ENVIRONMENTAL MANAGEMENT FOR DEVELOPING COUNTRIES

ENVITEK A.Ş.

PREPRINTS

II

A Contribution of ENVİTEK A.S. to the "International Drinking Water Supply and Sanitation Decade"

Milliyet Yayın A.Ş.

Ayazaga Ofset Tesisleri'nde hazırlanmış ve basılmıştır.

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II

ENVIRONMENTAL TECHNOLOGY
RESEARCH AND DEVELOPMENT CENTER
ISTANBUL, TURKEY

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PROPER MANAGEMENT OF HAZARDOUS WASTE--A TIMELY CONSIDERATION FOR INDUSTRIALIZING NATIONS

Lyse Duhamel-Helsing and Thomas T. Shen

Columbia University
60 Haven Avenue
New York, NY 10032

This paper examines problems associated with improper management of hazardous wastes and suggests approaches to help promote adequate management of these wastes in industrializing countries. Environmental, health, and economic costs related to contaminated hazardous waste sites in the U.S. are illustrated, as are some of the related environmental and health problems already apparent in many industrializing countries. Cost/benefit methods are discussed and the need pointed out for models based on a broader concept of 'cost' for use in environmental pollution assessment, especially in developing countries. An integrated approach to hazardous waste management, combining administrative policy, regulations, and appropriate technologies also is presented as an illustration of existing and tested solutions that can help minimize or reverse environmental deterioration due to hazardous waste pollution.

Responsible hazardous management undertaken concurrently with development of industry and commerce is of crucial importance in industrializing nations. The challenge of choosing appropriate management and disposal approaches within the context of regional conditions and economic needs is enormous. Many decisions related to environmental, health, and economic costs and benefits of controlling pollution from hazardous waste and other sources must be made in the face of significant scientific and economic uncertainties.

Most developed countries with a long history of industrialization have a heritage of contaminated sites where hazardous wastes have been improperly disposed of for several decades. The full economic, environmental, and health impact of past practices is not fully known. In response to hazardous waste pollution problems, environmental policies have been adopted in many developed countries in the last 10-15 years:

environmental statutes have been put in place; regulations have been promulgated; and treatment and disposal technologies have been standardized, refined, and new ones developed. As a consequence, there is at present considerable knowledge and experience of the short-term and some of the long-term economic, health, and environmental costs from inadequate management of hazardous wastes in these countries.

For most developing countries, however, the seriousness and potential impact of the problem are unknown. Many developing countries have more recent and less expanded industrial sectors and present different histories and patterns of industrialization. Certain developing countries, such as India and Egypt, have experienced some three decades of industrialization. Others, such as Brazil, Mexico, Venezuela, Spain, Greece, Ireland, Hong Kong, Singapore, Taiwan, and South Korea, have shorter histories of industrialization, but very rapid development when compared to the more classical pattern of gradual industrialization of the developed countries. Frequently, rapid development has been concentrated and concurrent with rapid urbanization, creating social and environmental pollution problems of different kinds and magnitude.[1]

Most developing countries have only recently become aware of the environmental, health, and direct and indirect costs that result from improper management of hazardous industrial waste. Important lessons can still be learned by industrializing nations to correct or still avoid similar harm to public health and the environment as chemicals and allied products, petroleum, ferrous and non-ferrous, textiles, and other industries are developed and expanded. Additionally, developing countries can benefit from the experience and from the different administrative policies, hazardous waste regulations, and various technologies adopted and tested in developed countries when selecting approaches most suitable to national and/or regional hazardous waste management problems within the context of specific economic conditions.

HAZARDOUS WASTE GENERATION

There is currently no internationally accepted definition of hazardous waste; legal definitions in use are generally based on technical criteria addressing short-term acute hazards and long-term environmental hazards, i.e. criteria such as toxicity, flammability, corrosivity, ignitability, and reactivity. Although radioactive and pathological wastes may present hazards to health and the environment, they customarily have been excluded from definitions of hazardous waste.

Worldwide, various industries generate enormous amounts of industrial waste each year. Table 1 lists frequently encountered substances which based on their toxicity and hazard characteristics, must be given attentive treatment and/or disposal consideration.

Table 1. List of toxic or dangerous substances and materials selected as requiring priority consideration

1. Arsenic and compounds
2. Mercury and compounds
3. Cadmium and compounds
4. Thallium and compounds
5. Beryllium and compounds
6. Chromium (VI) compounds
7. *Lead and compounds*
8. Antimony and compounds
9. Phenolic compounds
10. Cyanide compounds
11. Isocyanates
12. Organohalogenated compounds, excluding inert polymeric materials *and other substances referred to in this list or covered by other directives* concerning the disposal of toxic or dangerous waste
13. Chlorinated solvents
14. Organic solvents
15. Biocides and phytopharmaceutical substances
16. Tarry materials from refining and tar residues from distilling
17. Pharmaceutical compounds
18. Peroxides, chlorates, perchlorates and azides
19. Ethers
20. Chemical laboratory materials, not identifiable and/or new, with unknown effects on the environment
21. Asbestos
22. Selenium and compounds
23. Tellurium and compounds
24. Polycyclic aromatic hydrocarbons (carcinogenic)
25. Metal carbonyls
26. Soluble copper compounds
27. Acids and/or basic substances used in the surface treatment and finishing of metals

Source: World Health Organization, *Management of Hazardous Waste*, European Series, No. 14: 14 (1983)

Hazardous Wastes from the Chemicals and Allied Products Industries

Approximately 20,000-30,000 chemicals are currently manufactured worldwide in quantities exceeding one ton per year.[2] A few examples of manufacturing processes will illustrate the large volume and variety of hazardous wastes that result.

Primary organic chemicals are produced from oil, natural gas, and coal in large-scale continuous-process plants. They are in turn converted into secondary or intermediate materials either for in-house processing, sale to chemical processors, or for various industrial applications. Intermediate materials are processed into a wide variety of final products, e.g. fine chemicals, pharmaceuticals, pesticides, plastics, resins, dyestuffs, synthetic detergents, synthetic fibers, elastomers, and many others. The production processes are based on specified feedstock and standard plant conditions, thus generating residues of fairly constant composition and properties. Residues also may be extremely complex materials, however, with the detailed composition not always known. Residues may be liquids, sludges, or solid tarry wastes.

Processing of organic chemicals into end-products involves both batch and continuous processes. In batch processing, residues often are complex mixtures which may contain unreacted feedstock, filter-cakes, precipitated materials, tars, solvents, acids, or alkalies used in the washing process, as well as off-specification products, spent catalysts, contaminated filter aids, and contaminated containers. Residues may be liquids, sludges, and solids of varying physical or chemical complexity. The substances present may be soluble or insoluble, inert, corrosive, flammable, chemically reactive, or toxic, and may contain human carcinogens.[3]

Inorganic chemical products, including sulfuric, phosphoric and nitric acids, chlorine, sodium hydroxide, lime, ammonia, and many others, account for 9 out of 10 major products of the chemical industry worldwide.[4] Manufacture of many of these inorganic products generate large volumes of hazardous waste. For example, more than 100 million tons of phosphate rock are mined worldwide annually for production of phosphorus, phosphoric acid, and phosphates. Up to 13 tons of by-products result from each ton of phosphorus produced; these include calcium silicate slag, which may be used as a concrete aggregate or hard core; ferrophosphorus, which may be used as an additive to steel; phosphorus mud, which may be recycled; precipitator dust; and condenser gas. Environmentally, the most serious problem is posed by the so-called "phossy water" which is produced from condensing the furnace gases with water sprays. This water contains dissolved and suspended elemental phosphorus, phosphorus oxyacids, hexafluosilicic acid, ammonia and silica. Treatment of the "phossy water" usually is through settlement, neutralization with lime or ammonia, resettlement, and final treatment with chlorine to destroy residual phosphorus.[5,6]

Fluorine chemicals production has greatly increased in the last 40-50 years. For example, anhydrous hydrofluoric acid world production was estimated to be about one million tons in 1975.[7] For each ton of anhydrous hydrofluoric acid produced, an estimated three tons of calcium sulfate by-product and a solution of about 30% fluorosilicic acid are formed.

Table 2. The use of organic solvents in various industries

Use	Organic solvent
Formulation of adhesives	Ketones, aliphatic and aromatic hydrocarbons
Formulation of cleaning materials and polishes	Aliphatic hydrocarbons
Formulation of pesticides	Aliphatic hydrocarbons
Degreasing of fatty skins in tanning	Aliphatic hydrocarbons
Extractive industries, e.g. essential oils	Alcohols and aliphatic hydrocarbons
Manufacture of food flavourings, essences and toiletries	Glycols, alcohols and glycol esters
Photographic industry	Alcohols, ketones and glycol esters
Reaction media in the pharmaceutical industry	Hydrocarbons, alcohols, esters, halogenated solvents and others

Source: World Health Organization, *Management of Hazardous Waste*, European Series, No. 14:21 (1983)

Halogenated and non-halogenated organic solvents are used in many industries with a large volume of dirty solvents discarded as waste. Table 2 lists several uses of organic solvents by different industries. The engineering industries, for example, uses various organic solvents to degrease metal components either by cold or hot dipping in a solvent bath, or by contact with solvent vapor. A sump residue is formed containing cutting oils, lubricants, fine metal particles and general dirt. The residue either is left to build up until the dirty solvent must be removed for disposal or recovery, or it may be continuously removed and recycled through an on-line purification plant. An oily sludge waste is left for disposal which contains solvent of varying concentrations depending on whether solvent recovery units are used or not.

Organic hydrocarbon solvents sometimes also are used for degreasing, cleaning, and general maintenance of transport fleets. The spent hydrocarbon solvent usually contains high concentrations of oil, grease, dirt, and frequently phenolic compounds used as industrial degreasants.

The dry-cleaning industry also uses a solvent, mixed with a small quantity of detergent and water. In large factory-type installations, the solvent is continuously filtered and redistilled. In small operations, filtration without distillation is common in the plant with dirty solvent replaced and recovered by distillation off-site. The residue usually contains soluble fats, oils, filter powder, dirt, and solvent in concentrations reaching up to 60%. The residue for disposal may be a dry, crumbly solid, or an oily liquid.

A wide range of organic solvents also are used in the manufacture of paints that are not water-based in order to give products the needed viscosity. Solvent may be hydrocarbons, alcohols, ketones, glycols, glycol ethers, or glycol ether esters and is added to paint mixture composed of organic and/or inorganic pigments, resins, and various additives. Reject batches of paints with dirty solvents are discarded as wastes. Wash-down solvents generally are reused and then either recovered or disposed. Solvent wash-down wastes contain various concentrations of heavy metals used in paints as pigments, fungicides, flame retardants or anti-corrosion additives. Toxic heavy metals in paint may include antimony, barium, cadmium, chromium, copper, lead, manganese, mercury, tin, and zinc.[8,9]

PROBLEMS ASSOCIATED WITH IMPROPER MANAGEMENT OF HAZARDOUS WASTES

Developed Countries

For many years hazardous substances and wastes were virtually unregulated and uncontrolled in many developed countries. In the U.S., for example, the impact of releases of hazardous substances into the air, land, or surface and ground water was not realized until the mid-late 1970s, and the full environmental, health, and economic impact of past practices is not yet known. To help remedy environmental and health problems associated with inactive contaminated hazardous waste disposal sites, and to provide an emergency response for hazardous substances released into the environment, the U.S. Congress in 1980 passed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly referred to as the "Superfund Act." CERCLA establishes a Hazardous Substance Response Trust Fund to finance cleanup activities which is expected to reach about $1.6 billion by December 1985. As of April 1984, 546 sites had been placed on a U.S. Environmental Protection Agency (EPA) National Priority List (NPL) for remedial action under Superfund. EPA estimates this list may eventually reach 2,200 sites. CERCLA's National Contingency Plan (NCP) prescribes steps which the government will take in response to accidental release of oil and hazardous substances.

Environmental and health impact of abandoned sites. As of early 1984, approximately 881 sites had been evaluated and scored using a "Hazard Ranking System" (HRS) designed by EPA to determine priority remedial and removal actions. According to these data, 15%, or 133 sites, may have had an adverse impact on the air, potentially exposing an estimated 1.2 million people *within a 4 mile radius*; 51%, or 450 sites, may have adversely affected surface water, with an estimated 6.5 million people potentially exposed; and 60%, or 526 sites, may have an adverse effect on the ground water, potentially exposing an estimated 8.2 million people.[10]

Analyses of hazardous substances at the 881 sites identified 444 toxic pollutants. Virtually all of the most commonly encountered pollutants are known to exhibit chronic toxicity, and therefore may lead to health injuries after months or years of extremely low levels of exposure.[11] The most likely pathway for such low-level exposure is contaminated drinking water.

The abandoned sites typically contained myriad substances in varying concentrations. The precise health effects from exposure to many of the individual substances are only partially known, and those from exposure to combinations of substances are almost unknown. In fact, very few data are currently available on either the short- or the long-term health and environmental effects of exposure to actual hazardous wastes. The scientific data that do exist, though useful, are based on extrapolations from animal to human health effects, from high to low concentration of hazardous constituents, and from exposure to pure chemicals to exposure to complex mixtures.

Nevertheless, there is little doubt that health damage to people who are exposed to toxic chemicals over long periods of time is a serious problem which may become even more dramatic in the next twenty years. The recently released Woburn Health Study by Harvard School of Public Health,[12] directly links the incidence of neighborhood childhood leukemia and reproductive and childhood disorders to contaminated wells in Woburn, Massachusetts, the source of local drinking water. The wells, ranked as one of the nation's ten most hazardous waste sites, are known to be contaminated by hazardous substances, e.g. chlorinated organic compounds, including trichloroethylene, a known carcinogen.

Economic impact. As of April 1984, EPA had approved 310 removal actions under Superfund authorities, 217 of which had been completed at a total cost of $61.5 million. EPA also has allocated $170.9 million for long-term remedial work at 178 NPL sites, with remedial work completed at six sites. If the current level of operation continues, EPA predicts the Superfund will be exhausted early in 1986. Federal cleanup at all 1400-2200 NPL sites will cost between $8.4 and $16 billion (83 constant dollars) and will take well into the 1990s to complete.[13]

Developing Countries

Environemntal and health problems related to indiscriminate disposal of hazardous waste on land and into bodies of water already are apparent in many developing countries. The full impact of these practices is unknown. A growing awareness of the short- and long-term health and environmental effects as well as economic costs from industrial pollution on local fishing, farming, cattle, and other industries, has led many governments to institute measures to improve pollution control especially water pollution. Design and control standards for treatment and/or disposal of hazardous wastes, however, generally have not been addressed, and existing air and water pollution control standards frequently are not enforced.[14]

For example, following three decades of industrialization India has a fairly well-developed industrial sector that includes production of pesticides, dyes and pigments, pharmaceuticals, organic chemicals, fertilizers, non-ferrous metals such as copper, lead, and zinc, and other industrial products. Large scale production of these and other chemicals has resulted in substantial discharges of hazardous wastes on land and into surface waters; toxic compounds are increasingly detected in water supplies. Fish kills in estuaries, rivers, and other water bodies contaminated with arsenic, heavy metals, and acids frequently have been reported as have many cattle deaths. [15]

The government of India enacted Water and Air Pollution Control Acts in 1974 and 1981 respectively to regulate conventional pollutants. These acts do not contain provisions for controlling treatment and disposal of hazardous wastes. Most industries to date have discharged these wastes into wastewater drains.[16]

The use of pesticides is on the increase in India's agricultural sector. Pesticide consumption in 1982 and 1983 reached close to 14,000 tons/year each for DDT, malathion, and parathion; 5,000 tons for carbaryl; and 40,000 tons for BHC (hexachlorocyclohexane). The pesticide industry generally collects all toxic wastes in containers, which are stored for later disposal into specially constructed pits within factory premises. No information is available on the final method of disposal. [17]

Pesticides and related wastes if mishandled, can cause serious environmental and health problems. For instance, organochlorine insecticides such as DDT, BHC, lindane, and others are very persistent in the environment and tend to accumulate in biologic and nonbiologic media. Although considered less acutely toxic than organophosphate and carbamate pesticides, they have a greater potential for chronic toxicity, and also can be classed as neuropoison. DDT and metabolites accumulate in natural food chains through a process of biologic concentration in ecosystems. Studies have shown that various species of wild birds are adversely affected by exposure to DDT or its metabolites, and that fish and some lower aquatic organisms are extremely sensitive to the acute toxicity of DDT.[18]

Organophosphorus insecticides, on the other hand, most frequently have been the offensive agents in human poisoning from insecticides. Parathion, for instance is the pesticide most frequently involved in fatal poisoning.[19] Carbamate insecticides, contrary to the organophosphorus insecticides, have low dermal toxicities even though aldicarb (Temik) has extreme toxicity by both the oral and dermal route. One of the least acutely toxic carbamate insecticides, carbaryl, has reportedly produced teratogenic effects in experimental animals.[20]

Egypt also has been industrializing for approximately three decades, shifting in the early 1950s from a traditional agrarian base to heavy industry, including production of steel and machinery and manufacture of organic and inorganic chemicals. This new industrial development is concentrated in the metropolitan areas of Cairo, the Delta, and Alexandria. Degradation of water resources due to the industrial pollution that resulted has become evident in the decreased fish catch from the Nile, from lakes and from the Mediterranean and Red Sea; in deterioration of valuable recreational areas; in severe operational problems in sewage networks and treatment stations; and in serious effects on public health. [21]

There is no central agency responsible for the management of wastes in Egypt. Liquid and solid emissions from industrial sources are presumed to be handled on-site and pre-treatment systems before discharge to public systems. Intensive industrialization in the Alexandria metropolitan area where 1243 industrial plants and production units are located, has resulted in an 80% decline in fish production in Lake Mayrut in the last decade. Organochlorine pesticides detected in Lake Mayrut include DDE and DDT. Accumulations in the lake fish Tilapia have been measured in concentrations far higher than those in the lake water. [22,23]

Early results of a study assessing the effect of mercury on fish in the discharge zone of a caustic plant in Alexandria indicate considerable accumulation of mercury in aquatic organisms. This plant is currently implementing a major project to recover the mercury and limit its discharge into the sea.[24]

Various episodes of environmental contamination from organic forms of mercury, principally methyl mercury amply illustrate the devastating environmental and health effects from exposure to this compound. Perhaps the most widely known episode of mercury poisoning occured in Minamata Bay, Japan, from 1953 to the early 1960s, followed by a similar episode in Niigata, Japan. In both cases, consumption of fish contaminated with mercury from industrial waste resulted in 1200 reported cases of poisoning. Methylation of mercury occured from the action of aquatic organisms, leading to transfer and bioconcentration up the food chain to the large carnivorous fish. [25]

The potential adverse effect of industrial hazardous waste is also already apparent in other developing countries which began rapid industrialization more recently. For example, in Thailand, Taiwan, and South Korea, high concentrations of toxic metals, especially mercury, have been measured in waterways and in tissues of fish, animals and humans.[26] In the greater Sao Paulo area, 40,000 industries each daily discharge an estimated total of 36 tons of chemical pollutants into the city's rivers.[27] Some 14 tons of hazardous waste also are dumped daily into Rio de Janeiro's Guanabara Bay; satellite reconnaissance photos show pollution plumes extending some 90 miles long, 12 miles wide, and 15 feet deep which are carried out to sea from the bay.[28] The impact of these practices on the environment and people's health undoubtedly is far more serious than is presently known or expected.

COST/BENEFIT ASSESSMENT

Assessing the short-term and especially the long-term costs and benefits of pollution control technology for reduction, treatment, and/or disposal of hazardous waste is extremely difficult. At present, there are no theoritical models that can be readily used to weigh the short- and long-term costs of using such technology in industrial projects against short- and long-term benefits the technology may bring to the environment and people's health.

Existing models for evaluating development projects are not useful in this instance. One approach, based on a "discounting back to the present" concept, allows comparison of income and expenditures during each year of a project's lifetime to determine profits it would yield. All investment becomes an exchange between future income and present or forthcoming expenditure.[29] Another approach, based on the "Cost-Effective Evaluation of Energy- and Resource-Saving Technologies" method, considers a technology efficient if it makes a minimal demand on natural systems, i.e. on all physical resources in the natural environment. Efficiency is expressed in terms of cost-effectiveness where the concept of 'cost' may be construed in a broad sense because some environmental services are not associated with cash flow and hence appear to have no price.[30]

Neither of these nor similar models are suited to assessing the costs versus the benefits of pollution reduction since the impact of pollution on the environment and people's health must necessarily be expressed in terms of judgmentally assigned weighs based on factors that include several unknowns.

INTEGRATED APPROACH FOR HAZARDOUS WASTE MANAGEMENT

An integrated approach combining administrative policy, hazardous waste legislation and regulations, and appropriate technologies offers a means of helping minimize or reverse deterioration due to hazardous waste pollution.

Government Policy

National solutions to the problems of hazardous waste management vary according to each country's legal and legislative systems and its cultural background. They also reflect the level of industrialization, economic system, population density, and geological, climatological, and other conditions. However, regardless of national differences, any comprehensive approach to management of hazardous waste first must have at its center a national policy that promotes proper transport, storage, treatment and/or disposal of these wastes and include a workable enforcement mechanism.

Legislation and Regulations

Hazardous waste legislation can take many forms, depending on the legal system and other factors in the country concerned. Legislation may focus on environmental quality standards, environmental discharge standards, technical design and operating standards, economic incentives and disincentives, or any combination of these.

The first essential of legislation should be to define hazardous waste, thereby establishing the scope and framework of the law, which ideally also should harmonize with or incorporate legislation on hazardous substances. This approach has the advantage of regulating the entire life cycle of chemicals, i.e. production and use of chemical substances, avoidance of waste generation, and transport, treatment and/or disposal of hazardous waste.

An essential requirement for implementing an effective system of hazardous waste management is establishment of a legal mechanism for controlling waste-generating processes, as well as licensing procedures for all activities related to hazardous waste management, including transport, storage, treatment, and/or disposal. The control mechanism should be a "cradle to grave" system of notification to establish a link between different activities. As a means of tracking all movements of waste, many countries also use a manifest system or a "trip-ticket." This document accompanies the waste from point of generation, through places of collection and transfer, to the ultimate treatment and/or disposal point.

Economic incentives and disincentives are used by many European countries to foster use of low- and non-waste technology, and recovery and recycling of waste.[31] In the U.S., economic disincentives take the form of a fee system on waste effluents and emissions, based on "not to be exceeded" limits imposed by various laws. Economic discentives can be viewed as 'permanent incentives' to induce efficient resource use in industrial production or to reduce generation of by-products and wastes. Most importantly, any hazardous waste management system will be effective only in the context of an enforcement mechanism that is rigorously applied at all stages of the process.

Hazardous Waste Management Technology

Treatment and disposal technologies are currently available for nearly every known hazardous waste. No single technology, however, is a panacea for handling all waste types. The choice of the best practicable approach for treatment and/or disposal of a given waste depends on many factors, usually including cost, waste type and volume, availability and suitability of treatment or disposal facilities, and safety standards.

Table 3. Hazardous Waste Management

I. MINIMIZING INPLANT WASTE PRODUCTION
  A. Process Modification
  B. Recycle and Reuse

II. CONVERTING HAZARDOUS WASTE TO LESS- OR NON-HAZARDOUS MATERIAL
  A. Land Treatment
  B. Incineration
  C. Thermal Treatment
  D. Chemical, Physical, and Biological Treatment
  E. Ocean and Atmospheric Assimilation

III. MAKING USE OF PERPETUAL STORAGE
  A. Landfill
  B. Underground Injection
  C. Waste Piles
  D. Surface Impoundment
  E. Salt Formations
  F. Arid Region Unsaturated Zone

Adapted from: National Research Council, Management of Hazardous Wastes: Research and Development Needs, National Academy Press, p. 4 (1983)

As illustrated in Table 3, three general technological options have to varying degrees been incorporated into hazardous waste mangement approaches of most countries. The first option is preferable in terms of economic return as well as short- and long-term protection of the environment and public health. It involves reduction or elimination of waste material through process modification or recovery and reuse of waste material. Waste reduction alternatives include: (1) source segregation or separation, (2) process modification, (3) end-product substitution, and (4) material recovery and recycling. Often, these processes may be used simultaneously or sequentially. End-product substitution offers a long-term solution, but also requires major investments. The other three alternatives may be more easily implemented, but offer only short- and medium-term solutions.

Waste hazard and/or volume are reduced, but some waste still must be managed.

The second technology option involves conversion of hazardous waste to a less-hazardous or non-hazardous material through a variety of chemical and physical techniques, biological treatment processes, the assimilative capacity of the land or the ocean, and thermal methods using heat or open flame. Incineration, for instance, finds a widespread use in a large variety of installation including boilers, kilns, furnaces, rotary hearths, and vertical shaft incinerators. For many organic materials such as PCBs, chlorinated hydrocarbons, pesticides, distillation residues, oil waste, and off-specification chemicals, incineration offers the most complete means of waste management currently available. However, emissions controls usually are required to prevent air pollution; inorganic compounds present in waste produce slag and ash that must be disposed of; and toxic volatile materials must occasionally be collected.

The third technological option involves 'perpetual' storage, at present the most prevalent waste management technique in most countries. Landfilling of waste is emphasized in this paper since this is an important form of disposal in many countries. The objective of secure landfills is to isolate waste physically from the surrounding environment. The landfill is designed to provide long-term containment of wastes and to prevent escape of both leachate and gas from the site. The economics are perceived as favorable compared to other alternatives. Properly designed and operated facilities reduce the mobility of waste to groundwater, minimize the release of wastes to the air, and allow reclamation of valuable materials when technology becomes available. It should be emphasized, however, that the design, operation, and monitoring of contemporary secure landfills is essentially a new technology, less than a decade old, and that much is still unknown about long-term landfill behavior. Further examination is needed not only of groundwater protection, but also from air emissions from the site.[32] The risk of causing health and environmental problems may be higher with landfills than with other options. Additionally, long-term management of secure landfills is required. For the immediate future, secure landfilling represents a necessary technology for disposal of hazardous industrial wastes. In the long-term, however, this method may not remain the preferred alternative for perpetual storage. In the future, it may be considered only for non-reducible inorganic residues.

Economic Considerations

Ideally, all possibilities for reduction, recovery or reuse of the waste should first be exhausted before opting for treatment or ultimate disposal. However, this is not the case in most countries today. Since economics almost inevitably underlie decision-making in selecting hazardous waste management options, it is essential to compare not onl short-term but also long-term costs of different options. Specifically, cost comparisons of different technologies must be made on an environmentally equivalent basis. For example, comparing land treatment systems or various detoxification processes to secure landfilling involves comparing only current costs, ignoring the long-term costs which for landfills may involve societal care for as long as 500 years until hazardous characteristics have permanently disappeared.[33] Such an approach also does not lend itself to comparing waste reduction options to various treatment or perpetual storage options. In fact, the three basic options--waste reduction, waste detoxification, and perpetual storage--cannot be compared in terms of short- and long-term costs, since they are not comparable in environmental equivalency. Further, ignoring the long-term costs of certain technologies helps perpetuate their use, undoubtedly to the detriment of further research and development in waste reduction approaches and detoxification techniques which environmentally should be the preferable options.

CONCLUSION /PROPOSED ACTIONS

While one cannot accurately quantify the short- and the long-term deleterious effects of improper hazardous waste management, ample evidence already exists of damages to the environment, human health, and economic resources of both industrialized and industrializing countries.

Several Areas Need Serious Attention:

1. It is important for developing countries to build the institutional and scientific capacity to utilize available technology to solve site specific environmental and health problems related to hazardous waste pollution.
2. There is an urgent need to develop cost/benefit assessment methods using concepts relevant to development projects in industrializing countries which can evaluate the impact of hazardous waste management on the environment, people's health, and the country's economy and resources both in the short- and in the long-term.
3. Development of an international information network is needed which addresses all facets of hazardous waste management--economic aspects, technological development and application, environmental impact, health effects, societal considerations, and others.
4. Development of an international manifest system would help limit the number of entry points for hazardous waste into any given country, reducing the possibility that these wastes are unknowingly and/or illegally dumped in countries ill-equipped to handle them properly.
5. Pesticide guidelines need to be developed for industrializing countries, including information about various product's potential health and environmental hazards, in order to help reduce their misuse and environmentally damaging effects.

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HIGH OR LOW TECHNOLOGY FOR INDUSTRIAL WASTEWATER TREATMENT IN DEVELOPING NATIONS

Mogens Henze

Department of Environmental Engineering
Technical University of Denmark, Bldg. 115
DK-2800 Lyngby, Denmark

INTRODUCTION

Wastewater represents a severe environmental problem in many developing countries. The discharge of these wastes to receiving waters can create problems, which in one way or another ends up as a ressource depletion (fish death, drinking water deterioration etc.).

INDUSTRIAL WASTEWATER

Industrial wastewater represents in many cases the ultimate environmental problem, due to a concentrated discharge of large amounts of pollutants. Two industries are discussed below: breweries and palm oil mills, representing very different types of wastewater, but both characterized by their content of organic matter. The high content of organic matter gives a possibility to consider a series of highly different wastewater treatment processes and a supplementary possibility to recover ressources like energy and animal fodder. The results reported in this paper are based upon the work of a study group under the Danish Academy of Technical Sciences[1]. Table 1 shows the typical composition of two wastes discussed below.

Table 1. Wastewater from breweries and palm oil mills[1].

Parameter Type of waste	Brewery	Palm oil mill
BOD ppm	1.500	25.000
COD ppm	2.000	50.000
SS ppm	1.500	20.000
Temperature °C	40	60
Specific wasteproduction:		
kg BOD/t product	15	75
kg COD/t product	20	150
kg SS/t product	15	60
m^3/t product	10	3

In order to study the effect of industrial plant size upon wastewater treatment costs, two sizes of each industrial plant have been considered (small production and large production). Table 2 shows the production size and the wastewater generation.

Table 2. Production size and wastewater[1].

		Breweries		Palm oil mills	
		small	large	small	large
Production	t/d	25	250	25	250
Wastewater	m^3/d	250	2500	75	750
Max. hour (wastewater)	m^3/h	42	167	13	50
Production period	days/year	365	365	250	365
	hour/day	10	24	10	24

WASTEWATER TREATMENT METHODS CONSIDERED

A major objective of the study has been to compare economy and resource consumption/production of wastewater treatment technologies of varying technological complexity. The following unit processes have been used in various combinations:

- sedimentation
- flotation
- activated sludge
- [illegible] trickling filters
- [illegible]bic filters
- [illegible]bic contact processes
- [illegible]c ponds (facultative)
- [illegible]ed ponds
- [illegible]bic ponds
- m[illegible]ation ponds

All unit processes have been designed using standard design rules [illegible] some of which are given in Table 3.

The effluent from all treatment plants are assumed to be 25-50 ppm BOD, corresponding to disposal to inland waters.

Table 3 Design criteria for various treatment processes.

Activated sludge plants	
Organic loading	0.2 kg BOD/(kg SSxday)
Sludge production	0.5 kg SS/kg BOD
Clarifyer, hydraulic load	0.7 $m^3/(m^2xh)$
Overall power consumption	1.2 kWh/kg BOD in influent
Aerobic filter	
Organic loading	0.5-2.6 kg BOD/(m^3xday)
Sludge production	0.6-0.9 kg SS/kg COD
Overall power consumption	0.3 kWh/m^3 wastewater
Anaerobic filter	
Organic loading	3-6 kg COD/(m^3xd)
Gas production	0.3 Nm^3 CH_4/kg COD (reduced)
Sludge production	0.2-0.3 kg SS/kg COD (influent)
Anaerobic contact process	
(thermophilic) (palm oil waste)	
Detention time	10 days
Gas production	0.15 Nm^3 CH_4/kg COD
Sludge production	0.9 kg SS/kg COD (influent)
Anaerobic ponds	
Organic loading	0.1-0.4 kg BOD/(m^3xd)
Facultative ponds	
Organic loading	max 0.03 kg BOD/(m^2xd)
Aerated ponds	
Organic loading	0.04-0.1 kg BOD/(m^3xd)
Maturation ponds	
Detention time	7-10 days

COST CALCULATIONS

The cost calculations have been based on capitalized investment costs (15 year lifetime and 10% interest rate) plus annual operation costs. All prices are given in USD (US$) and related to a price level corresponding to September 1983. Calculations are based on unit costs as shown in Table 4. The unit costs for the specific developing nations quoted in the table have been collected from several sources of varying reliability, which means that single figures should be interpreted with care. The overall picture of costs is believed to be reliable to a degreee that allows for calculations and comparisons of costs for different processes and different countries. In cases where the total costs have been rather unaffected by specific countries, the costs have been quoted as general costs for developing nations.

Construction costs have been calculated based on civil works costs and machinery. Civil works have been estimated from design of major structures in the various treatment plants. Machinery costs are based on Danish machinery delivered and installed in the selected countries.

Operation and maintenance costs have been estimated from calculated labour costs, chemical costs, electricity costs, sludge transport and disposal (15 km), maintenance (2% p.a. for civil works and 10% p.a. for machinery) and produced resources (electricity, plants for fodder 0$ton and palm oil waste concentrate (also for fodder) 33$/ton).

Detailed description of cost calculations are given elsewhere[1].

TREATMENT COSTS

Wastewater treatment is performed under economic laws, that assemble those of other industries, which means that big treatment plants have unit costs considerably lower than small treatment plants. *This is shown in Figure 1, which also shows the effect of* wastewater BOD concentration upon treatment costs per m^3 of wastewater. In general ponds are the cheapest treatment method, when land costs is not included.

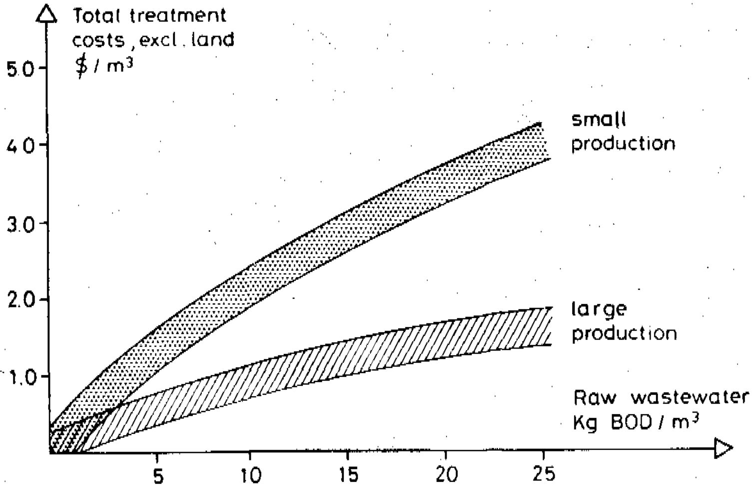

Figure 1. Variation in total treatment costs between small and large industrial production.
Effluent BOD: 50 ppm.
Developing countries 1983.

The distribution of costs for civil works, machinery and running costs is shown on Figure 2 and Figure 3 for Kenya and Mexico respectively. It is seen that local variations in cost may change overall economy of the various processes considerably. High construction costs makes ponds uneconomical in Mexico. The general tendency is however, that the various treatment processes have costs that are comparable. This is especially pronounced for concentrated wastes, as shown in Figure 4 for palm oil wastewater.

A factor which influences the overall treatment costs is

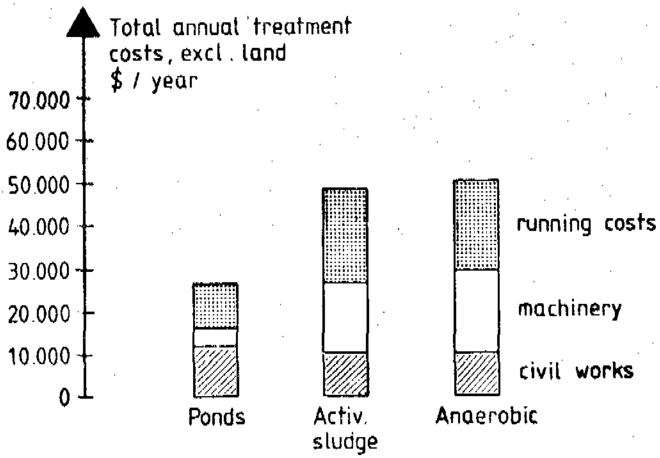

Figure 2. Wastewater treatment costs. Small breweries. Effluent BOD: 25 ppm. Kenya 1983.

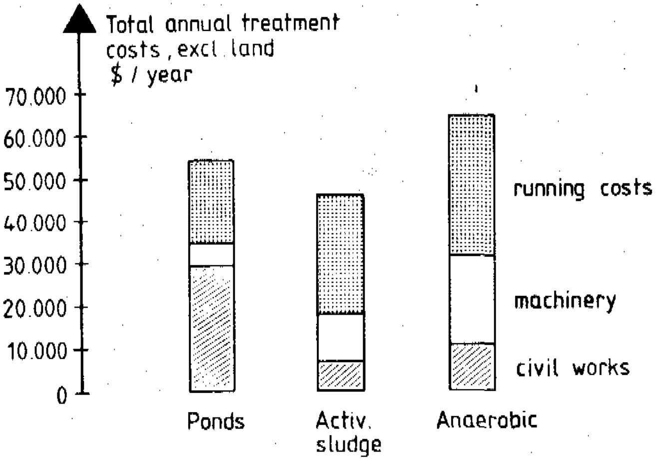

Figure 3. Wastewater treatment costs. Small breweries. Effluent BOD: 25 ppm. Mexico 1983.

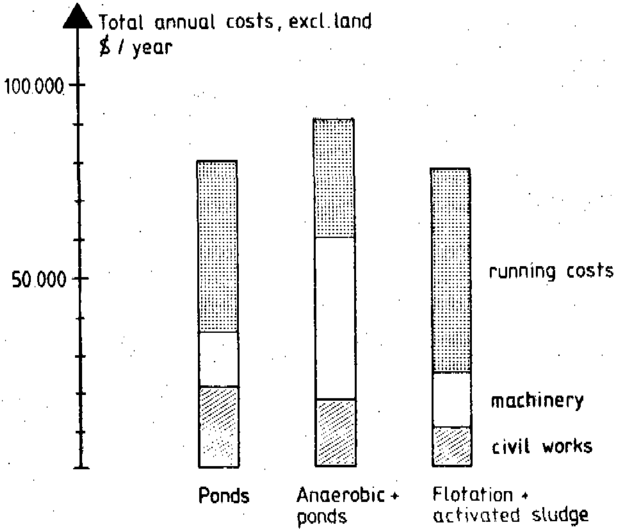

Figure 4. Wastewater treatment costs. Small palm oil mills. Effluent BOD: 25 ppm. Nigeria 1983.

the cost of land. Often this is not taken into account in wastewater tratment cost calculations.

The land space requirements are highly varying from one treatment method to another, as seen in Table 5. The effect of this is shown in Figure 5 for brewery waste treatment and in Figure 6 for palm oil waste treatment. Figure 5 shows that oxidation ponds turns uneconomic when land cost exceeds approximately 5$/m^2, whereas anaerobic processes are most economic when land costs exceed 100$/m^2.

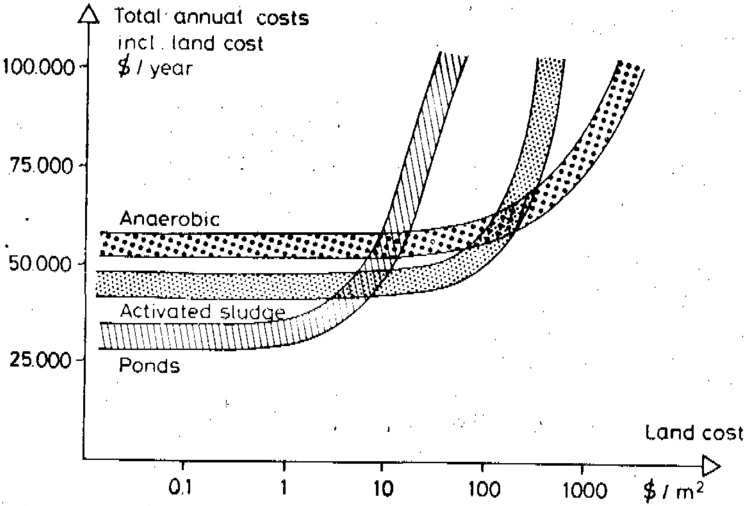

Figure 5. Total annual costs incl. land cost. Brewery wastewater, various treatment methods. Effluent BOD: 25 ppm. Developing countries 1983.

For palm oil waste treatment (Figure 6), the transition from low to high technology are found at even lower land costs, 5-10\$/m^2. The land costs quoted here in the range 5-100\$/m^2 are typical for many countries and gives the variation from farmland areas to bigger cities.

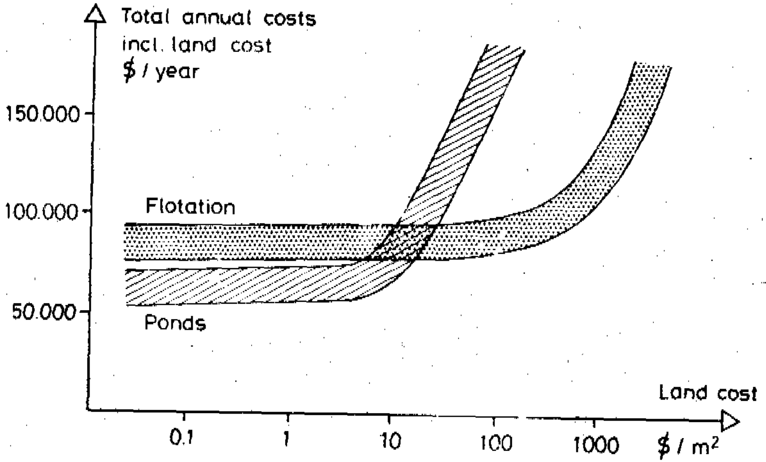

Figure 6. Total annual costs incl. land costs. Palm oil wastewater. Various treatment methods. Effluent BOD: 25 ppm. Developing countries 1983.

DISCUSSION

The results shown in Figures 5 and 6 illustrates one of the major factors involved in selection of a favourable wastewater treatment method. The economy is an important factor but may be outweighed by non-economic factors like resource availability and stability and socio-economic considerations. If, for example, electricity supply is unreliable, then activated sludge treatment can be taken out of consideration, if chemicals are not available then flotation can be excluded and if land space is limited then pond treatment can be omitted (even in cases where land costs are small).

Several non-economical factors are of course basicly economical of nature (a reliable power supply is solely (!) a matter of money, but the costs involved in that is of another magnitude than the costs discussed here).

It has been shown that wastewater treatment costs may vary due to local factors, but that the general magnitude is the same for different developing nations and in fact for developed nations as well[1]. The variation in costs between high and low technology processes are not very marked, but in general the low technology processes tend to be cheapest when land cost is not included in the overall calculations.

It might be argued that it is not advisable or possible to use high technology industrial wastewater treatment processes in developing countries. One must however realize that this investigation deals with wastewater from industries using a far more complex technology in the industrial plant itself, than the one which has to be used even in so-called high technology wastewater treatment. Or as stated elsewhere[1]: 'If one can can pineapples one can treat pineapple wastewater, using a high technology process, as well'.

CONCLUSIONS

Industrial wastewater treatment possibilities in developing countries, does not deviate significantly from industrial wastewater treatment in developed countries. This holds for the multitude of processes available as well as for the economy involved.

The selection between various watewater treatment processes will often be based on non-economical factors, as the cost of processes of varying technological complexity tends to be rather equal.

It is possible to use high technology wastewater treatment processes in developing countries.

High or even moderate land costs favours high technology processes considerably. Land costs should always be included in the overall treatment cost calculations.

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„DETERMINATION OF SULPHUR DIOXIDE (SO_2) LEVEL IN DIFFERENT SITES NEAR PRIŠTINA"

B. Jonuzi, A. Djeli
Institute of Recearch and Development "INKOS"
38000 Priština, Yugoslavia.

The problem of SO_2 emission in Priština is significant. This problem occurs because of the sulphur content in Kosovo lignite, which is promarely used for energetic needs. Reserves of lignite coal in the Kosovo basin is estimated at about 10 billion tones, which has and will have significant contribution in satisfying Yugoslav energetic needs.

The power plants of "Kosovo" are located near the town of Priština, and they are the major contributors of air pollution. The problem becomes more serious because the area is one of the most popullated in Europe. The source of multiplied air pollutants are the power plants Kosovo A, Kosovo B, Coal gasificatio plant, Tawn heating plant, and also private heating systems, which are less significant.

The quality of air in a city is impossible to estimate just on the basis of data of sulphur dioxide measurement but since main contamination of Priština becomes from the chimneys of the Power Plants of "Kosovo" obtained resusts can still represent the degree of air pollution.

Emission of sulphur dioxide may be determined calculatively on the basis of statistic data for coal consuption and sulphur content in coal, however air pollution is liable to weather and spatial fluctuations even in cases of constant emission of pollutants. Therefore contstant measurements of air quality above certain areas is necessary.

According to the model[1] for dispersion of pollutants greatest concentrations can be expected to be more than 10 kilometres away.

Emission of SO_2 From Technological Process from EPK (Ekektro Economy Kosovo)

The calculation of SO_2 emission on the basis of coal consumption by power plants makes it possible to estimate the amount of sulphur oxides in smoke, which gives the opportunity to accord defelopment plans with air quality control. Emission is calculated on the basis of three values: fuel mass, sulphur content in fuel and emission grade of sulphur. By analysis of coal the total sulphur oontent determined was 1-2.5% (calculated on dry substance), ignited sulphur 0.13-0.20% while the rest of the sulphur remains in the ash. Of course this is very favourable ration because sulphur in the ash remain bounded with ash therefor it dasn't present any great problem to air pollution and corosion.

Table 1. shows quantities of sulphur dioxide emitted from technological process EPK.

Table 1.

Plant	Power	Quantity of SO_2 t/day
Thermopwer plant "Kosovo" A	790 MW	87.4
Thermopower plant "Kosovo" B	2 x 330 MW	73
Gasification plant	1 x 10^6 Nm^3/day	29.7
Heating plant	3000 t steam/day	4.6

The degree of sulphur oxide emission depends considerably on the moral ratio S/Ca in coal as well as combustion point. Hence sulphur dioxide may be established only by measuring.

Results of SO_2Measurements

Determination of sulphur dioxide concentration was done by Standard British Method[2]. Certain air volume (1.5-2.0m^3) passes through a diluted solution of peroxide during 24 hrs. and from the obtained quantities of sulphuric acid SO_2 was determined by use of gas eqvation. Samples were taken from thise sites: Obilić, Priština (servis Boško Čakić) and Uroševac (Hospital).
Obtained results for daily sulphur dioxide concentrations in the above mentioned sites are shown in Figs 1, 2, 3 and Fig 4. shows frequency distribution of ambient SO_2 concentrations. Fig 1. shows daily SO_2 concentrations at the Obilić site, Fig 2. shows daily SO_2 concentrations at the Priština site, Fig 3. shows daily SO_2 concentrations at the Uroševac site and the frequency

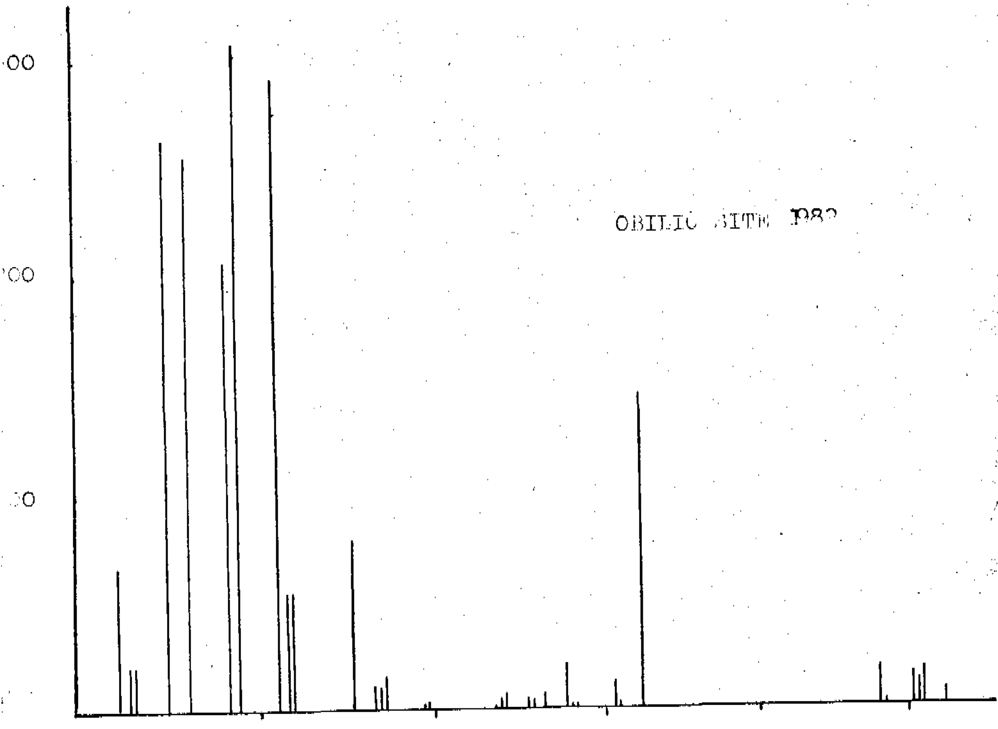
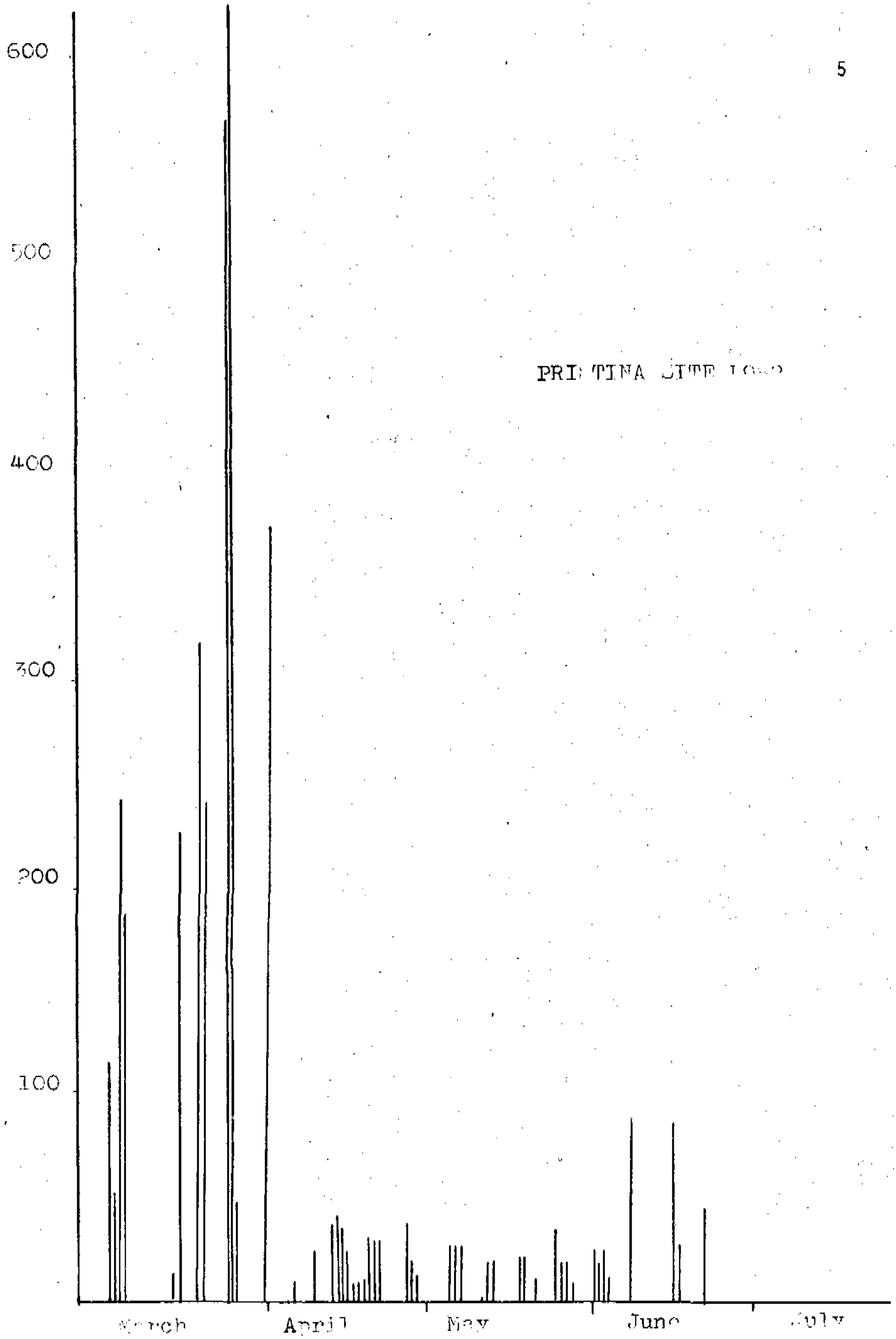


Fig. 1. Daily SO_2 concentrations



2. Daily SO_2 concentrations

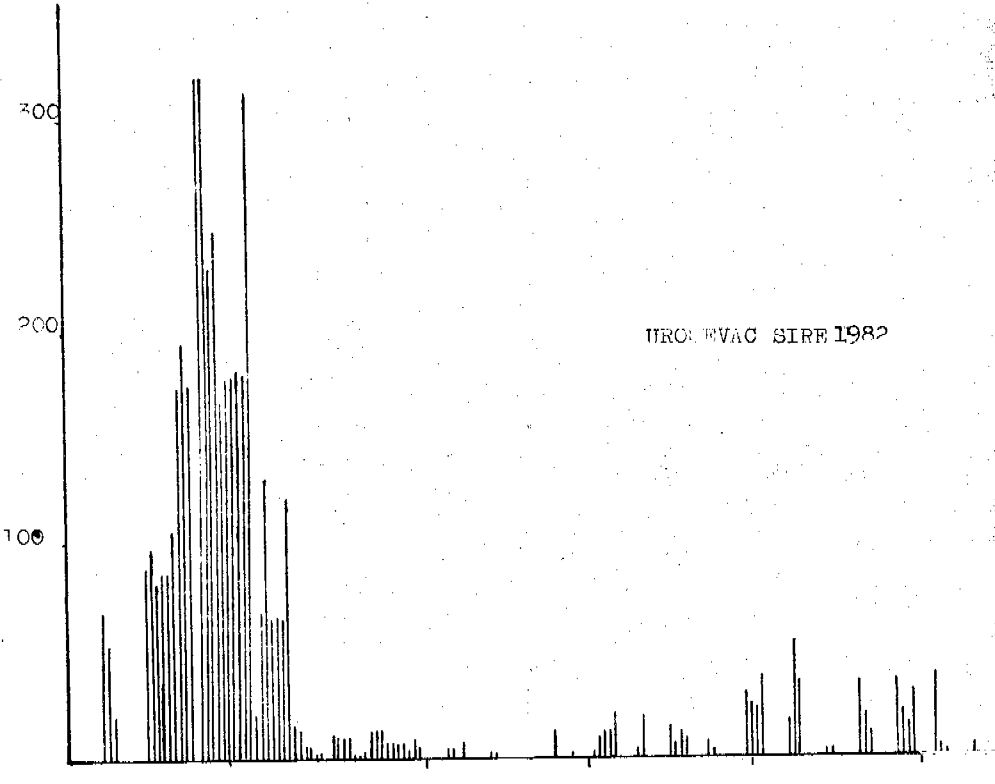


Fig 3. Daily SO_2 concentrations

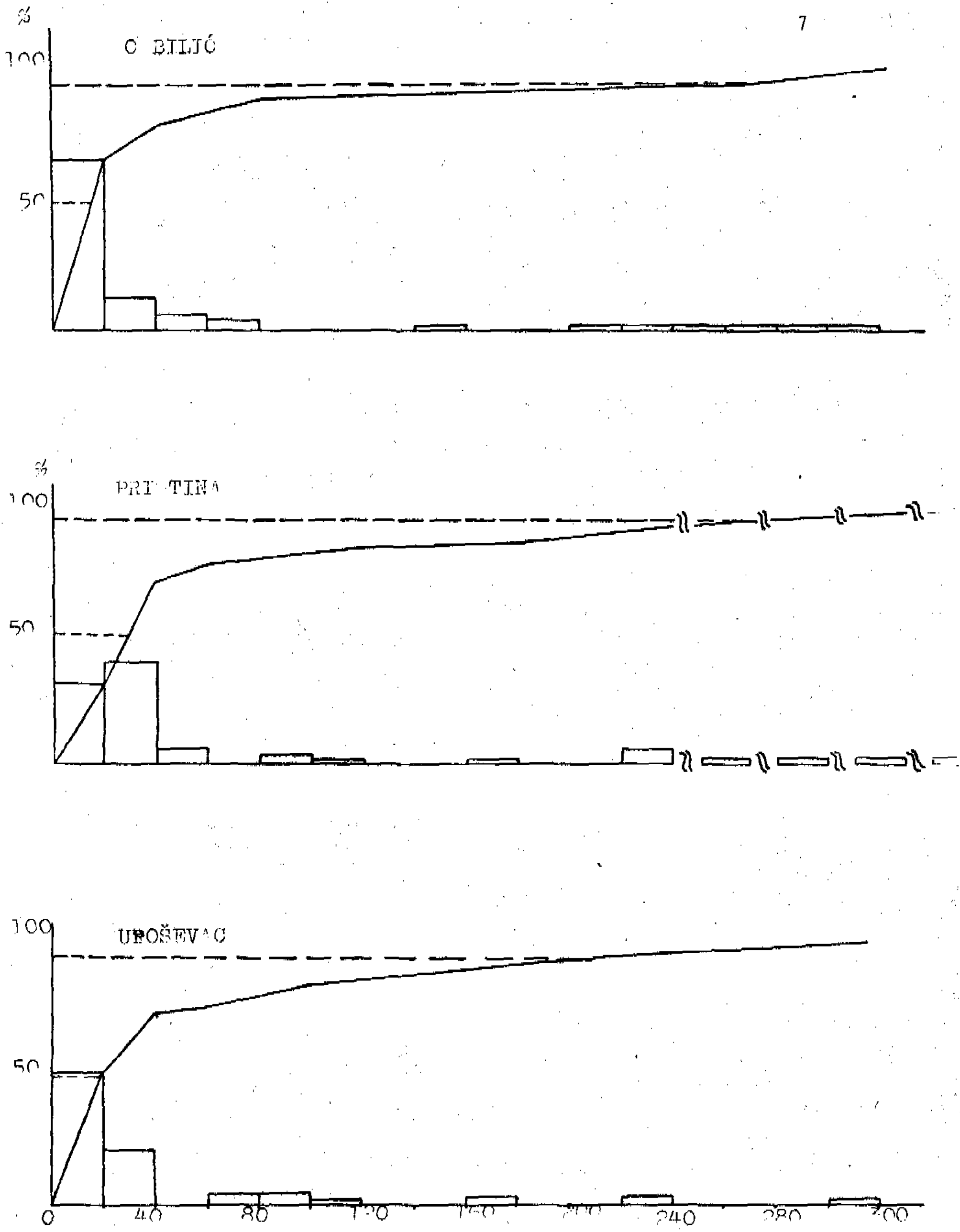


Fig. 4. Frequency disribution of ambient SO_2 concentrations

Distribution of the results obtained so far is presented in Fig 4.

