been analysed with special reference to the geological, hydrogeological and hydrological available data. The methods and techniques of groundwater recharge are studied for their feasibility and have been proposed for appropriate geological suitable left infiltrating parts of the area. The industrial strip lying between Islamabad and Rawalpindi should be transferred towards the southern part of the Soan river, because the waste water of these existing industries can pollute the aquifers in the thickly populated Rawalpindi area. The remaining village irrigation settlements ought to be usefully preserved as a contribution towards groundwater recharge. Water with sediment load from the monsoon and winter period floods could be used to raise the level of groundwater after having been treated through already established sedimentation and filtration plants in times of low consumption of drinking water.

Results and Conclusions

Emphasis should be placed on methods yielding shallow water instead of continuous pumping of deep and sometimes also saline groundwater. Broadly conceived measures for increasing the amount of available groundwater in the study area would improve drinking water both qualitatively and quantitatively, reduce loss through uncontrolled runoff, evaporation losses, stabilise fluctuations in the groundwater levels. The stored groundwater would be a reliable reserve in times of drought and in the case of contamination of surface water. Moreover this could repress back the an-thropogenous contamination in the south and the geogenous water burden of gypsum layers in the west.

Since losses due to evaporation at the surface in the dry period would be too high, methods of groundwater recharge would at this time be limited to those involving little water surface exposure to sun (covered trench method). Surface water spreading through flooding, ditch-furrows, basins and other methods would consist of leading surface water from rich rain areas from the NE into dry ones in the west and south via gravity flow where they would contribute especially during dry periods for groundwater recharge. Margalla Hills, National Park and other already allocated green belts should be retained free from urbanisation. To control erosion and to create favourable conditions for seepage, there is a need for forestry and other measures like „watershed management". Artificial lakes and dams are already contributing unconsciously towards groundwater recharge. Around these lakes the potential of groundwater exploitation through the technique of bank filtration along the geological suitable sites should be utilised. The chessboard regional city planning of Islamabad, as laid down in the 1960

„Master Plan", has to be corrected interdisciplinary according to the modern hydrogeological and other environmental aspects. Already available local authority should have a special department not only to collect the groundwater concerning long run data, but also to make ordinances and regulations to control the quality and quantity of water resources. Sustainable ecological solutions ought not to be sacrificed to political expedience.

The development process of the Metropolitan Region of São Paulo: Contradictory and accelerated - SP Brazil - social and environmental aspects

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This article addresses the contradictions within the process of economic development and urban growth experienced by developing countries. São Paulo synthesizes these contradictions because it is the Brazilian state that has showed the largest economic and population growth between 1950 and 1980, resulting in severe social and environmental problems.

The Metropolitan Region of São Paulo, placed in the drainage area of the Upper Tietê River basin, consists of 38 municipalities besides the capital of the state, has an estimated population of 18 million inhabitants (53% of the population of the State and 11% of the population of Brazil), and accounts for 50% of the GNP produced by the State.

Among the problems the region frequently faces, the water is one of the most representative issues. Due to the government's limit autonomy towards private interests - both industrial and real estate development sectors, it has never been able to meet the needs of the social demands and the urban infrastructure, especially those of the less privileged population. Environmental issues related to urban expansion have been totally overlooked. The consequence of the intense and disorganized occupation of the metropolis is the severe problems it presents today as to quality and availability of water resources.

The data presented here show the need for change in the attitude of the public sector. Traditional coping strategies, which created sector strategies, are among the factors responsible for the serious situation the area goes through today. Another factor was the creation of institutionalized and centralized mechanisms for decision making about investment and construction planning related to the occupation of the territory. As a consequence, it is high time we should search for alternative policies that would integrate both qualitative and quantitative aspects of water management, taking into consideration the variables involved in the occupation of the urban space and the importance of a democratic component, including the participation of the population.

The formation of the Metropolitan Region of São Paulo

In 1930, the consolidation of the city of São Paulo as the leader of the industrialization process of the country began. Public policies implemented by successive authorities have favored the concentration of industries and population, fostering migration movements and the transfer of capital from coffee plantation into industrial activity.

The occupation of the territory was defined by the logic of urban/industrial concentrations, which explored enormously natural resources, liaising closely with the economic interests of the real estate sector. In the 30's, the industries were settling down near the headwater of Tietê River, along the railways, due to the existence of large prairies, abundance of water and transport advantages for shipment of the production.

Peripheral spaces were occupied, originating industrial and residential suburbs.

The accelerated growth of this peripheral area[1], together with the low urban pattern, has spread into all directions. In the 60 and 70's, the problems became even worse, multiplied by important social differences, which led to lack of housing, transportation, sanitation, leisure areas, highly polluted air, water and soil, waste contamination, and consequently, the increasing degradation of the quality of life for most of the population. The demand on habitation became critical. A disorganized occupation was then experienced and areas for the production of supply water were also affected.

The dramatic transition from an almost exclusively rural population into indexes of urbanization higher than 95% in just few decades and the concentration of a significant portion of the national economic activity into a somewhat limited territory resulted in an unheard-of concentration of population. Moreover, the lack of sector policies integration, as well as the absence of conciliation between public and private interests, originated conflicts regarding the different potential uses of water, leading to floods, pollution, silting, etc.

In the 70's, in order to cope with the problems arising from the disorganized growth of the population, legal instruments were created, such as the Metropolitan Plan of Integrated Development, the Metropolitan Region (1973) and the Water Source Protection Act (1975). However, they did not prove to be effective in preventing the occupation of land, and the resulting degradation of the quality of public supply water sources.

In the 80's, the crisis was aggravated because of income reductions for the majority of the population, dropping drastically the public investments made on the social area. The main consequences of this process in our days are: dilapidation of natural sites; disorganization of infrastructure networks; aggravation of social problems on the outskirts of town (illiteracy rate is 7.8% for people older than 15 years; children mortality rate is 27/1000 live birth - Data from 1997); involvement of public financial systems; invasion of areas that should have been preserved; excessive expansion of the urban system, and the creation of segregated areas bearing poor urban quality that were designed for low income families.

Water supply, sewage systems and industrial loads

According to information provided by the State Company of Sanitation, there are 89m^3/s of superficial water available at Upper Tietê basin. Although it may seem a lot, urban and industrial effluents of the metropolis already require the largest part. From this total, only 26.2% m^3/s are used for public supply. Added to 32.8% m^3/s coming from nearby basins, it amounts to 59 m^3/s of average production of drinking water. However, there is a loss of approximately 20% of the total amount produced by the distribution network.

In 1996, the average demand of consumption was 59m^3/s and the difference between the supply and the demand justified the supply in alternate days in high-risk areas.

In 1990 the Upper Tietê basin received daily discharges of organic material estimated on 1,100 tons. Thirty percent of this pollution load was generated by industries, also responsible for the daily discharge of 4.8 tons of inorganic loads that

[1] Between 1930 and 1960, the urban region grew 9 times and between 1974 and 1980, it grew 46.2%.

polluted the river with metals, fluorides and cyanides. According to the values obtained for the Index of Water Quality of Tietê River, in the portion that constituted the basin the quality of the water varied from very bad to bad throughout 1995.

In 1998 the household sewage collection system serves approximately 80% of the total population of the Metropolitan Region of São Paulo. Only 40% of the collected sewage is directed to the treatment plants (the real capacity is 55% of treatment); the remaining part is discharged in natura on watercourses.

For the future it will be necessary about US$ 500 million to finish the main works of the water supply network, and about US$ 4 billion to have the wastewater treatment plants completely built.

The 90's: applied strategies for problem solving

Owing to this problematic situation and supported by the democratization process under consolidation in the time, in the 90's the State started to transform its traditional practices of policy making. In 1991, Act 7.663 turned into effect, creating the Integrated System of Water Resources Management. Through decentralized, participate and integrated management principles, it integrated the management of qualitative and quantitative aspects of water resources, considering the watershed a planning unit.

A revolution took place in the management of water resources, since technicians of the state and municipal authorities, representatives of non-governmental organizations and business people in general started to debate the aspects regarding the definition and the implementation of policies in new meetings named Watershed Boards, and within the state structure, integrating the Committees in an Advisory Board. Besides, technical data have been made available in order to support the definition of the allocation of financial resources, available in the Fund-FEHIDRO. The Upper Tietê Basin counts on a very active Committee and Sub-Committee, besides the Technical Boards composed similarly to the Committees and that should support decision making.

Another issue that is also being discussed, as part of the System of Water Resources Management is the water charging (as an instrument of planning). The Draft Law was handed in and is waiting for approval in the Lawyer House. After its approval we will have another source to implement our policy.

Obviously, problems are not completely solved, but they seem to be properly taken care of. A continuous challenge is the protection of water source supply areas, strongly affected by the urbanization process previously described. Legally speaking, pursuant to Act 9.866, it is guaranteed that supply water is a priority of public supply, that all activities regarding the area should be integrated with habitation and environmental policies, and that effluent discharges in the water are expressly forbidden. However, the controversy still remains between intended and obtained profits of the construction sector and the need to guarantee room for water production.

Nowadays, groups are being organized in order to negotiate environmental goals and actions, welcoming all parties interested in occupying such areas or already doing so, so that everybody feels responsible for them.

Moreover, the state government presently tries to protect and recover the main water source areas that supply the Metropolitan Region of São Paulo, by applying projects of de-pollution and conservation, financed by the state treasury, IDB - Interamerican Development Bank, IBRD - International Bank for Reconstruction and Development, and OECF - Overseas Economic Cooperation Fund (Japanese Government).

Tietê Project - Started in 1992, it consists of various programs, including sewage treatment. Its goal is to improve gradually the quality of the water in Upper Tietê Basin and Billings Dam.

Guarapiranga - Guarapiranga's reservoir, producing approximately 12 m^3/s, is one of the most important water sources of the region. It is responsible for the drinking water supply of nearly 30% of the population of the region. In its watershed, almost 300 illegal housing developments contribute to the pollution of the water source. In order to recover the quality of the water, the Program provides an investment of US$262 million, divided into US$119 million sponsored by the IBRD and the balancing part provided by the state government and the municipality of São Paulo. The priority of the program is to build basic sanitation works, benefiting an estimated population of 600,000 people. Objectives of the program: water and sewage service, collection and final disposal of waste, urban recovery, projects of environmental protection and watershed management.

Billings Project - The mission of the project was to enable the optimization of the multiple uses of water in the Upper Tietê Basin, especially in the Billings reservoir, giving priority to public supply. Owing to governmental policies and proposals approved by all the parties involved in the project (Environment, Energy, Water Resources, Sanitation and Construction State Agencies) the main use to the Billings water is to serve the public supply. The project provides numerous actions, some of them being carried out presently, such as: water catchment in Billings armlets to supply the population improvement in monitoring and quality information system; improvement in the water quality of Tietê and Pinheiros rivers and Billings; control of floods; improvement in the operational management model of Upper Tietê System, and institutional articulation.

The water sources protected, the water supply network finalized, the wastewater treatment plants working are the urgent targets to the Government. Our main challenge to attend these goals is to obtain the financial support.

CHALLENGES TO URBAN WATER MANAGEMENT

(Review Iranian Experiences)

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Introduction:

Iran, with an area of 1,648,000 km², and a population of 60 millions is located at vicinity of both dry and wet regions, therefor the climatic condition of the country is very varied. Annual rainfall changes from 25 mm in Loot desert to about 2000 mm in the Caspian area. However, Iran is not a rainy region except for some parts at North. Mean annual rainfall is 251 mm with the amount of 416 BCM. Evaporation rate is 296 BCM per year, which is about 72% of the total rainfall. Total water supply of the country is 82BCM from which, 76 BCM is used in agriculture, 5.0 BCM for domestic and sanitary use and 1.0 BCM for industries. 96% of the urban population are benefited from water supply networks.

Constraints:

Water crisis in Iran that is located in a semi-arid region, is most probable in near future. Therefor wise solutions should be considered for this oncoming problem. Some of the important constraints are as follow:

1 – Limitation of water resources

Data shows that the average precipitation over Iran is about 416 BCM from which only 135-140 BCM can be used as renewable water resource. At the present time we are using some 82 BCM of that. It is estimated that this figure will be 112 BCM by the year 2020.

2 – Population growth

Urban population increase and development of towns and their effects on the quality and quantity of water resources have made the feature of urban water supply to be unsustainable. The population of Iran has increased from 18.9 millions in 1956 to almost 60 millions in the year 1996, which is more than three folds. In the past 40 years, urban population has increased 6.18 folds while the rural population has increased only by 1.79 folds. However, creation of population poles without any consideration regarding water supply or planning beyond the capacity of natural water resources, has caused the problem of water scarcity to be more sever.

3 – Decreasing per capita of renewable water

Although we have more than 135 BCM of renewable water, but because of the economical, technical and environmental limitations we have not been able to use all of it. Therefore by the year 2020 we will not be able to utilize more than 112 BCM of either surface or ground water resources.

Based on population increase, per capita renewable water has decreased from 5800 CM in 1956 to 1830 CM in 1996 and will be 1200 CM by the year 2020. It seems that per capita renewable water has decreased 5 folds during the last 65 years. So new generations have to live with same amount of water although their need will increase.

4- Non uniformity of rainfalls

Distribution of rainfalls over the country is dramatically non-uniform, 56% of all precipitation covers 30% of the country whereas the rest of the country receives 44% of the rainfall. Annual precipitation ranges from 1800 mm at North to less than 50mm in central deserts and southeast of country. 50% of surface water flows at times when not needed. 50% of the total population live in western part of the country, which consists of 70% of the water resources.

5- Degradation of water quality

By increasing the population and industrial development, more wastes are produced for contaminating the water resources. Wastewater and chemicals from agriculture or industries are the main source of water pollution. The most important sources of water pollution are: 4.6 BCM per year of urban and industrial wastewater, 27 BCM of annual agricultural return water, 38000 tons of daily urban solid wastes, 253 tons of daily hospital wastes, 27590 tons of yearly pesticides, and 2,500,000 tons of yearly fertilizers. Nitrate contamination of ground water in Mashhad has been recorded to be more than 189-mg/l. Salt intrusion is also a big problem in those aquifers close to desert areas.

6– Over-withdraw of ground water

Most urban water used in Iran is supplied from ground resources, such as wells, qanats, and springs. Because of the over–withdraw, we are faced with a negative water balance in most of the plains. In 1993, more than 26 of watersheds (from the total 37 in the country) have been facing with over-withdraw. By 4.85 BCM of over withdraw each year, the ground water level is dropping between 0.23 and 3.68 meters each year. Subsidence, and salt intrusion are another consequences of over-withdraw.

7– Increase of demand

Besides the population growth, because of the higher level of living standard, the water use per capita is also increasing. In Tehran, water use per capita was 247 liter/day in 1986. However in 1996 this rate was increased to 353 liter/day per capita. Therefore water supply for this city increased from 98.43 MCM in 1966 to 870 MCM in 1996.

Countrywide, per capita demand is 242 liter/day and water supply has increased from 200 MCM in 1956 to 3.8 BCM in 1998. It is also anticipated that by the year 2020, the total amount of 7 BCM will be needed for urban uses.

8- Necessity of delivery of water from remote areas

Population increase and limitation of water resources has made the decision-makers to think of delivering water from remote areas. For this purpose, at the present time there are 15 projects for water delivery from 20 to 330 km by pipes up to 2000 mm in diameters. In most cases pumping to high elevation is required.

9– Allocating agricultural water for domestic uses.

In many cities, because of the lack of water, allocating agricultural water for domestic uses is inevitable. In 2020 almost 65 cities may use the water which is now being used for agriculture.

10– Higher costs of the projects

Regardless of the increase of annual cost due to inflation, the cost of the implementation of water projects is increasing rapidly. It is estimated that supplying 2.1 BCM of more water to meet the demands of the population in the year 2020, some 84.4 Billion dollars will be required.

Strategies to overcome constraints:

Since we may be faced in the future, with both lack of water and degradation of water quality, and there is no clear sign of new resources, some strategies should be applied in water resources planning. These are: water recycling, increasing water use efficiency, and reallocating the water rights. Our specialist have now agreed that the most effective strategies are those which include the long-term conservation of water. Here, I would like to point out some of these strategies.

1. Integrating urban water and wastewater management.

One of the most effective actions that took place at the beginning of this decade was the integrating management of urban water and wastewater affairs. This was achieved by the establishment of the provincial water and wastewater companies. These companies are based on clear concepts such as decentralization, public participation, non-governmental organization, unified regulations, upgrading technical skills and high efficiencies of manpower. The model in which independent water and wastewater companies are established in the provinces and the national water and waste water engineering company is supervising them, is called "orbital model".

2. Conservation of urban water

After a fundamental reform in the management of water and wastewater, next strategy was the conservation of water. In planning this strategy, the national program of unaccounted for water is being studied. This plan was started in 1995 and up to now it has covered some major cities. As an example, the amount of unaccounted for water in Tehran is 42%. At least some part of it can be saved and used as a new source of water.

3. Multi-use of water resources

Reuse of wastewater and the use of potability of water before any use in agriculture or industry, is also one of the important solutions in those cities with limited fresh water resources. As an example, we are following this strategy in Mashhad (the second greatest city in the country). So, the farmers should offer their fresh water for domestic consumption. Instead they will receive the equal amount of treated wastewater for their agricultural uses.

4. Water quality control and management

In our country degradation of water quality means the losses of some part of the quantity of available water. Water quality degradation may cause the country to reach the crisis point sooner than the expected time. For this reason monitoring the quality of water resources is vitally important for us. Establishing the special commission with full authority in this respect is one of our goals to achieve this strategy.

Conclusion :

As it was mentioned above The model in which water and waste water in the Iranian Cities, is managed, is called "orbital model". This model is based on the goals of the Islamic Republic of Iran Government .

The management of the above mentioned model has caused a fundamental evolution in the Iranian water and waste water industry and has brought new capabilities such as , improving the productivity, developing man power abilities, developing industries , people participation and self sufficiency of the water and waste water units.

Application of the above model for the water and waste - water management in the other developing countries can be recommended.

PARALLEL WATER SYSTEMS IN DAR ES SALAAM, TANZANIA.

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Introduction

In developing countries, the way people acquire and dispose of water varies considerably. While piped water may be the norm for richer urban households, the poorer segments of the population often struggle with a number of alternative means for accessing water. However, many more factors than wealth are involved in shaping the local water system, and these factors are explored through research on institutional forms of water provisioning in Dar es Salaam.

Water vending, by informal street vendors or organised truck suppliers, is an important complement to Dar es Salaam's piped water supply system. Most of the bulk supplies to the city, from the river Ruvu and complemented by boreholes, are undertaken by Dar es Salaam Water and Sewerage Authority (DAWASA). However, as only about a quarter of the households have direct access to piped water, the water distribution is mostly in private hands.

Scope and Methodology[1]

The paper emanates from a research project for exploring the heterogeneous political, social and physical urban landscape, aiming to explain how and why intra-urban variation in modes of water provisioning occurs. The historical and spatial development of formal and informal institutions around water provisioning will be examined through a series of case studies of different areas in Dar es Salaam, Tanzania. Drawing upon a range of existing explanations of how such institutions develop and reproduce, the case studies will be synthesised in a multidisciplinary analysis.

The present paper is concerned with the informal business of water vending – the main water distributor in areas where water is rationed or household connections are rare. A 'snowball' questionnaire survey was carried out in four areas of Dar es Salaam, where the municipal water supply is problematic. Residents in Buguruni and Temeke have to cope with rationing, those in Tandika with very low pressure, and in Kiwalani there is currently no municipal water infrastructure. Street vendors make up a large part of the shortfall in these areas.

Results

Street water vendors are in some areas the main water distributors to both households and restaurants. They use pushcarts to carry six or seven plastic containers, which when filled to the rim, carry some 22 to 25 litres of water. Thus, the load can weigh up to 175 kilos, plus the weight of the (iron) pushcart itself. Many vendors suffer pains from this

[1] Fieldwork to date has been supported by Ahlmann's and Lagrelius' funds for geographic research.

heavy trade, and so do the flimsy bicycle tyres, especially where roads are not paved. Thus, most vendors sell from a fixed station, and deliver water to customers when called upon.

The more established vendors usually have a few customers to deliver to on a regular basis, and some would honour these stable sources of income with a discount. Vendors usually obtain water at 20 shillings[2] per container, and resell to consumers for between 70 and 150 shillings. When water is difficult to obtain, the price to consumers climbs. At times of severe water scarcity, some had sold water for over 700 shillings per container. The retail prices seem to be determined mainly by the amount of work that go in to securing that water. Even in times of acute shortage, most vendors buy water at the normal wholesale price (20 shillings per 20-25 litre container), or only slightly higher. The increase in the retail price is motivated by having to walk and queue for hours in order to obtain the little water there is.[3]

In Buguruni and Temeke, end consumers suffer supply interruptions because of rationing on behalf of the water authority. In Buguruni, rationing is done through allowing water to flow only on certain days of the week (two days per week in the studied part), while in Temeke water flows certain hours per day. Consumers respond by investing in water storage containers and tanks. Some households and institutions have very large reservoirs, and sell water to vendors during the 'off' turns. With water turns in Temeke being more frequent (usually two turns per day), and deep wells (operated by DAWASA) located in the area, vendors in Temeke would under normal circumstances not have to venture too far away from their customers in order to draw water. On the contrary, in Buguruni, with no water in the pipes for days, and no boreholes, water has to be hauled over long distances. This could be an important factor rendering the retail price in Buguruni (generally 100 shillings per container) significantly higher than that in parts of Temeke (70 shillings).

Households go through a lot of trouble to secure water in Kiwalani, one of the poorer areas of Dar es Salaam, and also considered to be the start-off point of cholera outbreaks. The paucity of water infrastructure requires vendors to collect water from far outside the area. This is reflected in the higher sales price of 150 shillings per container. However, water vending does not feature as strongly as in the other areas, probably reflecting the lower economic status of the residents. Thus, the women householders themselves carry out most of the labour. They collect water from shallow wells or at one of the recently sunken deep wells (supported by Médecins sans Frontières). In Tandika[4] there seems to be no planned rationing, but the supply is irregular, and in particular, the water pressure is low. To overcome problems of low pressure, people have dug holes in the ground in order to tap the water at the level of the underground pipes. Still, the little water in the pipes cannot cater to the needs of the residents, and vendors bring in much of the water used.

[2] At the time of the interviews, there were about 670 Tanzanian shillings to a US dollar.
[3] Thus, part of the 'rental value' of the water is 'dissipated' by vendors spending their time queuing.
[4] An interesting feature in the Tandika area is the presence of (four) women water vendors – a trade otherwise completely dominated by (younger) men.

While these parallel systems for accessing water are all interdependent, the end prices paid by consumers vary considerably. Vendor users (both truck and pushcart deliveries) pay around 4 shillings per litre. Households with a connection to the public water supply pay the lowest price, 0.2 shillings per litre. (Expatriate households pay 1.1 shillings/litre.)[5] People collecting water themselves from public standpipes or neighbours tend to pay around 0.5 shillings per litre (10 shillings per bucket/container). To connect to the municipal piped system requires the payment of a connection fee and the cost of piping. This makes it difficult for poorer households to access this cheaper source of supply.

Conclusions

The different water systems in the studied areas are the outcomes of the unique constellation of the public supply conditions, as given by DAWASA, voluntary initiatives by individuals and (foreign) organisations, as well as the actors on the secondary water market. The private, commercial and community initiatives compensate for the shortcomings of the public water distribution system, and should thus be seen as help towards meeting the city's demand. Any attempt by the authorities to eliminate some of these parallel systems would result in much hardship. Continued co-existence of these interdependent systems is clearly necessary.

Notwithstanding, residents of disadvantaged areas currently suffer from inadequate water supply by way of poor health and economic hardship. To keep informal water prices to consumers down, it would help if DAWASA would reduce rationing or increase the frequency of 'on' turns. Thus, the price augmentation to compensate vendors for long and cumbersome haulage distances would be diminished, or disappear altogether. Still, to stop rationing would probably save water in the long run. The necessity for households and intermediaries to store water at almost every point in the system certainly leads to wastage, as some proportion of the safety margin will inevitably be lost. Furthermore, with pipes being empty most of the time, unintentional breakage of pipes will rarely be detected – and certainly not remedied.

To improve the situation, emphasis should be put on a more abundant and stable supply to disadvantaged areas. A more efficient municipal water distribution system (with more taps and fewer leaks) is key to addressing the current inequities. Most people in Dar es Salaam would certainly welcome this, and up to some point also the vendors. A very efficient distribution system would of course eventually drive vendors out of business. However, there is currently a large scope for bettering supply and at the same time improve working conditions of vendors.

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[5] It should be mentioned that most households in Dar es Salaam do not have water meters, and therefore pay a flat rate. Households that have their supply rationed pay the minimum rate.

CHALLENGES TO URBAN WATER MANAGEMENT IN SRI LANKA

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Introduction

Sri Lanka has 18 million population in 65519 sq km land area, out of that urban population is 3.8 million in 1998. Main urban population concentrates in Greater Colombo area. The high density of population concentrates in Western Province with 1/3 of population. The coastal area also has 1/3 of population due to its productivity. The high density Districts are Colombo, Gampaha and Jaffna due to its productivity in agriculture, industries and commercial ventures. Second level density is recorded in Kalutara, Galle, Matara, Kegalle and Kandy Districts due to its water resources and productivity. Jaffna lies in limestone region, which has ground water resources than surface water. Wet zone relies on surface water runoff and shallow ground wells provide drinking water to households. Traditionally this water is utilized for drinking, bathing, cooking and washing covering wide range of water supply. Jaffna limestone region uses deep wells with "andia" leverage for all activities.

At present 76% of 3.8 million urban people are given water supply. Those who live in MC, UC, TC limits were considered as urban and others were considered as rural. Many urban areas are situated in the coastal belt where the supply is mainly from the perennial rivers, which originate in the central mountains. Coastal cities had the hazard in recurrent flooding and many areas were abandoned as low- lying areas without permanent housing. Safe areas were traditionally occupied but due to its population explosion unsuitable areas are becoming residential with a high demand for drinking water. Colombo has the highest demand for future residence as the big markets, schools, hospitals, state machinery and banks are located with a main sea port for loading and unloading of containers. Many businessmen live in Colombo. Present trend of partitioning land and selling for a new residential block increases the population.

Water supply and sanitation methods and limitations

Wet zone towns rely on storm water, which collects into a supply reservoir. Few towns directly tap water from the main stream. The gravity system helps the distribution but otherwise pumps are used to elevate filtered water from the deep well under the riverbed. This purified water is then aerated and flocculated using alum. Water is then chlorinated and filtered and lime is added to attain basicity. This water is pumped to distribution tank and finally released to consumers. The coliform count is reduced to 10 % of samples. The domestic effluent is added to ground water and people do not use it.

40 % of urban population use public stand posts provided along the roads. People collect water by pots and same place is used as a bathing place. This free supply encourages the resident to expand any housing unit in the vicinity. The supply tank is designed for a definite capacity and daily output is limited. In all towns maximum

capacity is reached before the expected dates. This was well marked before 1991 when water meters were not fixed. In 1998 all domestic, commercial, industrial and subsidy connections are metered. The wastage is now arrested and the consumer is monthly billed. During dry periods the supply is limited to few hours. In Galle project salinity is mixed with water at the intake. Bowser supply is used to meet any urgent or difficult situation. Isolated towns have different water strategy to meet the need. Puttalam water supply has high hardness and people use a tube well for drinking. Wet zone storm water is soft and people migrate to coastal towns to get good quality water. Dry zone water has excess fluoride but people drink it without any alternative.
For 6 years demand management Rs 63 billion is estimated. The demand will be doubled.

Tariff structure

Water supply is a state duty. 50% of the supply cost is passed on to the urban consumer. The balance is supplied by the state. Commercial sector for industries and hotels pay a higher rate while the domestic rate is limited to 1% of the per capita income (US$ 650) with exponentially increasing slabs for water use. Water subsidy is 85% for rural schemes. Charity organizations and state services get it freely. The annual increase is proposed to meet the operation cost and interest on debt component but ministry of planning decides the increase according to state policy. This situation encourages rapid urbanization. Illegal tapping is also recorded in many areas. The capital cost is obtained from foreign sources. New projects are undertaken with foreign funding, as the local funds are limited. When the house connection is given, ground water well is abandoned. To meet interruptions a storage tank is necessary for every house.
Rainwater harvesting is necessary in future to meet water demand.

Discussion

76% of urban population get water supply and 40% use public stand post supply. Only 20% are fortunate to get 24 hour supply. Consumer constructs his own storage and distribution system, which needs demand management practices. Present sanitation system uses more water, which has to be modified by new methods and practices. Treated water is used for gardening purpose but rainwater is wasted down the drain. Rainwater tank must be erected to cater to non-drinking needs. This will be a definite issue in the next few years. If water rates are increased, automatically people will reduce treated water use.

Conclusion

Projected demand for 2020 in Greater Colombo area alone is 0.915mcm / day (90% of domestic capacity) and present capacity is 0.546 mcm / day, which is equaled in year 2000. The financial requirement for domestic supply alone is Rs 63 billion. NWS&DB can earn Rs 4 billion with Government and donor funding for Rs 24 billion in over 6 years. Balance of Rs 35 billion is left for private sector investments and NGO mediation.

The tariff structure shall be modified from present subsidized level to viable level by

incorporating following slabs.
(a) The life-line slab (10 units) to look after the poor for basic water needs.
(b) Two volumetric tariff for regular scale for consumption (10 units and 10 units)
(c) Higher slab for discouraging over use.

The GOSL has the policy to provide safe drinking water to all in 2010, and present level is at 62%. Wet zone has no facility to store water in dry periods as the storage reservoirs are limited, The construction of upstream tanks are badly needed to provide water in months of February and August to all wet zone cities. It is very easy to convert the saline lakes into freshwater lakes in the coastal belt due to its location close to the sea with a sand bar formed annually. This sand bar is usually cleaned seasonally to evacuate and drain water to control upstream inundations. Presently paddy lands are abandoned due to salinity and low income but it is useful to build a freshwater tank to cater to domestic use using the same storm water.
Gin, Nilwala Rivers are controlled by flood evacuation using low lift pumps. This water is now drained to sea. With the same pumping an abandoned area can store water for future drinking purpose. The abandoned paddy tracts are due to excess acid sulphate developed after control of floods. This defeated the purpose of flood control and now flooding is necessary to flush acid sulphate. Conjunctive use of groundwater and surface water will maintain quality of water in future perspective.
Water Board has to improve efficiency by reducing excess staff and undertaking many other small scale water supply schemes. Illegal tapping of water and non- payment of bills must be effectively controlled using awareness programs. Wet zone has gravity storage potential in each valley and pipelines are easily fitted to supply water to villages in the command areas. Traditionally villagers travel long distances in search of water in the lowlands. Private sector and NGOO can take lead in this task as such schemes are profitable
Rubber dam reservoirs are suitable for riverbed storage under flood discharge situation in all wet zone rivers. This is planned together with irrigation authorities.
Demand management through public teaching is essential in urban areas and presently wet sanitation equipment waste drinking water at 28 liters per flush. Most of these units were designed without proper research data. This quantity is to be reduced to 8 liters.
Rainwater tank can supplement water needs if properly constructed. Release of raw sewage to open water bodies in cities shall be prohibited. Dry zone privy vaults are not creating problems and spread of cholera is due to drinking of canal water. Beira Lake in Colombo is polluted by raw sewage entry.
Discouraging methods to prevent urbanization is needed from state policy decisions. Regional development shall be planned, by improving Galle Harbour.
Dry zone needs selected wells for reduction of fluoride in drinking water. Rainwater has low fluoride level but villagers drink ground water. All residents bear symptoms of fluorosis, specially in teeth.

Workshop 6

Posters

GROUND WATER RECHARGE IN NORTHERN UGANDA

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Introduction

Provision of potable water supply for Uganda's predominantly (>90%) rural population depends upon the development of ground water. Recent research into ground water resources in Apac district of northern Uganda indicates that most ground water moves by way of shallow weathered soils (regolith) rather than underlying bedrock fractures which have traditionally been developed. Indeed, the Lango people have long relied upon this shallow source through unprotected spring discharges and had dug "scoop wells". During the last three years, a number of agencies (WATSAN, UNICEF,CPAR) have constructed shallow wells with competent yields in the regolith for domestic, hand pump abstraction rates (=$3m^3$/day). However incidents of well failure and waning spring flow have been attributed to presumed fluctuations in shallow water table and raised concerns over the sustainability of ground water development programmes in the region. Nevertheless, studies of ground water recharge in Apac have shown that replenishment is in the order of 0.2m/year and occurs exclusively from intense (>10mm/day) rainfall during monsoons. Monitoring of water level in the unconfined regolith aquifer was therefore initiated in June 1994 in order to investigate both the magnitude of water table dynamics in the regolith and the nature of the water table's response to recharge events predicted by developed models of ground water recharge.

Scope

Weekly water levels from the monitoring wells in Loro and Apac are plotted along with weekly volumes of incoming rainfall and estimated recharge. Clearly the well hydrographs demonstrate the delayed response of the regolith aquifer to the onset of the rainy season and hence monsoon - fed recharge. These preliminary data also appear to support, by and large, the magnitude of recharge predicted by the soil moisture balance model.

Of considerable significance is that the observed water levels appear to confirm the timing and magnitude of predicted ground water recharge in Apac. In this paper, it has been noted that the soil moisture balance method of evaluating recharge and hence sustainability of ground water development programmes, may prove effective in other regions across Uganda and Equatorial Africa.

The water level data also suggests that fluctuations of 0.5 m occur in the regolith aquifer. This dynamic may account for the variability in depression spring discharges which drain the crest of the water table and should also be considered when positioning *screen and gravel packs during shallow well construction.*

Both assertions are however tentative based on the very limited time frame over which the data have been collected. It is critical that efforts to monitor ground water levels be continued and extended in order to improve the accuracy, validity and extent of the results.

Conclusions

Quantitative hydrogeological studies of the regolith reveal that the unit is considerably more permeable that the underlying bedrock and where a substantial thickness exists, it is likely to provide a significantly better aquifer.

In Uganda, where the practice has until recently been development of only the bedrock aquifer, *the above findings stress the need to develop the regolith aquifer* which is likely to provide a more sustainable and less costly source for rural water supplies than the bedrock fractures. This would be possible through construction of shallow wells (*augered and or dug*) *in areas* where the conditions are favourable. In areas where the regolith aquifers are so thick to provide enough water, deep wells exploiting the bedrock aquifer and screened in the regolith would be more sustainable. All in all the regolith is very important in ground water development, as it is able to raise a cheap and a more sustainable source of water supply and can recharge the weaker bedrock aquifer through vertical leakage.

Workshop 7

Urban areas as seen in the river basin context

CHONGQING, WUHAN AND SHANGHAI , THREE MAJOR URBAN AREAS ALONG THE YANGTZE RIVER, CHINA'S LARGEST RIVER, THEIR SUSTAINABILITY IN 21ST CENTURY

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Background

The Yangtze River is China's largest River, with its total length of 6 300 km, ranking third in the world, only after Nile in Africa and Amazon in South America, with its drainage area of 1 808 500 km^2, with an average annual runoff of 933.4 billion m^3, while the whole Yangtze River basin carries 400 million population, one third of China's total population, surpassing the total carrying population in other three big river basins in the world, i.e. Mississippi, Nile and Amazon, GDP produced in the Yangtze River basin accounts for 40% of China'total GDP. Chongqing, Wuhan and Shanghai are three big municipalities, located at upper reaches, middle reaches and lower reaches of the Yangtze River separately, they all have population scale of 10 million and play key important role in China's national economy, in the river basin context, they are distributed from upper reaches to lower reaches, the world biggest hydropower station, well-known Three Gorge project, planned to be completed in 2013, is just located between Chongqing and Wuhan, Shanghai is the largest municipality in China, Chongqing is the newest established municipality directly under the Central Government.

Flooding and environmental deterioration in the Yangtze River basin

In the period of more than 2 000 years from Han Dynasty(206BC-220AD) to 1949, the Yangtze River has flooded for more than 200 times, approximate one time in a decade in average, in 1931, the Yangtze River had a very serious flooding, all the cities from the Shashi city down in the middle and lower reaches had been submerged, even Nanjing, the Capital of China at that time also included, Hankou had been submerged for one hundred days. As global warming process goes on, monsoon-type climate in the Yangtze River basin becomes more and more unpredictable, it deviates far away from mean values in historical records and extreme values occur more and more frequently, since the 1990's, the Yangtze River floods in 1995, 1996 and 1998 of sequential years, the catastrophic flooding in 1998 strikes public media around the world and makes world people surprised. Though maximum flow rate in Yichang in 1998 is only 63 000 m^3/s, accounting for 68.1% of historical records in the year of 1860(92 500m^3/s) and 57.3% in the year of 1870(110 000m^3/s).

China's rapid economical growth in recent two decades has negative impacts on environment of Yangtze River basin, because of lumber production and increase of both population and wood fuel consumption in the upper reach area of the Yangtze River, deforestation happened everywhere in both the Jinsha River and other tributaries of the upper reaches of the Yangtze River, this area is also a poverty stricken area, because of its inaccessibility and remoteness, soil erosion in upper and middle reaches of Yangtze River makes annual sedimentation recorded 2 400 million tons in the lower river courses, surpassing that in the Yellow River, several billion tons of direct discharge of wastewater into Yangtze River from Chongqing, Wuhan and other big and medium cities, large and medium scale enterprises make water quality in the trunk Yangtze River deteriorated seriously, the Three Gorge Reservoir, planned to be dammed and formed in 2013, is probable to become a wastewater pool, if wastewater treatment facilities not completed in time and functioned normally in Chongqing and Sichuan Province, located at upper reaches of Yangtze River, direct wastewater discharge without any treatment is still the main form in most cities and medium and large enterprises in the Yangtze river basin, added with huge quantities of phosphorous detergent use, water qualities in many lakes and other water bodies in the middle and lower reaches of the Yangtze River basin have deteriorated because of the process of eutraphication, many cities located in delta of Yangtze River have suffered from water shortage caused by surface water pollution, local overexploitation of groundwater also causes groundwater quality deterioration and other environmental deterioration, such as land surface subsidence, the Yangtze River basin also has the largest area of acid precipitation in China, because of its energy structure and large proportion of high sulfur coal consumption without desulphurization treatment, due to unfavorable weather conditions, Chongqing municipality has suffered most, sometimes the PH value of the precipitation is less than 4, bio-diversity and many endangered species in the Yangtze River basin, e.g. *Lipotes vexillifer, Neomeris Phocaenoides, Allegator sinensis*, etc. are threatened.