Uroševac is considered as zero state because in its surroundings there is no industry which emits SO_2 in the air.

Standard for emission of sulphur dioxide in SFR Yugoslavia for extreme values of permitted concentrations is as follows:

0.15 mg SO_2/m^3 - avarage daily value
0.5 mg SO_2/m^3 - short-term value

Table 2. shows average monathly concentrations of SO_2 in ug/m^3 intabove mentioned sites.

Table 2.

	M O N A T H					
site	III	IV	V	VI	VII	VIII
Obilić	148	66	9	45	5	9
Priština	246,0	25	21	59	109	-
Uroševac	147,3	23,7	5	13	25	16,4

Results and Discussion

Results that were obtained during six monaths of research show that the highest concentrations of sulphur dioxide are during March, and that high sulphur dioxide concentrations are to be expected in winter. Common currents in the atmosphere are more expressed in summer, this influences faster and easier dispersion of pollutants, while in winter wery often occurs the phenomenon of certain specific weather situations favorable for accumulation

of pollutants in lower atmosphere layers, and are not adequately diluted minly because of the cumulative effect of SO_2 and smoke[3]. As a result of varying emission and meteorological conditions sulphur dioxide air pollution levels differ significantly beetween diferent sites in the Priština region. For right interpretation of results it is necessary to obtain meteorological data. Compounds that influece result accuracy during determination of sulphur dioxide concentration such as nitrogen oxides and amonium are significantly prezent in this region and orginate from the Fertilizer Plant. Even though there are a number of methods for determination of SO_2 concentrations it is difficult to find some method which is unsensitive to the interference of acidic and basic compounds. Some comparative analyzis of British Standard Method and titrate method by Thoron did not give any signifcant difference in results.
The aim of this preliminary study was application of methodology for the determination of SO_2 before starting to work on the study "Inventory of pollutants released from the power plants of "Kosovo" and we intended to gain limited information on the spatial and temporal distribution of SO_2 air pollutant. Even though British Standard Method dont offer stable resusts for determination of SO_2 condentration it is still used because of its simplicity and economy.

Conclusions

The major conclusions of this study was that the main sources of pollution by powerplant of "Kosovo" A, "Kosovo" B as well as the Gasification plant.

On the basis of the limited sampling period, it appears that the concentration of SO_2 at the investigated sites is low in comparison to calculated emission amounts. The reason for this phenomenon is high content of CaO in coal ash 30-50% as well as MgO 5-6% which adsorbes S oxides. Therefore future researches must be oriented on chosing optimal conditions of coal burning, in order to lower emission of SO_2. Sulphur dioxide in the area of Priština is relatively low compared to the second major urban area i. e. Titova Mitrovica.

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CONTAMINATION OF DRINKING WATER NETWORKS BY PERCOLATING PITS: AN EXAMPLE OF A DISRUPTED ECOLOGICAL BALANCE

Dr. H. Kanaaneh and Engineer F. Farah

The Galilee Society for Health Research and Services

P.O. Box 92, Rama, Israel

INTRODUCTION

More and more countries in the Third World currently take action in line with the International Drinking Water and Sanitation Decade, which sets the target of safe drinking water and sanitation for all by 1990 (WHO, 1980). It is instructive to review the experience and point out some problems with such action that preceded the announcement by the WHO of this target and which had been carried out in communities in Israel that share many characteristics with developing communities. In particular we wish to point out from our experience the danger of taking hasty action to bring water supply, with the sewage disposal not being given adequate and thorough consideration at the same time.

BACKGROUND

In the Galilee there are 64 non-Jewish villages and 18 partially settled Beduin groupings with a total population of about a quarter of a million inhabitants by the end of 1980 (Central Bureau of Statistics, 1982). Eighteen of these communities are considered to be urban localities with a population of 5 to 16 thousand each. Despite their size, all these communities have several distinctive rural socio-economic attributes. In these aspects, as well as in their demographic and environmental health characteristics, they are similar to developing communities in other parts of the world. For example, the natural growth rate is quite high, resulting in an average population doubling time of less than 20 years.

Over a period of 15 years, from the late 50s to the early 70s, these communities passed spontaneously through a stage of development which fits into the overall goal and strategy of the current WHO

Drinking Water and Sanitation Decade, though not designed intentionally to be so.

Prior to this development and to the socio-economic changes that preceded it immediately, these communities were typical Middle Eastern farm villages that depended mainly on subsistence farming. As such they had existed in a balanced ecological relationship with their environment. In terms of water supply and waste water disposal, this balance was maintained at very low levels, typical of such farming communities throughout the Third World (WHO, 1972). Water was carried bodily from the village's small spring or, eventually, as the demand for water increased beyond this limited supply, from private cisterns in which rainwater was collected during the short rainy season. Such cisterns were dug in the yards of most homes to depths of 4-6 meters. They were well sealed to prevent water loss by seepage into the ground. The quantities of water available for consumption were therefore quite low. Sewage effluent did not present any serious or visible health hazard. The main detrimental effect to the population was rather due to the shortage of water and to its poor quality.

In the late fifties, Israel suffered from a drought period lasting several years in succession. The near total dependence of these communities on rain water made them particularly vulnerable to this drought. Convoys of tanker vehicles carrying water to seriously hit areas were employed. This greatly heightened the awareness at local levels as well as in official circles of the need for a modern piped water supply network. In response to the insistent demands of the population in the face of this near emergency situation, water supply systems were hastily designed and constructed, without the needed detailed studies for long range planning, and employing low standards of execution. Thus during the period from 1958 to 1965, through an intensive campaign, pipe networks and distribution systems were constructed and connected to existing water projects or to especially built ones. Throughout this entire process, no specific action was taken at the community level regarding sewage disposal.

THE PROBLEM

As pointed out above, these communities have been growing in terms of their number of population. Likewise, the number of houses grew in the absence of prior planning. The limited land area available for building purposes resulted in overcrowding. New buildings were added on top and alongside existing ones. Thus, presently the typical village is made up of a very densely populated old section with almost no open spaces and narrow winding steep alleys. In addition, there is the newer section added within a belt surrounding the older one with no particular pattern or plan, the houses having been individually built and public housing schemes virtually non-existent.

In considering the second half of the ecological equation of drinking water supply and waste water disposal, two additional aspects concerning these villages are particularly relevant. The first is their particular geological and topographical setting (Farah, 1974). Most of these villages are traditionally built on rocky mountains and hill slopes. Their terrain is predominantly steep, reaching up to 1:5 or even more in special cases. The substratum is usually soft to medium-hard limestone with shallow if any topsoil overlaying the rock.

The second aspect relates to the distinction we must make between a community's health needs as judged objectively by health professionals and its health wants as expressed subjectively by its members, which depends on the degree of their awareness of a certain health problem and hence their willingness to prevent it. Safe drinking water supply is an acknowledged health need throughout the world. In the present case it happened to be an urgent health want of these communities as well. In contra-distinction, the awareness of the benefits of a well maintained system of waste water disposal is almost completely lacking. Thus, the gap between this health need and the community's health wants is very difficult to bridge on the motivational health level. Add to this the technical difficulty of grafting a modern sewage disposal system to an already existing crowded, unplanned community.

With the introduction of piped water and sanitary installations (baths, washing machines, kitchen sinks, etc.) into the houses, water consumption increased drastically from that in line with the limited supplies of stored rainwater (10-15 l/capita/day) to levels of about 100-150 l/capita/day (Farah, 1974). Over the ten-year period of 1970-1980 alone, the overall increase in domestic water demand in these communities rose by 215% as against a net population gain of 45% for the same period.

As expected, the villagers with little technical sophistication adopted the simplest and most convenient form of sewage disposal which seemed even to professionals to be an appropriate technological solution for a rural setting. Thus with no means of sewage collection or treatment, they either turned their cisterns into sewage pits or dug new cesspits for that purpose. This was supposed to act as a percolator pit where sewage water seeps through the shallow topsoil and fissures in the rock. Actually, however, it soon clogged and eventually acted as a collecting and storage tank. Great effort and a continuous costly process of emptying filled cesspits is needed, the raw sewage being pumped out by tanker vehicles and dumped not far from the village area. Because of its tremendous cost and inefficiency, many cesspits are not emptied regularly, resulting in serious health hazards on account of the cesspits overflowing right in the heart of the overcrowded built-up area. The vast number of these cesspits in a typical village and the difficulty in emptying and transporting their contents makes sanitary control a very difficult, perhaps an impossible task. Continuous increase in water consumption further aggravates the problem.

The most serious problem, however, is the contamination of the public water system as a result of the above-mentioned situation. Accidental cross connection between sewage lines and drinking water networks is not a rare occurrence, and usually leads to sizable outbreaks of disease. In this situation, however, there is ample occasion for cross-contamination. The main water supply pipes lie close to cesspits buried within soil which is deeply saturated and contaminated with sewage effluent that percolates from the cesspits or flows freely above the ground. Effluent sewage containing usually highly corrosive by-products can cause extensive damage to the galvanized steel pipes used as water mains. Pieces of such pipe material extracted from the ground for repairs are often shot with holes after no more than 10-15 years after installation. The steel simply corrodes, allowing leakage at several points, which accounts for the high water losses, reaching up to one third of the total water supply to the village. In a survey which we conducted on 45 Galilee rural Arab communities, this loss of water, calculated on the basis of the difference between overall water supply to the community and total actual consumption figures, was found to be higher than the maximum accepted water loss of 10% on a nationwide basis (State Comptroller, 1980) in 75% of the cases. In 35% of these communities, the loss was more than twice the maximum level. The leakage especially occurs at joints, washers, couplings and other fittings on the water supply mains. As long as positive pressure is maintained in the water network, the loss to the village is only economic. However, when water stoppage occurs intermittently, whether because of being shut off at the source, or in parts of the network for repairs, negative pressure is created, causing contaminated earth or raw sewage to be sucked into the water network. This situation is potentially disastrous. Such was found to be the source of a typhoid outbreak in Arraha village in 1978-79 (Kanaaneh, 1980), affecting some 40 known hospitalized cases. Likewise, this was the source of water contamination in 5 communities in 1981-82 and we expect that it is happening in most of the rest quite frequently. It is more likely to occur as time goes on, making it difficult to remedy the situation at all. The only alternative so far has been to bring drinking water from neighboring villages by tankers, or boil the water in line with the instructions issued in these cases by the Ministry of Health. The small local sources of water including even some deep wells usually located within the village's limits which had for ages served the village's population before piped water was introduced have long been contaminated and rendered unusable for drinking purposes. A fact that should always be borne in mind is that the geology of the region (limestone rock with many cavities and underground fissures caused by the dissolving action of water) facilitates the flow of waste water and sewage with minimum exposure to the filtering effect of the soil, such as is the case in sandy and loamy soils predominant in other regions of the country.

This easy access that liquid waste matter has to the drinking water network is most likely the cause of the high incidence of gastrointestinal disease, particularly among the young, creating a hyper-endemic situation, where it constitutes the first cause of childhood hospitalization and, until recently, the first cause of infant mortality in these communities (Rogov, 1976).

CONCLUSION

We see here an example of a major, beneficial step taken on the road to health improvement of developing communities leading to a potentially grave environmental problem. This, because it was not coupled with all the appropriate precautions and long-term planning, because of the lack of full appreciation of these communities' particular demographic, topographic and motivational characteristics. The lesson to be learned is obvious: we must balance both sides of the ecological equation of the water supply and waste water disposal in a studied and planned manner.

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WERY WASTE TREATMENT BY ANAEROBIC ILTRATION

Sinan Karan[a]

Chemical Engineering Department
Boğaziçi University
İstanbul, Turkey

Mahir Arıkol[b]

Chemical Engineering Department
Boğaziçi University
İstanbul, Turkey

Giray Velioğlu[c]

Civil Engineering Department
Boğaziçi University
İstanbul, Turkey

INTRODUCTION

Large quantities of wastewater are generated during the production of beer. The final composite wastewater of any brewery is the combination of wastes coming from various batch type operations and its strength varies considerably. Unless adequate treatment is provided, oxygen depletion and sedimentation will occur in the receiving waters.

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w Material Engineer, Northern Electric Telekomunikasyon A.Ş., niye, İstanbul, Turkey.

hanical and Energy Engineering Department, Marmara Research titute, Gebze, Kocaeli, Turkey.

il Engineering Department, Yarmouk University, İrbid, Jordan.

The fact that brewery industry wastewater contains large amounts of organic matter in solution but relatively small amounts of suspended solids suggests treatment by anaerobic filtration. This process basically involves passing the waste upwards through a bed of solid packing material. The biological solids responsible for treatment are attached to the surface of packing material and, therefore, are not carried out with the effluent stream. Mc Carty [12] compared the anaerobic filter with other existing biological processes and pointed out a number of distinct advantages in using the former:

1. The anaerobic filter is ideally suited for the treatment of soluble wastes.
2. No effluent or solids recycle is required with the anaerobic filter. The biological solids remain in the filter and are not lost with the effluent.
3. The treatment of dilute wastes (up to 6.000 mg/L COD) is possible even at low temperatures.
4. Very low volumes of sludge are produced by the anaerobic filter. The effluent is essentially free of suspended solids, and sludge wasting in some cases is almost nonexistent.
5. The anaerobic filter suggests the possibility of a treatment plant with low maintenance requirements, and one in which sludge handling and disposal problems are minimized. Furthermore, the resulting sludge is stable and inoffensive, hence suitable for direct use as a fertilizer or soil conditioner.
6. Methane gas will be produced as a by-product of treatment with anaerobic filters. According to Kormi and Keenan [9], considerable potential of energy recovery by methane generation exists in brewery industry.

The main disadvantage of anaerobic filtration is a slow reaction rate at ambient temperatures. For this reason, Mc Carty [11] suggests that the mesophilic range ($35^o \pm 2^oC$) is the optimum temperature range to obtain a suitable efficiency and gas production rate with anaerobic filters. However, according to Drohobyczer [4], artificial brewery wastewater with a COD of about 900 mg/L can be treated by anaerobic filtration at ambient conditions with a COD removal efficiency of 60% when detention time is 1 day.

PREVIOUS WORK

Anaerobic filtration has been the subject of numerous investigations during the recent years following Young and Mc Carty's original work in 1967 [18]. In their study, which demonstrated the technical feasibility of anaerobic filters in treating soluble wastes, COD removal efficiencies ranging from 60 to 90 per cent at different organic loads and hydraulic detention times were observed. Furthermore, solid production rates were extremely low which enabled operation for long periods of time without sludge wasting.

Subsequent investigation by Mc Carty [12] using an artificial waste led to similar results. COD removal rates of 74 to 88 per cent were achieved and the produced gas had a high methane content. Again, sludge removal was not found necessary during the entire period of operation.

On the basis of these results which demonstrated several advantages of anaerobic filtration over other methods in treating soluble wastes with moderate to high organic strength, the process has been applied to a variety of such wastes. The treatability of brewery press liquors [6], artificial brewery wastes [4], starch plant wastes [17], flour processing industry wastes [13], pharmaceutical wastes [7], distillery wastes [14] and potato processing industry wastes [10] by anaerobic filtration have all been under investigation. In each case, satisfactory results have been obtained despite significant variations in influent COD concentrations (2500 - 24000 mg/L), hydraulic detention times (5 hrs - 24 days) and operating temperatures (10^o - 35^oC). Besides satisfactory COD removal rates with little or no sludge removal, the produced gases were observed to have a rich methane content.

The anaerobic filter has also been applied successfully for treatment purposes other than organic matter removal. Removal of heavy metals [3] and denitrification of subsurface drainage [16] are among those applications.

With the growing interest in anaerobic filtration, different system designs were also considered. El-Shafie and Bloodgood [5] investigated performance of several filters in series while Chian and DeWalle [2] studied a completely mixed anaerobic filter and Landine [10] studied a horizontal filter. Again, satisfactory removal efficiencies were obtained under different operating conditions.

The brief summary of the current research presented here indicates that anaerobic filtration has a high potential as a waste treatment process and further developments in system design should be expected. Proper utilization of anaerobic filters in conjunction with modifications and/or improvements in system design is likely to offer the best solution in a wide variety of waste treatment applications.

PURPOSE AND SCOPE

It is estimated that the Turkish brewery industry discharges 10 million gallons (3,785,000 L) of waste annually, or more than 80,000 lbs (36,287 kg) of BOD_5 per day [1]. Although large quantities of wastewater are generated during the production of beer, the present wastewater treatment facilities of the breweries in Turkey are practically nonexistent. Hence, determination of the technical feasibility of treating brewery wastewater with anaerobic filters should be a contributing factor in planning such treatment facilities in this country.

The purpose of this study was to determine the technical feasibility of treating brewery wastewaters with anaerobic filters. To this end, the performance of a laboratory scale anaerobic filter was investigated utilizing diluted beer as artificial waste.

The experiments were carried out at different detention times ranging between 0.5 and 2.0 days. Furthermore, the effect of inlet concentration was also studied using three different influent substrate concentrations between 44[illegible] and 4050 mg/L COD. The filter was operated at the mesophilic temperature (35 ± 2°C) to obtain optimum treatability and gas production. However, special experiments were also conducted at 25 ± 2°C to observe the effect of temperature on filter performance.

Finally, the effects of nutrient addition and intermittent operation on filter performance were also investigated.

EXPERIMENTAL SET-UP

The anaerobic filter system used in this study consists of a feed tank, a flow regulation system, three anaerobic filter columns, a temperature control system, gas flowmeter-collection chambers piezometric tables (Figure 1).

Feed Tank

The feed tank was a rectangular steel reservoir 100 cm (39.37 in.) long, 50 cm (19.68 in.) wide and 50 cm (19.68 in.) high. It was painted with an anticorrosive paint to prevent the formation of acid bacteria. The substrate level was controlled by submerging a special ruler into the tank. A 3 mm (0.12 in.) ID plastic tube connects the flow regulation system and the tank outlet which is 3 cm (1.18 in.) higher than the bottom of the reservoir. This system was used only for Filter III.

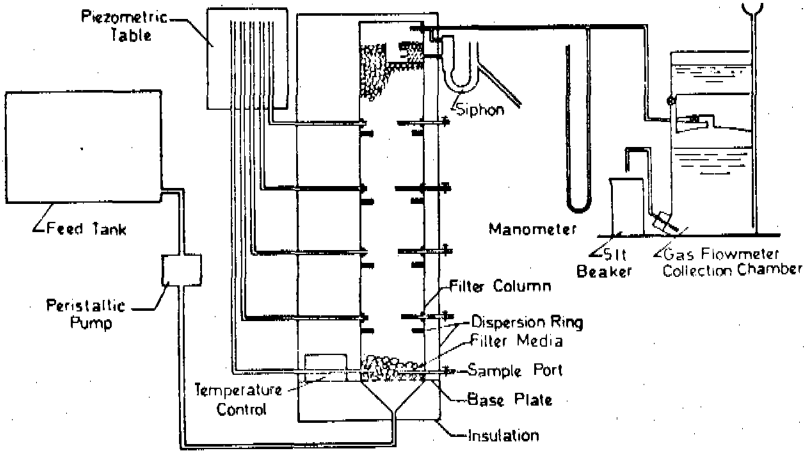

Fig. 1. **Schematic diagram of experimental set-up.**

Flow Regulation System

The pumping unit used to feed the filters was a Masterflex ten channel driver and C-7015-20 pump head with suitable silicon tubes. The speed of driver varied between 5 and 100 rpm.

Filter Columns

The filter columns, which were essentially cylindrical PVC pipes were constructed by Drohobyczer [4] . The details of construction can be found in his thesis. The characteristics of the three filters used in this study are summarized in Table 1. Experiments were carried out with Filter III only, the others were kept ready as back-up.

Plastic funnels were attached firmly to the filter base plates. Each filter base had eight uniformly located 8 mm (0.315 in.) diameter holes so that the substrate would be dispersed uniformly.

Sample ports were placed on the side walls of the columns at vertical invervals of 30 cm (11.81 in.) with an additional first port 5 cm (2 in.) from the bottom. There were also piezometric ports located at the levels of sampling ports (except the first one). An extra one was placed at the base plate level. Sample and piezometric ports were made of 3 mm (0.118 in.) ID glass tubes. Each

Table 1. Filter Characteristics.

Filter No.	I	II	III
Gravel diameter, cm/inch[a]	$\frac{2.54-3.81}{1.0-1.5}$	$\frac{2.54-3.81}{1.0-1.5}$	$\frac{2.54-3.81}{1.0-1.5}$
Height of media bed, cm/inch[a]	154.4/60.79	154.6/60.87	154.8/60.95
Filter ID, cm/inch[a]	15.3/6.0	15.3/6.0	15.3/6.0
Empty filter volume, L/gl	28.38/3.64	28.42/3.64	28.46/3.65
Funnel volume, L/gal[a]	1.3/0.17	1.3/0.17	1.3/0.17
Total empty filler volume, L/gal	29.68/3.81	29.72/3.81	29.76/3.8
Liquid volume (with funnel), L/gal	12.49/1.60	13.10/1.68	12.01/1.54
Porosity	0.421	0.441	0.404

[a] Data taken from Drohobyczer [4].

sample port was equipped with plastic tubing connected to a plastic valve to control the flow rate during sampling.

The piezometric and the sample ports were sealed into the wall of column with rubber grommets to make them watertight [4]. The columns were filled with smooth quartzitic stones of 2.54 to 3.81 cm (1 to 1.5 in.) diameter. Plastic dispersion rings of 15.1 cm (5.95 in.) OD and 11.1 cm (4.37 in.) ID were placed at 30 cm (11.81 in.) intervals to prevent channelling of the substrate between the filter media and the filter wall.

The top of the filter column was closed with a glass cap to make it airtight. An inverted siphon system separates the gas produced from the liquid effluent of the filter by passing through it. The details of the filter columns are explained by Drohobyczer [4].

Gas Flowmeter - Collection Chambers

The gas produced by the filters was measured and collected in specially designed gas flowmeter collection chambers which were made of 40 cm (15.75 in.) high copper cylinders with 25 cm (9.84 in.)

ID. The working principle was the displacement of the confining solution in which carbon dioxide and methane gases are not soluble. The composition of the confining solution was 20% (by wt) Na_2SO_4 and 5% (by volume) H_2SO_4. The pressure of the gas holder was maintained at atmospheric value by making use of a manometer and manually leveling the discharge siphon of the gas flowmeter-collection chamber. A 5 liter (1.32 gal) beaker was used to collect and measure the volume of the confining solution which was equal to the volume of the gas entering the gas meter. The gas was burned or analysed during refilling of the gas flowmeter-collection chamber.

Temperature Control System

Two layers of nylon were wrapped around the filter assembly and glass wool was filled between the two layers as the insulating material. Three heating mantles (Glas-Col, 380 W, 115 V) and a fan were placed inside this enclosure. Temperature was maintained at 35 ± 2°C by means of an on-off control thermoswitch (Fenwal Corporation, Cat. No. 17502-0) which controls the mantles and the fan at the same time. After a certain time, the fan was switched off since it was determined that the air circulation in the enclosure by natural convection was sufficient. Temperature was checked by the thermometers placed at four different points in the enclosure (Figure 1).

EXPERIMENTAL PROCEDURES

Substrate Description

A waste simulating the brewery wastewater was used as substrate in this study. The artificial waste was prepared by diluting Efes Pilsen beer with tap water. In order to observe the performance of the filter, three different concentrations of substrate were tested by diluting 1.5, 4.5 and 9 liters of beer with 220 liters of tap water, respectively. Sodium bicarbonate (1000 mg/L) was added to the first two diluted concentrations of substrate, in order to raise the pH to the optimum condition for anaerobic treatment. In the most concentrated substrate the bicarbonate dose was doubled to achieve the desired pH level.

The representative characteristics of the substrate used in this study are shown in Table 2.

Table 2. Characteristics of Substrate (4.5/220 dilution)

COD, mg/L	pH	Suspended Solid, mg/L	Total Solid mg/L	COD: N.P
1742	7.10	25	1650	100:1.24:0.3

Preliminary Preparations

The filters were washed by passing water through the columns for a period of five days with a detention time of 0.5 days. The porosity of the filter media was determined by filling the filter to the top of the packed material with water and then measuring the volume of this water. Inner walls of the feed tank were painted carefully with an anticorrosive paint.

The seed for the anaerobic filtration was prepared from the sieved fresh cow dung, placed in a 10 liter (2.64 gal) plastic bottle and kept for 15 days under anaerobic conditions in an incubator at a temperature of 35°C until biogas was produced. During this period, some sugar was added to the sludge as nutrient and beer was also added for acclimatization. pH of the seed was adjusted to 7 by adding sufficient sodium bicarbonate, ($NaHCO_3$). The sludge was later diluted with water to prevent clogging problems in the filter and sample ports.

Start-up Period

When the system was ready to operate, the filters were seeded with 3 liters (0.8 gal) of prepared seed by injection through the sample ports 30 cm (11.81 in) above the base plates. Meanwhile, 1.5 liters (0.4 gal) of beer was diluted with 220 liters (58.12 gal) of tap water and fed to the filters with a detention time of approximately 2 days.

After 25 days, gas production was observed at ambient temperature. Subsequently, the system was insulated and the temperature was maintained at 35 ± 2°C. The system was now ready for regular experimental runs. Data were collected using only Filter III which was the first one to produce gas. The other two filters, which were kept ready as back-up, were occasionally fed to maintain gas production.

Gas Production Period

In order to observe the performance of the anaerobic filter under different conditions, data were collected with different detention times and inlet substrate concentrations. Gas production data and the COD concentration profiles were obtained daily, while gas composition, suspended solids, COD removal and pH change data were collected for each run.

In the first part of the experiments, 12 runs were carried out with detention times of approximately 0.5, 0.75, 1.0 and 2.0 days at the three different substrate concentrations of 1.5, 4.5 and 9.0 liters of beer diluted with 220 liters of tap water.

In the next phase of the experimentation, temperature effects were observed by switching off the temperature control system. The most concentrated substrate was used in this run with a detention time of 2 days.

In the third part of the experimentation, nutrient deficiency was compensated by adding nitrogen and phosphorus to the most concentrated substrate as it was prepared. For this purpose diammonium biphosphate ($(NH_4)_2HPO_4$) and potassium nitrate (KNO_3) were added so that the COD:N:P ratios were 100:2.68:0.5, which were the minimum values reported in the literature [2]. Detention time was 0.5 days in this run.

Finally, the influent flow and temperature control were stopped for a two week period. When substrate feeding was restarted at 35 ± 2°C, the same performance was achieved in spite of the two week pause in the operation.

The sequence of the runs carried throughout the whole experimentation period is outlined in Table 3.

Table 3. Summary of Experimental Program

Runs	Days of Operation	Substrate Concentration (L/beer/220 L tap water)	Detention Time (day)
1	1 - 7	1.5	2
2	7 - 11	1.5	1
3	11 - 18	1.5	0.5
4	18 - 24	1.5	0.75
5	24 - 33	4.5	0.75
6	33 - 36	4.5	0.5
7	36 - 40	4.5	2
8	40 - 43	4.5	1
9	43 - 50	9.0	0.75
10	50 - 54	9.0	1
11	54 - 59	9.0	0.5
12[a]	59 - 64	9.0	0.5
13	64 - 71	9.0	2
14[b]	71 - 77	9.0	2
15[c]	91 - 95	4.5	2

[a] Nutrient Effect

[b] Temperature Effect

[c] Intermittent Operation

Throughout the experimental work, sludge disposal from the filters was not found to be necessary.

Methods of Analysis

Analyses on influent, effluent and samples from the various levels included COD, pH, suspended solids, total solids, total nitrogen and phosphorus determinations. The composition of the gas produced was determined by means of a modified Orsat Gas Analyser, where the carbon dioxide content of the gas is determined by absorption in strong caustic potash solution.

The remaining analyses were made by following the procedures outlined in Standard Methods for the Examination of Water and Wastewater, 1975 [15].

RESULTS AND DISCUSSION

Approach to Steady State

Since the microorganisms in a biological system continuously change in population using the substrate for both synthesis and energy liberating reactions, it is very difficult to achieve steady state conditions. In this study, the stabilization of effluent COD removal rates were assumed to be indicative of steady state conditions.

During the regular experimental runs, it was assumed that three days were sufficient to achieve steady state conditions and the observations indicate that this was indeed the case for all practical purposes. Consequently data were collected only during the first four days of each experimental run. As a general rule, it should be understood that the tables and figures presented in this chapter are based on data collection under steady state conditions, i.e., during either the third or fourth day of each experimental run, unless otherwise specified.

pH Variations

During the start-up period, a decrease of pH was observed in the filter columns. After the first seven days of operation with 2 day detention time, the pH values of effluent, influent and seed of Filter III were 6.85, 7.65 and 6.60, respectively. The pH of the filter effluent was about 6.4 for the other two filters in this period. It was observed that pH drops sharply near the bottom of the filter and then remains practically constant after a height of 60 cm (2 ft) from the bottom is reached.

pH profiles during steady state operation were also investigated. Again a sharp decrease of pH at the lower part of the column is observed (Figure 2) for an inlet COD of 536 mg/L. Similar results were obtained for other inlet concentrations [8].

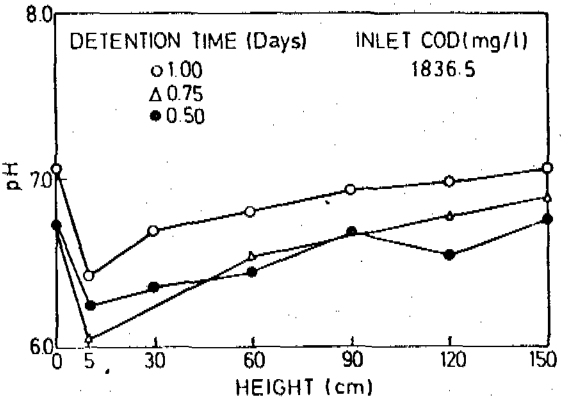

Fig. 2. Variation of pH with filter height.

This phenomenon may be attributed to the fact that the rate of acid formation is greater than the rate of acid conversion to methane in this part of the filter. The methane forming bacteria may not use the acid intermediates as rapidly as they appear, hence conversion may continue up to the top of the filter. Consequently, pH increases continuously after the sharp drop near the bottom of the filter.

Deviation from linearity of pH values above the 30 cm (1 ft) level of the filter in Figure 2 should be attributed to experimental errors.

Gas Production and Composition

Responses of the filter to different infulent concentrations and detention times are best illustrated by the gas production rates. Figure 3 shows the variation of the gas production throughout the experimental study. In order to observe the effect of hydraulic detention time and influent substrate concentration on the volume of the gas produced, Figure 4 is drawn. The data plotted shows that the volume of the gas produced is directly proportional to substrate concentration and inversely proportional with hydraulic detention time. These results are in qualitative agreement with the observations of Drohobyczer [4] who reported gas production rates of 2.7, 2.6 and 1.48 L/day with detention times of 0.5 and 1 day, respectively. As previously mentioned, his COD concentration

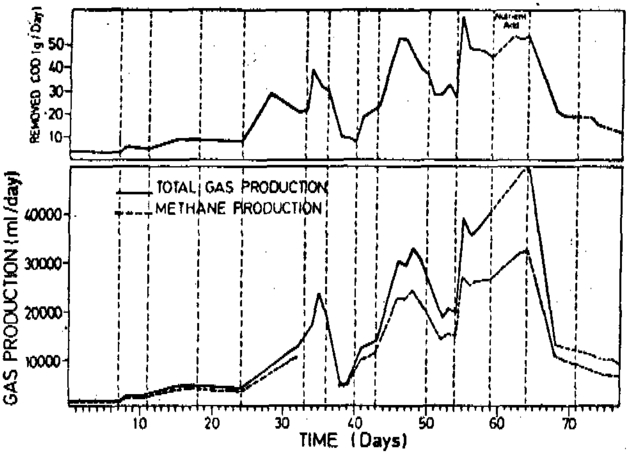

Fig. 3. Variation of gas production and COD removal with time.

of diluted beer was 900 mg/L. Unfortunately, it is very difficult to make a quantitative comparison with Drohobyczer's findings, since operation temperature and influent substrate concentrations in this study were different from his. In this study, average gas production rates of 4.5 and 2.5 L/day were observed with 0.5 and 1.0 day detention times, respectively (mean influent COD was 536.5 mg/L). This difference in gas production rates may be attributed to the difference in operating temperatures.

Variation of the gas production with detention time and substrate concentration was considered in Russo's [14] study also. It was reported that total gas production decreases with detention time, increases with substrate concentration which is in agreement with the results obtained in this study.

The variation of gas production rate (mL/day) and COD removal rate (g/day) with different inlet substrate concentration and hydraulic detention times are compared in Figure 3. As can be observed from this figure, the correlation between the two curves (COD removed and gas production) are quite high and exhibit almost the same qualitative behaviour with a few exceptions.

Daily methane production (mL/day) is also illustrated in Figure 3. It is observed that methane production decreases with increasing

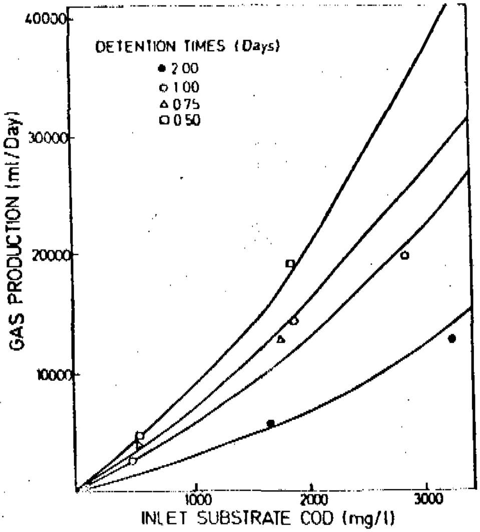

Fig. 4. Variation of gas production with inlet substrate concentration and detention time.

detention time and vice versa. This is also in agreement with Russo's results.

The effect of detention time and inlet substrate concentration on the methane production per gram COD removed (mL/g COD removed) and the gas composition (%CH_4) are illustrated in Figure 5. It is observed that methane percentage increases with decreasing inlet substrate concentration, which is in agreement with Russo's findings. On the other hand, the fact that methane percentage increases with increasing detention time is contradictory to Russo's results. However, change in methane percentage with detention time is very small in Russo's work. Furthermore, an observation similar to the one made in this study was also reported by Keenan and Kormi [9] whose methane to carbon dioxide ratios were 1.67 - 1.68 and 2.13 - 2.17 for detention times of 8 and 15 days, respectively, at the same substrate concentration.

The ratio of mL CH_4/g COD removed increases with increasing influent substrate concentration and decreases with increasing detention time. The effect of detention time can be explained as follows: At high detention times, the conversion of COD to methane is more

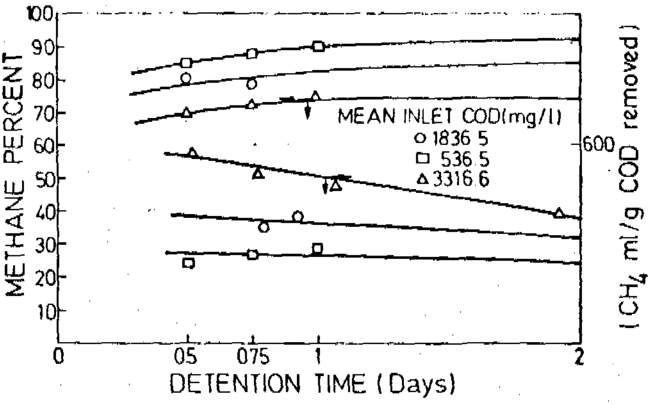

Fig. 5. Variation of methane composition and volume per gram of removed COD with detention time.

complete, however a certain amount of COD is converted to new cell growth. At lower detention times, the organic loading increases, but the percentage of COD converted into new cells may not increase at the same rate. This leads to an increase in CH_4 produced per gram of COD removed, despite the fact that methane percentage in the produced gas decreases.

As for the effect of inlet substrate concentration on the ratio of mL CH_4/g COD removed, similar results were obtained by Russo [14] who observed that the ratio mL CH_4/mg COD removed increased from 0.52 to 0.55 as the influent COD increased from 6250 mg/L to 15750 mg/L. However, he found that the ratio of mL CH_4/g COD removed decreased with increasing organic load whenever the organic load exceeded 1 kg/m^3/day (0.9624 lb/ft^3/day). This result had not come out as he had expected and explained it as a consequence of excess volatile acid concentration.

In this study, methane production (mean) was 467 mL per gram of removed COD which was greater than the theoretical value of 380 mL [11]. However, Russo had also reported a mean value of 470 for distillery wastewater which also exceeds the theoretical value.

Suspended Solids Removal

During the first run of the experiments, suspended solids in the substrate and the samples taken from different heights of the filter were determined. The results indicate that the biological solids are flocculated densely and they are not dragged easily by the rising substrate and gas bubbles.

As shown in Figure 6, SS removal increases with detention time. Explanation of this expected result may be the following: more SS were accumulated in the filter (at the bottom and in the filter media) during the rise of substrate at higher detention time. On the other hand, a larger amount of the accumulated material was flushed out due to the increase in velocity at lower detention times, thus concentration of SS in the effluent increases with increasing effluent velocity. The same result was obtained by Drohobyczer [4].

In this study, it was observed that the influent suspended solids concentration was always greater than the effluent suspended solids concentration. However, there is no definite relationship between influent concentration and the SS removed (Figure 6). Jennet and Dennis [7] support this result saying that the major factor that affects solids loss seems to be hydraulic loading, because the major fluctuations occur after decrease in detention times, rather than after changes in effluent concentration.

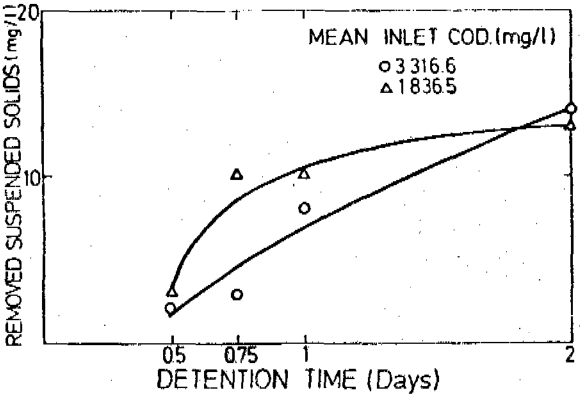

Fig. 6. Effect of detention time on suspended solids removal.

COD Removal

The effluent COD concentration and COD removal efficiency are both affected by influent COD concentration, detention time and temperature. Figure 7 shows the daily variation of effluent COD and efficiencies with respect to these parameters during steady state operation. As can be observed from this figure, COD removal efficiency is directly proportional with hydraulic detention time and inversely proportional with influent COD concentration. During the period of steady state operation with different substrate concentrations and detention times, samples were withdrawn from the filter at various heights and analyzed. The resulting curves for efficiency are shown in Figure 8 for a constant hydraulic detention time at three different substrate concentrations. A very high rate of COD removal in the lower part of the filter (especially up to 5 cm (2 in) above the base plate) and a stability in efficiency is observed higher than 30 cm (11.8 in) above the base plate of the filter. Similar results were obtained for other hydraulic detention times [8].

As a general trend, at the higher detention times and lower influent COD concentrations, the rate of COD removal was much higher in the lower part of the filter. This means that at lower loading rates, acids were converted to methane gas almost as rapidly as they were formed. pH profiles discussed at the previous subsection, support this explanation. Parallel results were obtained by Young and Mc Carty [18], Foree and Lovan [6], Jennet and Dennis [7] and Russo [14].

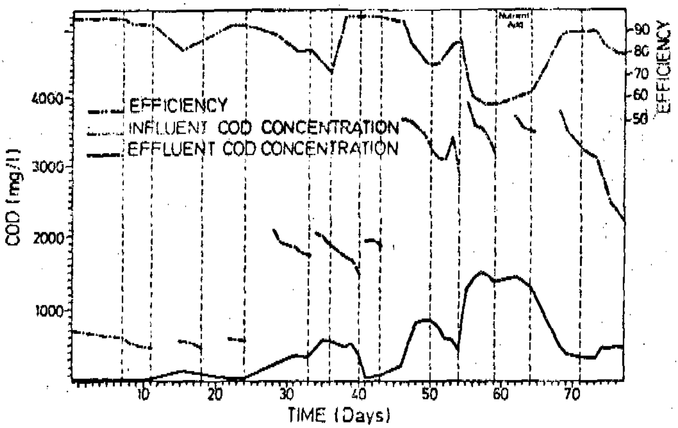

Fig. 7. Variation of influent, effluent COD concentrations and COD removal efficiency with time.

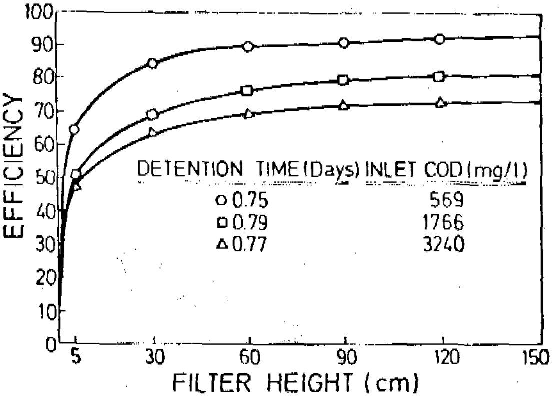

Fig. 8. Variation of COD removal efficiency with filter height for different influent concentrations.

To further study the effect of detention time on COD removal, the data were statistically analyzed. It was found possible to define three different inlet concentrations, low (536.5 mg/L COD), medium (1,836.5 mg/L COD) and high (3,316.6 mg/L COD), by simply averaging over the different inlet concentration values corresponding to the three different dilutions of the feed. Then data points corresponding to inlet concentrations which deviate significantly (more than twice the standard deviation) from these averages were discarded. Figure 9, where the selected values of percent COD removal based on measured inlet and outlet COD values are plotted versus detention time for the highest inlet concentration, clearly shows the effect of detention time on COD removal when inlet concentration is constant.

Finally, the COD removal efficiency was plotted versus organic load (Figure 10). It is observed from this figure that there is considerable scatter in these data, especially at organic loads corresponding to lower detention times for each inlet concentration. Hence, it was decided that representation of these data by means of a single curve is highly inappropriate. The explanation is as follows: Both inlet concentration and detention time affect the removal efficiency, but not at the same rate. For example, doubling the inlet concentration and the flow rate by half leave the organic load unchanged, but a considerable change in removal rate may occur unless the overall reaction is independent of substrate concentration. However, this will require a zero order

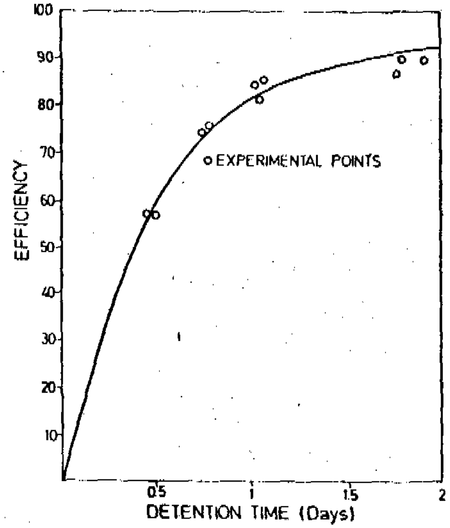

Fig. 9. Variation in COD removal efficiency with detention time for the highest influent concentration.

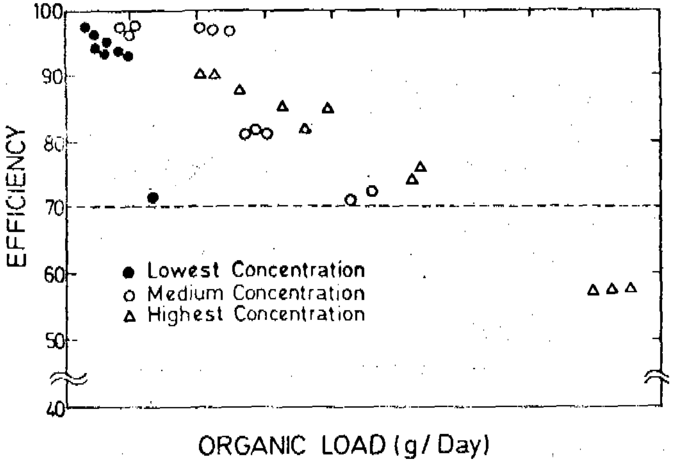

Fig. 10. Effect of organic load on COD removal efficiency.

reaction mechanism with respect to substrate concentration which is not in accordance with previous investigations. The effect of inlet concentration on COD removal will be more pronounced at lower detention times where the entire filter appears to be reactive (Figure 10).

Temperature Effects

In order to observe the effect of temperature on the performance of the filter, a specific run was carried out 25 ± 2°C, trying to keep the detention time (2 days roughly) and the influent concentration (3,200 mg/L COD) unchanged with respect to the previous run. However, the inlet concentration decreased gradually down to 2,200 mg/L COD although the detention time remained constant. The deviation in the influent concentration from a constant value, was compensated by using percent removal efficiency as a parameter during the evaluation of the data.

The temperature control system was switched off and data were collected till steady state was reached at the ambient temperature (25 ± 2°C). The effect of temperature on substrate removal efficiency along the filter height can be observed in Figure 11. With the decrease of temperature from 35 ± 2°C to 25 ± 2°C, the COD removal efficiency showed an obvious decrease from 90% to 79.5%. But, it should be noted that the loading rate decreased from 21.88 to 15.35 gm COD/day also and since it was observed that efficiency increased as loading rate decreases, at the same loading rate, the difference between these two efficiencies should be greater. While

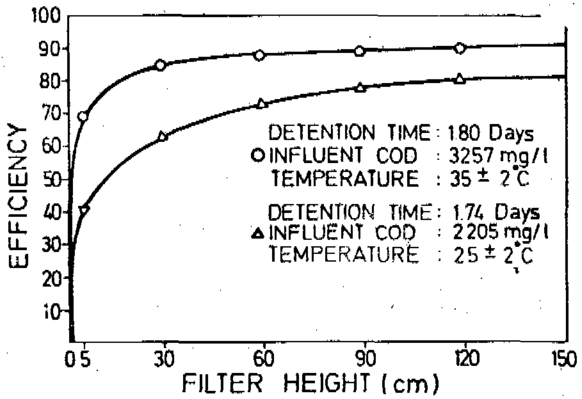

Fig. 11. Effect of temperature on COD removal efficiency.

the total gas production decreased from 12 L/day to 9 L/day, the methane percent decreased from 75% to 65% and related to it, the CH_4 mL/g COD removed ratio showed a decrease from 488 to 482.

The general trend of the pH changes remained the same during the run.

The results obtained in this run agrees with Young and Mc Carty's comments [18] about the effect of temperature on the anaerobic decomposition. The rate of reaction in the mesophilic range increases with temperature. Though the optimum temperature is 37°C, it is still possible to attain anaerobic filtration with an appreciable performance at ambient temperatures.

Effect of Nutrient Addition

On the 59th day of the experimental study, the COD:N:P ratios of the substrate were increased from 100:1.24:0.3 to 100:2.68:0.5 by adding diammonium phosphate ($(NH_4)_2HPO_4$) and potassium nitrate. A new substrate satisfying the new condition was used keeping the influent concentration (3,500 mg/L COD) and the detention time (0.5 days) constant with respect to the previous run. Data were collected for five days until steady state was reached.

Figure 12 shows a negligible increase of about 5% in the COD removal efficiency and again it is observed from Figures 3 and 7 that there is no significant increase in the performance of the filter with the increased nutrient ratio.

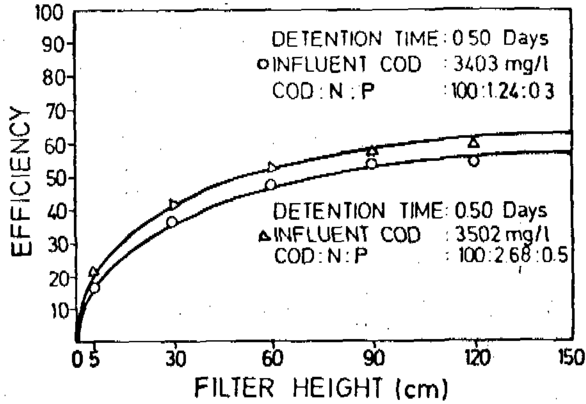

Fig. 12. Effect of nutrient addition on COD removal efficiency.

While the total gas production increased from 41 L/day to 50 L/day, the methane percentage decreased from 70% to 65% after the addition of nutrients. In the ratio of CH_4 mL/g COD removed, a slight increase from 588 to 602, was observed.

According to the results obtained in this run, slight changes in the parameters determining the total performance of the filter are recorded. However, a significant increase is observed in the total gas production which can be explained as an experimental error.

Intermittent Opération

After 77th day of the experiments, operation was stopped for 14 days. At the end of this period, the filter was started with 2,000 mg/L COD substrate concentration and 2 day detention time at 35 ± 2°C. Data were collected after the attainment of steady state. 96.0% COD removal efficiency, 5,970 mL/day gas production and 80% methane were reached after 7 days from the beginning of this run. Also, CH_4 mL/g COD removed ratio was calculated as 467.

Before the pause in the operation, 96.96% COD removal efficiency, 5,240 mL/day gas production, 85% methane and 460 mL CH_4/g COD removed had been obtained at the same detention time and influent COD concentration.

According to the above data the 14 day pause in the operation did not affect the filter performance.

Effluent Quality

The effluent from the filter was clear and colorless and contained a very low concentration of suspended solids, even at the higher hydraulic and/or organic loading rates. pH of the effluent varied from 5.5 to 7.5 during the study.

However, it had an objectionable odor which can be attributed to sulfides (primarily H_2S) and other obnoxious gases.

CONCLUSIONS

The conclusions which can be drawn from the experimental findings of this study can be summarized as follows:

1. For brewery wastes with COD values in the range of 440 - 4050 mg/L the anaerobic filter appears to be an efficient means of treatment at mesophilic temperatures with detention times as low as 12 hours.

2. COD removal efficiency decreases with decreasing temperature, however with higher detention times (2 days), appreciable COD removal rates (80%) are still possible at ambient temperatures around 25°C.

3. The maintenance requirements of the anaerobic filter is minimal since the solid production is very low and sludge disposal is not necessary for long periods of continuous operation.

4. The operation of the filter is also quite easy, since addition of nutrients is not necessary, and operation can be continued without noticeable change in efficiency after pauses which may take as long as two weeks. Furthermore, the hydraulic head loss through the filter is also negligible, indicating that the accompanying energy requirements are very low.

5. The liquid effluent is practically free of suspended solids; however, it has objectionable odor which may arise from sulfides and other obnoxious gases. This may require additional treatment, hence constitutes a disadvantage.

6. The production of methane gas, which can be used as a source of energy is an additional advantage. Total gas production and methane production increase with increasing organic load. The ratio of methane produced (mL) to the removed organic load (g) is found to be 467. The percentage of methane in the produced gas increases with decreasing substrate concentration and increases with increasing detention time.

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"ASSIMILATIVE CAPACITY OF THE KALAMAS RIVER AND THE LAKE PAMVOTIS"

A. Katsiri, A. Andreadakis and D. Koutsoyiannis

Department of Civil Engineering

National Technical University of Athens

1. INTRODUCTION

The city on Ioannina, an old and historical city of Greece, is the cultural, commercial and industrial center of Epirus the northwestern part of Greece. The current population of Ioannina is 65,000 people with some additional 40,000 leaving in the surrounding villages and small-towns.

In the process of decentralization, the Greek Government has given incentives for the development of the greater Ioannina area and therefore more intensive activities both civic and industrial are anticipaled for the near future. Potential sectors of development exist in agriculture, animal raising, fisheries, hand-crafts and tourism. As a basic infra-structure works, the sewarage of the city of Ioannina is almost completed.

The area includes two important and scenic surface water bodies the lake Pamvotis and the river Kalamas which support a wide variety of plant and animal life and whose conservation is of parament important. It is well recognized that very often unprogrammed and quick development can cause serious and sometimes irreversible damage to the quality of the environment. The quality of the surface waters becomes therefore a critical parameter in the process of development of the area and which will enable the decision maker to establish priorities and fields of action.

This paper which is intended to be of informative rather than of a highly technical nature identifies the problems and outlines the methodology of establishing water quality criteria and controlling wastewater effluent in an integrated matter.

It presents the preliminary results of a research programme currently carried out by the Department of Water Resources of the National Technical University of Athens on behalf of the Ministry of the Environment.

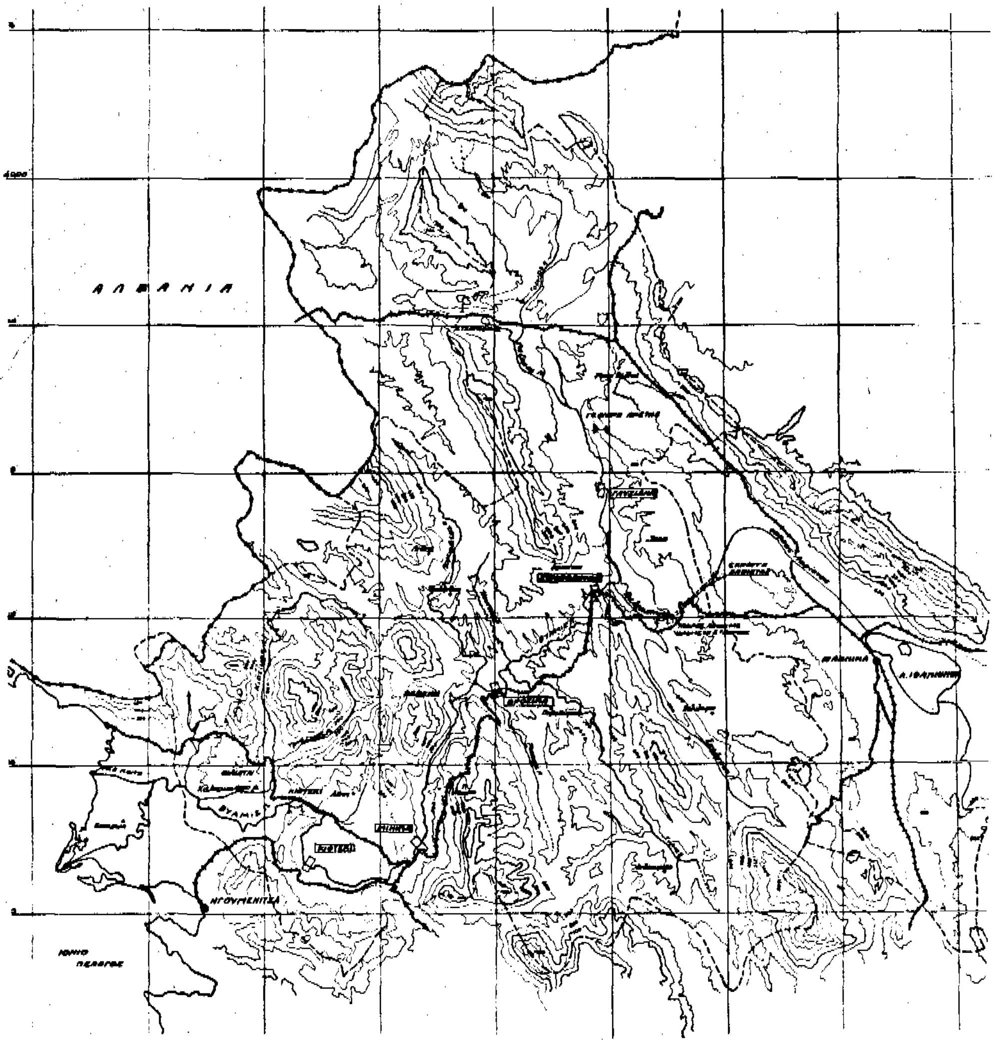

Fig. 1 The study area.

2. PHYSICAL AND TECHNICAL BACKGROUND

The study area comprises two major catchments-the cathment of the Lake "Pamvotis" and the catchment of the Kalamas river (Figure 1).

The lake Pamvotis or lake Ioannina is the largest lake of the Epirus area having a surface area of 22 km^2 and a maximum length and width of 8.5 and 3.5 km respectively. The total capacity of the lake is estimated around $95X10^6m^3$. The lake lies at the lowest point of a closed drainage basin of 475 km^2 in a region of predominantly limestone geology with strong carstic character. Thus a big amount of the water falling in this area is lost to neighbor basins i.e. to the Kalamas and Arachthos basins.

The lake originally extended mostly to the northwest and also to the south-east forming shallow marshy areas of some 45 km^2. In the 1950's a series of major works were built in order to drain the area and reclaim it for agriculture. These works comprised the Lapsista canal which extends 42 km to the north-east of the lake and drains the Lapsista area to the Kalamas river. The canal is connected by a gravity flow tunnel to the "Veltistikos" a tributary that joins the Kalamas near the village "Soulopoulo". The outflow from the lake to the canal is controlled by headworks. Water is drawn directly from the lake for irrigation of the south-east area, appr. 1000 ha in 1983 and also to supplement. Water needed for the irrigation of Lapsista area and which is taken mainly by springs.(2.100 ha).

The Kalamas river is classified among the most important rivers of Greece with an average flow of 57 m^3/sec near its mouth to the sea. The river flows through a natural cathment area of 1722 km^2, which lies almost entively within the Greek territory. The annual precipitation of the basin is 1360 mm and the surface run-off coefficient was estimated at 0.76. The total length of the river is 120 km, with 80 km downstream the Soulopoulo confluence. It is a swift flowing river with velocities ranging from 2.0m/sec near its spring to 0.5 m/sec. The time of flow below Soulopoulo is estimated at 1 day.

Water is drawn from the Kalamas river to irrigate an area of 2,000 ha at the Kioteki plain . Small amounts of water are also drawn for water supply and fisheries.

3. HYDROLOGICAL BALANCE OF THE LAKE PAMVOTIS-TIME OF RESIDENCE

Very little is known about the flow into and out of the lake due to the large amount of subterranean flows.

However in the basis of available flow records, irrigation practices etc. an attemp was made to estimate the average time of residence in the lake.

The equation for the water balance sheet for the lake can be written in the following way.

$$\underbrace{P + Q + G_I}_{\text{inlet}} = \underbrace{E + Y + A + G_o}_{\text{Outlet}} \quad \text{where}$$

P = annual precipitation on the lake surface
Q = surface runoff
G_I = ground-water inflows
E = evaporation
Y = overflow to the Lapsista canal
A = irrigation
G_o = sub-terranean losses

Each one of these terms was assessed separately based on long rainfall records and evapotranspiration analysis. Thus the average annual inflow to the lake was estimated around 140×10^6 m^3. The average renewal time for the lake is therefore 0.79 years or 1.27 times/year. For dry and wet conditions respectively with a return period of 5 years the residence time is estimated as 1.14 and 0.60 years.

4. MINIMUM FLOWS OF THE KALAMAS RIVER

Data from three flow-gauging stations in the Kalamas river for which records exist for period longer than 10 years were analysed and processed statistically in order to draw the flow-duration curves. Ten-day average values were used in the calculations as these are known to represent pollution transport phenomena better Min values for 6 characteristic sites of the Kalamas (including the exit of Lapsista tunnel) are shown in table 1.

Table 1. Min flows (10-day average)

	Return period-years				
Site	2	5	10	20	50
Lapsista	0.02	0	0	0	0
Soulopoulo	8.22	7.02	6.32	5.72	5.02
Vrossina	11.45	10.16	9.42	8.78	8.03
Minina	14.13	12.78	12.00	11.33	10.53
Irrigation dam	15.29	13.91	13.11	12.42	11.61
Near outfall	17.34	15.94	15.11	14.39	13.55

5. BENEFICIAL USES

The present uses of the lake are fishing for carp and crayfish, eel culture in cages, the supply of irrigation water and recreational boating. Swimming in the lake is also observed occasionaly.

The Lapsista canal serves primarily as a drainage canal for irrigated areas but it also receives the effluent from a number of industries and farms.

Finally the Kalamas river offers to the people of the area a number of beneficial uses which include fisheries of trout and carp, irrigation, water supply and recreational fishing and swiming. It must be noted here that abstraction for water supply is carried out in the summer months, not directly from the river but from wells lying close to the river bed. A total number of 3.000 inhabitants are served in this way. Finally the esthetic and cultural value of the river can not be overemphasized.

6. CURRENT WATER QUALITY ASSESSMENT

Existing data on the quality of the surface waters were scarce and sporadic. For the purposes of this study a systematic sampling program has been organized. The program will be completed at the end of July 1984.

Lake Pamvotis. The sampling program for the lake includes sampling from 7 characteristic points in the lake and 3 points in the Lapsista canal. Parameters measured include BOD, COD, SS, temperature mineral nitrogen, phosphates, dissolved oxygen, transparency and chlorophyl.

Table 2 shows the evolution of some characteristics parameters in the lake from measurements taken in the period 1976-1983 by various organizations.

Table 2. Quality of lake Pamvotis (1)

Parameter				Date - source
D.O	BOD p.p.m	NH$_4$ p.p.b	PO$_4$-P p.p.b	
-	5-7.0	-	-	77-79 PERPA
8.4-10.8	-	14-40	16-40	77-79 IOKAE
-	3.05	-	-	June 1981-University of Ioannina
9.0-10.2	3-6	12-56	30-80	Nov. 1982-PERPA (3)
10.2-10.8	0.50	<100	60-150	Nov. 1983-This study

Although some localized pollution occurs seasonally at the lake margin, the lake as a whole is still basically free of pollution. Its water is clear with a greenish tint due to a light plankton growth. The major ecological disturbance which causes considerable concern to the people of Ioannina is a substantial reduction in total fishery catch in the last two decades, a serious reduction in the proportion of carp and a total disappearance of the eels from the lake. It is almost sure however (2) that the reduction in carp production is a result of the physical changes brought about to the lake by the reclamation works which have reduced the shallow margins of the lake (suitable breeding grounds for carp) and have cut off the natural communication between the lake and the river Kalamas.

Kalamas river and Lapsista canal. The river quality monitoring program for the Kalamas river was carried out between July and December 1984. Samples were taken from 4 points in the river and at the outlet of the Lapsista tunnel at 3-hourly intervals. Water quality parameters recorded on 9.8.83 were slightly higher than on other occasion and are shown in table 3.

Four samples taken from the canal in June 1978 by P.E.R.P.A (1) gave BOD values from 5-7 mg/l COD,15-33 mg/l and E.coli counts from 2400-240000/100 ml. Also two samples from the Kalamas river taken at Soulopoulo and Vrossina gave BOD of 5 mg/l,COD of 17 and 22 mg/l and E.coli counts of 1100 and 2400/100 ml.

6. WASTEWATER LOADS

Waste loads applied to the surface waters originate from two sources: point or discrete sources like sewer outfalls, industrial discharges etc., and non-point or diffuse sources such as urban storm water run-off, precipitation and run-off from agricultural land. Precipitation run-off from undeveloped lands will have certain

Table 3. Average water quality parameters on 9.8.83

		Sampling location		
Parameter		Lapsista	Soulopoulo	Kioteki
pH		7.3	7.3	8.1
temp. 0^{C}		20.0	16.5	19.0
Conductivity		364	703	483
D.O	p.p.m.	85%	100%	112%
BOD	p.p.m.	-	0.50	0.60
COD	p.p.m.	24.0	7.0	14.2
NO_2^{-}-N	p.p.b.	56	2	3.0
NH_4-N	p.p.m.	1.1	0.1	0.5

Table 4. **Pollution loads** from domestic sources

Year	Popul. equiv.	Waste flow m^3/d	BOD kg/d	SS kg/d	Total-N kg/d	Total-P kg/d
1985	63,000	13,000	4095	4410	756	190
2011	81,000	20,000	6480	6885	1215	324

physical, chemical and biological characteristics which will affect water quality in the river and lake, yet this natural load cannot considered as a waste.

6.1 Point sources

Domestic wastewaters: Present and future domestic wastewater flows and pollution loads are shown in table 4.

In the calculation of these figures, the past records of increase in water consumption, in the last 20 years were considered. Population projections were made on the basis of the anticipated development of the area.

Industrial effluents. The main industrial effluent point-sources are localed on the north side of the lake and along the Lapsista canal. They represent effluents mainly from food-processing industries and slaughter houses. Effluents from fish farms were also included in the survey as sometimes they can affect the quality of the receiving waters mainly due to unused food, fish wastes and disease infection. There is evidence (4) that effluent quality vary considerably throughout the year depending on the river flow and temperature.

For the assessment of pollution loads from industrial sources, 24-h composite samples were taken and analysed. These results were verified with data taken from the literature.

Table 5 shows the total amount of pollution contributed by industry. Future projection assume a 30% increase in all loads.

Table 5. Pollution loads - Industrial sources

Year	Flow m^3/d	BOD	SS	Total-N kg/nμ	Total-P
1985	1,440	580	243	470	-
1985 (fish-farms)	110,000	77	330	44	4.4

6.2 Non-point sources

Non-point sources of organic pollution and nutrients are a result of agricultural activities (irrigation, animal raising), natural activities (atmospheric precipitation), run-off from paved areas, subsurface disposal of wastewaters etc.

Whereas phosphates are retained to a great extent by adsorption and precipitation in the ground, nitrates are very mobile and can easily be transferred through ground water to the lakes and rivers.

Annual areal contributions of nitrogen and P to the surface waters are shown in table 6.

Table 6. Nutrient loads - Non-point sources

Source	Drainage area km^2	P		N		Water body
		Unit rate $gr/m^2/y$ (6) (7)	tn/year	Unit ráte $gr/m^2/y$ (6) (7)	tn/year	
Urban run-off	3.5	0.1	0.35	0.50	1.75	Lake
Irrigation	10,0	0.05	0.50	0.50	5.00	lake
"	21,0	0.05	1.05	0.50	10.50	Laps
"	15,0	0.05	0.75	0.50	7.50	Kalamas
Uncaltivaled	345	0.01	3.50	0.30	103.50	lake
	100	0.01	1.00	0.30	30.00	Laps
	1700	0.01	17.00	0.30	510.00	Kalamas
Precipitation	22	0.025	0.05	2.0	44.0	lake

Run-off from the spreading of piggery-wastes In the study area there exists a great number of pig-farms. For the purposes of this study the most important, from a point of view of size and potential pollution, were singled out and investigated. With the exception of two farms lying near the Lapsista tunnel which treat their effluent in anaerobic laggons prior to land disposal, all other units spread their wastes directly on farm land. Because of this fact the pollution caused by piggery wastes is considered as a diffuse source. In order to be able to estimate the amount of pollutants leached out to the lake the criteria for land disposal of wastewaters and sludges put forward by EPA (9) were used. Data for the amount of wasteflows produced were obtained from the farmers from a national survey carried out by the Ministry of Hygiene and were correlated with published information(10). Pollution loads were estimated using data aquired in our laboratory from analyses of similar wastes as well as literature sources. Two different soil types were recognized: soils with very slow infiltration rates in low areas lying very close to the lake, with max annual application rates of 0.25 m/year and soils which can support application rates of the order of 1.0 m/year.

Given that the max. BOD rate which can be supported by a fallow soil rich in organics cannot exceed 30 t/ha (9) it is obvious that leaching of BOD to the drainage water will occur. Assuming an average drainage run-off coefficient over this part of the area of 0.30, the loss of BOD to the surface waters is estimated as 20% of the total. This result is in excellent agreement with work done in Ireland (11). For N and P the recommended values for crop production should not exeed 500 kg N/ha and 26 kg P/ha (11). Based on experiments done in Ireland and an extensive survey of the literature done by Kolenbrander the corresponding losses of N and P to the surface waters is estimated at 40% and 20% respectively. The later will be almost entirely in the mineral from (11). Pollution loads from piggery wastes are shown in table 7.

Table 7. Piggery wastes - Pollution loads to surface water

Sows	Flow m^3/y	BOD t/y	Total-N t/year	Total-P t/year	Water body
1250	33200	130.0	60,0	7.0	lake
475	11170	-	48,0	2.4	Lapsista

Calculation of effluent standards by mass-balance. Effluent discharge loads can easily be calculated using simple mathematical models. For the Kalamas river a mathematical model based on the Streeter-Phelps equation and prepared by SOGREAH for the Pinios river is being used (Programme CARIMA). In addition the model makes use of the Saint-Venant equations of the unstready flow. The adjustment of the model for the Kalamas river and its solution for a series of typical situations is outside the scope of this paper.

For the lake, a eutrophication model proposed by Jones (8) is being used. To model is used to predict the long-term concentration of phosphates in the lake, since PO_4-P is known to be the limiting factor.

8. CONCLUSIONS

This paper has outlined a comprehensive approach to the problem of controlling water pollution in an important catchment. This method is currently being used by a number of water authorities in Europe and the U.S. Despite the high amount of time and effort required it offers the opportunity to tackle water pollution problems in a rational way and to promote, co-operation within a given catchment especially in cases such as this where administrative jurisdiction over the waters is exercised by different authorities. It also offers a unique way to establish priorities and make cost-benefit assessments.

Finally it is a means for the public to be involved in the problem of preserving the environmental quality.

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RECYCLING OF SOLID WASTES
IN THE CITY OF İSTANBUL

Günay Kocasoy
Department of Civil Engineering, Boğaziçi University

İsmail İlkin Esen
Department of Civil Engineering, Kuwait University

INTRODUCTION

All developed countries, being aware that natural resources are limited, have started to get concerned about recycling their wastes since 1970. This was a result both of the energy crisis and the for the environmental impact of rising living standards. For example, although for a very long time the problem of solid wastes was considered only from the point of view of eliminating pollution, on 15 July 1975 European Economic Community (EEC) has adopted general directives on waste management in which "recycling" was accepted as mandatory. Furthermore, the Community Waste Management Committee which was established in 1976, started to work on "...studying ways of reducing waste at the moment of production and consumption, increasing the life of goods and modifying the design and recycling, encouraging manufacturers to use recuperable material as much as possible...promoting selective waste collection systems to facilitate reprocessing and reuse of wastes " (Commission of the European Communities, 1979). However, since recycling usually requires less energy than producing from raw materials, minimization of the use of energy emerges as a second important objective. Furthermore, recycling reduces the amount of wastes to be disposed.

Although developing countries are in tighter constraints for producing the materials required for their development, they usually waste most of the recycleable material due to improper management. In the present paper, the practice of recycling in the city of İstanbul is summarized.

SOLID WASTES RECOVERY IN THE CITY OF ISTANBUL

Istanbul is a city where recycling has started to be practiced a long time ago. The "eskici" is a well-known figure in Istanbul who is still going around in the streets of the city, buying all the recycleable items, usually at a very low price.[x] However, although recycling has started since very old times, it is difficult to say that it has managed to reach any technological level.

Recovery of Domestic Wastes

Different methods are used for the recovery of domestic wastes. The most common of these can be classified as follows:

a) Separation and Recovery of Materials at Source

Materials such as newspapers, bottles and metals are sometimes not disposed into the refuse can, but instead they are separately collected and sold to small merchants who operate collecting depots, or wander in the streets. This method, however, is most common in the low income areas - where of course recoverable materials are very limited - and because of that it is hard to say that it has any significant share in the overall amount recycled.

b) Sorting and Recycling by the Building Janitors

Buildings located in medium and high income areas usually have a janitor acting as a door-keeper and superintendent who among other duties collects the garbage from individual apartments and disposes them through the waste collection truck. These people usually sort out materials such as paper, glass, etc. before disposing off the wastes and they sell them to collectors.

c) Collection from the Refuse Receptacles

Special collectors examine early in the morning or late at night the contents of the refuse receptacles and collect items which they sell either after processing (cleaning, washing, drying, etc.) or directly as they are.

d) Collection from the Disposal Sites

Special scavangers sort and collect the solid wastes as soon as the collection trucks empty their loads at the disposal sites.

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[x] eskici means "old article collector" in Turkish.

These collectors sell the material which they recover to the "aga - lord" of the waste disposal site every day. The "aga" resells these to the factories which reprocess them.

Recovery of Industrial Solid Wastes

The solid wastes produced by different industrial activities are not collected by the solid waste collection trucks of the municipality. Usually these materials are sorted and stored within the factory premises. The recycleable part of these is either used within the factory or sold to interested parties. The remaining parts are disposed to the solid waste disposal site of the municipality.

EFFICIENCY OF SOLID WASTE RECYCLING

The efficiencies obtained with the primitive methods of recycling explained above are not very high. The composition of the solid wastes of Istanbul as they are delivered by the refuse collection truck to the solid disposal site is given in Table 1. Curi and Esen (1984) have tried to determine the amount of solid wastes recycled by the scavangers in the disposal site. After sorting the load of a truck, the scavangers were allowed to take whatever they considered useful, and the amount which remained was determined. From these values, the recycling efficiency which is defined as the ratio of the amount taken by the scavangers divided by the total amount existing initially was determined. The data obtained are summarized in Table 2.

Table 1. Composition of the solid wastes of Istanbul as delivered to the solid disposal site

Component	Composition, %
Food Remains	42.2 - 61.4
Paper and Cardboard	12.3 - 25.3
Plastics	2.8 - 8.2
Glass	0.2 - 0.9
Textiles	0.0 - 6.1
Metals	5.4 - 8.2
Ash	5.2 - 23.5
Miscellaneous	0.0 - 9.2

Table 2. Recycling of Solid Wastes

Component	Composition as delivered (%)	Composition after scavangers picked up useful material (%)	Amount of not recycled material (%)
Food Remains	58.2	71	100
Paper-Cardboard	14.0	9	66
Plastics	2.8	3	48
Glass	0.9	1	27
Textile	1.2	6	83
Metals	5.4	3	30
Ash	9.3	5	90
Miscellaneous	8.2	2	100

As can be seen in Table 2, the recycling efficiency is rather low. In reality, the actual efficincies will be even lower, since the scavangers will not be able to work that carefully in actual. On the other hand, Patrick (1981) estimated that the amount of domestic solid wastes recovered would be in the order of 50.000 tons per year. This constitutes only 15% of the potentially recoverable material which amounts to 330.000 tons per year.

The composition of the remaining recoverable material is estimated as 93.360 tons paper, 28.050 tons plastics, 5.980 tons glass, 29.620 tons textile and 13.150 tons metals (Patrick 1981). On the other hand, according to a survey conducted by the staff of the Project of Solid Wastes Management in İstanbul Metropolitan Area, out of the total amount of one million tons of solid wastes produced by industries, 45% is recycled. Table 3 gives the percentage of solid wastes recycled in different industries.

NEED FOR RECYCLED MATERIAL

Turkey,as a developing country, has to recover as much recyclable material as possible. The need for these materials is so large that sometimes some such materials are imported. For example, Turkey presently needs 10^6 tons of scrap iron annually for the iron and steel industry. However, only 250.000 to 300.000 tons are obtained locally, while the remaining part is imported (Curi and Kocasoy,1982). If it is considered that the total amount of scrap iron available for recycling is in the order of $1.3 - 1.9 \times 10^6$ tons/year, then it is easy

Table 3. Percent of Solid Wastes Recycled in Different Industries (Patrick 1981)

Type of Industry	Percent Recycled
Food	55.1
Drink	65.6
Tobacco	16.9
Textile	66.5
Clothing	55.8
Furs and Leather	5.7
Footwear	58.4
Wood and Cork	66.2
Wooden Furniture	45.6
Paper and Paper Products	81.6
Publications and Related	79.8
Principle Chemical Products	60.6
Other Chemical Products	15.7
Petroleum and Coal Byproducts	57.6
Rubber Products	58.1
Other Plastic Products	7.8
Pottery	84.8
Glass Products	18.8
Extraction	72.3
Iron and Steel Productions	14.9
Non-ferrous	38.3
Metal Goods	48.4
Machinery (except electrical)	55.0
Electrical Machinery	27.3
Vehicle	26.9

to realize that the lack of an efficient recycling methodology is causing important financial problems (Kocasoy,1984). Sevinç (1981) on the other hand, emphasizes the importance of developing the appropriate technology for plastic recycling. Kıran (1979) informs that only 27% of the paper produced in Turkey is recovered, and only 70% of that is reused , the remaining is poor quality paper. In 1980, only 61.088 tons of waste paper was recycled in İstanbul for the production of new paper products (Doğan,1980), while the amount required is much larger. Improvement of the paper recycling techniques will not only have a financial benefit, but at the same time contribute to the protection of nature.

CONCLUSION

The need for improving recycling of solid wastes in the city of İstanbul is an unquestionable fact. Some simple measures which can be taken are the following:

a) Encourage "Seperation at Source"

The sorting of solid wastes at the source gives better results, because i) it is possible to reuse the materials with a simple processing, ii) the recyclable materials are prevented from becoming dirty by contacting other wastes, iii) the resale of the material becomes easier.

Such practices have given very satisfactory results in other countries. For example, Belgium is carrying out successfully a separate household collection of glass in a number of towns. Among these, the city of Ghent has managed to recover 85% of glass (Claes,1980). On the other hand, the Law on Waste which came into force in the Netherlands in October 1979 encourages seperation at the source (Troeder,1980).

b) Improvement of the Recycling Technology

The method presently used for solid waste recycling by scavangers at the waste disposal site should be abondened. However, this method should not be replaced by a complicated technique. Simple and efficient methods should be adopted. For example, a method which can be recommended is to dispose the solid wastes on a moving belt, on both sides of which workers will stand and separate the materials by hand. Such a technique will be more efficient than the existing system. Furthermore, it is simple and it does not depend on imported technology. Finally, being man-dependent, it won't replace man-power by machine, thus, it will not contribute to the unemployment problem presently faced.

c) Development of Technology

Necessary technology and facilities for processing recycled goods should be developed. This will contribute to increased recycled materials, and will motivate improvement of recovering solid wastes.

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OVERLAND FLOW WASTEWATER TREATMENT POTENTIAL IN DEVELOPING COUNTRIES

Andrew P. Kruzic, Ph.D.

Alexander von Humboldt Fellow at
Technical University of Hamburg-Harburg
2100 Hamburg 90, W.-Germany

INTRODUCTION

Overland flow wastewater treatment appears to be a viable process with several important advantages for developing countries. The overland flow process in the United States has evolved from the British grass filtration process which dates back to the 1960's.[1] The major difference between a grass filtration process and overland flow is in operation. A grass filtration system is operated continuously for up to eight months, while in overland flow systems wastewater is applied only part of the day but throughout the year.

This paper will describe the overland flow process in detail and discuss the potential advantages of an overland flow system as well as some of the potential problems. Furthermore this paper will discuss how to design and operate an overland flow process to maximize organic material and nitrogen removal. Much of this discussion will be based on the results of research performed on experimental facilities at the University of California, Davis (UCD) and at the United States Cold Regions Research and Engineering Laboratory in New Hamsphire (CRREL).

OVERLAND FLOW PROCESS DESCRIPTION

Overland flow is categorized by the USEPA as one of three processes for land treatment of wastewater. It differs from the other two systems, slow rate (SR) and rapid infiltration (RI) in several aspects including type of soil used, hydraulic loading rates, hydraulic pathways of the applied wastewater and cover crops grown.

In overland flow, wastewater is applied at the top of a carefully graded, vegetated slope and flows primarily over the soil surface. The effluent is collected for further treatment (e.g. chlorination), reuse or discharge to a receiving water. Although the overland flow process may appear simple, the pollutant removal mechanisms and pathways are varied and complex. The major pathways for organic material and nitrogen removal in overland flow will be discussed later in this paper. Physically the system can be divided into three major components: the distribution system, overland flow slope and effluent collection system. A process schematic illustrating these components and the hydraulic pathways is shown in Figure 1. The design of the physical components of an overland flow system will be discussed briefly here. Smith and Schroeder[2] provide a more detailed discussion based on experience at the City of Davis overland flow treatment plant.

With a properly designed and operated distribution system, wastewater should be applied at a controlled rate uniformly across the width of the overland flow slope. Non-uniform application will result in higher loading of part of the slope and decreased treatment efficiency. Fluctuations in the application rate can also affect treatment efficiency but to a lesser degree than non-uniform application. Several distribution systems have been used successfully for overland flow application including impact sprinklers, fixed head spray nozzles, rotating boom spray, gated pape and slotted troughs. Selection of a distribution system should be based on the wastewater and site of the project.

The overland flow slope refers to the physical surface of the sloped soil and cover crop. Uniform flow of water down the length of the slope must be maintained to achieve maximum process efficiency. Therefore slopes must be designed, constructed, and maintained with that objective in mind. The variables in overland flow slope design include the length and grade of slope, type of cover vegetation, and type of soil. These variables affect process performance but cannot be easily altered once a system is constructed.

The soil of an overland flow process serves several functions. It is the primary surface on which microbes are attached and grow; it provides mechanical support for the cover crop, and it may have chemical properties important in the treatment process (i.e. cation exchange capacity). Typically, overland flow systems have been used at sites with soils of low permeability. Soils with low permeability have been considered prerequisite for groundwater protection due to the relatively high loading rate (2 to 4 cm/day) and limited pretreatment associated with the process. However, this precaution may not be necessary since even sandy soils will eventually acquire a very low permeability due to biological clogging.

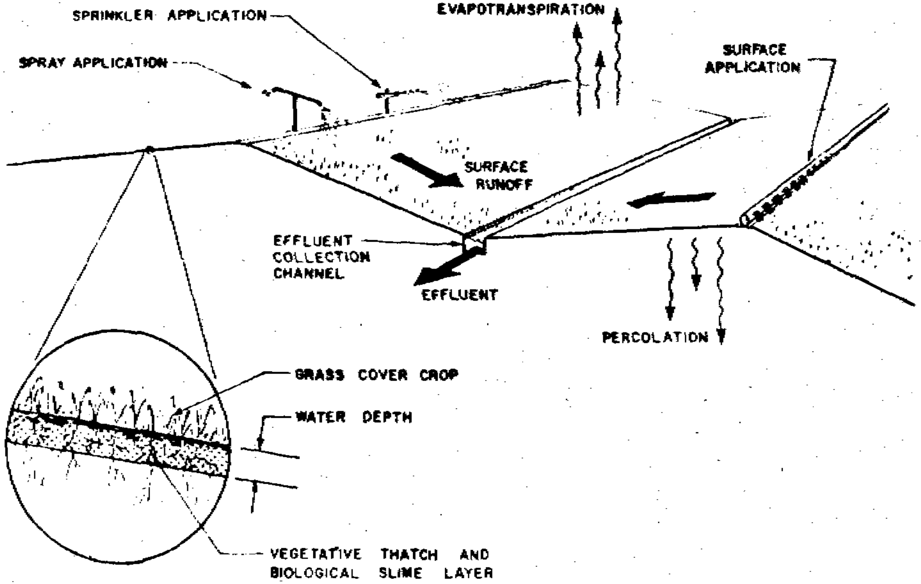

Figure 1. Overland Flow Process Schematic

Only one study has been performed to examine the effect of different soil types on process performance.[3] The study was predicated on the concept that overland flow systems with sandy and loamy soils might perform equal to or better than the typical clay soil systems in nitrogen removal despite lower mineral cation exchange capacity. The result was that within three months the four different soils studied produced approximately the same nitrogen removal results.

Cover vegetation also has more than one function in an overland flow system. Its primary function is to stabilize the soil from water erosion. In addition cover vegetation takes up nutrients during growth and may enhance the soil environment for microbial conversion of pollutants. It is also possible that through evapotranspiration the cover crop increases the transport of water and nutrients into the soil. the best types of cover vegetation for an overland flow system are water tolerant grass species. Planting a mixture of grasses is desirable and if the grass is to be harvested it may be necessary to maintain a fairly active program for weed control. However, from the standpoint of process performance there may be little difference between various cover crops as long as the primary function of soil erosion control is maintained.

The function of the slope grade in an overland flow system is fairly obvious but its effect on performance is not. The current design guidelines in the USEPA land treatment design manual specify slopes grades between 2 and 8%, but slopes grades as low as 0.5% in Melbourne, Australia and as high as 12% on a small experimental system in Carbondale, Ill., USA have been used.[4,5,6] It has been demonstrated by Smith[7] that slope grades between 2 and 6% have no statistically significant effect on process performance in degradable organic material removal. Researches at CRREL include slope grade in their design procedure for overland flow systems, but this inclusion is based primarily on theoretical considerations and not on a demonstrated relationship. Unfortunately there is very little data on the effect of slope grade on process performance. Nevertheless, in most cases the design slope grade will be largely controlled by the topography of the overland flow site.

The slope length is the most important physical design parameter in an overland flow system. The slope length and application rate (discussed later) are the main parameters postulated by researchers for predicting degradable organic material removal.[7,8] USEPA overland flow design guidelines call for slope lengths in the range of 30 to 45 m for raw and primary municipal wastewater. However, this guideline is based primarily on limited experience. The slope length should be determined as part of an overall design in conjunction with application rate using one of the degradable organic material or nitrogen removal design relationships summarized in this paper.

The effluent collection system consists of a network of ditches or channels in which runoff is transported to additional treatment facilities or discharge. Channels are sized to accommodate both storm runoff and effluent flows. The channels may need erosion protection in some sites and should be designed to prevent degradation in effluent quality.

In the past most designers and researchers have used hydraulic and/or pollutant loading rates as the main operating parameters in an overland flow system. Hydraulic loading rate (cm/day or cm/wk) is obtained by simply dividing the volume of wastewater applied per day or per week by the surface area of the overland flow slope. By itself it supplies only limited information about the operation of the system. Pollutant loading rate (kg/ha-day) is the mass of any pollutant, e.g. BOD , TOC, NH -N or PO -P, applied to the slope per day divided by the area of the slope. It is also often expressed as a weekly or yearly rate, and is most commonly used in describing the organic material loading of the process. Pollutant loading rate can be used to compare the overland flow process with the other land treatment processes but is not useful in predicting or describing process performance with the possible exception of high strength industrial wastewaters.

Smith[7] defined and developed three parameters to describe and analyze organic material removal in the overland flow process: application rate, application period, and application frequency. Application rate (m^3/h·m) refers to the flowrate of wastewater applied per unit width of slope. Application period (hrs on - hrs off) is used to specify the consecutive hours of application (wetting) and non-application (drying). Similarly the application period (days on - days off) is used to describe days of application followed by days of non-application. The application period and application frequency are convenient parameters to use in describing the process operating schedule when the unit application period (on time plus off time) is 24 hrs, which is the usual case. However, for different periods the parameters become cumbersome.

Obviously application rate, period and frequency are more descriptive than hydraulic loading rate. The problem with hydraulic loading rate is that it is too general. For example, different combinations of application rate and period can result in the same hydraulic loading rate. It is not reasonable to expect the same process performance when 2 cm of wastewater is applied in a few hours versus over a much longer period.

In overland flow system, the cover vegetation, usually a water tolerant forage grass, is usually harvested periodically and can be sold as feed depending on the quality of the crop. Harvesting is necessary if nitrogen removal by plant uptake is to be achieved. The frequency of harvesting will depend on site climate but is usually less than three times per year. The slopes must be dried prior to harvesting to prevent rutting by the harvesting equipment. However, the drying period should be as short as possible to minimize the reduction in biological activity on the slopes. Proper maintenance of the cover crop is important as weed infestations can greatly reduce or destroy the value of the harvest. The effects of harvesting practice on process performance are not well-documented, however, there are some indications that harvesting may not be necessary to achieve optimum treatment.

POTENTIAL ADVANTAGES AND PROBLEMS

The overland flow process appears to be ideally suited for use in developing countries with moderate and warm climates when sufficient inexpensive and suitable land is available. There are many advantages of the overland flow process over other treatment processes, expecially when a new wastewater treatment plant is needed, but there are also some potential problems which should be considered.

One advantage of overland flow is that construction methods are relatively simple. Overland flow slopes can be built using simple road construction or farming equipment and techniques. However, overland flow wastewater distribution and collection systems should be designed and constructed to assure ease of operation and maintenance, and the overland flow slopes should be constructed such that short circuiting or channeling of the wastewater is minimized.[2]

The day to day operation of an overland flow system appears to be and is for the most part quite simple. In theory, the process could be operated without operators using automatic timers and values. The degree of operator control of the system is dependent on several factors oncluding the degree of treatment required, the relative treatment capacity of the system, and the type of application and collection systems used. Nevertheless the process requires less operator control than other treatment systems capable of meeting the same effluent standards.

Overall the cost of construction, operation and maintenance of an overland flow process should be approximately equal to the costs for pond systems with the advantage that overland flow can produce a higher quality effluent. An example of the low cost of overland flow is that the only major energy requirement is for wastewater pumping. In addition, overland flow systems can be designed to treat raw domestic and some industrial wastewater without primary settling thereby eliminating the need for sludge handling and disposal.

Finally overland flow has the capacity to remove a wide variety of pollutants, including nitrogen, phosphorus, and toxics down to low levels. In addition, it can handle shock and toxic loading without upset or a major drop in process performance. However, like any biological system, process capacity decreases with decreasing temperature. Overland flow systems have been operated with air temperatures below freezing but the pollutant removal rates were substantially reduced.[9]

A potential problem with overland flow systems using surface application and receiving either raw domestic or industrial wastewaters with high BOD_5 and/or suspended solids is the smothering of the cover vegetation at the top of the slope. The result may be odor generation and fly breeding. This problem can be avoided by using spray application methods but these methods also have disadvantages. Generally, they cost more and tend to clog more easily than surface application methods, and uniform application is sometimes difficult because of wind drift.

Overland flow is not gaining wide acceptance in the U.S. This may be due to several reasons but one big factor may be that it is often difficult to "add on" an overland flow process to an existing treatment plant. Often there may not be sufficient suitable land near the existing plant. Another problem with adding on an overland flow process is that overland flow systems are most efficient, and cost effective with higher strength wastewaters. For example research at UCD on nitrogen removal found better nitrogen removal with screened raw wastewater than with primary effluent.[10] However, most operators and city officials are reluctant to abandon an existing process even though it may be unnecessary or detrimental with an overland flow system.

ORGANIC MATERIAL REMOVAL - DESIGN PROCEDURES, AND OPERATION

The exact mechanisms or pathways of removal of organic material, measured as SS, BOD, COD, TOC or TOD, are not known but it is likely that the larger particles are removed by settling, and the suspended particles are removed by filtration. Soluble particle removal is probably dependent on, and the rate controlled by, biological conversion in the soil, but it is also possible that transport to, and capture on, the soil may be the controlling factor. Nevertheless, once organic material is removed from the wastewater, it is used as substrate for microbial growth in ths soil. Some fraction is incorporated into cell material and some is oxidized to mineral compounds (e.g. CO_2, NH_4^+ , NO_3^- , SO_4^{++}) while the non-degradable fraction builds up in the soil. Temperatures near freezing reduce the removal rate of the process particularly for soluble organic material.

Removal of organic material by overland flow has been studied extensively and the effects of design and operating parameters on removal of organic material are understood more completely than they are for other wastewater constituents. Two rational methods have been developed for the design of overland flow systems to remove organic material. One procedure was developed by Smith from his research at UCD and the other procedure by Martel et. al from research at CRREL in New Hamsphire.[7,8,11]

Smith proposes that BOD_5 and TOC removal in overland flow be modeled using a fixed film reactor analysis. He assumed that the flux of substrate into the slime layer is equal to reaction rate and that the reaction rate follows Monod kinetics. After several simplifying assumptions, the resulting "design" equation is:

$$\frac{Cz}{Co} = \exp\left(-\frac{K'z}{q^n}\right) \qquad \text{(eq. 1)}$$

where

Co = organic material concentration at a distance z downslope, gm/m^3

Cz = influent organic material concentration, gm/m^3

K' = overall rate constant, m/h

z = distance down slope, m

q = application rate per unit width of slope, $m^3/h \cdot m$

n = empirical constant

Although this equation describes very well the removal of soluble organic material in a pilot scale system at UCD, there are problems in applying the equation directly to a full-scale system using either screened raw or primary effluent wastewaters. One problem is that domestic wastewater contains a substantial fraction of non-soluble material which is removed at a different rate in the overland flow process than soluble material, resulting in higher removal rates over the first several meters of downslope distance. Another problem is that according to the model, effluent organic material concentrations should approach a value of zero with very long slope lengths. However, typically effluent values approach a non-zero background level. The end result is that it is simpler and more accurate to use a family of curves of the general form:

$$\frac{Cz - c}{Co} = A \exp(-Kz) \qquad \text{(eq. 2)}$$

where

c = background organic material concentration

A = intersection of the second stage regression line with the vertical axis

K = second stage rate constant which includes the application rate factor

Table 1 is a list of such organic material (BOD_5 and TOC) removal equations which were generated from results with the UCD field-scale experimental system. The recommended design procedure is:

1. Calculate the required removal ratio from C-c/Co.
2. Select the maximum value of application rate (q) in the valid range of the model (0.10 - 0.37 $m^3/h \cdot m$) and calculate the required slope length (z) using equations from Table 1, or alternatively, choose a slope length based on site conditions and calculate the application rate.
3. Select an application period less than 16 hrs/day. It is recommended to use 8 hrs/day as a general safety factor.
4. Compute q' for the area calculation by dividing the design application rate by 1.5.
5. Compute the required total area assuming 7 day/wk application frequency using:

$$\text{Area} = \frac{(Q)\ (z)}{(q')\ (P)} \qquad \text{(eq. 3)}$$

where

Q = daily flow, m^3/day

z = downslope distance, m

q' = application rate, $m^3/h \cdot m$

p = application period, h/d

It should be noted that, theoretically, the land area required to treat any given volume decreases as the application rate increases. The upper limit of design application rate with the current data base in 0.37 $m^3/h \cdot m$ but the actual upper limit is not known. One problem with higher application rates is potentially greater soil erosion. The choice of application period is somewhat arbitrary. Smith found no decrease in treatment efficiency with an application period of 16 hrs/day but a substantial reduction with

Table 1. Summary of Regression Equations for BOD and TOC Removal with UCD Field-Scale Experimental Overland Flow Slopes[11]

Applied Wastewater	Measured Parameter	Application Rate, $m^3/hr \cdot m$	Regression Equation*	Correlation Coefficient, r
Primary Effluent	BOD_5	0.10	$C-5/Co=0.36e^{-0.0578(z)}$	0.993
		0.16	$C-5/Co=0.38e^{-0.0549(z)}$	0.999
		0.25	$C-5/Co=0.51e^{-0.0533(z)}$	0.966
		0.37	$C-5/Co=0.71e^{-0.0478(z)}$	0.987
	TOC	0.10	$C-7/Co=0.32e^{-0.0498(z)}$	0.995
		0.16	$C-7/Co=0.44e^{-0.0608(z)}$	0.994
		0.25	$C-7/Co=0.47e^{-0.0519(z)}$	0.980
		0.37	$C-7/Co=0.59e^{-0.0404(z)}$	0.982
Screened Raw Wastewater	BOD_5	0.10	$C-5/Co=0.47e^{-0.0729(z)}$	0.989
		0.16	$C-5/Co=0.45e^{-0.0669(z)}$	0.996
		0.25	$C-5/Co=0.60e^{-0.0558(z)}$	0.979
		0.37	$C-5/Co=0.59e^{-0.0428(z)}$	0.987
	TOC	0.10	$C-7/Co=0.39e^{-0.0786(z)}$	0.983
		0.16	$C-7/Co=0.33e^{-0.0517(z)}$	0.991
		0.25	$C-7/Co=0.57e^{-0.0562(z)}$	0.986
		0.37	$C-7/Co=0.59e^{-0.0459(z)}$	0.999

* z in meters

continuous operation. Application periods between 8 and 12 hrs/day are recommended to allow for summer cover crop harvesting.

Smith also found no significant difference in organic material removal in the temperature range experienced (water temperatures between 10 and 28°C) at Davis, California. However, it is expected that temperatures near freezing will result in lower treatment efficiency.

Martel et. al. propose using a first order kinetic model, with wastewater detention time on the slope as the major variable, for modeling the removal of several pollutants including BOD and ammonia. The general form of the resulting equation is:

$$\%\ \text{Mass Removal} = \left[1 - A \exp(-k\overline{T})\right] 100 \qquad \text{(eq. 4)}$$

where

A = empirical constant

k = average kinetic rate constant, min^{-1}

$\overline{T}$ = detention time, min

The detention time, $\overline{T}$, can be calculated using the following theoretical equation:

$$\overline{T} = 5.65 \left[\frac{\nu}{ag}\right]^{1/3} \frac{L}{s^{1/3}\, q^{2/3}} \qquad \text{(eq. 5)}$$

where

ν = kinematic viscosity, $m^3 s^{-1}$

a = resistance coefficient

g = gravitational constant, $9.81\ ms^{-2}$

L = slope length, m

S = slope grade, mm^{-1}

q = application rate, $m^3/h{\cdot}m$

Using chloride tracer results to obtain a relationship between a and q and assuming a value for ν, Martel et. al. reduce eq. 5 to:

$$\overline{T} = \frac{0.0078\ L}{s^{1/3}\, q} \qquad \text{(eq. 6)}$$

Although it is possible to estimate detention time with given values of application rate, slope length, and slope grade, the use of eq. 6 in design is to calculate application rate to attain a desired detention time. Furthermore it is necessary to have a predictive relationship between pollutant removal and detention time. Martel et. al. related BOD, SS, ammonia, and phosphorus removal to detention based primarily on their research results at CRREL. For the BOD and ammonia removal results they calculated curves of best fit:

$$\text{BOD Mass Removal (\%)} = \left[1 - 0.52\exp(-0.03\,\bar{T})\right] 100 \qquad \text{(eq. 7)}$$

Correlation coefficient, $r = 0.92$

$$NH_4^+\text{-N Mass Removal (\%)} = \left[1 - 0.81\exp(-0.03\,\bar{T})\right] 100 \qquad \text{(eq. 8)}$$

Correlation coefficient, $r = 0.91$

The design procedure proposed by Martel et. al. briefly stated is:

1. Determine the detention time requested to meet a specified treatment level using equation 7 or 8. Choose the longer detention time. It will be necessary to estimate the runoff fraction (typically 0.6 to 0.9) from local evapotranspiration and percolotion rates for a calculation of % mass removal.

2. Calculate the application rate, q, using eq. 6 and assuming values of S and L based on topography of the potential site. The application rate should be less than $0.2/S^{1/3}$ to protect against soil erosion.

3. Calculate the land area required based on the application rate and the volume of wastewater that must be treated each day. Martel et. al. recommend winter storage in regions with cold climates. They also recommend application periods of 8 to 10 hrs/day when raw wastewater or primary effluent is applied.

Obviously the design procedures proposed by Smith and Martel et. al. are quite similar. Besides the differences in the pollutant removal model used, there are only relatively minor differences in the procedures. Smith recommends using a high application rate when possible to minimize land area and bases pollutant removal on concentration rather than mass as recommended by Martel et. al. Both procedures are empirical and do not deal with operation in cold temperatures other than to recommend storage.

NITROGEN REMOVAL - DESIGN PROCEDURE, AND OPERATION

The sequence of reactions responsible for nitrogen removal in overland flow is not well defined. On the surface, it might appear that nitrogen removal mechanisms in the wastewater are much more important than those in the soil. However, it is likely that all the important nitrogen storage and conversion reactions are occurring in the soil. Nevertheless, the nitrogen must first be transported from the flowing wastewater to reaction sites in the soil. A schematic indication possible relationships between the important nitrogen removal mechanisms in the wastewater and in the soil is shown in Figure 2.

It is obvious from Figure 2 that the mechanisms of nitrogen removal in overland flow are complicated: Research on the UCD experimental overland flow facilities was conducted in 1981 and 1982 to identify the main nitrogen removal mechanisms and to establish guidelines for the design and operation of overland flow systems to achieve nitrogen removal.[10] From the result of that study, it is hypothesized that the removal of nitrogen in the overland flow process occurs mainly through the following sequence of mechanisms:

1. Suspended and colloidal organic nitrogen is removed from the wastewater by sedimentation and filtration. Some of this organic nitrogen is later ammonified on the slope.

2. Soluble organic nitrogen is also removed by ammonification but the rate of removal is mass transport limited.

3. Ammonium in the applied wastewater is largely removed by ammonium exchange occurring at the soil surface.

4. The exchanged ammonium is nitrified, mainly during the drying phase of the application period, but also possibly during the application phase while aerobic conditions prevail in the soil. Ammonium exchange sites are thereby replenished.

5. The nitrate which is generated in the soil may be partially denitrified during the drying phase and during the next application phase.

6. During the next application phase, the remaining soil solution nitrate is transported off the slope in the effluent.

In terms of nitrogen removal performance, the research at UCD demonstrated that organic nitrogen removal was relatively insensitive to most of the design parameters except slope length while ammonia removal was dependent on many factors including application rate, length of drying time, air and water temperature and slope length. Winter and summer ammonia removal results from the UCD study are summarized in Table 2. The family of curves presented in Table 2 are similar to the BOD and TOC removal curves from the previous UCD research and can be directly inserted into the design procedure recommended by Smith. However, it should be noted that ammonia removal is more sensitive ot application period (actually drying time) and it is recommended to limit the application period to 8 hrs/day when using this procedure for nitrogen removal. Furthermore, the winter removal curves are only representative for mild climates (water temperature > 10°C) and reduced ammonia removal should be expected with colder winter conditions.

SUMMARY

The overland flow process has many advantages that make it attractive for use in developing countries. In this paper a description of the process and discussion of the potential advantages and problems are provided. Additionally the current state of the art in design of overland flow systems for organic material and ammonia removal is briefly described.

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ACCELERATED COMPOSTING OF WASTES IN DEVELOPING COUNTRIES

Jean Pierre LEVASSEUR

Technical Department

OTV, 11 Avenue Dubonnet - 92407 COURBEVOIE

Until recent years, the problem of household refuse disposal was not considered in developing countries as one requiring an immediate solution.

Indeed the development of their industries, agriculture and public works such as dams,roads airports and potable water plant had been given top priority.

Following the population explosion and ever-growing consumption however, these countries are now faced with the problem of waste disposal, especially in big towns, and an seeking suitable ways of dealing with it.

Among a number of techniques for the treatment of household refuse, compost production, i.e. converting it into an organic soil ameliorant is not only an inexpensive solution but one that turns a negative product into a farming asset.

Moreover, other organic wastes (sewage sludge, farming waste) can be added, providing an attractive solution that combines the disposal of several types of waste at the same time with the means of obtaining an end product of excellent quality.

Because of the agricultural use of these composts the processing techniques must automatically supply a sanitized matured and refined product of an appearance likely to appeal to future buyers.

OTV has been specializing for twenty years now in the design and development of composting plant and has acquired worldwide fame in this particular field.

CHARACTERISTICS OF REFUSE AND THE APPROPRIATE TREATMENT

Before a composting unit can be designed, the following data must be carefully studied :

- composition and characteristics of refuse,
- social and economic background and local sanitary conditions,
- collecting method,

TABLE 1 - Refuse composition in different countries

Country	TURKEY	EGYPT	GHANA	ETHIOPIA	INDONESIA	PAKISTAN
City	Istanbul	Cairo	Accra	AddisAbaba	Jakarta	Lahore
Refuse Composit. (% in weight)						
Vegetable putrescible	60,8	52,4	87,1	8,8	60	51,1
Paper	10,1	9,2	5,7	2,1	2	3,8
Leather/ Textiles	3,2	3,9	1,2	2	-	11,8
Plastics	3,1	2	1,3	0,8	9	2,5
Stones	-	24,7	1,4	54,4		24,5
Glass	0,7	1,9	0,7	0,6	2	2,7
Metals	1,4	3	2,6	0,9	2	0,8
Others	20,7	2,9	-	30,4	25	2,8
Moisture content (%)	45/65	30/40	50/60			50/60

In Europe, the composition of household refuse is in fact very similar from one country to another. As can be seen from table 1. this is not the case for developing countries.

The production of refuse per capita depends on the standard living ; e.g. in the U.S.A. we find 1.4 kg/d per capita compared with only 0.4 in India.

The composition of the refuse is also dependent on living standards :

TABLE 2 - Estimated Average Household Waste Composition for high, middle and low income Neighbourhoods (Cairo) March-June 1980 - (Ref.1)

Solid waste component	Percent weight		
	High	Middle	Low
Vegetable/putrescible	75,00	72,00	27,00
Mixed paper	16,00	14,43	10,00
Mixed glass	3,00	2,59	1,00
Textiles and bone	2,00	4,50	1,50
Ferrous metals and tin cans	2,10	1,40	0,00
Mixed plastics	0,59	0,21	0,00
Non ferrous metals	0,21	0,16	0,00
Inerts, rejets and organic fines	1,10	4,80	60,50

Density also varies. In Europe, the density is about 0.25 as against 0.5 in developing countries. This can be explained by the much higher proportion (40 to 75 %) of ashes and inorganic fines, especially in the poorer countries.

As a general rule, refuse in developing countries also appear to have characteristics rendering them hardly suitable for disposal by incineration. The extremely high moisture content and percentage of ashes substantially reduce the LHV making it necessary to add some kind of makeup fuel.

On the other hand, the composting technique is perfectly adapted to refuse rich in fermentiscible organic matter. Moreover the process is a relatively simple one to implement and operate. These two points are important in our opinion because it is preferable to use techniques that do not need qualified personnel or sophisticated machinery that require special maintenance.

As was suggested by the World Health Organisation (ref.2), by observing five simple conditions, the problem of composting household refuse can be successfully solved :

- suitability of waste
- point of utilization of finished produced less than 25 km distant from composting plant
- a reasonable selling price for potential users
- help of agricultural institutions and notably the Ministry of Agriculture
- net treatment costs within the means of the local authorities.

The WHO appears to have checked that these conditions are met in the majority of developing countries.

Another favorable argument is the fact that rubbish dumps, often uncontrolled and badly kept create a big environmental problem :

- obnoxious smells
- pollution of the atmosphere
- pollution of the water by lixiviation.

PRINCIPLE OF COMPOSTING PROCESS

- Aerobic composting can be schematically described by the following basic reaction :

(reaction 1) Fermentiscible organic waste $+O_2 \longrightarrow$ stable organic residue + CO_2 + H_2O + heat

The types of microorganisms chiefly responsible for creating this heat are the bacterias, fungi and actynomices and the successful accomplishment of the whole process depends on the environment of this microbial life, i.e.,

. Moisture content

In effect, they can only absorb the nomishment they require in a dissolved form through their semi-impermeable outer cell layer. For this reason, they must find a humid ambient environment during their metabolism. The optimum moisture is usually between 50 and 65 %.

. Aeration

As can be seen from reaction 1, the biological activity can take place if extra oxygen is supplied.

Aeration allows the excess heat and CO_2 to escape.

. Carbon/Nitrogen ratio (C/N)

This ratio should be between 25 and 40 before composting.

- Industrial production of compost can be adviewed in two ways :

. by slow fermentation : a technique consisting of stacking the feedstock in windrows after physical treatment, and turning it over periodically with a loader, in order to let enough air into the mass to enable the compost to develop (time taken : 3 months).

. Accelerated fermentation : in this case, the feedstock is placed in fermentation silos (time taken : 8 to 10 days). Accelerated fermentation offers the advantage of being simpler to conduct (product more easily controlled, process more convenient to apply) and provides compost of a very reliable quality. Moreover, the moisture content and aeration can be kept under control with greater facility.

Room saving is another attractive feature of the accelerated process, especially for large capacity installations.

Despite its greater sophistication of principle, accelerated fermentation is technically simple and straightforward to operate.

The design of the SILODA process is a perfect illustration of this criteria.

THE SILODA PROCESS

In order to obtain a good-looking compost, it is vital to remove all undesirable material before composting begins (glass, plastic, metal objects, etc), thus recovering all the fermentiscible organic matter.

Several types of machinery may be used for this purpose and their utilization on the treatment line will depend on the characteristics of the refuse and on the quality of the end product.

As a rule, the machines used are :

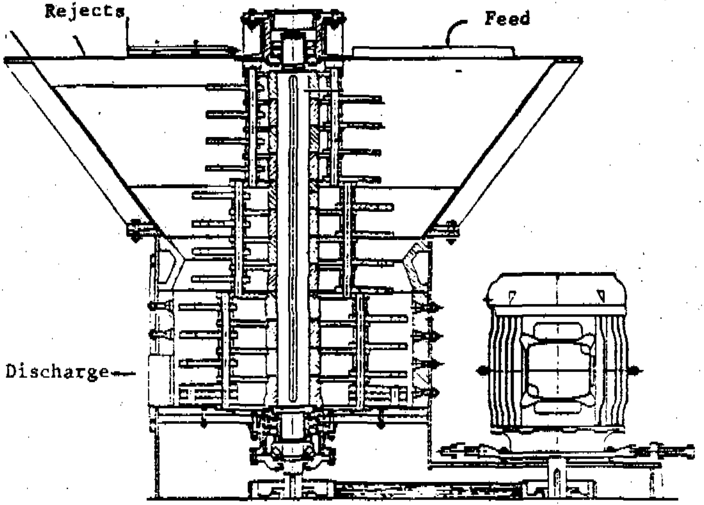
- Grinders - Often located at the head of the line. The initial grinding stage is intended firstly to give a texture to the refuse that will be conducive to fermentation and secondly to reduce it to a granulometry to make it suitable for agricultural use.

There are several kinds of grinders. We prefer the vertically-mounted model (see fig.1) specially designed for the treatment of household refuse. It has the advantage of being able to eject by balistic screening those heavy objects found in refuse that are undesirable in the compost.

Moreover, the number of hammers and their layout can be easily changed according to the grain-size required by the operator.

FIGURE 1

TOLLEMACHE PULVERISER



Owing to its operating principle, this grinder consumes very little energy (5 to 7 kWh/metric ton treated. This is most important factor when one considers the grinder's share in the energy balance of the plant.

Fastly, in order to wear the hammers on both sides, the operator simply reverses the rotating direction of the rotor, instead of having to turn the hammers round by hand, thus saving considerable time and labour.

- Screens - The aim of the screening stage is to separate non compostable scraps such as plastic, rag or non-ferrous metal. According to the nature of the feedstock and the treatment already performed the screens will be of either the vibrating or the rotating type.

- Specific separation devices

. Ferrous-metal scraps can be removed by magnetic separation, then baled in a special press for recycling when it is profitable to do so.

. Heavy inert particles (glass, etc) can be treated by simple ballistic separation (by blowing air into material coming off a conveyor belt) or by more sophisticated methods (flat-deck vibrating screen).

The choice of techniques also depends on the use to which the compost is to be put by the purchaser. In all cases, this will include a biological phase, the most important part of the treatment since on it depends the quality of the compost as regards sanitization and agricultural value.

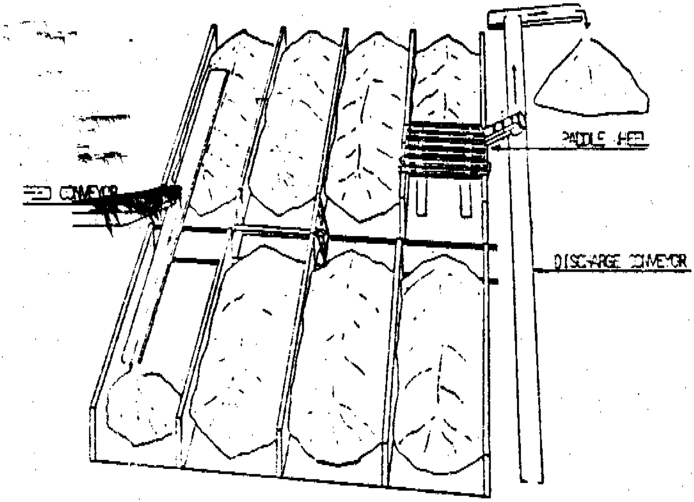
The SILODA COMPOSTING PROCESS is illustrated in Fig.2

Fermentation takes place in silos which are side by side and divided by walls, all inside a building. The silos are open at each end to allow the passage of a paddle wheel, which traverses the full length of each silo on rails which are mounted on the top of the dividing walls.

The number of silos can vary according to the volume and quality of product required. The minimum being 8 silos with a unit capacity equal to one day's production. The product being treated is retained for 2 days in each silo. Therefore depending upon the number of silos, the total fermentation time is between 8 and 10 days.

FIGURE 2

SILODA COMPOSTING PROCESS



Every other day, the product is turned over by the paddle wheel, the blades of which slice the product from bottom to top and drop it by gravity into an Archimedean screw, which is housed in the centre of the paddle wheel. This screw flings the product into the adjacent silo and in so doing aerates the product and equalises fermentation.

The wheel is transported from one silo to the next on a crab. To compost certain waste (e.g. very moist household refuse, a mixture of sludge and garbage), extra air must be injected.
A series of nozzles are therefore provided in the silo floors, and the blowing air is supplied from a compressor.
After the compost has passed through the silos in what is called the thermophilic stage, it is matured, screened if necessary and put into store.

All this installation can be fully automated.

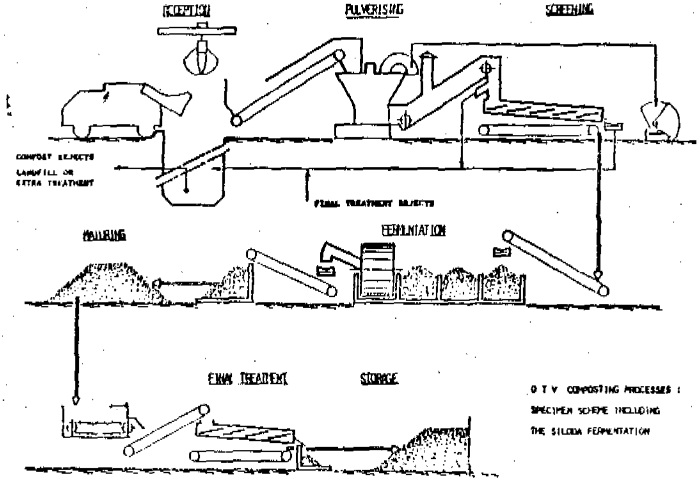
Fig.3 illustrates one example of a composting plant including the physical and biological treatment stages, with a final refining treatment stage.

COMPOST QUALITY CONTROL

It is the operator's responsability to see that the product is of good quality, and so the physical and chemical characteristics of the compost have to be checked. The former are discernable at sight, but determining the right degree of maturation can be more difficult.

There is not, in fact, any thoroughly reliable and standard method for determining the absolute degree of maturity for compost in general, although there are criteria for judging the evolution og a given compost. One of these consists in applying the C/N ratio i.e. Organic Carbon/Kjeldahl nitrogen. The drawback in this method is that it is both long and costly, since it can only be undertaken by a specialized laboratory. Moreover, a knowledge of the nature of the carbonaceous elements is also necessary in order to interpret the results. The measurements obtained on vegetable matter are of course fully reliable, but the process really takes too long. Our objective was to work out a method sufficiently simple to be applied by a plant operative, but at the same time to be reproducible and produce reliable results.

FIGURE 3



O T V COMPOSTING PROCESSES :
SPECIMEN SCHEME INCLUDING
THE SILODA FERMENTATION

It was with the collaboration of ENSAIA, Nancy (ref.3) and INRA, Dijon (Ref.4) that we tested two methods, and compared the results we obtained with the usual criteria (C/N, age, pH, organics, tests on vegetable matter).

The two methods are as follows :

1) Colorimetric analysis

ENSAIA, Nancy, designed a test based on the colorimetric analysis of the alkaline extract of a compost. This technique enables the maturity of a compost to be determined according to a nombered scale. It was observed that this alkaline solution went from yellow to dark brown as the compost ripened.

On-site testing has shown that a product could be considered as ripe when the alkaline extract had sufficient optical density.

However, to simplify the method, we developed a colour range representing the compost at different stages of maturity to serve as reference. In this way, all the operator has to do is to compare his sample with the reference colour chart.

2) Respirometric analysis

INRA, Dijon, found that accidents to crops (inhibition of the nitrogen, renewal of the fermentation process, etc) were attributable to the presence of carbonaceous products that are easily biodegradable.

The method consists of measuring the respiration of a compost sample for 3 days, in a confined area, by partly reducing the oxygen pressure and trapping the resulting carbon dioxyde with an alkaline substance.

The pressure measured after 3 days will give the consumption of oxygen. If this is sufficiently low, the compost is ready for risk-free agricultural use.

The operator can use these two quite simple and inexpensive methods to check the quality of the compost product.

Reference plants equipped with SILODA accelerated fermentation unit :

We have chosen for one description facilities using all the equipment previously described.

-The ENVERMEU (France) plant

This plant, designed to treat 80 tonnes per day of household refuse, comprises mainly :

- One physical treatment unit containing :
  - . a vertical pulveriser type Tollemache 42 F
  - . a magnetic separator
  - . a vibrating screen
  - . a glass extraction unit
- One biological treatment comprising the accelerated fermentation SILODA process, followed by maturation in the open air
- One compost refining unit : it has been installed with a device to improve the physical quality of the product in consideration of the exact use to which the compost is to be put. This unit consists of a secondary grinder and a 6 mm mesh screen with which a very fine compost is obtained free of all impure matter.