Countermeasures

Some important measurements have to be taken:

1. Deforestation and reclaiming in steep slopes with slope degrees larger than 25 degrees, in upper reaches of the Yangtze River basin from September and October 1998, are no longer permitted, some important documents have been issued by the Central Government and the provincial governments and a huge project of protective forest belt along middle and upper reach of the Yangtze River is being carried out.
2. Poverty alleviation projects in some poverty stricken area in upper reaches of the Yangtze River basin have to be carried out, in order to help local people reduce their wood fuel consumption, improve their deteriorated environment and life quality, an overall planning of local social and economical development has to be worked out, making those remote and inaccessible area more suitable for human inhabitation.
3. Environmental protection education in different kinds of schools, colleges and universities, all other institutions and public media must be carried out

enthusiastically, energetically and incessantly. Enforcement of water law and environmental protection law, it is no longer permitted to have direct waste water discharge in future decade, in Chongqing, Wuhan, Shanghai and other major cities and medium and large enterprises in the Yangtze River basin, by decreasing the proportion of waster water discharge gradually, and forbidden use of phosphorous detergent.

4. Huge investment in wastewater treatment facilities, improving energy structure and desulphurization equipment in some major thermal power plants and other medium and large enterprises in the Yangtze River basin is being put in. China's economical pattern is now at the transition process from planned economy towards market economy, during this period, it is of great importance and necessary to have harmonious relationship between development and environmental protection, though sometimes it is in very sophisticated and difficult situation.
5. Optimization of industry structure and enhancement of energy utilization efficiency in the Yangtze River basin must be carried out, in Information Age, in order to increase the competence and decrease environmental pollution, some traditional industries must be transformed by new and high technologies and in the process some new added value products will be produced, as mankind is approaching post-industrial age, it is the best opportunity for the improvement and recovery of the environment of the Yangtze River basin.

Environmental vulnerability in middle and lower reaches of the Yangtze River basin can no longer be neglected, in the time both challenge and opportunity co-exist, it is necessary to pay great attention to sustainability of Yangtze River basin as a whole, Chongqing, Wuhan and Shanghai included. The sustainability of Chongqing, Wuhan and Shanghai development as well as the Yangtze River basin management is not only China's success but also a great contribution to the whole mankind.

DESTRUCTION OF LOW COST TRADITIONAL SOURCES OF DRINKING WATER SUPPLY FOR HIGH COST SYSTEMS
A CASE STUDY OF WATER SUPPLY TO BANGALORE CITY, INDIA.

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This case study examines the process and impacts of neglecting the local resources for the sake of high cost projects to supply drinking water to an urban area.

Introduction In India, Bangalore city is the fastest growing city. This growing population has placed an enormous stress on the planners to plan for the supply of water both for domestic as well as for drinking. To meet this demand, the planners right from 1896 have planned to bring in water from sources away from the city than utilizing the locally available resources called tanks. According to an estimation nearly 481 tanks of various sizes were prevalent within the city. One of the studies says that these sites could have met more than 30 per cent of the present demand in addition to the present supply of 25 per cent of the demand from such sources but outside the city (Subrmanian 1987). Accroding to the official sources, the cost of supply from such sources would have costed Rs.2 per 1000 liters, when compared to the supply from the river (Rs.12) (BWSSB 1996). The process followed in destruction of these systems built several centuries ago stands out as an example for scale than economics.

Bangalore is located on the ridge of three tributaries Arkavathi, North and South Pennar to river Cauvery at an altitude of 3000 feet. Geologically, the location is in hard rock area where recharge of ground water is difficult. To facilitate recharge of ground water and also to utilize surface run off for irrigation purposes rain water in the catchment was harvested and stored historically in a system called tanks. Numerous tanks had been constructed historically (from 3rd century B.C) to harvest rain water from the catchment. In this systems of tanks called 'chain tanks' the surplus from a tank always flowed into tanks of succeeding sizes in the down stream. At the termination of the chain, each chain gave raise to a stream through an huge tank (STS Reddy 1991). There were several such tanks in and around Bangalore. Two major tributaries, North and South Pennar of Cauvery were originating from these tanks. Many of them have been converted into bus stands stadiums or as housing complexes.

Traditional Water Supply

Prior to 1896, tanks such as Dharmabundi tank, presently housing the city bus stand and the Sampangi tank presently housing the sports complex were the sources of water supply. Later on, Jakkarayana kere, Kempabundi tank and Sampangiramanagra tank were the sources. Presently, these tanks are areas totally encroached by the residential areas.

Traditionally, prior to large scale supply of drinking water, in this city, normally drinking water was procured separately from wells owned privately. About 37,000 wells were prevalent in50s. As a result recharge of ground water through harvesting surface runoff into tanks was essential.

As the city was also an cantonment area, for the army stationed, tanks were the major sources of water supply. Two differential set of pipes were laid to supply water for drinking and for household purpose. A tank at Domlur, which is now totally occupied by the residential area was exclusively identified for watering and washing horses. Ulsoor tank was the training center in boating. Chellaghatta tank which is now a big sewage spot was the place for watering and washing dairy cattle maintained by the army.

History of large scale water supply

The large scale investment to supply water to the city started in 1896, when tanks located within the heart of the city, dried up due to droughts in two consecutive years. Plans were made to bring in filtered water from an another huge tank located at Hessarghatta above 25 Kms away from city. From that time, to enhance the scale of supply from 55 liters per day to 145 liters a day, an another tank 'Thippgondanahalli tank' was constructed in 1925, about 40 Kms away from Bangalore. This was a tank constructed across river Arkavathi, a tributary to river Cauvery. When the supply from this tank ran short of supply in 70s, a plan to tap river Cauvery at a distance of 90 Kms was planned. Visualizing the arithmetical growth of population in the city, following the first stage, other stages were planned. Presently, fourth stage is under construction. Quantum of water tapped from the river is given in the table With these plans the supply of water as increased tremendously to 270 million liters per day.

Increase in population

One of the reasons for tapping the resources far away from the city was the enormous growth in the population. The population of Bangalore city was 0.4 million in 1941. It increased to 2.92 million by 1981 and by 1991, it has almost doubled to 4.13 million. The area of the city has also increased from that of 29 square kilometers to that of 446 square kilometers. This arithmetical growth in population and the area has been the main reason for the planners to tap Cauvery river located about 98 kilometers away from the city.

However, as the area of the city expanded, the number of tanks falling within the urban zone also increased. Number of such tanks is about 380. These were of various sizes and capable of supplying at least water for domestic usage.

The Destruction of Traditional system

As the sources away from the city was tapped for supply of water to the city, tanks that were supplying water prior to 1896, were deserted and destroyed to make way for the urban growth. According to a study, prior to 1981, about 236 tanks were destroyed and after 1981, another 320 tanks have been breached. By taking into consideration the average annual rainfall (580 mm) into consideration, about 45000 million liters (30.8 % of the present day requirement), in addition to what is tapped from this source (25 per cent) could have been obtained from these sources.

The destruction of tanks followed a systematic process that of choking, turning it into a spot for public health hazard and then destruction.

Choking

According to the agency that mans water supply to the city, about 80 per cent of the supplied water is wasted. Till last five years, no plant was built to treat sewage systematically. Alternatively, using gravitational flow the sewage was let into the tanks nearby.

After receiving the sewage, the tank becomes vulnerable for the growth of weeds especially hyacinth. Proportional to the growth of weeds the storage capacity of the tank declines with the accumulation of silt in the tank.

The process of choking of a tank, is also an act that initiates the process of choking other tanks in the down stream. As the choked tank losses its capacity, the tank in the down stream will be the recipient and with it, its life is marked. This process of choking one after the other happens, as the tanks in and around Bangalore are linked to one another and the surplus from the upstream tank flows into the tank in the down stream. Thus choking is a process of not destroying a single fresh water body but a series of tanks that are linked to one another.

Health Hazard

With dumping of urban sewage into a tank, in a very short time, that tank will be identified as a spot for public health hazard as that spot is, firstly, a breeding ground for mosquitoes after the sewage is let in, secondly, for the foul smell around the area and for occasional flooding. Prevalence of snakes and other reptiles is considered as an another hazard. These public hazards creates a public opinion favorable for breaching the tank. In a country that paid dearly to malarial disease, any act to contain mosquito menace is regarded as a rightful step.

One of the committees constituted for planning for the growth recommends that "Elimination of all tanks within the city limits is desirable step.......The city has not suffered - on the other hand has gained much - by the elimination of some old tanks in the course of years.." (T. Ramachandra Rao 1985)

Costs incurred and Benefits lost

Energy Costs

If the rainwater within the area would have been utilized the present cost on energy to pump water to an height of 480 meters and a distance of 90 Kms could have been saved. The energy cost of pumping 10,000 liters has increased from 75 paise in 1980 to Rs.6 by 1991. About 40 per cent of revenue goes to meet energy costs. About 58.8 per cent is only used for domestic purposes. The rest is non-domestic usage. Which means the domestic demand could have been met by harvesting the rain water through tanks.

Ecological

The impact of the policy can be seen in the loss of water bodies, irrigated areas, flooding during rainy season and above all, the entire surface flow from 446 square kilometers is wasted.

Political

An another impact is the political dimension. The latest source tapped is the Cauvery river, which is an inter state river that is in dispute between the two riparian states. When the demand exceeded six TMC of water the lower riparian state has requested the external donor agency to halt the funds for the project.

The other conflict is from the communities that live on either side of the 90 Kms pipe line that conveys water to the city. When the project to tap river Cauvery progressed from stage 1 to stage 4, the communities on either side of the pipe line are questioning the distributive justice. When the demand was not conceded there were threats to break the pipe line to draw water for irrigation purposes. It also raised the question, whether water is for productive purpose or for the luxury consumption. In many places, the pipe line was broken to register the protest.

With Bangalore experiencing 70 per cent growth in a decade, the demand for space has increased tremendously. Consequently, tank beds are the easy places for encroachment and emergence of slums. With legal conflict ensuing over the encroachments, the conflict between the political parties emerges. Consequently, the social conflict assumes larger space and places an additional demand on water.

Of late, with Bangalore emerging as 'Sillicon valley' of India, there is spurt in the demand for housing colonies and holiday resorts on the banks of a river or big tanks. Consequently, one of the tanks, at 28 Kms to the city and is supplying 25 per cent of the demand is threatened with a new housing colony. The citizens of Bangalore are fighting against it.

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GROWTH CENTRES OF THE NEPALESE RIVER BASINS REQUIRED TO BE IN OPERATIONAL INTER-LINKAGES FOR SUSTAINABLE URBAN GROWTH

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I. Introductory background

The nature of bifurcating Himalayan axis and the configurative pattern of evolving ranges develop three major trans-Himalayan river systems in Nepal with the tributaries draining potentially resourceful Himalayan hinterlands inter-linked in network pattern with successive settlements distributed along the upper reaches of the valleys. North to the major Himalayan axis the east-west aligned valleys are having scattered settlements engaged to pasture - livestock raising and caravan trade networking. The adjustmental orogenic trend of the midland structuring in conjunction of the Siwalik Range reorient the river valley alignment to due east-west in a curvilinear pattern; this does develop extensive river terraces higher up in the river provinces developing peculiar asset of easy access and land productivity, as well as zone of luxuriant urban growth and micro-climatic horizon in the east-west aligned corridor. Referable to this horizon and wedging between the two major river provinces, the rain-fed midland river system emerge with limited hydrological potentiality which in the course of urban and industrial perspective, require inter-basin transfer of snow-melt surplus water. The unconsolidated Siwalik terrain is the multiple mini-basins of monsoon-fed torrential rivulets: the belt is either flooded or dry and desolate. It is the horizon wherein foothill urban centres are built up at selected sites opened by mid-land river or major river system. The adjoining lowland terai plain is the ideal horizon for flood water retention and wetland distribution for the interlinked surface and ground water management.

II. Recorded urban centres

Besides the pre-modern urbanised settlements developing clustures of market centres at variable belts there are 36 formally categorised urban centres: 13 in the midland hills, 5 at the foothills, and 18 in the terai belt; and these are holding 47, 14 and 39 percents of declared urban populations in the referred belts respectively. In an average percentages of urban population (1994) in the urban settlements is in the order of 90, 82 and 71; and the population size (in average in a centre) is estimated to be of the order of 112, 85 and 60 thousands respectively (during 2002) in the midland, foothill and terai belts.

In the urban centres the municipalities observe the generalised requirements such as, solid waste management, drainage, sanitation, conservation of natural sites and water supply; but with reference to the nature of prioritisation worked out (HMG/UNDP 1994), water supply, solid waste management, sewerage/drainage conservation, open space provision and urban roads are the components referable in common; whereas, urban industry zoning, and provision of open market are recorded in the foothill and terai centres.

III. Nature of problems

Urbanisation in the two valley provinces of the midland - Kathmandu and Pokhara Lake horizon, are alarmingly straining the available resources. To rehabilitate urban management and build up healthy environment, depopulation, dispersal of the institutional centres and relocation of industries at appropriate places have become imperative. This measure is to be organised and directed to strengthen the growth centres building up in variable directions of the river basin provinces extended to wide horizon of morphological features and ecological complexities.

Paucity of industrial growth, lack of management of mountain terrace and industrial pull of Gangetic provinces, open up the southern corridors widely; massive migration to the southern terai and urban centres in pursuit of subsistence has resulted imbalance in population distribution resulting economic disorder. It has raised managemental problem of the potential watershed provinces having network inter-relationships with the market oriented settlement centres.

The major components of urban management as recorded for consideration and follow-up measures are:

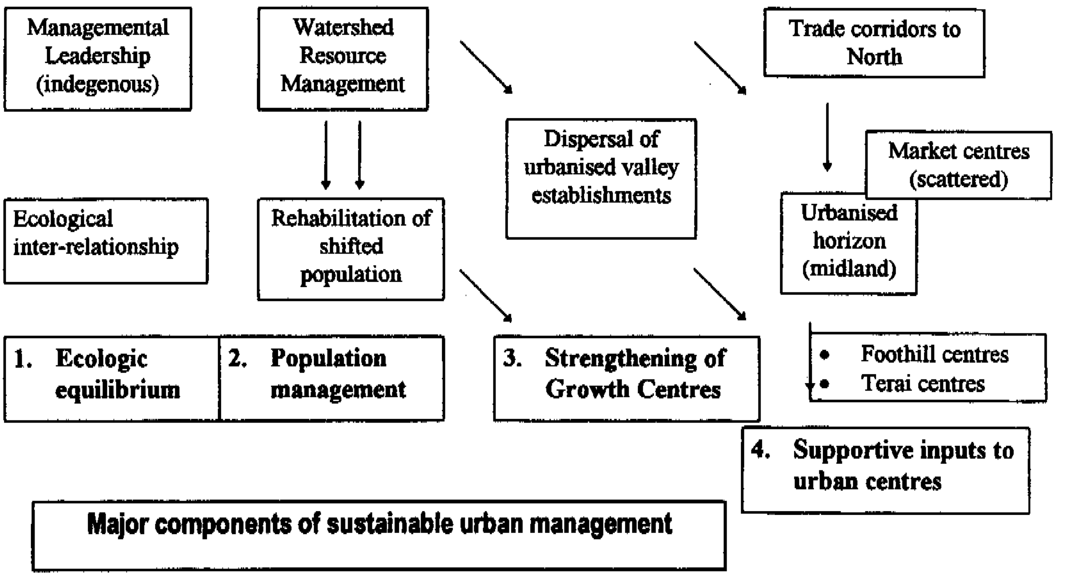
- Land use planning - zoning
- Enhancement of water resources
- Management of solid waste, sewerage and drainage system
- Improvement of sanitation and public health facilities
- Institutional capabilities and qualitative implementation
- Managemental skill and resource mobilisation

IV. Sustainable management

Rehabilitative management of the two urbanised valleys - Kathmandu and Pokhara are referable to the Gandak River basin, part of the Koshi basin and the midland Bagmati River basin in terms of development in the regional dimension. It may be deemed to comprise:

1. Rural urban supportive programme through hinterland and growth centre interlinkages;
2. Hydropower commissioned and micro plants may develop adequate room for industrial base in the whole region specially in the upper reaches of the midland hill provinces;
3. Watershed management and community level users' groups resorting to resource management raise boldly the vital question of developing local leadership with explicit authority at the decision making level. Legislative support to dwell to the mountain perspective becomes imperative. The Annapurna Conservation Area in combination with Langtang and Chitwan National Parks (in the terai) widen the managemental horizon with prospect of enlarging tourism to the transnational sphere. The National Parks belonging to the Koshi and Karnali river basins, in the realm of eco-tourism, activate briskly the sporadic trade centres and settlements of the highlands in their respective spheres.

4. Commitments and meaningful considerations regarding relocation of industries from the valley provinces have been under vacillation as it requires political will to be faithful to the nation. The upper reaches of the river basins opened by the transport linkages are the potential centres to take up selected industrial undertakings. The belt for systematic industrialisation are around curvilinear horizon and to the further south near the frontier of Siwalik and Terai within the provinces of Butwal and Hetauda foothills urban establishments.



V. Broader concept of urbanisation

Growth of the urban-oriented centres of the river basin provinces referred herein, are widely distributed from the pronounced highland region to the lowland provinces. Strengthening the centres require wide vision, assimilative attitude, and integrative measures for the emerging institutions, management and organisations meant to operate for development.

The concept of integrated urbanisation needs to be faithfully considered both at the philosophical and political level to ensure bold and explicit policies related to development of urban management based on ecologic and economic stratum. The clear vision and genuine effort have got to be endogenous. It is imperative that the terai and foothill urban centres support the midland centres strongly to maintain a revived balance in the north-south urban assemblages and trade growth corridor. It is warranted that the population balance as per ecologic horizon be restored in phases to rectify unhealthy imbalances and economic disorder. This is a hard task without any alternative to resuscitate genuine growth of the developmental spectrum with a firm and creative footing. This calls for systematic mechanism of observation and decision making capability.

VI. Conclusive remarks

- Mountain perspective interrelated to and integrated to the sustainable development of the lowland provinces, is the central theme to be focussed in the development of the Himalayan terrain.
- Community level management of the forest through the users' groups is widely under operation; integrated village development has demonstrated rural/urban economic integration and assimilation of gender issues in practice in some leading rural areas; all these lead to exposition of hinter horizon to the distributive centres. However, hinterland and market centre two-way participatory interlinkages need to be effortfully exercised by undertaking appropriate nature of studies periodically. Local leadership and authority for decision making are vital for ensuring managemental implementation. Political will and disciplines need to be evolved for initiating relevant proceedings and fulfiling required legislative enactment.
- Kathmandu and Pokhara urban valleys in the course of rehabilitative management and healthy growth, need to strengthen the growth centres distributed almost radially in the river basin provinces. The two major river basin corridors referable to these valleys are open for substantial trade inter-responding to the market establishments of the north and the south.
- Major growth axis of the urban horizon needs strengthening in the midland belt incorporating major plexux of referred valley urban provinces utilising due north-south and east-west aligned valley corridors towards inter-connecting hinterlands of the adjoining eco-belts.
- Major shift of population growth is required to be corrected by effortfully rehabilitating the indigenous population in their respective geo-ecological horizon. Population management and systematic growth of midland urban establishments are challenges to be met with phase-wise preparedness.
- Terai and foothill centres are heavily engaged; much more attention is required to develop foresight safeguarding developmental norm and national interest in the sphere of industrial alignment and urban management.
- Apart from import/export promotion cooperative engagements in conservative partnership, raising of alpine pastures and livestocks & medicinal herbs, eco-tourism and applied industrial establishments are the emerging realities in the sphere of urban growth corridor in the northern horizon of Nepal. Homework at the technical, diplomatic and commercial counters are imperative with the pursuasive vision of regional cooperation and international insight to promote national and transnational undertakings. It must as well be noted herein that speculative investment, mature foresight, and willingness to act faithfully in partnership as per commitment, as well as effortfully organised undertakings, are warranted to promote trade with the plateau related establishments.

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GROUNDWATER RESOURCE ASSESSMENT FOR MAUN AT THE DISTAL EDGE OF THE OKAVANGO RIVER DELTA NORTHERN BOTSWANA

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WORKSHOP THEME 7: URBAN AREAS AS SEEN IN THE RIVER BASIN CONTEXT

A Phase I Groundwater Exploration Project was completed with the objective of locating a secure and sustainable water supply for the rapidly expanding town of Maun, Botswana until the year 2012 and beyond. The population is projected to grow from 30,000 in 1997 to 75,000 in 2012. The Government of Botswana Department of Water Affairs initiated the project in 1995 to explore for and evaluate potential areas for groundwater development over a 12,500 km^2 study area near Maun in Northwest Botswana.

Maun lies about 15 km south of the seasonal swamps of the Okavango Delta and along a major delta distributary channel, the Thamalakane River. This delta is one of the world's largest inland river delta systems. The Okavango River, which heads in the highlands of eastern Angola, forms the border between Angola and Namibia for about 300 km before entering Botswana at its northwest corner. The river enters Botswana in a large channel called the Panhandle at a substantial annual flow rate of around 9,000 MCM/yr. Upon entering the delta, the river spreads out into perennial and seasonal swamps.

The outlets from the delta comprise a complex distributary system characterized by rivers which receive yearly delta outflow and a number of fossil river valleys that only receive delta outflow during years of above-normal inflow into the delta. Presently, the outflow is primarily via two channels, the Boro River and the Khwai River. One of these, the Boro River, is tributary to the Thamalakane River which flows through Maun. The average annual flow leaving the Delta via the Boro River is a trickle compared to the delta inflow (about 2 percent) or 195 MCM/yr.

In recent years (the 1990's), the water leaving the delta flows through Maun for just a short time each year. The mean annual flow for the 1990's in the Boro and Thamalakane Rivers is about 20 percent of what it had been during the 1970's.

Since the mid 1980's, the town's principal source of water has been a wellfield in the Shashe River Valley, a delta distributary. This valley contains a thin (50 m thick) fresh water aquifer system, 1 to 2 km in width, which is bounded and underlain by saline groundwater. As this river valley has not seen any surface water flow since 1989, there has been essentially no recharge to the shallow fresh water aquifer system in this valley. As a result, the aquifer is being depleted and the water quality is declining.

The Maun Groundwater Study followed the proposal of large-scale engineering schemes by an engineering firm. The proposed schemes entailed dredging, dams and reservoirs. These schemes were judged faulty by the International Union for the Conservation of Nature (IUCN) review team, who recommended that the conjunctive use of surface water and groundwater be examined.

The Maun Groundwater Study resulted in the identification of 5 areas along and proximate to delta distributary channels that could be utilized for future groundwater development for Maun. The principal aquifer recharge mechanism was determined to be surface water infiltration, with precipitation being a very minor component. Therefore, the development of a sustainable groundwater resource is inextricably linked to surface water infiltration/recharge to the pumped aquifers.

Three of these identified areas are located where the annual delta floods are still active and ultimately two areas were selected for development on the basis of proximity to Maun, relatively large quantities of groundwater in storage, and being the most reliable areas in terms of infiltration/recharge from the annual delta outflow.

In the long term, the sustainability of the groundwater resources will depend not just on the natural climatic and hydrologic regimes, but given the origin and geography of the Okavango River Catchment, very heavily on international cooperation between Angola, Namibia, and Botswana. Plans by Namibia to divert water from upstream points of the Okavango River to its capital city area (Windhoek) are currently undergoing intense scrutiny by interested parties in Botswana. In addition, increased usage of the Okavango River for large scale irrigation would impact inflows to the delta. The future of the delta and Maun will be determined by how these issues are resolved.

The Maun Groundwater Project concluded that groundwater is a viable source to meet Maun's demand thirty years into the future. The areas selected for development consideration were chosen on the basis of sustainable recharge. The study results also highlighted the vulnerability of the recharge sustainability to upstream river diversions which would diminish aquifer recharge via outflow from the Delta.

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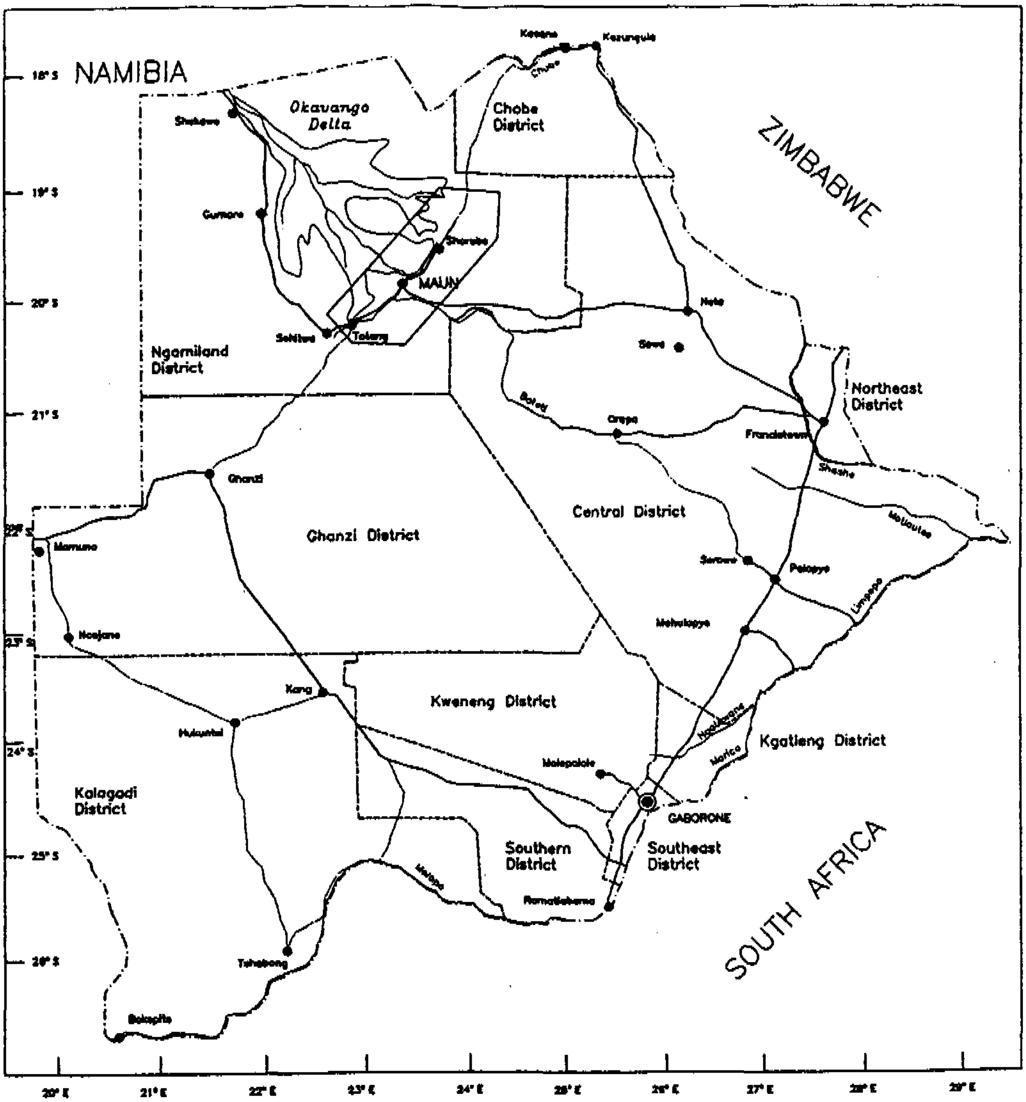

LEGEND

- Project Area
- Main Road
- Minor Road
- Village/Town
- District Boundary
- International Boundary
- River

N

0 50 100 150 200
kilometers

DEPARTMENT OF WATER AFFAIRS

MAUN GROUNDWATER DEVELOPMENT PROJECT
PHASE 1: EXPLORATION AND RESOURCE ASSESSMENT

EASTEND INVESTMENTS (Pty) Ltd.
Joint Venture of
WATER RESOURCES CONSULTANTS (Pty) Ltd., Botswana
&
VINCENT UHL ASSOCIATES, Inc., USA

Project Area Location Map

Figure 1

QUALITY OF ST. PETERSBURG URBAN AQUATIC ENVIRONMENT: FROM THE PAST TO THE FUTURE

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The major cities are sources of various severe environmental problems, but also the sources of solutions to the problems. The cities conducted first serious natural scientific studies on pollution in the end of the 19th – in the beginning of the 20th century. St. Petersburg was among them. The main object of this study is the reconstruction of the history of water pollution and eutrophication during the past 100 years.

In May, 1703 on the coast of the Gulf of Finland at the River Neva delta Peter the Great founded the sity of St. Petersburg, which became the Russian capital in 1712. By the end of the 18th century its population had reached 200 000 people, and there were 4 huge factories in the city. In the middle of the 19th centure St. Petersburg was ranking the 3rd major industrial city of the country. Now St. Petersburg has ca. 5 millon inhabitants and more than 3000 enterprises producing 4.5 millon m^3 d^{-1} of waste waters. Today only 40% of this sewage was biologically purified.

The key element that determines the economic and social development of the St. Petersburg is the water system the Ladoga Lake - River Neva - Neva Bay - eastern Gulf of Finland. This system is the important strategic region of multifunctional purpose. The complexity of an ecological conditions in the ecosystems of these water objects is determined by peculiarities of anthropogenic and natural factors.

The presence of industrial and advanced region on the whole catchment-area of this water system belongs to the first factors as the presence of such megapolicy as St.-Petersburg. Besides, navigation, coastal building, underwater careers, recreation, agricultural activity, water supply, hydraulic engineering structures etc. also concern to the anthropogeneous factors.

The top part of this water system is the largest in Europe the Ladoga Lake, which last decades is exposed to intensive loading. As a result, the Ladoga Lake two decades back has passed from oligotrophic to mesotrophic condition and the process of its eutrophication is continueing. The most eutrophic area of the Ladoga Lake closely adjoins to a source of the River Neva, defining thus water quality of the lower parts of this water system. It is especially important because the River Neva is practically unique source for St.-Petersburg water supply. The River Neva receives large mass of polluting substances in city boundaries. The River Neva, connecting the Ladoga and the Neva Bay, is a short river (its long is 74 kms) with the fast current (about 1 m/s) and some polluting substances get to the Neva Bay less than for one day. Therefore water quality of the Bay is determined by a condition of the Ladoga Lake, the River Neva water quality and waste water discharges. Ecological studies have shown that the waste water of city makes up only 2 % from total water volume of the Neva Bay, but its contribution on separate elements makes up about 40 percents in pollution of the Bay. Despite of significant loading from the upper parts of the water system the condition of the Neva Bay remains rather stable. It is connected with its morphological and hydrodynamical features. The Neva Bay is a shallow reservoir with a good running water. In its central transit zone the water exchange is carried out within 2-3 days.

To the other natural factors it is necessary to attribute a fitting of the eastern Gulf of Finland to slightly saline nontidal estuary with complex hydrodynamic and morphological peculiarities.The important meaning among the natural factors, increasing ecological risk, belongs to periodically arising floods, bringing significant material damage.

The first studies of the separate elements of the water system the Ladoga Lake – the River Neva – the Neva Bay – the eastern Gulf of Finland were conducted as early as in the 2nd half of the 19th century. Since then a lot of hydrological, bacteriological, sanitary and chemical studies have been done to find solutions to various water-related problems.

The most unfavorable problem of ecological condition of aquatic systems is the development of man-made eutrophication processes. Other corollary of man actions is the contamination and pollution. The evidence of extremely poor quality of waters in the River Neva and Neva Bay at the end of 19th centure and by the begining of 20th was a sickness rate of the population in St.-Petersburg. The city dwellers suffered from constant epidemics of a typhoid and of severe cholerabecause of drinking water was collected from the River and Bay and was utillized without any preliminary treatment and decontamination. Appreciable pollution by an organic matter of the River Neva and Neva Bay at this time also specifies by informations about the species in a plankton composition, which indicate considerably polluted waters. At the same time eutrophication degree of the Neva Bay and shallow-water area of the eastern Gulf of Finland as well as the Ladoga Lake was insignificant.

Further, sanitary condition in the Neva Bay and River Neva had not the so large value for city, as already in 1920s the obligatory disinfection of drinking waters was injected, which has lifted a sharpness of a problem of infectious diseases. It, in turn, and also high self-purification ability of the River Neva and Neva Bay have slowed down the construction of waste water treatment plants in St.-Petersburg up to 1970s of our century. To this time eutrophication symptoms in the Bay were moderate but have increased in comparison with the begining of the century. However the largest problem of water quality in this water system at this time was an organic pollution of the River Neva and Neva Bay.

After putting in operation the waste water treatment plants of St.Petersburg, since the second half of 1980s, in the Neva Bay the decrease of a saprophytic microflora quantity as well as total bacterioplankton number, decrease of such parameters as BOD5 and ammonuim nitrogen and others, testifed the reduction of an organic pollution of the River Neva and Neva Bay, was watched. However at the same time in the eastern Gulf of Finland visually have begun to appear such marks of eutrophication as increase of bluegreens contribution to total phytoplankton biomass.

Thus, numerous studies have shown that from the beginning of 20[th] century in the water system the Ladoga Lake – the River Neva – the Neva Bay – the eastern Gulf of Finland the disturbance tendency of the ecological balance expressed in progressing antropogeneous eutrophication and pollution was watched. The most unfavorable situation was at the end of 1970s - middle of the 1980s. In the 1990s the steady stabilization of an ecological situation in the River Neva and the Neva Bay is traced. In the eastern Gulf of Finland it remains tight.

The modifications of ecological condition of the water system are doubtlessly linked to various aspects of economic activity and development of water-supply systems. So, the stabilization of ecological condition in the Neva Bay is explained not only by high self-purification ability of this basin, but also by treatment of sewage waters and by collapse of industrial production now.

POLICY IMPLICATIONS OF URBAN AREAS AS SEEN IN THE RIVER BASIN CONTEXT: THE CASE OF THE AMMAN-ZARQA BASIN

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Introduction

The interests of urban areas are neither a summation of individual interests nor the pursuit of optimum city size. Instead, policies and programs can be said to be in the interest of cities whenever the policies enhance the economic position, or political power of the city. Three types of urban public policies shape the future of a city. These include developmental, redistributive, and allocational policies. Developmental policies enhance the economic position of the city. Redistributive policies benefit low-income residents but at the same time negatively affect the local economy. Allocational policies are more or less neutral in their economic effects. These public policies are usually the outcome of the dynamics of urban politics.

The major schools of thought that characterize urban politics are based on the following notions: (1) the community power; (2) the conflict between political machines and reform movements; and (3) the comparative urban policy. These policies have certain impacts on sustainable water development. Externalities may result from these public policies which in turn will be reflected on cost of utilities. This paper aims to explore both urban politics and urban public policy with respect to urban areas as seen in the river basin context. The methodology adopted to address the above questions will be based on document analysis. A case study of Amman-Zarqa Basin will be presented.

Problem Statement:

In light of the three types of public policies and the dynamics of urban politics. This paper intends to address and explore possible answers to the following questions:

1. What is the criteria for selecting the location of major urban water services?
2. How urban externalities are dealt with in the river basin?
3. Who pays and why for the negative impacts of urban water services?
4. How urban growth is controlled or managed within the river basin?
5. How does urban politics shape urban development?

The Case of Amman-Zarqa Basin

The limited amount of water in Jordan is by far the most serious and important factor that constrain and cause a great risk to investors in irrigated agriculture. Jordan already suffers from lack of water supply to meet various demands. The amount of agricultural land in Jordan that needs irrigation exceeds the amount of water available, and in addition there is competition from municipal and industrial uses for the same water source. Another concern is the overexploitation of groundwater aquifers that has occurred in recent years.

This case study about urban areas within Amman-Zarqa basin sheds some lights on critical policy issues and implications on sustainable water management. Trade-offs between equity and efficiency are addressed within both urban areas and river basin. The following is a brief description of the major water-related issues and constraints in Amman-Zarqa basin in Jordan.

The impact of both domestic and industrial wastes on water resources in Amman-Zerqa Basin poses a serious threat to sustainable water management. Significant indicators of pollution in King Talal Reservoir (KTR) are recorded. Water has become stratified by sediments which contribute to undesirable impurities near the bottom of the reservoir. According to the Royal Scientific Society (RSS) reports, certain heavy metals and organic pollutants are already reaching levels sufficient to be detrimental to biota. The performance of Assamra Treatment Plant (ATP) is becoming unsatisfactory. The Jordan Valley area experiences some pollution by wastewater, organic fertilizers, insecticides, plastic and hormones. Salinization, soil-quality deterioration, and lack of fertility are emerging in many areas.

KTR receives runoff from a relatively large basin. Part of this runoff originates from Zerqa-Amman basin which is heavily populated and industrialized. This water carried large quantities of organic pollutants, nitrogen, and phosphorous. Treated effluents from urban areas (Greater Amman area and the towns of Rusefa, Zerqa, Jerash, Baqaa' and Abu Nuseir) started reaching KTR in 1985. These discharges resulted in imparting negative impacts on the water quality used for irrigation in the Jordan Valley. Records show that EC has increased steadily since 1985. There was a problem of non-biodegradable detergents and Boron in the effluents of Assamra Treatment Plant. Organic pollution in terms of eutrophication elements and biological contamination in terms of fecal coliforms is increasing. In 1990, KTR discharged water was not fit for unrestricted irrigation due to high count of fecal coliforms.

Conclusions

Developmental public policies at the national level govern the decision making process in Jordan. Involvement of local people in the policy formulation was not practiced in the last two decades. Recently, redistributional policies were developed to address the needs of low-income people. However, those groups are under-represented in the decision making process. The externalities of the development of urban areas are carried by low-income people.