-The MOSUL (Iraq) plant

The process is particularly well suited to the type of refuse occuring in the Middle East.

It has been successfully used for several years in Syria, Lebanon and Saudi Arabia.

The plant commissioned in MOSUL is designed to treat 300 tonnes/day of household refuse.

The treatment line consists of :

- 2 vertical shaft pulverisers type Tollemache 58 A
- 1 magnetic separator
- 2 perforated plate screens, mesh size 50 mm
- 1 SILODA biological treatment unit
- extra fine screening with a 15 mm mesh size
- a glass removal unit.

After refining, the compost is stored in the curing area.

Following a sustained marketing and information compaign, notably on the part of the local utilities department, the compost is now a product in great demand.

THE UTILIZATION OF COMPOST IN AGRICULTURE

A - Advantages of compost in agriculture

The organic matter contained in compost affects the soil in four different ways :

. physical properties of soil :

- it increases the degree of permeability and reduces cohesiveness
- increases water retaining capacity
- improves structural stability. This last factor facilitates the work of farm implements because the soil is made more flexible and is subject to less damage due to the repeated passage of heavy machinery.
- the soil warms more quickly in Spring.

. Chemical properties of soil :

- compost brings extra mineral substances, that are conserved by the soil or, in some cases, turned into solution form (P_2O_5, K_2O, trace elements)
- it has a regulating effect on mineral input, particularly nitrogenous compounds.

- **Biological properties of soil :**

  - it affects the development of fauna and microflora
  - renders plant life less vulnerable to attack by parasites.

- **Crop yields :**

  Compost, if adequately cured and used in normal proportions, has invariably procured higher yields, wherever it has been tested.

B - Examples of compost applications

In developing countries, compost may be mainly used in large scale cropping.

Intensive cropping demands a soil with large reserves of humus and offers a potential market for compost which is usually lightly turned in during Spring or Autumn.

- Wheat

In a 3 years crop rotation including one year fallow, then beets or potatoes followed by wheat, the Wagnouville School of Agriculture compost was ploughed into the soil before root crops (Ref.5).

The yields obtained following the above test are shown in the following table.

Type of treatment	Wheat yield (15 % water) Q x /ha (average of 4 repeated parts)
Urban compost 20 t/ha + P.K.	42,9
Reference	44,3
Manure 20 t/ha + N.P.K.	45,2
Manure 20 t/ha	46,3
Urban compost N.P.K.	46,4
Urban compost 20 t/ha + N.P.K.	50,3

Differences are quite meaningful.

- <u>**Maize**</u> (Indian corn)

Successful trials were made by P. Husson on two types of soil :

Alluvion soil			Acid sandy soil		
Kind of manure	Compost 45 t/ha	Reference mineral fertilizer	Compost 40 t/ha	Compost 20 t/ha	Reference mineral fertilizer
Yields in Qx/ha	76,9	74,7	38,8	36,2	29

CONCLUSIONS

The aerobic fermentation of household refuse takes place in the best of conditions providing a minimum of care is taken :

- the product must have the optimum moisture content, if necessary by adding water, or even sewage sludge which is a way of disposing of the latter while enriching the compost with extra organic matter and fertilizing substances.

- the whole volume must undergo the thermophilic stage of fermentation in order to make the product sanitary.

This fermentation process is substantially improved by an efficacious mechanical treatment.

Another essential factor is the appearance of the compost that may be a condition of sale. Hence the ultimate refining process is very important.

In order to treat household refuse in such a way as to turn it into high-grade compost, it is important to use suitably designed and easily operated equipment. Techniques exist that, when correctly implemented, give an attractive and chemically adequate product that sells readily and renders a real service to agriculture.

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NUTRIENT ACCUMULATION AND RELEASE ON INTERTIDAL FLATS IN THE VICINITY OF SEWAGE DISCHARGES*

Peter Literathy and Sami Nima Mohammad

Environmental Sciences Department
Kuwait Institute for Scientific Research

P. O. Box 24885, Safat, Kuwait.

INTRODUCTION

Pollutants (substances that can be directly toxic to humans or to the biota at a certain level in the environment) and nutrients (substances that may increase the primary production, i.e. euthrophication, and those that can indirectly affect the water quality, particularly by lowering the oxygen content) occur in the aqueous phase of the water column and in the interstitial water as well as in suspended and sedimentary solid phases. The concentrations depend on natural processes and anthropogenic effects, including the geochemical environment, water and sediment characteristics and wastewater discharges.

A high proportion of the most important pollutants, e.g., heavy metals, and nutrients, particularly phosphate, are bound to the solid phase. This is primarily valid for natural waters, but the dissolved form of these compounds can reach high concentrations in wastewater discharges. After mixing the wastewater with the recipient water, both physical and chemical processes affect the distribution between dissolved and solid components. Processes include precipitation, dissolution, adsorption and desorption. A number of different interactions such as erosion, sedimentation, mixing, take place between water and sediment. Biological reactions occur in both the sediment and the water.

Although the sediment can be characterized as a "sink" for a number of pollutants and nutrients in the aquatic ecosystem, it should be remembered that exchange can occur in both directions at

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the sediment-water interface. This exchange depends on the character of the sediment and the interstitial and overlying water and is controlled by the equilibrium, which is dynamic in nature and varies from one ecosystem to another.

After deposition of the suspended sediments, their chemical environment can drastically change, i.e. from an oxidizing to a reducting environment, which means a possible remobilization of different compounds. The possible benefical and detrimental impact of sediments have been studied from different viewpoints, primarily due to their binding and release mechanisms.

The particulate nutrients, especially phosphorus, can be partitioned into different forms likely to exist in the sediments. In recent years, attention has been given to speciation in various studies since, depending on the environmental conditions, different forms will be altered to release phosphate into solution and make it available to aquatic organisms.

The most frequent forms of phosphorus in the particulate matter are the following:

- nucleic acids and phospholipids in organic matter;
- occluded in iron and manganese oxides, which commonly occur in the coating of larger particles;
- bound to carbonates;
- adsorbed--with electrostatic or specific adsorption--onto small particles, such as clay minerals and organic colloids in the form of $H_2PO_4^-$;
- in specific minerals such as calcium phosphate (apatite).

Determination of the bioavailable fraction of the various phosphorus forms has been the challenging objectives of several studies.

In this study, we used the results of the early stages of multi-stage carbon dioxide leaching experiments for characterization of phosphate release from marine sediments. It has been found that this technique closely simulates natural conditions of phosphate release from the inorganic solid phase as a result of carbon dioxide production during bacterial decomposition of the organic matter.

RATIONALE

Phosphorus is naturally present (mainly in the solid phase) in the aquatic environment, but both solid and dissolved forms can originate from anthropogenic sources. Aston and Hewitt (1977) studied the dispersion of dissolved and particulate phosphorus from sewage discharge into a tidalbay, with particular reference to phosphorus distribution in intertidal sediments. The effluent outfalls were important sources of particulate phosphorus.

Particulate phosphorus can settle directly, but the dissolved form is either adsorbed onto fine particulates or precipitates-coprecipitates with iron and manganese hydroxide or with calcium carbonate. Nevertheless, it finally also accumulates in the bottom sediment.

The part of the bottom sediment with the most influence on water quality is that which is reactive. This includes the particulate organic matter from natural and anthropogenic origins, carbonates such as calcium-carbonate, which is present naturally but can also precipitate (Wiedemann, 1969) as a result of evaporation in the tidal flats and or of photosynthesis (biogenic lime precipitation), and others. The identification and characterization of these materials is very difficult. The effect of various environmental changes on the different phosphorus forms is summarized in Table 1.

A major source of phosphates in the water is organic matter during biodegradation. Under aerobic conditions oxygen is provided by the dissolved oxygen; while under anaerobic conditions by nitrate and sulfate. During the decomposition of organic matter, carbon dioxide, which will lower the pH and may dissolve metal hydroxides and carbonates (Andersen, 1975), is produced.

Bacterial mineralization of the organic matter in the sediment is much more intensive than in the water (Vosjan and Olanczuk-Neyman, 1977). During this process, organic matter is transformed into inorganic compound, e.g. the organic carbon is transformed into carbon dioxide.

Sediment shows a high rate of phosphorus release when the ferric hydroxide coating binding the sediment particles together is reduced and dissolved to ferrous ion (Mortimer, 1941; Banoub, 1977). This reduction can only occur when the amount of oxygen and nitrate (as source of oxygen) is less than required for decomposition of the organic matter. Anaerobic versus aerobic conditions paly an important role in the phosphate release and uptake processes (Lee et al., 1977).

Several experimental procedures have been proposed to determine chemical speciation of phosphorus in the solid phase. Most can be considered as sample pretreatment used to extract or to solubilize the fraction of phosphorus corresponding to one speciation.

LITERATHY

Table 1. Fate of Phosphorus in Different Particulate Phases When Submitted to Environmental Changes.

Environmental Changes	Particulate Organic Matter	Fe & Mn Oxides	Carbonate	Electrostatic Specific Adsorption	Specific Minerals
Bacterial degradation	-	0	0	0	0
Oxidizing conditions	0	+	0	0	0
Reducing conditions	0	-	0	0	0
pH variation	0	0	+/-	+/-	0
Transfer to saline water	0	0	0	-	0
Intestinal tract of organisms after ingestion	-	-	-	-	0

0 = no marked change; - = release from solid to dissolved phase; + = gain from dissolved to solid phase.

Early fractionation techniques (Chang and Jackson, 1957) separated the particulate phosphorus into iron-P, aluminium-P, calcium-P and organic-P. Williams et al. (1977) suggested that particulate phosphorus be separated into iron plus aluminium bound-P, calcium-P, reductant soluble-P and organic-P. Later they suggested a simplified version for separating non-apatite and apatite inorganic-P, and organic-P in sediments (Williams et al., 1976).

Golterman (1977) suggested that nitrilotriaceticacid (NTA) extractable-P for characterizing bioavailable phosphorus, be used.

Phosphate can be selectively fractionated using ammonium chloride, sodium hydroxide and hydrochloric acid for the extraction of loosely bound and calcium carbonate adsorbed phosphates, iron and aluminium bound phosphates, and calcium bound phosphates, respectively (Hieltjes and Lijklema, 1980).

The phosphate "buffering" by sediment adsorption/desorption may be an important control in different waters. It has been demonstrated (Pomeroy et al., 1965; Butler and Tibbitts, 1972) that an equilibrium concentration of phsophate in estuarine waters was in the range of 22-46 μg $P.l^{-1}$ during experiments to measure the release of phosphate from sediments. Oloya and Logan (1980) also showed that phosphate adsorbed onto particulate matter will be released when mixed with water, providing the available phosphorus for algae from the adsorbed form.

Phosphate adsorption on particulate matter (Burns and Salomon, 1969) increases with increasing temperature and decreases with increasing pH. At a fixed temperature and pH, the adsorption was found to be depressed by increasing salinity. Adsorption is favoured by the presence of $H_2PO_4^-$ rather than HPO_4^{2-} ions, which dominate the phosphate dissociation at higher pH (Kester and Pytkowicz, 1967).

McCallister and Logan (1980) demonstrated that the results of laboratory experiments on adsorption-desorption studies should be critically evaluated because, depending on local conditions, Chemical extraction methods with chemicals that are unexpected under natural conditions, e.g. HCl, may extract more phosphorus and probably other forms than those available or potentially available for photosynthesis under environmental changes.

In recent years, a broad range of research has dealt with the identification of bioavailable phosphorus forms (Lee et al., 1980). It has been demonstrated that an immediately available form is dissolved inorganic-P, and partially, dissolved organic-P; all labile forms (e.g., adsorbed, exchangeable, easily dissolved and hydrolized) are potentially available in particulate matter, but unknown percentage of relatively stable primary and secondary minerals with iron, calcium, aluminium inorganic-P, as well as of the relatively stable humus compounds such as inositols are potentially available.

The results of this study demonstrated the importance of calicum carbonate bounded phosphorus and the characterization of that fraction with carbon dioxide extraction.

MATERIALS AND METHODS

Study Area and Sampling

Off-shore and intertidal areas in the territorial waters of Kuwait have been studied; the results of three case studies are presented in this paper. The sampling sites are shown in Fig. 1.

During these case studies, seawater, tidal creek, interstitial water and sediment samples were taken by the following techniques:

- Seawater and tidal creek samples were taken directly into amber glass bottles and stored in an ice box until analysis.
- Interstitial water samples were taken with a probe lowered to the desired sadiment depth (10 cm). The interstitial water was drawn through the glass fibre filter covered sampling port by a vacuum generated in the sampler, which also included the sample bottle. The whole system had been flushed with nitrogen before sampling to prevent changes in composition of those dissolved species present in anaerobic solution and sensitive to oxygen, e.g., ferrous ion.
- Sediment samples were taken either by a Van Veen grab at the off-shore stations or by a plexiglass gravity corer at the intertidal flat stations. The top 0-2 cm sediment layer was subsampled from the grab sampler. Intervals of 5 cm were extruded from the core sampler.

Sample Preparation

Water samples were analyzed either immediately after sampling, e.g., phosphate, or within six hours in the laboratory without special preparation, but stored in an ice box or refrigerator.

Off-shore sediment samples were wet sieved through a 230 mesh (63 μm) nylon sieve to obtain the clay-silt fraction. The intertidal sediments were used in total because the percentage of the clay-silt fraction (1-5%) was very low. Each sediment sample was quickly rinsed with a small volume of distilled water adjusted to pH 8.3 for flushing out the traces of pore water.

All sediment samples were freeze dried in a Virtis Co. freeze-mobile II, Model 10-MR-Tr hypholizer and were carefully homogenized without breaking the original particles into smaller ones.

Sediment Treatment with Carbon Dioxide

An all-glass Millipore membrane filtration apparatus with a 250 ml funnel was connected to a Multiplex peristaltic pump. This pump provided pressure in forward and vacuum [illegible] backward operation in the filtration flask. The pump's tubing was a[illegible]hed to a reaction flask used to introduce carbon dioxide (evolve[illegible]otassium bicarbonate with sulfuric acid) into the air flow, w[illegible]ssed through

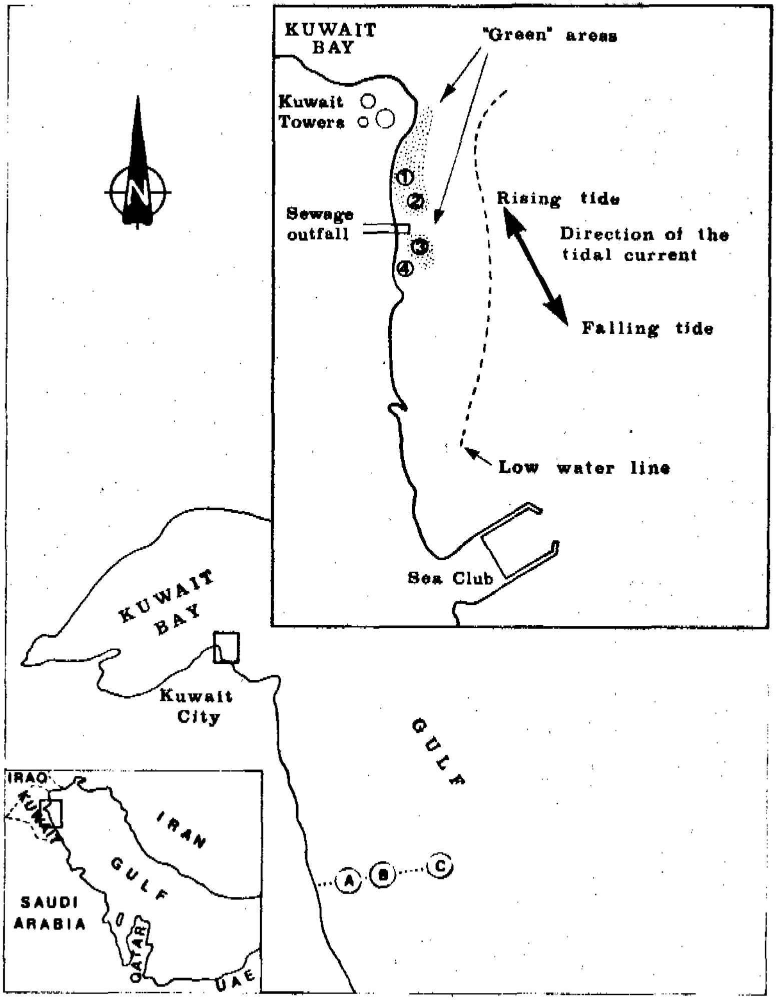


Fig. 1. Study area and sampling sites (A-C and 1-4).

the filtration apparatus during the forward operation of the pump.

A total of 200 ml of seawater with the pH adjusted to 8.3 that was filtered through a membrane was poured into the Millipore funnel. Continuous aeration was maintained with the pump. Then 2 g of the sediment sample was suspended in the seawater and aerated without carbon dioxide feeding. After 15 minutes, the pump was switched to backward operation, so the seawater filtered into the flask and was later analyzed for selected characteristics. A new 200 ml portion of seawater was added to the funnel, and the sediment was resuspended and aerated for another 15 minutes. The same procedure was repeated until the orthophosphate concentration of the filtrate reached a low value at most 1/10 of the first fraction. The amount of orthophosphate released during this treatment was considered the labile phosphorus, mainly the adsorbed phosphates. Usually, the second 200 ml of seawater removed all the labile P from the sediment.

The treatment of the sediment with 200 ml seawater portions was repeated several times. During these treatments, carbon dioxide (approximately 1 mg CO_2-C per minute was continuously introduced into the air flow. The filtrate fractions were analyzed separately. After collection of 4-6 fraction, the sediment was washed with 200 ml of 0.1N HCl and the filtrate was analyzed for total carbonates and related compounds.

Details of the apparatus and the treatment procedure are given in Literathy and Mohammad, (1984).

Chemical Analysis

Orthosphosphate ions in the original and treated seawater samples were determined by the standard reduced molybdate complex method. Ammonia was determined by the indophenole-blue method, and the nitrite and nitrate after reduction to nitrite on the cadmium column was determined by the sulfanilic acid-naphtilamine technique. Sulfide was analyzed colorimetrically in the form of methylene-blue.

Total alkalinity was determined by titration with 0.02 N hydrochloric acid to the equivalence pH of 4.5 for carbonic acid. The hydrocarbonate equivalent was calculated from the alkalinity. The calcium and magnesium were determined by titration with EDTA using Murexide and Eriochrome-Black-T end point indicators. The total carbonate content of the sediment was measured by dissolution in excess 0.1N HCl and back titration in sodium hydroxide.

The total organic carbon (TOC) in the sediment was determined by wet oxidation with dichromate and by absorption of the carbon dioxide oxidation product in barium hydroxide (Literathy and Al-Ghadban, 1982).

RESULTS AND DISCUSSION

Case Study 1

The migration of the interstitial (pore) water influences development of the anaerobic zone in the sediment. The importance of both the upward and downward migration of the interstitial water on the kinetics of phosphorus release from the sediments has been shown by Kamp-Nielsen (1974). The effect on biochemical and chemical reactions between sediment and interstitial water should be emphasized. This is especially important in intertidal flats, where pore water migration is controlled by tidal flashing (see Fig. 2). Depending on the slope of infiltration of the fresh,

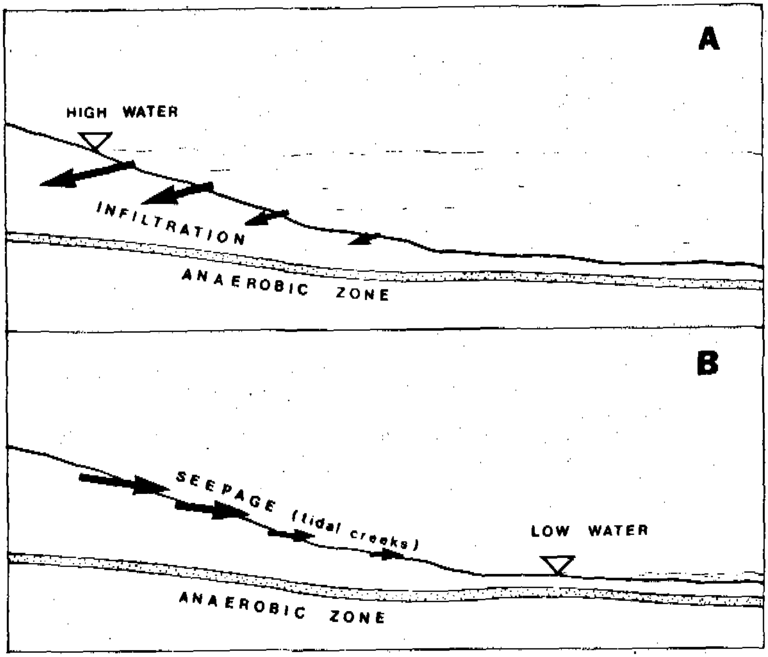
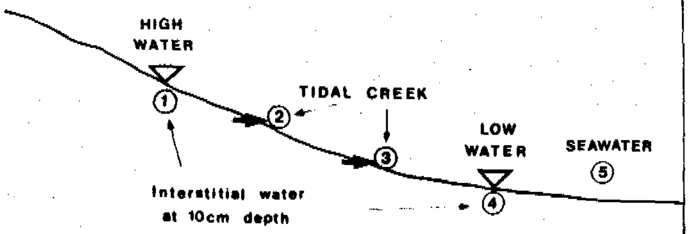


Fig. 2. Migration of the water during high tide, seawater infiltration into the sediment pores (A), and during low tide, pore water seepage into the seawater (B).



	①	②	③	④	⑤
NH_4-N (μg/l)	18	27	38	440	11
NO_2-N (μg/l)	11	44	98	0	7
NO_3-N (μg/l)	300	700	860	0	330
PO_4-P (μg/l)	15	18	20	155	6
S^{--} (μg/l)	0	0	0	570	0

Fig. 3. Nutrients in seawater, interstitial water and tidal creeks during falling tide.

aerobic seawater and of seepage of the pore water will be different. The higher the slope the higher the level of seawater-pore water migration and deeper the position of the anaerobic zone.

For characterization of the seawater, pore water (seepage, tidal creek) and interstitial water composition for nutrients and sulfide, samples were taken in the A-B-C transect on an intertidal flat relatively far from sewage discharges. As shown in Fig. 3, interstitial water samples were collected during high tide and low tide, and two tidal creek samples during falling tide. One seawater sample was taken for comparison. The results of analysis (Fig.3) indicate the following:

- the composition of interstitial water near the high water mark at 10 cm depth is almost identical to that of the seawater.

- the composition of the tidal creeks in the intertidal zone indicates the effect of pore water migration from the deeper layer, represented by an increasing concentration of each nutrient under aerobic conditions.
- the interstitial water composition near the low water mark is very different. It shows high anaerobicity, indicated by zero nitrite and nitrate, by high ammonia and sulfide, and by the high release of orthophosphate.

Migration of the interstitial water near the low tide zone is limited to nearly diffusion. The highly exchangeable pore water layer is located closer to the high tide zone and, because of the aerobic condition and the relatively lower rate orthophosphate release, the photosynthesis is phosphorus limited and does not create the same problem as in the vicinity of the sewage outfalls.

Case Study 2.

Eliminating the direct impact of phosphorus loads from anthropogenic origins, the immediately bioavailable orthophosphate-P is liberated during the mineralization of the organic matter, the desorption of the labile-P and as a result of dissolution of materials (such as calcium carbonate) coprecipitated with phosphate. In nature, carbon dioxide dissolves calcium carbonate and the dissolution intensity depends on the amount of carbon dioxide present.

As mentioned, the various chemical extraction techniques are usually far from natural processes and the carbon dioxide extraction, especially if it is characterized by a multistage technique, can more closely simulate natural conditions.

As long as calcium carbonate is present, especially in the sediment, it acts as a buffer against changes in pH. If carbon dioxide is produced during the decomposition of the organic matter, it will begin to dissolve the calcium carbonate. Usually a negative correlation exists between the calcium carbonate and organic carbon content of the sediment (Olausson, 1980).

During dissolution of the calcium carbonate, orthophosphate is also liberated proportionally to the calcium carbonate/orthophosphate ratio present in the surface of the calcium carbonate or calcium carbonate coated particles.

Under natural conditions, the release of orthophosphate has a nearly linear correlation with the amount of calcium carbonate dissolved. This is demonstrated in Fig. 4, which shows the multistage carbon dioxide treatment results on off-shore sediment. The

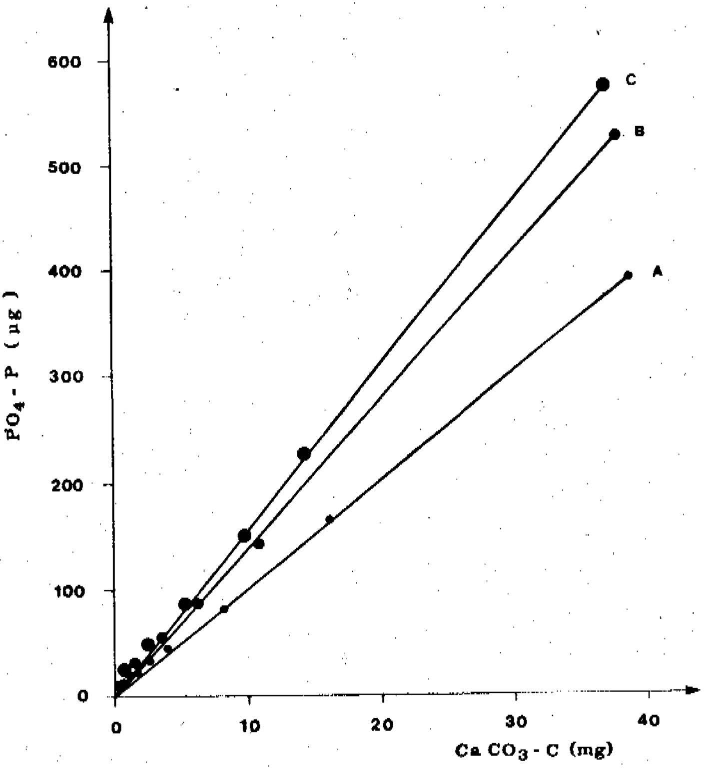


Fig. 4. Relation between phosphate release and calcium carbonate dissolution during the carbon dioxide treatment of offshore bottom sediments (see Fig. 1).

samples were collected at the A-B-C transect points in the territorial waters of Kuwait (see Fig. 1).

The end of the curves represents the total amount of carbonate-carbon in the sample and the relevant amount of orthophosphate bounded to the carbonates.

It can be seen that the release rate of the phosphate is slightly higher at the very beginning, showing that the surface of the calcium carbonate is richer in phosphate than the deeper layer.

Taking into account that dissolution and precipitation of the calcium carbonate is in dynamic equilibrium in nature, the characterization of phosphate release from the sediment by an infinite amount of carbon dioxide is significant for environmental quality assessment.

Case Study 3

The main objective of this study was to characterize the accumulation and release of phosphorus in intertidal flats in the vicinity of sewage outfalls.

It is a common phenomenon during February and March each year that the area surrounding the emergency sewage discharges become green. It is also notable that the area to the north or northwest from the discharge along Kuwait City's shoreline has more intensive productivity. The only explanation for this is in the direction of the tidal current, which is predominantly north-south in the Gulf and west-east in Kuwait Bay. Rising tide makes a north-west movement and falling tide a south-east movement.

The vicinity of the emergency sewage outfall close of Kuwait Towers was selected for this case study. It is clear from Fig. 1 that the wastewater moves into the intertidal flat, during a rising tide partly settling there and partly infiltrating into the sediment. This circumstance is favourable for the accumulation of particulate organic matter and phosphate in the intertidal sediment. During a falling tide, when the direction of the water movement is into the open sea, the wastewater is practically removed from the intertidal flat and mixed with the seawater.

Sediment core samples were collected at four locations (two north and two south of the discharge) on the intertidal flat during early February, when production started. The sampling sites, Stations 1 through 4, are shown in Fig. 1.

Samples of the top sediment core taken at 5 cm intervals were analyzed for several characteristics. Special attention was payed to the carbonate content and carbonate bounded phosphate. During the multistage carbon dioxide treatment, analysis of the leachate showed that the carbonate is practically 100% calcium carbonate, and its percentage significantly increases in the sediment with depth (see Table 2).

Table 2 also demonstrates the amount of carbonate bounded phosphate as well as the labile-P that can be easily released into the water. The results assume the higher accumulation rate of phosphate in the upper layer of the sediment. This is clearly

Table 2. Concentration of Calcium Carbonate, Calcium Carbonate Bounded Phosphate and Labile Phosphorus in Sediment Cores (Sampling Sites in Fig. 1).

Depth Station	1	2	3	4
$CaCO_3$ (%)				
0-5 cm	18.3	21.3	18.2	16.2
5-10 cm	26.2	26.0	23.4	18.2
10-15 cm	20.9	-	-	26.4
$CaCO_3$ Bounded Phosphate (μg P/g)				
0-5 cm	49.0	45.0	46.2	39.8
5-10 cm	45.6	33.4	27.0	32.4
10-15 cm	30.0	-	-	35.4
$CaCO_3$ Bounded -P (μg)/$CaCO_3$-C (mg)				
0-5 cm	2.17	1.78	2.09	2.05
5-10 cm	1.45	1.07	0.96	1.48
10-15 cm	1.19	-	-	1.12
Labile Phosphorus (μg P/g)				
0-5 cm	3.0	1.8	3.1	0.8
5-10 cm	5.0	0	1.7	0
10-15 cm	1.6	-	-	0.6

demonstrated by the ratio between the carbonate bounded-P and the carbonate-C. Decrease in the labile-P concentration with depth can also be recognized. The TOC values are randomly distributed between 0.8 and 2.0% in the different samples, showing insignificantly higher values at Stations 1 and 2.

Fig. 5 shows the results of phosphate release during the multistage extraction with an infinite amount of carbon dioxide. It is clearly demonstrated that more phosphate is released in the sediments from Stations 1 and 2 than from Stations 3 and 4 if only 1-2 mg of $CaCO_3$-C is dissolved with carbon dioxide.

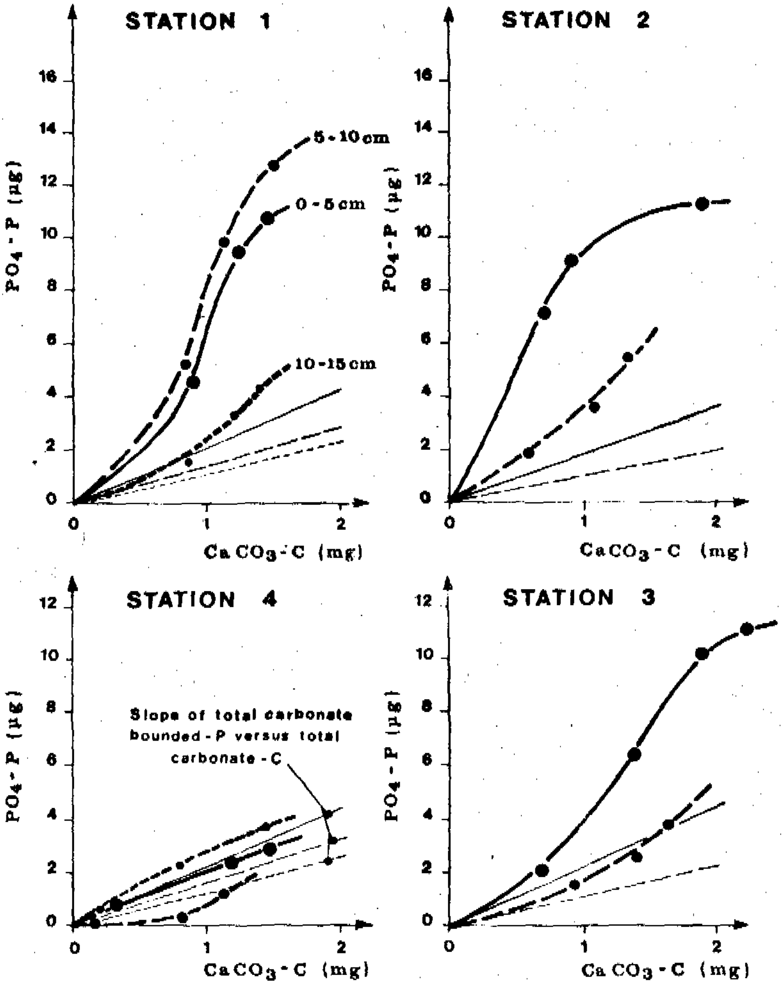


Fig. 5. Phosphate release during calcium carbonate dissolution of the sediment core samples collected around the sewage outfall on the intertidal flat (see Fig. 1).

CONCLUSIONS

The multistage carbon dioxide treatment technique for studying potentially available phosphate release from sediments was found to be a good practical approach for bottom sediments.

Intertidal flats are particularly sensitive areas for nutrient accumulation and release according to seasonal cycles. During the planning and construction of wastewater outfalls on intertidal flats, circumstances such as slope and wideness of the intertidal flat, direction of the tidal current, and mixing conditions should be carefully studied and considered.

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POULTRY WASTEWATER TREATMENT IN SUDAN

DR. ISAM MOHMED ABDEL MAGID

B.Sc., DDSE, Ph.D.

UNIVERSITY OF KHARTOUM, P.O.Box 321, SUDAN

BACKGROUND

Poultry processing is drawing more interest in Sudan for many reasons such as amelioration in living standards, prosperity, relatively easy profit and revenue from this sort of investment, increased prices of meat together with relevant enviromental, socioeconomical and cultural factors and local impacts. Therefore, old poultry processing centres are expanding and new sectors are emanating to existance. The net result is an augmentation in waste generated creating problems with their handling, treatment and final disposal. This aggravated inconveniences such as occurance of obnoxious odours, fly nuisance especially the common fly[1], breeding places for mosquitoes, accumulation of large volumes of wastes annualy and presence of unwanted, harmful wild life in the vicinity of the poultry farm as for example the case in the Sudanese-Kwati poultry farm in Khartoum. In that farm there is a large number of wild birds pecking and feeding on the accumulated manure and aiding in spreading it in the neighbourhood. The problem of manure is being aggravated by the absence of farm animal and usage of more potent fertilizers than poultry wastes

SOURCE OF POULTRY WASTE AND COMPOSITION

According to Salvato[2] the major source of poultry waste results from battery and feeding rooms, this is followed by wastes from killing, scalding and picking operations.

The liquid waste from washing down a poultry house has been reported by Scott and Smith3 to be high in nitrogen, phosphate and potassium, compared with other live stock wastes. They stated that about 8 hens produce the same BOD per day as one human. Johnson and Mountney[4] indicated that the poultry manure is moist and contains nutrients and organic matter and higher fatty acids (butyric, valeric, capronic, and caprylic).

The wastewater generated from poultry processing plants is highly versatile in its composition and characteristics. Mead, et.al[5] stated that the BOD and suspended solids (SS) are high during the processing day, while the BOD, SS, grease and flow rate vary considerably throughout the nightly wash down period. During weekends and holidays, wastewater flow may be nill. Furthermore, the type, kind and quality of bird being killed has a notable substantial influence on the characteristics of the wastewater produced.

TREATMENT OF POULTRY WASTE

Treatment of poultry wastewater necessitates incorporation of:-

a) holding tanks to cater for peak flow and they may demand aeration to avoid septic conditions.

b) pretreatment including screens (depending on the type and capacity of the plant) and grease or fat traps to prevent any detrimental effect such materials can supervene on the operation and performance of the treatment plant.

The treatment and disposal processes may include trickling filters, activated sludge, extended aeration, waste stabilization ponds, lagooning, oxidation ditches, DAF, ridge and furrow, incineration, dehydration, composting, spray irrigation..etc. The choice of appropriate units for a particular poultry farm depends on the amount and character of waste generated, climotological conditions, socio-economical factors, enviromental conditions and impact and technical factors associated with the process.

The activated sludge process needs careful handling, supervision and precautions against skock loads together with proper maintenance. Chemical precipitation process is expensive and also demands intelligent supervision. Composting offers a possible way for manure stabilization if the material could be handled efficiently and kept aerobic for aerobic bacterial growth and activity.

Chemical coagulation and dissolved air flotation (DAF) treatment were applied to poultry processing wastewater plants.

Crieves, et.al[7] stated that DAF foam separation is a promising technique for the removal and concentration of colloid-size particles. The method have been shown to be efficacious by Shannon and Buisson[8], and the cost of installing and operating a DAF unit has been estimated to be similar to that of conventional sedimentation units of the same capacity[8]. The tremendously large surface area presented by the emerging small air bubbles provides the possibility of extremely efficient collection of dissolved and suspended solids. However, the flotation process alone has been shown by Woodard, et.al[9] to be incapable of producing a satisfactory effluent, SS removals of 40-50 % were reported by Gray[10]. Consideration of the characteristics and nature of solids remaining in the effluent from plain flotation, i.e. suspended proteinaceous matter and blood cells, both of which carry a surface charge, suggested that chemical coagulation in connection with DAF could produce the required results. Gray[10] reported SS removals of 90% with chemicals. Also an optimal removal of excess of 90% of SS in the effluent was reported by Levy, et.al.[11] on application of DAF process. Woodard et. al[9] by using this method, obtained BOD removals in excess of 85%, and SS removals greater than 98%, while the under flow from the flotation unit was of excellent clarity with no visible grease or blood and very little turbidity. However, this does not agree with Gray's findings.

The advantages offered by the DAF method include:-

1. stability of process efficiency even with large liquid loading rates and influent SS concentration.
2. rather thick sludges are being removed from the unit[12].

This process was being applied at the Sudanese-Kwati poultry processing centre at Khartoum, but the unit performance was neither satisfactory nor beneficial, and after a short period of operation it stopped completely for a number of reasons such as :-

1. sophistication of the plant.
2. lack of the appropriate personnel capable of operating and maintaing the unit.
3. lack of needed spare parts.
4. power failure for rather long periods of time.
5. unstability of wastes introduced to it.
6. chemicals needed are not always found, besides the needed requirements and conditions,e.g. dose, pH., etc, are not adhered to.
7. lack of proper supervision and method of know-how.

3. method of effluent disposal from the plant is inadequate.

The result is that the unit is now acting simply as a bypass and wastes are finding their way, somehow, to the depressions in the near vicinity of the poultry centre.

Waste stabilization ponds (WSP) upon proper maintenance and regular supervision would prove a useful means for treatment of poultry waste. The system is a rudimentary and a simple version of biological wastewater purification. It is a low cost technique, likewise operation and maintenance costs are low with perhaps only one person being required to look after a small site. It stipulates less energy, highly skilled operators are not essential and effluent can cope with required standards. Being of simple construction with no mechanical or electrical equipment WSP's are cheap to install, easy to maintain provided land costs are plausible. Poor design and construction and maintenance may end up in :-

a. excessive seepage through the bottom which may contaminate groundwater.
b. eroded embankments.
c. too much water weed growth.
d. breeding places for mosquitos and flies with an associated potential health hazard.
e. silting and blockage of inlet and other problems.

When deciding to use WSP for treatment of poultry waste primary treatment is needed. It consists of screens and grease or fat trap as unemulsified oils can be a special nuisance since they spread over pond surface obstructing the passage of solar radiation and stopping surface adsorption of atmospheric oxygen[13].

Sufficient nuitrients are indispensable to satisfy the high demand carbonaceous BOD to have proper plant performance and efficiency and to avoid troubles that may materialize. Domestic sewage may be added to alleviate the problem or perhaps commercial ammonia and phosphoric acid may be used[14,15] although the latter one implies more costs.

The high degree of purification that could be attained by WSP's in warm and sunny climates, such as in Sudan, makes it possible to use the generated effluents for crop irrigation.

WSP's may not meet effluent standards for SS because of the presence of high concentrations of algal blooms, but for BOD and bacteria reduction Gloyna15 stated that ponds have little competition. BOD removals of 90% and above are achieved in ponds while for bacterial reduction they are more efficient than the conventional treatment plants (99.5% removal is possible). Viruses also were claimed by Ahmed[16] to die off in maturation ponds along with bacteria because the enviroment is hostile and unfavourable.

Taiganides[1] proposed digestion for poultry wastes to utilize methane gas as a power source and to have an end product that is more profitable and desirable than the raw manure as a fertilizer, followed with a lagoon. Also usable gas production by digestion has been suggested by Johnson and Mounteny[4]. Merits to be gained from anaerobic digestion of the poultry waste include:-

1. waste stabilization and reduction of the organic content.
2. less pollutional and contamination problems.
3. usage of the end product as a fertilizer.
4. sludge concentration.
5. commercial usage of gas produced.
6. reduction of rodents, mosquitos and flies problem.

Like any other process, digestion, has limitations such as high initial capital costs incurred, careful supervision of the feeding of the digestor desiderated and care needed to avoid problems such as explosions.

In case of scarcity of water, conservation through renovation and reuse could provide an economical and logical solution in a poultry processing plant. Charles[17] concluded that waste material can be safely and profitably recycled by feeding without hazard to animal or human health, but this may be questionable. Mead, et.al[5] found that some microorganisms such as Pseudomonas, are considerably more resistant to chlorination than E.coli and they recommended a dosage of 5-20 mg/l of available chlorine in the water used for poultry processing. Saad, et.al[18] found that renovation of reused water by filtration-chlorination may effectively reduce water consumption needed for the washing and chilling process to approximately one-third of the ordinary levels without affecting the bacterial and chemical quantities of the freshly consumed carcasses. However, they reported that application of chlorination may accelerate the rate of free fatty acid release, as chlorine may enhance the breakdown of triglyceride into glycerol and free fatty acids.

RECOMMONDATIONS AND CONCLUSIONS

From the forementioned discussions it could be concluded that when deciding to use a system for poultry wastewater treatment in Sudan it must be:-

- a. simple to construct and operate utilizing capabilities of unskilled personnel.
- b. inexpensive to install.
- c. easy to manage and maintain.
- d. capable of operation without creating a nuisance at high temperature levels.
- e. ruggedly robust and reliable and efficient.
- f. coping with social aspects and beleifs and impact on people concerned.
- g. does not necissates usage of chemicals that are not to be found locally.

According to Hamm[19] improving techniques and equipments used for killing, scalding and defeathering should prove beneficial in reducing pollution from poultry processing plants. Salvato[2] advocated the following waste reduction measures:-

- a. separate collection and disposal of the blood, feathers and offal from the killing bench or trough in a proper way inorder to reduce volume of waste and cost of treatment and decrease nuisance problem.
- b. avoidance of carelessness usage of water in scalding and chilling operations.
- c. separate collection of wastes generated from evisceration process.

Therefore, one would advocate for the treatment of poultry wastewater in Sudan a system that includes:-

1. screens for separation of feathers, bones..etc.
2. simple clarifier or sedimentation unit.
3. passing the effluent from the preceeding unit to a natural biological process for treatment. Examples include: waste stabilization ponds, oxidation ditches or primary and secondary lagoons.
4. effluent generated from the chosen unit could be used for irrigation purposes or it could be evaporated in a neighbouring area in a satisfactory sanitary manner.
5. solids gathered from the forementioned units could be:
    - a. dewatered and the product may be rendered to produce an animal feed supplement.

b. digested with help of poultry manure and the gas produced could be engineered for power generation, while the end product begetted could be used as a fertilizer.

SUMMARY

In Sudan there are many poultry processing centres some of them without any sort of waste treatment, while in others rather sophisticated, unreliable and unefficient methods were used. This situation resulted in many problems and malfunctions. A number of treatment options were discussed in this paper and their merits should be counterpoised against the incurred expense of the selected units, availabilty of skilled labour and man power with certain prerequisites, spare parts arduousness, training facilities for people involved and supply of power and chemicals.

The treatment plant should be located as far as possible from the processing centre to avoid contamination, and workers should be aware and careful about what they should wear, how should they handle equipments, products and wastes inorder to preserve the hygiene of the enviroment both within the plant and its surrounding.

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Distribution of Phosphate, Nitrate, Ammonia and Heterotrophic Bacteria Along Stretch of the Out-flowing Water of a Dam-Reservoir.

ADEL MAHASNEH

Department of Biological Sciences
University of Jordan, Amman.

INTRODUCTION

Many fresh water management strategies are based on estimates of phosphate and nitrate in these waters. Ammonia also is a critical compound in the nitrogen cycle. Not only is it an important and often the primary source of nitrogen for the phytoplankton of oligotrophic regions (Thomas, 1966 and 1970), it is also one of the products of demineralization of the organic matter of decomposing organisms and excreted material. Thus it is clear that ammonia is consequently of great interest to both biological and chemical water researchers. The Zarqa-river, with a catchment area of 3300 KM^2 (Fig. 1) enters King Talal dam reservoir 35 KM north of Amman. For the first 13 KM of the river course before it enters the reservoir, it flows through industrialized and urbanized area bringing many pollutants to the reservoir (Mahasneh,1982). This resulted in some environmental stress on the reservoir waters. Although every effort is made to monitor and control the quality of the incoming water to the reservoir but still some problems are there. The aim of the present work was to determine primarily the concentration of some nutrients and bacteria in the outflowing water of the reservoir along a stretch of 1.5 KM down stream towards the Jordan Valley.

MATERIAL AND METHODS

Water Samples.

Nutrients: Two weeks interval samples were collected in 500 ml polyethylene bottles which were stored in an ice-box during transportation to the laboratory. The estimation of total ammonia, nitrate and phosphate were according to Strikland and Parsons (1972).

Bacteria: Samples were collected in pre-sterilized glass bottles (150ml) which were stored in an ice-box for transport to the laboratory. The standard plate count on plate count agar (PCA) Difco was used for the enumeration of heterotrophic bacteria according to APHA standard methods (1965). Total coliforms were determined as above using membrane filtration method. Sterile Millipore filters (0.45 μm) pore size over-layed onto a sterile cellulose pads imprignated with Endo-broth were used to grow coliforms. Form both determinations plates were incubated for 24-48h at 30 and 37°C respectively.

Sampling Sites.

Five sampling sites (I,II,III,IV,V) were chosen (Figure. 1). The first site (I) is directly behind the reservoir discharge gate and the rest (II to V) are 200,600,800 and 1500 meters down from the discharge gate towards the Jordan Valley.

RESULTS AND DISCUSSION

Chemical Analysis.

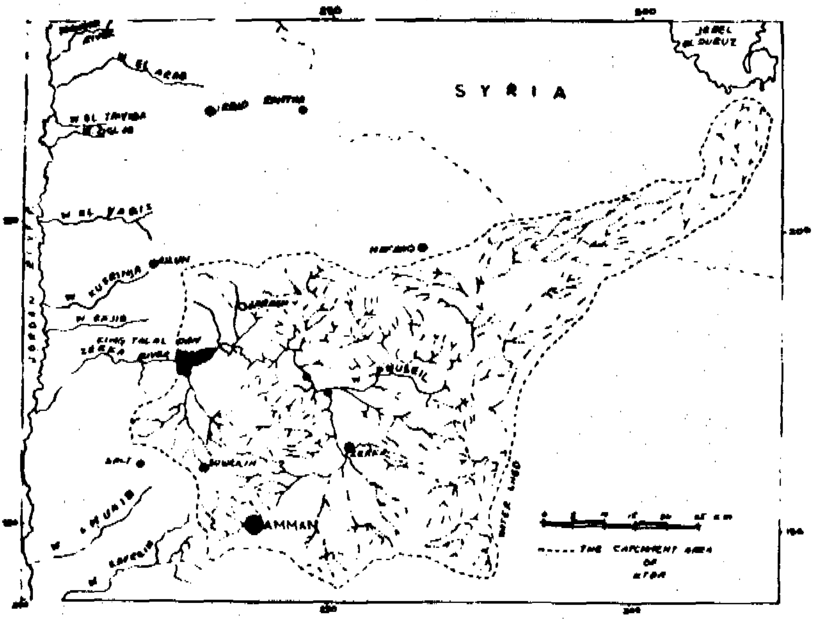
Phosphate concentration is considered one of the parameters indicating the self-purification capacity of the river. This process is definitely influenced by the loading to the streaming water which inturn is changing with time. This when linked to the utilization of phosphate by algae enhances the release of O_2 to the water which may encourage the aerobic degradation of pollutants reaching the river course. This uderstanding, in our case, may explain the slight change of phosphate along the 1.5 KM stretch of the river behind the reservoir discharge gate, where the mean values for the different sites were of the order 80,130,100,100,100 $\mu g\ PO_4\text{-}P\ L^{-1}$ for sites I,II,III, IV and V respectively (Fig. 2). The lowest value of site I was recorded in October 1982 coinciding with the late algal blooms. Later on in November,December of the same year and January 1983 the concentrations were increased probably due to fresh rainfall.

For nitrogen-nitrate, mean values during the study period were 50,45,60 and 80 $\mu g\ N\text{-}NO_3 L^{-1}$ for sites I, II,III,IV and V respectively (Fig. 3). This observed increase in nitrate concentration with down stream may indicate a good aeration condition in the running water which inturn enhances the aerobic microbial nitrification (Guter, 1982).

At the same time ammonia concentration decreased down stream with mean values of 35,50,45,40 and 10 μg NH_3N L^{-1} for sites I to V respectively (Fig. 6). This is expected since the settlement of organic matter through inflow to precipitation of dead algal cells will be minimal in such shallow running waters. In addition, some of the ammonia will be oxidized to nitrite and nitrate in surface water (Soub and Mahasneh,1982). Nazneen (1980) gave values (25-1250 mg L^{-1}) which are higher than our values but with more eutrophic water. Wetzel (1975) gave ammonia concentration mean values of 70 μg NH_3-N L^{-1} for the lake of Veirwaldstahersee. Considering the changing concentrations of phosphate, nitrate and ammonia during this work, it is very clear that the self-purification ability of the Zarqa river is not pronounced; probably studying these chemicals on a longer stretch of the river may indicate otherwise, hence the continuation of this study is eminent to give a broader understanding of the water quality and the ability of the river for self purification.

Bacteriological Analysis.

Water has always been a medium for the transmission of human microbial diseases (Scarpino,1971). As a result total viable bacterial counts and total viable coliforms were sought inorder to assess the water quality and also to see the effect of running water upon the viable bacteria. Results in Figures 4 and 5 show that actual decrease in both counts was observed as you travel from site I towards site V with mean values of 0.5 to 1.5 expressed as $\log_{10}$ cells ml^{-1}, the lowest value being recorded at site V (Fig. 5). Walting and Emmerson (1981) recorded similar observations concerning coliform counts with down stream river water. Mahasneh and Soub (1983) reported higher viable counts in water samples from the main body of the reservoir during 1980. However, looking at the results of both chemicals and bacteriological analyses of the waters we cannot conclude that the self purification ability of the river is sufficient to reduce the pollutants concentrations. This should be coupled with control measures that help in reducing the incoming pollutants to the main reservoir.



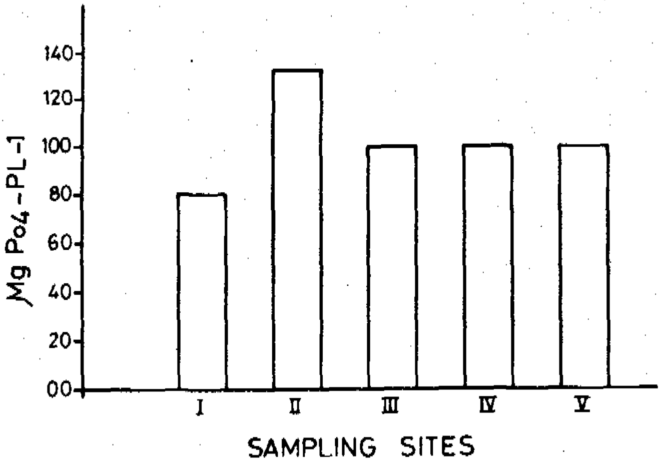


Figure 2. Mean values of phosphate phosphorus during the study period.

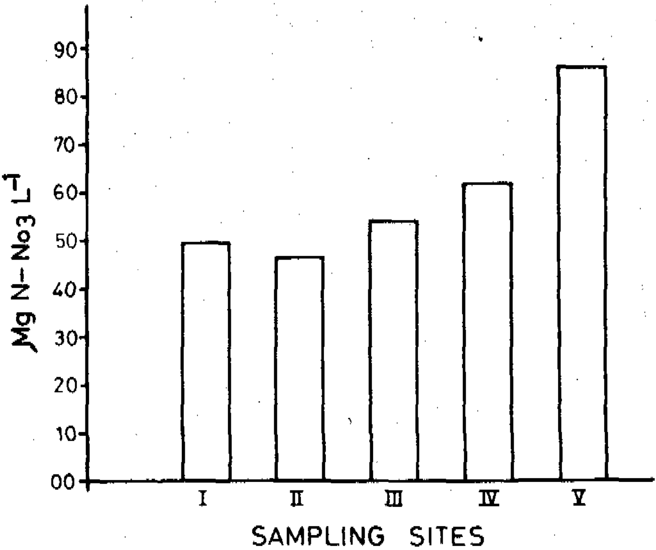


Figure 3. Mean values of nitrogen_nitrate.

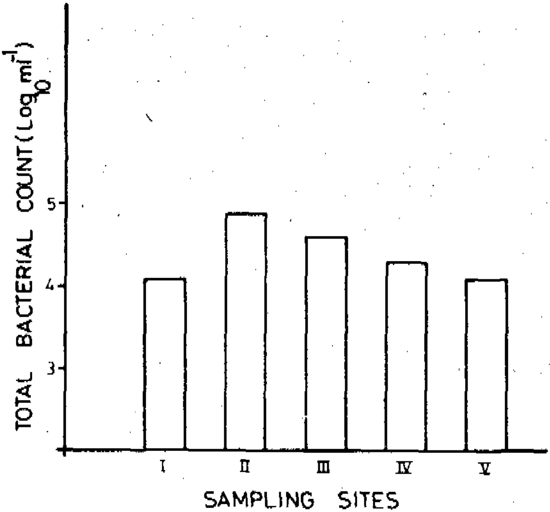


Figure 4. Changing bacterial counts (Mean values) during the study period.

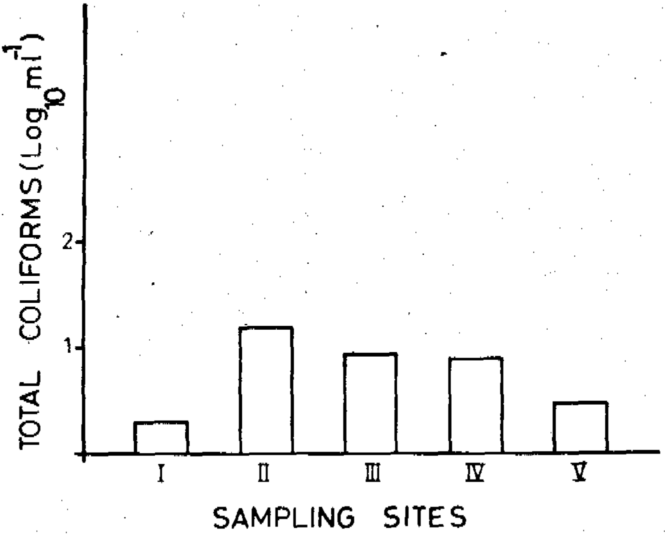


Figure 5. Changing coliform counts (Mean values)

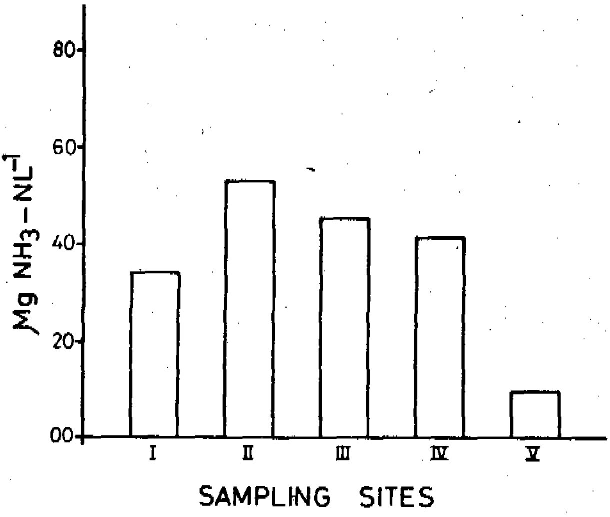


Figure 6. Mean values of ammonia_N .

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MITOTIC CHANGES IN VICIA FABA ROOT-TIP CELLS EXPOSED TO RAW AND TREATED INDUSTRIAL LIQUID WASTES

Adel M. Masry and
Samia G. Saad

Assoc. of Genetics, Faculty of Agriculture, Alexandria University
Prof. of Environmental Health, High Institute of Public Health, Alexandria University, Egypt

Cytological aberrations in plants serve as an excellent monitoring system to detect the effects of chemical environmental pollutants that may possess genetic hazard. As early as 1925, the effects of chemical compounds on cell nuclie was studied by Dustin (1925). He was the first to report that certain chemicals affected the nucleus, but not the cytoplasm of the treated plants.

Several higher plants such as Onion (Allium cepa), barly (Hordeum vulgar), maize (zea maize), pea (Pisum sativum) and broad bean (Vicia faba), provide unique and valuable system for detecting and analysing the effects of chemical mutages (Nilan and Vig 1976). Numerous studies have demonstrated that chromosomes of these plant materials are sensetive indicators to environmental pollutants (Grant 1978). Mutagenic effects of different pesticides and other chemical compounds have been reported by Anderson (1969); Lignowski and Scott (1972) working on cotton and wheat, Galal and Abd Alla (1976) and Mousa (1982) working on onion and broad bean.

Some of the advantages in utilizing plant system for analysing most genetic and chromosomal aberrations which may be induced by chemical mutagenes have been reviewed by Niland and Vig (1976). One of these advantages is the positive correlation which has been observed between aberrations induced by the same chemical in plant root-tip cells and in cultured mamelian cells. There is also a good correlation with respect to the mutagenic activity as shown by Kihlman (1971). He reported that the type of chromosomal aberration in root-tip cells induced by a specific chemical may not be the same as in animal cells, but if a particular chemical will induce chromosome aberrations in one group, generally, it will be so in the other as well. However, Hall (1962) showed exactly the same morphologic "C-mitotic" picture occurring in plant and animal cells.

Industrial waste effluents are discharged in the raw form partially to sewers and the rest to the surrounding bodies of water. Alexandria metropolitan area is facing the problem of decision regarding the final disposal of its domestic and industrial effluents. The choice is between discharge to the sea by an outfall or land irrigation. The mutagenic effects of the different industrial effluents have to be assessed in order to through more light on the percussions of land irrigation with this kind of mixed waste.

The present investigation was carried out to test the effects of some industrial waste effluents on mitotic activity and mitotic aberrations in the root-tip cells of Vicia faba.

The chosen three effluents were generated from the biggest dye manufacturing plant in Egypt (Ismadye) involved in production of all types of dyes. The second effluent was the waste of Moharram press in which all types of paper printing is a carried out leading to a waste with moderate biological toxicity when tested on fish and algae.

Egyptian Copper works is one of the biggest plants for copper, steel and aluminium processing and refining.

The three effluents in the raw form varied in levels and causes of toxicity. Treatments were applied to make them meet the standards specified by the Egyptian law in their characteristics.

Materials and Methods

The different raw and treated industrial waste effluents were collected and chemically analyzed to see if the treatments applied were sufficient to make those effluents acceptable.

The chosen treated effluents used to test their mitotic abnormal activity were those accepted chemically by the standards set by the Egyptian law.

Chemical characterization of all effluents were carried according to the Standards methods of water and wastewater Analysis (1975).

Treatments used for each plant effluent were as follows:

1. Ismadye effluent was treated by chemical coagulation using Alum at a dose between 200-400 mg/l, followed by adsorption at d dose of 250-400 mg/l with powder active carbon.

2. Moharrem Press: the raw effluent was subject to oil skinning followed by chemical coagulation using ferric chloride at a dose ranging between 150-250 mg/l followed by mixed carbon-sand filtration for residual organics removals.

3. Egyptian Copper Works: The raw combined waste was treated by lime coagulation at a dose range of 50-100 mg/l for heavy metal precipitation followed by sand filtration and pH adjustment.

Effluents were tested with respect to their effect on mitotic activity and mitotic abnormalities in Vicia faba root-tip cells.

Each effluent was used in three different concentrations as 100, 50 and 25% of raw waste, using distilled water for dilution.

The seeds were germinated between two layers of wet filter paper in petri-dishes. A few drops of each dilution were added daily to the filter papers to keep the suitable moisture constant. After seedling germination, the main roots were exercised to enhance development of the secondary roots.

When the secondary roots reached about 1.5 cm in length, the seedling were grown in vials containing the assigned concentrations of the waste. The roots were exposed to the waste for a period of 24 hrs. Seedlings grown in vials containing distilled water, with no waste added, were used as untreated control. At the end of the treatment, the roots were fixed in a solution of alcohol-acetic acid (3 parts of ethyl alcohol: 1 part active acid). After about 24 hrs of fixation, the material was washed and stored in 70% ethyl alcohol and kept in refrigerator.

For cytological examination, temporary smears for the root-tips were prepared using the acetocarnine technique. Five preparations were made for each treatment. The percentages of the different mitotic aberrations were estimated from randomly five selected fields from each preparation. Percentage of mitotic activity (mitotic index) was calculated as the ratio of normal dividing cells to the total cells examined for each treatment. The percentage of each mitotic aberration was estimated as the ratio of cells containing the aberrations to the total number of cells examined (Badr et al. 1972, Galal and Abd Alla, 1976 and Mousa, 1982).

Results

The main objective of the present investigation was to study the effects of some industrial effluents on the rate of mitotic activity and the mitotic aberrations in the root-tip cells of vicia faba. For this purpose, the roots were exposed to different concentrations of the raw and the treated waste without dilution. In each case, percentages of the different mitotic stages and mitotic aberrations were recorded. The results obtained for each effluent are presented separately.

1. Ismadye Effluent

Ismadye effluent is characterized by the presence of a wide variety of organic chemicals including quinone, benzene, benzedene, toloune as well as aromatic halides, ketonues and aldehydes. Organic solvents are also present as a result of dyes intermediates preparation. The toxicity problem of this effluent is basically created by the combined effect of not less than 150 chemicals organic and inorganic, present together in a wide range of variable concentrations.

Although the waste when chemically treated was acceptable from the chemical point of view with respect to the BOD, COD, Solids, Colors and trace metals content yet biological effects on living cells were not completely eliminated.

Table (1) presents the percentages of the different mitotic stages for the different treatments and also for the untreated control. The results clearly indicated that the waste was effective in reducing the rate of mitotic activity recorded for the control. Different concentrations of the raw waste, showed general reductions in the percentages of the four mitotic stages, i.e. prophase, metaphase, anaphase and telophase. However, the rate of mitotic activity slightly decreased with decreasing the concentration from 100% to 25% raw waste. The results also indicated that the treated waste was effective in the inhibition of the mitotic activity. There was no much differences in the effects between the raw and the treated waste as the mitotic index indicated.

It has been also observed that the waste was effective in producing some different mitotic aberrations. These aberrations were C-metaphase, teraploid cells, lagging chromosomes and binucleate cells. The frequencies of different aberrations are shown in Table (2). Percentages of these kinds of aberrations were comparatively higher at the higher concentration of the raw waste.

The treated waste was effective in producing such aberration but in low frequencies when compared with the raw waste.

2. Moharrem Press Effluents

This plant effluent is basically characterized by the presence of heavy metals as well as pigments and organic aromatic solvents used in the cleaning operations of the printing machines as well as the preparation of new designs on the metal cylinders using metal etching techniques.

Table (3) presents the effects of the raw and the treated waste on the mitotic activity of the root-tip cells. Treatment with different concentrations of the raw waste caused general reduction in the percentages of different stages of mitotic division. Hence the mitotic index at each concentration was reduced. However, differences in the reduction of mitotic activity between different concentrations were very small. Exposing the roots to treated waste reduced the mitotic activity of the cells. There were no much differences in the reduction of mitotic index induced by the treated and the raw waste.

Comparisons between Ismadye and Moharrem Press effluents indicated that their raw waste (100%) had same effect on the inhibition of the mitotic activity as the mitotic index indicated (Tables 1 and 3).

Table (4) shows the percentages of mitotic aberrations caused by the raw and treated waste. The only kind of mitotic aberrations was lagging chromosomes, this kind of aberrations was observed in low frequency in treatment with 100% raw waste because of the general low solubility of the chemicals present in the waste. The percentage of abnormalities induced by their waste were lower than those recorded and Ismadye.

3. Egyptian Copper Works Effluent

The Effluent of this plant is not highly polluted and its content of organics are relatively very low, yet being involved in Iron, Steel, Copper and Aluminium processing and refining raise the probability of heavy metals presence as Zn, Mn, Fe, Cd, Ni and Pb, As, Cu and Aluminium in the effluent. Lime addition was successful in reducing the total content of all metals to 1 mg/l dictated by the law.

Percentages of different mitotic stages induced by different concentrations of the raw and the treated waste are shown in Table (5). Percentages of each mitotic stage was greatly reduced when compared with the corresponding value in the control. The reduction in mitotic index decreased with decreasing the concentration of the raw waste. Moreover, differences in the effects between the raw and the treated waste were very small.

Comparisons between the effects of Egyptian copper works and Ismadye effluents indicated that the former waste was more effective in reducing the mitotic activity than the latter one as the mitotic index indicated (Tables 1 and 5).

This effluent was also effective in producing mitotic abnormalities. The aberrations observed at different treatments were C-metaphase, tetraploid cells and lagging chromosomes. Binucleate cells were only found at the high concentration of 100% raw waste. The percentages of different abnormalities are presented in Table (6). The percentages of abnormalities decreased by dilution of the raw waste.

The treated effluent showed the same types of mitotic abnormalities in the cells of the root tip, yet at relatively lower frequencies.

Discussion and Conclusion

The present results indicated that the three different effluents derived from Ismadye, Moharrem Press and Egyptian copper works had different effects on mitotic divisions in the root-tip cells of vicia faba. The three effluents were generally, effective in reducing the mitotic activity even at low concentration of 25% raw waste. Moreover, the treated wastes were also effective in producing the same reduction in mitotic index as the raw waste. The inhibition of mitotic activity caused by the Egyptian Copper Works waste was greater than that caused by the other two effluents. These results revealed that the three effluents were effective antimitotic agent.

The wastes were also effective in producing some types of mitotic aberrations such as C-metaphase, tetraploid cells, lagging chromosomes and binucleate. The presence of C-metaphase may indicate that the waste caused an inhibition to the spindle formation. The production of tetraploid cells can be explained by the inhibition of the simple formation in the next cell division. The possibility of elimination by lagging chromosomes would affect chromosome number in the two daughter cells leading to aneuploidy. Binucleate cells would be due to cessation of cytokinesis. However, the presence of tetraploid cells with other types of abnormalities would suggest that the waste caused an inhibition to the spindle formation, but did not prevent chromosome replication. These aberrations are similar in character to those induced by wide variety of pesticides and other chemical compounds in Allium cepa, vicia faba, Pisum sativum and other plant materials (Anderson 1969, Nicoloff et al. 1971, Bada et al. 1972, Lignowski and Scott 1972, Galal and Ab Alla 1976, and Mouse 1982).

The frequencies of these aberrations varied according to the source of the waste and also to the concentration applied. The most effective effluent was the one derived from Ismadye while the less effective waste was the one derived from Moharrem Press. The frequencies were generally higher at the raw than the diluted or treated wastes. Such differences are expected since their chemical contents are not the same. Vaulina et al. (1978) reported that cadmium chloride induced disturbances in nuclear division and cessation of cytokines in Crepis capillaris. They suggested that the disturbances of mitosis were caused by blocking of SH groups in the contractile proteins of the spindle. This effect can be extrapolated on other heavy metals present in combinations of variable quantities in the raw and treated effluents. The inhibition of mitotic activity would, seriously, affect the growth rate and the productivity of the plants exposed to these effluents. On the other hand, the mitotic abnormalities would reflect the possibility of disturbing the mechanism of cell division leading to individuals with chromosome aberrations either in number or structure. Such effects would, generally, reduce the viability of the exposed plants the biological activity changes in living cells should not be overlooked in the standards specified by the international laws since the chemical and physicochemical parameters will not show the trace deterioration of the biological life exposed even to the treated effluents. The receiving bodies of water or land should assure reasonable dilution to the treated effluents to minimize their biological deteriorating effects.

Summary

The present investigation was carried out to test the effects of some industrial waste effluents on the mitotic activity and mitotic aberrations in the root-tip cells of Vicia faba. Three effluents from different sources were used in different concentrations. These concentrations were 100, 50 and 25% of raw waste. The effects of the effluents after biological treatment have been also tested. The results revealed that the three effluents acted as antimitotic agents and they were effective in reducing the mitotic index than the untreated control. The inhibition of mitotic activity increased with increasing the concentration of the waste.

The effluents were also effective in inducing different types of mitotic aberrations such as C-metaphase tetraploid cells, lagging chromosomes and binucleate cells. The frequencies of these aberrations varied according to the source and the concentration of the waste.

The effects on mitotic activity and the induced mitotic abnormalities were not completely eliminated by the standards treatment technology.

Acknowledgement

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Table 1: The Effect of Ismadye Waste Effluent on the Rate of Mitotic Activity

Mitotic stages	Waste concentrations Cont.		100		50		25		W.A.T.	
	N	%	N	%	N	%	N	%	N	%
Interphase	1675	83.8	2891	95.98	2495	95.16	3169	95.12	1677	93.95
Prophase	130	6.5	22	0.73	9	0.34	33	0.69	25	1.40
Metaphase	20	1.0	38	1.26	39	1.49	52	1.56	38	2.13
Anaphase	35	1.7	29	0.96	31	1.18	48	1.44	31	1.74
Telophase	140	7.0	32	1.06	48	1.83	39	1.17	14	0.78
M.I.	325	16.2	121	4.02	127	4.84	162	4.86	108	6.05

W.A.T. :	Waste after treatment
M.I.	Mitotic index
N	Number of cells tested

Table 2: Percentages of Different Mitotic Aberrations induced by Ismadye Waste Effluent

Type of aberrations	Concentrations %			
	100	50	25	W.A.T.
C-metaphase	5.9	4.6	2.7	3.9
Tetraploid cells	4.3	2.1	0.9	2.2
Lagging chromosomes	4.1	3.8	2.6	-
Binucleate cells	2.4	1.1	1.3	0.6

Table 3: The Effects of Moharrem Press Effluent on the Percentages of Different Mitotic Stages

Mitotic stages	Waste Concentrations									
	Cont.		100		50		25		W.A.T.	
	N	%	N	%	N	%	N	%	N	%
Interphase	1675	83.8	1998	96.20	1928	95.56	1800	95.13	1941	95.95
Prophase	130	6.5	22	1.12	19	0.94	22	1.16	21	1.04
Metaphase	20	1.0	33	1.67	35	1.74	34	1.80	35	1.73
Anaphase	35	1.7	16	0.81	25	1.24	24	1.27	16	0.79
Telophase	140	7.0	4	0.20	10	0.50	12	0.06	10	0.49
M.I.	325	16.2	75	3.80	89	4.41	92	4.86	82	4.05

W.A.T. Waste after treatment
M.I. Mitotic Index

Table 4: Percentages of the Abnormalities Induced by Moharrem Press Effluent

Type of aberrations	Waste concentrations %			
	100	50	25	W.A.T.
C-metaphase	-	-	-	-
Teraploid cells	-	-	-	-
Lagging chromosomes	2.1	-	-	-
Binucleate cells	-	-	-	-

Table 5: The Effects of Egyptian Copper Works Effluent on Mitotic Activity

Mitotic stages	Concentrations %									
	Cont.		100		50		25		W.A.T.	
	N	%	N	%	N	%	N	%	N	%
Interphase	1675	83.8	1821	98.34	1789	98.14	1665	95.97	1764	98.00
Prophase	130	6.5	12	0.65	2	0.11	18	1.04	6	0.33
Metaphase	20	1.0	5	0.27	16	0.87	26	1.50	18	1.00
Anaphase	35	1.7	9	0.49	9	0.49	18	1.04	8	0.44
Telophase	140	7.0	4	0.22	17	0.93	8	0.46	8	0.44
M.I.	325	16.2	30	1.62	44	2.40	70	4.03	40	2.22

W.A.T. Waste After Treatment
M.I. Mitotic Index

Table 6: Percentages of Different Mitotic Aberrations induced by the Egyptian Copper Works Effluent

Type of aberration	Waste concentrations			
	100	50	25	W.A.T.
C-metaphase	3.1	2.0	0.9	2.3
Tetraploid cells	4.3	1.4	1.1	1.9
Lagging chromosoms	3.9	2.1	0.8	2.4
Binucleate cells	1.8	-	-	-

LOW ENERGY CONSUMPTION MANAGEMENT OF AGRICULTURAL RESIDUES

Vincenzo Mennella,Egidio Zavattiero,Olimpia Castagnoli
Università-Istituto Costruzioni Rurali-Perugia-Italy
Istituto Superiore Sanità-Reparto Suolo-Roma-Italy
Istituto Superiore Sanità-Lab.Igiene Territorio-Roma

INTRODUCTION

In most developing countries the agriculture residues management includes,among other things,control and use of pig wastes.

There are (in 1981) 779 million pigs (Table 1.)in the world,57% of those are reared in developing countries where lives 73% people of the world.

Table 1. Pigs in the world in 1981
(in million of heads)

Asia	370
south America	54
north and middle America	93
Africa	10
Europe	174
Oceania	5
U.R.S.S.	73
Total	779

This work has been realised thanks to financial help from Ministero Pubblica Istruzione.

The average world pig production is 18 heads per 100 inhabitants but this value is different from country to another with peaks in somè countries which are over the average of their own Continent.For instance,in Brazil the number of pigs per 100 inhabitants is 35,in China 31 in Vietnam 18 in the Philippines 16 and in Thailandia 10 whereas in Asia the pigs per inhabitans are 7 per 100. In Africa the continental average is 2 heads per 100 inhabitans while in some countries this number is greater like in Lesotho (6.6),Swaziland (4.2) and in Zambia (3.3).

Many of the problems associated with the disposal of pig wastes by landspreading arise by the fact that the excreta is being applied in semi-liquid form.

Heavy doses of liquid manure contribute to the degradation of soil structure,might lead to salinisation and acidification of the soil to have negative influence on plants and to be a risk for pollution and nutrient enrichment of surface waters and groundwaters.

In contrast to the problem of liquid manure are the long known advantages of the use of farmyard manure.

Spreading liquid manure on soil should depend on soil type,cropping system and climate.

The complete treatment of slurry by biological methods similar to those used for domestic and industrial sewage,is not economical.Physical and Chemical methods of treatment and anaerobic treatment for methane production are being investigated.

At present in developing countries the making use of pig liquid manure is as a fertiliser by appling it to the field and in shallow pond in symbiosis or partnership with commun bacteria for the culture of algae. Organic Waste materials constitute the major source of the nutrients of algae, that are used for the production of livestock feeds.

Pig effluents is also used to fertilise fish ponds. The water from the algae pond is always drained into the fish pond to conserve the large volume of water with algae washings,which serve as feed for the fish (carp or tilapia).

There is an increasing interest about the implication for health of the solid waste management problems in developed as well as in developing countries.

Optimum utilization of the resources,and wastes are part of these resources,is the most important goal in the world.Use of wastes is looked at from two points of view.In developed countries there is much concern for the disposal of massive quantities of wastes which accumulate and,if not handled adequately would have adverse environmental impact.In developing contries there is an increasing concern on the utilisation of resources present in wastes.

The urban wastes are not the same in different regions of the world.The amount and nature of household refuse varies greatly too from one country to another and between urban and rural areas depending on living standard,climate and customs.

Table 2. Composition as a percentage of solid waste in different regions of the world.

	U.S.A.	ASIA	G.BRITAIN	ITALY	MIDDLE EAST
food	18	75	28	50	50
paper	40	2	37	18	16
metal	20	0.1	9	3	5
glass	10	0.2	9	4	2
plastic	4	1	2	4	1
others	8	21.7	15	21	26
weight/ man/day (chilo)	2.6	0.4	0.8	0.8	1.1
density (Kg/m^3)	-	570	132	240	211

Cities of developing countries are growing at very fast rate.The World Bankreport referred that,for the year 2000,40 cities of 52 containing more than 5 million inhabitants will be found in developing nations.In these countries more than eighty percent of all collecting solid wastes is organic putrescible.

This organic fraction forms the great bulk of waste and is therefore the most significant element to consider in waste disposal recovery.

In large towns,the better disposal of wastes in an economic manner conforming to the pollution abatement standards is that of processing these in composting plants.

AIM OF THE RESEARCH

The prospect of reducing the pollution level of the liquids,and at the same time enriching compost with the elements it lacks,has stimulated research into the finding of systems that use compost as a filter bed for the liquids.In this manner one should obtain a reduction of pollution levels in the liquids and an enriching of compost with nutritive substances for the land.

The various experimental investigations have shown that a filter made only of compost blocks too rapidly, thereby loosing its functionality.It follows that a study of systems and devices is necessary in order to obtain the following objectives:

- raise the filtering capacity of the compost in relation to the quantity of liquid treated;
- obtain the greatest possible reduction of the pollution level of the liquids.

We tried to reach these objectives by experimentation in laboratory using a specially designed and built apparatus.

It was found from the experiments carried out and from the elaboration of the data,that the hypothetical procedural scheme for the treatment of liquids caused by swine breeding by filtering through compost can lead to an adequate reduction of the values which characterise the pollution load of the liquids.

The efficiency of the various unitary operations of the process allow the utilization of both the effluent and the compost treated with the liquid in agriculture.

In particular the introduction of straw into the make up of the filters led to a substantial improvement of the filtering capacity and to a reduction of the pollution load.

Usuful indications for the furthering of field experience as to the disposition of the straw and compost for the filter's formation.

MATERIALS AND METHODS

On the basic results obtained we have installed a pilot plant in a farm near Perugia in Italy with intensive methods of pig rearing.

A tank was built the sides and the bottom of which was made pressed bales of wheat straw 1.10mx0.55x0.35.

This straw tank was mounted on a corrugated sheet-iron through which the leaching filtrate is drained to a container.

The volume of this tank was 845 l.The volume of compost which was obtained from the waste recycling plant of Perugia was 363 l.It was spread in a 30 cm layer.

The tank was filled at a rate of 2.5 l/sec and in following times,with 2141 l of pig liquid manure,via a supply pipe from a lagoon.

A complete analysis of the liquid manure,of the compost and of the effluent was regularly carried out.

After 10 days, when the leaching of the liquid manure was ended, the filtering system was sectioned and various layers different in composition were identified; dry fraction of manure, straw and compost. Samples of various layers were taken and analyzed. At last the filtering system was destroyed and the materials were carefully mixed.

Analysis of farmyad manure obtained were made from two different aspects: one agronomic and the other environmental when it will be used, as fertilizer, on the land.

RESULTS

From the analysis of the original liquid manure and the filtrates obtained we are able to observe that there is a removal of B.O.D. (63%), C.O.D. (85%), suspended solids (56%), sedimentable matter (100%), N (78%) and P (88%) and an increased BOD/COD ratio which is an index of better biodegradability.

Table 3 shows the significant results from a agronomic point of view, of the material obtained from mixing the filtering system, compared with those of compost, of straw and of usual farmyard manure.

One can notice that while the organic matter is almost costant there is an increase of N and P in the resulting material compared with compost and a lower C/N ratio which is like that of farmyard manure.

Analysis of heavy metals like Zn, Cu, Pb, Co, Ni, Mn and Cd which could be a hazard for health and/or for the enviroment indicated that the concentrations of heavy metals are much under the tolerable limits proposed from EEC.

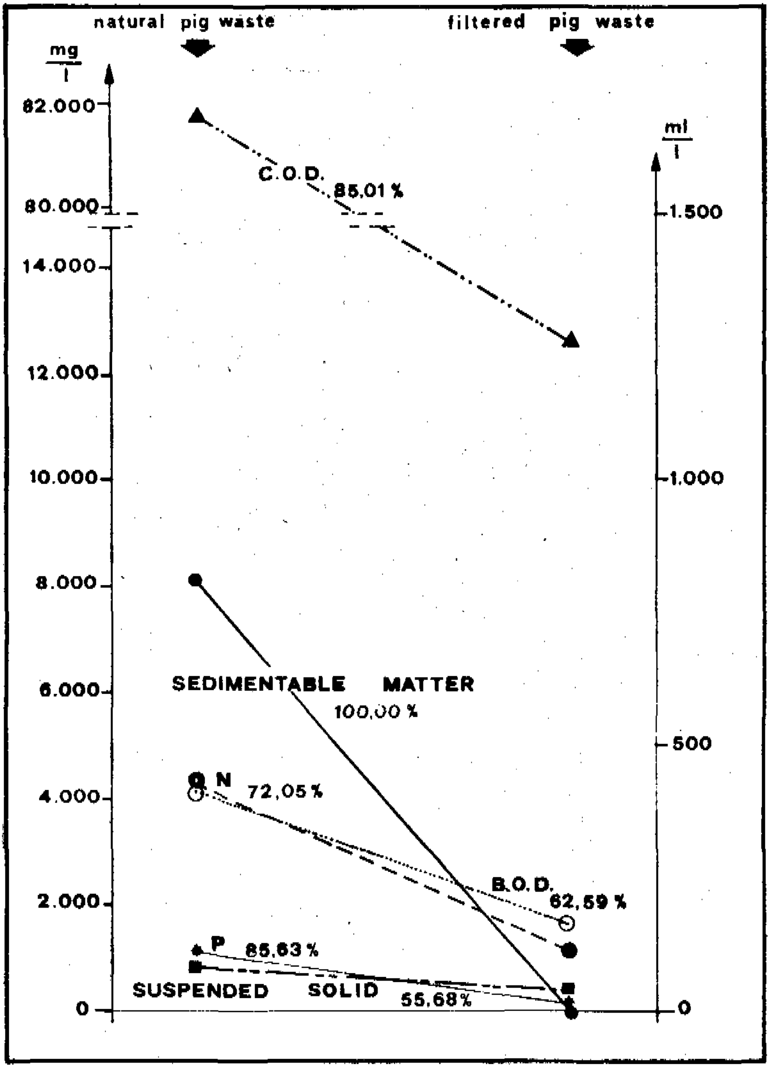

Fig.1 Results from the analysis carried out with the liquid manure as it was and the filtered part and percentage varations.

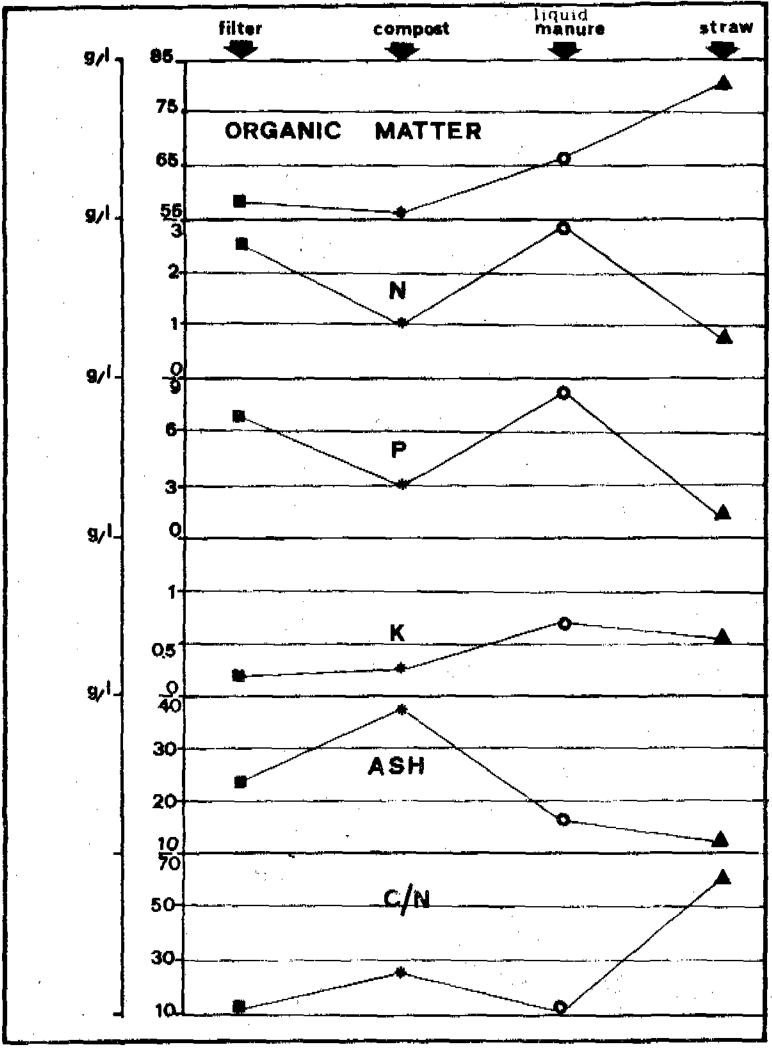

Fig.2 Comparison of same significant parameters from agronomic point of wiew of the materials of the filtering system with other materials (compost,straw, liquid manure).

Table 3. Significant results in %

matter	filter	compost	manure	straw	
organic matter	58.83	56.36	66.66	81.04	
N	2.53	1.09	2.85	0.77	
P	6.92	3.04	8.58	1.16	
K	0.23	0.29	0.68	0.54	
ash	23.48	38.55	16.65	12.48	
C/N	13.01	25.72	13.35	60.54	

CONCLUSION

From the results obtained we can conclude that the experimental system even if it is not able to completely reduce the pollution level of the liquid manure, it is a good pre-treatment plant for separation of the solid fraction with the following advantages:

1. reduction of pollution load to acceptable values to be treated in conventional aerobic treatment or to be used as feed for algae in shallow ponds or to be disposed of by landspreading;

2. no mechanical means are necessary;

3. no use of first quality expensive materials able to resist the corroding action of the liquid manure;

4. no use of electric power;

5. use of straw, cheap and readily available material;

6. enriching compost in nutrients;

7. whole recovery of all used materials when, at the end of the filtering cycle, the filtering capacity is almost null;

8. heavy metals values under the tollerable limits pro-

posed to avoid environmental pollution.

At the end of the filtering cycle,the treated liquid can be conveyed to another treatment while the new raw slurry can be carried to another tank when the old plant is put out of service and dismantled.The resulting material,thoroughly mixed,can be put in a static pile to stabilize and then used as fertilizer (f.)The stabilisation process is made easy in the presence of compost which is already stabilized before the filtration process.

The experimental plant was designed to deal with a slurry from 40 pigs for a period of 10 days(f.4)Increasing the tank size from 2.2m x 2.2m to 4.4m x 4.4m,with the same height,one can treat a pig liquid manure amount nine times greater and can deal with a slurry from 360 pigs.

The modular system make it suitable to the requirements of the use.

At last the plant experimented with wheat straw as support and compost as a filter used both as fertilizer can be replaced by other agricultural wastes such as rice straw,maize stalk,millet stems,banana cotton and coconut trash and so on,baled or bound in fagot.

In place of municipal solid waste compost,one can use other kinds of compost obtained from agricultural wastes such as leaves,husk,bark and so on.

In conclusion the experimental system could be accepted with good results and with minimum use of energy for treating heavy polluting liquid manures and,at the same time,for obtaining a good organic fertilizer.

The system is a clear example of reclamation of waste material i.e. of recycling of the waste in a useful form.As the increasing interest for developed as well for developing countries is the optimum utilisation of resources,we believe that this experimental work can contribute to solve some problems in developing coun-

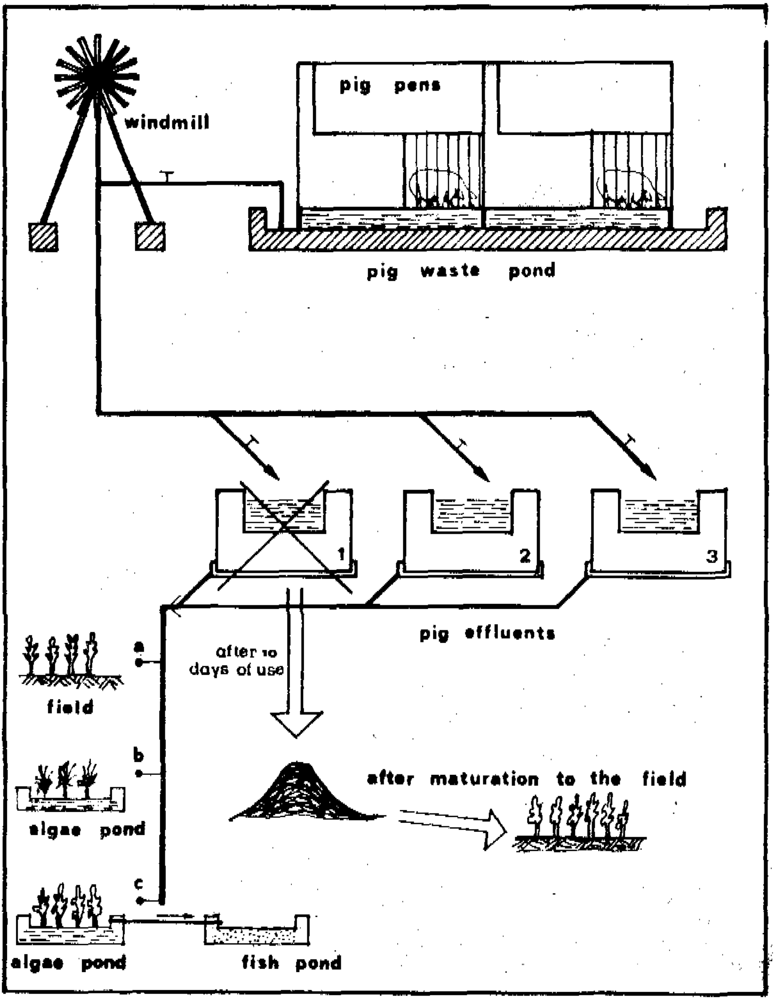

Fig.3 A recycling system of agricultural production.

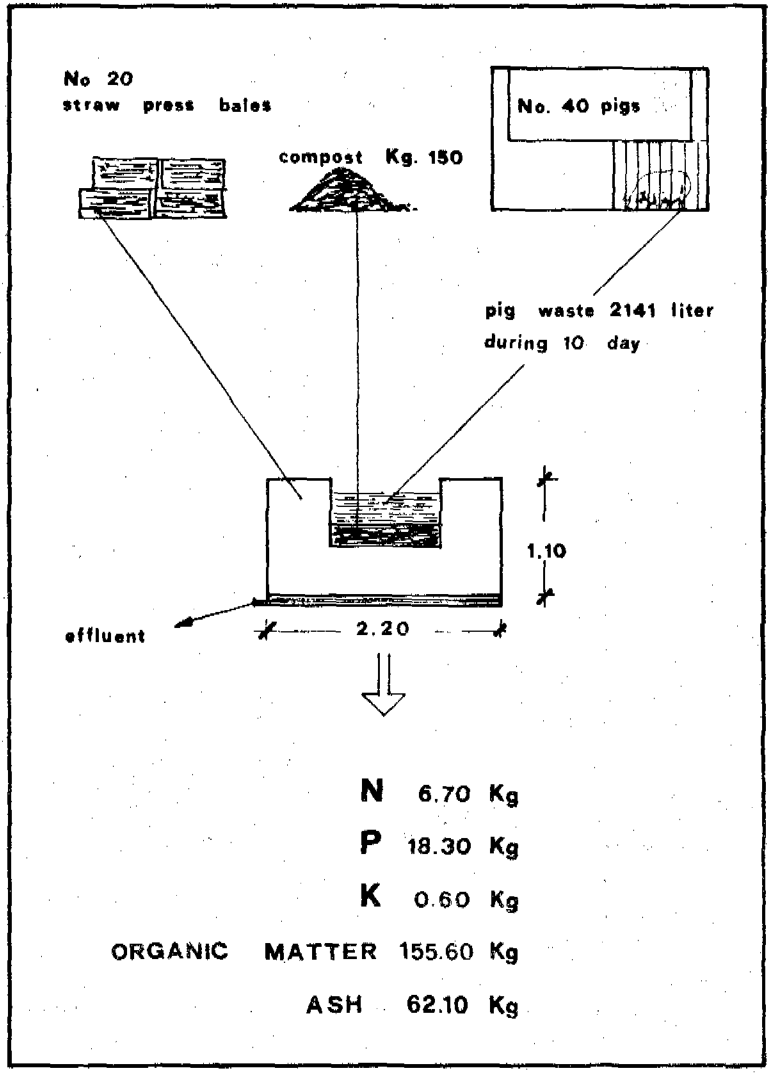

Fig.4 Equivalent quantities of the substances contained in the whole filtering system expressed in Kg

tries because waste and energy usage are minimised and self sufficiency is maximised.

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PROBLEMS OF ENVIRONMENTAL ASH POLLUTION CAUSED BY THE CONSUMPTION OF LOW HEAT VALUE COALS IN YUGOSLAVIA-ANALYSIS AND POSSIBLE SOLUTIONS

DJ. MILOVANOVIĆ, T. JEVREMOVIĆ
ENERGOPROJEKT CORPORATION
BUL. LENJINA 12 BEOGRAD, YUGOSLAVIA

1. INTRODUCTION

The greatest part of future energy requirements in Yugoslavia will be met by use of solid fosil fuels (first of all lignite).These coal deposits are concentrated in five great basins. For economical reasons (reduction of fuel transport costs and total investment costs) construction of a larger number of thermal power units on a certain location appears to be the optimum solution. In Yugoslavia, several thermal power plants with capacity over thousand MW have already been constructed on some locations and the construction plans for the future anticipate expansion of the existing and construction of new similar power plants. One of basic limiting factors for selection of the total power plant capacity on a given location, beside the resource availability, is the socalled ecological capacity of the environment. It is defined on the basis of assumed sources of all essential pollutants and their immissions over considered area existing legal regulations and environmental characteristics.

In addition to sulphur-dioxide, which has already been registered as an international pollution problem, in Yugoslavia is appearing as a problem the existence of another pollutant - ash. Considering the characteristics of the coals used in most thermal power plants, big quantities of ash appear as a by-product of combustion. The biggest portion of ash is discharged to disposal areas but a small portion (up to 2%) is emitted into the atmosphere in the form of flyash within flue gases. The influence of ash disposal areas and fly ash to the environment is manifold and is demonstrated by polluting of air, land, ground and underground waters. The secondary effects of these pollutions are unfavourable for the ecosystem as a whole.

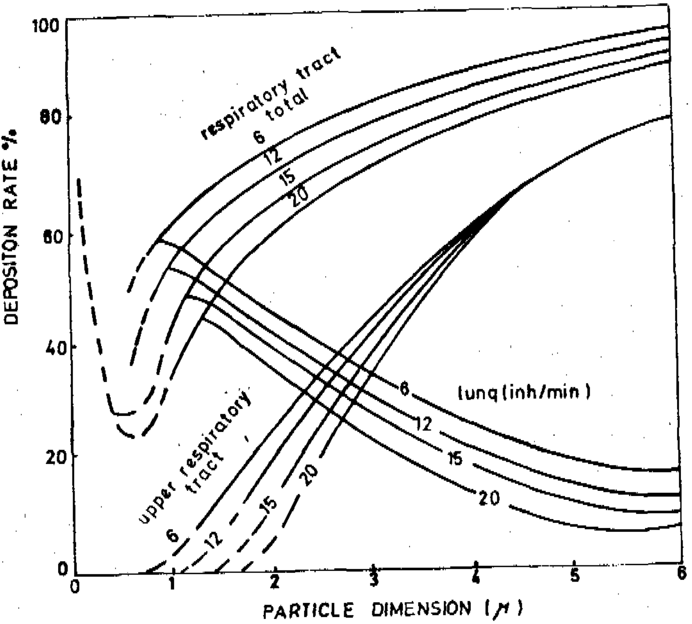
Particles of fly ash are together with flue gases, diffused into the atmosphere in the vicinity of a thermal power plant and may produce considerable threat to human health particularly through synergetic effects with other pollutants. The particles penetrate human body through respiratory system and subject to its size form sediments in it and cause mechanical damages giving possibility for appearance of different diseases (bronchitis asthma emphysema etc.), Fig. 1. The influence of these particles on vegetation is also considerable Fly ash, being deposited on leaves of plants in a smaller or greater extent affects their normal life as their growth and development are endangered and yield reduced. This particularly concerns some sorts of plants which develop a bulb and have broad leaves. Therefore, it is possible that during the period of plants growth particles of fly ash form permanent deposits among leaves *or in fruits. There is also the question of polluting* underground and ground waters with chemcal substances in the form of solution or suspension which are incorporated in infiltration flow from disposal areas.

Having in mind the above mentioned consequences of environmental pollution by ash, it is quite clear why it is necessary to monitor the expansion of this pollutant. Particularly, when the construction of a thermal power plant is envisaged one should anticipate real effects of ash dissipation to the environment. This is the aim of ecological reports which make an integral part of any feasibility study for the construction of thermal power plants in Yugoslavia. This paper shall present the basic elements of methods for calculation of fly ash deposition in the surroundings of a thermal power plant (TPP), giving estimates of disposal areas effects, as well as protection measures to be applied in order to bring pollution level to the optimum in accordance with established norms and necessary investment costs.

2 CHARACTERISTICS OF COAL IN YUGOSLAVIA AND INTENSITY OF POLLUTION EMISSION

Pollution levels and emission intensities greatly depend on characteristics of coal used in a thermal power plant. The basic characteristics of lignite used in Yugoslav thermal power plants are low heat value and considerable content of moisture and ash . Table 1

FIG. 1 PARTICLE DEPOSITION IN RESPIRATORY TRACT



shows basic characteristics of these coals. Considering their heat value ranging from 5500 to 7000 KJ/kg, the consumption of coal per 1 MW of produced electric power is substantial and amounts to about 2 t and, therefore, the quantities of by-products occurring in combustion are proportionally big. About 8 · 10^3 m^3/s of flue gases and 0.3 - 0.5 t of ash and slag occur per each MW produced. The content of fly ash in flue gases and its grain characteristic are mainly subject to the kind of built-in dust collectors.

The chemical composition of ash which is important for effects on the environment i.e. pollution of ground and underground waters, is shown in Table 2, including the solubility of some essential components.

Table 1 BASIC CHARACTERISTICS OF COALS IN YUGOSLAVIA

Product	Average value (%)	Range of values(%)
Moisture	48	40 50
Ash	20	16 - 28
Sulphur (total)	1	0.4 - 1.6
Combustible sulphur	0.5	0.2 - 1.5
Carbon	20	18 - 22
Hydrogen	2	1.8 - 2.1
Nitrogen + Oxygen	9	8 - 10

Some kinds of ashes contain considerably bigger quantities of CaO which due to its chemical properties essentially affects the way of transport to disposal areas and also possible effects to the environment.

3 DETERMINATION OF FLY ASH DEPOSITION LEVEL

Together with flue gases, fly ash is discharged into the atmosphere through a chimney of a thermal power plant. Its further spread out shall depend on thermal and kinetic energy of flue gases and weather conditions prevailing at that moment in the surroundings. In the first stage a plume moves upwards and then in spreads out under the influence of atmospheric diffusion in the wind direction. The behaviour of fly ash particles incorporated in such a plume is specific when compared to gaseous components, as ash particles are separated from the plume and deposited on the ground under the influence of turbulent morements and earth s gravitation.

In this paper Pasquill s diffusion model is used as a basis to determine fly ash deposition level in the surroundings of a considered plant. Despite the already known limiting factors in its application (diffusion along wind is ignored, linear movement of plume is considered, only concentration of the considered substance in a plume follows Gaussian distribution weather conditions at the source point extend to several tens of kilometers around the source), this model is still widely applicable in practice when movements of a plume containing polluting substances coming continuously from point sources are to be described. Accordingly, one starts from a basic equation for calculation of the pollutant concentration in a plume at the height z above the ground and in the point defined by the coordinates (x, y)

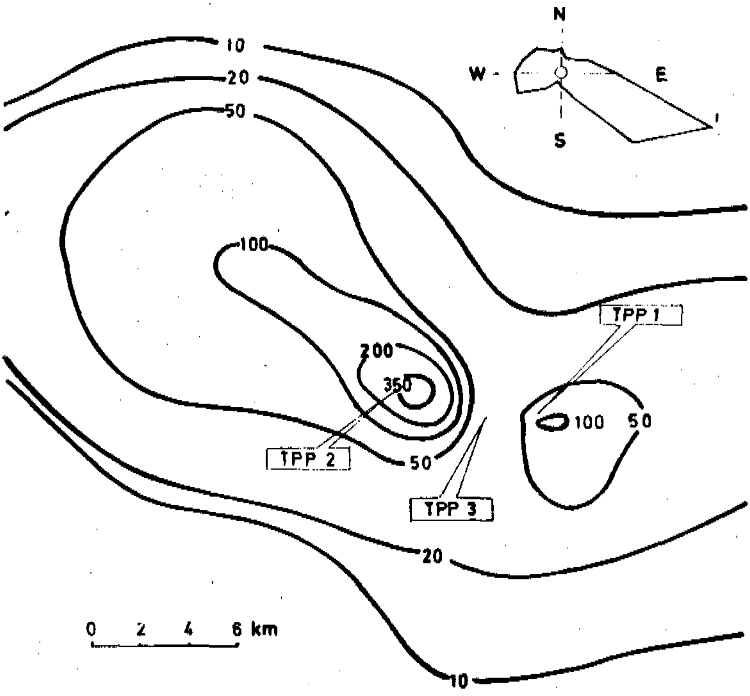


FIG. 2 DISTRIBUTION OF FLY ASH DEPOSITION RATE IN THE THERMAL POWER PLANTS ENVIRONS (mg/m^2 day, SEANSON - AUTUMN)

It is necessary to point out that one should have available exact data for a realistic survey of pollution. This particularly refers to meteorological data and data on particles characteristics, which esentially affect spatial distribution of pollution.

Table 2 CHEMICAL PROPERTIES OF ASH

Product	Average value (%)	Quantities disolved in water (kg/t of ash)
SiO_2	44 - 55	0 035 - 0 070
Al_2O_3	21 - 27	-
CaO	1 - 10	0 75 - 1 41
MgO	1 5 - 2	-
SO_3	2 - 9	2 4 - [illegible]
Na_2O	do 0 5	-
K_2O	0 5 - 2 0	-

in relation to a considered source. The equation has the following form:

$$C(x,y,z)=\frac{Q}{2\pi\sigma_y(x)\sigma_z(x)\bar{u}}\exp\left(-\frac{y^2}{2\sigma_y^2(x)}\right)\cdot\left\{\exp\left(-\frac{(z-h)^2}{2\sigma_z(x)^2}\right)+\exp\left(-\frac{(z+h)^2}{2\sigma_z(x)^2}\right)\right\} \quad (1)$$

where:

$C(x,y,z)$ - concentration of pollutant on the point (x, y, z) in relation to a source (g/m^3)

Q - source intensity (g/s)

$\sigma_y(x)$ - diffusion coefficient in y-direction (m)

$\sigma_y(x)$ - diffusion coefficient in z-direction (m)

$\bar{u}$ - average wind velocity at plume height (m/s)

h - effective plume height (m)

The diffusion coefficients σ_y and σ_z are defined by measuring the changes of diffusion with distance. The curves given by Gifford for flat terrains as well as corrected curves for different configuration of terrain are most frequently used. The effective height of a plume is subject to flue gases characteristics and actual height of a chimney[2].

Separation of the fly ash particles depends on their grain characteristics and the quantity of deposition can be defined by the following relation:

$$W(x,y)=v_g\cdot C(x,y,o) \quad (2)$$

where:

$W(x,y)$ - quantity of deposited particles (g/m^3s)

$C(x,y,o)$ - concentration of particles in the ground-level of the atmosphere (g/m^3)

v_g - velocity of particles deposition (m/s

Velocity of deposition is mainly defined experimentally For the particles having a dia up to 100 μ this velocity is in the range of (5-100) mm/s. Concentration C (x, y, 0) is defined on the basis of the initial equation (1) with the introduced correction factor which takes into account creation of an independent plume of fly ash particles beside the other one which is created by gaseous components. Besides one should also take into account attenuation of the source along the path resulting from the particles deposition. According to "Source depletion" model[3]

$$\frac{\partial Q}{\partial x} = -\int_{-\infty}^{+\infty} W(x,y)\,dy \qquad (3)$$

and consequently

$$Q(x) = \int_{-\infty}^{+\infty} \frac{\partial Q}{\partial x}\,dx \qquad (4)$$

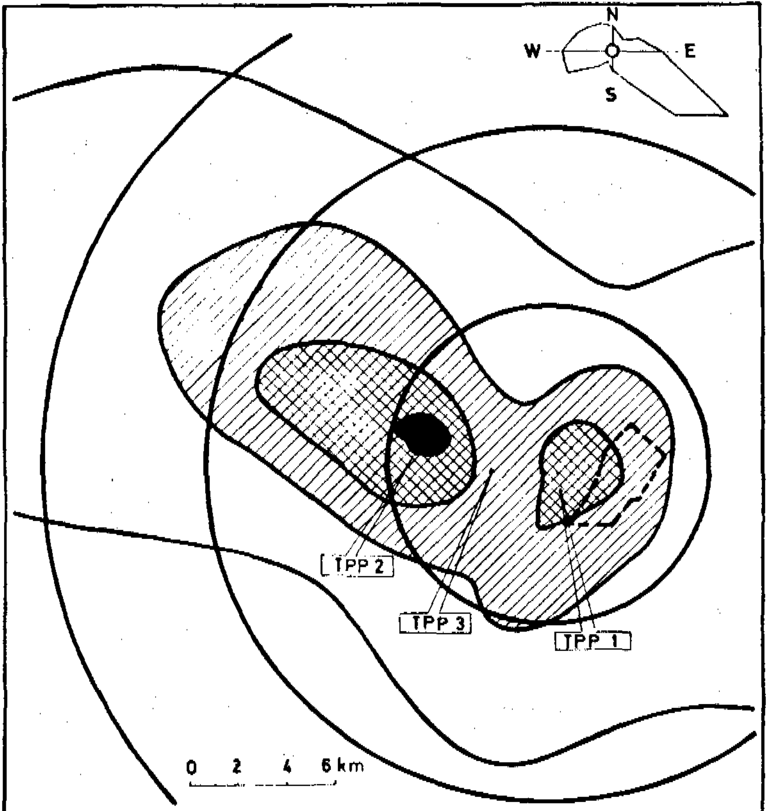
Considering the existing legal norms, as well as nature and possible effects of environment pollution by fly ash, one could define daily mean values of its deposition on the ground for individual seasons and for the whole year. For the calculation of these values Energoprojekt Corporation has developed and uses the computer programme DITAL[4]. The following data are used for these calculations:

1. Data on emission (quantity, temperature and outlet velocity of flue gases, quantity of fly ash and its grain characteristic)
2. Data on geometry of a pollutant source
3. Meteorological data for the considered location (distribution of velocity and wind direction in the ground level as well as on the plume height, distribution of atmosphere stability per seasons, as well as air annual temperature and temperature gradients)
4. Data on orographic characteristics of the terrain in the considered area.

The daily mean values of the concentration for the considered period (season or whole year) and area are obtained by averaging the values W(x,y) for each category of particle size and eachch category of atmosphere stability subject to their individual contributions. After that spatial distribution of deposition is computed in conformity with the wind rose. Fig. 2 shows the results of such a computation which has been prepared for three thermal power plants located closely to each other. Capacities of these power plants are 1400, 1500 and 300 MW the first two being scheduled for construction, while the third one is already in operation. The assumed efficiency of an electrostatic precipitator for the units to be constructed is 99 5% and for the existing ones it is 98%. The particles grain characteristics are as shown in Table 3.

The position of the thermal power plants in relation with the direction of dominant winds is such that their pollution effects partly interfere. The entire area under pollution spreads out and occupies a circle having a dia of several tens of kilometers. The pollution levels within this area vary and are essentially influenced by the wind rose (they are higher in the direction of frequent winds) and ash grain characteristic (larger grain sizes are deposited on shorter distances from the source). If these calculations are made for all seasons it is possible to define zone of moderate, average and increased effects of fly ash to the ecosystem. Example of the zonal effects for studied TPP is shown on Fig. 3. The zones of the greatest effects are those located in the close vicinity around the plant and should be taken into account when development of human settlements and activities of population in a given area are considered (with regard to the presence of individual kinds of flora and fauna). One should also anticipate adequate protection measures.

Similar calculations could be made when pollution levels in accident conditions are considered, i.e. when efficient operation of electrostatic precipitators is reduced. In such a situation beside the increased quantities of emitted ash, its grain characteristics are also different due to increased grain size. Therefore, in relation to normal operation one may expect zones with considerably increased deposition levels, especially in the area which is closer to the polluting source.



☐ ZONE OF MODERATE EFFECTS (10 - 30 mg/m^2 day)

▨ ZONE OF AVERAGE EFFECTS (30 - 100 mg/m^2 day)

▨ ZONE OF INCREASED EFFECTS (100 - 300 mg/m^2 day)

■ ZONE OF DEPOSITION MARE THAN 300 mg/m^2 day

⬚ MINE PIT SURFACE

FIG. 3 ZONES OF FLY ASH EFFECTS DURING THE YEAR

Table 3 ASH GRAIN SIZE AT CHIMNEY OUTLET

Particles category (μ)	0-12	10-20	20-30	30-100
Participation in weight (%)	12	60	16	12

4 ANALYSIS OF DISPOSAL AREA AFFECTS

Considering increased quantities of ash, the problem of its collection, transport and disposal becomes more and more complex. The choice of transport system and technology of disposal shall depend on physical and chemical properties of ash and its (possible) effects on the environment. For that reason this problem has been given full attention from the ecological point of view. Estimates have been made with regard to possible air pollution, effects on ground and underground waters.

In Yugoslavia there are two ways of dealing with ash disposal: disposal areas where useful surface, under normal operation is about one half or two thirds under water (hydro ash disposal areas) and dry ash disposal areas which have to be sprinkled. Ash can be transported to disposal areas by hydraulic or mechanical means In hydraulic transport ash is permanently under water (in the hydro-mixture the most frequent ratio of liquid to solid contents is about 10:1). When mechanical transport is used ash free surfaces must be continuously sprinkled with water.

At the beginning of ash disposal, the areas designed for disposal are usually divided into two stages: an operating stage into which ash is disposed and a stage in preparation in which dams are constructed. Period of ash disposal in a stage is at the same time the period of construction of dams and future structures in the preparation stage. The stages are filled up from a ring or from the front.

In Yugoslavia ash is disposed in specially prepared zones not far from thermal power plants or in abandoned mine pits which are incorporated in large industrial-energy complexes.

Practically there is no effect of an ash active disposal area to air pollution if ash is properly handled. After the stages are filled up with ash there is a possibility of air pollution by Aeolian erosion. This can be, however, avoided by choosing adequate protection measures.

Water pollution by ash disposal areas is caused by dissolving some substances in water. This happens with hydraulic transport of ash from TPP to disposal areas as well as during disposal, or in case of mechanical transport and dry disposal due to water sprinkling When the rate of pollution of ground waters has to be determined one considers change of contents of sulphate calcium and magnesium as well as total of dissolved salts as basic parameters for evaluating the quantity of water which comes from waste waters from disposal areas On the basis of total quantities of accured ash for a TPP of 1400 MW and with chosen hydraulic disposal of ash the estimate of increased contents of these substances in a river having the capacity of the river Danube (its average flow is 5400 m^3/s), would be as follows:

- increased contents of sulphate	0 6%
- increased contents of Ca	0 08%
- increased contents of Mg	0 05%
- increased contents of other insoluble salts	0 07%

which has no bigger effect on the change of quality of the natural recipient

Underground waters can be polluted by infiltrated waters from disposal areas, whereby change of their regime is also possible. On the basis of data on pollution emission through infiltration waters in case of a TPP of 1400 MW the estimated emissions of substances into underground waters would be as follows:

- sulphates	0 03 kg/s
- Ca	0 01 kg/s
- Mg	0 002 kg/s
- other insoluble salts	0 004 kg/s

Calculation of the pollution annual flux of the these substances is done when location characteristics of a disposal area as well as initial condition and regime of underground waters are known. On the basis of these data one estimates the rate of the disposal area influence. Considering the chemical property of ash and rate of solubility of some of its ingredients in water all analyses and measurements so far prepared in Yugoslavia have shown the need to monitor sulphates and magnesium in underground waters even after the stage had been filled up with ash. Migration of these substances is such that even on greater distances from a source of their emission (more than 1 to 2 km) they could appear in a concentration which cannot be ignored.

5 PROTECTION MEASURES

The basic protection measures which are applied against environmental pollution by ash are a high chimney and system of dust collectors for flue gases. High chimneys help spread out of pollutants to a larger area around a plant which reduces the level of pollution per unit of area. The consequence of such spread out of flue gases is superposition in relation with other sources of pollution. For that reason it is necessary to build in a system of dust collectors for flue gases too. In the most cases the system consists of electrostatic precipitators with high efficiency rate of over 99% subject to the capacity of a plant and actual pollution of the surroundings by pollutant particles.

Subject to a stage of operations on ash disposal (stage in operation stage in preparation and final filling up of the ash disposal) there are various protection measures against air pollution (operative protection - temporary measures and permanent protection - recultivation, respectively).

A design solution of a disposal area defines the operative or temporary protection measures (physical or chemical methods). It may be concluded (based on the experience of the existing disposal areas) that if a pollutant is correctly handle during transport and on the disposal area itself, there is practically no possibility of air pollution (hydro disposal area) or it has local significance only (dry disposal). Combined protection is used for final recultivation of ash surface. Physical protection of dry ash surfaces assumes coating with a layer of soil, most frequently in mixture with water. The chemical protection is based on the reaction with an additional chemical agent (cement, lime, resin, tarpaulin, tar, polymers, cellulose compounds) The best results have been achieved by use of polymers, tarpaulin and tar.

The final protection of ash must be permanent and of good quality, therefore a combined type of protection is to be applied which includes chemical , physical and biological measures aiming at stabilization of disposal areas. Biological stabilization assumes vegetation planting on the ash covered area. It has proved to be a good base for cultivation of some plants (such as alfaalfa oats wheat, small fruit trees, bushes, some sorts of poplar). The ash should be covered with a layer of soil for insulation (particularly in case of inter or aggressive ash, this layer of soil should be about 40 to 50 cm in thickness).

In Yugoslavia another form of biological protection against ash spread out has been applied, i.e. planting of protective green belts around a disposal area in the direction of most frequent winds. The belts consisting of cornus mas, sambucus migra, ailanthus glandulosa or broussonetia papyrifera, could have from 30 to 100 m in thickness

However it should be pointed out that this form of protection is only a supplement to the basic recultivation of the surface.

As already mentioned pollution of ground waters by waste waters drained from disposal areas is negligeable. Therefore, design solutions of ash disposals do not anticipate any protection measures except that the water from a pipeline transporting ash mixed with water does not get directly to adjacent natural recipients.

Pollution by and protection against infiltration waters are however more complex problems. Due to rising of piezometric pressures in the zone of a disposal area and in its vicinity two negative effects appear:
- rising of underground water level which causes appearance of water on the ground around a disposal area (direct effect of this is degradation of adjacent land) and
- change in underground water composition which is manifested by increased concentration of sulphates, calcium, and magnesium. The consequence is that special waterworks have to be installed for surrounding settlements in the direction of underground water movements.

Protection of underground waters against infiltration waters is carried out by construction of drainage canals around a disposal area whereby the level of underground waters is brought down. This prevents degradation of surrounding land and expansion of increased concentration of sulphates beyond a disposal area limits[5]

6 CONCLUSION

Consequences of lignite utilization for production of electric and heat energy in Yugoslavia with regard to environmental pollution are rather disturbing and they require special attention in all stages of a plant construction and operation. The estimates of pollution around designed plants in some cases show that the level of pollution is considerably high and even close to maximal permitted levels. For that reason it is necessary even at the stage of a plant operation to monitor spread out of all essential pollutants so that necessary and sufficient protection measures could be arranged adequately. This means that, considering its importance and costs, even in the stage of investment planning one should foresee a monitoring system for pollution in the environment and adequate systems for protection of the surroundings.

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THE KUWAITI EXPERIENCE IN MANAGEMENT OF MUNICIPAL SOLID WASTE

M. Hayssem H. Minkara* Hamed A. Shuaib*
Hassan M. El-Baroudi**

Technical Advisor* Chief Architect* Manager, ENV.**
Kuwait Municipality, P.O.Box 10, Safat, Kuwait*
KISR, P.O.Box 24885, Safat, Kuwait**

BACKGROUND AND OBJECTIVES

Handling and disposal of solid waste is one of the oldest environmental problems facing urban communities. As soon as these communities learned about potential impacts of solid waste on public health and environmental quality, environmental laws and regulations were enacted requiring special procedures for solid waste storage, collection and disposal.

Protection of the environment in Kuwait is a national concern that has been gaining an increasing attention by Government and industry. In the area of Municipal Solid Waste (MSW) we find that the situation in Kuwait has unique features which should be addressed for developing any cost-effective management plan. Major examples of these features are:

1) Very high rate of housing and urban development - It is practically impossible for the Cleansing Department and other municipal services to expand at a proportionate rate.

2) Imported technical and administrative manpower is of varied professional experience and background.

3) The multi-nationality of the urban community in Kuwait and unpredictable situation for planning MSW management system as well as enforcing Public Cleansing Ordinances.

4) Shortage of technical and administrative staff in the area of solid waste management.