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Water Resources Management Scheme for Cochin Region

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Introduction

Management schemes on water resources mainly attempt to strike a balance between availability and beneficial utilisation. Practising judicious methods on either aspects promotes to achieve acceptable results as partly observed in this study. The Cochin city - Queen of Arabian Sea- is situated on the scenic tropical maritime coast of Southern Indian peninsular region blessed by a network of waterways. Two large river basins, spreading across the hilly terrain to mid-plains to coastal region constantly drain, seasonally fluctuating amounts of fresh water, in addition to regulated water inflow, from a collection of four other subsidiary river systems. The Cochin City is thence a water city on the Vembanad backwaters; the waterbody covers an area of approximately 250 km^2, the largest on the west coast of India. The longitudinal north – south span extends about 110 km and width varies from a few100 m to 4.5 km. This backwater plays a significant role in the socio-economic development of the State of Kerala - nearly one third of its population is directly or indirectly dependent on this water body and the resources of its watershed/drainage. The paper addresses the different aspects of water resources and the current management schemes for Cochin region along with future project(s).

Scope

As common experience, this waterbody too supports inland navigation, clam and shell fisheries, a variety of complex marine brackish webs, apart from exhibiting assimilative capacities of differing orders to account for contaminants (point and non-point sources); the embanks accommodate an excellent shipyard, minor ship building docks, oil terminal and houses the second largest port on the west coast of India.

A case study on the water environment concerns the critical dependence of city supply on the freshwater resource and the extent of vulnerability of the middle and lower sections of streams during floods. Whereas a population of 32 lakhs has to meet the daily chores on the freshwater requirement from the two rivers, a sizeable proportion of the population is handicapped by the factors of salt water intrusion, contaminated sources and riparian ill effects. In actuality, though the total quantity of available water would far exceed even for the projected figures of 2010 A.D., the vital question leads us to the judicious management of the precious resource towards better beneficial utilisation.

Approach

The stream data for the two west flowing rivers as well as the other four rivers which drain from the adjoining paddy fields for a period of 20 years supports the findings in this paper. The annual average rainfall of bimodal distribution is 300 cm, the higher peak occurring during south west monsoon with characteristic features of tropical variability but is free from climatic extremities like cyclones, or storm surges and the region is not vulnerable to seismic disturbance. The west flowing rivers originate from the Western Ghats at altitudes 2500m to 3500m from MSL as an agglomerate of number of streams joining the trunk in the mid-plains (width 50-75 km) showing normal meandering behaviour before joining the coastal waterbody. Among the rivers the longest one is Periyar (250 km) with a basin area of 4500 km^2 followed by Muvattupuzha river (121 km) of 1550 km^2 basin area (Table I). The other four rivers mostly drain into the vast expanse of Kuttanad paddy fields where the water balance is maintained by a regulator such that saline water intrusions are prevented from the backwaters entering the agricultural lands but during times when piling up of excess water occurs within, it is drained away by opening the shutters. The water utilisation based on needs, wastage, open drainage and other related aspects are covered based on the recent five years of data which helps to throw better light on the finer aspects of management scheme(s).

Table I

Rivers draining into the Cochin Backwaters

River Basin	Basin area (km^2)	Length (km)	Monsoon Flow(Mm^3)	Total flow (Mm^3)
Periyar	4500	250	4725	5180
Muvattupuzha	1550	121	3760	4780
Meenachil	1250	78	887	1190
Manimala	850	90	1070	1217
Pamba	2250	176	3221	3961
Achencovil	1500	128	1410	2017

Source: Department of Public Works 1994

Results and Discussion

. A close investigation reveals three striking features inviting special attention:

1) Control measures on salt water intrusion
2) Demand and supply, area wise for the expanding city and
3) Major water resource management schemes such as barrages, balancing reservoirs and diversion canals.

Cochin City has undergone changes more and above the expected scenario that would have been influenced by urbanization. The alterations are pronounced in the areas of land utilisation, landscape management, agricultural practices, siting of industrial units and conflicts between traditional practices and modern technological innovations.

Attitudinal changes in the upkeep of ecofriendly environmental planning and related numerous aspects have influences of varying degrees but issues being interconnected, location wise, this gives rise to the necessity for area wise, sector management plans. The question on saltwater intrusion is relatively a recent problem brought about by the project on bore wells whereas the demand and supply refers to an age old problem of three decades or more between a large number of scattered islands. The issues to be addressed on major management schemes will cover projects implemented for extensive agricultural practices, supply schemes to new impoundment and minor forestry schemes. In addition, proposals are being formulated for construction of small hydropower plants.

This study reviews the resource potential of each river and its basin in the context of the Greater Cochin Metropolitan City Development. Also illustrations are provided on the past two decades of development, the present status and prospective future plans. A glaring contrast is reflected in abundance of water resource, but inadequacies in coordinated management towards ensuring better stability of urban situations, against in most appealing cases, it is the shortage of the resource that preclude furtherance in integrating rural, semi-urban and urban development.

IMPACT OF KALABAGH DAM PROJECT ON URBAN WATER SUPPLIES IN THE INDUS PLAIN CITIES - DILEMMA FOR KARACHI

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Introduction

The Indus River is the lifeline to the Lower Indus Plain (Sindh Province), and the one and only reliable source of water in the province, and particularly to Karachi, the capitol of Sindh. Water supply in Karachi and the Indus Plain cities such as Dera Ghazi Khan, Taunsa, Pat Feeder, Sui, Dharki, Guddu, Sukkur, Jacobabad, Larkana, Nawabshah, Kairpur, Mirpur Khas, Shikarpur, Hyderabad, Latifabad, Jamshoroo, Tando Adam, Kotri, Thatta, Sujjawal, Badin, Gharo, Mirpur Sakro, Keti Bander, Steel Town, and Bin Qasim exemplify inadequate urban water supply and sanitation scene in the arid and water-stressed regions in Pakistan.

Karachi, a megacity of about 11 million people, is the largest hub of commerce and industry in Pakistan. Karachi alone accounts for almost half of Pakistan's gross domestic product (GDP). Situated in an arid Arabian Sea coastal belt, Karachi averages 200 mm of precipitation annually. Karachi is a water-stressed megacity and is totally dependent on its water supply from the Indus River. Karachi's annual water quota from the Indus River source of about 0.5 million acre-feet (MAF) has not increased since 1961, though the population has increased by almost 300 percent during the period.

Water Supply Crisis in Karachi

Karachi lies at the terminal end of the tailend supply line of the Indus River source. With a current shortfall of 200 million gallons daily (MGD) in its municipal supply, Karachi faces acute water crisis extending into the next millenium. With the continuous influx of people from all over Pakistan's rural areas, a number of katchi abadis (uncharted settlements) have emerged, and almost 40 percent of the population lives in these urban ghettos. With declining per capita water supply, Karachiites face day-to-day shortages in water supply and inadequate sanitation. Karachiites pay a high premium for urban water supply, with 120 percent increase in water charges since 1994. Paucity of water supply, its breakdown and intermittence nature fuel civic discontent and water riots. To meet shortages citizens pay top prices to private water suppliers, the so-called water mafia.

Water quality scene in Karachi is so alarming that the Pakistan Medical Association (PMA) issued an alert in February 1999, citing the city's administrators for widespread water pollution plaguing the citizens and rise in number of serious cases of water-borne illnesses due to supply of contaminated waters. An estimated 70-percent of the 11 million people who live in the Karachi metropolitan area get contaminated water. The Federal

Government of Pakistan (GOP) has neither catered to turn the rural migration away from Karachi, nor filled the begging bowl of the Indus River water for Karachi's citizens.

Impounding of the Indus River

The philosophy of building dams, large or small, grew out of the belief that the Indus River System had to be tamed. In Indus River Basin, all free flowing rivers were thus dammed and/or barraged. Pakistan has many large dams that store water on major rivers and deliver water long distances for irrigation by canals to farms, and is also used to generate electric power. Major impounding of Indus water flow in dam storage is at Tarbela (24,200 ha), Ghazi Botha (2,650 ha), and Chasma (2,500 ha) reservoirs. Other abstractions of the Indus flow occur at Chasma, Jinnah, Qadirbabd, Kashmore, Guddu, Sukkur and Kotri barrages.

In the past, dams were evaluated using engineering and economic analyses, to the general exclusion of biological, ecological, or cultural factors. The result was that waterworks projects in the Indus Plain had severe environmental impacts. In almost every case, the GOP only learned about these negative impacts after it constructed the dam project. The Upper Indus Plain (Punjab) receives high rainfall and is better drained than the Lower Indus Plain, which is arid and poorly drained. Myriad of government-funded schemes to clean up irrigation-induced salinity and waterlogging in the Upper Indus Plain has left the Lower Indus Plain worse off vis-à-vis water quality of Indus waters, and accumulation of salts in the soil. It is estimated that almost 60 percent of soils in Sindh are of high salinity, and only about 15 percent of groundwater are of usable quality.

Diversion of the Indus River Supply at Kalabagh and its Impact

With the announcement (Prime Minister of Pakistan, May 1998) of the building of Kalabagh Dam (KBD) upstream on the Indus River, the water supply dilemma facing Karachiites has brought into focus sustainability of urban settlements in the Indus Plain as well. The planned upstream storage and diversion of another 6.9 MAF annually of the Indus waters in a large reservoir at Kalabagh (54,000 ha) will take away a major chunk of water reaching downstream. Increased competition and water use upstream for irrigation, outstream diversions would take away the bulk of river water reaching cities and towns along the 600 km stretch of the Lower Indus Plain. The cities in the Lower Indus Plain and coastal Karachi face diminishing water supplies. The length of river that would dry up because of KBD project would be the largest impact on the river ecosystem and urban water supply. The Indus being an endangered river will become devoid of biological and ecological life. Adverse environmental impact of the KBD will render the Lower Indus Plain to a salinized and water-stressed plain. Social, cultural, economic consequences on the population will be similar to what happened to the ancient Indus Valley Civilization.

Indus River Water Quality and Drinking Water Supplies

Since the 1970s, the assimilative capacity of the Indus water has been consistently reduced with storage of its flow, and its upstream diversion. Basin-wise, about 22.4

million tones (MT) of salts are brought in annually by the rivers. However, only 11.6 MT are carried out or flushed to the sea, resulting in deposition of approximately 10.8 MT salt to the Indus Plain each year. Each acre-foot (AF) of irrigation water leaves net deposition of 0.16 tones of salt in the Upper Indus Basin (Punjab) and 0.29 tones in the Lower Indus Basin (Sindh). The adverse salt balance has given rise to salination of soils and barren landscape in the Lower Indus Plain.

Quality of the Indus water has been degrading for the past twenty-five years and further restriction and upstream storage will make it unfit for most urban consumption downstream. Irrigation water returns to the river and adds up to the higher salinity downstream. Further-more farm chemicals add up to the biological pollution of river water. For instance, pesticide use increased from 665 tones in 1980 to 44,872 tones in 1998 in the Indus Plain. Pesticides become serious pollutants when these wind up in rivers and groundwater. Similarly, fertilizer consumption has jumped twenty folds during the same period, contributing to high salinity downstream and eutrophication. The salinity of the Indus water is about 90 parts per million (PPM) at Kalabagh (Upper Indus Plain) and about 575 PPM downstream at Kotri (Lower Indus Plain).

With cumulative effects of water pollution due to salt deposition, agricultural runoff, human and livestock sewage and wastes, and industrial effluents thus are added for subsequent users, and particularly for those at the downstream tail-end receiving hand of the water supplies (Karachiites). Thus the cities in the Lower Indus Plain and Karachi dependent on the Indus source face staggering losses in water supply and declining water quality resulting in greater public health and environmental risks.

Sustainable Water Management and Protection of Indus River Water Supplies

Pakistan has the opportunity to devise a water policy that builds on what the world has learned in the past forty years of unchecked river basin development, and that involves civil society in the decision-making process. Increasingly contentious provincial conflict over the KBD and allocation the Indus water brings debate in all four provinces about sanctity of *'Our Common Future'* in the Federation of Pakistan.

The GOP should recognize adequate allocation of water to preserve urban sustainability for the Lower Indus Plain cities and Karachi. and for provision for some degree of ecological health of the Indus. It should provide human development and public health basis for the protection of the quality and sustainable supply of drinking water resources to all the settlements in the Indus Plain. It is earnestly recommended that:

1. The GOP should give up plans on building the KBD project and any other storage dams on the Indus River. It should implement sustainable water development and environmental management in the Indus Plain on the basis of the United Nations' Agenda 21; and
2. The GOP should resolve to remove uncertainty in supplying water to Karachi by increasing the Indus supply quota in line with the urban growth rate in the megacity.

THE CASE FOR THE HYDROCOMMONS APPROACH TO RIVER BASIN MANAGEMENT: A Comparative Study Of The San Diego-Tijuana Transfrontier Metropolis And The Monterrey, Mexico, Industrial Corridor.

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Introduction

This paper examines the links between urban growth, environmental concerns, and transbasin diversions by introducing the concept of viewing urban regions within a hydrocommons context rather than a river basin context. The hydrocommons framework is applied to the analysis of serious water management issues in two regions: the San Diego-Tijuana transfrontier metropolis and the Monterrey, Mexico, industrial corridor.

A hydrocommons is a geographic entity that incorporates water supply, water quality and endangered species concerns associated with transbasin diversions. A hydrocommons incorporates two regions: first, the problem region defined as the region experiencing degrading levels of water quality and subsequent aquatic/land based habitat destruction due to transbasin diversions; and second, the solution region – places within and beyond the boundaries of the problem region -- which contributes to the water quality problem, and is integral to its resolution. What differentiates the hydrocommons approach from watershed or river basin approaches is that the hydrocommons recognizes the environmental linkages between the exporting basin and receiving region of transbasin diversions. In addition, a hydrocommons approach recognizes the environmental linkages between water pollution of surface/ground waters, aquatic ecosystems degradation and drinking water quality.

Presentation of the Project

The San Diego-Tijuana Transfrontier Metropolis

Sharing the western border between California and the Mexican state of Baja California, the Tijuana-San Diego metropolitan region is the most densely populated and economically prosperous region along the US-Mexico border. It is also the one place in the world where the Third World abuts the First World. The region is home to over three million residents, and boasts a regional economy of approximately 80 billion dollars. However, the metropolitan region is located in an arid region with scarce water resources. Hence the region's rapid urban and economic growth has resulted in an increased dependence upon imported water. In fact, primary waterways along the western section of the US-Mexico border are not river basins but aqueducts that transport large amounts of water to rapidly growing urbanizing regions along the west coast of California and Baja California.

Hydrocommons based water resources management has evolved from the fact that long distance transbasin water transfers in California and Baja California have further degraded water quality. San Diego imports 95% of its water from the Sacramento River

Basin, six hundred miles north, and receives water from the Colorado River that travels approximately 300 miles via the Colorado River aqueduct. During times of drought, Tijuana imports up to 90% of its water supply from the Colorado River, and the city plans to build a second aqueduct to accommodate increasing water requirements for the rapidly growing industrial and residential needs of the city.

Transbasin diversions breach one drainage basin and bond the exporting and importing basins. Transbasin diversions impact water quality in the export region, because diverting water away from a river basin reduces the amount of water within the basin to dilute solids such as salts, resulting in increasing levels of salinity. An increase of salinity can adversely impact aquatic species, migratory birds, as well as downstream users who divert water after the transbasin diversion.

On the receiving end (or the 'the end of the pipeline' as San Diego is often referred to), transbasin diversions may exacerbate the problem of non-point source pollution or polluted runoff in urban regions which receive the water. Transbasin diversions are linked to the receiving region's water quality, in that urban regions which receive these transfers experience increasing rates of urban sprawl. One question that arises is just how much urbanization, andresulting increases in levels of polluted runoff can waterways take before aquatic ecosystems collapse? In addition, increased water supplies to an urban region result in increased wastewater to be transported, treated and disposed of. Neither San Diego nor Tijuana have adequate infrastructure to handle current wastewater loads.

In California, a hydrocommons based water quality management program is currently underway to address the water quality degradation problem and wetland restoration of the export region (Northern California's Sacramento and San Joaquin Rivers Delta). This hydrocommons project, known as the CALFED process, attempts to link the politics of water quality, the politics water supply, and the politics of endangered species management. A particular appeal of CALFED is that it is a governance process which is committed to active public participation.

A hydrocommons based management program for the border region of Baja California and California, or a CALFED south, has not been implemented. However, environmental organizations are examining such an option. The region's primary waterways are not large river basins but a network of manmade canals and aqueducts which divert the Colorado River to agricultural fields in Imperial Valley and Mexicali, and west to expanding urban regions such as Los Angeles, Tijuana and San Diego. The total amount of transbasin diversions range between 6-8 million acre feet each year. These transbasin diversions are the primary cause of numerous water and land based environmental degradation problems along the California and Baja California border. In the receiving end of the basin, water transfers are one of the primary factors responsible for rapid industrialization and urban sprawl in Southern California and Tijuana. Both urbanization and industrialization have resulted in large amounts of inadequately treated wastewater deposited in coastal waters, and large amounts of urban non-point source pollution.

Currently, laws and government organizations in the United States do not adequately address the linkages between water quality, transbasin diversions, water pollution, and habitat destruction. In Mexico, federal and municipal umbrella agencies manage water supply and quality; however laws and infrastructure planning rarely address the linkages between diversions, water quality and habitat destruction.

At present there is little to no environmental representation on governance of Colorado River water transfers or even urban planning (and hence non point pollution control) in the Tijuana-San Diego metropolitan region. On the other hand, special interest groups from urban, agricultural and business communities have had extensive representation in border water resources governance. A hydrocommons approach would include all stakeholders.

The Monterrey Urban-Industrial Corridor

Monterrey is Mexico's largest industrial center after Mexico City, and also third in size in terms of population. It is a concentrated hub of advanced global enterprises, some of which feature in the Fortune 500 list of largest corporations in the world. Monterrey is located in a semi-arid region three hours drive south of the Texas-Mexico border. Political factors (including corruption, mismanagement, and local-federal feuds) resulted in wildly ineffective water resource management for Monterrey from 1954 until 1980. Meanwhile, the city's population grew at a rate faster than any other in Mexico, and the city's industrial complex expanded exponentially. By the late 1970s Monterrey was in a major water crisis with the real supply of water less than 60% of demand and citywide urban protests multiplying with every passing year.

Until 1990, water resource management for Monterrey was in the hands of a consortium of local, state, and federal actors who viewed Monterrey's needs from a very localized perspective. In short, water managers did not place Monterrey's water needs even within a watershed perspective, let alone a much larger regional perspective.

After 1990, the growth of the Monterrey urban-industrial corridor outstripped local water availability. Water needed to be brought from hundreds of kilometers away. In turn, this meant that water resource management for Monterrey had to embrace a complex package of multi-state and binational issues, and decisions became a set of compromises between policy makers and politcal figures in two states and across an internatioanal boundary. In addition, this coincided with the enactment of a new Federal Water Law in 1992, the creation of a new federal water agency in 1989 which oversaw new regional water councils, and the emergence of regional environmental groups. No longer was water supply the sole focus of water resource management; now water supply, wastewater and sanitation, and water quality/environmental degradation all were considered issues of substance. Clearly a hydrocommons approach is the most realistic for this complex water management situation that spans watershed, states and national boundaries.

Conclusion

This paper uses case studies of river basin management in the Tijuana-San Diego transfrontier metropolis and the Monterrey, Mexico, industrial corridor to provide an in-depth discussion of the hydrocommons approach. The paper responds to the following questions. How are river basin management issues defined by the hydrocommons approach? What decision-making processes and what types of solutions result from applying the hydrocommons approach? What are the short and long term impacts on river basin management that result from the hydrocommons approach? We suggest that water resources policy makers who manage transbasin diverions in other world regions would be wise to consider the hydrocommons model.

THE IMPLICATIONS OF URBAN DEVELOPMENT FOR WATERSHEDS AND WATER SUPPLIES IN RAPIDLY GROWING, DEVELOPING WORLD CITIES

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Introduction

Many urban areas that have undergone or are undergoing extensive growth find that development can severely impact water resources. In particular, urban expansion encroaches onto previously greenbelt watershed areas surrounding drinking water reservoirs or overlying aquifer recharge zones. Depending on the particular environmental context, problems of reservoir sedimentation or surface and groundwater contamination ensue. This phenomenon occurs in both industrialised and developing nations alike. In the United States, for example, two pressing problems of the last decade have been the contamination of groundwater with hydrocarbons from leaking underground gasoline storage tanks, and the massive non-point pollution loading entering urban and suburban streams from neighbourhood streets and industrial facilities. The situation is equally troubling and complex in many developing countries where urban growth rates of principal cities may result in populations doubling in less than a decade; a combination of already high fertility rates coupled with rapid rural-urban migration. The expansion of shanty towns, industrial parks and other land-use modifications encompass previously rural watershed lands and the demand for resources, food, fuelwood, and building materials strips much of the remaining land of its forest and soil cover.

Project Presentation

In the most general of terms, the closer the water source and its watershed to a city when developed, the lower the capital cost due to the avoidance of building a long overland water transmission system, all things remaining equal. However, nearby watersheds and recharge areas are also most prone to environmental health and degradation pressures related to their proximity to existing urban zones and availability as sites for urban expansion, natural resource exploitation, and commercial land uses (Lee 1996). In many developing countries, the urban planning framework is weak, with few controls on citizens' or corporations' use of private watershed and recharge area land, and a lack of co-ordination between government sectors concerning the protection and exploitation of state-owned lands. In many cities, there has been little history of co-operation between public authorities, city residents and the private sector concerning sustainable environmental management, and the stewardship of watershed lands has been neglected. Existing land-use regulations and environmental protection laws designed to prevent water resource deterioration, while often more than adequate on paper, may not be applied due to a lack of will and/or the necessary resources for monitoring and enforcement. Where water sources are located close by, immediate and very real socio-economic pressures to satisfy multiple resource needs often clash with the more singular need for clean and reliable water supplies. Sources may undergo rapid deterioration if contributing watershed and recharge area land is not protected from point and non-point source pollution and from damaging hydrological modifications. The rapidly expanding cities generate incredible demands for affordable building space close to the existing city infrastructure; for a convenient supply of livestock, vegetables and other foodstuffs; for plentiful building materials including lumber, sand, gravel, fired bricks and tiles; for firewood for cooking and heating; and for space for recreation. These demands continue to grow exponentially each year with the growing urban population.

Developing country cities often face the staggering responsibilities of trying to maintain and expand water service coverage to urban residents in the face of increasingly antiquated infrastructure, crushing debt crises and shortages of investment capital, increasing costs, shortages in skilled personnel, and many other economic and technical disabilities. It is perfectly understandable, therefore, why water sector managers ignore or at least fail to prioritise water resource protection through watershed and recharge area management. While organisations such as the FAO have been promoting watershed management in developing nations for several decades (e.g. FAO 1986), much of their training has been theoretical and few practical, working models have been developed and transferred to water sector decision-makers and technicians. This is not a situation exclusive to developing nations. Even in the United States, systematic watershed protection as a basic environmental planning and protection tool has only just found its way into federal government policy with the EPA's formal adoption of "the watershed approach" in its Clean Water Act implementation, although wellhead protection initiatives for groundwater resources go back several decades. This lack of watershed and recharge area protection in developing countries must be seen as a tremendous cause for concern because it threatens to undermine the sustainability of water supplies and compromise water quality, risking human health impacts at worst and increased per capita water supply costs at best. With the majority of attention being placed on the downstream end of the plumbing system in the form of urgent programs for expanding coverage, the water sector is at risk of following a three steps forward, two steps back model of development. As piped, potable water coverage expands to previously un-served shanty-towns, the volumetric demand for treated water and the expectations of service quality and reliability increase. At the same time, carryover storage volumes in reservoirs and aquifer recharge rates are being reduced, and the quality of the raw water is declining and hence the difficulty and cost of water treatment are increasing. Clearly, this is a model the water sector cannot afford to promulgate.

Discussion of results

The example of Tegucigalpa, the capital city of Honduras, provides a useful and graphic illustration of this phenomenon. With an estimated population of around one million, and growing at well over 50,000 per year, the city is served by three principal watershed and recharge areas within a 10-50 kilometre radius of the city centre. The sustainability of the city's water sources has been placed at great risk by the failure to adopt systematic, effective and long-term source protection. One watershed, Guacerique, has experienced extensive degradation in recent years from the effects of a government low-cost, high-density housing project of 10,000 homes; the siting of a string of military bases, industries and training institutions; the siting of the new peripheral transport route around the city; the development of several commercial poultry plants; the industrial-scale extraction, both illegal and legal, of firewood; and the production of both subsistence and cash-crop fruits and vegetables (Lee 1996). Numerous laws including the State Constitution were ignored in the process of exploiting this watershed, often by the government officials themselves. Awareness among water users concerning the value and susceptibility of their watersheds and water sources has historically been low, and thus accountability for watershed stewardship has been limited, resulting in little financial or institutional support for watershed management.

The situation in Tegucigalpa clearly brings into focus the biophysical implications of the failure to co-ordinate national and municipal policies in managing and protecting the watershed, and the legal and institutional impediments that have given rise to this situation. These include the lack of clear zoning restrictions and institutional commitments to watershed protection (Lee 1996). The resource inefficiency and social costs of failing to integrate the planning and management of key resources including the land, soils, forests and water of the Guacerique River watershed are also clear. The lack of co-ordination between government departments has led to government projects that have directly caused a range of avoidable environmental and fiscal externalities for the water sector. These include the loss of investments in watershed reforestation areas bulldozed to make way for development projects; active surface water reservoir storage loss through accelerated sedimentation from erosion-plagued development project sites; and increased water treatment costs related to biological and sediment contamination from development project facilities.

Conclusions

The situation facing developing country cities like Tegucigalpa shows that the failure to adequately care for the health of watershed and recharge areas of existing and future water source developments can be expected to have a range of undesirable effects. It is clear that to ensure sustainable, healthy water supply systems, greater investment must be made in watershed stewardship as a proportion of total water sector expenditures. If not, total expenditures will be forced to rise to even greater levels as a result of several important consequences. Firstly, the real costs of capital projects will inflate due to shortened working lives and annual yields as aggravated, acute sedimentation reduces reservoir storage volume and permeability reductions reduce groundwater recharge. Customer and general taxpayer costs will rise due to the need to invest greater amounts of public and private funds in developing new water sources and supply infrastructure earlier than planned, while continuing to pay off old debt (Serageldin, 1995). Secondly, running costs will systematically increase as simple treatment is replaced by more sophisticated and expensive technologies as water quality deteriorates and the costs of adding filters, etc. and materials budgets for coagulation, flocculation and disinfection rise. Thirdly, there will be increased social and economic costs imposed by periodic water shortages, and water contamination with constituents such as pesticides and metals introduced to the watershed and recharge areas from anthropogenic sources which cannot easily be removed by treatment plants.

International donor agencies and national water agencies need to take seriously the notion of watershed and aquifer recharge area protection in developing countries, particularly around the fastest growing cities. They must pay greater attention to the professional development of management teams and to the adequate funding of systematic programs of land-use management, pollution prevention, and monitoring and enforcement of environmental legislation.

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Workshop 7

Posters

SUSTAINABILITY AND STATE ESTIMATION OF WATER ECOSYSTEMS OF URBAN TERRITORIES FROM THE ATTITUDE OF ECOLOGY NORMALIZING

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Introduction

North-West of Russia – is one of Russian border territories to which much attention is paied by many countries from the point of view of the ecology control. It is connected with the fact that at the Baltic Sea basin catchment territories of several countries are situated. Hence, a number of items appeares which are based on the estimation of each state share in the Baltic sea contamination in the whole. The ecological state of strongly urban area of Sankt-Petersburg should be decided most of all from the attitude of hydrological cycle peculiarities of the given territory.

One of the basic trends of urban territories hydrology is revealing of urban impact on the environment and water objects in private. At present, there are difficulties in determining of the delinite elements of the urban territories hydrological cycle. One of the leading trends for this problem solving is hydrological processes modelling in urban conditions. However, a number of important questions on urban landscape parameters determining which is necessary for modellind of processes of runoff formation from urban territories characterized by a variety of asphall territories, buildings and lawns. Naturally, physically ungrounded runoff formation from urban territories will give considerable errors when determining urbanization and industry influence on water objects quality.

Presentation of the project

Quantity estimation of contamination degree of water ecosystems is rather formal if one speakes about river systems crossing regions having different degree of urbanization and industry level. In this case catchment dividing into the plots by the degree of their use and estimation of ecological state and adaptation sustainability for each of them by the number of representative parameters is reasonable.

For estimation of the state water ecosystems of urban territories application of free indices building method is possible. This way allows to unite various (of different types) parameters of hydrological and hydrochemical regimes.

On the base of consolidated indices an opportunity of carrying out of ecological normalizing will appear to estimate stability degree of each Petersburg catchment region; to determine maximum admissible loads at the each of the regions which in its turn will make the ecological controle more strich).

Discussion of the results

The suggested methodology is based on the multicriteria estimation of water ecosistems state and stability and allows to take into account different parameters of regimes. Together with hydrological, hydrochemical and hydrobiological criteria, parameters taking into consideretion a degree of water use in industry, for water of populated areas can be chosen, amely, the parameters determining the area of zone of influence of urban territories hydrological regime changing (for surface flow, for water bodies, for undeground waters separately); parameters of microclimate as a derivatives of urbanization (ratio of the average precipitation amount over the urban territory to the average amount of precipitation at the adjoining territory, which is out of the zone of city and industry influence). The per cent of irrevocable losses of water resources and so on can be used.

The estimation criteria, alfebets of the state classes and water ecosystems stability have been proposed, the procedure of multicriteria estimating in the information deficite conditions has been worked out. Priorities changing when calculating the folding indices of ecosystems state (stability) leads to characterising of the class of the state (stability) by numerical meaning of the folding index.

The procedure of separation of the maximum loads by the dependences (dose-effect) for water ecosystems is proposed. It gives the opportunity of predicting of the maximum admissible loads at the intermediate control river lines from the altitude of ecological normalizing which in its turn will be expressed in the concrete recomendations for nature waters use planning.

Conclusion

The given methodology is practised at many water bodies of North -West of Russia. Different folding indices of hydrological state of the Gulf of Finland are received. The received results allow to carry out predicting of the further development of water ecosystems of Petersburg which are refered to the weak areas of the Baltic Sea catchment.

THE COMPARATIVE STUDY OF SANITARY-MICROBIOLOGIC AND ABIOTIC WATER FACTORS IN SYSTEM "LADOGA LAKE - NEVA RIVER - THE NEVSKY BAY - EASTERN PART OF THE GULF OF FINLAND" IN THE DEVELOPMENT OF STRATEGY ON INTEGRATED WATER MANAGEMENT

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Introduction

At last years biological contamination of environment connected with the insufficient quality of clearing of economic-home and industrial sewage constantly increases. More than 120 different types of intestine viruses, which are agents of the most actual infections of the population of SAINT PETERSBURG (virus hepatitis A, rotaviruses hastroenteritus, bacterial dysentery, salmonellesis and other) get into the streams with sewage waters (Fig. 1). Direct finding of agents of actual intestine virus infectious diseases for sure indicates presence of risk of disease of city population.

Scope

Objects of study are: data of dispositional investigations of water samples (about 11300), selected from hydrologo-hydrochemical and sanitary-bacteriological stations in the system: Ladoga lake - Neva river - the Nevsky Bay - eastern part of the Gulf of Finland, some information from the database of the "Morzaschita" Board and own data for period of observations (1987-1998).

Methodology

Novelty and urgency of study consist in that, what it is a first attempt of complex evaluation of degree of water contamination by intestine bacteria and viruses, as well as a first study of abiotic factors dynamics with use a mathematician-statistical methods. Together with classical laboratory methods, other - determination of electroforetypes of viruses in polyacrylamidic gel, finding an antigen of virus of hepatitis A (Ag VGA) and rotaviruses antigens (Rota Ag) , as well as modern express-methods (latex-test) were used, that has allowed to get unique data on contamination of water of the Neva basin by intestine viruses.

Together with intestine bacteria and viruses following laboratory factors were analyzed: pH, temperature of water, general microbial number at 22° C, general microbial number at 37 °C, BOD-5, phosphorous total.

Specific laboratory studies of intestine viruses were conducted in the laboratory of Common and Military Epydemiology Department in the Military-Medical Academy, in the M.P. Chumakov Institute of Poliomyelitis and virus encephalitis of Russian Academy of Medical Sciences (Moscow), in the laboratory of virology of environment.

Results and Conclusions

Valuing these results of water quality in mentioned above areas, it is necessary to note a big range of differences of these factors during the annual cycle. So, the most amount of positive samples, containing entero- and rotaviruses, accounted for January-May. At other periods of year the amount of virus-containing samples decreases.

It is necessary to note also etyologic features of detected markers of enteroviruses contamination. Winter-spring season was characterized by the activation of rotaviruses circulation in the comparison with the virus of hepatitis. A, at the same time, in summer-autumn period the leading place belonged to contamination of water by the hepatitis A virus. Correlation Ag VGA and Rota Ag in water samples characterizes phase of epidemic process of intestine virus antroponoses amongst population of SAINT PETERSBURG and correlates with morbidity by intestine virus antroponoses.

Water areas, adjoining to discharges of aerial stations and coastal areas are most dangerous. The main goal of sanitary-virologic water studies is an evaluation of this with point of view the epidemiological safety of water for man.

Biological particularities of intestine viruses, such as surviving in water, make viruses of hepatitis A and rotaviruses the indicative objects, characterizing direct virus load on streams.

Presented data were received with use of original, developed by us two-staged method of discovering the antigens of intestine viruses in water objects. Method in detail is described in published Methodical recommendations, but briefly essence of test consist on the first stage in concentrating enteroviruses form water by means of ion-exchange resin AV-17-8 or bentonite with following indication of virus antigens on the second stage with using of immuno-enzyme analysis. Concentrating the intestine viruses from water samples and its detection were realized on the basis of "Methodical recommendations on sanitary-virologic control of the environmental objects (M., 1998).

We have determined virus load on the Nevsky Bay and eastern part of the Gulf of Finland. On duration of surviving of enteroviruses in water its contamination by organic material affects, moreover in polluted by organic materials water terms of surviving increase. Surplus amount of bacteria in water promotes more long surviving of enteroviruses.

As it was shown above, modern methods of mechanical and biological cleaning do not ensure a full purification of sewage from enteroviruses and they are a main reservoir of intestine viruses in the nature.

It was determined that about 2,1% of studied samples of water have been contaminated by intestine viruses (agents of hepatitis A and rotaviruse infection). The most polluted areas are: the Nevsky Bay (2,8%), Ladoga lake (2,7%) and the river Neva (2,3%). In water of the Gulf of Finland enteroviruses were defined only in 1 from 100 samples.

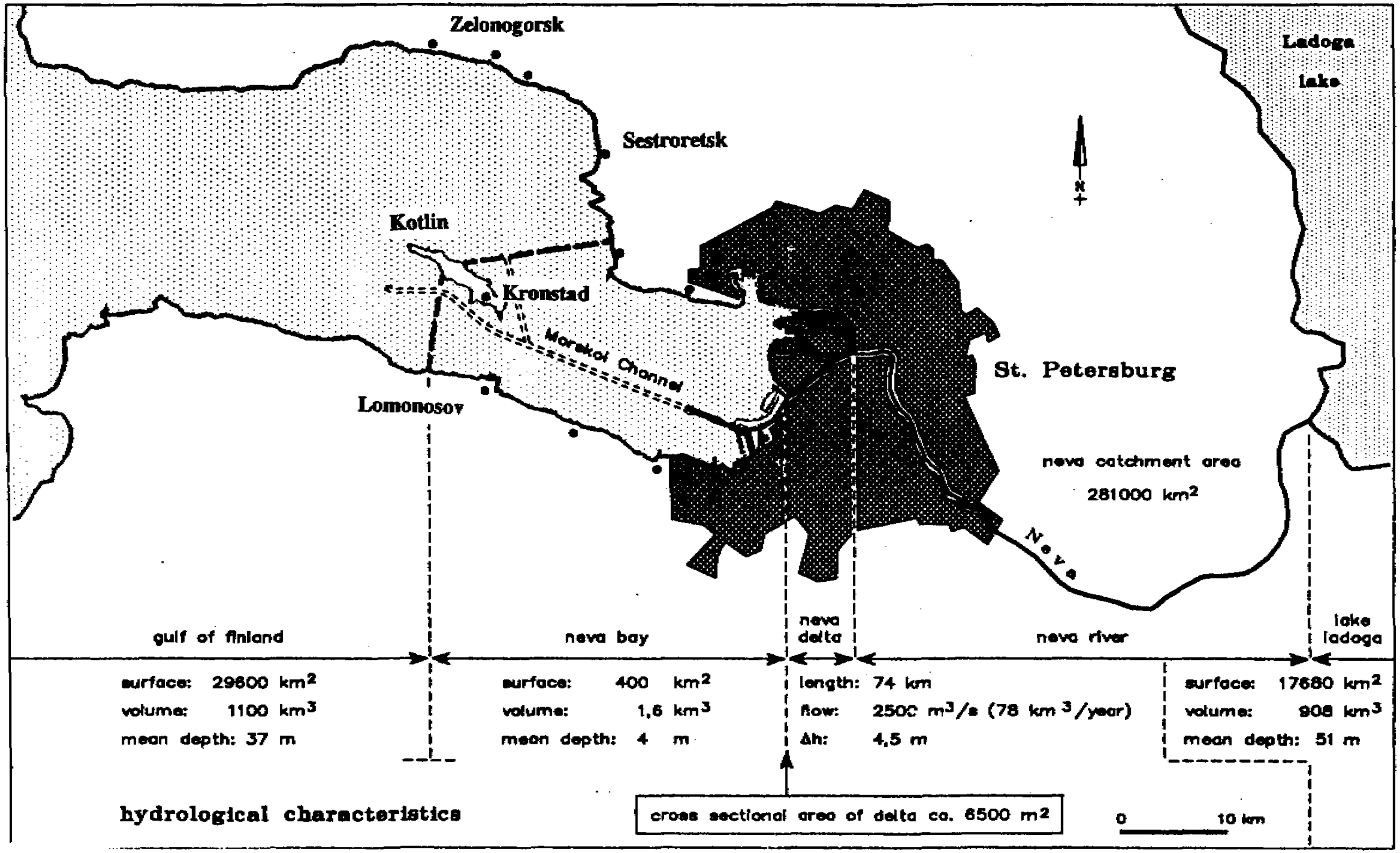
Results of long-standing dynamic observations on circulation of intestine viruses in water objects of NORTHWEST region are the actual base for development of mathematical model of virus contamination of streams.
Developed mathematical model of enterovirus contamination of streams in conditions of large city has served a base of elaboration of concrete practical recommendations on normalization of environment and preventive maintenance of intestine infections in SAINT PETERSBURG.