In spite of the above difficulties, Kuwait Municipality has been collecting and disposing of about 2000 tons of municipal solid waste per day. The current situation may be considered as the fourth stage in following historical chronology.

1 - <u>First Stage (Uncontrolled Land & Coastal Dumping)</u>

This stage started when Kuwait Municipality began the public cleanliness service more than 50 years ago. At that time, the pick up service was limited to manual operations and the transport was performed by animal pulled carts. The final disposal method constituted dumping of all solid wastes in the open space outside the City fence without any precaution except a surface sand layer for cover. In some occasions, the solid waste was dumped in the coastal area so that the tidal movement would convey it to far away places in the sea.

2 - <u>Second State (Open Burning Dumps)</u>

During the fifties, methods of solid waste collection were developed and expanded. Manpower increased and manual carts were added. The practice of excavating pits for final disposal has also begun. In that system, solid waste was placed on the sides of the pits and set on fire and the combustibles were ashed (wood, paper - etc). Afterwards, the incineration residues were pushed into the holes and covered with a layer of sand. Such disposal system had the advantage of reducing the waste volume to about 15% of the original size. Main disadvantages of the system were the spread of smoke and air pollutants, harboring and breeding of files, insects and rodents and accessibility of dumping sites to people who sought to salvage organic wastes for animal feed in a hazardous environment.

3 - <u>Third Stage (Mechanized Collection)</u>

In the last 15 years, the operations of public cleanliness became mechanized in pick-up and transport. However, unsanitary conditions still existed at the disposal site resulting in spreading of insects and rodents as well spontaneous fires with the attendant odor and air pollution problems.

4 - <u>Fourth Stage (Safe Landfill Disposal)</u>

About four years ago, Kuwait Municipality began converting solid waste disposal sites to ideal operations for sanitary landfills by providing adequate equipment and following good practice procedure for compacting and covering solid waste. The advantages of the well-engineered landfill operation are:

1) Increased volume reduction by the appropriate use of heavy compactors,

2) Control of odor, insects and rodents

3) Control of spontaneous fires

4) *Better reclamation potential of filled land*

Throughout the above history as better engineering methods were applied, more information was obtained on solid waste composition and quantities. Such information has led to a growing awareness of the materials and values that can be recovered from solid wastes. The challenge of solid waste management is gradually shifting from safe disposal to maximum utilization of recoverable fractions. This shifting is also enhanced by the shortage of suitable disposal lands near municipal centers. With more than 2000 tons/day of municipal solid waste generated, available land for disposal is being used up at a high rate, and the cost of proper collection and disposal are increased.

The first National effort in the direction of municipal solid waste utilization was the construction of a 100 ton/day pilot composting plant in 1969. Presently, there is a growing interest in broader and more diversified application of solid waste reclamation technologies and methods. Solid waste reclamation will conserve material and energy resources, and will protect environmental quality by reducing the quantities of wastes requiring final disposal. From the economic view point, certain reclamation systems may prove to be more cost effective than final disposal either at the present time or in the future.

It may be stated that a fifth stage of solid waste management has already started in Kuwait which has reclamation as its primary thrust. In the present study, the feasibility of applying selected reclamation systems in Kuwait was assessed. Based on this preliminary assessment, a program plan was developed to enhance and guide the adoption of the best MSW reclamation systems for Kuwait.

ASSESSMENT OF CANDIDATE RECLAMATION TECHNOLOGIES

Table 1 shows the average composition of MSW in Kuwait. The relatively high percentage of food wastes, with associated high moisture content, (Approx. 45%) suggests more suitability of waste to composting than to incineration with energy recovery. In addition to waste parameters, other National environmental and socio-economic factors are considered in the assessment and selection of MSW systems. In Kuwait, the following were major factors to be considered:

1) Environmental conditions; meteorological, surface, sub-surface, and protection of natural resources.

2) Scarcity of organic resources.

3) General poor quality of the natural soil.

4) Food security policies for the country emphasizing various forms of agricultural expansion.

Since the mid-sixties, the State of Kuwait performed four general assessment studies. They have conclusively recommended landfilling, composting, and mass incineration with energy recovery, in that order, as the most feasible reclamation/disposal alternatives for Kuwait. Table 2 shows the comparative unit costs obtained for these three systems, in mid-82 prices. Composting has proved to be economically viable, in addition to being compatible to environmental conditions and rational policies.

Table 1. Composition of MSW in Kuwait

Component	Weight percent average
Food waste	53.3
Paper & Carton	22.2
Plastics	8.4
Metals	4.4
Glass & Ceramics	2.6
Textiles	2.1
Bones	1.4
Wood	1.6
Shoes	0.6
Miscellaneous	3.4
Total	100.0

Table 2. Cost Revenue Analysis and Various Reclamation Methods

System	Processing Costs KD/Ton*	Revenues KD/Ton	Net (Disposal) Cost KD/Ton
Landfilling (Reference)	3	-	3
Composting	11.1	8.4	2.7
Incineration with Energy Recovery	10.3	6.4	3.9

* 1 KD ≈ 3.4 U.S. Dollars.

RECOMMENDED PROGRAM PLAN FOR MSW RECLAMATION

Presently, there are numerous methods and technologies for reclamation of MSW. They represent different levels of sophistication and different stages of development, different costs, outputs and environmental impacts. In Kuwait, there is enough information available in order to draw the most suitable policies for reclamation of MSW. Based on these policies, selection of commercial applications and R & D investigations can be made to implement and support these policies. Therefore, the recommended Program Plan is divided in the following four categories.

A - Formulation of National Policies

B - Promising Commercial Applications

C - Applied Research & Demonstration

D - Basic Research & Development

A - Formulation of National Polices

The ever increasing quantities of MSW in urban communities has prompted many countries to adopt policies or legislate laws and regulations to secure the best solutions to the problem. The following broad principles or materials policies seem to have gained universal acceptance:

1) Minimize MSW generation rates
2) Maximize recycle and reclamation of MSW
3) Ensure that final disposal of MSW is performed with the least impacts on water, air and land resources.
4) Secure community awareness and participation in the selection of policies and in their implementation, if necessary (as in source separation and buying drinks only in returnable bottles).

The specific procedure and technologies for implementation of these goals may vary widely from country to country or city to city. To minimize MSW generation rates it is required to survey the MSW composition and the source of each fraction. Subsequently, government or community actions may be sought. In the USA, some States have outlawed certain disposable bottles as a form of undesirable packaging. In Kuwait, food wastes represents more than one half of the MSW and it is thought that a significant portion of it is wasted food and not food waste. Subsequent recommendations indicate the technical investigations required for developing and implementing these policies.

B - Commercial Application of Composting

Figure 1 illustrates how composting is considered to have the optimum environmental benefits and commercial development stage for application in Kuwait. Preliminary assessments of market demand and economic feasibility are promising. Further studies for commercialization of MSW composting need to be performed to provide answers to the following:

1) Optimum capacity and best source of MSW for the plant
2) Conceptual design of preferred system and costs
3) Economic and cost/benefit analysis
4) Composting of combined MSW and sewage sludge.

The figure also shows landfill and incineration as commercially established disposal systems with typically small environmental benefits. However, if landfilling is designed and operated for reclamation of bad lands or production of methane gas (not established technology) then the environmental benefits will increase. The same with incineration if the energy of combustion is reclaimed in a usable form. Rejected portions or residual byproducts from incineration or any other processing or reclamation technology will ultimately be disposed of by landfills. Therefore, the practice of landfill disposal will continue for the unreclaimed portions of MSW.

In summary, composting and landfilling are the two commercially established technologies for MSW reclamation and disposal which should be investigated and implemented for maximum resource conservation and environmental protection in Kuwait.

C - Applied Research and Demonstration

The program termed as Applied Research and Development represents two types of investigations. Figure 2 shows one type as being support to commercial applications on one hand, and the other represents the next step to successful Basic R & D. The following are suggested areas of investigation in both types.

1) Quality control surveys and assessment of MSW quantities and composition in all stages of handling and processing. This information is essential for upgrading composting applications in the most cost effective ways.

2) Detailed environmental impact studies of commercially adopted or planned systems such as composting or landfilling. These will address pathways and accumulations of critical pollutants.

3) Pilot studies of viable source separation systems with various degrees of community participation. The greatest obstacle toward effective reclamation is that MSW is a heterogenerous mixture of many components which contaminate each other. Separation at the source can support reclamation schemes whether in the commercial or innovative stage of development.

4) Pilot studies of centralized mechanical separations processes to handle completely mixed MSW or in support of source separation.

5) Feasibility studies of systems which have proved conceptually promising. These studies include preliminary environmental evaluations and technical economic feasibilities.

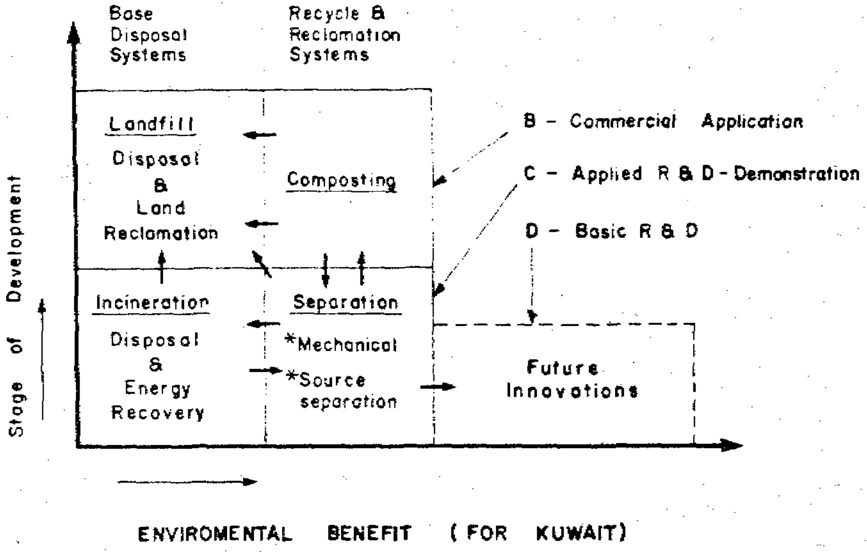


Figure 1. Categories of MSW Reclamation & Disposal Technologies

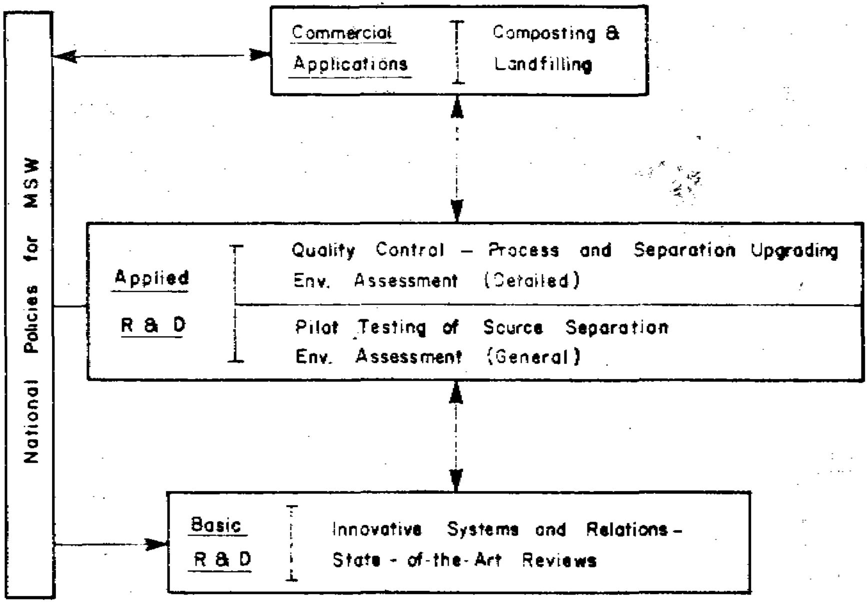


Figure 2 : Applied R & D as a link between Commercial Application and Innovative Systems

D - Basic Research and Development

Technologies for disposal and reclaiming of MSW have been undergoing revolutionary developments and innovations during the last two decades. In principle, developing countries should be more concerned first with transfer of established feasible technologies, rather than extending the state-of-the-art by basic research. However, Basic R & D would be necessary to be performed to develop appropriate and required technologies that meet local socio-economic demands. Implementation of the above became more realistic if the country's economic resources permit the performance of such basic research and development, as in the case of Kuwait. Therefore, recommended that Basic R & D on MSW be performed according to the following objectives and criteria:

1) Review and assessment of universal technological development of the subject so that feasible applications to Kuwait may be considered. Examples are chemical conversions of cellulose or pyrolytic processes.

2) Basic R & D on concepts which have been evolved from local experiences and opportunities. Examples are composting of MSW and sewage sludge under Kuwaiti conditions or use of solar energy for enhancing system performance and feasibility. (Preliminary work in this respect has taken place by KISR).

3) Basic R & D on existing materials specifications for various industrial and municipal uses and assessment of their replacement with secondary materials from MSW.

4) Basic R & D on MSW systems including model development of generation as function of community socio-economic parameters, materials balances for predictive models, long term forcasts of MSW and its values - etc.

CONCLUSION

Municipal Solid Waste continues to present a challenging case to Municipal authorities around the world. Previously, handling of solid waste was a case of disposal while controlling potential public hazard and environmental health. Presently, however, scarcity of natural resources and high cost of their development are creating a demand for reclamation of material and energy values in municipal solid wastes. Reclamation potentials of MSW are varied and amaenable to creative and innovative concepts. Developing nations should assess these potentials in respect of the following:

1) Quality and quantity characteristics of MSW.

2) The nation's environmental conditions which might affect directly the best reclamation alternative.

3) Focal and regional market values for reclaimed by-products.

4) The socio-economic factors of the community which might enhance its cooperation in minimizing waste generation and implementing special handling procedures at the source.

The Kuwaiti experience so far provides a good case study for developing nations in respect of seeking the appropriate national policies and technologies for reclaiming MSW.

ESTIMATION OF MAXIMUM FLOOD FOR TABRIZ STORM SEWER SYSTEM USING P.M.P AS A DESIGN PARAMETER.

A.A.MOVAHED-DANESH

Professor of Hydrolcgy-University of Tabriz

P.O.Box 103 - Tabriz - Iran

ABSTRACT: The present analysis was undertaken to develop apropriate extreme flood design criteria for the North-western city of Tabriz in Iran.The choice of design flood for storm sewers system was made possible by using the P.M.P as a Design Parameter .The results of analysis of recorded storms are presented as a mathematical model for estimation of selected P.M.P at different time durations. Graphical relationships of the model used for P.M.P at different time durations and for daily rainfall estimated for different return periods provided a convenient means for estimating design storm .

The relationships may be applied for drainage area up to 25 km^2.

INTRODUCTION

The rapid development of human aglomerations in combination with urbanisation of various regions alters the natural ecological conditions governing existence of old cities.The rapid population growth in theses areas and especially in the arid and semi-arid regions such as Tabriz is a major cause of water supply systems development from basins other than the cities natural ones.Changes in landuse in the vicinity of old cities and implementation of urbanisation projects in the green surfaces , create a new conditions for hydrological balance equation in these areas. Consequently the agricultural lands are transformed into the impervious surfaces on which rapid runoff is resulted from rainfall hence major floods can be observed.

Usually in such rapidly developing regions, particuarly in Iran, the water supply systems are developed whilst he wast-water and storm sewers systems neglected. As a reult, infiltration wells are utilized for wast-water dejecion and sometimes for roof runoff as well. Whenever this situation occurs and especially in areas where the water supply system is operated from water extracted from the adjacent basins, the rise of water table is considered.

In Tabriz with a population of approximately 1 million, such condition exist entirely. Water supply system uses water from different adjacent sources other than those existing in the city basin. The wast-water system is not yet developed for the whole area exept for a very small part of the city. The rise of water table, through infiltration of wast-water in absorbent-well system was considered and caused some severe problems in the western part of the city.

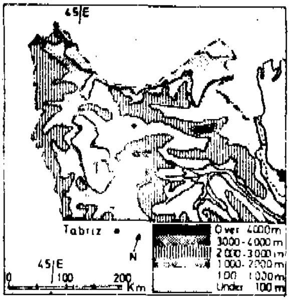
Runoff resulted from storms is an important problem in most parts of the city. A wast water project is designed, which is partially considered for a mixed-system, i.e, wast-water and storms sewer systems included within one project. For other parts of city , storms sewer systems will be designed separately. In the present paper following a brief notes on areal characteristics of Tabriz, data on daily rain fall will be analysed in order to estimate the urban flood magnitude and choose a designe parameter for storms sewer systems.

HYDROLOGICAL and GEOGRAPHICAL CONDITIONS IN TABRIZ:

Tabriz, capital of Eastern Azarbaidjan is located North-westerly in Iran in 38,08 N.L, and 46,15 E.Lg. In the present paper the historical view will not be discussed but to mention is that the city is one of the oldest in Iran, being located at the uppermost part of Urmiah lake plain (M.Dansh, 1977), in azarbaidjan province which is a mountaneous area (Fig.1). The morphological situation of Tabriz area is demonstrated in Fig.2 by perspective representation. Mean altitude is about 1341m, the general slope being from the Eas towards the West and from the North as well as the South towards the center in which a natural channell situated at thalweg of the area.

City's hydrological basin is limited Northerly and Southerly by mountains of about 2500m high , whereas its Eastern limits are nearly 1500m, and the western part remains open and a continuous plain towards the lake of Urmiah shore is developed there (M.Danesh, 1977) (Fig.3).

Tabriz plain, particularly the city's location is dedeveloped from alluvial materials and dejection cones. A seasonal stream originated from eastern mountains go



1-Lake of Urmiah.

Fig.1-Topgraphical map of North-Western Iran.
(Azarbaidjan)

throught east to west of the city; at its western unification with other rivers, the final part of regional main river, Adji-Chay originated from Sabalan mountains(about 5000m high) is accomplished.Hydrological basin of Tabriz is about 61.9 km^2(M.Danesh,1977);the runoff originated from this area forms the city's flood.

The mean precipitation of Tabriz being about 321.5mm yearly, most frequently occurs during winter and spring.

The general principle of spatial distribution of precipitation is orographical, according which the local storms causing major floods particularly towards the end of spring and at the start of summer are frontal(M.Danesh,1978).

WAST-WATER and STORMS SEWERS SYSTEMS IN TABRIZ, SUMMARY OF PROPOSED PROJECT:

The need for wast-water sewers systems in Tabriz has been proved due to the rise in ground-water level and development of urbanisation projects.In 1973 a Consulting Engineering Company was appointed for studying and establishment of this project.Two main channels were suggested for this project and in order to be implamented at the natural stream bed at the thalveg of the city area,each for a maximum discharge of about $10m^3$/sec, with possibility of spill into the natural bed in the case of major floods. Certain partial canalisation within central area has been suggested for combined sewerage, runoff and wast-water and in the other parts the storms sewers will be designed separately.

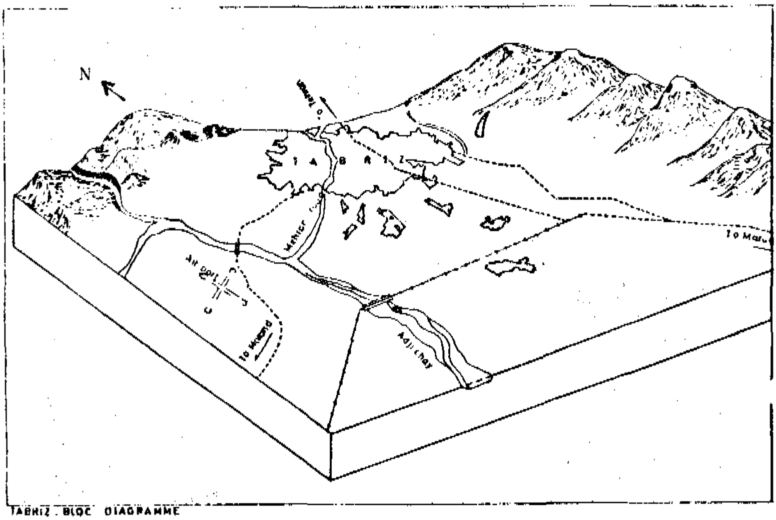


Fig.2-Perspective view of Tabriz area.
(from:Movahed-Danesh,1977)

For this area the runoff coefficient was chosen to be 0.8, tha maximum discharge being about 8.111m^3/sec/km^2 from that 1.37% wast-water and 98.63% runoff resulting from storms.Hence the maximum estimated flood can be determined as 8m^3/sec/km^2.It was assumed that the project will be designed in such a way that it would be effective in Tabriz area for 25 years herafter.It could be easily seen that for projects of this kind the maximum flood has to be evaluated for a long return period.Accepting a 1% permissible risk of faillure for a 25 years project life, it could be indicated that the return period for flood comptuation is about 2487 years and for a life project of 50 years about 4975 years(Hjelmfelt and Cassidy,1975). For this reason it is suggested to use the P.M.P in evaluating *the maximum flood of these systems.*

In this paper, the analysis of maximum daily rainfall records for 26 years was carried out. In evaluating of the P.M.P the statistical procedures are used(WMO,1973),and in estimating the daily rainfall for various return periods the extreme values type II distribution has been used in logarithmic transform(Larras,1972).

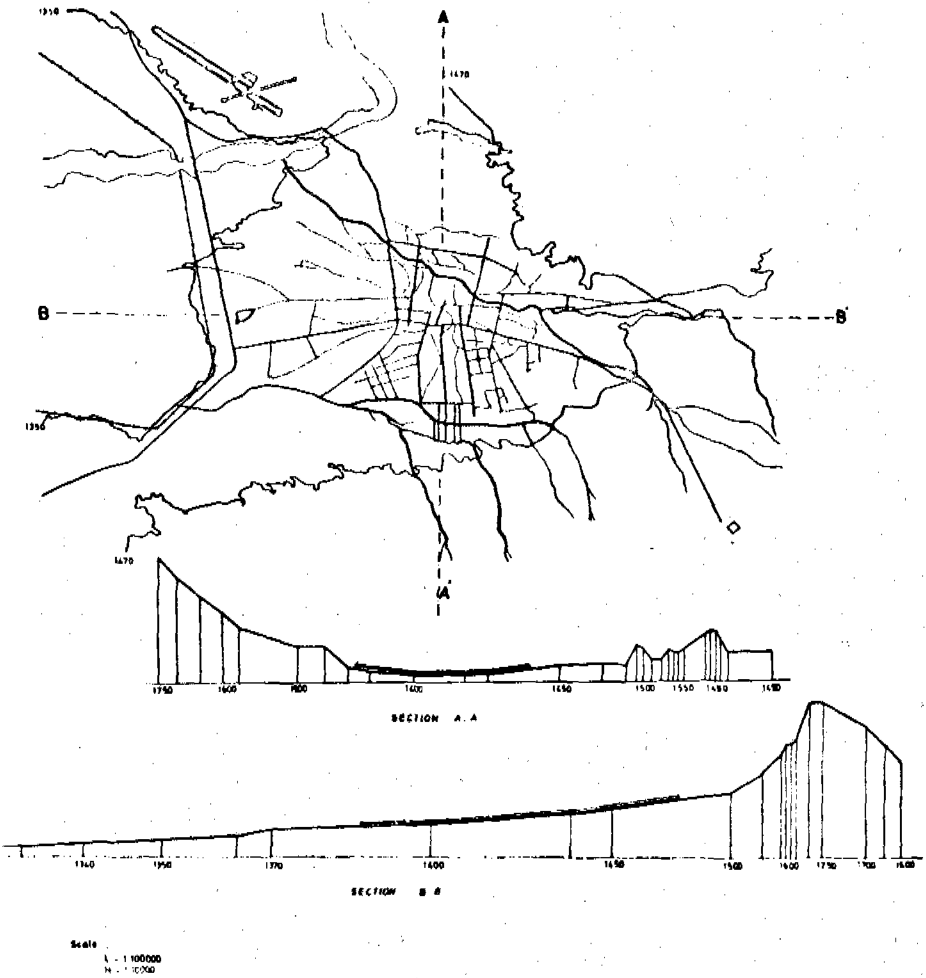


Fig.3-Topographical map and cross sections of Tabriz area(from:Movahed-Danesh,1977).

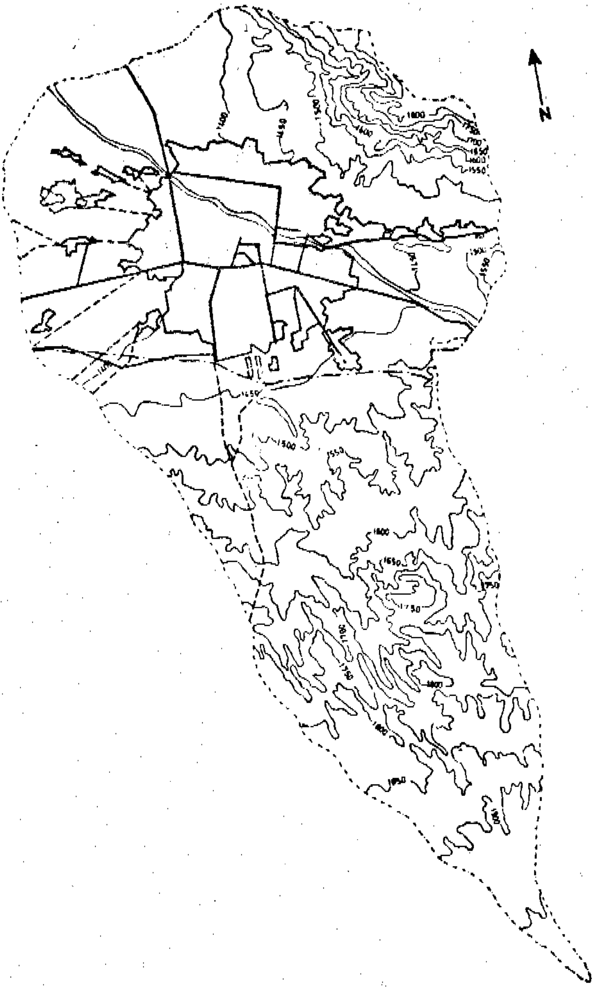


Fig.4-Hydrological Basin of Tabriz area.
(from:Movahed-Danesh,1977)

EVALUATION OF PROBABLE MAXIMUM PRECIPITATION(P.M.P):

The probable maximum precipitation(P.M.P) at any location should represent the depth-time and spatial distribution of precipitation that approaches the upper limit of that of atmosphere and regional topography can produce under optimum precipitation yielding conditions(Kappus.U. et all, 1978).Probable Maximum Precipitation was estimated by statistical analysis of the 26 years daily rainfall records in Tabriz area.

The time distribution model for 24 hr.P.M.P is based upon a mathematical model as below:

$$P\% = 48.9T^{0.225} \qquad (1)$$

where:P% represents the percentage of daily rainfall and T,the time in hr.This model has been coputed analysing the hyetographs of precipitation for a period of 2 years in Tabriz.Comparison of this model with the standard curve of time distribution of P.M.P(WMO,1973) demonstrates a close coherence existing between them.Another daily rainfall analysis was undertaken using a partial duration series (Table 1)using Gumbel probalistic paper with a logarithmic transform of rainfall scale.The transformation was done because the distribution of observed data on ordinary paper indicated concavity from which it is clear that this form of distribution should be presented on a logarithmic scale(Frechet Distribution)(Larras,1972).

STATISTICAL MODEL OF P.M.P:

The statistical procedure used in estimating P.M.P was that discussed in the World Meteorological Organisation Mannual(WMO,1973).Thus P.M.P, the probale maximum precipitation is described as below:

$$P.M.P = \overline{P} + KS_p \qquad (2)$$

where:$\overline{P}$ and S_p are the mean and standard deviation respectively, of the annual series of 24 hr.maximum precipitation and K is an empirical coefficient.K is a function of $\overline{P}$ and rainfall duration.

Some correction factors have been used in the statistical procedure regarding the P.M.P evaluation and all have been applied in this paper, the summary of comptuations is given in table 2.

From simple statistical model , tha daily rainfall for different return periods have been evaluated as represented in time distribution graph using formula 1.

Using Gumbel distribution equation to estimate the return period of P.M.P for different durations, it can be

Table 1-Partial Duration Series of Tabriz daily rainfall(base=14mm)

Year	rainfall	Year	rainfall
1958	14.6	1969	23.6
	23.2		32.4
	22.9		16.8
	15.2		31.4
1959	19.6	1970	16.0
	18.9		14.0
1960	14.4		14.0
	30.4	1971	31.0
	16.2		16.6
1961	14.1	1972	18.6
1962	18.0	1973	24.8
	19.8		24.0
	15.5		17.8
1963	21.8	1974	16.2
	28.6		17.4
	19.5	1975	16.0
	20.8		19.0
	23.8		16.0
1964	19.0	1976	27.0
	97.6		25.0
	38.0		17.0
1965	14.8	1977	63.0
	28.4		24.0
	17.2		17.0
	18.2	1978	17.4
	22.2		18.6
1966	15.3	1979	15.8
	19.5		25.0
	20.4		33.7
	14.0	1980	22.0
	22.8	1981	53.0
	19.0		20.0
1976	26.3		15.0
1968	16.6	1982	15.1
	26.4		20.1
	22.6		32.1
	17.0		15.9
	15.6		17.6
	32.0	1983	14.0
	23.4		

From:Data of daily rainfall of Iranian Meteorological Department(1958-1983)

Table 2- Comptuation of probable maximum precipitation(P.M.P). Annual series of maximum precipitation ,mm.

Year	rainfall	Year	rainfall
1964	97.6	1973	24.8
1977	63.0	1958	23.2
1981	53.0	1966	22.8
1979	33.7	1980	22.0
1969	32.4	1962	19.8
1982	32.1	1959	19.6
1968	32.0	1975	19.0
1971	31.0	1978	18.6
1960	30.4	1972	18.6
1963	28.6	1974	17.4
1965	28.4	1970	16.0
1976	27.0	1961	14.1
1967	26.3	1983	14.0

$n=26$, $\bar{P}_n=29.44$ $S_n=17.76$

$\bar{P}_{n-m}=26.71$ $S_{n-m}=11.27$

$\bar{P}_{n-m}/\bar{P}_n=0.91$ $S_{n-m}/S_n=0.63$

Ajustment factors for $\bar{P}$ are 0.94 and 1.02
Ajusted $\bar{P}=29.44\times0.94\times1.02=28.23$
Ajustment factors for S_n are 0.70 and 1.05
Ajusted $S_n=17.76\times0.70\times1.05=13.05$
From standard curve, K=18

$PMP_{24}=28.23+18(13.05)=263$ mm
Ajustment based on time interval data to time maximum values: $PMP_{24}=1.13(263)=297$ mm
Ajustment to 500 km^2: $PMP_{24}=297(0.9)=267$ mm

Note: $\bar{P}_{n-m}$ and S_{n-m} are the mean and standard deviation, respectively , of the annual series computed after cluding the maximum rainfall amount in each series(WMO, 1973).

showen that the 3hr P.M.P calculated from 24hr P.M.P using formula 1, coincides with a return period equal to 2980 years. If this return period is used to calculate the project life allowing 1% chance of faillure, using general risk analysis formula:

$$P(\text{faillure within n years})=1-(1-p)^{n} \qquad (3)$$

where p=1/Tr and n=project life, the project life can be found according to the quantity equal to 30 years. The so calculated time for project life can be adopted as resonable.

ESTIMATION OF MAXIMUM FLOOD:

P.M.F is determined following determination of probable maximum precipitation(Linsley et all, 1975). In this analysis the procedure used in transforming rainfall to runoff, will be the triangular hydrograph model for an area equal to 1 km^2. Two 3hr rainfall depth, P.M.P$_3$, and P$_{1000(3)}$ will be applied. In computing P$_{1000(3)}$, the partial duration series has been used. For long return periods such as 1000 years, the plotting positions for duration series and partial duration series would be the same(Chow, 1953, 1964). The quantities are computed using formula 1 and P.M.P$_{24}$=267, and P$_{1000}$=220 mm.

$$P.M.P_3=63\% \text{ of } P.M.P_{24}=168 \text{ mm}$$

$$P_{1000(3)}=63\% \text{ of } P_{1000}=139 \text{ mm}$$

For application of triangular hydrograph model, the concentration time is necessary and its value has beeb calculated as 90 minutes using the follofing equation derived from an standard nomograch used in computing the concentration time in urban areas(Sheaffer et all, 1982),

$$t_c=2.64L^{0.5} \qquad (4)$$

where: t_c is the time of concentration in minutes and L being length of travel in meter. Applying this formula for L=1000m, yielded to t_c=83.5 minutes and adding the time of concentration of gutters systems, 90 minutes for this time could be accepted. According to the hydrograph analysis concept, the base time of triangular hydrograph will be:

$$T=t_r+t_c \qquad (5)$$

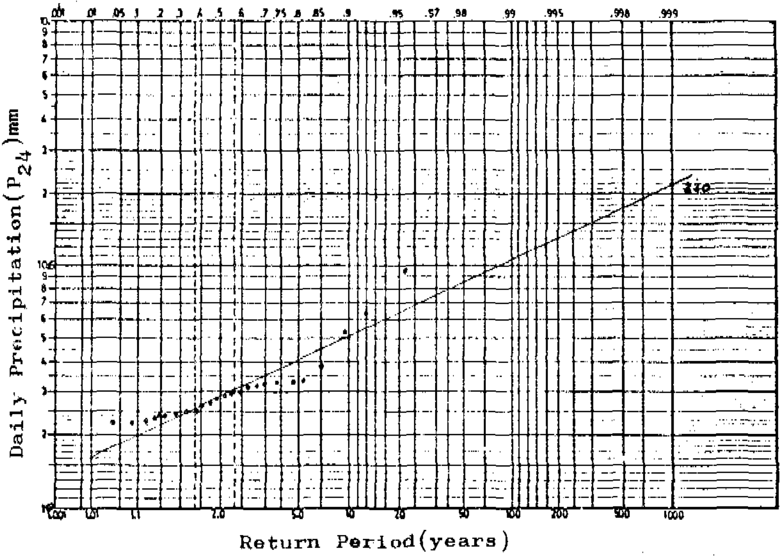
$$T=180+90=270 \text{ minutes}=16200 \text{ seconds}$$

The volume of total runoff with a coefficient of 0.8 is:

$$P.M.P_3(0.8)(A)=0.168(0.8)(10^6)=134400 \text{ m}^3/\text{km}^2$$

$$P_{1000(3)}(0.8)(A)=0.139(0.8)(10^6)=111200\text{m}^3/\text{km}^2$$

According to triangular hydrograph concept this volume



T_r= 2 years , $P_{2(24)}$=29mm. T_r=5 years, $P_{5(24)}$=41mm

T_r=10 years , $P_{10(24)}$=51mm. T_r=50years, $P_{50(24)}$=85mm

T_r=100years, $P_{100(24)}$=108mm. T_r=1000years, $P_{1000(24)}$= 220mm.

Fig 5-Frequency analysis of daily precipitation.

has to be evacuated in 16200 seconds, by means of a tiangular shape hydrograph with an area equal to total volume .The peak flow can be calculated as below:

$$Q_p=2V/T$$

Thus we can draw:

$$PMF=2(134400)/16200=16.57\ m^3/sec/km^2$$

$$Q_{1000}=2(111200)/16200=13.73\ m^3/sec/km^2$$

There are now 3 parameters for design flood; the first is 8m^3/sec/km^2 chosen for the existing project, as already mentioned, this quantity having a reduced return period would be omitted. The second one is PMF=16.75 m^3/sec/km^2; the third being Q_{1000}=13.73 m^3/sec/km^2. The PMF should be chosen, for it can be indicated that the reduced difference between them cannot result in a major change in investment for the project; in fact certain parts of canalisation will be included within a combined system. To choose PMF as a design parameter has the advantage of reduced risk (1%) for a resonable project life equal to 30 years.

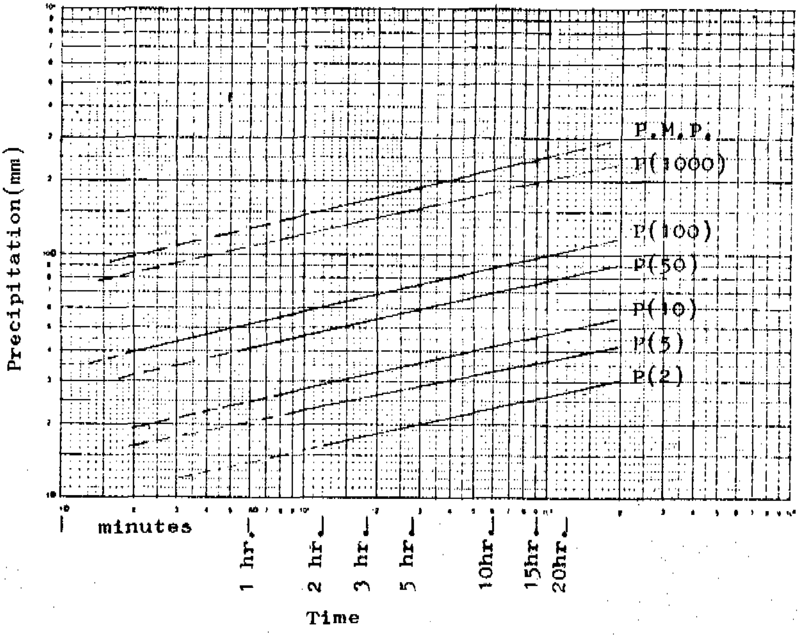


Fig 6- Time distribution of PMP$_{24}$ and estimated precipitation for different return periods.

CONCLUSION:

A comprehensive understanding of precipitation and its distribution patterns both in space and time is essential to the proper design of many structures.

Frequency analysis of point rainfall usually provides the basis for designing storm sewers in typical urban developments, drainage works at airports and so on. Certain damages could result if the design capacity exeeded; under these circumustances, if the design parameter is chosen with appropriate methods such as presented in this paper , it is unlikely to be catastrophic in magnitude.

For areas where data on rainfall intensities is not available for admissible length of periods, the analytical procedures of operational hydrologic models and mathematical modeling of various phenomena represent useful means of obtaining sufficient knowledge to choose design parameter.

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Retention of Lead dissolved by a bentonite.

Dr. Gh. NEZZAL - F.BENKESSIOUER.

Université des Sciences et de la Technologie Houari Boumediene.

Institut de Chimie.

Bab-Ezzouar - B.P. 9-Dar El-Beïda - ALGERIA.

-Abstract.

The study consists of the determination of optimum conditions of dissolved lead retention by ion mineral exchanger very widespread in Algeria, so as to apply to the purification of polluted industrial waste waters.

-Introduction

Water pollution by lead has reached an important level following that by mercury; these two elements are considered to be the most toxic for environment and more particularly for the health of man through food. The pollution becomes more dangerous if the receiver is a closed one as is the case of the Mediterranean sea where high contents of mercury and lead have been detected [1]. For example the allowed lead content in drinking water and waste water, according to international standards, are 0,1 mg l^{-1} and 0,5 mg l^{-1} (Swiss standard)[2] respectively.

were present here the results of a study on the treatment of water polluted by lead, by fixing it on bentonite, a natural mineral sorbant widely available in Algeria. We have chosen the bentonite of Maghnia deposits known as "Roussel".

Following an account of its physico-chemical properties, the results on the optimum conditions of dissolved lead retention by this sorbant are presented. The Kinetics of the characteristic reaction and the influence of different factors are considered.

1.Physico-chemical properties of bentonite.

Activity of natural sorbants called "bentonites" is determined by the constant presence of a clay mineral, the montmorillonite.Besides, bentonite can contain other clay minerals (Kaolinite,Illite...), as well as impurities like gypsum,carbonate , biotite,mica,magnetite,limonite and silica[3.4] .

The bentonite is a delicate,friable rock very onctuous to the touch.It is white, grey or light bleu[3.5]

1.Structure of Montmorillonite.

Montmorillonite is a phyllitic silico aluminate,characterised by three layer complex leaves : one octahedric layer alumino-magnesium comprised between two tetraedric silica layers:[6.7]. Figure 1. Water molecules oriented on these octahedric and tetrahedric groups separate these different layers.

In the horizontal plane, a unit cristal lattice can be represented by the following theoretical formula, taking into account the symmetry plane passing through the centre of the octahedrons:

$$Si_8^{IV}\ Al_{(4-x)}^{VI}\ Mg_x\ O_{10}\ (OH)_4\ M_x$$

The indexes IV and VI indicate the coordinate positions of tetrahedrons and octahedrons; Mx indicates the compensatory ion placed outside the leaves.In part,according to HOFMANN and al[6]

a small number x of Al^{3+} ions of the octahedric layer is replaced by Mg^{2+}; Fe^{2+}, or Fe^{3+} ions.The substitution of Al^{3+} ions by Mg^{2+} or Fe^{2+} leads to a deficiency of positive charges which is compensated by the compensatory ions Na^+, Ca^2 , K^+, which

take positions between the leaves[3.6.7.8.9.10.11.] The Roussel bentonite considered, has a substitution rate of x equal to $0.9\ 10^{-3}$ eq.g^{-1} which constitues 80% of the exchange capacity. The lattice parameters "a" and "b" are 5.3. Å and 9.05 Å;thickness of a leaf (001 plane) is 9.6 Å [12] .Hexagonal arrangement of the tetrahedrons makes appear cavities at the bottom of which OH ions are found.The compensatory cations are localised between the leaves (interior cations), at the periphery of leaves and on the surface of particles (superficial cations).The compensatory ions determine the total exchange capacity.These are classified in three groups according to their behaviour: interior cations, superficial cations localised on the (001) faces and superficial cations localised at the periphery.

2. Hydration and ion exchange properties

The interior hydration of montmorillonite provokes its swelling.This swelling is due to water penetration between the leaves by ions dipoles (compensatory interior ions,water molécules) attraction.According to KENZIE[13.14] this hydration takes

Figure 1-Structural schema of the Montmorillonite according to Hendricks[6].

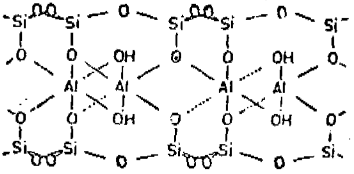


Table-2- Structural Composition.

Argillaceous mineral		Others		
montmorillonite %	illite %	quartz %	dolomite %	calcite %
100	0	traces	0	0

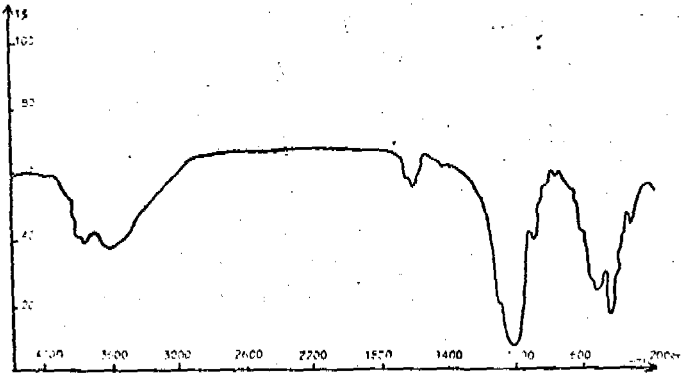


Figure 2 : The infra-red spectrum of natural "Roussel" bentonite

place at first. In the case of montmorillonite saturated with monovalent cations, water molecules are arranged in planar molecular layers, spreading a part the leaves which facilitates the exchange reactions, between the interior compensatory ions and those of the solution. In the case of Montmorillonite saturated with earth alkaline cations, the water molecules are arranged in octohedrons around the cation thus forming hexahydrates M $(H_2O)_6$ which spread apart the leaves. So, this hydration mecanism is according to[8], related to the disordered distribution of compensatory ions. More over, each of them is found to be away from the charge it compensates. These phenomena are revealed by the modifications of differential thermal analysis curves. Superficial hydration of montmorillonite crystals transform these crystals into negativelly charged micelles by fixing OH ions coming from water molecule decomposition. These negatively charged micelles are surrounded by positive ions present in the solution [9,11]. The suspension stability then depends on the dimensions and the charge of the positive ions forming the ionic atmosphere.

The exchange properties of the cations of bentonite are hence due to the existence of compensatory ions, their disordered distribution and the different hydration mecanisms of the mineral when it is dispersed in a saline solution.

3-Physico-chemical characteristics of Roussel bentonite

a) Chemical composition

This was determined by classical methods of silicate analysis. The ignition loss was obtained by calcination of samples at 1000°C up to a constant weight $(CO_2 + H_2O)$ - Table.1.

Table 1- Chemical composition of natural and activated bentonites.

Especies	$S_i O_2$	$Al_2 O_3$	$Fe_2 O_3$	Ca O	Mg O	$Ti O_2$	Na_2O	K_2O	I.L.
[a] Natural Bentonite % Weight	58.58	20.87	2.22	1.42	5.05	0.19	1.5	0.56	9.35
[b] Activated bentonite with H_2SO_4 5% weight	70.12	13.01	1.07	0.30	2.2	0.15	0.45	0.52	12.19

b)Structural position

Some authors[3] present the ratio SiO_2/Al_2O_3 as the characteristic index of the montmorillonite when its value varies between 2 and 3.5.According to the table 1, this ratio is equal to 2.81.Classification of Roussel bentonite as montmorillonite was confirmed by X ray diffraction and analysis by I.R. spectroscopy.

The results of X ray diffraction analysis presented in table -2- show the clay mineral contains mainly montmorillonite with trace impurities of quartz.

Analysis by I.R. spectroscopy can reveal the absorption bands of the clay and those of the impurities:

-Domaine - OH

The I.R spectrum figure-2-shows two bands in the zone 1600-1700 cm^{-1} and 3200-3800 cm^{-1}. This corresponds to the deformation of water molecules absorbed between leaves and to the valence vibrations of the attached -OH species (constitution water).To characterise the montmorillonite, the 3200-3800 cm^{-1} band is generally used[15].

-Domaine Si - O

The I.R. spectrum shows a band series characteristic of Si-O vibrations in the form of picks at 425-455-600-700- and 780 cm^{-1}.More over, the absorption bands also appear between 1000 and 1150 cm^{-1}.Considering the theory according to which the substitution of Si by Al in the ratio 3/2 displaces the bands towards lower frequencies [3.15], we can affirm that these bands characterise only the bands Si-O-Si and SiO - Al^{VI}.

-Domaine Si-O-M^{VI} (M^{VI}: Al,Mg,Fe)

The spectrum shows a pick at 455 cm^{-1} indicating the presence of Mg in an octahedric site.Considering the works of STUBICAN and ROY[16], absence or reduction of this pick corresponds to the presence of Al in tetrahedric site.We conclude that the quantity of Al in tetrahedric position is practically zero.More over the Si-O-Al^{VI} band is revealed by the picks of frequencies 1040 and 1050 cm^{-1}.

-Domaine M^{VI} - OH (M^{VI} : Al,Mg,Fe)

The spectrum shows an absorption band with its maximum at 910 cm^{-1}. According to [3], it corresponds to vibrations of Al^{VI} - OH. The Mg-OH bonds are revealed by absorption at 505cm^{-1}. As they are generally observed by those of $Si-O_2$ vibrations,it is impossible to characterise them.

The I.R. analysis confirms that the bentonite considered is montmorillonite.

-Differential thermal analysis given by the figure 3 st

Figure 3 : Differencial thermal analysis diagram of natural "Roussel" bentonite

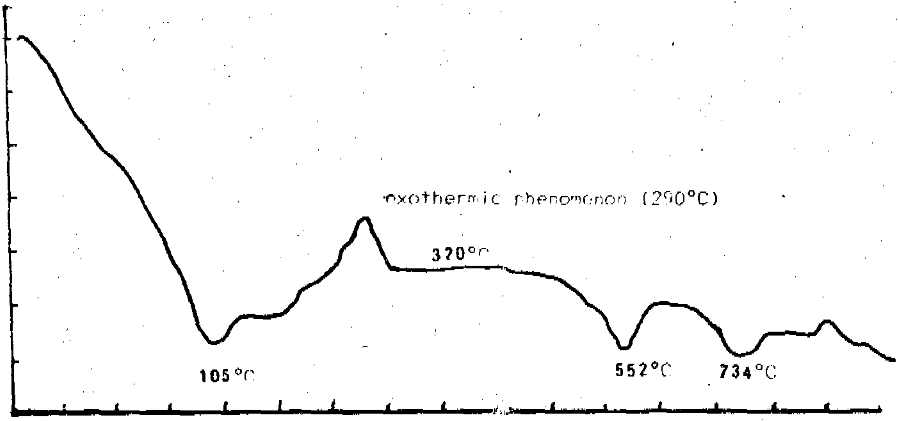
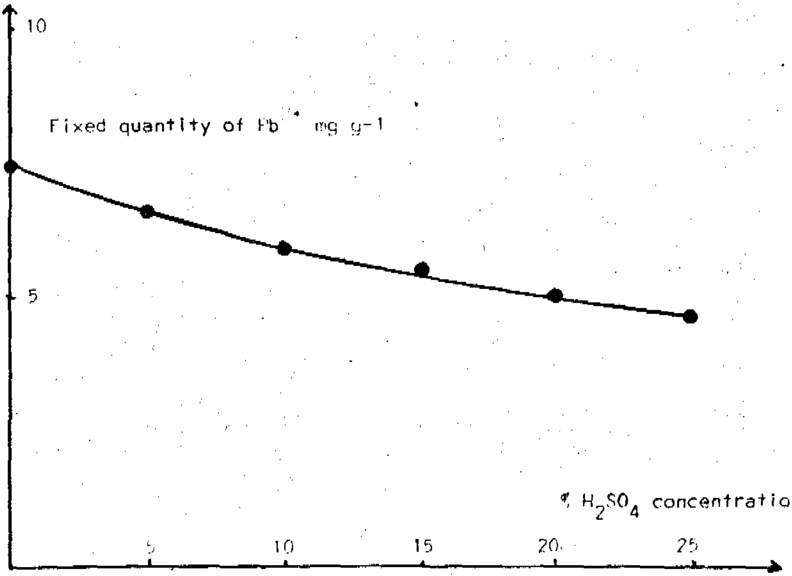


Figure 4 : Influence of acid activation (H_2SOn) on the capacity retention of Roussel bentonite towards Pb^{2+} case of
1 - initial concentration = 50 mg l-1 of Pb^{2+}
2 - initial concentration = 150 mg l-1 of Pb^{2+}



three endothermic effects as revealed by three picks:

The first pick at 105°C, corresponds to the departure of hydration water. Between 105°C - 350°C it is zeolitic or interfoliar water which leaves the lattice.[11] 3.11.12.

The record pick at 552°C corresponds to dehydroxylation and the third at 734°C to the destruction of the crystal lattice. The presence of quartz is usually revealed by an endothermic reaction between 500°C and 635°C. This reaction is absent in our case because the quartz is present in traces.

This study confirms that the bentonite considered is practically a pur montmorillonite.

II. Experimental results

1. Bentonite activation.

The properties of argillaceous minerals are determined by their composition and their structure[3]. They can be modified or improved by physical or chemical treatments. A comparative study of the activation by H_2SO_4 acid, at a temperature of 100C° and another thermic activation at temperatures of 105°C and 320°C is being presented.

The activation by sulfuric acid at a temperature of 100°C has been realized for different concentrations in H_2SO_4, different mass ratios pure H_2SO_4 /dry bentonite and different contact times .

The optimal conditions of dissolved lead retention have been determined to a base of these activation parameters in connection with a natural bentonite dried at 105 °C. The results showed that the activation of the bentonite by H_2SO_4 diminishes its retention capacity towards dissolved lead -Fig (4).
while its specific surface increasis:
112 $m^2\ g^{-1}$ instead of 77.5 $m^2\ g^{-1}$ for H_2SO_4 at 5%.

The acid treatment at 5% of H_2SO_4, is shown by a phenomena of partial dissolution of alkaline metals oxydes, alkaline earth metals, iron, aluminum. However, silica is not dissolved. Table -1-

Acidic activation has shown an improvment of the retention capacity of other bentonite[17]: which is explained, according to THOMAS[18], by the removal of 2 ions of aluminium out of the four of the central layer, replaced by H^+ ions, brought by the acid in the interfoliar space and exchanged with cations of the solution. Figure -5- represents the structural diagram of the transformation of an elementary montmorillonite cell after activation[18] Besides, the thermic activation at a temperature of 105 °C causes the outlet of hydratation water, at a temperature of 320°C, it causes the outlet of zeolitic or interfoliar water.

. The dissolved lead retention has been taken into consideration in each of these cases.

-2- Retention of dissolved lead.

Aqueous solution of lead nitrate of different concentrations are put into contact with bentonite in the different states previously written about. The lead retention is controlled by the analysis of the solutions after the separation of bentonite by filtration. The lead which remains in the solution is analysed by atomic absorption with the help of PERKIN-ELMER spectrometre of the 290B serie equiped with a hollow cathod lamp. The absorbance measure is done at a wave change of 283.3 nm.

2.1. The Influence of the concentration of the activation acide (H_2SO_4)

The study of this parameter means to prove the need to make activation or no of the bentonite and if yes, to research the value of the concentration of the acide (H_2SO_4) of bentonite activation, for which the retention of dissolved lead is maximum. This study has been directed in the following experimental conditions: - with grains diameter Ø is: $\simeq$ 0.1µm

- initial concentrations in dissolved Pb: 50 and 150mg l^{-1}
- bentonite dried at a temperature of 105°C
- relation bentonite mass/solution volume: 4g /200 ml.
- activated bentonite with H_2SO_4 at different concentrations and dried at 105°C.

Such mixtures are shaked during 6 howrs at 20°C. The results are given in table-3- for the solution at 150 mg l^{-1} and figure-4-

Table -3-

Concentration of the activation acid % mass	Fixed quantity of Pb^{2+}		Purification efficiency
	mg l^{-1}	mg g^{-1}	%
natural bentonite	150	7.5	100
5	134.4	6.72	89.6
10	118	5.9	78.7
15	110.7	5.54	73.8
20	102	5.1	68
25	91	4.55	60,7

This table shows that the activation of "Roussel"bentonite by H_2SO_4 at different concentrations diminishes its retention capacity towards Pb^{2+} dis. This determined us to consider the retention properties of this bentonite in its natural state,

Figure 5 : Structural schema of unit cell of the montmorillonite after acidic activation according to THOMAS[18].

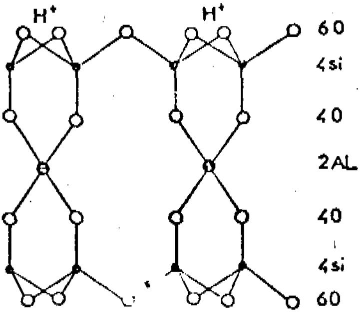
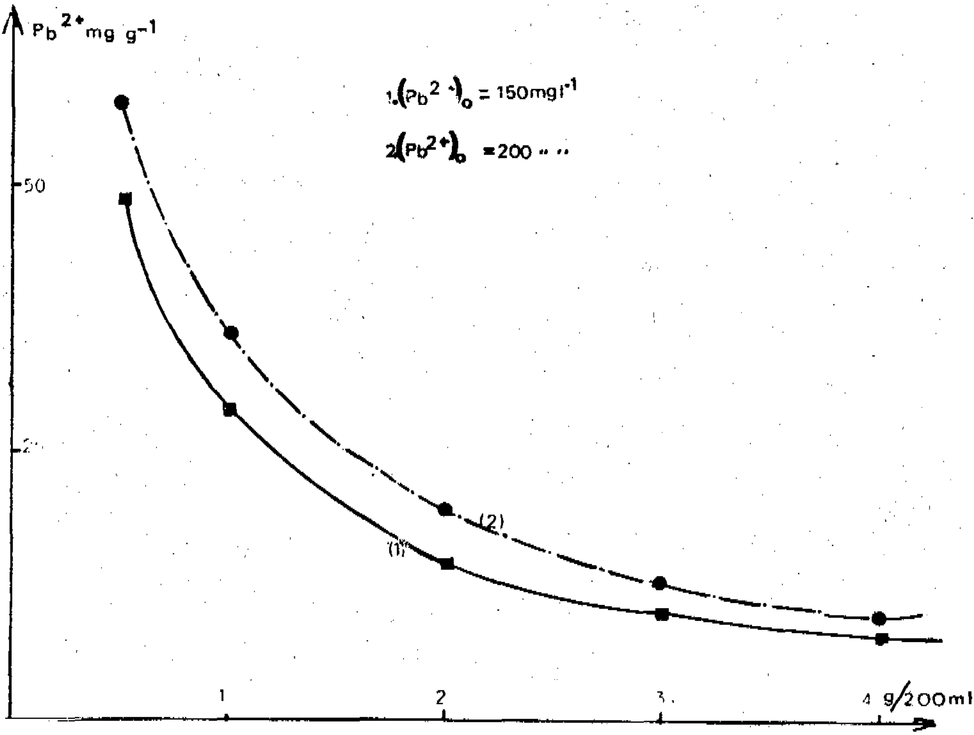


Figure 6 : Influence of the bentonite/mass/solution volume ratio on the capacity retention of "Roussel" bentonite towards Pb²⁺



dried at a temperature of 105°C and 320°C.

2.2-Determination of optimal relation:bentonite mass /solution volume.

For a constant solution volume,the mass of natural bentonite dried at 105 and 320°C is varied; the other operating conditions are identical to those given previously.The results are given in table -4-

Table-4- A case of a solution at 150 mg l^{-1} in Pb^{2+}

Mass of natural dried bentonite at 1 5°C g	Fixed quantity of Pb^{2+}		Efficien--cy %	final pH
	mg l^{-1}	mg g^{-1}		
0,5	121,2	48,5	80.8	5.6
1	146,3	29,2	97,3	6.2
2	149.7	14.97	99.8	6.4
3	150	10	100	6.5

The optimal relation estimated according to the waste water standard (i-e- 0,5 mq l^{-1}), changes according to the initial concentration of the solution in Pb^{2+}. It is given in table -5- for natural Roussel bentonite dried at 105°C.Fig.6

-Table -5-

Initial Concentration Pb^{2+} mg l^{-1}	50	100	150
Purification Efficiency %	99	99.8	99.75
Relation mass/volume	$\frac{0.5}{100}$	$\frac{1}{100}$	$\frac{2}{100}$

2.3. Kinetics of the retention of Pb dissolved by bentonite

This study has been done for the different reserved concen--trations for an optimal relation mass/volume of solution on a natural bentonite dried at 105°C.and 320°C.The results given in

Figure 7- are relative to retention kinetic of dissolved Pb for different concentrations at a temperaturé of 20°C.These curves show that the retention kinetic of dissolved Pb is very quick, practically total after 0.5 hour of contact.A light passing back reaction of fixed Pb is observed after a contact time superior to 2 hours.This observation orders the separation of the two phases after a contact of 2 hours.