These results had shown that the most "dangerous" are water areas, adjoining to discharges of aerial stations and coastal areas. Actual sanitary-virology data on the group of intestine viruses present particular interest of the determination of enteroviruses load to the water system Ladoga lake - river Neva - the Nevsky Bay and eastern part of the Gulf of Finland.
Thereby, introduction of sanitary-virology monitoring allows to define the load of intestine viruses on the Nevsky Bay and eastern part of the Gulf of Finland, to study seasonal ascents and the most "successful" periods of year for such agents of intestine infections, as virus hepatitis A, rotavirus gastorenteritis, poliomyelitis and others.

A system of ecological monitoring is developed in respect of bacterial and virus contamination of streams in conditions of large city. It can be recommended to broader introduction. On the base of hydrological system "Cardinal" mathematical model of enterovirus contamination of water demonstrates graphically mosaic of spreading in studying areas of water virus pathogens that defines the need to continue complex study of sanitary-bacteriological, sanitary-virology and abiotic water factors in these areas of water.

Integrated Water Management St. Petersburg

situation



AMBUR TOWN: "Water Problems due the Industrial Activities in Upstream of Palar river Basin"

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Water resources occupy a special place among other natural resources. Water is the most widely distributed 'priceless liquid' on our planet: albeit in different amounts, it is available everywhere and plays a vital role in both the environment and human life. Water resource problems at regional and global scales fall within the sphere of activities of many international governmental and non-governmental organisations.

River water is of great importance in the global hydrological cycle and for the supply of water to humankind. This is because the behaviour of individual components in the turnover of water on the Earth depends both on the size of the storage and the dynamics of water movement.

Ambur is a industrial town located in Tamilnadu state of Southern India. The main activities are tanning and allied process. This operations are a source of considerable environmental impact on the river and river ecosystems in that areas. There are 600 registered tanneries and more than 3 times of unregistered tanneries in this district. River Palar runs through this town which were supplied water for domestic, agricultural and industrial purposes. Now the river water is not useful any other activities because of high salinity due to tanning activities.

Water in Industry: Water in industry is used for various activities like cooling, transportation and washing. The volumes of industrial water withdrawal are quite different within individual branches of industry and also within different kinds of production, depending on the technology of the manufacturing process. The extent of industrial water consumption is usually an insignificant fraction of actual intake. Where as in tannery most of water is being used for soaking of skins and hides and making tannin with hazardous chemicals like Cr.III. After the process the wastewater is being discharged in to the river Palar without any treatment. The development of industrial water withdrawal is one the main causes of water pollution in the world. This is explained by the rapid industrial growth in different countries and exacerbated by the fact that much of the intake is discharged as waste water to natural water courses, for the most part untreated or only partially purified. The tanners consume almost most of the water in the Palar sub-basin. Now the water table has gone beyond the limit. To struggle with such pollution problems, many counties have undertaken energetic measures to decrease industrial water withdrawals and discharges.

Water for Agriculture: Land irrigation has been practised for millennia through the necessity to maximise food supply for humanity but the dramatic expansion in irrigated land has mainly taken place during the 20th century, with irrigation becoming the principal waster use in many counties. Indeed, agriculture is now reckoned to be the largest consumer of water, accounting for some 80% of total water use. In Ambur agricultural activities are predominant four decades back. Now there is no major agricultural activities in this areas. The causes are primarily the very high cost of irrigation networks followed by soil salinisation due to the lack of proper drainage, the depletion of irrigation water-supplying sources, and the problems of environmental protection. At present, about 15% of all cultivated lands are being irrigated. Irrigation therefore plays a large role in increasing arable production and cattle breeding efficiency, with irrigated farming expected to continue to develop intensively in the future, mainly in those countries with extemely rapid population growth and sufficient land and water resources.

In addition to irrigation, there may also be the problem of supplying rural populations and livestock with high quality fresh water in many developing countries located in arid regions. However, costs for drinking water are insignificant compared with those of irrigation. Water is being supplied to the household @ Rs.3 per can (5 liters). The water is being fetched from the Anai madagu a foothill above 10 kms from the town.

Conclusion: At the present time and for the foreseeable future, the most realistic and efficient measures will be:

economy in the use of and protection of water resources by a drastic
decrease in specific water consumption, especially in irrigated land use and industry;
reduction or complete cessation of wastewater discharge into hydrological systems;
more use of salt and brackish waters
spatial and temporal redistribution of water resources.

Workshop 8

Long-term water supply and sanitation solutions

A) Water management
B) Water supply systems

A) Water management

SUSTAINABLE SANITATION: REUSE OF OLD IDEAS?

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Urbanisation and general population growth increase the stress on natural resources such as water and biomass production. A point of conflict arises when water is partitioned between urban and irrigation uses. As virgin water sources run out of stock, we need to consider using used water for various purposes. Demand management is being designed to give incentives for such redistributions. The flow of nutrients to the food production is man-driven as opposed to the mainly sun-driven water cycle. Nutrients are shifted from mines to lakes via food passing through the human body. Urban agriculture could benefit from reusing such nutrients as fertiliser. Urban water management includes the co-ordination of the water cycle and the nutrient flow.

Today, most governments seem to envisage an evolution of piped systems for their rapidly expanding cities. However, cost-effective methods to do this may not be affordable in the near future. This is apparent from the fact that 95 per cent of the sewage from cities in the Southern Hemisphere is discharged untreated. Alternative solutions to arrange water and nutrient circulation for towns are becoming crucial for improving urban living conditions.

Can the past guide us in planning the future?

It may prove beneficial to look at history in order to deepen our understanding of the complex relationships between man, water and nutrients. Today, we know the outcome of some of the measures taken a century ago, but not what alternative solutions that were discussed and abandoned before the piped systems were chosen as the standard solution to the water and sewage problems in the growing cities of the western world. How did people in those days reason and act, and why?

Water management history provides interesting examples of discussions about i.a. ecological, technical, economic, agricultural and hygienic aspects of water management. Dramatic changes were experienced a century ago in European towns. At that time well and lake water was slowly replaced by piped water. Flush toilets became compulsory in new houses in British towns from 1848 and much later in most other countries. Latrine pits and bucket systems were replaced by sewerage at a slow pace. Storm water was collected in the sewers or in separate pipes and emptied into rivers. Worries about ever-increasing pollution of lakes and rivers turned professional interest to disposal and treatment management. However, modern wastewater treatment plants based on chemical processes were not built until after World War II, when the contamination of the lakes and rivers had reached serious levels and there existed affordable technical solutions and administrative capacity.

Nutrients in human excreta - a health hazard or resource?

Animal dung and human excreta have often been used to retain soil fertility. It was a must especially before guano from Peru was imported to Europe in the mid-nineteenth century. When Victor Hugo in his book Les Misérables (1862) gave a critical view of the sewage system in Paris he concluded that "the sewerage is a wrong idea" because the river Seine was full of disease and the soil was becoming ever poorer as a result of discharging human waste into the river instead of returning them to agriculture. He echoed the views of an ongoing discussion at the time.

Not only farmers but also scientists knew the value of nutrients in human excreta. Krepp (1867:33) summarised that "the proportion of value of the fertilising ingredients held in solution in urine to that contained in faeces is as six to one". At the time, there were few health considerations concerning the use of human-derived nutrients in agriculture. However, for more than a century, urban public health concerns have competed with the need for re-circulation of nutrients. The use of sewage water to irrigate farms close to the towns may be seen as a compromise between the two. The same issues are at stake today in the discussions of what is a sustainable city.

Various groups in society felt the economic effects of the installation of WCs, not only farmers. The sewerage put some people out of business as indicated by Krepp (1867) who wrote that in the 1860s the yearly trade in human waste for fertiliser totalled 500 million francs, while the French national budget was some 2,000 million. In English towns the servants in wealthy households were entitled to sell the excreta produced in the house. This fringe benefit "went down the drain" when sewers were installed. Similarly, the concierges of Japanese terraced houses had the right to the waste of the tenants that was collected in the common toilet. Japanese farmers paid the manure collectors cash for their treasures up to the mid-twentieth century (Ishikawa, 1998). The commercialisation of human excreta led the Japanese to grade its quality; that derived from feudal lords and people who worked for the government being the best, while that from jails was graded the poorest quality. It is of interest to note that a greater portion of urine in the human waste was regarded as of poorer quality. In England most of the excrements were collected in well-constructed watertight cesspools, which were emptied twice a year by market gardeners, and they paid for it in proportion to its solidity. In Milan in Italy there were but few water closets in the mid-19th century because the farmers refused to buy excrements diluted by water (Krepp 1867:59).

Could the economic value of excreta become high again under new conditions? Urban residents gained health benefits by getting rid of excrements through WCs. However, irrigation with raw sewage was not successful in the long run (Hamlin 1980). Instead, sludge was deposited in landfills and only recently is it technically, but hardly economically, possible to convert it to biogas or high-quality sludge. The extent of urban agriculture will be crucial for reusing nutrients.

Perceptions of water quality in effluent-receiving rivers and lakes

We highlight the development of perceptions concerning the introduction of WCs by giving the example of Stockholm. Swedes were not isolated as trade links and professional contacts between Sweden and the rest of Europe also included the sanitation issues. A century ago the upper classes aspired to acquire fancy items like flush toilets from abroad, and professionals went on study tours to water and sewage works in foreign industrial cities. Thus, the discussion about options arising from the fact that urine contained most of the nutrients was well known at that time. Only in this century did the Swedes become urine-blind (Drangert, 1998).

The pollution of water bodies by effluents was considered a serious problem in Stockholm, also before flush toilets were introduced. This prompted the city council of Stockholm in 1888 to commission a study of the potential harmful effects on the Lake Malaren by introducing WCs on a large scale. Some interesting conclusions came out of the study. The increased faecal contamination would be negligible at the then existing water intake, not the least because most of the urine was already discharged into the lake (Sondén, 1915:8). In fact, many residents did not mix urine and faecal matter in the bucket, but collected the urine in small bowls and disposed of it in the sink in the kitchen. By doing so they radically reduced the amount of material in the bucket and, also, they reduced bad odour from the closet.

In 1893, despite the reassurance that the water quality at the water intake would deteriorate only slightly, the city council banned new WCs by not allowing piped water to be used for flushing toilets. A decade later, 1904, the ban was lifted and a rapid increase in numbers was recorded. By 1915 there were 46,193 WCs. But still the 33,186 bucket latrines in houses and flats, and 43,627 bucket latrine units in yards outnumbered the WCs. On average there was one toilet per three inhabitants (Sondén, 1915:20).

A legal requirement for a WC was that it was connected to a cesspool in the cellar or under the yard. Already at that time, however, a discussion started whether to construct cesspools for individual houses or centralised treatment plants (Westerberg, 1904).

Some concluding remarks

New ecological and sustainability requirements on sanitation put new demands on central wastewater treatment plants – or on good behaviour and loyalty to the system by all the users. The historical account above points to the fact that urban inputs and outputs are linked, but usually different departments address them. Therefore, there is a risk that solutions to an input problem may have negative impacts on solutions to output problems and vice versa. Equally important is the fact that the prevention of groundwater quality seems to have been considered a lost case very early in the urbanisation process, thus impeding people's use of dug wells for their water demands. History also shows that change usually is a slow process. As we have seen long periods of time were needed for even simple improvements, also when the technology was known. Old ideas are being reused and social acceptance seems to remain crucial in the process of change.

In Sweden, China, and other countries commercial firms market no-mix toilets today. Ecological alternatives in sanitation range from no-mix toilets to using sanitised urine in urban agriculture. As seen above this is not new but has a long tradition in many countries. However, a distinct difference is that present-day urban residents often expect piped solutions, which was not the case in Europe a century ago.

Sustainable ecological sanitation is a truly multidisciplinary field and relevant issues concern cultural and social desirability, hygiene risks, potential of reuse of nutrients from human excreta in agriculture, affordability, promotional issues, and technical construction. We can learn from history and also from a growing number of research projects dealing with these issues.

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WATER SUPPLY AND SANITATION: TRENDS AND DEVELOPMENTS

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Introduction

Rising water demands and the lack of sanitation are two areas that have given rise to considerable debate, discussion and worry during the last four to five decades. Both these areas are closely linked with human development, which is constantly on the rise. As water demands escalate, there is the need to augment existing supplies by developing new sources. This problem becomes more challenging, as the world's fresh water supplies are limited to a finite 2% of the total available water. Sanitation requirements bear different sets of problems especially in locations where water supply is limited and hence the luxury of water-borne disposal systems are excluded. Appropriate systems that are as effective, but preferably less water-intensive, are necessary to curb the spread of disease and, if possible, to recycle the waste material. The main objectives of this paper are to identify the factors that account for the changing paradigm in terms of water supply and sanitation requirements, to analyze the existing situation and to put in perspective the developmental areas for the future.

Factors associated with water demand & supply

Water demand throughout the world has been growing at variable rates. The demand for water is closely related to sectoral requirements in the domestic, industrial, agricultural areas. The availability of water and its cost are also factors that will influence the demand.

Domestic demands are closely related to population growths. Annual growth from 1950 to 1998 has increased at a rate of 2.8%. Though future populations (in 2050) are expected to increase upto 9367 million, the rate of growth decreases to 2.14% (upto 2025) and further drops to 0.66% (upto 2050).

Globally, total water demand from 1940 to 1990 has doubled from about 400 to 800 m^3 per capita per day. Water consumption rose six fold between 1900 and 1995 which was more than twice the population growth and it continues to grow rapidly due to the increasing agricultural, industrial and domestic demands. Agriculture currently accounts for 70% of water consumption and by 2025, industrial water demand will double if current growth trends persist.

The growth in urban areas is four times that in the rural population and has resulted in the increase in the number of megacities from 2 in 1950 to 23 in 1995. Besides, between

1990 and 2025, the number of people living in urban areas is projected to double to 5 billion in which case two thirds of the world's population will be living in towns and cities out of which 90% will be in developing countries.

The demand for water is also driven by its price. It is not unusual to find water being supplied free for irrigation purposes, particularly in developing countries. Prices for potable water vary and it is seldom that government-sponsored projects charge highly. The demand, however, is quite sensitive to the price and more to stringent controls if administered by any water authority.
Demand can also be managed to a certain extent by ensuring that the overall system is optimally operated and that water supplied is not lost by poor operational practices leading to largely unaccounted-for losses.

Measures to cope with escalating water demands

With the prevailing high rates of water demand, the quest for augmenting water resources should be one of the most pressing issues in the next millennium. Global available renewable freshwater lies between 9000 to 14000 cubic kilometers per annum. A substantial amount of this quantity is needed to sustain natural ecosystems. The remaining finite quantity, has to be managed appropriately to ensure that national interests are met with and no animosities are harboured.

As the agricultural sector accounts for a large amount of the demand, it is imperative that water- intensive crops be studied so as to reduce the volume of water being used. Besides, practices like drip irrigation which have been proven to be great water savers have hardly been exploited.

As many industries use excessive water, they should be limited to finite quantities and encouraged to optimize its use. In this context, use of a parameter (water used/ value added of a product) should encourage industries to improve their operation methodology.

Demand management should be an integral part of every water authority which should have elaborate working plans to reduce unaccounted-for water, utilise water-saving devices and educate the user to make the saving of water as a way of life. Progressively increasing the cost of water can also be used as a tool for controlling demand.

The emergence of a number of megacities by 2010 could be the main cause for the rapid increase in water demand in the industrial sector. Urban populations will be spread around the cities and will encroach on catchment areas which will then be strife with pollution due to intense human activity. By adopting suitable management measures, urbanized catchments are currently being used in water-scarce countries like Singapore.

Urban living is synonymous with high-rise buildings and large paved areas. These are ideal areas for carrying out rainwater harvesting. Roof water can be tapped from high-rise buildings and the water can be used for non-potable uses. Larger tracts like educational institutions, airports, army camps etc can be fruitfully utilised for augmenting supply and integrating with existing systems.

The quantity of sewage generated is very large and very often finds its way into the ocean. Recycling of treated or untreated sewage is currently being practised and appropriate studies should be undertaken to eliminate the possibility of spreading disease. Industrial wastes should also be recycled and due tax incentives should be given.

Desalination appears to be the panacea for all water supply requirements but more work needs to be done in processing techniques to arrive at economically viable options.

Existing sanitation facilities and influencing factors

For human well-being, adequate sanitation is essential. Any facilities provided should be able to break the faecal-oral transmission route for the spread of disease.

As populations have increased, there has been an upsurge in the facilities provided. In 1980, 40.5% of people did not have sanitation facilities and this was reduced to 23.3% at the end of the Sanitation Decade in 1990. By the year 2005, it is anticipated that this figure will rise again to 43.3%. During this period, the rural population lacking sanitation facilities will only marginally decrease whereas the urban population lacking facilities will increase from 13.1% .0. to 33.3%

The urban poor constitute a large part of the urban population, and can vary from 17% (in Bangkok) to 35.5% (in Jakarta). The urban poor, particularly in developing countries, live in blighted areas that can be in found in public lands, factories, dump sites, idle private land etc.,

Currently, urban areas in developed countries have public sewers, which transfer wastewaters. In rural areas, packaged treatment plants or septic tanks are available. In developing countries, where the supply of water is inadequate, there are some facilities like pit privies, pour-flush latrines, septic tanks and communal toilets that do not require large volumes of water for conveying the wastes.

Most cities in third world countries cannot afford the necessary resources in terms of water, money and institutional capacity for a flush and discharge systems linked to public sewers.

Measures to be adopted for enhancing sanitation levels

For appropriate sanitation to be maintained, the provision of potable water of an accepted level is crucial. In case wastewater can be conveyed through sewers, there should be adequate treatment facilities to produce acceptable effluent and to handle the large volumes of sludge.

As wastewater collection systems increase, the large volumes of sewage effluent generated should be used as irrigation water. For utilizing the full potential of this major source, there is the research need for the development and adoption of suitable crops and appropriate agricultural methods.

With an imminent population explosion in megacities and the ubiquitous presence of the urban poor in developing countries, a pragmatic approach should be adopted for maintaining adequate sanitation. The existing methods for removing wastes have to be looked into and an integrated system of collection, treatment and disposal should be worked out. Ultimately such wastes should be rendered harmless and be part of the environmental cycle.

Conclusion

As water demands escalate, there is the need to pursue appropriate demand management techniques. Special emphasis has to be placed on urban areas, particularly in the emerging megacities where urban catchments have to be utilised and water harvesting actively pursued and be an integral part of a larger system. Irrigation requirements should be minimized and drip irrigation should be fully exploited.

Sanitation has not kept pace with population growths, particularly in developing countries. Where large volumes of sewage effluent are available, they can be used in agriculture. The urban poor in megacities should be provided with eco-friendly sanitation systems that will not impinge on water demands.

Challenges to Urban Water Management in Developing Countries

(Dr. Hari Baral, Vice-President – ISOCARP)

Introduction:

Water is not only the vital resource for the survival of all forms of life but also the common vector and an essential capital for all development activities whether they are urban or rural. During the last half of the century, **the gap** between the population growth and urban development and the availability of more water resources has been **steadily increasing** and this backlog is widening every day, particularly in the developing countries where the existing water resources are subjected to continuous pollution from industrial and human wastes and uncontrolled extraction from the aquifers reserves. We are already witnessing serious consequences of this situation in our life supporting and fragile environmental ecosystem, on our economy and the degradation of general health condition of the settlement centres.

Facing to this hyper concentration of population in the rapidly expanding urban centres, the existing urban water supply and sanitary systems of the developing countries, are becoming **unfunctional and obsolete** to meet the growing demand of their cities and pushing them to launch into ambitious development programmes often **beyond their economic capabilities**. Even the **rehabilitation costs** of the existing systems are quite difficult to meet from their available economic resources. **In the absence** of adequate anticipatory actions **at the up-stream level of water collection and management** and lack of appropriate **spatial development strategies at the national level**, the existing urban centres are subjected to high water stress due to excessive concentration of population growth with unplanned built-up areas in their peripheral zones without any apparent solution to further resources. This situation today are seriously affecting not only the quality and the quantity of their water resources but increasing steadily the cost of water without increasing the supply. To meet this demand, many city authorities have to go far away areas to look for new water resources and to invest heavily on large infrastructure networks with high system loss and the installation of complex and costly water treatment plants.

This situation is becoming so critical at the social level in many countries of Asia, Africa and Latin America that during the dry seasons, due to water shortage, not only the epidemics of endemic diseases are doing havoc with loss of life, particularly to the children, but also generate frequent riots within the poorer communities living in the peripheral areas having little quantity of drinking water.

This shortage of supply of adequate drinking water has also serious impact on their economic growth both at the local and at regional level with all negative consequences on the future development of their socio-economic prosperity.

Problems:

1. – *Institutional reforms and holistic approach to water resources management.*

Most of the developing countries, since their independence, did not undertake an **in depth change in their institutional organisation**, responsible for preparing national strategies on spatial planning and water resources development in a comprehensive manner. Whereas, this is an essential support for assuring a balanced economic development and **rational distribution of population concentration** at the regional and national level. Whatever actions have been taken up in this direction, they were either, a more or less continuation of the previous policies or, follow up of piece meal proposals prepared by experts from different aid organisations – themselves are lacking clear policies in this issue. Consequently, many of those actions were not quite efficient and becoming unsustainable for lack of appropriate development strategies based on a holistic approach to national priority requirements and in terms of the carrying capacities of their economic, natural and other resources. As a result, actions taken up as follow up to these policies to meet the national needs in water resources development are often been ambitious or inappropriate to achieve the desired results in a sustainable manner.

2. – *Costly and risky approach to extract water from extra territorial regions instead of less costly techniques already available.*

Most of the current water resources development projects in these countries are oriented to ease the situation by concentrating the efforts mainly on increasing the supply of water from extra territorial areas by extending the existing networks from a centralised system at the cost of high investment without the evaluation of its impact on the economy and the ecosystem of the area of intake. Whereas, consideration of other alternative methods are often been neglected such as Water Demand Management system (WDM) or autonomous units of drinking water production plants of varying capacities consuming less energy, less piping with selected point distributions most suitable to meet the real time water demand at the local level. These approaches would have decreased the water installation cost substantially, particularly in areas of high water shortage. More over, such approaches would have been within the economic capabilities of these countries to improve in short term, communities' water demand without involving the public finances into heavy investment. On the other hand, it would permit to practice a more equitable pricing of the water, narrowing the gap between its real cost and highly subsidised social price.

We should bear in mind that the cost of water is largely tributary to its treatment, its infrastructure installations and the maintenance costs of the distribution system. Shorter being the circuit between the production of water and its consumption, less will be its cost and the risks of contamination. More concentrated out look in a comprehensive manner is therefore necessary to those parameters influencing water consumption cycle at their up stream level in order to improve the efficiency future water demand and management policy.

3. – *Planners' and developers' role in developing rationalised land uses for equitable use of water.*

From the planning point of view it is necessary to review the urban design pattern and the inter-related byelaws of many megacities in these countries, particularly where the water supply situation is under high strain. Most of these cities are divided into three built-up patterns – low density green individual houses, high density compact apartment houses and peripheral shanty towns of urban poors. This configuration of the land uses leads to a very unbalanced water distribution of per capita consumption. In the first case, there is a high wastage of costly drinking water in nonessential uses depriving others citizens from their appropriate share of water. In the second case, there is an excessive demand at peak periods which has often encouraged the people to stock excess quantity of water more than necessary for the fear of shortage and, in the last case, there is very little availability of safe drinking water leading to health risks and very often free uses of water due to high cost factor. The planners and land developers should have legal obligations to assure justified use of water in their development concept. The policy of "users pay" is good but without adequate control on consumption, it would leads a blank cheque to wastage for those who can able to pay.

4. – *Social attitude to water and its uncontrolled use as well as abuse.*

As water being an essential necessity of life and a gift of nature, it has often been considered as a social endowment in most of these countries rather than a value added product having a certain price. Or, its distribution and management rests entirely with the public authorities – a situation does not usually develop a sense of common responsibility to its justified uses and hence it's social cost amongst its consumers. This situation leads to abuses of water without any legal accountability either on the managers or on the users. The price of water has thus been highly subsidised irrespective of the economic condition of the users ending up with high amount of unpaid bills – not among the poors but amongst those who can afford to pay for their use. Appropriate legal framework and financial reforms are therefore urgently necessary to follow up comprehensive water management policy at this level to save water from wastage.

5. – *Control of water conservancy and contamination risks through co-ordinated and up-stream level actions.*

In general, rivers and natural watercourses constitute the major sources of fresh water. However, ground water resources from shallow depth are also providing substantial supply, particularly in the under supplied areas or where municipal water services are lacking. Unfortunately, both these sources are vulnerable to pollution especially from industrial, agricultural and unsanitary treatment human wastes for the following reasons.

The Water supply and the Sanitation authorities in many a developing country are working as separate entities. As the waste disposal systems in most of these countries, as like elsewhere, are based on the water borne system or open air land filling of city garbage, most of the disposed wastes finally ends up at the natural water courses or to the shallow aquifers through infiltration usually with the rain water. Therefore, close co-ordination between these two authorities and preferably, the management of both the systems by a single authority would be an efficient measure for managing environmental condition of natural water resources and to protect the existing water sources through a sustainable water conservation policy. Perhaps, at the same time, countries which suffer from chronic draughts or dessert climate should undertake studies of affordable new technologies of intensive recycling of used water as well as compact and dry system of waste treatment – an approach getting increasing attention in many a developing countries where water is not abundant.

6. *Consolidated role of all planning and building professionals as well as legal obligation to incorporate rainwater-harnessing fittings in the buildings and sites.*

Countries do not have enough ground water resources or suffering from frequent draughts have seldom practised any appropriate techniques integrated with the building construction plans to collect the rain water and to get them stocked for domestic or other uses. Even in tropical countries which receive heavy seasonal rains, often suffer from heavy water scarcity during the summer season. If a good quantity of rain water instead of being lost through run off could be recuperated through appropriate collection and storage system, particularly in the built-up areas of urban centres, many local area needs could have been satisfied without over extraction of precious underground water. Therefore, it is an important task for the architects, planners, building professionals and the related authorities to undertake serious studies of developing appropriate techniques for collecting rainwater as an integrated part of the building and urban design at all levels of development, from the individual building plans to built up neighbourhood areas. This would also be a good initiative for conserving existing water resources of the local urban basin.

At the regional level, such objective could be realised by building up reservoirs of varying dimensions depending on the topographical and the hydrological characteristics of the sites rather than the construction of large dams and barrages which often bring unknown ecological risks and disasters (Bangladesh, West Bengal, India etc.). Traditional methods of water collection and preservation systems, which were less costly and more adapted to local capacities, are required to be reintroduced and developed in most of the Asian and African countries to develop adequate water resources at micro level. In the delta regions of these countries it had been the traditional practice to dig large tanks protected by embankment within the settlement centres which constituted perennial supply of sweet water sources to the communities even during the flood seasons. They are now either filled up for habitation or become unsuitable due to lack of maintenance.

7. – *Reforms of agricultural lands and techniques to economise fresh water use through land consolidation and better irrigation approach.*

The agricultural sector which consumes a large part of the fresh water resources do not receive adequate attention in the national development strategy during the last half of the century, particularly, on the reforms of land tenureship and in the evolution of agricultural practices. Irrigation being one of the efficient methods for economising water for agriculture. Unfortunately, most of the agricultural lands in these countries have been composed of small parcels distributed in an irrational manner both in their physical forms as well as in terms of their ownership title. As a result, economic irrigation system minimising loss of water is almost impossible to develop within such micro-parcelling system. **Urgent land reforms and titleship review of agricultural lands through land consolidation or other forms are some of the most important tasks to develop rationalised use of water in the agricultural sector**. This will also help to divert a substantial quantity of fresh water thus saved to other uses of high economic return.

8. – *Shadow cost of water on social and economic development.*

If we consider the indirect and other accumulated cost that the society has to bear for not providing adequate supply of water to those thirsty communities who present economic conditions do not permit to pay the economic cost of water we will be surprised to know that in many countries that amounts to almost ¼ of the national G.D.P. This handicap not only denies them their social share of water but also exclude them from the national economic development opportunities and pushing them more and more to the poverty and social exclusion – a situation responsible for many social stress and degradation.

Policy Approach:

Water, environment, development and health are four important elements integrally related for any policy planning of balanced spatial development. Planning and execution mechanism on land development should be closely complementary, interrelated and adapted to the environmental water resources conditions of the region in order to achieve a sustainable development. In the developing countries and even in many a developed countries, the major handicaps are encountered between policy definition of water management and execution mechanism of landuse development in relation to these policies. They are very often contradictory and not sequential with the approved conservation programmes on regional water resources. As a result, programmes of objective achievements are often been lost in the procedural mechanisms and in the delay of the process of decision making of the administration. This in turn aggravates the critical water situation both time, dimension of the problem and financial implication. In practice, too many authorities are simultaneously involved in these countries with water management and sanitation control, each having their own territorial jurisdictions and administrative formalities with little interdepartmental co-ordination and information exchange. Therefore, developing an effective holistic strategy on water resources development and environmental health management is often an impossible task. This handicap is perhaps one of the major challenging tasks of the developing countries in order to address urgently the critical water situation and to develop a sustainable water resources development and management policy, particularly for their growing urban centres.

To meet this objective, particularly for the urban areas, one of the important tools is to set up an observation and monitoring system of water uses which should be linked up operationally and administratively in the decision making process of all the authorities involved in water use systems and environmental health control.

One of the efficient systems and which can be considered as an effective tool to address the water scarcity problems and to ensure a balanced use of water in the urban areas is the Water Demand Management system (W.D.M). This system, in fact, allows a rationalised use of already produced water through controlled distribution in terms of the real time demand at the local level as well as by checking non-conforming uses of costly drinking water. It can permit to save as much as 30 to 40% of lost water to productive uses without investing to new resources which are very costly and risky to environmental ecosystem.

We must look for all possible solutions for rationalised use of water and to decrease its real as well as shadow prices, starting from unit distribution plants to decentralised distribution system instead of looking always to centralised system of water supply management to meet the demand which are costly to maintain and involve lot of management efficiency to control system loss, wastage and unpaid water bills – an aspect easily criticisable but cannot be overcome at least in the near future in view of the legacy of other bureaucratic factors inherited in the colonial periods.

Lastly, the educational authorities are to be involved very closely with the development and execution of holistic water conservation and management policy, particularly at the microlevel of the educational system. To develop effective and sustainable water sensible attitude to water use among the present as well as the future generation of the society, the children's' education play a vital role. Because they are the future citizens of the society – what they learn today they will practice tomorrow.

Conclusions:

A holistic and integrated water management strategy with a long-term vision of development is the backbone of a sustainable water resources management in the developing countries where rural economy is still one of the major activities of the national population. A balanced development strategy in terms of water resources and infrastructure facilities is a priority action for sustainable development. Political strategy, economic policy and development programmes are needed to be complementary and to be based on the national capacity of resources (material, economic, technical and human) so that they can be affordable and applicable within the functioning frame-work of the country.

The effects of adequate availability of water in the settlement development and its socio-economic evolution are very deep rooted. It is in fact, the locomotive of all developments. The shadow cost that the society has to bear for not providing adequate quantity of safe water to the community in terms of health hazards, development handicaps, social stress etc. can amply justify the supply of a basic quantity of water to the very poors at a highly subsidised solidarity price to enable their development from the poverty – an aspect becoming a serious handicap to-day to the social development.

On the other hand, administrative structure, funding mechanism, consumers' pricing and users' guidelines are very important for developing justified uses of water. Unless these actions are introduced and made operational, the means to meet effectively the challenging problems of water resources development in these countries would remain long time an unsolving issue.

URBAN WATER AND WASTEWATER STRATEGY FOR THE UPPER YANGTZE BASIN, CHINA

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Introduction

In an increasing concern for the health of its citizens and the well being of the environment the Government of China has embarked on an ambitious programme for a nation wide improvement of the environmental quality in all major cities.

Rapid industrial growth during the past 20 years has sparked a massive rural to urban migration increasing the pressure on the environment within and around the cities, and turned upstream water availability and downstream water quality into major issues.

In the Upper Yangtze Basin, above the future Three Gorges Reservoir, the Government is supporting provincial authorities to develop and implement an Urban Water and Wastewater Resources Strategy that will contribute to a social, environmental and financially sustainable delivery of water supply and sanitation services.

This paper presents key findings and recommendations of a Strategy Study, that was conducted by COWI and DHI for the Governments of Sichuan and Chongqing under co-ordination by the World Bank and with funding from Denmark.

Scope

The Upper Yangtze Basin above the Three Gorges Dam comprises some 750,000 km^2 with a total population of 150 million who are concentrated in the fertile Sichuan or Red Basin. The Strategy Study focuses on the demands for water and wastewater services within 14 major cities with a total population of 8.5 million (1995) projected to rise to 15 million by year 2020, and on their impact on water quality in the 4,500 km of major rivers upstream of and including the future Three Gorges Reservoir.

Methodology

The Strategy Study comprises inventories of population, water consumption, environmental infrastructure, and municipal and water company finances, as well as river regimes, river flow, water quality and pollution loads on the major rivers from municipal, industrial and rural wastewater discharges, with projections up to year 2020.

Water company data feed into models to derive price and income elasticities for the historic water consumption and projections of future per capita water demand for different levels of cost recovery of water and wastewater services.

Population, infrastructure, and water demand projections feed into a model predicting infrastructure and investment needs for different scenarios of cost recovery, service level and environmental protection.

The river flow, water quality and pollution projections feed into the MIKE11 and MIKE 21 river and water quality models which were set up and used to model water quality in the 4,500 km of major rivers upstream of and including the future Three Gorges Reservoir. The modelling comprised different scenarios of pollution reduction and the impact of the proposed Strategy.

Comparison of environmental benefits and financial costs leads to a Strategy for expansion of, and investment in, urban environmental infrastructure, that over 25 years will ensure adequate safe water and environmental sanitation for the population in major cities and towns in a social, financial and environmentally sustainable manner.

Results and Conclusions

Service levels, social and financial sustainability

In 1995 the urban water supply companies had an aggregate water treatment capacity of 3.3 Mm^3/day with a domestic consumption of 85 lcd within their service area. In contrast, the wastewater treatment capacity of the same cities was 116,000 m^3/day corresponding to 4% of the municipal wastewater discharge.

Current water prices (1997) average CNY 0.80 (USD 0.10) per m^3 and need to increase 35% to cover the cost of operation and maintenance. Secondary wastewater treatment would incur a cost of the same magnitude as the water price. In order to achieve full cost recovery including depreciation of investments, loan service and a small profit margin for future investment, the combined water fee would need to rise to 300% of the present level.

Full cost recovery may reduce future domestic water consumption from 250 lcd that would result from an unchanged tariff policy, to an estimated 180 lcd which is adequate for comfortable and sanitary household hygiene, thus making the service level socially acceptable. The full cost corresponds to 2% of average household income which by World standards is within the affordability and willingness to pay for water, thus making the price socially sustainable and the improved service financially sustainable.

Choice of technology

The inventory of water pollution shows that urban and industrial wastewater discharges are the main sources of pollution by organic matter and ammonium, while agriculture is the dominating source of nutrients. This implies that secondary treatment of urban and industrial wastewater may achieve a significant reduction of organic pollution, while the reduction of nutrients by tertiary treatment would be insignificant on the background of leaching and run-off from rural areas. The inventory thus identifies mechanical - biological wastewater treatment with nitrification as the environmentally optimal technical solution.

River modelling and environmental sustainability

Monitoring data and water quality modelling show that in the upper parts of all sub-basins and within cities in the middle part of sub-basins the dry-season pollution with bacteria (E-coli), organic matter and ammonium violates the Class III water quality objective, which enables the use as domestic water after conventional treatment. In contrast, the water quality on the Jinsha-Yangtze mainstream will satisfy the stricter Class II objective up to year 2020 even within mega-cities such as Chongqing.

The modelling illustrates the high assimilative capacity of the rivers causing decay of organic pollution within 30 - 70 km of the discharge site, depending on dilution, river flow and morphology. Modelling also illustrates that well designed centralised outfalls downstream of cities cause negligible increase in pollution compared with the existing diffuse discharge from many individual outlets scattered within the cities.

The modelling thus identifies intercepting sewers in all cities as the first priority to improve the urban environment and enhance the value of large on-going investments in an attractive urban waterfront, and secondary wastewater treatment within cities in the upper part of catchments as second priority, while mechanical treatment will be adequate in cities on the Jinsha-Yangtze river. Targeting wastewater treatment in cities in upstream catchments will thus achieve greater environmental benefits than a uniform progressive coverage of all cities.

Strategy

The analysis of environmental benefits and financial costs leads to a Strategy recommending demand management by a gradual introduction of full cost recovery for water service delivery and a phased upgrade of water and wastewater infrastructure. In the short term up to year 2005 the Strategy is to upgrade water service levels to 170 lcd net and divert wastewater for centralised discharge downstream of urban areas. Primary and secondary wastewater treatment will be introduced sequentially starting in major cities on minor rivers in the upper part of the basin, and possibly postponed beyond 2020 in cities that discharge directly to the Jinsha-Yangtze rivers.

Upgrading of water and wastewater services in the major cities in accordance with the Strategy is estimated at CNY 18.8 billion (USD 2,450 million) up to year 2020, of which CNY 8.8 billion (USD 1,100 million) would come from continuation of the present level of investment.

The introduction of cost recovery has reduced the need for source development and capacity increase of water works by 2.6 Mm^3/day and the corresponding investment need by CNY 3.2 billion (USD 400 million), compared with an unchanged tariff policy.

The sequential implementation of wastewater treatment in the major cities in accordance with the Strategy would postpone investments of CNY 4 billion (USD 500 million) until after year 2020, and by CNY 6 billion (USD 750 million) compared with complete coverage by tertiary treatment.

Redirection of the redundant investment from the major cities, towards large towns located on tributaries to the major rivers may provide significant improvement of health and hygiene for a large segment of the rural population who mainly depend on the these rivers for their domestic and irrigation water.

SUSTAINABLE URBAN WATER MANAGEMENT

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Introduction

The Swedish urban water systems have been in use and under continuous development for more than a century. In most cases, the urban water systems of today fulfil the basic requirements. For the past ten years, however, these systems have been criticised from the viewpoint of sustainability. Other requirements have been imposed on the systems; other technical systems have been suggested and tested on a small scale; and other distributions of responsibility are being discussed. The directions for future Swedish urban water systems are to add requirements relating to ecological sustainability to the former basic ones. Examples include recycling nutrients, energy savings and public participation.

MISTRA (The Foundation for Strategic Environmental Research) has granted SEK 30 M for the period 1999 - 2001 to the research programme "Sustainable Urban Water Management". Research departments from eight Swedish universities participate in the programme, from Luleå in the North to Lund in the South.

Systems approach

Society and its urban water systems are growing increasingly complex. In order to cope with the requirements both now and in the future, it is necessary to apply an holistic view to the systems and the surroundings they will serve. It is necessary to study the drinking-water system, the storm-water system, and the waste-water system in an integrated manner in order to avoid sub-optimisation. Moreover, it is necessary to study the interaction between the urban water systems and the environment, particularly watercourses and agriculture. Studying the social systems that use, plan and manage the urban water systems is unavoidable. Human needs and behaviour must be addressed. Institutional interaction must be taken into account. The future development of Swedish cities and towns and the implications for urban water systems must be observed. The demands and restrictions the water cycles impose on urban development should also be considered.

The central task for the entire programme is to answer the question:

> *How should the urban water and waste water systems be designed and operated in the future "Sustainable Sweden"?*

As we now have professionally designed and operated urban water systems for all the urban areas in Sweden, the following questions naturally arise:

> *Do the urban water systems that we use today have such fundamental shortcomings that we must plan for and implement changes to new systems?*
>
> *Under which conditions do we have to change the systems? Which criteria do we use?*
>
> *In cases where the current systems should be kept, how do we develop the systems in a sustainable direction?*
>
> *In cases where the current systems should be changed to new systems, how should these new systems be designed and operated in order to achieve sustainability?*

The main objective for the programme is to answer these basic questions. The tool for doing this is the systems analyses, which is the core of the programme. All research projects within and associated with the programme aim to supply the systems analysis with the knowledge needed to answer the basic questions. The systems analysis also obtains knowledge wherever it is to be found - in other national and international projects, in literature, in other scientific disciplines, from actual cases in municipalities and so on.

Priority research areas

Within a restricted budget, project areas have been selected on the basis of the important problems that have been identified. The research areas are divided into "integrated research areas", which encompass the entire urban water system and its interacting surroundings and "technical research areas" which deal with important problems within the drinking-water sector, the storm-water sector, and the waste-water sector, respectively. Within each area, research projects that play a central role in providing solutions to the identified problems have been selected, in total 15 projects.

Under "Integrated projects" the following research areas have been defined:

- Socio-economics
- Hygiene
- Risk assessment and communication technologies
- Use of products from urban water systems

The following research areas have been selected under "Technical projects":

- Drinking water – treatment and distribution
- Storm water management
- Waste water and sludge - recovery of products

Sustainability criteria

A set of sustainability criteria has been developed, in order to be able to compare alternative water systems. We apply an anthropocentric interpretation of the expression sustainability. Five groups of criteria are used, each with a number of sustainability indicators:

- Health, hygiene and comfort criteria
- Social and cultural criteria
- Environmental criteria
- Economic criteria
- Functional and technical criteria

Model cities

The programme cooperates with the water industry and with several Swedish communities. The research is carried out in five model cities, which of four are typical of Swedish conditions. The identification of research needs and the application of research results within the systems analysis will be made for these model cities. The model cities are:

- A newly-built urban area
- An old urban area in or near the city centre
- A small town surrounded by agricultural areas
- A densely populated urban area built during the "Million programme"
- A "pipe-less" city

The Urban Water Research School

The Urban Water Research School is an important activity within the programme. The objective of the school is to give the post-graduate students within the programme a broad-based, inter-disciplinary education within urban water management. The main result of the research school will be a new generation of urban water researchers and managers who will strongly influence the development of the urban water sector in the future.

INTEGRATED WATER AND NUTRIENT MANAGEMENT APPLIED AT AN URBAN MULTI-STOREY BUILDING

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Introduction

The private households are besides the industry the main producer of waste water and water pollution in Germany. Although a high developed waste water treatment technology and a nearly 100% connection rate to treatment works has been realised, the water quality of our rivers is far away to be natural and it is not possible to swim in it: The effluent of our toilets fertilises our rivers, lakes and oceans and the run-off from our houses causes hydraulic stress and pollution.
Primary pollution, caused by the installed water management system itself, is derived from the effluent of sewage treatment works and direct overflows of the sewerage system to the rivers during rain events. Secondary pollution is caused indirectly by those industries, which are necessary to compensate the effects of the established treat-to-get-rid-of philosophy in waste water management. On the one hand there are the emissions of the fertiliser industry, namely potassium mining and phosphorus mills and at a minor extent, the Haber-Bosch-Process to produce nitrogen with its consumption of energy. One the other hand there is the production of water treatment chemicals (precipitation, flocculation, disinfection and adsorption agents) with the emissions during production and use. At last there is an intake of pollutants to the arable land itself, caused by the use of mineral fertiliser which is exploited at naturally occurring geological deposits which are contaminated by heavy metals and radionuclides. In former times the people were strongly dependent on closing the nutrient cycle from the households back to agriculture to survive. Only the availability of cheap fossil derived energy allowed the last 100 years to leave the old-fashioned and sustainable way of waste use. Besides this quality aspects there is the challenge to recreate the natural waterhousehold in urban districts. This would provide a comfortable living climate in summer and enrich the low water level in our water courses.
Could the application of innovative technology in densely populated areas be a way to achieve sustainability again? The examination of our project will give an answer.
To present a consistent alternative to the existing predominant „diverting-philosophy" in wastewater management, to demonstrate practically the applicability of new solutions, and to evaluate its effects on the environment scientifically we have recently implemented available new sanitation technologies in an urban multi-storey housing building. It is situated within the densely populated district „Sahlkamp" in the city of Hannover, which is typical for the fifty and sixty-years architecture of multi-storey urban districts.
The aims of the project are: to recreate the natural water household, to present the end-product "humus" to the public, to close the nutrient cycle, to involve the inhabitants and the schools of the district in the project, to minimise the energy consumption of

wastewater treatment, to investigate the energy, water and mass fluxes to have the data basis to design larger projects.

Project-building

An existing four-storey building comprising of 32 flats built in 1962 was renovated in 1998. The technical installation of the building has been to be replaced by a new one, and this allowed the introduction of innovative sanitation technologies: The old water flushing toilets with 9 litres per flush have been replaced by vacuum toilets with 1,2 litres per flush. The effluent of the toilets is collected separately, called blackwater, by a vacuum pipe system of 50 mm diameter. The run-off from the 690 m² roof is collected in cisterns and used to flush the vacuum toilets. The surplus of rainwater from the underground storage cisterns is locally infiltrated on the football green in front of the building. The greywater is diverted to the existing public sewer without reuse. The effluent of the vacuum toilets will be treated in a small one step biogas plant at 55°C which is situated in a nearby cityfarm project. The heating energy for the farm building is supplied by the produced biogas. The addition of biowaste collected at the surrounding households is foreseen. The seasonal changes in energy demand of the building are compensated by the addition of native fat wastes from the households. The effluent of the biogas digester is diverted to a reed and willow planted basin and naturally dried. After several years it is foreseen to examine the humus residue for pathogens, nutrients and pollutants and to bring it out as fertiliser in the nearby situated alotments.

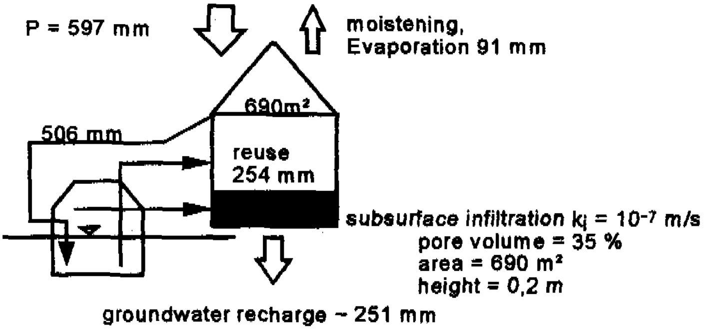
Social context

The project-building provide council flats and is situated in a problem neighbourhood. It was a challenge to install new and so-called unproofed technology in this environment. But after it was successfully functioning under this worst case conditions, there is no argument left to restrict such techniques on green, environmentally engaged neighbourhoods. The treatment facilities are going to be built on the estate of a social cityfarm project, which is located 500 m apart from the project building. The main purpose of the cityfarm is to give the children of the district an opportunity to get in touch with farm animals on a green island within the concrete. Another point is the employment of long-time jobless people to manage the farm and to collect the biowaste. The biogas plant is to be built by the apprentices of the training workshop of the local energy and water supplier "Stadtwerke Hannover AG", and the soil filters are constructed by technical students during a summer course in July 1999.

Results

On the basis of a long-time-simulation of rain data over 28 years, we could compute the water balance of the building on a reliable basis for different cases:
i) The former state based on total diversion like it is conventional in Germany. ii) The present, new state applying source separation, reuse and infiltration of rainwater. iii) The former natural state, before the building has been built. The results show, that even in the case of a high density of population under one roof, it is possible to recreate the natural water household of the site, before the building was built. The infiltration rate of the

surplus of rainwater from the storage tanks is the same amount as the natural rate of groundwater formation at the place of the building.



The differences in evaporation from nature to the dead roof are balanced by the water *consumption for the flushing of toilets.*

The energy consumption of the vacuum system and the pumps was measured in detail and compared to the energy balance of a conventional system. The costs of electricity for driving the vacuum are Euro 15,-- per year and household or flat. The savings in water and waste water costs are about Euro 60,-- per year and household. After 6 months testing and modifying there have been no faults in the system.

Conclusions

Even in densely populated urban districts the natural water balance can be restored again. The usage of run-off water in the households is an useful and effective method to handle rainwater. Vacuum toilets are a suitable technology for separate collection of faeces and provide the accustomed comfort of usual water toilets. In newly built up areas, where there is no gravity sewer existing already, the system can compete with conventional drainage economically. The environmental advantages are free of costs. To ensure an economic management of the biogas treatment step, a number of at least 1000 inhabitants connected to the system is necessary. The availability of waste fat enhances the gas production and allows the production of surplus electricity and heat.

Where is the forward-looking city council who will apply the demonstrated system on a larger scale?

BULAWAYO-MATABELELAND-ZAMBEZI WATER SUPPLY FEASIBILITY STUDY

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Background

The City of Bulawayo is Zimbabwe's second largest city with an estimated population of over 850 000 in 1995. It is an important industrial centre and the focal point of national and international communications.

Bulawayo lies in a semi-arid and drought-prone region. The long-term average rainfall is 650mm per year with wide variations. The City's average annual rainfall, based on the monthly averages for the period 1979-1992 is 521 millimetres. This rainfall is seasonal and notably variable. For a long period, the City has experienced severe water supply deficits.

The City's present raw water supply is derived from 5 dams located to the South-east in the Limpopo catchment.

Bulawayo had to introduce water restrictions first in 1983. Water rationing was introduced in 1984/85, 1987/88 and 1991/93 when the City came very close to a complete water supply collapse. In the water emergency situation a large number of boreholes were drilled in the City and a 47 km pipeline constructed to transfer water from the new well-field in the Nyamandhlovu aquifer.

The 1994/95 season was poor and the City, for the fourth time, introduced water rationing measures. The 1995/96 rainy season was fortunately about normal. However, this is no reason to become complacent.

The drought has had significant negative effects on industry and commerce. Many industries have relocated elsewhere or cut down on operations causing unemployment. It is clear that industry is far more interested in a secure, adequate source of supply rather than price of water.

Bulawayo is situated far away from any large source of water so that water will become increasingly more expensive to develop.

Bulawayo is in the grip of a severe water shortage. Another drought will have catastrophic effects unless a new source of supply is brought on line as a matter of great urgency. In the meantime, it is imperative that an emergency source of groundwater is provided as soon as possible.

Purpose of the Study

The purpose of the Study is to prepare a water resources development plan which will meet the water supply requirements of the City of Bulawayo and Matabeleland North along the

Pipeline Corridor for the next 25 years and to produce a Feasibility Study of the project recommended for implementation.

Long-Term Strategy
New water supply sources which could make-up part of the Long-Term Strategy of supplying Bulawayo with additional water are:

- New dams at Gwayi-Umguza and Gwayi-Shangani river confluences
- Zambezi River (Deka River mouth)
- Reuse of wastewater, leakage reduction
- Groundwater from the Karoo/Kalahari aquifers along the Pipeline Corridor and to the northwest of Nyamandhlovu if their potential can be established

The potential yield from the first two sources is expected to be enough to keep Bulawayo and the corridor along the pipeline, supplied with adequate water until the 2030s, with the Zambezi being the future source.

Philosophy of Approach
The basic philosophy of approach in the conceptualization of the BMZ-Water Supply Project and the development of strategies has been as follows:

- Drought
  Drought shall be an integral feature of the planning process

- Change in attitude and life-style
  Changing behaviour among all consumer groups to adjust to the water scarcity situation

- Demand-oriented approach rather than supply-oriented
  Use of market economy principle to maintain equilibrium between supply and demand

- Tariff structure based on users-pay-principle
  Keeping a minimum amount of water affordable for basic needs

- Development strategy to satisfy the 3 main objectives:

  - security
  - economy
  - speed of implementation

- Conjunctive use of groundwater and surface water
  Use of groundwater both as a normal source and emergency source of supply

- Sequential development of water resources
  Development and connection of the nearest sources first

- Leakage detection and rehabilitation of the system

- Water conservation measures
  Efficient use of water, public relations

- Water reuse
  20% of the domestic water consumption should be recycled as potable water. However, up to 100% should be reused for other purposes such as agriculture and industry

- Regional co-operation and development of water resources
  Consultation and collaboration with the Zambezi basin States

- Maximum supply security provided by the Zambezi river
  Dams alone cannot provide the degree of security needed

- Ancillary works
  The distribution system for Bulawayo should be computerized, rehabilitated and extended as soon as possible to receive the extra water from the Project. This should include meter replacement, calibration and proper water audit procedures

- Bankability
  The report in its present form contains a "Bankable Document" for the alternatives studied.

- Irrigation
  Large scale irrigation is not feasible using water from the pipeline. Limited irrigation for horticulture of high-value corps could be viable.

The Project
The Project recommended for implementation consists of the Gwayi-Shangani Dam, pipelines, pumping stations, power supply and central facilities including wastewater reclamation plant and water treatment plant. The link of the Zambezi River will provide maximum security but at a price, and should come on line at the same time as the Gwayi-Shangani Dam.

Investment Costs
The initial investment costs (1997-2003) for the recommended project would be about US$430 million. The Zambezi Link would require an additional US$110 million. The total investment costs (1997-2020) is estimated at about US$800 million.

Action Plan
The Action Plan including Immediate Measures must be implemented immediately. These include reduction of water leakage in the existing system, reuse of wastewater, other wastewater conservation measures and a study of the groundwater potential in the Karoo-Kalahari aquifers along the Pipeline Corridor.

Emergency Groundwater Source
The provision of an emergency groundwater source to improve the water supply security for Bulawayo for the next 5-10 years (the time it could take to get any of the new supply system on stream) should be given top priority.

B) Water supply systems

PLANNING AND MANAGEMENT FOR LONG TERM WATER SUPPLY FOR BOMBAY AND METRO REGION – A CASE STUDY

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Introduction

The urban population of developing countries is predicted to rise from one third in 1990 to over 50% by 2025. In 1950 the world's total urban population was 734 Million, of whom 448 Million were in developed countries and remaining 286 Million were in developing region. By 1980 the world's total urban population had increased to 1.8 billion of whom the majority, 958 Million were living in developing countries. The corresponding figures for the year 2000 are expected to be 3.2 billion and 2.3 billion respectively in 2025. On the basis of these figures and other global population trends, it would appear that Africa & Asia will have the highest share of worlds urban growth in the next 25 years and India's population would be more than 1.0 billion resulting considerable rise of large number of metropolitan cities. The water demand will increase due to ever increasing population and needs long term planning & management of water supply projects for it sustainability. Access to safe water remains an urgent human need in many countries. The problems are compounded in some places by growing water scarcity, which make it difficult to meet increasing demand except at escalating cost.

This paper deals with present scenario of water supply for the Bombay city and its metropolitan region and lessons learned for the past efforts to ensure the economic development of Bombay metro region. It will also discuss the strategic planning for meeting future demand and policies for equitable distribution of water among different stake holders.

Some Aspects of Bombay Metropolitan Region

The Bombay Metropolitan Region as a whole is a lowland lying on the west of Sahyadri hill ranges. Its river system consist of 5 major rivers that alongwith their numerous tributaries, drain the region into the Arabian sea. The average annual rain fall is abut 2000 mm. The whole area of Bombay metropolitan region is divided in to eight zones as mentioned in the table3. The Metropolitan Region of Bombay consist of five Municipal Corporations namely Greater Bombay, New Bombay, Thane, Kalyan & Ulhasnagar, 16 Municipal councils and near about 1000 villages covering an area of 4335 sq.km. The estimated population of this metro region in the year 2010 is 22.4 million. Out of this the population of Greater Bombay is expected to be 12.9 million. Providing sustainable water supply to this population is a big challenge for the planner & policy maker. Bombay's water supply is unique in more ways than one. It ranks amongst the largest urban water supply undertakings in the world. Its sources are at a greater distance than those of many water systems in the world. It will be no exaggeration to say that the importance the Bombay enjoys today not only as the second largest city in India but also as one of the largest in the world, due in great measure to its urban water supply. For city of Greater Bombay, the present average quantity available form the six reservoirs and lakes is 2995 MLD, shown in the table1, out of this 2630 MLD is supplied to Bombay city because of the capacity of the conveyance and distribution system is constructing factor.

Table 1 Sr. No	Source	Average quantity available in MLD	Live storage in MG.
1.	Vihar	90	6791
2.	Tulsi	18	1770
3.	Tansa	430	31910
4.	Modak Sagar		31130
5.	Upper Vaitarna	1092	76042
6.	Bhatsa I/II/III	1365	193000
	Total	2995	

This demand will increase by the year 2011 due to large increase in population. The estimated demand is 4041 MLD for domestic, 430 MLD for Industrial purpose. The planning and development of water resources is thus urgent, resource intensive and complex task. This requires planning and policy direction, allocation of resources and arbitration in disputes, resource mobilization and financial management, deciding the water charges and source development.

Water supply norms and Estimation of Water Demand in BMR

Water supply norms depends on the economic activities in the region, desired health and hygienic standards of population, household, income levels and availability of sewerage system. The estimation of water demand for various areas in BMR for a period of up to year 2011 is made within the brand frame work of norms recommended by the central public health and environmental engineering organizations (CPHEECO) manual.. Within the range prescribed, the supply norms are increased progressively for 2001 and 2011. Norms adapted for Gr. Bombay and New Bombay are 200, 225 and 250 lpcd respectively. This is based on the observations that the water consumption in these area is much higher than other areas in BMR. For the other urban areas in BMR the norms are between 100 to 200 lpcd and for the rural region it is about 40 to 100 lpcd.

Water resources availability & Development Cost

The water demand will increased due to the increase in population in BMR and envisages augmentation of existing sources or development of new sources. The water availability in BMR in 1970 was abut 1350 MLD. To meet the estimated water demand from 1991, the water resources which could yield 5600 MLD were identified. Although most of these sources have been identified, the development costs for the projects are given in table2 below.

Table 2	Capacity in mld	Total Cost Rs. In Millions	Capacity in mld	Total Cost Rs. In Millions
Source	1991-2001		2001-2011	
1. Middle Vaitarna	477	3770.00		
2. Kalu			590	3280.00
3. Gargai			452	3710.00
4. Usagoan-Shiravali	20	460.00		
5. Kaman			35	243.60
6. Surya ((Maswan/Kevdas)	100	2452.50	100	732.00
7. Ulhas	90	480.30		
8. Barvi	540	264.50		
9. Shahad (Temghar)	620	1828.00		
10. Poshir	296	940.00		
11. Rasayani Left Bank	74	143.80		
12. Morbe	350	1124.00		
13. Salpe-Tiwane			131	481.50
14. Mohil			85	311.60
15. Hetawane	150	910.00		
16. Balganga			350	1028.70
17. Amba Valley			117	343.90
Total	2707	12363.1	1850	10121.3

Pricing policy for sustainability

There has been considerable increase in the operational cost in recent years due to rise in electricity charges , the commissioning of the new facilities and increased labour cost .How ever the water charges for domestic use continue to be low and the Greater Bombay has the lowest domestic water charges as can be seen from the Table. The water production cost per 1000 liter was increased from Rs 1.86 to 2.75 during 1994 to 1998,but the increase in water rate is very small , i.e. Rs0.50 to 0.60 in this period.

The rates, shown in table3, are varying in BMR as per various uses such as industrial, domestic recreation commercial and social purpose.

Table 3 Total Domestic and Industrial water Demand In BMR For 1991-2011

S.No.	Region/Sub-Region	Population in Million			Gross Domestic Water Demand in mld.			Gross Industrial Water Demand		
		1991	2001	2011	1991	2001	2011	1991	2001	2011
1	Greater Bombay	9.92	11.43	12.93	2647	3429	4041	379	419	430
2	Western Region	0.59	1.06	1.62	97	224	385	5	21	56
3	North East Region	2.92	4.21	5.28	542	937	1285	341	401	452
4	New Bombay Region	0.54	1.16	1.81	123	325	549	119	156	320
5	Neral-Karjat Region	0.16	0.18	0.17	14	21	26	68	75	77
6	Panvel-Uran-Region	0.18	0.22	0.28	14	32	59	20	34	39
7	Pen Region	0.08	0.09	0.13	8	14	28	1	3	9
8	Alibag Region	0.10	0.11	0.18	8	11	41	71	152	162
	Total	14.49	18.46	22.40	3,453	4,993	6,414	1,004	1,361	1,545

S.No.	Region/Sub-Region	Gross Overall Water Demand in mld.			Rate of water supply for domestic purpose in INR per 1000 ltr.
		1991	2001	2011	
1	Greater Bombay	3026	3848	4471	0.60
2	Western Region	102	245	441	1.80-2.50
3	North East Region	883	1338	1737	2.00 or Rs40 /Month/Family
4	New Bombay Region	242	581	869	2.8 or Rs15-42 / Month/Family
5	Neral-Karjat Region	82	96	103	1.5 to 2.0
6	Panvel-Uran-Region	34	66	98	1.6 to 2.5
7	Pen Region	8	17	37	1.5 to 2.8
8	Alibag Region	79	163	203	1.8 to 2.8
	Total	4,457	6,354	7,959	

Some long term alternatives to sustain the water supply in BMR.

In Bombay metro region there are various possibilities of suitable long term alternatives for water supply solutions. The first one is recycling of waste water as dual stack system is used in BMR separating waste water and soil. It may be possible to reuse waste water for the cooling , gardening or commercial purpose where the quality criteria is not much significant. Changing sanitary systems in co-urban regions of BMR is another alternative which would minimize the wasteful use of the treated water which is carried out from hundreds of kilometers. Use of seawater /brackish water after treatment is being practiced in some states of India. In BMR along the coast line where the availability of the water is either difficult or uneconomical , the treated saline water could prove a most suitable alternative. Changing the pricing policy in some areas will help in saving the water if the water is charged on volume basis instead of on family basis which is done at present.

Conclusions

Though the city receives at present average water supply it is not adequate for population of almost 13.8 million in coming years. Inspite of some of the important measures proposed by planner it is necessary to investigate the economic ways for long term water supply solutions for urban region. As no new water source was developed since 1980 the water supply situation is worsening year after year for the Bombay metro region. The availability of finance is a major factor in the source development and this requires resource mobilization effectively to meet the future demand. It is necessary to minimize the wasteful use of water used for commercial purpose which is brought from several miles, after treating and pumping to save the energy and reduce the development cost. The allocation of water in all developing countries is as complex issue and is governed by legal and social traditions. Reallocation is a contentions and ponderous process that generally responds to changes in demand only with long langs. Without effective management of water resources, the cost of supplying water to cities will continue to rise the long term alternatives for water supply planning and management for Bombay city are becoming realistic satisfactory. From the experience from the long terms water supply for Bombay city and region, effective and efficient policy measures should be adopted while preparing the master plans for other megacities in developing world.

LONG TERM WATER SUPPLY AND SANITATION SOLUTIONS- A Case Study from Istanbul, Turkey

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Introduction

Istanbul with a population over 12 million, is one of the crowded metropolis of the world. It receives a high level of migrating population, about 400 000 people per year, from various regions of Turkey, and houses 1/6 of the Turkish population and almost half of the Turkish industry within its vicinity. Annual population increase in the city is 4.6% which is twice the average of the country. Daily water supply for Istanbul in 1998 was about 2.5 million cubic meters per day, 95 % of which is supplied from six main reservoirs. These water resources are vital to the well being of the city. However, it is equally hard to maintain the water quality therein at an acceptable level for the beneficial use of the water supply, and maintaining their sustainability for the prescribed purpose is even harder. With the increasing population, care should be exercised to secure the reservoirs as water supply resources and measures should be taken for pollution abatement. The key idea is to use the reservoirs in accordance with the tendencies of the society in a controlled manner, while protecting the quality of the waterbody, and to assure continuing control by implementing economic sanctions.

Omerli Reservoir is the major reservoir of Istanbul in terms of water supply potential. This paper proposes a management strategy on a short and long term basis and it originates from a comprehensive task undertaken for the Ministry of Environment of Turkish Republic in an attempt to protect the water quality in the reservoir.

Present and Future Status of Omerli Reservoir

Omerli Reservoir, with a catchment area of 621km^2 on the Asian side of the Metropolis supplies approximately 25 % of the water demand to the city. The southwest part of the catchment area has experienced an enormous and unplanned urbanisation where the increase of population was recorded as 35.67 % between years 1985- 1990. Comparison of the present population of 200 000 and future projected population of around 1 million puts forth the reality that if no short and long term precautions are taken, the reservoir will in the near future be under the threat of eutrophication along with health risks. The present water quality of the reservoir is overall Class 2 - according to the German Technical Standards which requires conventional treatment prior to use as a drinking water – and it tends towards eutrophic stage from mesotrophic stage on the contrary to the land use profile. The current land use reveals that 35 % is devoted to agriculture and 51 % to forests and meadows and only 9.5 % to urban and industrial area. Current significant problems associated with these areas include unplanned and illegal housing, irrelevant industries and motorways passing through the protection zones. There are 26 urban settlement areas, out of which 65 % are located within the long range protection zone, 15 % at the medium range, 12 % at the short range and 8 % at the absolute protection zones. Those settlements within the absolute and short range protection zones are of great importance considering the deterioration of the water quality and the ecology of the catchment area. The current Turkish Regulations prohibit the use of these highly protected areas for any type of settlement.

The environmental evaluation of the basin emphasises the significance of point sources especially of domestic origin as the present and future polluting sources. Thus, as an immediate precaution, all the construction activities should be suspended and existing construction and sales should be frozen. Accordingly, unoccupied fields should be owned as private properties and the owners should be required to protect their lands. Controlled very low density settlements and simple agricultural activities without the use of fertilisers and pesticides should be allowed from the medium range on, with a somewhat increasing population density towards the outer reaches of the watershed. For example, the population density should be as low as 10- 20 ca./ha at the absolute protection zone, 30- 40 ca./ha at the short range and 50-100 ca./ha at the medium protection zone, 50-100 ca./ ha., 100-150 ca./ ha. 150-200 ca./ha and 200-400 ca./ha. at various regions of the long range zone. The domestic wastewater of those settlements should be collected, treated and transferred outside the basin. The discharge of the treated effluent to the reservoir should be forbidden. As it stands now, the proposed treatment system has no provisions for diffuse sources of pollutants including pesticides and fertilisers from agricultural activities. The significance of diffuse sources for the abatement of further deterioration of water quality then becomes the key issue to be emphasised in the area. Land use plans to protect the area should be developed within the framework of zones. Therefore, the management and control strategy proposed will hopefully satisfy the targets for reducing especially diffuse pollution.

Establishment of a protection- usage balance in the basin is highly significant in terms of the current legal and administrative status. The enforcement of Turkish Water Pollution Control Regulation and of Istanbul Water and Sewerage Works Administration (ISKI) have not been properly practised so far. Rules and Regulations which are not supported by proper enforcement, supervision, resolution and sanctions create risks that certain groups have to face. This causes the rapid and unplanned establishment of illegal settlements in the area contrary to the current regulations. Therefore, it seems impossible to solve the problems of the basin with the existing regulation and administrative structure. The legal and administrative confusion prevents the solution of the problem and the share of responsibilities do not go beyond criticism.

Basic Approach of Protection Strategy

The basic intention is to protect the water quality and ecology in the basin. To achieve this approach; the land based pollutants directly or indirectly effecting public health must be removed away from the basin. The geomorphologic, geological, meteorological, hydrological, hydrogeological, ecological, socioeconomical and demographical structure of the area should be taken into account in establishing the protection-usage balance. The present status of the area should be rechecked and unnecessary nationalisation expenses should be avoided. Rights gained through other laws should be considered and legal problems should be kept at a minimum level. Those parts that cannot be controlled in the short term should be removed out of the basin. Planning in residential areas should be the priority task. State forests should be protected and those needing afforestration should be cared.

Land use plans should be prepared in accordance with the protection strategy. Alternative solutions for the long term water supply should be developed such as; low density settlement areas, establishment of recreational areas, afforestration, protection of state and private forest areas, forestration, vegetation and plantation alternatives with natural fertilisers, establishment of special protection areas like military areas with limited activities at the very sensitive regions of the basin. The application of these alternative solutions on the proposed land use plan of Omerli Reservoir will take place in the full manuscript.

As it is quite impossible to solve the problems of the area with the existing regulation and administrative structure, the responsibilities of local and individual governmental organisations will be integrated in what may be called an 'association'. This organisation will be responsible of proper practice of the proposed land use plan to maintain sustainable development of the area. Participation in this association should be widespread and be based on the principle of sharing the responsibilities. it should be capable of enacting the plans developed according to the new land use plan aiming long term water supply from the reservoir. It should be responsible for maintaining the water quality at least at Class 2 of the European Standards. This association should be controlled by an external organisation like the Ministry of Environment.

Income of the association will be; credits that are loaned from the Environmental Fund in the stage of establishment, a specific share collected from provincial administrations, sale and barter of land, sale of water to municipalities and industries, fees collected from people who visit the recreational areas, participation fees collected from the settlements, and share certificates. As such, this association will have no external financial support and the income will be returned as service.

Conclusion

One of the major water supply reservoirs of Istanbul, Omerli Reservoir, is under the threat of eutrophication due to unplanned urbanisation and rapid population increase in the watersheds of the reservoir. The basic approach to protect the reservoir from further deterioration and to manage a sustainable and long term water supply depends on developing a rational management strategy and planning, where the formation of a protection – usage balance should be considered. Such an approach is attempted to be developed for Omerli Reservoir. New land use plan is proposed in accordance with the various types of protection zones. The establishment of an association is also suggested to conduct all technical, financial , and supervision work of the basin.

MODEL WATER SUPPLY SYSTEM: A UNIQUE OPPORTUNITY TO DETERMINE THE LOWEST PRACTICAL LEVEL OF LEAKAGE

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Introduction

Severn Trent Water is a leading provider of water supply and waste water services in the UK. and has the best overall quality record. We achieve 99.9% compliance with UK and European drinking water standards - the most stringent in the world. Since privatisation in 1989 more than $6.4 billion has been spent on mains upgrading, replacing the system and our services.

In April 1997, Severn Trent Water acquired a small private water company serving the town of Cheadle in the north midlands of England. Average demand in 1997 was recorded as 2.5 Ml to 3 Ml per day whereas accepted per capita demand figures suggested this should have been of the order of 1.25 Ml per day. Leakage in Cheadle was estimated to be as high as 50% of the water put into supply, resulting in over abstraction from the borehole and variable water quality at times of high demand.

Scope

The paper covers the complete rehabilitation of the water supply and distribution infrastructure to the town with a population of approximately 8000 people.

The work involved the replacement of over 31km of distribution mains dia 50mm - 350mm with new MDPE pipe utilising a number of 'No Dig' techniques. All customer services were renewed including in many cases the customer owned service pipes. Radio read meters were installed for all properties. The sourceworks and storage facilities were also targeted for complete renewal.

The final result will be a unique opportunity to determine the "lowest practical leakage level" and gain a detailed understanding of degradation of system integrity with time.

Cheadle Water Works Company (CWW)

The private CWW company had been established in the early 19th century and fed the small market town of Cheadle, Staffordshire in the north midlands of England. The town is located entirely within the Severn Trent Water supply area and consists of approximately 3800 properties of varying age with a mixture of rural properties on the town fringes and a major industrial user in JCB.

The company's assets were in very poor condition and consisted of

- km of very old, small diameter, unlined iron mains
- two very old leaking service reservoirs (circa 1830 and 1935)
- two combined well / boreholes which were suffering from over abstraction in an attempt to overcome the significant leakage problems

The CWW was unable to meet current water demand effectively and did not have sufficient financial resources to fund investment required to meet increasing demands on the fringe of the town for new development areas. Massive rate increases to begin the process of improving its assets were being considered, but instead an approach was made to STW to take over the company for a nominal sum.

Severn Trent recognised that a significant programme of rectification was required and set up a Project Board to manage the assimilation of CWW.

The Cheadle Project - outline proposals

The base project included the complete replacement of the distribution system and the construction of a new reservoir together with the refurbishment of the borehole source and provision of a treatment system.

In addition, the company decided to extend the project by offering to provide, where practical, every property with a new separate service pipe and water meter. This would create a discrete area in which every property would be supplied through new pipework and a meter which could be remotely read by computer from the office base at Leicester some 60 miles away.

This would provide the company with valuable information with respect to

- leakage levels in a newly refurbished distribution system
- leakage detection and localisation
- water usage patterns and
- a completely new distribution system which could be monitored over a period of years to provide information on developing leakage patterns to assist with defining an economic level of leakage.

Construction Works

- Construction and installation work was broken down into three main elements:
- Mains and service pipes - this included the replacement of the whole of the mains network and individual service pipes to provide separate pipes to each individual property where possible
- Reservoir and borehole reconstruction - demolition of the existing reservoirs and construction of new storage tanks and treatment facilities.
- Meter and radio read installation - installation of meters at all properties and commissioning of a radio read system.

Progress to April 1999

Mains rehabilitation works have been completed, over 3000 meters have been installed and the radio read system is partially operational.

Works on the reservoir and borehole site are due for completion in July.

Summary and Conclusions

- STW set out to renew infrastructure and establish a complete metered system to monitor water usage and minimise leakage using a radio read system - the project should be fully operational by the end of July to provide on-line leakage detection and a new model system.

- It is the first known project of its kind, combining the provision of an almost totally new system, including the replacement of customer owned pipes, with all outlets metered and measured by an intelligent system.

- The work has been carried out within a very short timescale and overcome some significant problems during the process.

- Initial benefits of the improved service to customers are already apparent, supplies are more reliable and quality more consistent, the hose pipe ban has been lifted.

- The longer term benefits from the leakage and water usage information cannot yet be quantified but data gathered should provide benefits to both STW and the water industry as a whole.

Acknowledgements

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THE IMPORTANCE OF ASSET MANAGEMENT IN ACHIEVING SUSTAINABLE COMPETITIVE ADVANTAGE

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Introduction

Severn Trent Water is the second largest water company in the UK and the fourth largest in the world. It supplies drinking water and treats sewage effluents for seven million customers in central England. The company operates assets valued at £27 billion, comprising £5 billion surface installations, £17 billion sewers and £5 billion water mains and aqueducts. The surface asset inventory includes over a thousand sewage treatment works, two hundred water treatment works and more than three thousand pumping stations. The water and sewerage pipe networks are each approximately 50,000 Km in length.

The current investment programme (1995-2000) for maintenance and improvement of these assets is £2.35 billion, and is one of the largest water utility capital investment programmes in world. Delivery of the company's capital programme is controlled, in terms of both costs and outputs, by the industry's economic regulator, the Office of Water Services (OFWAT). The regulatory regime is extremely stringent, requiring predetermined investments and outputs to be delivered within very fine tolerances. Each UK water company's capital programme is reviewed and rolled forwards every five years, in the course of a major planning exercise, prescribed by OFWAT and known as the Asset Management Plan.

Asset Management Planning was introduced into the UK water industry by the Conservative government, as the chosen method for assessing future investment obligations at privatisation in 1989. The planning technique was borrowed from the oil and petrochemical industries, where reliable, long term investment forecasting had been imperative for commercial success for many decades.

The paper describes Severn Trent's experience in developing a computer-based approach to asset management planning, which now operates as the central generator of and control upon the company's capital investment programme.

Scope

UK water companies' privatisation Asset Management Plans were generally statistically derived. That is to say, they relied on sample surveys of problems and costs, which were extrapolated across similar asset groups to produce broad assessments of future capital investment.

consumption. Instead they will receive the equal amount of treated wastewater for their agricultural uses.

4. Water quality control and management

In our country degradation of water quality means the losses of some part of the quantity of available water. Water quality degradation may cause the country to reach the crisis point sooner than the expected time. For this reason monitoring the quality of water resources is vitally important for us. Establishing the special commission with full authority in this respect is one of our goals to achieve this strategy.

Conclusion :

As it was mentioned above The model in which water and waste water in the Iranian Cities, is managed, is called "orbital model". This model is based on the goals of the Islamic Republic of Iran Government .

The management of the above mentioned model has caused a fundamental evolution in the Iranian water and waste water industry and has brought new capabilities such as , improving the productivity, developing man power abilities, developing industries , people participation and self sufficiency of the water and waste water units.

Application of the above model for the water and waste - water management in the other developing countries can be recommended.

MAOs are issued, monitored and controlled by a single Headquarters-based senior manager who carries sole delegated responsibility establishing the capital programme.