The kinetics reaction of the Pb dissolved by the considered bentonite can be represented by a straight line having an expression:

$$y = k \log xt + z$$

where k,x and z are related to initial concentration.An average expression relative to each concentration can be written :

$$y_1 = 0.3 \log t + 18.6 \quad ; y_2 = 0.45 \log t + 24 \quad ; y_3 = 0.6 \log t + 26.6$$

2.4. Influence of various factors

2.4.a Influence of pH.

The results are relative to a solution of 50 mg l^{-1} of dissolved Pb at 20°C,for a natural bentonite dried at105 °C,for an optimal relation mass/solution volume.The variation of the Ph has been realized by adding Hcl 0.1N and NaOH 0.25N.Table-6-gives this influence.

Table-6-Influence of the pH.

Initial pH	3	5.7	7	9	11	13
Fixed quantity of Pb^{2+} mg g^{-1}	8.98	9.46	9.66	9.86	9.54	8.84
Final pH.	5.6	7.4	7.8	8.3	9.2	11.9

The results show that the pH. has little influence on the capacity of retention of bentonite towards dissolved Pb .However,a slightly basic pH increases the efficiency of the reaction,in relation with the concentration:Figure-8

2.4.b.Influence of the presence of various ions

The influence of the salinity has been taken into consideration so as to establish the elements in relation with a choice between an overall treatment or a separative one in case of industrial waste water.

The interesting ions are Na^+;Ca^{2+},cl^-,SO_4^{2-};naturally pre -

Figure 7 : Kinetics of the retention of Pb^{2+} dissolved by Roussel Bentonite at room temperature (20°C)

(1)- initial concentration = 50 mg l^{-1} ;(2)- initial concentration = 150 mg l^{-1} -(3)- initial concentration =200 mgl^{-1}

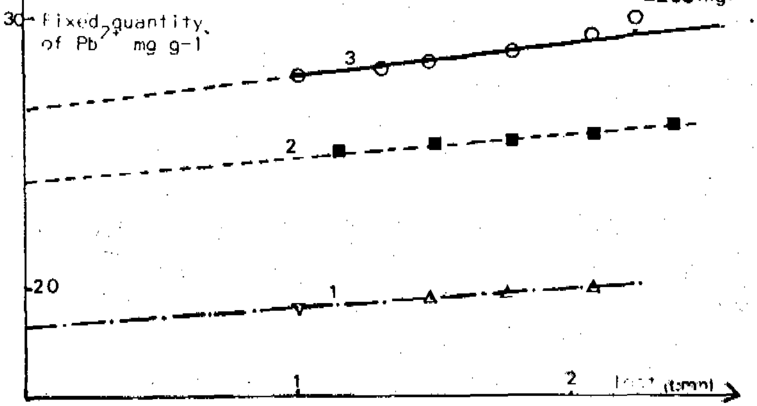
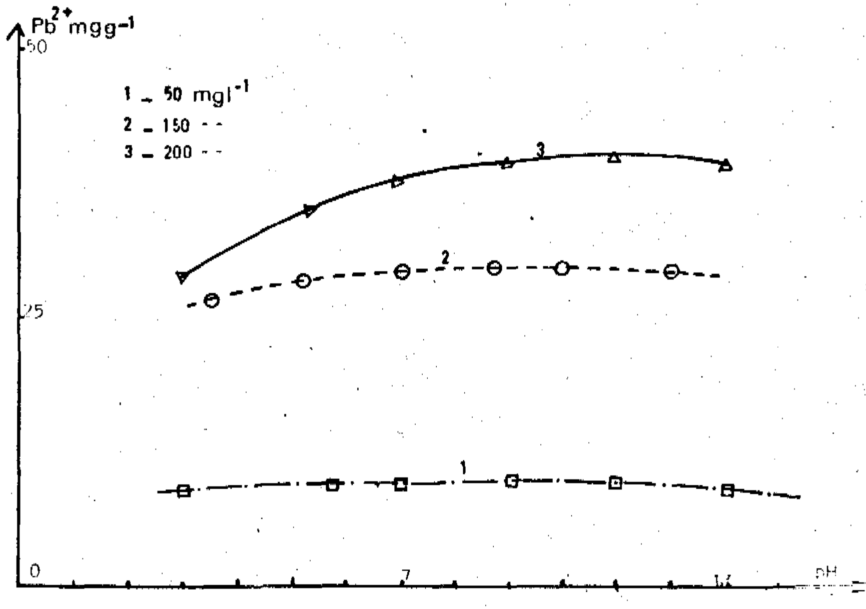


Figure 8 : Influence of the initial pH on the capacity retention of Roussel bentonite towards Pb^{2+}



-sent in the environment.The latter was considered in concentration field inferior caused by the precipitation of $PbSO_4$.

The results are relative to the different solutions with optimal conditions,for natural bentonite dried at 105 °C.Curves -figure-9-show that retention of dissolved Pb by the bentonite diminishes in base of an increase in chlorure of the solution , especially when the concentration in dissolved Pb increases.This is probably an effect resulting from the presence of Na^+ and cl^-. In effect the retention of dissolved Pb diminishes when the concentration in Na^+ increases:Figure-8-On the other hand the presence of Ca^{2+} ions and SO_4^{2-} ions,Figure-9- has less influence on the capacity of retention of the bentonite towards dissolved lead.

2.5.Study of the retention reaction

The retention of dissolved Pb by Roussel bentonite is mainly an exchange reaction between compensatory ions in the solid phase and the those of the solution.

The nature and the quantity of ions exchanged with those of the solution has been determined.The results reported in table-7- for bentonite dried at 105 and 320°C are relative to a solution Pb^{2+} of 200 mg l^{-1} .The compensatory ions are composed of Na^+,K^+,Fe^{2+},Mg^{2+},Ca^{2+},in a decreasing order of their concentrations.The exchange reaction first concerns the ions Na^+ and K^+.The ions Fe^{2+} and Mg^{2+} come in second position,and ions Ca^{2+} come last,with increase of the bentonite mass,solution volume ratio.

Table -7- Nature of ions which give out the bentonite in relation with retention of Pb^{2+} :
Case of a solution at 200 mg l^{-1} in Pb^{2+}

Species Quantity $\times 10^3$ eq g^{-1} Bentonite mass solution volume	Pb^{2+} fixed	Na^+ dis.	K^+ dis.	Mg^{2+} dis.	Fe^{2+} dis.	Ca^{2+} dis.	final pH
0.5 %	0.386	0.14	0.01	0.0082	0.0022	0	5.6
1%	0.193	0.12	0.005	0.0041	0.0016	0	5.8
1.5 %	0.128	0.12	0.0017	0.0027	0.0011	0.0003	6

Figure 9 : Influence of the presence of various ions on the capacity retention of Roussel bentonite towards Pb^{2+}
1 - Case of Na Cl ions ; 2 - Case of Ca^{2+}

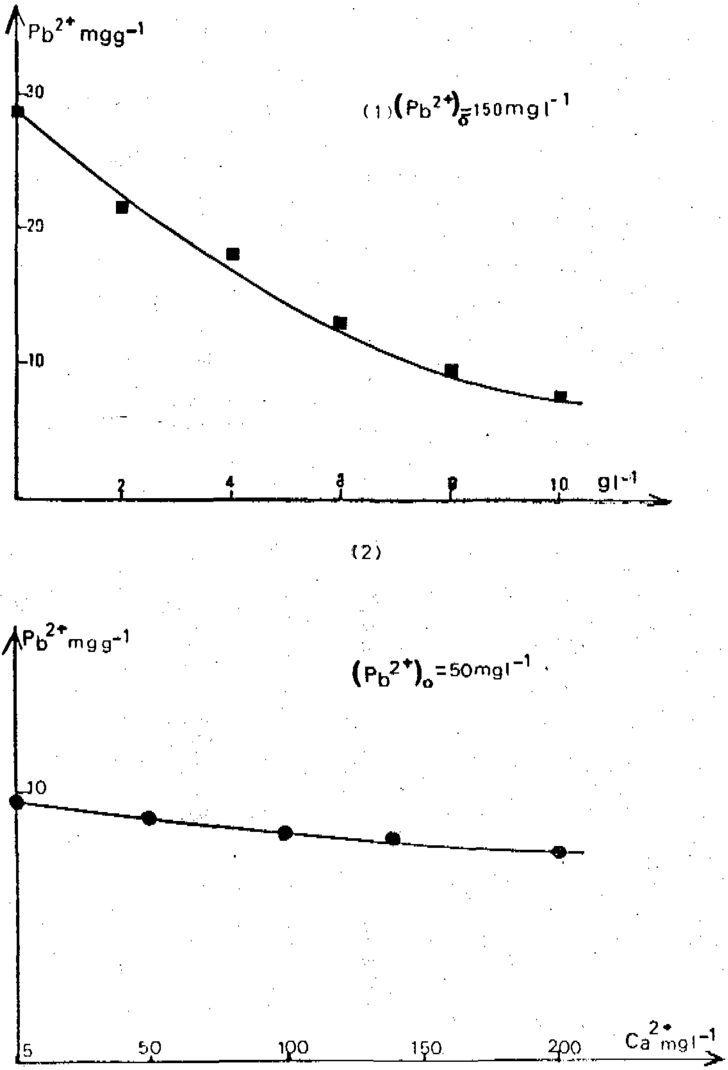


Table -8- Relation between the drying temperature of the bentonite and the nature of ions wich give in the solution for the retention of Pb dissolved.

Species Quantity $\times 10^3$ eq.g^{-1} Nature of Bentonite	Pb^{2+} fixed	Na^+ dis.	K^+ dis.	Mg^{2+} dis.	Fe^{2+} dis.	Ca^{2+} dis.	Final pH.
Bentonite dried at 105 °C	0.386	0.14	0.01	0.0082	0.0022	0	5.6
Bentonite dried at 320°C	0.38	0.35	0.018	0	0	0	6.4

- Bentonite dried at 105°C.

For a small bentonite mass, solution volume ratio, fixed quantities of Pb^{2+} is more than the amount of ions going into solution. On the other hand when this ratio increases, the fixed quantity of Pb^{2+} becomes practically equal to the amount of exchanged ions. This phenomenon suggests that there are two mechanisms : exchange and sorption in the first case, mainly exchange in the second case ; In fact, it has been observed that a small quantity of fixed Pb is going back into solution. A decrease of the pH has been observed too, caused probably by the hydrolysis of Fe^{2+} ions and Al^{3+} ions. A more detailed quantitive study is in progress.

- Bentonite dried at 320°C

The results assembled in table -8- show that retention of dissolved Pb is practically an exchange reaction. Exchanged ions are constitued only by compensatory ions : Na^+ and K^+. Consequently, retention of Pb^{2+} should be more stable in such conditions. The pH is also less acidic.

Absence of Mg^{2+} and Fe^{2+} ions going back into solution, suggests that there is a rearrangement of the structure of the bentonite which occurs when interfoliar water leaves the lattice.

III. Discussion.

1. The experimental results showed a decrease in the retention capacity of Roussel bentonite to fix the dissolved Pb if the bentonite was activated by sulfuric acid. This behaviour can be explained by two phenomenons.

The Pb retention is characterised by a high rate at room temperature. The retention rate has an expression of the form

$$y = k \log xt + z$$

whose coefficients are functions of the initial concentration, hence characteristic of the diffusion phenomenon.

The mecanism taking place during the Pb retention depends upon of bentonite mass/solution volume ratio and activation temperature.

Influence of different factors were considered :

. The pH should be slightly basic

. The presence of Na^+ and Cl^- ions at high concentrations influences negatively the efficiency of Pb retention.

The presence of Ca^{2+} and SO_4^{2-} ions at small concentrations modifies little the efficiency of the reaction.

A separation treatment of industrial waste waters are hence recommended.

A more detailed study of the Pb retention kinetics, influence of temperature and determination of thermodynamic magnitudes is in progress.

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WATER AND WASTEWATER PROBLEMS OF THE CİTY OF İSTANBUL

OF THE CİTY OF İSTANBUL

Ahmet Ölçer

Director, Istanbul Water and Sewage Works General Directorate

INTRODUCTION

Among the many problems which large cities in developing countries facing are :

a) The rapid increase in population,
b) Water shortage,
c) Lack of the appropriate wastewater collection and disposal systems,
d) İnproper industrialization

İstanbul as a large city of a developing country is also facing similar problems. In this paper, the water and wastewater problems of the city of İstanbul will be presented, and the solutions proposed will be summarized.

BRIEF INFORMATION ON İSTANBUL

İstanbul, the only city in the world located on two continents, is surrounded by the Black Sea in the north and by the Marmara Sea in the south. The city is seperated into two by the Bosphorus. The city was inhabited for more than twentyfive centuries. Today, the population of the city is reaching to five and a half million people, and it increases every year roughly by 200,000. The surface area of 7,500 hektars is used for different purposes. Almost half of the dwelling is "gecekondu"*. İstanbul Water and Sewage Works General Directorate (İSKİ) which was founded in 1981 is responsible for finding solutions to the water and sewarage problems of this city. This organization, beyond the supply of water and the collection and disposal of wastewaters, is also responsible for the protection of the water sources and the receiving bodies from pollution.

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*gecekondu : dwelling built in one night, slum

WATER SUPPLY FOR THE CITY OF İSTANBUL

Presently, Ömerli, Elmalı and Alibeyköy Dams, the Terkos Lake and several wells are the water sources of the city.

A. Amount of Water Supplied

İSKİ in order to be able to satisfy the water demand of the increasing population has started to work systematically. As a result of that a considerable increase (100%) in the amount of water supplied to the city has been achieved from 1980 to 1984 as can be seen in Table 1.

Table 1. Water Consumption in İstanbul

Year	Amount of Water Supplied (m^3/day)	Water Consumption (water supplied) (liters/capita-day)	Percentage of Population Utilizing the Service
1980	560,000	110	90
1982	800,000	150	90
1984	1,100,000	200	95

As can be seen in Table 1, the water supply per capita per day has reached the value of 200 liters. This value can be considered satisfactory for a developing country.

B. Water Distribution System

Until 1984, the water distribution system of İstanbul was of a regional character. In January 1983, the line connecting the Asiatic and European parts of the city was completed. The two pipelines constructed under the Bosphorus had a diameter of 1000 mm and a maximum capacity of 320,000 m^3/day. After the completion of this line and the Ø 1200 mm transmission line between Yedikule and Vatan Caddesi in 1984, the water distribution system of İstanbul has become entirely interconnected

1. Existing distribution system will be able to satisfy the demands until 1995, if ;

a) Küçükçekmece and Darlık Dams are completed,
b) Three pumps in Ömerli Dam are replaced with the larger ones, and
c) The water storage tank and pump station in Bahçelievler are completed.

2. Presently, 95% of the people takes the advantage of the water distribution system, while in 1980 this value was 90%. The water transmission lines of the surrounding municipalities and the villages are insufficient.

3. There were 1560 public fountains in the city in 1980. In order to take care of the public health, to prevent the unnecessary water loss, and to be able to collect the money for the water consumed, the water distribution system was expanded rapidly, and public fountains were closed in the places where system was completed. Only 450 fountains are left today.

C. Plans for the Future

İstanbul is stiff suffering from water shortage, and this shortage will become more severe in the near future due to the increase in population. To overcome this problem the following activities are planned.

1) In the coming 3-4 years water should be supplied from Büyükçekmece, Küçükçekmece and Darlık Dams.
2) Presently, the water losses in the distribution system are in the order of 30%. Transmission lines and the distribution system should be replaced and repaired in order to reduce the water losses to a value below 20%. Activities for encouraging the establisment of a pipe factory-something essential for this operation- has started already.
3) The Construction of İsaköy Dam should be started at the latest by 1995.
4) The preparation of a new master plan for the city of İstanbul should be undertaken by 1990.

WASTEWATER COLLECTION AND DISPOSAL IN İSTANBUL

The wastewater disposal problem which has been started with the migration of the first inhabitants to the city, still continues to be a problem. Although, after the Turkish Republic was founded, several studies like the Kern Study, the DAMOC Report and its revision by CAMP-Tek-Ser, NEDECO, etc. have conducted, the application was not realized due to different reasons.

A. Wastewater Collection System

In 1980, out of the 4,503,590 inhabitants of the city, only 2,716,000 people were able to utilize the sewer system. Table 2 gives information on the wastewater collection system while Table 3 gives the percentage of population utilizing the system.

As can be seen in Table 3, in 1983 only 60% of population was able to take the advantage of the sewer system. This value is far away from being satisfactory.

B. Wastewater Disposal

A large amount of the wastewaters of İstanbul is discharged in the Marmara Sea and the Bosphorus without any treatment, while a small amount is removed by septic tanks. In places where sewer lines do not

Table 2. Sewer System of İstanbul

Part of the City	Sewer		Collector		Total Cost* x10^6 TL
	Length km	Cost* x10^6 TL	Length km	Cost* x10^6 TL	
İstanbul Side	1355	16260	35	1925	18185
Beyoğlu	422	6330	15	825	7155
Asiatic Side	599	5990	20	1100	7090
Total	2376	28580	70	3850	32430

* Based on the unit prices of 1982

Table 3. Population Served by the Sewer System in İstanbul

Part of the City	% Population Served by the Sewer System	Length of sewer per cap. (m/capita)		Length of sewer per capita planned for the future (m/capita)
		According to population served by	According to the total population	
İstanbul Side	65	0.98	0.65	0.92
Beyoğlu	70	0.61	0.43	0.85
Asiatic Side	45	1.00	0.44	0.99
Total	60	0.82	0.54	0.93

exist, wastewater flows freely in empty fields, and through the small rivers it reaches the sea again. Because of that;

i) serious public health problems occur in districts where wastewater collection systems do not exist,
ii) the Sea of Marmara, the Bosphorus and especially the Golden Horn are facing serious pollution problems.

C. Plans for the Future

The future plans foresee first the determination of the appropriate discharge points, then the construction of the new collectors followed by the construction of the treatment plants. Along these, the construction of the wastewater collection systems will continue.

The population density was another factor taken into consideration in planning. According to the plan, the work will start from highly polluted areas and will extend toward less populated areas.

1. Districts with first priority

a) Yenikapı District - Treatment Plant

This district covers the area surrounded by Golden Horn, the Marmara Sea and a line passing through the middle of Bakırköy. The work will start in 1984, and it will be completed by 1987.

b) The Wastewater Treatment Plants of Tuzla and Ataköy

This work is expected to be completed by 1987.

2. Districts with second priority

a) Kabataş
b) Kadıköy-Kartal
c) Üsküdar

Realization of the works described in (a) and (b) will provide a collection system for the most populated parts of İstanbul. Furthermore, it will prevent entirely the pollution of the Golden Horn as well as the some regions of the Marmara Sea from Darıca to Küçükçekmece. The pollution of the wells from which water is supplied will also be prevented.

3. Districts with third priority

According to the investment plans the collection system of Küçükçekmece have the third priority.

4. Treatment and Disposal

a) Wastewaters coming from Yenikapı, Kadıköy and Üsküdar, after being subjected to a preteratment will be discharged through the ocean outfalls in the lower layers of the Marmara Sea and the Bosphorus at a depth of 50 m.

b) Wastewaters coming from Ataköy, Kabataş and Tuzla districts will be discharged after being subjected to biological treatment.

5. Industrial Wastewaters

According to the data obtained from the Chambers of Commerce and Industry, there are 70,000 commercial and 7,000 industrial establishments in İstanbul. İSKİ is presently completing a preliminary survey on the pollution strength of the wastes of these establishments. The Quality Control Directorate which is established within İSKİ, after the completion of the survey will start to collect samples and determine whether these establishments treat appropriately their wastes before disposal or not.

6. Regional Administration

İSKİ is a General Directorate which was formed by the joint of the İstanbul Water Works Directorate, Wastewater Department of İstanbul Municipality and the 16th District of İlbank (Provincial Bank). It works in cooperation with the municipality of İstanbul, but it has an independent budget. İSKİ within this frame is an organization which deals with all the water and wastewater problems of the city of İstanbul, namely it cares for the water from the source to the consumers and from the consumers to the disposal site.

WORKS TO PREVENT POLLUTION OF THE WATER SOURCES AND THE SEA

Due to the lack of any preventative measures the sea was polluted by the untreated wastes discharged. In a similar way, lakes used as water sources for the city of İstanbul are facing serious pollution problems due to the insecticides and fertilizers used in agricultural activities, animal feeding and urbanization.

İSKİ, utilizing the rights given to him by the law which its establihment was based on, has prepared the"By-laws for Protection of Water Resources"and the"By-laws for Discharge into Public Sewers". Both of them were based on the Law for the Protection of the Environment (Law No. 2872) and on the Law No. 2805 related to buildings constructed against the regulations.

a) By-laws for Discharge into Public Sewers

According to this law, all dwellings within the regions of İSKİ's authority, are obliged to take a special permit for discharging their wastes in the public sewers. In areas where public sewers do not exist, a permit will also be issued stating the condition of wastewater collection and disposal at predetermined points. Furthermore, industrial and other establishments named as "source of pollution" are obliged to treat their wastewaters until they are reached to the domestic wastewater quality, and to perform regular tests for the determination of the effluent quality.

b) By-laws for the Protection of Water Resources

According to these by-laws the watershed is seperated into four.

a) Entirely Protected Area: The area which its boundaries formed by a line drawn at a distance of 300 m from the nearest water body.

b) Protected Area of Primary Importance: The area between the lines passing from 300 and 1000 m distance.

c) Protected Area of Secondary Importance: The area between the lines passing from 1000 and 2000 m distance.

d) Protected Area of Tertiary Importance: The area remaining outside the previously explained three classes.

No activity can take place within the entirely protected area. In the protected area of primary importance, agriculture without using pesticides and fertilizers can be permitted. This area can be used for picnic,but without building any permanent structure. In the remaining two areas, large housing activities could not take place. Systematic animal farming, mining, activities (industrial,etc.) causing pollution could not take place. Before starting any activity in these areas,the permission and approval of İSKİ are required.

The protection of the water resources of İstanbul as well as of the Marmara Sea can not be realized by the by-laws of İSKİ only. Support of the governmental agencies and the municipality as well as of all the citizens is required to obtain satisfactory results.

FINANCIAL PROBLEMS AND THEIR SOLUTION

A. Projects Included in the Program of İSKİ

The cost of the dams, water treatment plants, pump stations and transmission lines included in the program of İSKİ are given in Table 4, while the cost of wastewater treatment plants, pump stations, collectors and sewer system are given in Table 5. If it is possible to find the necessary financial support, the Küçükçekmece, Büyükçekmece and Darlık Dams could be completed in three or four years, while all the wastewater systems could be built in ten years.

B. Financial Sources

The money required for the realization of these projects will come from:

1) İSKİ's tariffs
2) Ten percent of the budget of İstanbul and other surrounding municipalities located within the the authority boundiries of İSKİ.
3) The people taking use of the new facilities (according to Law No.2464, 1/3 of the cost of the new facilities is collected from those to whom the service is provided).
4) National loans
5) International loans

The investment which İSKİ can realize today with its own means and with the loans taken from the central government amounts to 10-15 billion TL. However, the amount required for the completion of water and wastewater projects is in the order of 400-500 billion TL. This amount of money could not be obtained from national sources, because of that an important amount of international loans is required. Contacts established in the last two years has created the suitable media for obtaining this loan. After realization of these projects, the income coming from the services provided will be enough for paying back the loan and its interest.

Table 4. Investment Required for the Development of the Water Supply Syste
(million TL)

Source	Dam	Treatment Plants & Pump Sta.	Water Intake Structures	Transmission Lines	Total	Eng.g Cons. %30	Grand Total
K.Çek.	1914	5580	94	485	8073	2422	10495
B.Çek.	8500	6200	100	9600	24400	7320	31720
Darlık	5600	8000	150	6600	20350	6105	26455
Total	16014	19780	344	16685	52823	15847	68670

* Based on unit prices of 1984

Table 5. Investment Required for the Development of Wastewater System

(x10^6 TL)

Districts	Pretreat. and pump stations	Ocean Outfall	Small pump st. and se.	Struc. Total	Collect.	Main Collect.	Street Sewers	Sewers Total	Struct. and Sewers Total	Land Purchase	Grand Total
Küçükçekmece	900	2400	500	3800	780	915	4410	6105	9905	495	10400
Ataköy	846	2640	500	3986	-	915	4410	5325	9311	465	9776
Yenikapı-Ahırkapı	2500	7200	2060	11760	5200	550	10690	16440	28200	1400	29600
Kabataş	1132	2600	500	4232	1400	50	6770	8220	12452	624	13076
Baltalimanı	344	400	500	1244	330	-	2204	2534	3778	190	3968
Tarabya	416	400	1000	1816	560	-	2204	2764	4580	230	4810
European Side Total	6138	15640	5060	26838	8270	2430	30688	41388	68226	3404	71630
Paşabahçe	399	400	1000	1799	386	-	2204	2590	4389	220	4609
Küçüksu	293	400	500	1193	384	-	1650	2034	3227	160	3387
Üsküdar	222	400	1000	1622	258	7	551	816	2438	120	2558
Kadıköy	3432	6000	3500	12932	2870	3070	18870	24810	37752	1885	39637
Tuzla	725	500	1000	2225	790	-	4960	5750	7975	400	8375
Adalar	200	400	400	1000	200	-	700	900	1900	100	2000
Asiatic Side Total	5271	8100	7400	20771	4888	3077	28935	36900	57681	2885	60566
Total	11409	23740	12460	47609	13158	5507	59623	78288	125907	6289	132196
Unexpected Exp.%15											19829
Total											152025
Eng.g Services %10											15202
Grand Total											167227

*Based on the unit prices of 1982

Al(III) SALTS IN THE PHYSICO-CHEMICAL TREATMENT OF SEWAGE

Sema Özgen[x], Gülerman Sürücü[xx]

[x]TUBITAK Building Res.Inst.,Kavaklıdere,Ankara

[xx]M.E.T.U.,Environmental Eng.Dept., Ankara

INTRODUCTION

Chemical precipitation has been applied since 1740's for the treatment of sewage. With the development of biological treatment, the use of chemicals was abandoned in wastewater purification, and biological treatment was adopted. In early 1930's attempts were made to develop new methods of chemical treatment. Considerable interest has been aroused in the past decade in physico-chemical treatment (PCT) in the U.K., Sweden, the Nederlands and the U.S.A.

Reduced land requirements and capital costs, easy control over treatment plant performance, reduced susceptibility of the chemical stage to toxic materials, improved color removal makes PCT systems more advantageous over biological treatment systems.

In the PCT systems stabilized colloidal solutions are destabilized by the addition of chemical coagulants and then the particals are brought into contact by physical stimulation; therefore they can stick together and form flocs large enough to settle down. In common wastewater treatment practice, aluminum salts, iron salts, lime etc. are commonly used as chemical coagulants. $NaAlO_2$, a less familiar aluminum salt, has gained attention recently. $NaAlO_2$ can be produced from the wastewater of aluminum anodizing plant[1]. In this study, $NaAlO_2$ is compared with alum by means of the experiments performed on two pilot plants operated in parallel.

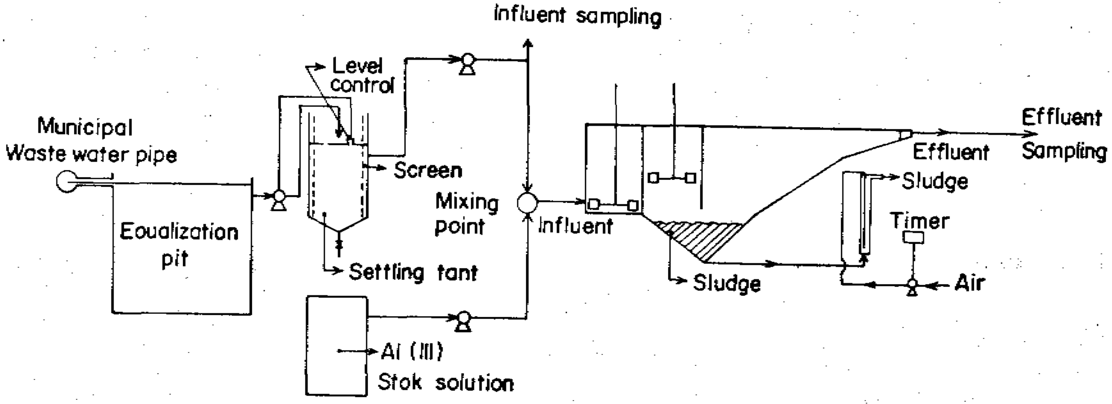

Fig. 1. Process flow chart of pilot plant.

In many applications, PCT is used as the primary treatment followed by the biological treatment. The biological treatibility of the PCT system effluent should therefore be considered. In this study the biological treatability of the PCT effluent, having Al(III) compounds in solution, has been examined by the sapromat technique.

MATERIALS AND METHODS

Materials

Wastewater. Wastewater used in this study was domestic sewage of the town Heverlee (Belgium). It was used as the influent for jar tests, after screening (mesh:0.51mm.) and for pilot plants; after presettling within a short residence time (less than 10 min.) and screening. As the wastewater was of the combined type, it also received surface water, therefore its characteristics fluctuated with weather conditions. The wastewater characteristics are summarized in Table 1.

Coagulants. Aluminum Sulphate: $Al_2(SO_4)_3.18H_2O$ stock solution is a proanalysis solution of 0.1 M, (containing 5.3963 g Al^{3+}/l). It is contained in a plastic bottle and renewed approximately every month (criterion: absence of precipitate).

Sodium Aluminate: Sodium aluminate produced from Al-containing effluent of aluminium anodizing plant, concentrated according to Wajc.

specific gravity : 1.66 g/cm^3
viscosity : 1000 cP
pH : 14
Al_2O_3 content : 33 %
Na_2O content : 23 %
heavy metals : Cu : 11 ppm, Zn : 10 ppm, Cr: 137 ppm,
Fe : 210 ppm
stock solution stability is more than one month
(criterion: absence of precipitate)

Methods

Pilot Plant Experiments. The global flow chart of the pilot plant is shown in Fig. 1. Two pilot plants were run in parallel: one with $Al_2(SO_4)_3.18H_2O$ and the other with $NaAlO_2$ at the same conditions. Raw wastewater from the Heverlee town sewer was presettled in a pit with an approximate retention time of 15 min., wastewater was

Table 1. The Wastewater Characteristics

Parameter	Average	Min.	Max.	Standard Deviation
Temperature (^oC)	13.16	7.7	19.2	3.49
pH	7.91	7.16	8.85	0.45
Alkalinity (meq.$CaCO_3$/l)	10.17	5.04	12.24	1.58
Conductivity (millimho)	1.43	0.76	1.86	0.28
Total hardness (mg$CaCO_3$/l)	30.84	18.32	37.63	5.04
BOD_5 (mg O/l)	169	79	336	85.34
COD (mg O/l)	385	148	575	115.23
TSS (mg/l)	130	26	300	55.27
VSS (mg/l)	103	15	203	44.96
Turbidity (NTU)	76	30	220	29.45
Total P (mg/l)	14	7.99	26.33	4.12
Total N (mg/l)	75	32	109	19.17

pumped into another small (volume : about 10 l) tank in the laboratory in order to supply continuous flow to the pilot plant. Pumping to the tank was automatically controlled by a level control in the tank. Wastewater was screened (mesh size : 0.51 mm) at the inlet of the tank to prevent blocking in the conduits and pumping system.

From this tank wastewater was pumped by means of a positive displacement pump into the mixing point. A side outlet was provided for excess flow of water. At the mixing point wastewater was mixed with the coagulant in a plexiglass cylindrical cell. A rapid-mix was provided in this cell within approximately 15-45 sec. Coagulant, on the other hand, was pumped by a peristaltic pump into the mixing cell. After this mixing point the solution entered into the plexiglass pilot plant. The volume of the first compartment in the pilot plant was about 6.75 l. Water was mixed in this compartment with a turbine type impeller having a diameter of 95 mm. at a speed of 80 rpm ($G : 25\ s^{-1}$). Stirring was applied for homogenity of the water.

Homogenized wastewater flowed to the second compartment which also had a stirrer of the same size and shape with a speed of 25 rpm. ($G : 5\ s^{-1}$). The volume of the second compartment was the same as the first one. In this compartment due to slow mixing the colloids were allowed to agglomerate.

Flocs grew enough to settle and slide down to the bottom of the settling chamber which had a volume of approximately 18.25 l. The sludge was removed from the V-shaped bottom by means of an air lift which was controlled automatically by a timer. Sludge was removed every 10 min with running period of 1 min., avoiding sludge blanket, sludge thickening and chanelling effect in the sludge.

Clear supernatant was removed as effluent over a weir. Samples were taken for influent from the entrance of mixing point and for effluent at the outlet of pilot plant where supernatant was removed.

Some independent and dependent variables were suggested as the frame of the study (see Table 2). From those variables independent variables are subject to alter by the experimenter arbitrarily, but the influent characteristic, which are the natural independent variables, can not be varied by the experimenter. They are dictated by the sewer system. Some of the forced independent variables like G, Alxdose, impeller type were kept constant during all the experiments. Temperature was kept as natural independent variable depending on the influent quality, since it costs very much if the system is liked to be kept at a fixed temperature. pH, on the other hand, was taken as a characteristic of influent changing naturally at the beginning, but later some experiments were performed by pH correction. So the experiments were performed in two catagories:

1. Residence time was independent variable (forced) and applied from 1 to 3 hours at Al - doses of 20 mg/l and 25 mg/l (for approaching the optimum).
2. pH was independent variable and controlled automatically to fix at a certain value (for $NaAlO_2$ pH : 7.0 ∓ 0.2, for $Al_2(SO_4)_3.18H_2O$ pH : 8.5 ∓ 0.2, by the addition of H_2SO_4 and NaOH respectively) where residence time and coagulant dose where kept at 1h and 20 mg Al/l respectively. (Glass electrodes of the pH control instrument were placed in the first compartment of the pilot plant).

Table 2. Independent and Dependent Variables Chosen for Pilot Plant Studies

Independent Variables		Dependent Variables
Forced	Natural	
Al - dose	Influent pH	Effluent pH
Kinetic aspects (G, impeller, etc.) and Hydraulics	Influent Temperature	Effluent Temperature
	Influent Turbidity	Effluent Turbidity
pH	Influent COD	Effluent COD
Retention time (flow rate)	Influent BOD	Effluent BOD
Temperature	Influent Total P content	Effluent Total P
	Influent Total N content	Effluent Total N
	Total Suspended Solids	Effluent TSS
	Volatile Suspended Solids	Effluent VSS
	Alkalinity of influent	Conductivity of effluent
	Total hardness of influent	% Transmission of UV light
	Conductivitl of influent	Sludge Volume
	% Transmission of UV light	CST
		TSS in sludge
		VSS in sludgo

Toxicity Tests for Al-Salts with Wastewater. Wastewater sample was taken from the inlet of the settling tank (see Fig.1) and let settled for about half an hour in order to remove most of the suspended solids which usually adsorb the aluminum introduced as coagulant to the medium. Rather clean supernatant was taken and its pH was adjusted to 8.5 ∓ 0.1 in order to keep almost all the aluminum in solution.

NaOH was added for pH correction. Then it was distributed into 12 sapromat bottles in 250-ml-portions. Into those bottles $NaAlO_2$, from a stock solution containing 300.674 mg Al ^{3}/1 and $Al_2(SO_4)_3.18H_2O$ from a stock solution with concentration of 54.0 mg Al^3 /1 ∓ 0.5 mg/1 were added as in Table 3.

Toxicity Tests for Al-Salts with Synthetic Wastewater. For the preparation of synthetic wastewater, the solutions used are given below:

- peptone solution: (As substrate for the microorganisms). 3 g. peptone and 1g sodium chloride (as nutrient) were dissolved in distilled water of 5.1 volume.

Table 3. Data About the Preparation of Toxicity Tests

Bottle	$NaAlO_2$ added (ml)	mg Al/l (error$^-$4%)	Bottle	$Al_2(SO_4)_3 \cdot 18H_2O$ added (ml)	mg Al/l (error $^-$ 4%)
1	0.000	Blank	7	0.000	Blank
2	0.166	0.2	8	0.930	0.2
3	0.416	0.5	9	2.320	0.5
4	0.830	1.0	10	3.240	0.7
5	1.660	2.0	11	4.170	0.9
6	2.500	3.0	12	4.630	1.0

(Type of peptone : MERCK Peptone from casein trypsin-digested for microbiology

Type analysis:	peptone concentration (from N)	85 %
	amino	4-5 %
	phosphorus compounts (as P)	2 %
	heavy metals (as Pb)	0.003%
	Mg	0.1 %
	Calcium	0.2 %
	Triptophane (DC)	1-2 %
	Drying loss	5 %
	Sulphate ash	5 %

- tap water : for dilution
- nutrients : Solution - I
  - 61.5 mg $MnSO_4.H_2O$/l
  - 33.75 mg H_2MoO_4/l
  - 8.35 mg 0.05 N NaOH/l
  - 49.36 mg $ZnSO_4$/l
  - 52.60 mg $CoSO_4$/l
  - 81.70 kg $CuSO_4.5H_2O$/l

  Solution - II
  - 25 g KH_2PO_4/l
  - 25 g Na_2SO_4/l

  Solution - III
  - 10 g $MgCl_2.6H_2O$ g/l
  - 10 g $FeCl_2.2H_2O$ g/l
  - 10 g $CaCl_2.2H_2O$ g/l
- biomass : Nitrobacter from sludge which was settled half an hour
- NaOH : to adjust the pH
- $NaAlO_2$ solution : Wajc's solution concentration 300.674 mg Al^3 /l
- $Al2(SO4)_3.18H_2O$ solution: commercial,concentration 54 mg Al^3 /l

Inspiring from the procedure described in Deutsche Einheitsverfahren zur Wasser-Undersuchung (1975), 1300 ml of peptone solution, 3.25 ml of nutrient Solution-I, 6.25 ml of nutrient Solution-II, 1.3 ml of nutrient Solution-III were mixed. Solution was diluted by tap water upto the total volume of 3.217.5 ml. From settled sludge precipitate was added to that medium with a volume of 32.5 ml. pH of the solution was adjusted to again 8.5 ∓ 0.1 by addition of NaOH.

The BOD values for the samples were measured by sapromat technique.

RESULTS AND DISCUSSION

Pilot Plant Experiments

The results of performances of the two coagulants, at different retention times, (see Table 4.) are summarized below:

1. At 3h retention time: although the difference is usually small, the performance of $NaAlO_2$ is better than $Al_2(SO_4)_3.18H_2O$ (only exception for COD removal). Beside better removal efficiency, $NaAlO_2$ sludge seems to have better settleability (i.e. less sludge volume), however, the filterabilities of both $NaAlO_2$ and $Al_2(SO_4)_3.18H_2O$ sludge are almost the same.
2. At 1h retention time: the performance of $Al_2(SO_4)_3.18H_2O$ improves abruptly from 3 to 1h retention time, while the performance of $NaAlO_2$ remains constant for some parameters (like BOD, VSS, P_{TOT}), improves slightly for some other parameters (like COD, N_{TOT}) and deteriorates appreciably for TSS. This may indicate that, the the retention time is an important design parameter for the systems running with $Al_2(SO_4)_3.18H_2O$. For $NaAlO_2$ systems, only inorganic suspended solids removal from the wastewater is affected by the retention time, and the other removal efficiencies are almost independent of both retention time and influent load. When Table 4 is looked over, it can be seen that VSS/TSS ratio of effluent of $NaAlO_2$ system is lower than that of $Al_2(SO_4)_3.18H_2O$ both at 1h and 3h retention times (comparison can be made more easily from the rearranged values (Table 4) where effluent

Table 4. Summary of The Results of Pilot Plant Experiments

	COD INFLUENT (mgO/l)				% COD REMOVAL EFFICIENCY								BOD INFLUENT (mgO/l)				% BOD REMOVAL EFFICIENCY							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
Residence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	148	553	354	126.00	13	82	42	18.15	21	70	39	12	114	294	188	58.72	11	88	32	21.51	12	75	34	16.37
1.5 h																								
1 h	101	575	370	69.80	29	63	51	11.52	33	49	42	5.46	79	336	198	110.70	34	55	45	8.55	18	46	34	7.54
1^p h	311	488	392	63.28	41	52	47	4.21	31	41	36	5.61	122	286	201	50.27	38	65	51	9.78	23	77	41	21.35

p: With pH control ($Al_2(SO_4)_3.18H_2O$: pH= 6.5 $NaAlO_2$: pH= 7.0)

	TSS INFLUENT (mg/l)				% TSS REMOVAL EFFICIENCY								VSS INFLUENT (mg/l)				% VSS REMOVAL EFFICIENCY							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
Residence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	26	251	119	66.39	4	88	50	21.47	20	76	51	14.20	15	187	86.3	50.93	5	90	48	25.86	20	89	58	20.50
1 h	91	242	148	53.11	37	81	60	16.24	18	60	39	15.37	58	203	109	44.59	43	85	70	13.00	29	72	58	12.60
1^ph	97	168	126	23,25	52	66	59	5.43	15	48	29	10.92	84	158	106	18.15	64	77	71	4.50	27	62	42	11.11

	P_{TOT} INFLUENT (mg/l)				% P_{TOT} REMOVAL EFFICIENCY								N_{TOT} INFLUENT (mg/l)				% N_{TOT} REMOVAL EFFICIENT							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
Residence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	7.99	26.33	14.48	5.82	21	85	60	19.18	49	85	64	15.11	39	103	68	16.53	2	56	19	15.11	2	58	21	15.25
1 h	11.10	17.0	13.85	1.72	61	88	78	8.16	49	69	64	5.63	32	109	82.7	21.37	6	49	24	13.32	6	41	24	10.50
1^ph	9.95	18.26	13.5	2.50	60	83	73	7.51	24	76	55	17.49	59.8	100	79	12.00	14	21	17	2.94	4	27	13	10.00

Table 4. Summary of The Results of Pilot Plant Experiments (Cont'd)

	TSS INFLUENT (mg/l)				SLUDGE VOLUME								VSS INFLUENT (mg/l)				CAPILLARY SUCTION TIME (s)							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
Residence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	26	251	119	66.39	25	880	319	254	64	780	286	187	15	187	86	50.93	10	65.4	34.34	15.49	26	41.2	34.93	4.86
1 h	91	242	148	53.11	445	980	747	180.73	300	960	823	213.6	58	203	109	44.59	27.5	66.5	42.73	11.37	21	50	35.19	7.43
1^Ph	97	168	126	23.25	850	995	944	44.82	320	980	658	192	84	138	106	18.15	25	55	37.74	9.29	20.6	45	33.96	8.87

	VSS/TSS RATIO x 100										VSS/TSS RATIO x 100 (REARRANGED VALUES)		
	INFLUENT		EFFLUENT				SLUDGE				INFLUENT	EFFLUENT	
			$Al_2(SO_4)_3.18H_2O$		$NaAlO_2$		$Al_2(SO_4)_3.18H_2O$		$NaAlO_2$			$Al_2(SO_4)_3.18H_2O$	$NaAlO_2$
Residence time	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	Mean	Mean
3 h	73	18	63	9.3	57	15	55	6.5	48	5.3	80	69	62
1 h	80	6.8	59	8.7	55	6	56	5.9	47	4.4	80	59	55
1^Ph	85	3	61	2.7	64	3	57	6.4	57	4	80	57	60

results are converted to $(VSS/TSS)_{inf}$ 80 % basis indicating that the organic suspended solids removal is achieved more efficienctly by $NaAlO_2$ than by $Al_2(SO_4)_3.18H_2O$ at these retention time.

Lower standard deviations from the mean for both coagulants at 1h retention time may be the evidence of better controllability of the flocculation system from removal efficiencies point of view at 1h retention time (this fact beign contrary for the $NaAlO_2$ sludge properties) than at 3h.

Since the TSS removal with $NaAlO_2$ is less than the removal with $Al_2(SO_4)_3.18H_2O$, CST values for $NaAlO_2$ is less than that of $Al_2(SO_4)_3.18H_2O$ while the volume of $NaAlO_2$ sludge being greater than of $Al_2(SO_4)_3.18H_2O$ sludge. Because of that $NaAlO_2$ may be regarded as disadvantageous for sludge settling.

3. At 1h residence time with pH control: for both coagulants removal efficiencies (except for BOD) drop to smaller percentages. But they are not still as bad as at 3h retention time for $Al_2(SO_4)_3.18H_2O$, on the other hand, they are worse than in the first case for $NaAlO_2$.

Effluent VSS/TSS ratio decreases from case 1) to 3) for $Al_2(SO_4)_3.18H_2O$ indicating relatively better removal of organic suspended solids rather than inorganic suspended solids. The increase in this ratio for $NaAlO_2$ may be interpreted as its diminishing VSS removal capacity at relatively acidic conditions.

Standard deviations of efficiency values decrease appreciably for $Al_2(SO_4)_3.18H_2O$, but they increase or remain relatively the same for $NaAlO_2$ system.

Sludge settleability of $Al_2(SO_4)_3.18H_2O$ deteriorates at pH 8.5. Volume of $NaAlO_2$ sludge and CST values for both coagulants decrease due to inefficient removals.

iological Treatability of Al(III) Treatment Effluents

Toxicity tests have been performed in two ways:

1. With bacteria present in crude Heverlee sewage, and
2. With synthetic wastewater with a biomass of

nitrobacter a sensitive and convenient microorganism to use in toxicity tests[2].

The main purpose of the tests is to determine the toxic effect of $Al_2(SO_4)_3.18H_2O$ and $NaAlO_2$ on microorganisms and the biological treatability of the effluent of the flocculators which still may contain some amount of soluble and precipitated Al.

pH of both sewage and synthetic wastewater were reduced to 8.5 ∓ 0.1 in order to keep Al in solution; the actual value was taken from the solubility curves[3]. Even if it is presumed to have Al totally in solution at the beginning, some precipitation may be expected because of time effect and presence of calcium and other salts. Almost in all aspects, the tests are representative for the real situation since they measure the inhibition effect of Al on microorganisms in partly soluble and partly precipitated form.

pH of the solution at the end of 5 days was measured again and found out to be risen between 9.18 ∓ 0.02 and 9.27 ∓ 0.02 (average = 9.23 ∓ 0.02) for $NaAlO_2$ (blank, i.e without Al, pH = 9.23 ∓ 0.02) and between 9.24 ∓ 0.02 and 9.35 ∓ 0.02 (average = 9.30 ∓ 0.02) for $Al_2(SO_4)_3.18H_2O$ (blank pH = 9.32 ∓ 0.02).

As it can be seen from the tables, the differences in BOD_5 values may not be attributable to any inhibitive effect of both coagulants. High value of BOD_5 for synthetic wastewater with 0.2 mg Al^3 /l ($Al_2(SO_4)_3.18H_2O$) may be regarded as an error, since it seems to be illogical to talk about reversed toxic effect, stimulating even, at one of lower dosages only. The appreciable

Table 5. Toxicity Test Results for 1h - Settled Sewage

Bottles with $NaAlO_2$	BOD_5 (mg O/l)	Bottles with $Al_2(SO_4)_3.18H_2O$	BOD_5 (mg O/l)
Blank	300	Blank	226
0.2 mg Al/l	300	0.2 mg Al/l	342
0.5 mg Al/l	306	0.5 mg Al/l	-
1.0 mg Al/l	308	0.7 mg Al/l	292
2.0 mg Al/l	312	0.9 mg Al/l	287
3.0 mg Al/l	300	1.0 mg Al/l	292

Table 6. Toxicity Test Results for Synthetic Wastewater

Bottles with $NaAlO_2$	BOD_5 (mg O/l)	Bottles with $Al_2(SO_4)_3.18H_2O$	BOD_5 (mg O/l
Blank	405	Blank	430
0.2 mg Al/l	340	0.2 mg Al/l	540
0.5 mg Al/l	384	0.5 mg Al/l	420
1.0 mg Al/l	405	0.7 mg Al/l	420
2.0 mg Al/l	430	0.9 mg Al/l	420
3.0 mg Al/l	360	1.0 mg Al/l	407

difference between the blant BOD_5 values confirms this error, as an evidence of low reproducibility of BOD_5 values (Sapromat reproducibility = ∓ 5 %).

Usually BOD_1 (BOD after 1 day) reflects the toxic effect of substances better than BOD_5[4] since the lag period for microorganisms to the external disturbance of their environment by the addition of toxic substances takes place within the first 24 hours. After that period they get adapted, and the differences in BOD_3 or in BOD_5 with respect to increase in dosage become relatively small.

In the present tests with $NaAlO_2$ and $Al_2(SO_4)_3.18H_2O$, BOD curves drawn by the sapromat recorder were also examined for an initial inhibition, but it was observed that BOD curves for all the best solutions tended to be exactly the same as the one of blank. Some small deviations were noticed due to some probable error in the preparation of the solution and in the addition of the coagulants.

Similar behaviour may be expected in practical full-scale application. The pH of effluent from the physico-chemical plant is usually 7.0 ∓ 0.1 when $Al_2(SO_4)_3.18H_2O$ is used as coagulant (at 20 mg Al/l) and 8.5 ∓ 0.1 when $NaAlO_2$ is used as coagulant so, the predicted precipitation degree is higher than in the toxicity tests, ending up with less Al^{3+} concentration in solution. By consequence, toxic inhibition effect of Al may be expected to be even less in real application.

CONCULUSIONS

The major conclusions of this study may be summarized as follows:

1. $NaAlO_2$ is less efficient in coagulating wastewater than alum. This is probably due to the higher solubility of Alum.
2. Retention time in a continuous flocculation system is an important design parameter, influencing the choice of the coagulant for coagulantion efficiency and sludge treatment.
3. For both coagulants no toxic effect on microorganisms detected, indicating the efficient biodegradability of the flocculation effluent, and applicability of the biological treatment at further steps.

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Independent Variables		Dependent Variables
Forced	Natural	
Al - dose	Influent pH	Effluent pH
Kinetic aspects	Influent Temperature	Effluent Temperature
(G, impeller, etc.)		
and Hydraulics	Influent Turbidity	Effluent Turbidity
pH	Influent COD	Effluent COD
Retention time	Influent BOD	Effluent BOD
(flow rate)		
Temperature	Influent Total P content	Effluent Total P
	Influent Total N content	Effluent Total N
	Total Suspended Solids	Effluent TSS
	Volatile Suspended Solids	Effluent VSS
	Alkalinity of influent	Conductivity of effluent
	Total hardness of influent	% Transmission of UV light
	Conductivitl of influent	Sludge Volume
	% Transmission of UV light	CST
		TSS in sludge
		VSS in sludge

Bottle	$NaAlO_2$ added (ml)	mg Al/l (error ± 4%)	Bottle	$Al_2(SO_4)_3 \cdot 18H_2O$ added (ml)	mg Al/l (error ± 4%)
1	0.000	Blank	7	0.000	Blank
2	0.166	0.2	8	0.930	0.2
3	0.416	0.5	9	2.320	0.5
4	0.830	1.0	10	3.240	0.7
5	1.660	2.0	11	4.170	0.9
6	2.500	3.0	12	4.630	1.0

Bottles with $NaAlO_2$	BOD_5 (mg 0/l)	Bottles with $Al_2(SO_4)_3 \cdot 18H_2O$	BOD_5 (mg 0/l)
Blank	300	Blank	226
0.2 mg Al/l	300	0.2 mg Al/l	342
0.5 mg Al/l	306	0.5 mg Al/l	-
1.0 mg Al/l	308	0.7 mg Al/l	292
2.0 mg Al/l	312	0.9 mg Al/l	287
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Bottles with $NaAlO_2$	BOD_5 (mg 0/l)	Bottles with $Al_2(SO_4)_3 \cdot 18H_2O$	BOD_5 (mg 0/l
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1.0 mg Al/l	405	0.7 mg Al/l	420
2.0 mg Al/l	430	0.9 mg Al/l	420
3.0 mg Al/l	360	1.0 mg Al/l	407

	COD INFLUENT (mgO/l)				% COD REMOVAL EFFIENCY								BOD INFLUENT (mgO/l)				% BOD REMOVAL EFFIENCY							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
sidence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	148	553	354	126.00	13	82	42	18.13	21	70	39	12	114	294	188	58.72	11	88	32	21.51	12	75	34	16.37
1.5 h																								
1 h	181	575	370	69.80	29	63	51	11.52	33	49	42	5.46	79	336	198	110.70	34	55	45	8.55	18	46	34	7.54
1^p h	311	488	392	63.28	41	52	47	4.21	31	41	36	3.61	122	286	201	50.27	38	65	51	8.78	23	77	41	21.35

p: With pH control ($Al_2(SO_4)_3.18H_2O$: pH= 8.5 $NaAlO_2$: pH= 7.0)

	TSS INFLUENT (mg/l)				% TSS REMOVAL EFFIENCY								VSS INFLUENT (mg/l)				% VSS REMOVAL EFFIENCY							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
esidence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	26	251	119	66.39	4	88	50	21.47	20	76	51	14.20	15	187	86.3	50.93	5	90	48	25.86	20	89	58	20.50
1 h	91	242	148	53.11	37	81	60	16.24	10	60	39	15.37	58	203	189	44.59	43	83	70	13.00	29	72	58	12.60
1^ph	97	168	126	23,25	52	66	59	5.43	15	48	29	10.92	84	138	106	18.15	64	77	71	4.50	27	62	42	11.11

	P_{TOT} INFLUENT (mg/l)				% P_{TOT} REMOVAL EFFICIENT								N_{TOT} INFLUENT (mg/l)				% N_{TOT} REMOVAL EFFICIENT							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
sidence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	7.99	26.33	14.48	5.82	21	85	60	19.18	49	85	64	15.11	39	103	68	16.53	2	56	19	15.11	2	58	21	15.25
1 h	11.10	17.0	13.85	1.72	61	88	78	8.16	49	69	64	5.63	32	109	82.7	21.37	6	49	24	13.32	8	41	24	10.50
1^ph	9.95	18.26	13.5	2.50	60	83	73	7.51	24	76	55	17.49	59.8	100	79	12.00	14	21	17	2.94	4	27	13	10.00

	TSS INFLUENT (mg/l)				SLUDGE VOLUME								VSS INFLUENT (mg/l)				CAPILLARY SUCTION TIME (s)							
					$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$								$Al_2(SO_4)_3.18H_2O$				$NaAlO_2$			
Residence time	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ	Min	Max	Mean	σ
3 h	26	251	119	66.39	25	880	319	254	64	780	286	187	15	187	86	50.93	10	65.4	34.34	15.49	26	41.2	34.93	4.
1 h	91	242	148	53.11	445	980	747	180.73	300	960	823	213.6	58	203	189	44.59	27.5	66.5	42.73	11.37	21	50	35.19	7.
1^P h	97	168	126	23.25	850	995	944	44.82	320	980	658	192	84	138	106	18.15	25	55	37.74	9.29	20.6	45	33.96	8.

	VSS/TSS RATIO x 100										VSS/TSS RATIO x 100 (REARRANGED VALUES)		
	INFLUENT		EFFLUENT				SLUDGE				INFLUENT	EFFLUENT	
			$Al_2(SO_4)_3.18H_2O$		$NaAlO_2$		$Al_2(SO_4)_3.18H_2O$		$NaAlO_2$			$Al_2(SO_4)_3.18H_2O$	$NaAlO_2$
Residence time	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	Mean	Mean
3 h	73	18	63	9.3	57	15	55	6.5	48	5.3	80	69	62
1 h	80	6.8	59	8.7	55	8	56	5.9	47	4.4	80	59	55
1^P h	85	3	61	2.7	64	3	57	6.4	57	4	80	57	60

DZGEN

FILTRATION OF TANNERY SLUDGES FOLLOWING A CHEMICAL-BIOLOGICAL TREATMENT.

Dott. Eng. Giacinto Petrillo

Polcon Italiana Srl

45, Viale Scarampo - 20148 Milan (Italy)

INTRODUCTION

The waste waters treatment plant outlined hereunder deals with waters coming from soaking stages, lime baths, deliming by formic acid and sodium chloride, maceration, chromium tanning, stuffing and dyeing.

The tannery processes 3,000 skins a day, both ovine and caprine. Factory domestic waters join the wastes flow coming from production lines: the staff total 100 people.

The treatment process adopted consists of:

a) mixing and averaging of alkaline and acid wastes;

b) neutralization;

c) automatic removal of solids retained by the grid;

d) primary sedimentation;

e) extended aeration, taking place in a compact basin and consisting of:

  1) biological oxidation;
  2) sludges periodic recycle;
  3) sedimentation;

f) post-aeration lagoon.

To have the process treatment started, the extended aeration biological stage utilizes domestic waters input. In case of absence of the limiting factors N and P, $(NH_4)_2H(PO_4)$ is added.

Liquid wastes mixing and oxidation are obtained by means of submerged static aerators **"Helixors"**.

The **Helixor** is a polypropilene cylinder incorporating a monolithic helix of design pitch which divides the tube longitudinally into two separate sections. **Helixors** are vertically aligned and anchored on basins' bottoms. Compressed air is blown in in each **Helixor** through orifices drilled on air feeding pipes.

Sludges settled in the primary sedimentation basin, mostly due to $Cr(OH)_3$, as well as sludges coming from sedimentation after extended aeration stage, are conditioned with $FeCl_3$ and $Ca(OH)_2$.

Sludges are then directed to an automatic filter producing cakes at 40 ÷ 50 % dry substance.

This treatment plant is fully automated and output waters, which are today conveyed to nearby fields, could be sent back to production lines following proper treatment.

DESCRIPTION

"Conce a Maffei", the company the plant henceforth described was realized for, is located at Montoro Superiore (Avellino), an area in Southern Italy where the tannery industry is most active.

Plant engineering data are given under table 1) and effluent waters characteristics are indicated under table 2).

The plant consists of two stages:

1) Biological Wastes Treatment

and

2) Sludges Dewatering.

1) BIOLOGICAL WASTES TREATMENT

A) Mixing and Averaging of Alkaline and Acid Wastes

Liquid wastes are conveyed to the aeration basin where eight submerged aerators **Helixors**, fed with compressed air, create turbulence in the wastes so that alkaline and acid discharges are averaged. In this very basin, liquid wastes pre-oxidation takes place as well. However, **Helixors'** main purpose is to aerate discharges and keep in suspension solids present in the refuse liquids. Being underground, the basin is gravity fed.

Civil works are concrete made and inside walls are protected with antacid varnish -

B) Neutralization

Waters flow in the neutralization basin where mixing is obtained with the installation of one **Helixor**.

Checking and regulation of pH concentration is assured by a pH-meter equipped with a chemically cleaned probe.

Caustic soda and sulphuric acid are the reagents used for the neutralization process.

C) Automatic Removal of Solids Retained by the Grid

Solids removal is fulfilled by an automatic grid which prevents fibers and thick particles from obstructing the lifting pumps.

The pumps, housed in a well close to the channel where the grid is located, consist of two submerged groups controlled by minimum and maximum level devices.