Severn Trent has, as a direct result of introducing advanced computer investment modelling, managed to drive 10% capital efficiency into its 1995-2000 capital programme, by comparison with unit prices sustained over the preceding 5 years. At the same time, all committed customer service and regulatory outputs have been delivered on time, and the asset base maintained to the standard agreed with OFWAT.

The company considers itself to be at the leading edge of capital investment management. Its success in consistently delivering financial inputs and physical outputs in full and on time over the last decade, with 10% capital efficiency over the last 5 years, and in relation to one of the largest water utility programmes in the world, is unparalleled by any other company.

The adoption of asset management principles, and their incorporation into powerful computer-based management systems, has therefore enabled Severn Trent to achieve and sustain a significant competitive advantage within the UK water industry.

This is not an idle boast. It has been clearly proven over recent months through OFWAT's publication of statistics which show that;

- Severn Trent's assets are in significantly better condition than the UK water industry average
- its levels of drinking water and sewage effluent compliance are among the highest in the industry (and Europe)
- while recording these remarkable achievements, Severn Trent is at the same time the only UK water company offering to cut its customers bills (by a committed 5% from March 2000)

MAJOR UTILITY INVESTMENT PROJECTS: SYSTEMIC APPROACHES TO DECISION MAKING AND STAKEHOLDER PARTICIPATION

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It must be a mistake to leave utility investment in the hands of straight-line corporate thinkers, since straight-line thinking almost inevitably leads to tunnel vision. We live in an extremely complex society, where every action seems to have unforeseen environmental implications, and the negative impacts of blinkered thinking are legion. Increased environmental awareness leads inevitably to the need for a more holistic approach to utility management, and wide-ranging participation in the decision-making process.

If we are to move towards a more sustainable use of resources, and to manage assets more wisely, then a different style of management is required. There is a need to define resources far more broadly, take account of a greater range of ideas, experiences and opinions, and work in unorthodox partnerships. This means developing new management processes which are able to respond to the demand for more inclusive, more resourceful and more long-term decision making.

The 1980's and 1990's were marked by a series of serious conflicts between 'big buisness' and environmental activists: Twyford Down, Newbury Bypass, Cardiff Bay barrage, Oxley's Wood Thames crossing, M11, Manchester airport's second runway. They were acrimonious, wasteful, and sometimes the battles even added to the resulting environmental damage. They clearly proved the need for a more conciliatory, constructive approach to decision-making and development. Part of the answer lies in wider stakeholder participation, and in sharing ideas, hopes and fears as far in advance as possible.

This represents a radical departure for many utility managers. The opportunity for stakeholders to actively participate in internal decision making systems is extremely rare and treated with caution and alarm in the boardroom. However it is clear that 'stakeholders' are becoming environmentally aware and are no longer politically naive. Direct action is an increasing risk as stakeholders realise that the attempts to engage them in discussion through traditional consultation stages may be no more than window dressing.

These consultation stages, however glossy and professionally managed, do not convince 'stakeholders'. They are no more than what might be called DAD knows best. DAD, decide-announce-defend, caricature's the consultation process employed by most utility managers. It results from at worst a professional arrogance, that they alone own the problem and that the identification and appraisal of solutions must be left to them; and at best a naive misguided and patronising judgement as to the expectations and environmental awareness of stakeholders. If utility managers are to avoid the risk of direct action and delays and difficulties in securing external statutory authorisations they must begin to reconsider their decision making systems.

This paper will explore the approaches to systemic decision making in use within Severn Trent Water, drawing on experiences gained from major investment projects and the application of innovative techniques. Case studies will be used to demonstrate the success of these techniques and the value of bringing external groups into what, traditionally, has been an internal decision making process. Although the process of participation may initially be perceived as creating delay, the overall speed with which statutory authorisations can be secured for controversial schemes confirms the efficiency and cost-effectiveness of this style of working.

Corporate Development Support Project for Vodokanal of St Petersburg: a blending of Russian and international utility management skills

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Introduction

Vodokanal of St Petersburg (VK) is the utility responsible for the provision of water supply and wastewater services to nearly five million people in the City of St Petersburg in Northwest Russia, and in adjacent satellite towns.

This paper discusses ways in which VK and bilaterally funded technical and institutional management specialists have sought to develop and implement corporate development planning capabilities through an ongoing institutional strengthening project. It also reviews the impact of the Rouble devaluation in August 1998 on VK's capital investment plans and the increasing importance given to corporate development planning by VK.

Theme

Over the last five years VK has taken firm steps to modernise its business, and has utilised various types of technical and financial assistance. Much of this work has revolved around work done with the European Bank for Reconstruction and Development (EBRD) on preparation for loans from the EBRD and the Nordic Investment Bank (NIB) for capital investment. VK's overall development objectives include:

- providing safe and reliable water supplies;
- meeting wastewater effluent standards set by the Helsinki Commission (HELCOM);
- achieving long-term increases in operation efficiency and associated costs savings: and
- the transition of VK to a modern and financially strong utility.

Following medium-term and long-term investment planning studies completed in 1997 by six European consultants[1], VK sought assistance from the governments of Finland, Sweden and the United Kingdom aimed at corporate development planning and associated institutional strengthening. This began in June 1998, when a team of British specialists financed by the British Government's Department for International Development under the Know How Fund assisted VK to produce its first Corporate Development Plan (CDP) as agreed in its loan covenants with the EBRD.

In September 1998 this work was intensified when a consortium of three European water

[1] Integrated investment, financial and institutional planning was carried out by Severn Trent Water International in association with Mott MacDonald, under assignment to United Kingdom Know-How Fund.

utilities[2] led by Severn Trent Water International started a 30-month Corporate Development Support Project (CDSP). The success of this assistance will be tested by VK and donor approval of various strategies developed during this period, and by measuring progress by VK towards achieving various financial and other performance criteria.

VK's draft CDP[3] of July 1998 was based on a capital development programme between 1999 and 2005 totalling US$ 633 million including taxes and duties. Together with a US$ 550 million programme of routine asset maintenance and replacement, this indicated a total cost of works nearing US$ 1.2 billion. This was to be supported by a loan[4] to enable short-term improvements to the water supply and wastewater systems in St Petersburg. This target, labelled at that time as the "pessimistic option", was reduced from an earlier US$ 2.1 billion "optimistic option" by considering:

- tariff levels and affordability, and the limits of increases from one year to another;
- various financial performance criteria set out in the VK-EBRD loan agreement;
- a manageable level of annual capital investment spending;
- possible levels of foreign investment support and loan repayment arrangements.

A financial model developed from an EBRD prototype was used as the principle financial planning tool, aimed primarily at maintaining an acceptable cash-flow and balance sheet. It was invaluable as a means of testing the sensitivity of the annual investment profiles to changes in the tariff regime.

In terms of affordability to the citizens of St Petersburg, associated tariff levels were expected to reach a peak of 2.4% of the average family income during the period 2003 to 2006, falling gradually to 1998 levels by 2015. This was assuming that the proposed tariff levels were to be accepted by the City Administration.

Anticipating that tariff increases would be difficult, VK intended to analyse the "optimistic" and "pessimistic" options in greater detail along with a "middle option" for discussion with the City Administration as part of the finalisation and approval process for CDP'99.

These concepts were rapidly overtaken by the devaluation of the Rouble in August 1998. This had immediate and dramatic impacts on VK and its revenue generation including:

- reducing VK's ability to fund capital investment costs;
- increasing the replacement costs of M&E equipment (e.g. pumps required to replace old, worn out, and inefficient plant);
- increasing the costs of imported chemicals for treatment processes;
- reducing the amount of work done by foreign specialist companies as part of the annual maintenance programme e.g. by trenchless water pipe/ sewer installers;
- increasing the costs of buying foreign exchange to service foreign loans.

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[2] Helsinki Water, Stockholm Water and Severn Trent Water

[3] CDP'99 – covering 1999 to 2005

[4] DM 158 million from EBRD & NIB, signed in July 1997 supported by a further DM 20.2 million from bilateral grants.

This immediately called for a reassessment of priorities, as a result of which VK concluded that (for example) it could no longer justify the extension of the Northern Water Treatment works – at $US 80 million the main component of the EBRD/NIB first loan. The 1999 – 2005 investment plan was therefore reduced to approximately US$ 150 million, with a corresponding reduction of over 70% in the EBRD/NIB loan requirements.

The presentation will show how VK re-directed its priorities, placing new emphasis on:

- protection of existing assets;
- maximising returns from its annual maintenance/ replacement programmes;
- energy conservation;
- leakage control and water demand management;
- corporate information systems development;
- improved financial management and billing & collection systems;
- plant automation and associated staff levels.

Several of these activities – notably those associated with corporate development planning, demand management and IT systems – are being supported by the joint British-Finnish-Swedish team, along with complementary programmes aimed at strategies for capital investment planning, human resources development and change management, and modifications to the current environmental (wastewater) norms.

One key issue is the balance between actions aimed at improving potable water supply and at reducing untreated sewage discharges to the River Neva system and Gulf of Finland.

Results

The presentation will discuss some of the issues confronted and results of the work carried out for preparation of the 1999 CDP. This will include an overview of VK's responses to new strategy proposals, capital investment priorities, action plans for achieving them, along with the various measures to be adopted to reduce operations costs, improve revenue collection, and to manage the change process.

Conclusions and Achievements

The presentation will elaborate on interim CDSP conclusions and achievements, such as:

- VK's response to the new constraints imposed by the August 1998 devaluation.
- Corporate development planning, management and organisational issues.
- Tariff increases, which remain both a social and political issue and the key to VK's ability to carry out much needed measures to protect existing assets and to expand and complete the water supply and wastewater systems.
- By working closely together, Russian and West European specialists can develop approaches which add to each others skills, and develop solutions to technical and management problems issues which fit the Russian environment whilst introducing appropriate elements of western ideas and methods.
- By taking such a proactive approach to modernisation over the last five years, VK is setting out a framework that will be invaluable to the many other Vodokanals in Russia wishing to update and improve their services.

Workshop 8

Posters

DRINKING WATER QUALITY IN THE TOWNS OF LATVIA

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The drinking water quality and water pollution in cities reflects existing environmental and institutional problems determined by the stage of development, availability of resources, structure of production, institutional system, but also reflects the attitudes against quality of environment and management practices. This is also the case in Latvia.

In towns in general water is pumped without treatment, direct from the wells into the distribution network. Some communities do have treatment facilities, but these are not always used because the equipment is inoperable or unsafe and operation costs are too high, particularly energy and chemicals. The distribution networks are built generally from a cast iron pipes with connected service pipes of mild steel. The cast iron pipes have joints, sealed with cement, unable to withstand movement in the ground. The steel pipes are heavily damaged by corrosion and leaks are frequent.

Among the activities which are aimed at improvement of water supply and sewerage in Latvian small and medium sized towns can be mentioned Project 800 + addressing investment needs. Recently are active more than 24 relevant on-going or planned water supply and sewerage projects developed in cooperation with Sweden, Denmark, Finland or by EU support.

Third level of drinking water problems is it quality in rural regions. Surveys of drinking water chemistry are important to citizens, the government, scientists and public health officials. Such studies are greatly needed for future planning of general and drinking water quality. In many countries the impacts on drinking water quality have been studied, ea. water acidification, agricultural pollution, monitoring of drinking water quality near pollution sources. However, in Latvia, most inhabitants in rural areas use water from dug wells and shallow boreholes, the water quality of which has not been assessed (a similar situation occurs in Eastern Europe and the western part of Russia).

So, waters from 2500 wells and boreholes, as well as drinking water in cities throughout Latvia, were sampled. This sampling size covers ~18% of the total well number in rural Latvia and 90 % of the drinking water sources in cities. The selected wells included all typical existing conditions, in relation to land use, agriculture habits, as well as geochemistry. The number of wells analyzed and the selected variety of sampling areas ensured the coverage of all conditions typical for the North Western part of Europe, and reflected the landuse patterns, agricultural habits, geological and geochemical conditions and soil diversity. Since the survey program included analysis of drinking water in small cities of Latvia, it covered 92% of all inhabitants of rural regions in Latvia .

Most rural wells in Latvia are quite shallow (65% of wells are less than 6 m deep), and they are the dominant source for water supply, a common situation in Eastern Europe and Russia. Predominantly, they are open (78%) and prepared from concrete prefabricated materials (68 %), but the remainder are wood wells. Mostly, the water sources are located in quartenary deposits.

The obtained analytical results show large variation in the composition of the drinking water. For some water parameters, the maximum/minimum ratios are more than 100, indicating not only the impact of pollution sources, but also appreciable differences in natural conditions. This is evident in the cumulative frequency distribution curves of water parameters which are determined by natural conditions: Fe, K, Na, Ca, Mg, Cl, hardness, color, TDS, conductivity. Also, concentrations of NO_3, NH_4, PO_4 are much variable.

From the viewpoint of impact on human health, nitrogen pollution from agricultural and domestic sources is most serious. In 17% of the wells surveyed, nitrate concentrations exceeded guidelines: this was also observed for ammonia, nitrites and phosphates. For all of these compounds, a decrease of their concentration with well depth is typical, thus indicating that pollution of the topsoil layer often determines the general water pollution levels. Since the territory of Latvia is covered with quaternary deposits with high filtration capacity, the high contents of nitrogen compounds in well water can be attributed to agricultural pollution. The same source seems to be responsible for common elevated concentrations of organic matter (tannins/lignins, humic acids, biologically degradable organic substances ea.).

Natural factors, as well as pipe corrosion determine increased concentrations of iron, which are higher than the EC guideline in 22% of the surveyed wells.

In well water of Latvia, the concentrations of some metals (Pb, Cu, Cd, Mn, Zn) may indicate anthropogenic pollution. In general, the contents of metals are low (guideline values are exceeded in less than 1% of the analyzed samples) and increased metal concentrations were local around waste facilities or other point pollution sources. Fluoride concentrations fit the pattern of heavy metals.

The most polluted wells were typically found in small villages and towns. Comparison of well water quality with drinking water guidelines of the European Community and the USA confirmed the significance of the polluted drinking water problem in Latvia.

The total number of wells with unacceptable levels of various substances exceeded 20% and the pollution source was most often agriculture. However, improvement of well water quality can be achieved by increasing sanitation and the use of more improved well construction (well cleaning, disinfection, deeper wells) and installation removed from local point sources.

So, unless drinking water quality presently in Latvia is far from perfect, there is a clear vision how to improve it and develop water supply system which can support necessary quality of human life. In the same time it is absolutely clear that improvement in this area of city life will absolutely depend on general changes of production, development of relevant legal and institutional system and awareness of citizens about importance of these questions.

FEASIBILITY STUDY AND EIA STUDY IN APPLICATION TO SMALL WASTE WATER TREATMENT PLANT IN ECONOMIC TRANSITION COUNTRY

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Introduction

It is designed a waste water treatment plant for small town (3.500 E.I. and small industry, 525 m^3/d, 210 kg BOD/d) in Black Triangle on Czech - Germany Border, with 21 km sewerage, partial in sub-pressure piping. The WWTP is designed as long - term activation and with pre-denitrification. It is expected, the effluent will be pure: BOD_5 20 mg/l, suspended solids 20 mg/l, nitrates 15 mg/l.

The EIA study says about engineer design: The points of view of environment are very important in this Town. The Town is situated on the high border between North and Baltic Sea Basin. The creek from the Town is a right-side Elbe inflow. This creek, called Krinice, flows to the Elbe above Dresden, Germany. It flows all trough the National Nature Park "The Elbsands". This park is situated on the both sides of Germany - Czech border. The area is also in the hygienic protected zone of Dresden Water Supply Sources. Therefore is very important to improve the quality of water, to limited the pollution of BOD and nutrients loading (eutrophication) in Elbe River Basin.

The Environmental Study (EIA) unambiguously recommends to realise this WWTP. Exists a clear requirements of European Union (91/271/EEC) and they are a component of conditions of Czech Republic to European Union receive.

Methodology and Results

It was be elaborated a Feasibility Study (FS) to engineer design. The Investment Costs and Operational Costs was approximated. The Town will pay this costs (and consequently inhabitants). The investment costs are on level 105 mil CZK (eq. 2,78 mil. EURO).

At the first in the tables and graphics is prepared pilot study, which determinates Operational and Fix Costs. The costs are in the level of 1998 and they are about 6,5 mil CZK (0,172 mil. EURO). At second: Model, which contents 3 variants of finance of the Work was prepared. Main condition for this variants was maintenance the IRR (Internal Return Rate) Index as constants. From the conclusions of economic conditions follows, that WWTP and sewerage are not realisable without external funds contribution. The Town can't otherwise obtain finance and the Phare CBC Fund was not friendly for support this Work. The financing in standard conditions in Czech Republic (and equal in others countries in economic transfer) is not available for small towns without great and excessive charges of inhabitants (Sewerage charges). Only sewerage charges are calculated in this case on 19 CZK (0,5 EURO) per 1 m^3, by optimal inhabitants loading of WWTP. Therefore total price water and sewerage charge will be more, as 30 CZK/m^3 (>0,8 EURO).

In this time, the total standards water charges in Czech Republic are about 20 - 23 CZK/m^3 ($\geq$0,5 EURO). Since 1989 this charges in Czech Republic was "improved" from 1 - 2,3 to 20 - 23 CZK/m^3.

Conclusions:

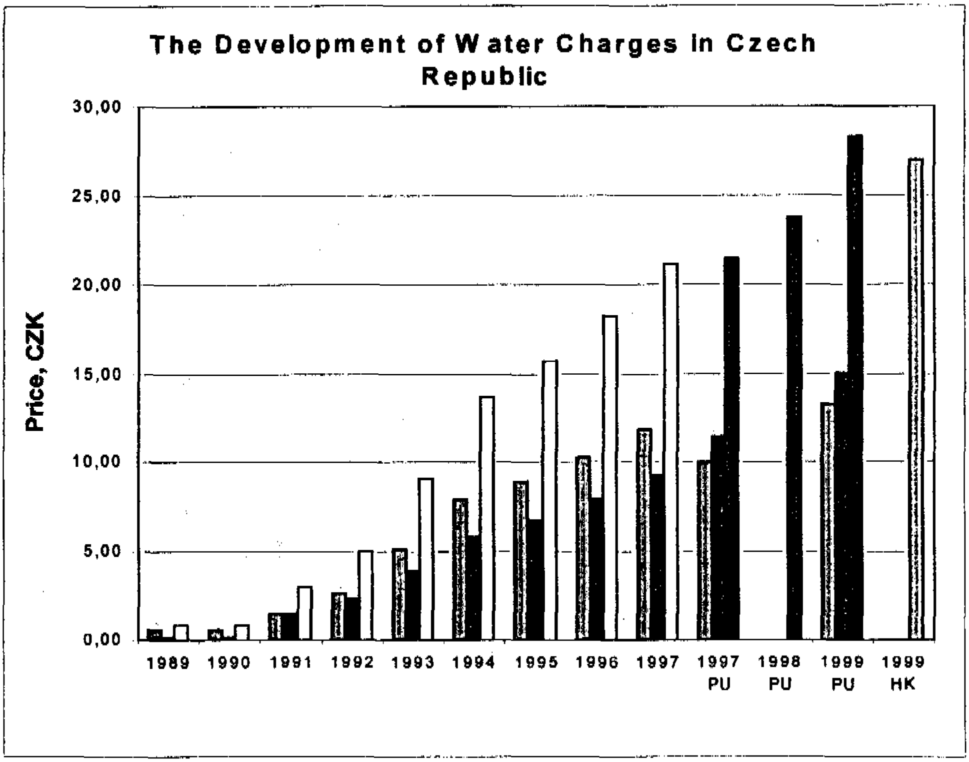
From environmental point of view it seems necessary, to construct the sewerage and WWTP.

But exist a danger signal, that the economical impact for inhabitants of Transition Countries (by EU receive), can be very hard in the case of receive to EU. The help of EU for municipal sphere in new countries is really necessary.

Tab. 1: Water charges in Czech Republic

(Prices for Inhabitants)

	Year	Water Supply Charges	Sewerage Charges	Total	Index % 1989	l/El.Day	Index %89	Validity
1	1989	0,60	0,20	0,80	100,00	171,00	100,00	
2	1990	0,60	0,20	0,80	100,00	174,00	101,75	
3	1991	1,50	1,50	3,00	375,00	161,00	94,15	from 1.1.1991
4	1992	2,67	2,33	5,00	625,00	159,00	92,98	from 1.9.1992
5	1993	5,18	3,91	9,09	1136,67	137,00	80,12	from 15.5.1993
6	1994	7,90	5,83	13,73	1716,25	129,00	75,44	
7	1995	8,94	6,80	15,74	1967,50	121,00	70,76	
8	1996	10,27	7,91	18,18	2272,50	116,00	67,84	
9	1997	11,86	9,31	21,17	2646,25	113,00	66,08	
	1997 PU	10,03	11,47	21,50	2687,50			Pardubice Town
10	1998 PU			23,80	2975,00			Pardubice Town
11	1999 PU	13,27	15,06	28,33	3541,25			Pardubice Town
12	1999 HK			27,00	3375,00			Hradec Králvé Town



The Development of Water Charges in Czech Republic
Price, CZK
30,00
25,00
20,00
15,00
10,00
5,00
0,00
1989
1990
1991
1992
1993
1994
1995
1996
1997
1997 PU
1998 PU
1999 PU
1999 HK

GAUGING AND MODELLING FOR IMPROVED WATER DEVELOPMENT IN ZIMBABWE

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Introduction

Zimbabwe is located in the subtropical zone of southern Africa with a climate typically characterised by seasonal rainfall and long-term cycles. Both the short- and long-term variations in water supply require a large degree of planning and water management to utilise the available water in an optimal way. During recent years, concerns regarding the water supply for the three largest cities, Harare, Bulawayo and Mutare have led to the conclusion that additional surface water abstraction and reservoir constructions are needed in the near future. The pressure on the available water resources in Zimbabwe is however extremely high because of water abstractions for the agricultural industry which is crucial for the national economy. The current planning of future water outtakes, catalysed by a newly introduced water act, have caused increased demands on reliable data and tools used by the national water authorities in Zimbabwe.

Against this background a co-operation project 'Streamflow and Sediment Gauging and Modelling in Zimbabwe' (GAMZ) between the Department of Water Development (DWD) and the Swedish Meteorological and Hydrological Institute (SMHI) was initiated in Nov 1997 with the objective to strengthen the capacity of the Hydrological Branch of DWD. The Swedish International Development Cooperation Agency (Sida) and the Government of Zimbabwe financed the project. This abstract outlines the objectives, methodology and results of the project.

Scope and objectives

The specific objectives of the project were to secure accurate river flow data in the future through introduction of a streamflow and sediment gauging program and to improve historical records as well as operational water management through introduction of the HBV hydrological model system. The fulfilment of the objectives was to be done through capacity building of key staff at DWD and provision of necessary equipment and software. Five pilot basins (Figure 1) covering all hydrological provinces in Zimbabwe were selected.

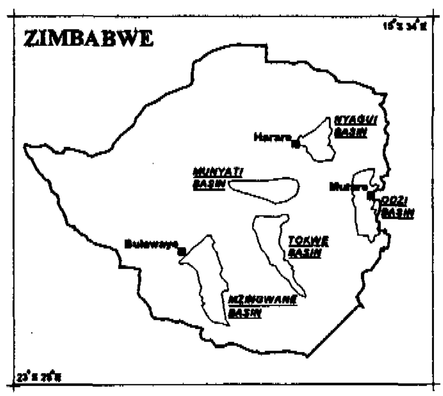

Figure 1. Pilot basins.

Results

The project has led to a primary network of river flow stations in the five pilot basins with cableway systems installed for current meter gauging and sediment sampling. Staffs from each province have been trained in the new measurement technique and a total of 89 river flow gaugings were performed during the 1998/99 wet season, which gave exceptionally high flows in the north-east part of the country. The subsequent analyses of the rating curves indicated that historically observed flow peaks above the designed notch capacities of the stations could be incorrect by ±50%. In the eastern province it was further found that the riverbeds could fluctuate several meters within one wet season, thereby requiring repeated current meter gaugings throughout the season to obtain accurate flow data.

Depth-integrated sediment sampling was done in parallel with river flow gauging at the primary stations to gain good quality data of the transport in the whole river section. An intensive sediment measurement campaign was also performed in the eastern erosion-prone region, which showed that the variation of concentration in space and time was very large. Concentrations of total suspended solids varied laterally between 0.1-12 g/l within the river section showing the importance of correct measurement procedures. Sediment transports up to 11,000 m^3/day were observed in the Odzi River illustrating the siltation problems in the region.

A hydrological modelling system including the HBV model was transferred to the DWD. On-the-job training programs have enabled the staff responsible for each province to run the hydrological model for their respective pilot basins. The nation-wide use of the HBV hydrological model indicated that the model could well describe the river flow generation in the much-varied climatic zones of Zimbabwe, including manmade influences through water abstractions and reservoirs. The model, thereby, can be used to prolong historical records of flow data and also provides an invaluable tool for water allocation in the basins where it is applied.

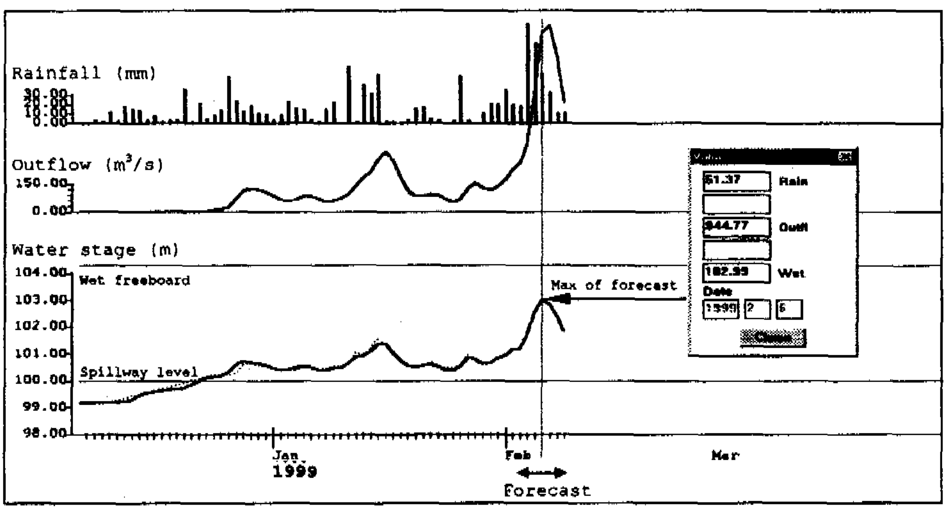

Figure 2. Example of HBV forecast for the water stage in the Chivero Dam made on 2 Feb 99. Bold line denotes simulated water stage, while the dashed line shows the observed water stage of the lake.

The application of the HBV hydrological model for the pilot basins including the main water supply reservoirs for the cities of Harare, Bulawayo and Mutare also showed that the model was capable of describing the hydrological dynamics of the catchments and the water balance of the reservoirs. During early 1999 the water stage in the Chivero Dam outside the capital Harare reached very high levels with severe inundation of the adjacent recreational areas as a result. Since rainfall was continuing to fall in the catchment, fear for even higher levels and possible damages on the dam wall prompted an urgent assessment of the coming inflow. The HBV model was used to produce daily forecasts on the inflow and water levels (Figure 2) during the first week of February to assess the risks. The forecasts showed that although the extreme rainfall and persistent high water levels, a high safety margin for severe damages was present.

Conclusions

A reliable database on river flow data is important for planning and management of surface water resources. The experience is that long continuous series of hydrological data are most cost-effectively obtained through a combination of a monitoring network and modelling to simulate data during periods of no measurements or at arbitrary points.

The results from the project showed that observed river flow data of good quality is only obtained if correct and continuous measurement procedures are applied. Repeated river flow gaugings are necessary to maintain high accuracy in flow data in Zimbabwe, especially for the floods above the designed notch capacities of the stations. Because of highly variable sediment concentrations, the river flow measurements should also be combined with a depth-integrated sediment sampling program to obtain a good estimate of the sediment yield.

The project showed that for surface water supply planning and management in highly influenced river basins as in Zimbabwe a hydrological modelling tool is absolutely essential. Efficient and equitable allocation of water between conflicting interests, e.g. industry, agriculture, urban and rural settlements, is otherwise practically impossible. The HBV model performance in the pilot basins indicated that it could provide a national tool for water management. Furthermore, the extremely high water levels in Chivero Dam during the wet season 1998/99 showed the need for hydrological forecasting and that the HBV model was capable of producing accurate daily forecasts of the Chivero dam levels.

Overall, the co-operation project between DWD and SMHI showed that improved measurement routines for river flow data combined with hydrological modelling can to a relatively low cost successfully be established in a country like Zimbabwe, and will benefit planning, utilisation and management of scarce water resources.

Acknowledgements

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Solar Water Disinfection (SODIS)
- a simple water treatment process

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Water Treatment Need

The number of people without access to safe drinking water is growing in spite of the efforts made to increase water supply coverage. Diarrhoeal diseases continue to be a local plague for the unserved people, and cholera a latent risk of epidemics.

Lack of adequate and safe water supply and sanitation is an important cause for transmittance of infectious diseases in developing countries. The most affected people are the poor living in rural areas, rapidly expanding urban slums and in squatter settlements. Water supply monitoring programmes indicate that more than 1 billion people have no access to save water, approx. 800 million people in rural areas and 300 million in urban settlements.

"Access to safe water" generally presupposes the availability of sufficient water (15 - 50 litres per person and day) within an reasonable distance (normally within 50 - 1,000 m). The available statistics do not provide information on the real number of people served nor about the quality of the water supplied. In fact, a large number of the current systems provide water on an irregular basis and / or of poor quality.

The consequences of the present water supply situation in developing countries have negative effects on the public health situation. Diarrhoeal diseases are the most important effects related to the consumption of unsafe water. Diarrhoeal diseases cause approx. 2.5 million deaths per year, 2 million children die before the age of five. Cholera which is still endemic in some 80 countries remains a latent reservoir for respective outbreaks.

New Water Treatment Approach

Perhaps the most economic way to achieve sustainable and reliable water treatment is to involve the households in this process.

Public water supplies in developing countries often apply conventional water treatment which might fail to produce water safe for consumption. The lack of trained operators, reliable supply of chemicals and spare parts, as well as financial problems often hinder a reliable operation and maintenance of the installations. Since even major urban water supplies are not always capable of maintaining a constant supply of qualitatively good water, the consumers consider the distributed water often as unsafe for consumption. Further water treatment at household level or the purchase of mineral water for consumption is more a reality than an exception in urban areas of developing countries.

Only a limited quantity of the water supplied is used for drinking. Water of drinking quality is pumped often into old and leaky distribution systems where it is exposed to secondary pollution. Should not a new concept of decentralised treatment be introduced in situations where the water supply authorities are unable to ensure a reliable supply of good quality water and maintain this quality up to the consumer's tap? Such a concept would require only preliminary treatment by the public water supply, leaving final treatment and especially disinfection of the drinking water to the consumers.

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Water Treatment Options

Since the available household water treatment methods only partly meet the users' possibilities, they have to be complemented by new processes:

Water can be stored, boiled, filtered or chlorinated at household level. However, water storage can only partly (up to 50 %) remove faecal coliforms - the common indicator organisms used to quantify the degree of faecal pollution. Boiling of water is usually not carried out as firewood which is the only energy source for 40 % of the world's population is often scarce and when available used to prepare food. Water filtration by ceramic candles is too costly and the taste of the chlorinated water is generally disliked by the people.

Alternative water treatment methods should, consequently, be safe in operation, not dependent on energy or chemicals, be cheap in terms of capital and running costs and produce an acceptable water in terms of taste. Solar Water Disinfection (SODIS) is such a treatment alternative which meets these requirements.

The SODIS Process

Solar Water Disinfection (SODIS) is a simple technology using solar radiation to inactivate and destroy pathogenic microorganisms present in the water.

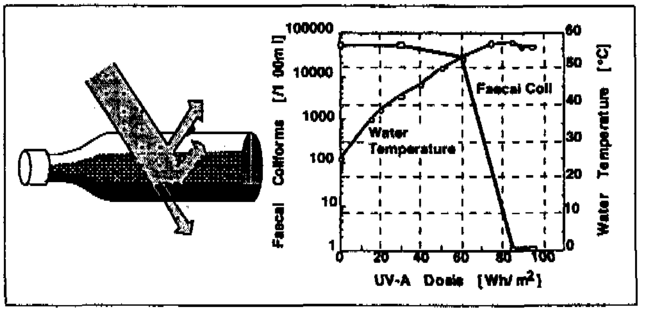
The use of solar energy, which is universally available and free of charge, is the basis of this low-cost and sustainable technology. Taste and odour of the treated water are not affected by the process, as opposed to chlorination which is often rejected by the customers.

Microorganisms are vulnerable to light and heat. So far, two different processes using solar energy for water treatment have been developed independently. The first focuses on solar water disinfection by radiation, and the second applies solar thermal water treatment. Extensive laboratory and field tests conducted by EAWAG and its partners revealed that synergies induced by the combined application of radiation and thermal treatment have a significant effect on the die-off rate of the microorganisms. Hence, the best use of solar energy is, therefore, the combined application of the two treatment processes.

The SODIS Application

SODIS is primarily used at household level to treat small quantities of drinking water. The treatment basically consists in filling transparent containers with water and exposing them to full sunlight for five hours.

The plastic bottles should be half blackened to increase heat adsorption. The 1 to 2-litre bottles are then exposed to sunlight during the morning hours. The water temperature rises from ambient temperature to over 50 °C. Fig. 1 shows a typical temperature development for a sunny day. Within three hours whose peak of approx. 55 °C is reached during mid-afternoon before slowly cooling down again. The treated water is usually consumed in the evening or left to cool down at night and used the next day.



Microorganisms are inactivated with increasing water temperature in the bottle. The initial faecal coliform concentration of a few hundred or thousand CFU/100 ml is entirely removed within four to five hours exposure time. In the first two hours, the inactivation rate is generally low as the water temperature is below the 50 °C threshold and the required UV-A doses. During this period, only radiation has an influence on the water. The inactivation efficiency increases considerably at water temperatures over 50 °C, since the micro-organisms are destroyed by synergetic effects induced by radiation and elevated temperature. After an additional one to two hours, a 100 % inactivation of faecal coliforms is achieved. Thus, a 3-4 log reduction of faecal coliforms requires a sunlight of five hours.

The Advantages of SODIS

SODIS will only be used and applied if the population is convinced of the SODIS advantages over the traditional systems of treating and handling drinking water.

The users are, in fact, interested in this new water treatment method for among others the following reasons:

- SODIS is very simple to apply.
- The plastic bottles are convenient containers to store and carry water.
- The treated water tastes good and has no bad smell.
- The method does not require the addition of chemicals, which are usually not available on the local market.
- The investment costs for the plastic bottles are low and the running costs neglectable.
- The water treatment method is reproducible with local resources, hence, the number of SODIS bottles per household can gradually be increased in accordance with the treated water demand.
- Drinking treated water improves public health and reduces medical costs.
- SODIS increases the status of the user, as the application of water treatment methods is usually associated with a higher level of education.

Apart from the listed advantages, SODIS also reduces the risk of a recontamination of the treated water. The water is treated and stored in the same closed container until consumption. The narrow bottle neck hinders fingers or any other contaminated objects from entering the bottle. This aspect provides a significant asset for SODIS application over other water treatment methods.

The Limitations of SODIS

Like any other water treatment method, SODIS has also its limitations and constraints.

The following technical aspects may be limiting factors and have to be studied prior to applying SODIS:

- SODIS only improves the microbiological water quality. The physical and chemical quality of the treated water remains virtually unchanged.
- The treatment method has a limited capacity and is, therefore, used to treat only the water to be consumed; i.e., 1-3 litres of water per person and day.
- A raw water of low turbidity is required to enable efficient inactivation of the microorganisms; i.e., the level of turbidity should be less than 30 NTU.
- SODIS requires favourable climatic conditions in terms of solar radiation intensity and duration including ambient temperature.
- Application of the process may be limited or inapplicable during the rainy season.
- The water treatment method also requires an adequate supply of empty plastic bottles.

THE WATER HARVESTING CO. – SOLVES WATER SHORTAGE PROBLEMS

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Introduction

The Water Harvesting Company Method offers an outstanding geo-technical method to collect, store and protect fresh water. Through the implementation of advanced eological designs, which harmonises to the laws and powers of nature, we provide our clients with clean and economically competitive fresh water.

Groundwater makes up 92% of the total volume of the world's fresh water; still many areas of the world suffer from water shortage. In some areas water shortage comes from extremely heavy consumption, in some because of the grounds inability to absorb the seasonally heavy downpours of monsoons, hurricanes and floods, that drains of the land quickly. In others areas it just a question of a meager precipitation. Whatever the root of the problem is, it is fact that an overwhelming extent of the rainwater falling in the world is lost to run-offs and evaporation while only a fraction of it manage to infiltrate the ground.

Water gets flushed away or evaporates because of slow ground infiltration and lack of natural storage capacity in the geology. It is certain that the amount of fresh water stored in the ground can never exceed the volume of porous in the ground and/or fissures in the bedrock; neither can it exceed the amount infiltrated in the ground. Hence, ground water available for consumption is limited to the volume accumulated in the geological structure. Meaning that, in order to increase consumption, one has to make a larger fraction of the rain infiltrate the ground.

Therefore today's water shortage problem is not a meteorological problem with inadequate precipitation, but a geological problem with poor ground infiltration and insufficient storage capacity.

Scope

The Water Harvesting Company can change the geological conditions, speed up ground infiltration, increase storage capacity and there by multiply the quantity of consumable fresh water. We increase potential consumption through allowing water, that under normal conditions would flush away or evaporate, to infiltrate the ground in a quantity larger than what is permitted by the existing geological structure. This new method to store and collect water is secure, hygienic, economic and free of the negative aspects associated with traditional open-air storage such as dams.

Methodology

The Water Harvesting Company increases storage volume through the construction of large caverns (can be several kilometers long). A cavern, from a hydro-geological point of view, is nothing else but a large fissure or porous. The cavern is adapted to the local conditions, excavated to a size determined by the desired amount of water consumption, and placed where the geological conditions are the most favorable. The cavern is now the lowest point in the hydraulic system, allowing water falling many kilometers away to find its way down to it.

To speed up the ground infiltration holes are drilled between the pre-constructed cavern and the surrounding water-carrying geological structure such as fissures, faults and reservoirs (man made and natural). The drill holes secure free passage for the water into the cavern. The cavern becomes a natural part of the geological structure, that safely collects and stores water otherwise lost to flush floods and evaporation.

Results and Conclusions

Implementing the Water Harvesting Method results in a substantially increased and easily accessible fresh water volume that is stored and protected underground. The method offers many advantages compared to alternative methods, such as dams and desalination plants.

- Evaporation can be neglected.
- No maintenance costs.
- Insignificant use of land area.
- Insignificant energy costs.
- The water is protected from pollution.
- The need for purification is often negligible
- The tunnels can carry the water over long distances. For example from one region to another.
- A Water Harvesting tunnel/cavern can due to its, compared to natural conditions, great volume of water, stabilize the groundwater level in areas sensitive for groundwater fluctuations.
- The excavated material from the tunnel can be used as construction material.
- Subsoil water can be exploited for heat exchange both for district heating and cooling.

Whether it is a developing country with little precipitation or an industrial nation with increasing fresh water demands, the Water Harvesting Company Method offers the most economical and the most environmentally sound solution to overcome water shortage problems.

Workshop 9

Sustainable sanitation

SUSTAINABLE SANITAITON IN PERI-URBAN AREAS: A LONG-TERM PERSPECTIVE

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Introduction

Considerable emphasis has been given in recent years to the problem of sustainable urbanization in developing countries. The focus of this discussion needs to be directed not so much with urbanization, but rather with peri-urbanization or marginalization – the inexorable and uncontrolled growth of peri-urban slum areas, areas which are characterised by high levels of absolute poverty and disease and by low levels (if present at all) of municipal infrastructure services. Mega-cities are not the problem, but mega-slums are.

These mega-slums clearly show the inequality of the world we live in – we have the rich and healthy, and the poor who are much less healthy. The number of poor people in the world is huge: over 1 billion live on less than US$1 per day, and 3 billions on less than US$2 per day – and this is out of a world population of some 6 billions, so one in every two people is poor.

The health of the poor is adversely affected first by malnutrition, and secondly by poor water supplies, poor sanitation and poor personal and domestic hygiene. In 1990 in developing countries:

- malnutrition was responsible for 15 percent of all deaths and for 18 percent of all DALYs lost;* and
- poor water, sanitation and hygiene together were responsible for 7 percent of all deaths and 8 percent of all DALYs lost.

If we, the world's specialists in public health medicine and public health engineering, believe that improvements in water supply, sanitation and hygiene are truly important to improve the health of the poor in developing countries, what can we do? The answer is not an endless debate about technologies and epidemiology, for we know enough about them. The answer has to lie in persuading governments, bilateral and multilateral donors, international and national NGOs and governments that, if they are serious about wanting to improve the health of the poor, they must invest in improved water supplies, sanitation and hygiene.

This is hugely important. Figures for 1979 (with the implicit assumption that no later data exist) show that some 360-400 billion working days were lost in Africa, Asia and

* Disability-adjusted life years (used as a more rigorously quantifiable measure of health burden).

Latin America in that year due to water- and excreta-related disease. Costing these working days at just US 50 cents means that in 1979 the developing world as a whole lost some US$ 180-200 billion. Their GNP was around US$ 370 billion, so output was below productive potential by around 33-35 percent. Put another way, improvements in water, sanitation and hygiene could have raised GNP by as much as 49-54 percent. Whatever the precise figures are, it is clear that the economy of the developing world is seriously affected by inadequate investments in water, sanitation and hygiene. So much still remains to be done as currently:

- one billion people lack safe water;
- two billion people lack safe sanitation;
- four billion people lack wastewater treatment.

These are round figures, obviously, but a major indictment of our global society.

A Long-Term Perspective for Sustainable Solutions

So, what should we as public health engineers do to improve the health of the poor? The key infrastructure services to be provided in slum areas are water supply and sanitation. These are required first in order to reduce the high levels of transmission of water- and excreta-related diseases. Such provision is, however, difficult. Water supply is not as difficult as sanitation, and one solution to water supply in high-density urban slums is a network of "standpipe co-operatives" – groups of 5-25 households sharing a single standpipe connected to the urban water reticulation system, with cost recovery through the Brazilian model of minimum tariffs paid monthly by each co-operative. Such a system should find favour not only with the communities served, but also with the (even privatised) water supply authority.

Sanitation solutions are harder, but not impossible. In high-density slum areas the only solution – depending on the precariousness of the housing – may be communal sanitation blocks; if these follow, for example, the Sulabh International model developed in India, they are likely to be successful. In rather more "organised" areas, low-cost sewerage (settled sewerage, or simplified sewerage – especially its condominial version) may be feasible and affordable. The Brazilian model may be generally applicable, but care has to be given to the levels of sand (used for pot scouring) and fats that are present: grit/grease traps may be required, and these may present O&M difficulties.

For both water supply and sanitation community involvement is required at all stages – planning, installation, operation and maintenance. An effective partnership must be developed between the public utility and the communities served. This is not only to reduce costs, but also – and more importantly – to ensure the long-term sustainability of the infrastructure. Only in this way can the health of the peri-urban poor be improved.

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AN ECOSYSTEM APPROACH TO WATER AND SANITATION

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Introduction

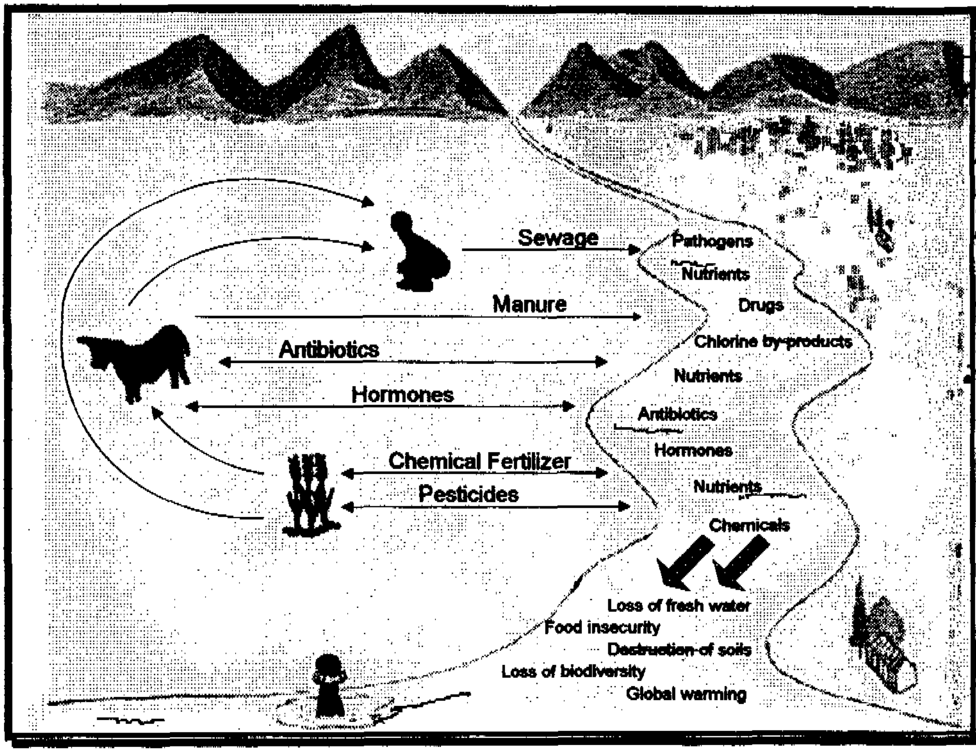
Conventional approaches to water supply and sanitation rest on certain premises that may no longer apply. Western sanitation solutions designed in the 19th century were built on the premises that human excreta and spent fresh water were wastes suitable only for disposal and that the environment was capable of assimilating the waste. There was lack of concern for the environment, population was sparse and rural, and there was no concept of the limits to natural resources. Current practices are based on the belief that we have the ingenuity and technical capacity to find water if it is needed, purify water if it is polluted, and control pathogens by disposing of human excreta.

The panacea of the 19th century is turning out to be the pandora's box of the 21st century. Today, the environment is of major concern, half of humanity will soon live in crowded urban settings, and we are continually confronted with the limits of natural resources, such as fresh water. In the process of finding water, cleaning water or disposing of excreta we have created a plethora of human and environmental health problems that are only now becoming noticeable.

The problem

Many of society's woes have as their root cause our mismanagement of human excreta. We believe that human excreta is suitable only for disposal, and in the process of disposing of human excreta, fresh water becomes sullied, nutrients become displaced and pathogens become concentrated and easily spread. We have focused on how to keep human excreta away from people by transporting it away from where people live and/or treating it. In the process, we have used huge quantities of fresh water, and in developing countries the sewage is discharged at large into receiving bodies of water without any treatment.

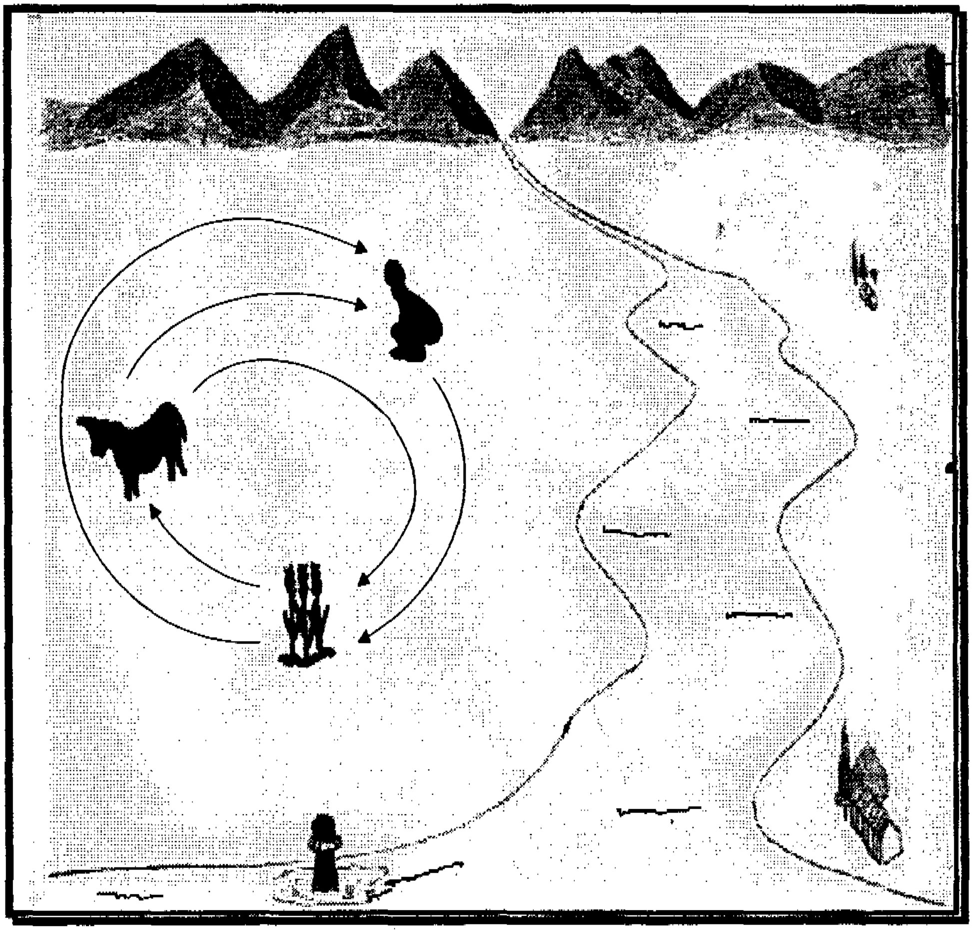
Mismanagement of human excreta results in a number of problems. Water-borne infectious outbreaks still occur with regular frequency in the West despite our diagnostic and technologic capabilities, enormous investments in infrastructure, and our standards and regulatory procedures. Pharmaceuticals from sewage treatment plants are finding their way into drinking water supplies. The implications to humans are not fully known, but sewage pollution is causing the feminization of animals as well as causing animals to be born with both male and female reproduction systems. Disinfection by-products used in the treatment of sewage, as well in the purification of water supplies, have been implicated as a cause of cancer, particularly bladder and rectal cancer. Nutrients from human excreta are discharged or seep into water supplies used for drinking. Nitrogen, which comes mainly from urine, can lead to a number of health problems including methemoglobinemia, *in vivo* growth retardation, and spontaneous abortions. Sanitation is also related to the dwindling supplies of fresh water. Flush systems require huge amounts of water to transport a small amount of dangerous material away from people. Fresh water is used, and in some parts of the world the competition for fresh water is so keen that water-borne sanitation is not an option. These problems, a direct result of waste disposal, are dealt with largely though a sector-oriented approach.



It is the more indirect consequences of these problems that are more intractable, and in the long run more serious: food and water insecurity. These problems are largely due to the misplacement of nutrients, which results in loss of soil fertility, loss of biodiversity and global warming. Declining soil fertility reduces food production, and disposal of nutrients into rivers and oceans destroys marine environments, resulting in declining fish catches. Nutrient pollution destroys different life forms and reduces the diversity of life; biodiversity provides us with the raw materials for our food supply. If ecosystems are disrupted, on land and in water, our food supply and our health will be threatened. Carbon from sewage dissipates from aquatic environments into the atmosphere contributing to global warming, which threatens global food supplies. No amount of human ingenuity and technical know-how can solve these problems if we continue to view human excreta as a waste suitable only for disposal. We need to take a holistic approach, recycling nutrients to the land. An ecosystem approach to water and sanitation is needed.

The Vision

There are three main components of human excreta that should drive our actions: pathogens, nutrients and water. Current approaches must reflect these components and give way to new technologies. Most pathogens come from fecal matter, while most nutrients come from urine. Most pathogens need nutrients and water to stay alive and reproduce. It is, therefore, highly desirable to keep pathogens (feces) apart from nutrients (urine) and water. It is the nutrients that we want to recycle and reuse, not pathogens. Keeping them separate allows nutrients to be returned to that land, reducing nutrient pollution.



The concept of waste is the problem, not waste itself. All waste is a food for a natural process. If that food is misplaced and toxic to a particular organism, we are guilty of destroying life. We must move away from building a device that disposes of waste toward devising a process to capture and utilize resources in excreta in order to work with nutrient cycles and to maximize our use of fresh water. We must also move away from pollution and towards zero-discharge. It is not how much can the environment handle, but how little we can pollute. The design of water and sanitation interventions must consider how each resource is managed through its natural cycles. This includes nutrients, water and chemicals for disinfection. We must create a design to return nutrients to land for food production, minimize the use of fresh water, and purify water without chemicals. And, we must devise a way so these solutions work in concert with each other. We cannot solve isolated problems without considering the effect elsewhere in the environment. Although it is important to break each problem down into its component parts, it is even more important that our solutions minimize adverse human and environmental effects in a holistic way.

DRY SANITATION IN MEXICO: IMPLEMENTATION STRATEGIES AND RESEARCH REGARDING AGRICULTURAL USE OF HUMAN EXCRETA

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INTRODUCTION

Inappropriate and inadequate sanitation causes severe water pollution problems throughout Mexico. Springs, wells and lakes are heavily polluted with fecal material. Gastrointestinal infections are the second cause of infant mortality and water-borne epidemics are quite common. Wastewater often mixes with irrigation water which was used until 1991 in peri-urban vegetable production in the state of Morelos, Mexico. Because of the resulting high fecal content on vegetables, the government prohibited using irrigation for these crops, affecting 43,271 hectares of rich agricultural land, where rain falls only four months out of the year.

At the same time, soil erosion is a problem throughout the country, synthetic fertilizer prices are increasing and rural to urban migration continues as peasants give up farming.

Espacio de Salud (ESAC), a small civic organization in Morelos, Mexico, works with communities in sanitation programs using a modified version of the Vietnamese double-vault dry toilet, which has been gaining in acceptance. One of the reasons for this increased acceptance includes the possibility of use of human excreta for agricultural purposes, with reduced pathogen content.

PROGRAM IMPLEMENTATION

As the need for sustainable sanitation services increases, ESAC has identified strategical areas which must be improved so that implementation can be successful. These include:

1) Participatory approaches in community education and training regarding water conservation and waste treatment, which have the potential to "go-to-scale."

2) Research in the fields of pathogen behavior, post-treatment and agricultural use of dry toilet products (urine and dried excrement), as well as socio-anthropogical studies which help identify family and community perceptions and roadblocks. The latter includes what role gender plays in the acceptance or rejection of this alternative technology and the agricultural use of its products. Research in these fields is underway through the Autonomous University of the State of Morelos, as well as in collaboration with the University of Linkoping, Sweden, and the Swedish Institute for Infectious Disease Control.

Well-financed alternative sanitation programs provided by governmental and international lending agencies often lack adequate community education, training, and partipation in decision-making, which leads to project failure on a large scale. Environmental non-governmental organizations are often successful in these areas, but on a very small scale. Espacio de Salud is refining a methodology which seeks to bridge the gap, focusing its work in communities with the possibility of multiplying the work within their regions.

ESAC is carrying out formation and training projects in alternative waste management in four states, in order to establish community-managed waste treatment projects. This two year program is funded by the Swedish International Development Agency/SanRes, the North American Fund for Environmental Cooperation, and Christians Linked in Mission.

Activities include training local outreach workers in popular education methodologies, gender issues and construction and maintenance of appropriate technologies pertaining to domestic waste treatment. As a result of this project, the participating groups and communities are becoming self-sufficient in establishing and maintaining waste management services. Due to the organizational experience of the participating communities, they are already multiplying the benefits of this project, and will act as self-sustaining resources within their regions.

ACHIEVEMENTS

An important accomplishment of the program has been the greater awareness that has been generated regarding sanitation-related environmental and health issues. Training workshops given by Espacio de Salud to experienced outreach workers in key communities show results in a brief period of time, as these persons are given methodological tools in order to broaden their impact. Groups analyze the relationship between water scarcity, pollution and conventional sanitation approaches. As a result, one community is opposing the installation of sewers in favor of dry toilets.

Questions still arise regarding possibilities of disease transmission, and eyebrows are especially raised regarding using urine and dried excrement for agricultural purposes. However, interviews done with dry toilet users in peri-urban areas showed that several were already using the dried excrement on ornamentals, and were receptive regarding using the urine as well. Most requested more information.

Outreach workers involved in this project easily grasp the importance of safely recycling human "wastes" and the potential of urine as fertilizer. They often prioritize experimentation with urine in their communities even before building toilets. In one region, dry toilets were built in a large government-financed project without community participation and were not being used. Community leaders began to show interest when they were later informed that the urine could be utilized for their pineapple crop.

Another achievement is the consolidation of a working group which includes civic organizations, community groups, entrepreneurs, local governments and local as well as foreign academic and research institutions in order to overcome obstacles in sustainable sanitation program implementation.

DRY SANITATION IN KERALA, SOUTH INDIA.

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Problem Description

In the fishing villages of Kerala, south India, the most common form of sanitation for men is open defecation on the sea shore. For the women the situation is much worse. Fear of molestation forces them to the marginal privacy of a few congested patches of land within the village behind a wall or amongst some bushes and occasionally snakes. In the two rainy seasons the situation becomes very grim indeed.

These villages have a very high water table, they are crowded and people depend for most of their water on open wells in the coarse sand. Piped water supplies are inadequate, irregular and badly maintained. Septic tanks and pour flush pit latrines are inappropriate in most places due to this high water table and presence of the open wells. Over 90% of the people defecate in the open. Anal cleansing is with water, but there is no evidence of hand washing after defecation (or before meals). Cholera and polio, worms and diarrhoea are evident amongst the village populations.

With no consideration for the high water table or the water quality in the wells a community latrine had been built at the request of a women's group in one of the villages. The primary motivation was for privacy. This small complex of 10 water flush squat toilets simply flushed its effluent into 5 soak pits close outside the toilet block. Unfortunately this experiment, although quite well managed socially, soon discovered that its own well, from which flushing and anal cleansing water was drawn, was visibly contaminated with sewage.

Whilst the community toilet has been kept operational for the last 5 years by retrofitting a lagooning system instead of the soak pits the real desire of many of the women was to have a toilet close to home. The problems with the community toilet effluent were a useful starting point for an education campaign on hygiene awareness and sanitation. The author began a project with a local NGO which supported the women's group. There were four mainobjectives:

1. To understand the local beliefs about "how we get sick".
2. Based on this knowledge to run an awareness campaign on hygiene, health water and environmental sanitation.
3. Find, or develop, a suitable sanitation technology for the local situation.
4. Teach a local team to build the toilets and provide continued education and follow-up.

How the problem was addressed

It was quickly clear that almost nobody had any idea where illnesses such as polio, cholera, dysentery and others came from. They did not find open defecation offensive or believe it to be a threat to their health. It was normal, it had always been like that. A latrine was a nasty smelly affair and one would not want one any where near the house. If a neighbour thought of building one you would try to prevent them or at least make sure they didn't put it near to your house. Women also considered latrines as smelly unclean things but had some interest in them for the privacy they might give and for the safety of their adolescent daughters.

The author trained the team in hygiene awareness and participative approaches to data collection and taught them about a variety of sanitation options. He taught them the advantages and disadvantages of different types, e.g. septic tanks, pit latrines and compost toilets. Whilst they already had experience of pit latrines failing in the village because of the high water table (in the rains the sewage would back up and overflow disgusting and outraging the villagers) they had never been conscious of the pollution of their wells. We tested the well water that people were drinking and found it to be severely contaminated with faecal coliforms. With this new knowledge they were able to work together and raise a new awareness amongst women in the village about sanitation, water, health and hygiene. The idea of a compost toilet was very alien to them. They could see that it would use very little water and, more importantly, would not contaminate the ground water and wells and this they believed was very important. However they could not believe that it would not smell.

The author developed a compost toilet to suit the high water table, custom of anal cleansing with water and the hot humid climate. A desiccating toilet was not really a possibility because of the constant high humidity and also the lack of direct incident radiation at ground level due to a thick canopy of coconut trees. There was no possibility of getting large quantities of carbonaceous bulking agents easily or freely so that the use of urine diversion was essential if the compost chamber was not to become saturated and odorous. There would have to be an absolute guarantee that the toilet would not smell otherwise it would be rejected very firmly and loudly by all involved.

The author developed a compost toilet with two faeces composting chambers to be used alternately (each six to nine months) and urine diversion at source to an evaporative plant bed outside the toilet. The evaporative plant bed is usually planted with *Cana Indicus* but appears to work well even if un-planted. Some users have planted bitter gourd. Both the composting chambers and the plant bed are above ground and are sealed to prevent any seepage to the soil (or water table). The toilet was cautiously accepted by a small number of women. It was true, it didn't smell, not at all! But they continued to be very fearful about what the compost would be like. When finally they could see the first compost and found, to their great surprise, that it was neither unpleasant to look at or to smell and bore no resemblance to its origins, they were convinced. Neighbours who had fought against them building a toilet nearby now wanted one too.

What has been achieved

Currently there are 150 of these compost toilets operating in a number of Kerala's southern fishing villages. The corporation and local government are at last becoming convinced of the success of the technology because it is so enthusiastically approved by the users themselves. But generally government decision makers are highly sceptical when simply told about the technology. If one can get them to visit the toilets in the villages and speak to the users they are invariably convinced within a few minutes. The hardest part is to get these decision makers to come to the village.

This work has revolutionised, in a small way, the approach to sanitation in this part of India. Compost toilets were really not on the agenda prior to this. Local people had not heard of them. National and international sanitation experts were almost exclusively of the opinion that they could not work in a culture so averse to "night soil" and where anal cleansing is with water. These conditions appeared to make composting toilets a non-starter. A toilet that was not going to be flushed or to have a water seal seemed a serious retrograde step. Having to empty it every six to nine months appeared like a call for the return of the degrading and objectionable task of scavenging (India's night soil used to be collected by a lowly *caste* of scavengers whose job was to collect the nightsoil in baskets and carry it away on their heads).

As the decision makers begin to realise, through this demonstration, that compost toilets are both viable and acceptable and are a very far cry from the days of scavenging the doors begin to open on a new approach to sanitation in India's towns and cities. The majority of these face perennial water shortages and are all inadequately sewered. Dry sanitation is not only a useful sanitation option for India's urban planners it must soon become a fundamental requirement if these towns and cities are ever to attain adequate water supplies and safe sanitation.

The author is currently working to promote dry sanitation in India and amongst its neighbours through pilot projects in new locations and by raising awareness amongst policy makers.

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1. INTRODUCTION.

Most Vietnamese live in rural areas, where only 17% of the households have some kind of hygienic latrines. Several risk factors and habits have resulted an high infection incidence of parasitic diseases (60-80%) and diarrhea cases (1240 cases/100 000 people/year). The potential risk of epidemic outbreaks of intestinal diseases is ever present.

Common types of toilets are pit holes and traditional Vietnamese double vaults, During the last fourteen years, double vault pour flush toilets have been introduced in rural areas. These types of toilets still have some weak points for protection of human health and environment. With the support of the Sida funded Sanres programme, the Nha Trang Pasteur Institute together with the Department of Preventive Health of the Ministry of Health, Viet Nam have developed a pilot ecological sanitation (eco-san) project in Cam Duc.

Cam Duc is a commune of Cam Ranh District, Khanh Hoa Province in central Vietnam. It is a hot and sunny place with a dry season lasting at least 8 months.. The commune has 1,831 households with 9,940 inhabitants. The main occupation is farming. A third of the households have hygienic toilets and half have dug well, most of which are contaminated by faeces. The prevalence of intestinal parasite infection is 65% and diarrhea incidence is 1,100 cases/100,000/year.

The results of pilot project in Cm Duc will be applied to other rural areas in Vietnam .

2.MATERIALS & METHODS

Sixty eco-san systems in five different designs were built in bricks and cement mortar, roofed with galvanized iron or asbestos-cement sheets. Each solar heater (if there was) was made of iron sheet, fixed on an iron or wood frame and painted with tar. Two Vietnamese double vaults toilets served as controls. All were provided with urine diversion. The types can be identified as follows.

Type 1: Vietnamese traditional double-vault dehydrating toilet (VDVDT). *Type 2:* Ventilated VDVDT (as type 1 but with a vent pipe); *Type 3:* Ventilated double-vault dehydrating toilet with solar heater; *Type 4:* Ventilated double-vault dehydrating toilet with removable shelter (as type 2 but with a removable upper structure made in light materials and the uncover part of squatting slab serves as a solar heater); *Type 5:* Ventilated one-bucket double-vault dehydrating toilet with solar heater; *Type 6:* Ventilated multi-bucket one-vault toilet with solar heater.

Each householder got basic guidance in relation to the handling of his/her toilet before use. After all toilets were used at least 6 months, we chose 12 toilets, two of each type, for testing the survival time of microbial indicators in processing chambers of the toilets.Two indicator organisms were used : *Salmonella typhymurium* phages 28B.

Ascaris suum eggs . The laboratory assays were modified and introduced by Swedish Institute for Infectious Disease Control.

The phages were mixed with faecal material in a concentration of 1.10^8 pfu/g. Eggs were put in "tea bags" made of polyamide cloth, with 10^4 eggs/ bag. All were put in stainless steel cylinders, 11-14 cm in diameter, which were drilled a large number of 2 mm holes. Then the cylinders were put in 12 toilet processing chambers or toilet buckets, in the midle of each faecal pile. The material samples were taken weekly and tea bags were taken every two-week to determine the survival time of phages and *As.* eggs.

The pH, moisture and temperature were determined at the same time of sampling.

3. RESULTS AND DISCUSSIONS

Moisture. The initial moisture of the fecal materials when the tests started depended on the added quantity of ash by the users after defecation. The range was between 25.4% and 58.5% with a median value of 34,9 %. The moisture decreased linearly by time of storage with a speed estimated from the slopes of the curves of moistures versus time (days) established by the minimum square method. The values are shown in Table 1.

***Table 1**: Drying speed of faecal material in processing chambers.*

Types	1		2 *		3 **		4 **		5 **		6 **	
Toilet No.	1	2	3	4	5	6	7	8	9	10	**11*** **	12
Drying speeds	0.07	0.08	0.18	0.12	0.16	0.16	0.12	0.21	0.08	0.10	**0.25**	0.08

(*) ventilated; (**) ventilated and solar heated ; (***) best irradiated.

The drying speed of the toilets with vent pipes or solar heaters are normally higher than the traditional ones. However, their location do affect the efficiency. Which are fully irradiated like toilet 11 dried up rapidly.

Temperature. In the toilets with solar heaters, the average air temperature in vaults was 34.7^{0}C, and the average temperature of materials was 33.9^{0}C (the highest was 40.1^{0}C), while the average out door air during the time of sampling was 32.4^{0}C The temperature of faecal piles were not high enough to kill pathogens but it took part in shortening their survival. For example, because the solar heaters of toilets 6 & 11 were fully exposed to the sun, the survival times of the two indicators were very short *(see Table 2)*.

pH. The pH values of the faecal material depended on the type and quantity of ash which was added. The quantity used was about 100-300 ml of ash. The pH of ash from wood was 11.3 and from rice-husks was 10.6. In the case of toilet 3.1 rice-husk ash was used in large quantities but the pH was the lowest. In our tests, the pH seemed to be the most considerable factor in governing the die-off of the organisms (see below).

The die-off.

The die-off of *A. suum* eggs was generally longer than that of *Sal. typhymurium* phages. Their shortest die-off respectively was 51 and 23 days and the longest was 169 and 154 days.

Although theoretically the survival is affected by pH, temperature and moisture, the results observed showed that pH was the most influential factor. Truly, the statistical interpretation of relationship between the survival time of each indicator and three variables (% moisture, T^{0}C, pH) confirmed this (see *Table 3*).

The same interpretation based on maximum material temperature also give us the similar results. Thus, we can say that in the range of pH from 8.4 to 10.3, temperature from 30.7 to 40.1^{0}C and moisture from 25.4 to 58.8% the survival time (as days) of two indicators can be evaluate by two following equations with the confidence of 95%:

$$Y_{phages} = -78.96pH - 5.328T^0C - 0.918\ M$$

$$Y_{as.eggs} = -49.69pH - 0.684\ T^0C - 1.859M$$

and that at the critical probability of 0.05 only coefficients of pH are really statistically significant.

Table 2: The survival time of A. suum eggs and Sal. typhymurium phages and three physical parameters

Number of Toilets	Survival time of Phages (days)	Survival time of As. eggs (days)	Average pH of faecal materials	Average T^{0}C of faecal materials	Initial moistures of faecal moistures (%)
1	37	79	9.8	31.2	35.6
2	79	65	9.6	31.2	41.5
3	37	65	10.0	30.7	34.1
4	37	169	10.1	30.7	40.4
5	154	129	8.4	32.8	34.0
6	23	65	10.1	34.8	28.8
7	93	65	8.8	34.2	58.5
8	114	142	9.0	35.5	39.8
9	23	65	10.3	31.4	32.1
10	23	51	10.3	32.5	25.4
11	30	51	9.5	36.2	49.9
12	30	65	9.7	33.4	32.6

Tables 3: *Interpretation results given by Excel **LINEST**- function on the relationship between the survival time of phages and As. eggs respectively and moisture, T^{0}C, pH.(assume that their relationship obeyed the following equation:*

survival time $Y = m_1.M + m_2.T^0 + m_3.pH$

Indicators	m_1 (Moisture)	m_2 (T^{0}C)	m_3 (pH)	b	r^2	F- test for r^2: F-observed	F-critical
Sal. phages	-0.918 (/t/=0.678)	-5.328 (/t/=1.797)	**-78.96 (/t/=8.314)** *	1026	0.9188	**26.4**	4.76 (P=0.05)
As. suum eggs	-1.859 (/t/=1.121)	-0.684 (/t/=0.181)	**-49.694 (/t/=4.103)** *	645.7	0.795	**5.695**	4.76

(*) t-critical = 2.365 at p = 0.05.

Social research. Although every household was instructed on how to use and maintain the new eco-san toilets, a number of households did not follow all the instructions.In the first investigation of ten practices at sixty two families, 56.5% to 85.5% (according to the kind of practices) of families had good practices. However, if more attention is paid to hygienic practice education that situation can be improved. In fact, after we repeated guidance during the first investigation the above percentages increased to 80.6% to 98.4% in follow-up investigation. One hundred percent of households interviewed said that their eco-san systems were suitalbe to them.

4. CONCLUSIONS AND RECOMMENDATIONS

- It takes 6 months of retention for faecal materials in the test toilets to become absolutely safe.
- Ash from wood is the best additive for shortening the survival time of the microorganisms and parasites in faeces and removing bad odour. Such ash is readily available in every Vietnamese rural households
- Although the survival time of the indicators in the majority of toilets having solar heaters is relatively shorter, the operation of these toilets is more inconvenient and the construction more difficult.
- Ventilation pipes, 10 cm in diameter and reaching at least 50 cm above the toilet roof, can effectively remove odours and control flies.
- Proper use is very important for these toilets to function well.

REDUCTION OF MICROORGANISMS IN DRY SANITATION DUE TO DIFFERENT ADSORBENTS UNDER LOW TEMPERATURE CONDITIONS

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Introduction

China is presently facing serious shortage of water resources and the distribution of water is uneven both seasonally and regionally. Sewage water as well as gray water pollute water sources in densely populated areas, exaggerating the present problems with water shortage. An nationwide investigation performed in China in 1993 showed that 85.9% of the population had access to some types of latrines. However, this figure also includes all types of simple toilets and only 13.5% could be regarded as safe as faecal sanitation facilities due to Chinese quality criteria. Although the rate of coverage have increased during the last years, the sanitary difficulties are paramount, due to the huge population of China, presently estimated to nearly 1,25 billion people. The impact on the water resources is large, since flush toilets are still regarded as the ideal, but the main alternatives, methane tank toilets, double-urn toilets and VIP toilets are mis-regarded as inferior in the rural areas.

Within the Sida sponsored Sanres programme, experiments were started in 1997 with dry toilets with urine diversion in China. This system of "no flush ecological sanitation with urine diversion" integrates ecology, hygiene, water- and energy saving and have been well received by the peasants in the project sites within three provinces where they have been introduced. Their application is regarded as a success. Presently sanitary officials from 13 provinces in China believe that this approach has a great development potential both for towns, villages and rural areas and for resolving the problems with faecal sanitation in China.

Scope

The ongoing Sida funded Sanres programme in China is performed in cooperation with NPHCCO and coordinated with Unicef/Beijing. It embrace three project sites in different parts of China. One in Qing Xu County, Shan Xi Province in northwestern China, with a cold climate and a mean annual rainfall of 460 mm. The second in Wang Qing County, Ji Lin Province in northeastern China with a cold climate, annual temperature of 4 oC, but with rich water resources and periodical flooding. The third is in a mountainous area of Tian Yang County, Guang Xi Zhuang Autonomous Region in southern China, with a hot and humid climate, with a mean annual daily temperature of 18-22 oC, its precipitation is much different seasonally.

Within the first, 21 outdoor dry toilets with urine diversion have been built. They represent 4 types of single-vault or double-vault toilets, with or without solar heating, built half-above the ground. Within the second project site more than 90 units were built outdoors with the processing chamber above, or half above ground and within the third 70 units of indoor toilets built, representing several construction types.

Methodology

We found that the absorbents were varied from different users while the toilets were in use. They are plant ash, coal ash, sawdust/husk and loess of four kinds. In order to know the influence of the different absorbents on the effect of sanitized feaces, we conducted a simulated experiment. Different absorbents were covered on layers of feaces according to the actual ratio (approx. 1:3) in processing chambers respectively. At the same time, the ' tea-bags' containing Ascaris eggs are place inside about 1 kilogram homogeneous mixture of feaces and different absorbents in different filling boxes respectively. In addition, there was about 150 gram of the homogeneous mixture mixed bacteriophages of Salmonella typhi 28B in each smaller box which was placed in the middle of the larger box respectively. Then the boxes were placed in the middle of the simulated faecal piles respectively.

The aim of the present paper is to discuss preliminary results of the relations between the persistence of microorganisms and environmental factors and the use of different absorbents under low temperature conditions. The investigations have included an assessment of the die-off of Ascaris eggs and bacteriophages added to the faecal material. In addition the number of faecal coliforms and Salmonella in the material have been measured. Other parameters included in the testing are pH, temperature, moisture and odour and the presence of flies or maggots associated to the material.

Results

Different absorbents are in use. In this investigation we included plant ash, coal ash, sawdust/husk and loess (Table 1).

Table 1. Characteristics of the absorbents used as additives to the faecal material

Type	pH	Moisture (%)	pH when mixed with the latrine material
Plant ash	11	1-3	9-10
Coal ash	8	<3	7
Sawdust/husk	7-8	*20	7-8
Loess	6-8	*20	6-8

The investigations were performed under low temperature conditions with a temperature varying during the day between minus 10 oC to plus 10 oC. There were 120 days in which the lowest daily temperature was below zero in the midnight. Meantime there were less 20 days in which the lowest temperature of faecal material was below zero. This led to a partial freezing of the material under investigation, however, usually not below minus 3 oC. The bacteriophages were added to the material in a final concentration of above 10^8/g. Ascaris eggs were included in bags of polyamid cloth (pore size 20 *m) in direct contact with the material.

Testing were performed periodically after the faecal material had been piled for more than 3 months. In these processing chambers, the moisture varied between 15-62%, the faecal coliform content varied between <1 to 10^2/ gram and the survival of Ascaris eggs varied between 0.95-20.2% after five and half months. Sampling was performed eight times during the periods of investigation. However, in Table 2 we have limited the results to the fifth and the eighth sampling periods and the results represents the mean values from two latrines with each of the investigated additives.

Table 2. Reduction of microorganisms in the latrine material with the respective adsorbent as additives. The values are expressed as log reduction during the indicated retention time as a mean of two latrines per additive. For Ascaris eggs the percentage of surviving eggs are given.

Type	Retention time	Faecal coliforms	Phages	Ascaris eggs
Plant ash	55 days	7 logs	6 logs	1,7
	3 months	> 7 logs	> 7 logs	0,95
Coal ash	3 months	5 logs	3 logs	28,3
	5.5 months	5 logs	5 logs	14,4
Sawdust/husk	3 months	4 logs	2 logs	32,2
	5.5 months	4 logs	4 logs	16.1
Loess	3 months	3 logs	2 logs	33,3
	5.5 months	5 logs	3 logs	20.2

Discussion and conclusions

The persistence of faecal microorganisms is normally greatly enhanced during cold or temperate environmental conditions. These, therefore, may represent the most difficult ones from a sanitary point of view. Partial freezing and thawing have by some investigators been assumed to enhance the rate of reduction. Investigations within this area are however lacking. Dry latrines may be regarded as less suitable during cold climates. But as the present data indicates a good reduction may be obtained also during such conditions.

The present data show that the addition of plant ash, resulting in an elevation of the pH value in the latrine material is the best absorbent, and well suited to reduce the numbers of faecal indicator bacteria, the test viruses and reducing the viability of Ascaris eggs to a large extent already within a couple of months.

Other absorbents, like coal ash, sawdust/husk and loess, will not give a similar rise in pH and also have a much lower reducing effect on the viability of the microorganisms, except for coliforms and coal ash. A reduction occurs also with the other absorbents. Further and prolonged investigations of these may give additional information in relation to the reduction of microorganisms. This reduction may be due to the low moisture content and also in partial variations in moisture due to the freezing and thawing. However, this process, by itself does not seem to have any countable effect.

The availability of plant ash may vary regionally, but coal ash may be prevalent, an aspect important to observe. For an elevation of the pH, lime may be used as an alternative. A short period of fermentation was observed when sawdust was used. Under the prevailing conditions this did not led to an enough rise in temperature (34 oC was noted during a couple of days). However, unpleasant smell was noticed when using this material, probably due to larger particle aggregates. Probable one year is needed for an acceptable sanitization with other absorbents than plant ash under the prevailing test conditions. Now the investigation is still ongoing.

Management as well as health education are still key factors in relation to latrines and can never be overlooked.

HYGIENIC ASPECTS ON THE REUSE OF SOURCE SEPARATED HUMAN URINE IN AGRICULTURE

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Introduction

The practice of separating human waste and use it as a fertiliser is an old tradition that has gained renewed interest in many countries. In Sweden source separating sewerage systems and the reuse of human urine have been introduced as a part of a sustainable future. Human urine is the largest contributor of nutrients in household wastewater even though it constitutes only 1% of the volume. An estimated 60% of the phosphorous (excluding detergent input), 80% of the nitrogen and 70% of the potassium originate from the urine (Sundberg, 1995). The urine separating sewerage systems are based on toilets with divided bowls; a front one collecting urine and a rear one collecting faecal material. The urine and a small amount of flushwater is collected in a tank and periodically transported to a storage tank at a farm for later use as a fertiliser on arable land. The sustainable engineering approach thus fulfils the combined requirements of water saving, reduced nutrient loads to wastewater treatment plants, reduced impacts on receiving waters and reuse of nutrients on arable land.

Although source separating sewerage systems may have several environmental advantages, it is necessary that the sanitary and hygienic demands are met in order to minimise the risk for transmission of disease. Urine normally contains low amounts of transmissible microorganisms. A few diseases; leptospirosis, typhoid fever and schistosomiasis, may be transmitted through urine, but are of major concern only in some tropical areas. Instead it is mainly the contamination of displaced faecal material that involves a risk. The possibility for faecal material to enter the front part of the toilet bowl is especially large at incidences of diarrhoea and for children using the toilet, and due to the low amount of flushwater used rather high densities of pathogenic enteric microorgansims may be present in the urine. The duration for sufficient storage will thus be dependent on the initial concentration of various microorganisms and their persistence in urine.

Methodology and Results

The presence of faecal indicator bacteria in the urine mixture (urine + flushwater) from 14 collection tanks of urine separating sewerage systems was analysed in order to quantify the faecal cross contamination. In 83% of the samples no *E. coli* was found. Enterococci were present in 91% of the samples, in 60% of the samples the density of presumptive enterococci was over 1000 cfu/ml. Sulphite reducing clostridia were found in 76% of the samples in densities between 1-2000 cfu/ml. The bacterial groups thus indicated different degrees of contamination.

Chemical analysis of faecal sterols in urine showed to provide an alternative to the traditionally used indicator bacteria. The degradation of coprostanol, which is a sterol excreted by humans, proved to be negligible in urine and urine sediment (Sundin *et al.*, 1998). Thus, coprostanol seems to be a suitable indicator for quantification of the cumulative faecal contamination of source separated urine. Analysis of coprostanol indicated up to 5 ppm (mg faeces per litre urine mixture) admixture of faeces in 85% of the samples from the liquid phase of the tanks and a maximum contamination of 13 ppm. As for indicator bacteria the concentration of coprostanol was higher in the sediment that had formed in the bottom of the urine collection tanks, with an average contamination of 120 ppm (mg faeces per kg sediment).

Furthermore, the hygienic studies have been focused on the survival of various microorganisms in source separated urine. Microorganisms were added to urine mixture from collection tanks and their inactivation was followed over time.

Bacteria investigated include *E. coli*, *Salmonella senftenberg/typhimurium*, *Aeromonas hydrophila*, *Pseudomonas aeruginosa*, enterococci and clostridia (Höglund *et al.*, 1998). All bacteria studied, except spore forming clostridia, were reduced well within the recommended storage time of six months with an initial density of about 10^6 cfu/ml. The major factor causing microorganisms to die off was probably correlated to the elevated pH in the urine. The pH is raised from 6-7 in fresh urine to 9 in the collection tanks, due to a rapid conversion of urea to ammonia. Except for clostridia, enterococci had the slowest reduction rate with a $\log_{10}$ reduction in approximately 30 days at 4°C.

Some pathogenic protozoa form cysts or oocysts in the transmissible stage of their life cycle that are very hardy to environmental pressures. The protozoa *Cryptosporidium parvum* showed a $\log_{10}$ reduction within 30 days in urine at 4°C (Höglund and Stenström, submitted). Lowering the pH to 7 and 5 increased the survival of *C. parvum*.

Studies of a bacteriophage (*S. typhimurium* phage 28B) indicated no reduction in urine mixture during 90 days at 4°C. At 20°C an approximate $\log_{10}$ reduction was obtained within the same period. In initial studies of a human virus a faster reduction was obtained at 20°C than for the Salmonella phage. However, at 4°C there seemed to be, as for the Salmonella phage, no or a very slow reduction.

By applying the faecal contamination, estimated from coprostanol analyses, in combination with the survival of various microorganisms, it is possible to evaluate risks associated with the reuse of source separated urine.

Conclusions

To estimate the risk of pathogen transmission for handling, transportation and reuse of source separated urine that follows, it is necessary to determine the amount of faecal material introduced in the urine fraction. Indicator bacteria normally used in water quality analysis seem, however, to be inadequate for these type of systems. *E. coli* was shown to have a very rapid die-off in urine whereas the high densities of enterococci found indicate a growth within the sewerage systems.

The die-off of the protozoa *Cryptosporidium parvum* showed that even this hardy organism not constitutes a major risk in agriculture if the storage is conducted properly for six months. Even though most other microorgansims also seem to be sensitive to the conditions prevailing in source separated urine, a more thorough risk evaluation including all steps, from the users through the persons handling the urine to consumers of crops grown on urine fertiliser, need to be conducted. This work will continue based on the faecal contamination estimated from the analysis of faecal sterols and estimations of microbial reduction rates in the urine.

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APPLIED RESEARCH PILOT PROJECT ON ECOLOGICAL SANITATION
(Recycling human waste through use in trees and crop production)

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Introduction

This paper is based on research in ecological sanitation by Mvuramanzi Trust in the rural and peri-urban areas of Zimbabwe. The research is expected to contribute to sustainable human and environmental development through safe recycling of valuable nutrients and other matter contained in human excrement for use in forestry, agriculture and other income generating activities. For ourselves we have termed the process as ecological sanitation and have defined it as "the disposal of human waste in a way that is beneficial to the growth of trees, food crops and does not contaminate the environment.

For the research a variety of designs have been made and include urine and faeces separation toilets known as uriseps, mobile or portable arbor loo's (tree toilets) and Blair composting latrines. As part of the research families with these toilets are given training on how to use the human waste for agriculture and forestry. The study will assess community attitudes towards the use of human waste in fruit trees and food crops production. An important component of the study is the time it takes to kill off any pathogenic organisms including the helminthes in aerobic and quasi-aerobic conditions in ecological toilets.

Zimbabwe has over a number of years been promoting sanitation in rural areas and has a national coverage of about 35%. The choice of technology has been the Blair VIP latrine, which has robust structure and a life span of about 15 years. However there has been a need to develop other latrines which are suitable for sandy collapsing soils, or rocky soils which make digging the pits difficult. Another problem has been that pit type latrine could contaminate water tables, especially high water tables. In rural agriculture inputs for fertilizer have risen steeply in recent years. The use of human waste as a potential fertilizer has been ignored, partly as a result of difficulty of access. The life span of pit latrines is dependant on the file span of the pit and not the structure.

Expensive inorganic fertilizers are sparingly used in the best of time, of late the prices of inorganic fertisers had sky rocketed to an extend that most small scale farmers are failing to purchase any fertiliser which has resulted in considerable drop in communal farmers maize production. Coincidentally human waste is said to contain phosphates, nitrogen and potassium in proportions that can be readily absorbable by plant material causing considerable growth. Given the foregoing the introduction of ecological sanitation has become one of the logical solutions to the problems faced by the rural communities.

Scope

This research has a number of studies which include the human and environmental health implications of recycling human waste as a fertilizer and soil conditioner and the nutritive value of faces and urine and how best to apply them to soil and plants. Another study examines attitudes and behavior towards ecological sanitation and human waste. At present trial are being done in rural areas of Zimbabwe and it is hoped to expand these to the region.

One trial is being carried out in the Zambezi valley where two movable toilets have been installed in a garden co-operative of ten women and two men. When we approached the co-operative it was already engaged in fruit tree and hot culture production. Ours task was to introduce the two movable Arbor- loo's (tree toilets) firstly as convenient sanitation technology appropriate for people who spend most of their time in the field and secondly as method of supplying manure and organic fertiliser to pits into which fruit trees seedlings are planted.

Another community are engaged in horticultural production and were introduced to the concept of ecological sanitation, and as a result a number of them are practicing ecological sanitation. The toilets have urine separators so that the urine can be used "instant natural fertilizer". Soil and ash are being added to the faecal contents, which will be allowed to dry out and will be used as a soil conditioner. The families are now applying urine as fertiliser to paw-paw trees, beans, peas and maize.

Ecological sanitation is now being tried in schools after long discussions with the parents and the teachers. Mvuramanzi Trust together with the parents has constructed ten ecological sanitation facilities at two schools. The children at these schools are taught about ecological sanitation and are practicing ecological sanitation from an early age. The toilets separate the urine, which is lead to school gardens for tree and crop production. There is a growing interest among the parents and it is hoped that they will see the benefits of the technologies and introduce them into their homes.

The use of human waste for agricultural production is not a new concept; it has been practiced in various forms in many Southern African countries and in Far East Asia many centuries. Experiences from other parts of the world has equipped and given us confidence to encourage communities to participate in ecological sanitation trials.

Methodology

Several Eco-sanitation technologies have so far been designed to address community needs. Trials have been done at different community situations. The following designs have so far been made and tried at community levels.
Arbor-loo's (tree toilets) these basically consists of a concrete slab fitted with handles on top of it is fitted a detachable supper structure. These units are placed on top of 1m pits into which human waste was deposited until the pits were ¾ full of human waste, leaves and ashes which was added by users as they used the facilities. The pit contents were then covered with soil, this forms an organic rich pit referred to as fertility pit into which

young paw-paw tree seedlings were planted. In other pits no human waste was added a control paw-paw tree was planted and the health and growth rates of the different crops were observed.

Urine separators: These were designed like VIP latrine but were fitted with urine diversion devices to allow for separate disposal of urine and faeces. Urine is lead by pipes into plastic collecting chambers where it is stored before use. Before urine was applied to any crop it was diluted at 1: 10 by volume and applied to crops and fruit trees its effect was observed over the life span of the plants. Faecal matter is collected into 1m chambers and left to decompose and accessed latter for further treatment.

Preliminary ethnographic focus group discussions were carried out among communities and environmental health practitioners exposed to ecological sanitation practice to assess their attitudes and beliefs with regard to the use of human waste for fruit and crop production.

Conclusion (preliminary)

The ecological sanitation initiative discussed above is still in its infancy; we planned it to go for three years 1999-2001. We can not therefore come up with detailed conclusions on all aspects being looked at. What we can only talk about now is success with regard to technological developments and lessons learnt while introducing ecological sanitation practice to different communities.
Three main appropriate eco-sanitation technologies were introduced to address specific community needs such as:

Fruit orchard production.
Five (5) fruit orchards have been started mostly by women groups in Mashonaland east, central and midlands provinces and communities have been encouraged to carry out ecological sanitation practice trials with minimum assistance. The arbor-loos were found to be the most appropriate eco-sanitation technology for people engaged in fruit tree production.

Horticultural production
As stated above urine separators were constructed for a number of families engaged in horticulture and the Uriseps were found to be particularly suitable for farmers engaged in horticulture.
We have also established that urine seamed to be more culturally acceptable for use in agricultural production and communities are applying it as fertilser to beans, peas, maize and fruit trees with encouraging results.

It has been demonstrated that human waste especially urine contain valuable organic nutrients readily absorbable by plants causing considerable growth. Differentiated growth and appearances were shown between plants to which organic waste was applied and those without with organically fertilized crops looking much health.. Community attitudes towards the use of human waste as manure and fertilizers for trees and crop tend to be more positive as they are exposed more to ecological sanitation practice.

WATER SUPPLY AND SANITATION OPTIONS FOR THE MANZESE PERI-URBAN COMMUNTY OF DAR ES SALAAM CITY

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Introduction

Manzese, a densely populated peri-urban community, which is about 15 km West of Dar es salaam, is a historical host for rural migrants from upcountry regions. Way back in the 70's the Dar es salaam City Council was supplying Manzese residents with piped water supply. A number of public domestic points were constructed in various locations in the streets of Manzese. An open channel drainage system was also constructed in this area to facilitate liquid waste disposal. Solid waste disposal was taken care of by the City Council's garbage collection system. The systems were efficiently operating in the beginning but, with time, and due to escalating economic constraints, these social services gradually deteriorated to beyond the City Council's manageable limits. This was mainly a consequence of the increasing rate of rural migrants who were "invading" the city suburbs in search of employment and better living conditions. The trend of deterioration of these services sparked community initiatives to look for options to alleviate the situation.

The Abhorrent Situation

The City Council could not cope up with the increasing number of Manzese residents. Hence, water demand surpassed the supply capacity of the system which existed then. The piped water supply network did not effectively serve many of the migrants. They therefore resorted to locally hand-dug wells. Moreover, since there was no regular maintenance of the water supply system, most domestic points broke down. This added to the stress of the water shortage in Manzese. Some relatively richer residents began making private water pipe connections to their houses, leaving the poor migrants in a much more desperate situation because the water pressure to the few remaining domestic points was being reduced by these private connections.

The sanitation situation became even worse as the population of Manzese increased. The City Council's garbage-collection trucks could not penetrate into all the congested squatters of Manzese. Therefore the open channels, which were meant for conveyance of liquid wastes, were now turning to be dumping sites for solid wastes too. Moreover, since the only alternative sanitation options for most residents were pit latrines and septic tanks, there was a seriously potential risk for groundwater pollution, which was affecting a large population of those who were using groundwater sources through locally dug wells. The congestion of houses in Manzese also led to blocking of almost every possible passage for overland flow of water during rains, leading to an apparently waterlogged environment around the houses.

The Problem

The unprecedented population expansion in this peri-urban locality, which led to a congested habitation, a high stress for water demand and an unfavourable sanitation situation has left Manzese residents in a socially and economically disadvantaged situation. They are always victims of water and sanitation-related contagious diseases. Lack of sustainable water supply and liquid/solid waste management systems gives the ugly face Manzese has now.

Community Initiatives

Two years ago, Manzese residents initiated a community-based organisation which was named: **Manzese Environmental Supervisory Committee (MESCO)**. Through established by-laws, this CBO was charged with the responsibility of organising and managing community resources to improve the environmental sanitation situation in Manzese. As a short-term sanitation option, MESCO has initially managed to effect the construction of more than ten concrete solid-waste disposal sites at various points in Manzese. These are emptied regularly by the City Authority's garbage trucks. MESCO has also paired up with a local NGO known as ***Community-based Water, Environment and Sanitation Organisation*** **(COWES)** to initiate a project which will make use of community resources to rehabilitate and improve both the Manzese piped water supply network and the sanitation infrastructure.

The currently proposed short-term option to deal with the problem of water supply is the construction of roof-catchment systems where appropriate. The rehabilitation of the piped water supply system that will be operated on a commercial basis is an option which is planned as a long-term strategy for solving the water problem in Manzese.

As far as sanitation is concerned, the rehabilitation will not only be limited to re-excavation of the old drainage channels, but will also extend the drainage network to some other parts of Manzese, which were not originally covered by the old network. Nevertheless, the congested situation in this locality is anticipated to be a major challenge to the project. This anticipated challenge has called for a fresh search for some other better sanitation options which are appropriate for the situation in Manzese. One of such options which are considered fit for this area is Ecological Sanitation which is said to have registered remarkable success in many developing countries such as El Salvador, Pacific Islands, China etc. However, before this sanitation option is adopted, MESCO and COWES have seen the primary need for providing basic community education to soothe the cultural barriers which might be hindrances for the community members to accept Ecological Sanitation. Hence, one of the initial activities for project execution is Community Training and Mobilization. One of the topics in the course outline of this training component is: Introduction to Ecological Sanitation (Basic concepts and practical approaches). A considerably minimised rate of water-borne and sanitation-related diseases is among the expected outcomes of the MESCO/COWES project.

"IBADAN COMFORT STATIONS"—AN INTEGRATED WATER SUPPLY AND SANITATION EXPERIMENT FOR URBAN SLUMS IN NIGERIA

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Introduction

Nigerian cities lack underground drainage system. Since independence in 1960 several blue prints were prepared and planned but no solution was found till to date. The problem of excreta and gray water disposal in unplanned overcrowded inner core areas of cities like Ibadan has been a difficult task to tackle. While the technology is available, factors such as unplanned nature of housing units, inaccessible roads, culture, socio-economic factors and lack of governmental will to provide a long lasting facility are some of the identified problems. "Ibadan Comfort Stations" project, however, was a well conceived and well-intended governmental project (which was originally conceived in 1969) embarked after the cholera epidemic, which affected 7125 people in 1971 living in the core areas. The epidemic was traced to poor sanitation and ground water pollution. Since then cholera has been endemic in the city and occurs at periodic intervals, practically every year. Unfortunately, cholera cases are not reported for the fear of sanctions by foreign countries and often recorded as "gastro-enteritis" for record purposes. Another epidemic occurred in 1996 affecting 1454 (with 70 deaths) and was reported adequately. Along with cholera, typhoid, diarrhea, dysentery and parasitic infections are common among the inner core dwellers. This paper deals with the status of these "Comfort Stations", the problems faced in utilizing these by the recipient communities and suggestions for future improvements in planning such public utilities.

The "Comfort Stations"

"Ibadan Comfort Stations" project was a joint programme among the State Government, World Health Organization, and the United Nations Development Programme. They originally planned to complete 500 units over a period of 10 years to cover the city's inner core areas distributed in 14 wards. Of these, the government as demonstration units shall provide 25 and the rest were to be built by the communities through "self-help" programmes. Unfortunately, only 17 more were built (totaling 42) by the target period essentially through State Government's participation and none were built by the community participation. However, the government was generous in handing over the units to the agreed communities using certain criteria. The remaining were provided subsequently, which took about ten years.

All the existing 42 Comfort Stations are grouped into categories: Type I (serving 1250 people), II (serving 880), III (serving 400), and IV (serving 250) depending on the population served. They were constructed between 1972 to 1988. Each Unit has aqua privy system for excreta disposal (182.8 cm deep and with toilet seats ranging from 10 to 28 depending on the Type), bath/shower rooms (ranged from 6 to 16), and a wash room for washing clothes. There were water taps, overhead tanks, and electricity supply. They were all functioning at start. Used water was to be recycled for flushing the toilets. Over the years, our Department has been monitoring their performance as a part of ongoing research and documenting the problems and prospects of these stations.

Methodology

The data were collected through -- community survey involving 450 randomly selected households (40 % of the total households) and the questionnaire were administered to senior most male or female inmates (900 respondents in total), activities checklist, and review and update of records and documents. The data reported addressed specifically: the number of viable comfort stations, ownership, the nature and number of actual users, the pattern and rate of use, the demographic and socio-cultural background of the users, knowledge, attitudes and practices, awareness of their responsibilities to and interest on the sanitary facilities at the station, visual observation of stations for sanitary state, and assessment of reasons for failure.

Results and Conclusions

The results brought out the following points of interest:

(i) Only 43 % of the respondents knew the purpose of the stations; about 2.2% did not know about the existence of the stations;

(ii) Reasons for non-utilization was attributed to lack of regular water supply (25%), electricity (5.4%), and inability to meet costs for maintenance(11.0%);

(iii) About 31.6% of the Stations lacked cleanliness, adequate repairs and maintenance; under misuse or disuse; the insanitary state of the units was striking with flies, offensive smell, dry faeces around and ill maintained structures; children at risk;

(iv) Some (19.4%) viewed the units as mere government amenities; 14.7% viewed them as common properties only to be used and nothing more;

(v) The relatively older stations built before 1975 were in a better sanitary condition (28%) as compared to the newer ones built after 1976 (17.6%); this difference was attributed to the health education given to the users in the past which was neglected subsequently;

A few conclusions may be drawn from this study:

(a) The Comfort Stations were planned and built by the government rather in a hurry without sufficiently educating the community; the siting was more of a convenience or due to pressure from influential people in the community rather than appropriate as some of the sites were not accessible for regular cleaning and maintenance;

(b) The communities were not adequately informed about the level of involvement of the government and the users; they were not fully aware about the payments for the water, electricity, and subsequent maintenance; as the structures failed, the communities were only watching in anticipation that the Government one day will come to their aid;

(c) The community members who contributed either land, cash or kind for the building of the station were the only people who were able to appreciate the facility more than others who were merely participating because they were given; the maintenance was totally lacking in all but 4 stations;

(d) Recently, some enlightened community members came together and started maintaining 4 of the Stations to our satisfaction; they engaged a retired man to oversee the station and monitor cleanliness; installed bill boards indicating Do's and Don'ts for the users and strictly enforced the instructions.

(e) In any government initiated community based projects, there is a need for consultation among all the stakeholders from the inception to the commissioning for the community to appreciate and willingly participate; Free facilities are bound to fail;

(f) In recent years, a couple of privately owned public toilet facilities in the city have proved good patronage as the users "pay and use" the facility.

It is suggested that to maintain urban sanitation, particularly the community sanitary facilities, the stakeholders should be involved before embarking on any project. Currently, Ibadan is chosen as one of the Cities under the Sustainable Cities Programme of HABITAT, and efforts are being put in to address the drainage, sanitation, waste management and drinking water supply. The stakeholder participation is yielding expected results and some of the programmes have been very successful.

GROUNDWATER CONTAMINATION BY SEWAGE IN SUB-SAHARAN AFRICA

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Introduction

Many low-income urban communities in both low and high-density population areas of sub-Saharan Africa use untreated groundwater obtained from wells, springs or water vendors. In such environments, where sanitary provisions have been made, domestic sewage disposal is generally through low-cost on-site sanitation. Whilst long-term plans for water supply improvement may exist, in the foreseeable future the use of small groundwater systems is likely to continue.

The predominant aquifer type in much of sub-Saharan Africa is weathered crystalline rock (such as granite). Groundwater is transmitted by fractures in the bedrock and unconsolidated weathered materials in the overlying mantle (regolith). The weathered mantle may be 10s of meters thick and highly variable in geological nature, even on a very local scale. The base of the mantle often consists of a poorly sorted muddy-sand, which is the most productive horizon within the weathered aquifer system, and of regional extent. Recharge to the fractured basement commonly results from leakage at the base of the weathered mantle; the commonly discontinuous nature of the fractures in the bedrock means that it cannot be considered as a regional aquifer. The heterogeneity of weathered basement aquifers makes prediction of contaminant transport highly uncertain.

Documented urban groundwater quality

A significant volume of data has been gathered regarding groundwater quality in sub-Saharan Africa, however, most of this data has been collected in rural areas. The limited volume of published data available for urban groundwater in the region generally relates to the issue of sewage contamination, with data for species such as NO_3, Cl and faecal coliforms presented. This data demonstrates a broad correlation between NO_3 and Cl values, with a generally high ratio of NO_3:Cl indicative of a sewage source. In summary, a regional picture of sewage contamination (both inorganic and microbiological) of urban groundwater is emerging. In the absence of extensive water-borne sewerage systems, this contamination can be attributed to disposal of sewage through on-site sanitation.

Ongoing research in Uganda

Ongoing research in Uganda (Kampala [35 sites] and Iganga [16 sites]) demonstrates widespread contamination of groundwater by sewage. Contamination pathways are controlled by bedrock geology (which controls, to a significant degree, the groundwater flow regime) and population density. Regional groundwater systems in areas of low relief (Iganga), where the regolith is thick and depth to water table relatively high, are contaminated by nitrate, but show little evidence of microbiological contamination. Localised flow systems in areas of pronounced topography (Kampala), where the regolith is thin and water tables are shallow, show microbiological contamination, but are only impacted by nitrates in areas of higher population density. Sanitary inspections and land-use surveys demonstrate that microbial contamination of localised flow systems in Kampala results largely from poor sanitary protection of spring sources, with additional base loading from pit-latrines. The correlation of Cl NO_3 (with high NO_3:Cl in the dry season; Figure 1) indicates a sewage source, likely pit-latrines, in the regional Iganga aquifer. The dry season ratio indicates a 25% leaching of nitrogen. The absence of faecal coliforms in Iganga samples is explained by the attenuation and survival characteristics of such species. Sampling during 1998 was carried out during both dry and wet (recharge) seasons at all field sites. Seasonal variation in groundwater quality is clear (examples in Figures 2 and 3).

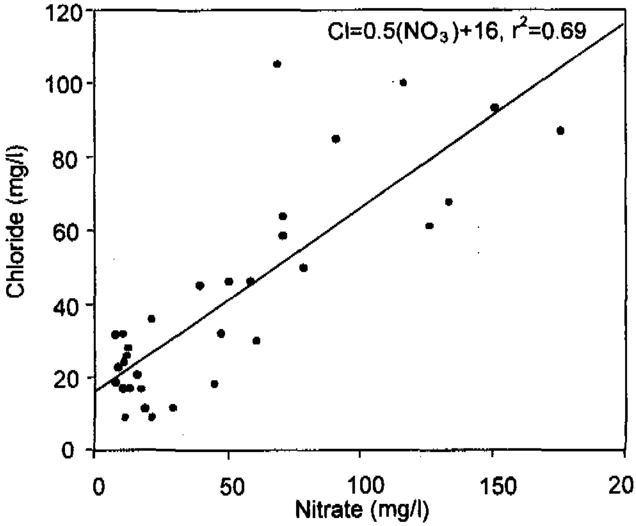

Figure 1. Nitrate and chloride data from Iganga (dry season)

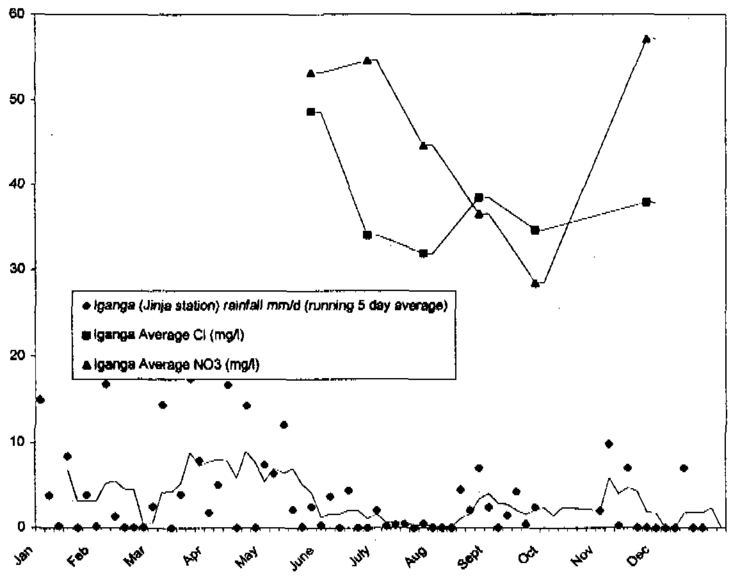

Figure 2. Variations in NO_3 and Cl with rainfall (Iganga)

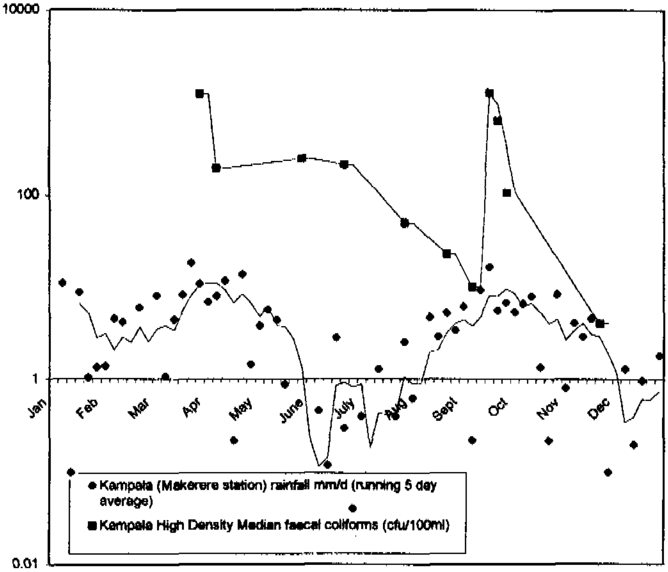

Figure 3. Variations in faecal coliforms with rainfall (Kampala)

Clear increases in faecal coliform populations are observed both in high and low-density population areas of Kampala with the onset of the rains and are believed to result from a rapid response to direct infiltration of faecally contaminated infiltrating waters. Chloride levels increase at approximately the same time as faecal coliform counts in Kampala. There is also a more damped Cl peak in Iganga, which is considered to result from the regional nature of the aquifer (reflecting fluctuations in base flow groundwater quality). Base flow quality will be a function of multiple diffuse recharge sources, all of which must pass through a relatively thick unsaturated zone in Iganga. In Kampala, where protection of springs is poor, flow paths from the point of recharge to the spring may be as little as a few metres. An interesting feature that becomes apparent through the temporal data analysis is the changes in nitrate. Overall, nitrate levels show a more 'damped' distribution (rather like the Cl levels in Iganga). As Cl and faecal coliforms peak, nitrate levels dip, but then show an increasing trend as coliforms and Cl levels drop. The only area where this is less pronounced is the low-density part of Kampala (the area least subject to pit-latrine loading to base flow, and therefore likely obtaining nitrate loading from localised sources).

It is thought that the Cl peaks may result in part from washing through of evaporitic deposits in the soil formed during the dry season in addition to sewage. The initial reduction in nitrate levels seen in the Kampala high-density population area and in Iganga (both subject to significant nitrate loading from pit-latrines) during the onset of the rains may be a result of dilution of groundwater with recharge containing little nitrate (but high organic nitrogen due to the presence of sewage) -i.e. a rate-limitation effect (process and transport controlled). This dilution is not pronounced in Kampala's low-density population areas due to the pre-existing low-nitrate levels. Rising nitrate levels after the initial rains may be caused by subsequent mineralisation/nitrification of organic sewage contaminants washed down to the groundwater during the initial rains. One unknown factor is the extent to which actual pathogens are present in Uganda's sewage contaminated groundwater, the transport and survival characteristics in groundwater of viruses, for example, being uncertain. A first attempt to resolve this issue within the current project has been carried out employing bacteriophage tracer experiments (at Iganga). The results demonstrate significant attenuation of bacteriophage within the weathered mantle, and also highlight the complexity of the hydraulic system (even on a small scale), with evidence of multiple flow paths.

Workshop 9

Posters

THE SUCCESSFUL PILOT ECOLOGICAL SANITATION PROGRAM IN DALU VILLAGE, TIANYANG COUNTY, GUANGXI ZHUANG AUTONOMOUS REGION, CHINA

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Introduction

Dalu Village in Tianyang County is the pilot project for the Sida funded Ecological Sanitation Program, cooperated with Unicef and the China National Patriotic Health Campaign Committee Office/National Ministry of Public Health (NPHCCO). This village is in a mountainous area in south of Guangxi Zhuang Autonomous Region (Guangxi), China. There are about 532 villagers, 128 households in this village. 98% of them are Zhuang minority ethnic groups. Each villager only has o.5 mu (330 square meter) of dry cultivated land. The main crop is corn and the cash crops are sugar and bamboo. In 1997, the average annual income for per person was 2138 yuan (USD 258 equivalent). 2/3 of the houses in this village was cement and brick structure and the other 1/3 are still grass and wooden cottages. This village suffers 3 to 5 months water shortage every year. During dry season, the villagers have to travel to a small town 6 km away to get their water. The natural condition is extremely harsh. The sanitation condition was also very bad before this project. Most of the households had no toilets (in the village there were only a few one-pit toilets). People in this village were living under the same roof with their livestock, i.e. the livestock enclosure is on the first floor and people lived on the above floor. Their houses were usually dirty and stink. The wet and dirty livestock enclosure has provided the fly and mosquito with an ideal breeding place.

Project Objective and Implementation

According to the Memorandum signed by Sida, Unicef and NPHCCO, 63 latrines will be built under this project in Dalu Village, and simultaneously health education, training of technical personnel and microbiological testing will also be carried out in the project area. When implementing the project, in addition to achieve the fulfillment of construction of 70 household latrines, we also built some rainwater collection systems and a public latrine with a solar heating and an oven to burn domestic waste, required by the actual conditions of the village. The implementation of this project has been combined with the old houses upgrading plan from the beginning, a total of 130 household latrines are anticipated to be completed by the year of 2000.

Result and Discussion

Construction of latrines and rain-water collection systems In order to reduce the cost and for the convenience of users, the new latrines were built inside of the houses that have been put into use. One wall of the houses could be used for the latrine. The types of latrine are one chamber, one chamber with a sloping trench, one chamber with two sloping trenches, and double chamber latrines. Normally, the chamber has about 1-2 cubic meter's capacity, and the feces retention time can reach up to one year. Some household also built rainwater collection systems on the roof of their houses and the capacity of these collection systems is around 3-6 cubic meters. It was the most serious year in 1998 that Dalu Village suffered from drought since the last 50 years and the rainwater collection systems had played a significant role in helping the local villagers with water supply.

In order to improve the sanitation situation in Dalu, we especially designed and built a pubic latrine with a solar heating processing chamber and an oven to burn domestic waste. After six months' observation, although being intensively used and there isn't a special caretaker, this latrine is still functioning well and remains odor and fly free.

Health Education A team of 13 persons was trained on how to build the latrines at the beginning and they are playing an active role in this project not just as the latrine constructors but as the project facilitators as well. Some persons are specially assigned to in charge of health education at county, township and village levels. The primary school in the village opened a health education class to teach hygiene and sanitation related knowledge. Through the students, the knowledge of which they have learned in school will be passed to their parents and other family members. In order to arouse public awareness, we organized a competition on health and hygienic knowledge for the villagers and a competition on writing articles subject to health education activities for the school students. An evaluation conducted recently shows that the percentage rate of people who know the health and hygiene related knowledge increased from 36.25% to 92.61%, and the percentage rate of people who practice a hygienic habit increased from 37.20% to 81.97%.

Microbiological Test and Evaluation The result of a questionnaire survey shows that 100% of the households are satisfied with the latrines and over 80% of the users know to add some ash and not to throw the used paper into the chamber after excreting. The result also reflects that most of the latrines are being properly maintained and have no odor and fly. The indoor and outdoor fly density has greatly dropped estimated by range. The species of fly has also changed. Previously, over 60% are chrysomyin megacephala, and now this figure has dropped down less than 10%. At present time, the major species is musca domestic vicina, which accounts 90% of the total.

The microbiological test on sanitized feces is being carried on, a final report will be produced when the test finish in October this year. The primary result we have now shows the colon bacillus has met the criteria of harmless, and the die-off rate of parasite eggs is 60%. Among the three factor (temperature, moisture and pH value), the temperature is less important than moisture and pH value in killing the eggs when it is under 30°C, and if the retention time is long enough.

Sampled from the rain-water collection system has been tested, the result shows that if the systems are under properly maintenance, the water can meet the criteria of national standard for drinking water and it's quality is much better than the water fetched from the wells in the village.

Conclusion and Vision

Through one year's observation, we found that all of different types of the new latrines that were built under the project largely satisfy the need of the villagers. The introduction of this project has also brought great changes to the health consciousness, environmental and sanitation conditions in Dalu Village. The construction of rainwater collection system helps to ease the water shortage during the dry season.

The observation we have conducted to the different types of latrines prove that double chamber latrine and single chamber latrine with a sloping trench are the most effective types, and double chamber latrine with a sloping trench is less effective. The single chamber latrine is also accepted if the capacity of the chamber is big enough to allow the feces to remain inside for at least for six months (not mixed with the fresh feces), and being properly used.

From the microbiological testing that we made to the samples, the feces has achieved the criteria of harmless standard, but the die-off result of parasite eggs remain a question and require a longer period to observe.

In Guangxi, there are still about 20 million rural inhabitants have no access to latrine so far at the present, and many small towns have no sewage treatment system, some face a serious water shortage. These have deteriorated the environmental condition and quality of people's living condition. Based on the above reasons and the experience we had from Dalu Village, we plan to popularize the concept of ecological sanitation to the rest of the province, not just in the rural areas, but to the urban areas as well. We are now trying to get financial aid through various sources to fulfill our target of building 1000 latrines by year of 1999. Our more ambitious objective is to build 1 million units of ecological latrines within the next five years. When that day comes, we believe the advantages of the ecological sanitation will be fully unfolded to world, from preserving our environment to protect our water resource.