D) Primary Sedimentation

Waters are conveyed to primary sedimentation basin where settling solids precipitate: in particular, chromium hydroxide deposit.

In this gravity-type sedimentation basin,any sludge deposit is continually purged and grease skimming is ensured by pneumatic skimmers.

E) Extended Aeration

Waters clarified during the sedimentation stage flow, by gravity, into the extended aeration basin.

This compact basin is divided into the following adjacent and communicating sectors:

1) Biological oxygenation.

2) Sludges recycle.

3) Sedimentation.

The Extended Aeration stage is the most important phase in the whole biological treatment process.

1) Biological Oxygenation.

Due to the turbulence originated by the twenty-six **Helixors** installed, microorganisms develop and grow in the aeration sector. Their growth is the direct consequence of the mixing which makes organic substances and microorganisms enter into intimate contact.

Adsorption (assimilation), first phase of the biological treatment process, takes place in the biological oxygenation sector: organic substances are oxygenated, substrates develop and microorganisms' cells are formed.

Nutrients present in domestic waters flowing in from the works are vital for control of limiting factors N and P. Nevertheless, addition of $(NH_4)_2H(PO_4)$ is foreseen.

2) Sludges Recycle

and

3) Sedimentation.

The best degree of sludges concentration during the aeration stage is assured by four **Helixors** whose motion compels sludges,deposited in the final sedimentation basin,to move into the aeration basin.

Overflow sludges, together with sludges coming from primary sedimentation, are conveyed to conditioning and dewatering treatments.

F) Post-Aeration Lagoon

Waters overflow by gravity from the extended aeration basin into the aeration lagoon which is divided into two sectors: a) the first, where fourteen Helixors provide a further supply of oxygen (post-aeration) and b) the second, where no mixing is created (stabilization).

Endogenous respiration, an important phase of the biological process, occurs in the aeration lagoon and air consumption is for this stage lower than for adsorption because of the smaller quantity of substrates.

Output waters flow today by gravity from the lagoon to nearby fields. However, should future needs require it, these waters could be utilized for the factory supply after proper treatment.

2) SLUDGES DEWATERING

Sludges purged from primary sedimentation and extended aeration basins are conveyed to a conditioning basin where, by means of one Helixor there installed, they are mixed with lime and iron chloride whose quantities are controlled by pumps and pneumatic valves respectively.

Sludges are then sent to a fully automated pressure filter consisting of sixteen stainless steel panels coated with acrylic bags. Table 3 refers to data concerning sludges conditioning.

Filtered waters are conveyed to extended aeration basin whilst sludges are withheld by the bags.

When filtering cycle is interrupted to allow discharge of the sludges, filter-top opens automatically and filtering panels move on guides towards the outside.

Sludges detach from the bags by shaking through compressed air delivered by a vibrator; sludges are collected in a suitable container and cakes produced contain 40 ÷ 50 % of dry substance.

Upon completion of the discharge phase, the filter automatically starts to operate again.

The filter installed was engineered on the basis of data gathered after testing the sludges with laboratory filter kits. Several chemicals such as $FeSO_4$, $CaCl_2$, $FeCl_3$, $Ca(OH)_2$ were applied in testing and different doses used.

For this selfsame utilization, the best filter's performance was obtained following the addition of $FeCl_3$ and $Ca(OH)_2$ at a concentration of 10 % and 5 % respectively.

Dosages used for the reagents' solutions are:

8 gr/l for $Ca(OH)_2$;

6.4 gr/l for $FeCl_3$.

TABLE 1

Engineering Data

Skins processed daily = 3,000

Daily flow = 300 cubic meters

Working hours per day = 8

Discharges from : Soaking stages
Lime baths
Deliming by formic acid and sodium chloride
Maceration
Chromium tanning
Stuffing
Dyeing

Chemicals used Kgs/day

Na_2S = 4.5

NH_3 = 4.5

Na_2S = 180

Lactic acid = 30

Na_2S = 30

$Ca(OH)_2$ = 100

Na_2S = 70

Solvents for degreasing
and oils = 60

NaCl = 200

H_2SO_4 = [illegible]

NaCl = 13[illegible]

HCl = 3.4

Cr_2O_3 = [illegible]

$NaHSO_3$ = 14

Alum = 34

Na_2CO_3 = 20

$NaHCO_3$ = 36

NH_3 = 6

Sulphonate greasing oils = 40

HCl and formic acid = 30

Phenolic tanning = 60

Total BOD_5 loading = 300 Kgs/day

Oxygen requirement = 450 Kgs/day

ETRILLO

TABLE 2

Output Waters Characteristics

BOD_5 = 30 + 40 mgr/l

Suspended solids = 30 + 40 mgr/l

Dissolved oxygen = 2 mgr/l

TABLE 3

Sludges Conditioning

Flow of sludges = 25 cubic meters/day

Filtering surface = 37.26 square meters

Solids' content in sludges = 2 %

Sludges' dried substances = 500 Kgs/day

Lime consumption = 20 % max on sludges' dried substances

Lime consumption at a 5% solution = 2 cubic meters/day

$FeCl_3$ consumption at a 10% solution = 160 Kgs/day

TABLE 3

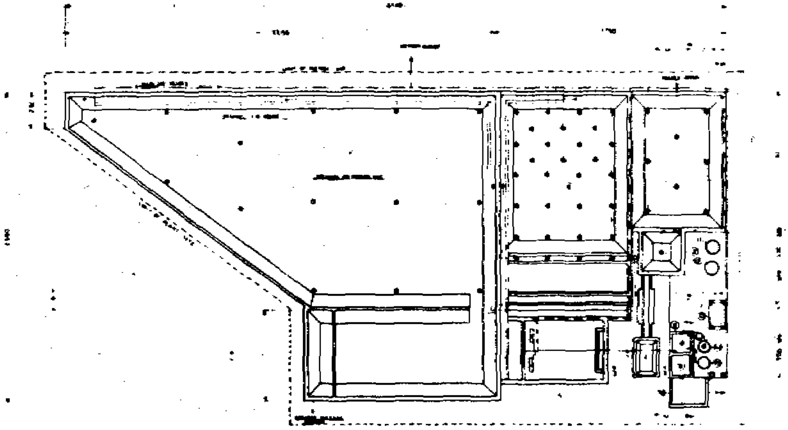
Power Consumption

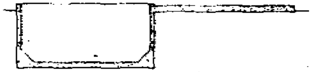
Blower	= HP 65	[illegible] Kw
Lifting pump	= HP 4	2 Kw
Automated grid	= HP 0.25	= 0.19 Kw
	Total	[illegible]

Other Consumtpions (Compressed Air)

Vibrator, sludges' feeding pumps, lime pumps and filter operation 65 cubic meters/day max value at 3 atm

Air supply to meet the above requirements is covered by the factory's pneumatic network.





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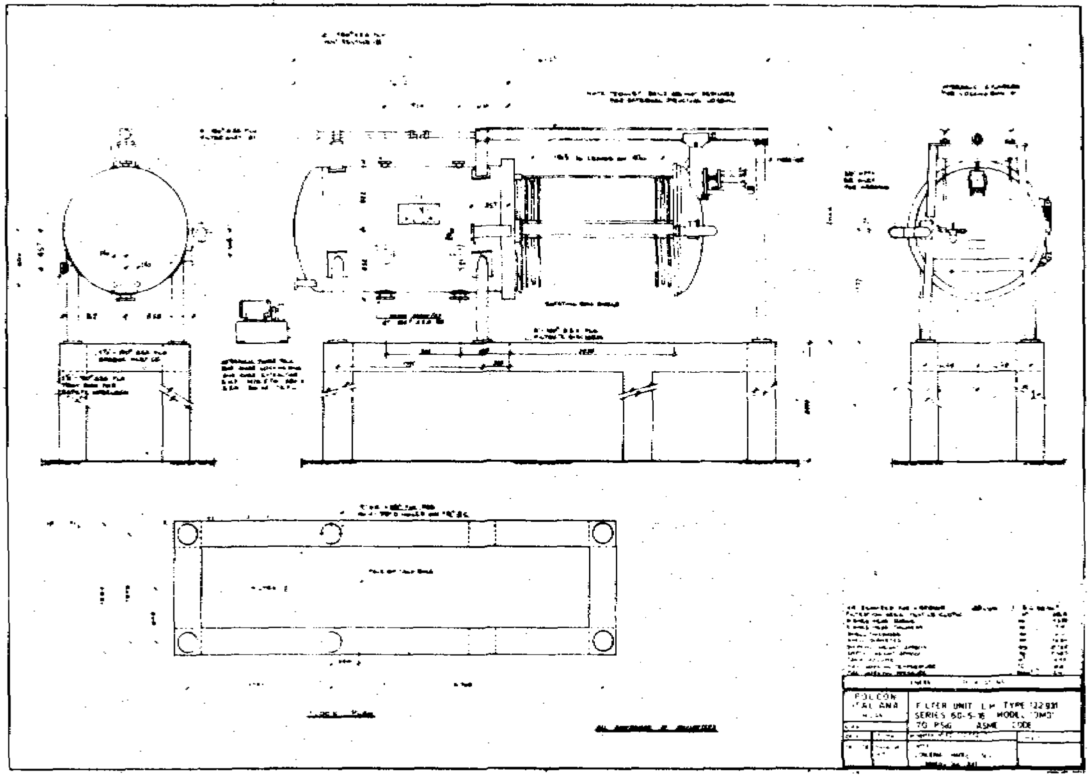
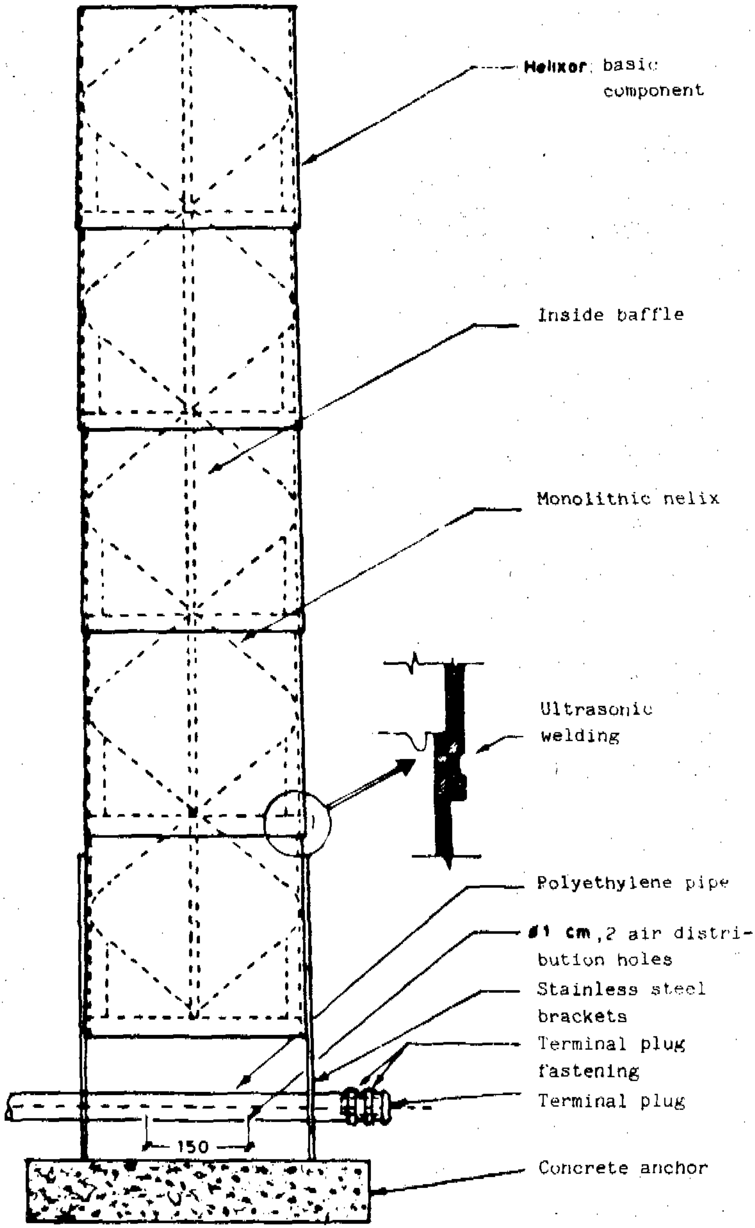


FOLCON
ITALIANA
[illegible]

FILTER UNIT L.H. TYPE 122.931
SERIES 60-5-16 MODEL "DMG"
70 PSIG ASME CODE


Helixor basic component
Inside baffle
Monolithic helix
Ultrasonic welding
Polyethylene pipe
ø1 cm,2 air distribution holes
Stainless steel brackets
Terminal plug fastening
Terminal plug
Concrete anchor
150

WASTE WATER TREATMENT PLANTS
FOR
SLAUGHTERHOUSES AND SAUSAGES PRODUCTION FACILITIES

Dott. Eng. Giacinto Petrillo

Polcon Italiana Srl

45, Viale Scarampo - 20148 Milan (Italy)

INTRODUCTION

The project for the "Swine and Bovine Meat Center of Cologna Veneta (Verona, Italy)" was developed bearing in mind its peculiar destination: the service to a slaughtering and sausages production center.

The essential goals to aim at in engineering a plant are:

a) high efficiency in pollution control;
b) high reliability;
c) easiness of operation.

In view of the above, a pollution control system ensuring high performance rates was chosen and very easy to use equipments were installed. A periodical plant control scheduled by a routine maintenance programme assures the greatest reliability.

Due to low operating expenses and small quantities of sludges produced, this process is widely used in Canada, the United States and is nowadays frequently applied in Italy too. The process is based on a special equipment, **Helixor**, capable of transferring the required oxygen in such a quantity as to obtain the best process speeds. It originates at the same time an optimum refuse liquids mixing so that contact among microorganisms' and organic substances' cells is most efficient. Furthermore, the absence of moving mechanical parts inside the **Helixor** and the high speeds through orifices assure operation without any inconveniences.

A peculiarity of the "activated, dispersed and mixed sludges" process adopted consists in that the sludge burden is eliminated. The production of overflow sludges is in fact reduced through total oxygenation to not more than 5 cubic meters on wet sludges every 2 + 3 months. The small quantities of sludges accumulating in the post-aeration basin, downstream the oxygenation stage, requires periodical removal and this operation is to be considered as an occasional and infrequent requirement.

The Cologna Veneta plant has been continually running since December 1975 when it was tested and started and no trouble whatever occurred during these past years.

PROJECT ANALYSIS AND PROCESS DESCRIPTION

The project was elaborated considering both the potential slaughtering of 400 cattle and 500 swine every week and the production of the connected sausages factory.

Pollution control cycles foresee:

a) floatation;
b) degreasing;
c) oxygenation;
d) final chlorination.

The plant proposed is based on a thoroughly oxygenating cycle. Because of this process, organic substances are decomposed by bacteria forming the activated sludges and the little quantities of developing overflow sludges is composed of mineral substances, non-degradable organic substances (cellulose, fibers) and inert residua of microorganisms (cell membranes).

Following the elimination of suspended solids by means of a manually operated grid, sewages flow into the floatation basin wherefrom they reach the oxygenation tank after degreasing. During the oxygenating treatment, refuse liquids are submitted to considerable aeration implying the abatement of organic substances.

After skimming and post-aeration stages, sewages overflow in the chlorination tank where waters are added with chlorine and conveyed to discharge.

PROJECT DATA

In order to suitably size the plant, reference was made to Customer's specifications and to literature published by A.N.D.I.S. - National Sanitary Engineering Association -. Further information were drawn from tests run on our pilot plants.

Data to work on were:

- daily water consumption is of 900 liters per each bovine and 600 liters per each swine;
- daily water consumption during stable-breeding equals 500 liters per each bovine and 200 liters per each swine;
- pollution caused by a bovine is equivalent to that originated by 28 people whereas a swine pollutes as much as 11 persons do;
- with regard to rainwaters affluent to the plant, maximum and minimum precipitations' values were considered corresponding to 15 mm and 6 mm of rain respectively.

Water consumption

Cattle Slaughtering
- Head slaughtered weekly = no. 400
- Daily water consumption per animal = liters 900
- Workdays per week = no. 5
- Total daily water consumption = 72 cubic meters

Cattle Stable
- Head on breeding per week = no. 100
- Daily water consumption per animal = liters 500
- Breeding days per week = no. 5
- Total daily water consumption = 10 cubic meters

Refrigerators' waters for cattle butchering
- Daily water consumption = 150 cubic meters

Cattle blood
- Blood affluent to the plant = 200 liters/day

Swine slaughtering and sausages production
- Head butchered every week = no. 500
- Daily water consumption per animal = 600 liters
- Workdays per week = no. 5
- Total daily water consumption = 60 cubic meters

Swine stable
- Head on breeding per week = no. 150
- Daily water consumption per animal = 200 liters
- Breeding days per week = no. 5
- Total daily water consumption = 6 cubic meters

Refrigerators' waters for swine butchering
- Daily water consumption = 240 cubic meters

Swine blood
- Blood affluent to the plant = 120 liters/day

<u>Total Waters Affluent to the Plant in Cubic Meters per Day</u>

- Process waters affluent to oxygenation tank = 148
- Cooling waters affluent downstream the post-aeration basin = 390
- Rainwaters entering the oxidation tank (surface 16,600 sq.meters) = 44

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Biological Oxygen Demand Loading (BOD_5)

Cattle butchering
- Head slaughtered per day = no. 80
- BOD_5 = Kg/day 135

Swine slaughtering
- Head butchered every day = no.
- BOD_5 = " 66

Cattle blood - 200 l/day x 100,000 mgr/l	=	Kg/day	20
Swine blood - 120 l/day x 100,000 mgr/l	=	"	12
Cattle stable - 10 cu.m/day x 1,000 mgr/l	=	"	10
Swine stable - 6 cu.m/day x 3,800 mgr/l	=	"	23
Rainwaters - 44 cu.m/day x 180 mgr/l	=	"	8
Total BOD$_5$ loading		Kg/day	274

PLANT ENGINEERING AND DESCRIPTION OF ITS DIFFERENT PROCESS PHASES

(See drawing enclosed)

Oxygenation and Post-Aeration Tanks

The flow volume affluent daily to the plant is 148 cubic meters; cooling waters, equal to 390 cu. meters every day, are conveyed downstream the plant in a pit where they mix with treated waters.

Volumes involved are:

- Oxygenation tank 148 cu.meters/day x 15 days	=	2,220 cu.meters
- Rainwaters increment	=	44 " "
- Post-aeration basin 148 cu.meters/day x 5 days	=	740 " "
Total volumes		3,004 cu.meters

Water depth considered is m 1.70 and the covered surface is therefore:

cubic meters 3,004/1.70 = 1,800 sq. meters.

With regard to oxidation tank's volume load, the following is obtained:

$274/2,264 = 0.12$ Kg BOD_5 per cubic meter.

To the oxygen theoretical requirement of 274 Kgs/day corresponds an actual necessity of $274 \times 1.5 = 411$ Kgs of O_2 per day.

To obtain the process' best performance, the installation of the following **Helixors**, each m 1.00 in length, is consequently required:

- no. 33 for the oxygenation tank;
- no. 4 for floatation stage;
- no. 3 for the post-aeration basin.

Water Raising

Waters flowing from both the bovine and the swine slaughterhouses, as well as outlet waters from sausages works, are conveyed to the plant through tarred metal pipes.

Waters are raised by means of 2 pumps - 2 others being installed and kept in reserve - each having a flow capacity of 20 cubic meters/hour.

The maximum flow to be lifted is roughly 40 cubic meters/hour; the submersible pumps foreseen have a special impeller, suitable to stand sewages' corrosion, and are equipped with a level control for their automatic start according to the incoming flow's volume.

Oxygenation phase

Refuse liquids are channelled through steel pipes from the water raising station to the oxygenation tank where **Helixors** are set up; they enrich the water with air at a given quantity such as to keep bacteria alive.

The oxygenation basin's bottom communicates on one side with the floatation and degreasing tank and, on the opposite side, with the skimming and post-aeration stage. Floating greases are directed to an offlet channel.

Post-Aeration Stage

After the oxygenation phase and following skimming by means of a metal siphon, sewages enter the post-aeration tank flowing on the basin's bottom.

Chlorination Stage

Two subsequent steps are foreseen for the chlorination stage:
a) reaction tank;
b) chlorine dosing station.

The reaction tank's useful volume is above 25 cu.meters; this allows for the most favourable contact time between the liquid and the free, activated chlorine.

The chlorine dosing station is formed of:

- one tank having a 200 liters capacity (equivalent to 25 days' autonomy as hypochlorite as 25 % concentration);
- one dosing pump;
- the necessary PVC connecting pipings with related special tools.

The quantity of activated chlorine required to disinfect waters biologically treated is equivalent to about 10 mgr/1 of NaCl, with a residual chlorine value correponding to 0.6 - 0.8 mgr/1.

Civil Works

Civil works entailed the digging and levelling of earth as well as the construction of a concrete slant walls lagoon; loose earth from excavation was used in order to lower realization's costs.

ANALYTICAL DATA

Table 1 and 2 given hereafter respectively show the results of analyses carried out on samples drawn upstream and downstream the plant.

POWER CONSUMPTION

Power consumption relates to blowers and raising pumps operating to lift refuse liquids from discharge collecting pits to the treatment plant.

Blowers are in service 24 hours a day whereas raising pumps are operated only while butchering and cleaning are being accomplished.

Powers consumption costs are the only operating expenses to be supported.

TABLE 1

- pH	= 7.5	= 7.5
- BOD_5	= 500 mg/l	= 320 mg/l
- COD	= 1,200 mg/l	= 1,250 mg/l
- Settling solids	= 6 ml/l	= - -
- Substances drawable with oil ether	= - -	= 137.8 mg/l
- Suspended solids	= - -	= 642 mg/l

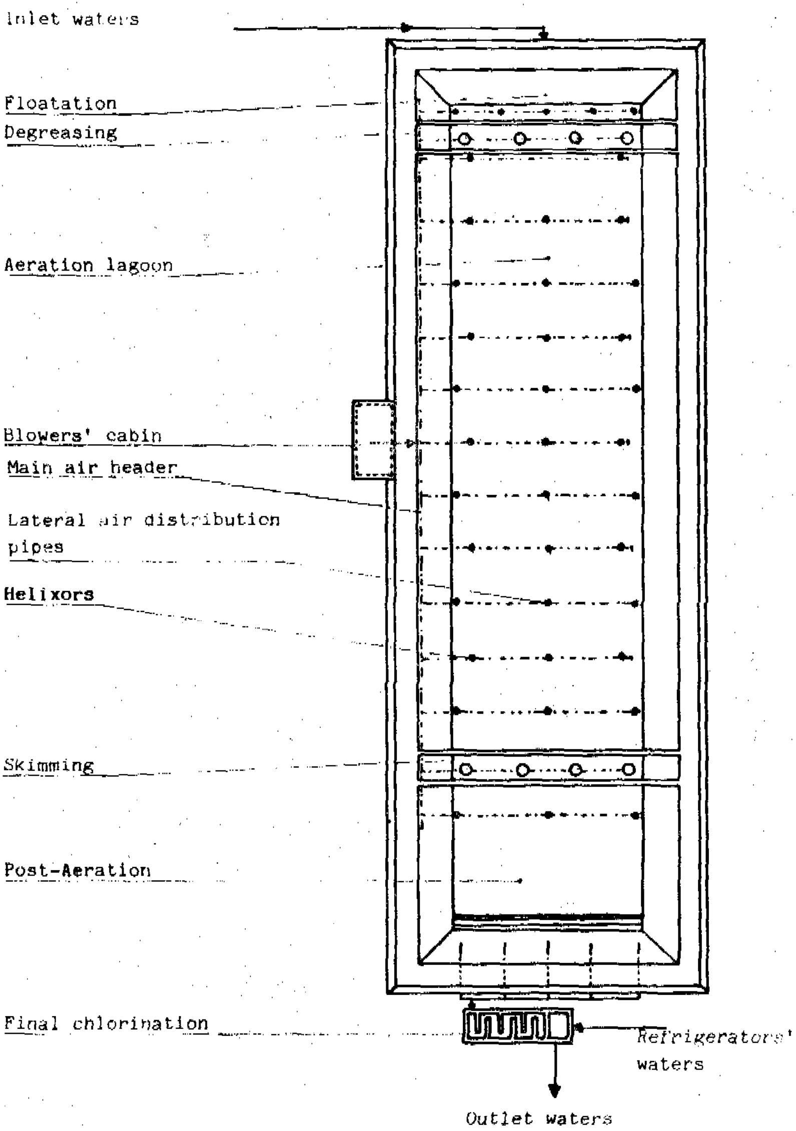
TABLE 2

- pH	= 7.9	= 7.9	= 7.9
- BOD_5	= 40 mg/l	= 20 mg/l	= 20 mg/l
- COD	= 100 mg/l	= 36 mg/l	= 90 mg/l
- Settling solids	= 1 ml/l	= - -	= - -
- Free chlorine	= 0.4 mg/l	= - -	= - -
- Substances drawable with oil ether	= - -	= 4.2 mg/l	= 9.4 mg/l
- Suspended solids	= - -	= - -	= 34 mg/l

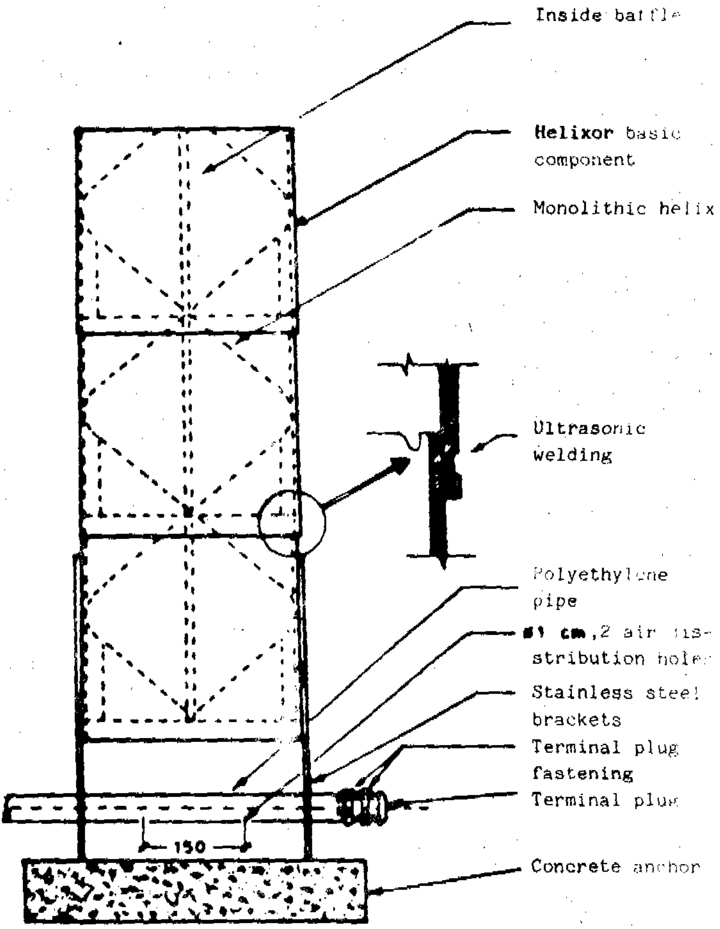
TABLE 3

Power Consumption

No. 2 blowers	Installed HP	= 40
No. 2 raising pumps	" "	= 12
Total	Installed HP	= 52 = 38.2 KW



WASTE WATERS TREATMENT PLANT FOR SLAUGHTERHOUSES AND SAUSAGES PRODUCTION FACILITIES - Covered area m 101 x m 31


Inside baffle
Helixor basic component
Monolithic helix
Ultrasonic welding
Polyethylene pipe
Ø1 cm,2 air disstribution holes
Stainless steel brackets
Terminal plug fastening
Terminal plug
150
Concrete anchor

SOLID WASTE MANAGEMENT IN THE [illegible]

PART I: SURVEY AND CHARACTERIZATION

A. [illegible] F[illegible], M. [illegible], [illegible], N. [illegible]

Kuwait Institute for Scientific Research
Biotechnology Department
P.O. Box 24[illegible]5, [illegible]at
Kuwait

INTRODUCTION

The treatment and disposal of [illegible] solid wastes are becoming increasingly important [illegible] proper management [illegible] environmental control. The objectives of solid waste management [illegible] encourage resource recovery and to protect human health and the environment.

ESIA, in common with most rapidly industrialized municipal areas throughout the world, faces a growing problem with solid waste management. The Kuwait Institute for Scientific Research (KISR), acting on the request of the Shuaiba Area Authority (SAA), began to study the reuse, treatment, and disposal of solid waste in the ESIA. The study began in 1983, and will last for two years. The program has five main tasks: 1. Survey and characterization of solid wastes; 2. Establishment of appropriate regulations and evaluation of technical solutions for effective solid waste control and management; 3. An economic analysis of technical solutions, including cost-benefit analysis and financial implications; 4. Engineering design of treatment and disposal facilities and development of the organization and management structure; 5. Integration of solid waste proposals with those for wastewater treatment programs. The present paper deals with the survey and characterization of industrial solid wastes (SW), semisolid wastes (SSW), and general solid wastes (GSW) which are present in the area.

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*EPC-SAA

MATERIALS AND METHODS

The data were collected through a questionnaire and visits to the industries. The data were classified according to each specific industry and grouped according to type of wastes.

RESULTS AND DISCUSSION

The total area of ESIA is about 23.66 million square meters. The ESIA now accomodates 30 industrial plants belonging to 26 companies. Because these plants contribute to industries considered vital to the growth of Kuwait, they are included in the state's master plan. Most of the products of these industries are either exported (oil refinery products, fertilizer, melamine), used for building and construction (cement, lime products, insulating material, asbestos pipes, sanitary ware, fabricated steel, concrete, pre-engineered stell building), or supply food (fish and shrimp) or local products for development (paper, paper bags, and different industrial gases). There are also two huge power stations, which provide Kuwait with electricity and distilled water.

These industries use various amounts of raw materials to produce different products and generate various solid and semisolid wastes. These wastes may be generated from the raw materials, the products, or the processing. Besides, large number of manpower working in these industries generate different types of the same. The major industrial solid wastes and semisolid wastes are shown in Table 1 and 2.

Industrial Solid and Semisolid Wastes (SW and SSW)

There are numerous sources and types of refinery solid wastes and each refinery may have problems specific to its process. The following are suitable for recovery or disposal:

a) Sludges. A huge amount of ESIA's wastes are oily process sludge, which is very difficult to handle. Oil sludge is a sediment obtained from storage tanks, crude desalters, sewer cleaning, vessel cleaning, oil/water separators, dissolved air flotation, lube oil processing, and alkylation.

b) Catalysts. Different types of used catalysts are disposed of periodically. Most contain hazardous materials such as nickel, aluminium, copper, iron, titanium, chromium, cobalt, zinc, and vanadium oxides, besides the ceramic saddles used as beds for catalyst.

c) Suspensions. Large amounts of crude oil are suspended in sea water, in concentration of 1-5%, stored in large lagoons.

[illegible] ular [illegible]s, char- [illegible] ed.

C[illegible] led and the remaining is [illegible] sludge. Others are dumped [illegible] drained. [illegible] sludge [illegible] of [illegible] special landfill [illegible] are [illegible] disposed of [illegible] landfills [illegible] locations.

Other chemical industries. [illegible] generate [illegible] amounts [illegible] the manufacturing process. Most [illegible] water streams [illegible] cleaning companies. The package plastic industries plant generates wastes from [illegible]ylene [illegible] and low density polyethylene.

Building and construction material industries. Eleven plants in ESIA manufacture materials for building and construction. The solid wastes are scrap steel, scrap pipes, bricks, concrete, gypsum plaster moulds, fibreglass insulators, and welding flux. The semi-solid wastes are mainly lubricant oil, clay suspension, cement slurry, asbestos slurry, lime slurry, and glass wool sludge. Most of these wastes are dumped, drained, or disposed of in landfills. Scrap steel is sold in some cases. Concrete waste and empty barrels are collected by special contractors.

Organic industries. Only three plants in ESIA deal with organic materials. One produces paper bags, the second tissue paper and roofing paper, and the third processsess fish and shrimp. The wastes of the first plant are used as raw material by the second. The second plant generates many sorted rejects of cellulose mud. The solid part of these wastes is dumped in ESIA dumping area. The semi-solid are drained. The fish and shrimp processing plant wastes are damaged fish, and shrimp heads and shells, which are dumped in the ESIA dumping area.

General Solid Wastes (GSW)

The industries located in or near ESIA generate large amounts of general solid wastes with a composition similar to that of municipal solid wastes (MSW): paper, cardboard, wood, metal, textile, rubber and plastic, food, glass, stone, and sand. The MSW is collected, at present, by the contractors, who move these wastes to various dumping areas in Kuwait. The composition of general solid wastes in the area is shown in Table 3.

CONCLUSION

The amount of [illegible] W, S [illegible] waste [illegible] by this survey [illegible] wastes generated at present [illegible] expansion [illegible] industries [illegible] ESIA or establishment of new [illegible] which will result in more types and amounts of wastes, [illegible] Information about future development [illegible] structure for solid waste management [illegible] tions for solid waste management, [illegible] the appropriate technologies for disposal of hazardous [illegible] wastes, are also being [illegible]

ACKNOWLEDGEMENT

The authors wish to [illegible] the Shuaiba Area Authority for funding the project SP[illegible] The authors [illegible] wish to thank the directors and specialists in the industries located in ESIA for their kind help and interest in [illegible] the data for their respective industries.

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Table 1: Solid Wastes Generated in ESIA (t/yr)

Type	Amount
Catalysts	7,239
Construction materials	32,109
Metals	1,348
Clay	850
Melamine waste	1,567
Polypropylene/polyethylene	102
Paper manufacturing waste	3,180
Silica gel	1
Molecular sieves	110
Activated carbon and charcoal	5
Fish and Shrimp	80
Total:	46,591

Table 2: Semisolid Wastes Generated in ESIA Plants Including Dewatered Slurries and Suspensions (t/yr)

Type	Amount
Lubricating Oils	2,219
Sludges	50,362
Slurries and suspensions[a]	10,519
Chemicals	138
Total:	63,238

[a] After dewatering (include: Lime slurry, Asbestos wastewater, Clay syspension, Cleaning water, and Cements slurry).

Table 3: Estimated Maximum Production of General Solid Wastes in ESIA (t/yr)

Paper	Wood	Metal	Metal drum	Textile	Household refuse	Sand stone, ash	Tire	Plastic containers	Other plastic	Total
1975	6424	2132	431	1141	4172	58908	451	335	636	76,605

SOLID WASTE MANAGEMENT IN THE ENLARGED SHUAIBA INDUSTRIAL AREA (ESIA)

PART II: TECHNOLOGY BASIS OF THE COMBINED ON-SITE/CENTRAL WASTE MANAGEMENT SYSTEM IN THE ESIA

K. Puskas, A.S. ElNawawy, A. Hammoud, N. Samarah, B. Isbiah*

Kuwait Institute for Scientific Research
Biotechnology Department
P. O. Box 24885, Safat
Kuwait.

INTRODUCTION

A comprehensive waste management system is being developed for all kinds of solid waste and industrial and sanitary wastewaters in the ESIA. This lecture deals with the nonhazardous waste treatment, reuse, and disposal technologies, which are one part of the combined waste management system.

The evaluation of the information from industries and the assessment of the waste generation, with respect to the handling technologies are the basic sub-tasks which determine the proposed strategy which will be appropriate to the present situation and also the future. With reference to solid waste generation, there are primary and secondary industries. The solid waste generation is significant at the primary industries and negligible at the secondary industries. The location of the primary industries (Fig. 1) determines the waste collection system and influences the selection of the disposal sites.

Categorization of the Nonhazardous Solid Waste

The industrial solid waste (SW) and the semisolid wastes (SSW) are derived from the production process and relate directly to the production level. The character of this relationship was studied to establish

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*EPC-SAA

the time function of the waste generation and to determine other significant factors. In respect of the handling and disposal technologies, the general solid waste (GSW) has to be studied in detail. One part of the general solid waste is in indirect relation to the production process. For example, the quantity of empty barrels which are filled previously with raw materials and other auxiliaries (chemicals, dyes, etc.), relates to production level but also depends on other conditions (manner of packaging of this material, etc). This type of general solid waste (IGSW) is handled separately from the general waste, which is only remotely related to the production process, influenced for instance, by the number of employees, etc.; this type of general solid waste is considered similar in many aspects to municipal waste. The assessment of the above-mentioned nonhazardous industrial wastes was done for each group of the primary industries. The industrial and general solid wastes were studied and grouped also with respect to the special or general treatment options.

RESULTS AND DISCUSSION

The on-site treatment or reuse technologies as final or preliminary options handling in a Central Treatment Plant; and combined treatment with the industrial and/or municipal wastewater creates many variations of possible processes (Fig. 2). The scope of the study includes suggestions for remidial engineering measures. The short term solution favours disposal while the long term solution emphasizes reuse.

Treatment, Reuse, and Disposal Technologies for Industrial and General Solid Wastes

The introduction of each handling technology for the individual industrial solid wastes and for the general solid wastes generated from either the productive section or from the non-productive departments and offices of the industries is not the aim of this lecture, but typical examples of organic, inorganic and general solid waste handling are shown to illustrate the methodology and results of the work.

The Melamine Industry in Kuwait produces melamine in powder form from molten urea. Melamine is a raw material of the plastic processing industry. The urea is converted to melamine in a melamine reactor at high temperature and the melamine is dried and packaged. The process technology had to be studied to arrive at the character of the mixed impurities, melamine scale, used absorbent, used activated carbon bed, solids and semisolids (Fig. 3). The mixed impurities are mainly the by-products generated in the melamine reactor. Their character depends on the process conditions. In the first step, possible improvement measures are summarized (Fig. 4), together with necessary remedial

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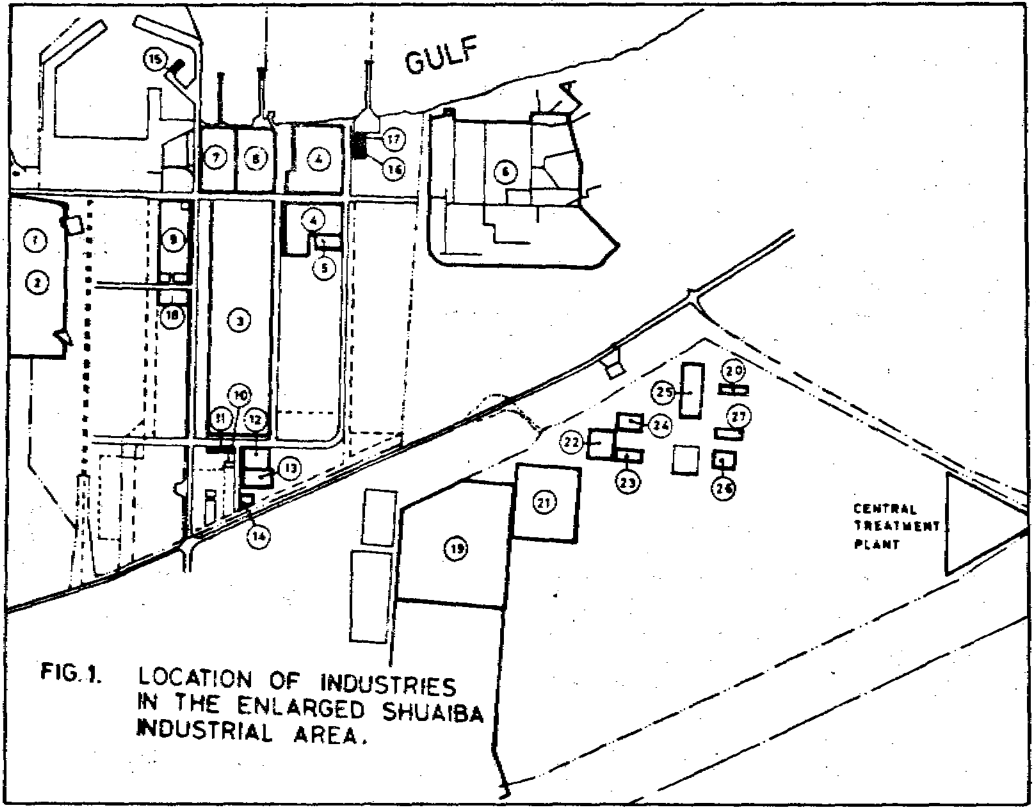

FIG. 1. LOCATION OF INDUSTRIES IN THE ENLARGED SHUAIBA INDUSTRIAL AREA.

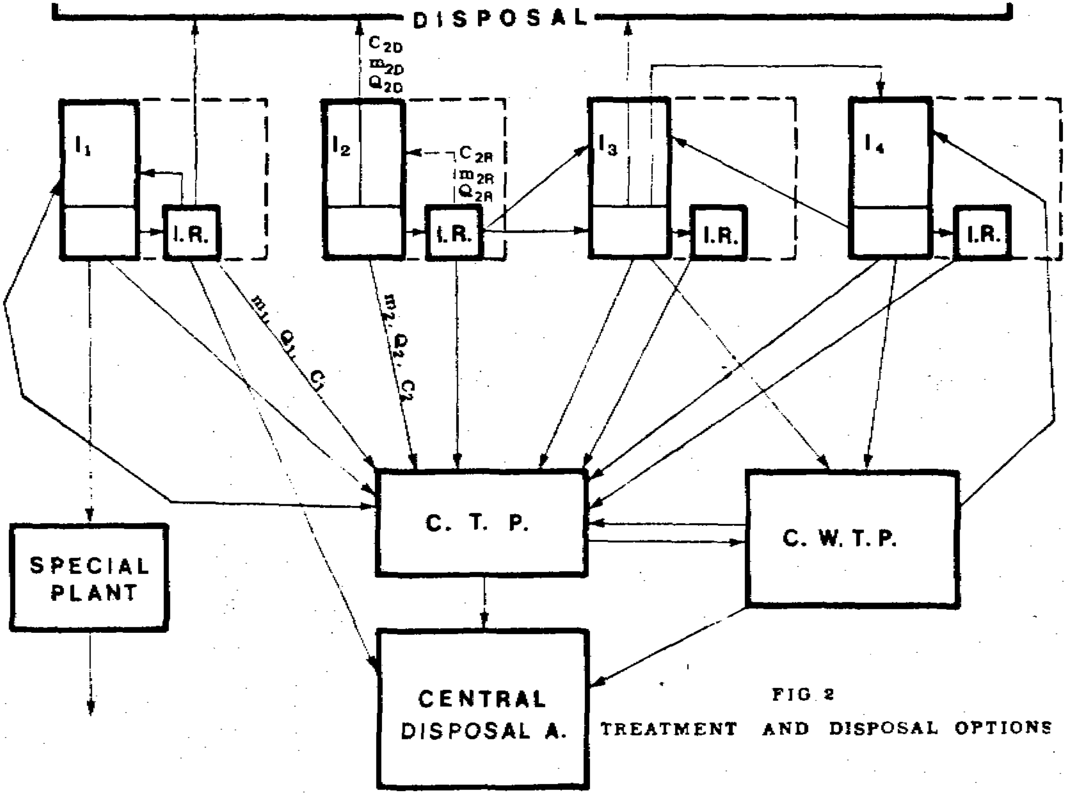

FIG 2

TREATMENT AND DISPOSAL OPTIONS

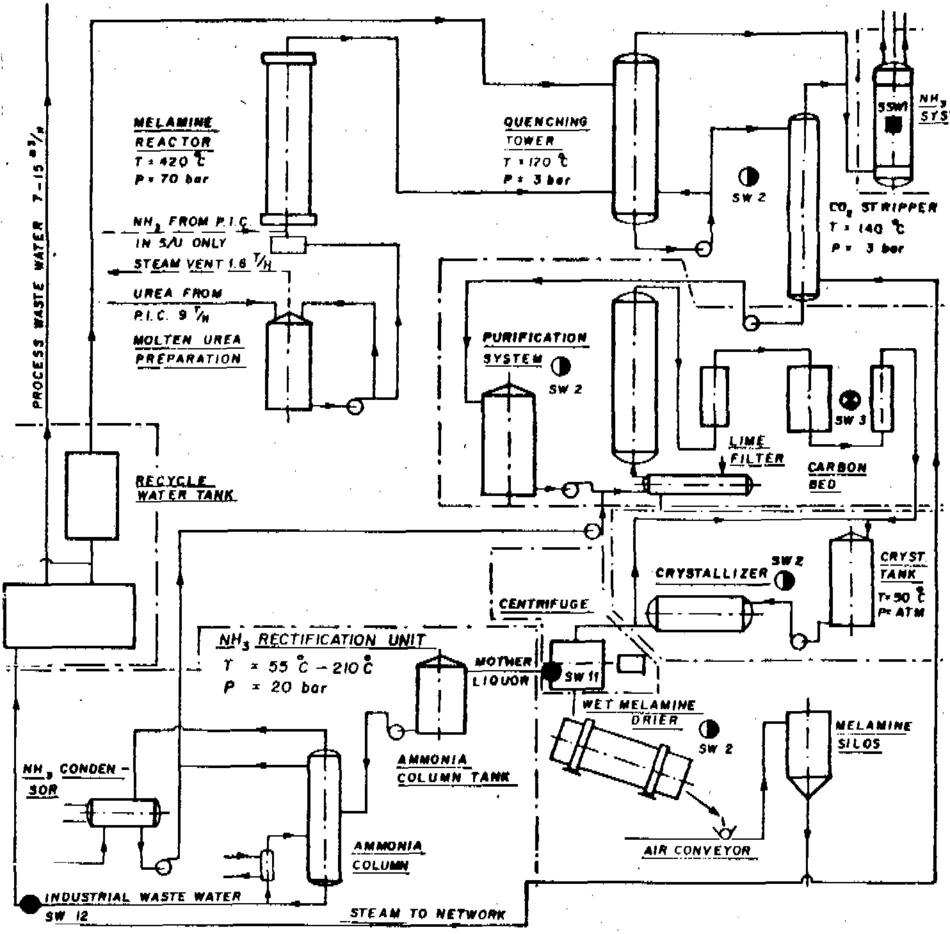

FIG.3.-KUWAIT MELAMINE INDUSTRIE
PRODUCTION PROCESS – WASTE GENERATION

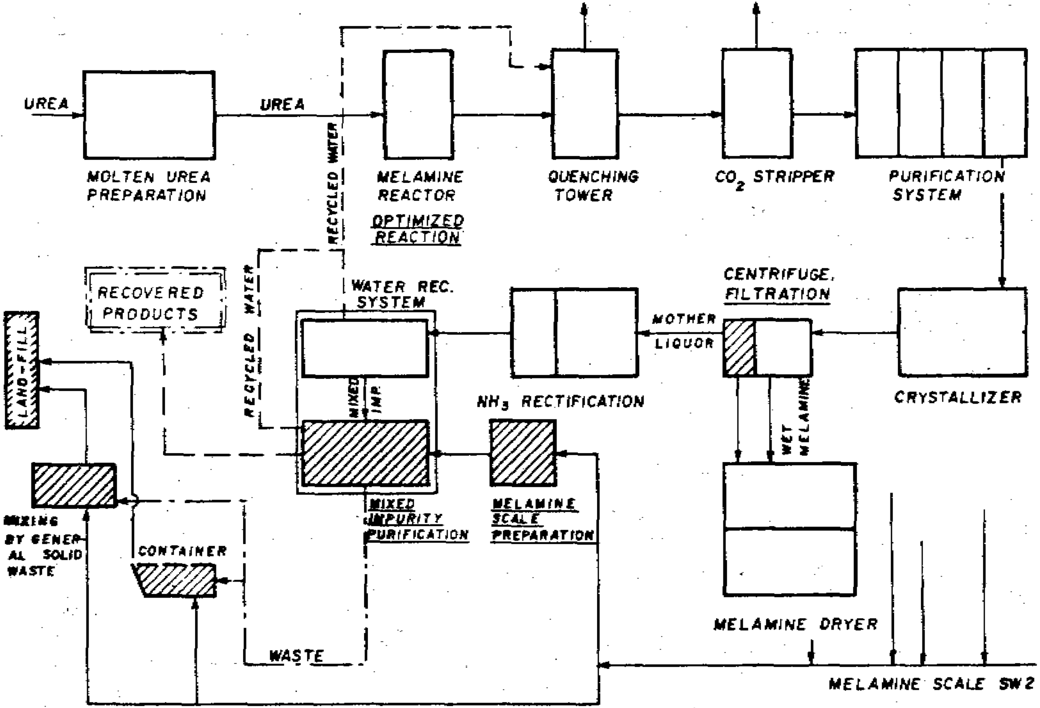

FIG. A. 4. MELAMINE PRODUCTION PROCESS WITH WASTE TREATMENT engineering measures. Thereafter, the on-site combined, outside treatment, reuse and disposal technologies were determined. Filtration by-product reclamation (Fig. 5), combined treatment with industrial wastewater, and disposal as solid waste, are the technology options for the mixed impurities and melamine scale. A major portion of the used absorbent can be recycled. The used activated carbon bed should be collected from this and other industries and regenerated in a centralized plant. The residual solid waste can be disposed of together with the general solid waste, or separately. This example of an organic industry, shows many options possible by the developed special waste management system. The selection will be done taking into consideration the results of the cost/benefit analysis.

One of the inorganic waste handling cases in the ESIA illustrates the options of combined treatment and reuse which might be applicable to the inorganic industry in general. In the ESIA, there are three construction industries producing precast elements for the local construction business. The steel mesh reinforced concrete elements are cast in steel moulds. The wastes are consolidated and fresh elements are cast in the steel moulds. The wastes are consolidated and fresh ready-mix concrete, broken and rejected precast element, steel scrap, used moulds and semisolid element slurry. The suggested treatment options are shown in Fig. 6. The fresh concrete could be reused by utilizing special precast technology. The consolidated concrete and rejected elements could be reused by a central handling facility or directly used for different construction purposes. The neighbouring industries are in a favourable situation concerning steel recycling which can realized by the Central Treatment Plant, (C.T.P.) where steel is sorted, selected and prepared for recycling or for sale. The cement slurry should always be pretreated on-site and the water could be recycled or drained, The above system demonsstrates the possible cooperation among the industries in waste management. The on-site treatment of general solid waste in not popular solution. It can be treated in the C.T.P. after collection. Transfer stations are not necessary because of the local circumstances. The handling technologies for steel scrap are shown in Fig. 7. It is suggested that it can be treated at the C.T.P after possible on-site recycling at the industry.

Central Treatment Plant

The prefeasibility study of a C.T.P. presented its advantages as a basic unit in the future waste management of the ESIA. In short term C.T.P. will exist as a disposal area for the nonhazardous and hazardous wastes. But later on the C.T.P. is expected to be a central unit of the waste management system in this area (Fig. 8). The C.T.P.

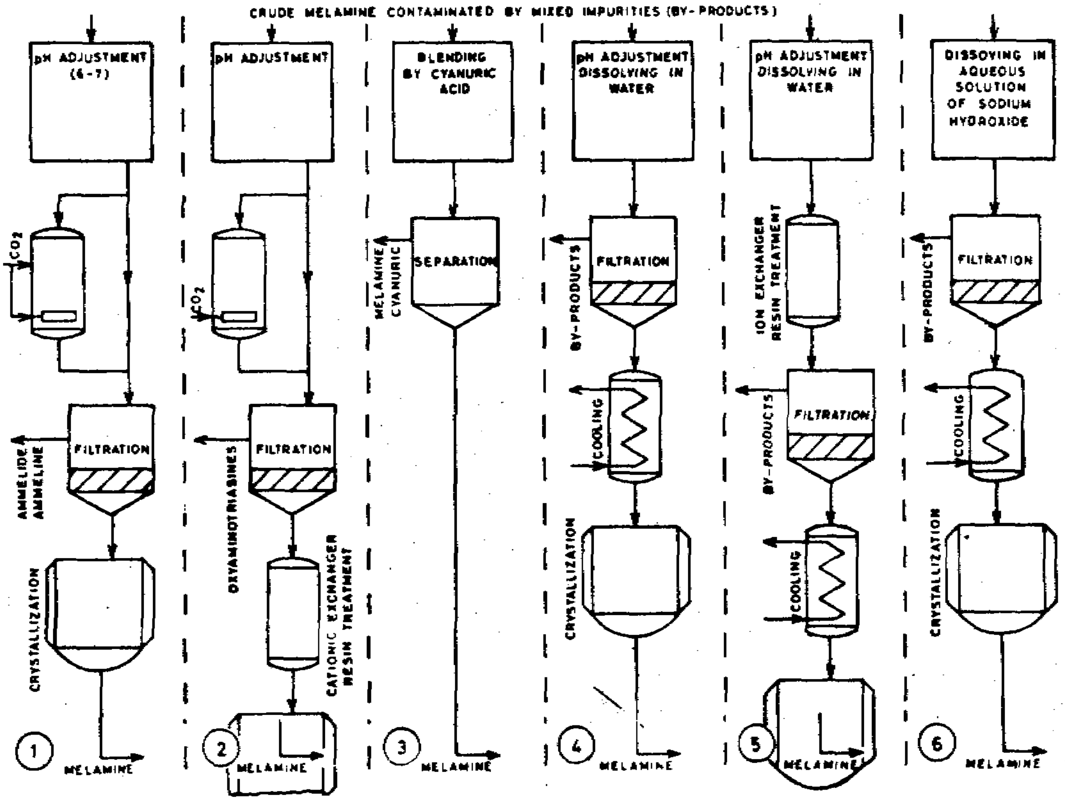

FIG. 5. PROCESS FOR CONTAMINATED MELAMINE PURIFICATION.

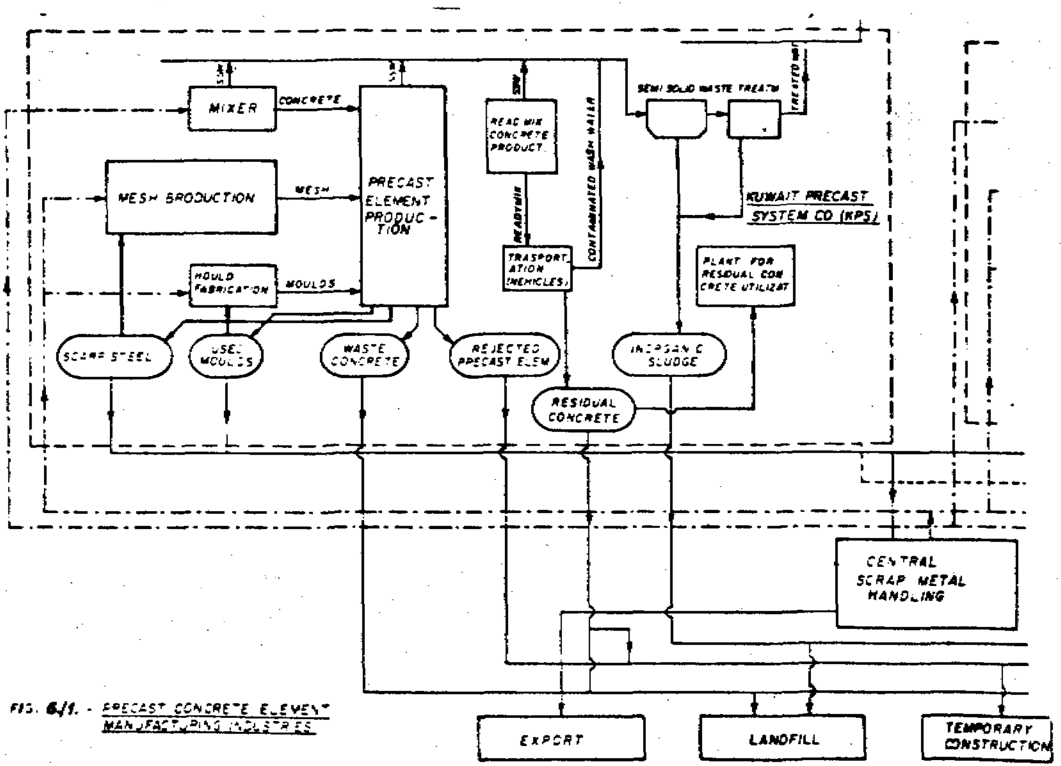

FIG. 6/1. - PRECAST CONCRETE ELEMENT MANUFACTURING INDUSTRIES

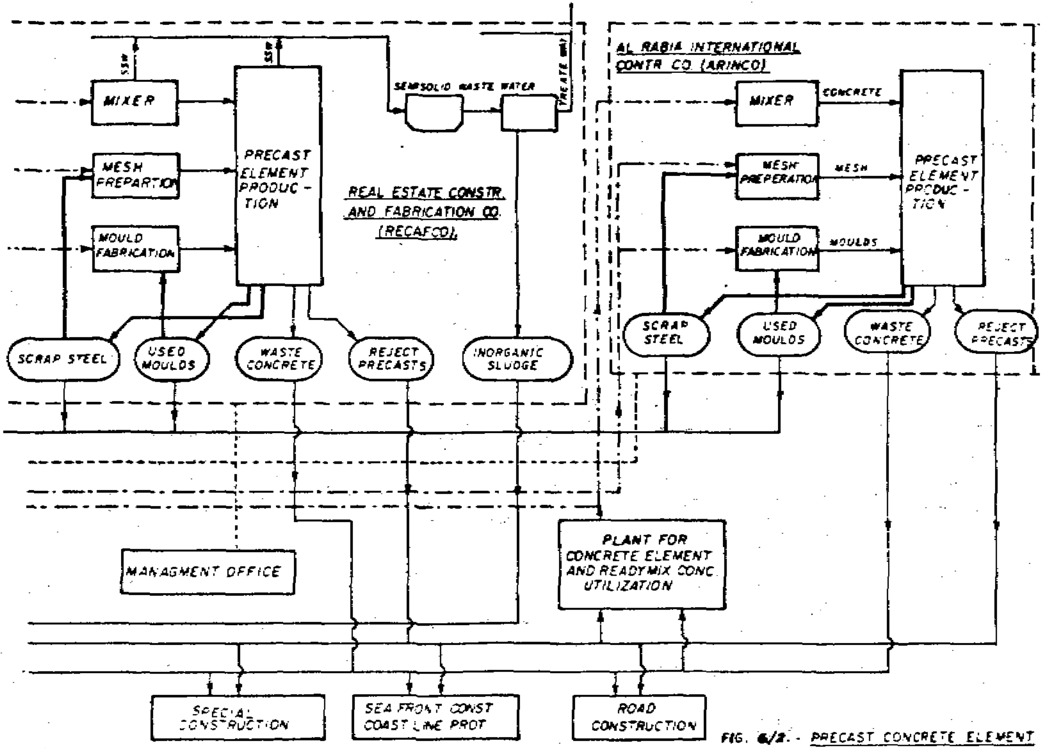

FIG. 6/2. - PRECAST CONCRETE ELEMENT MANUFACTURING INDUSTRIES

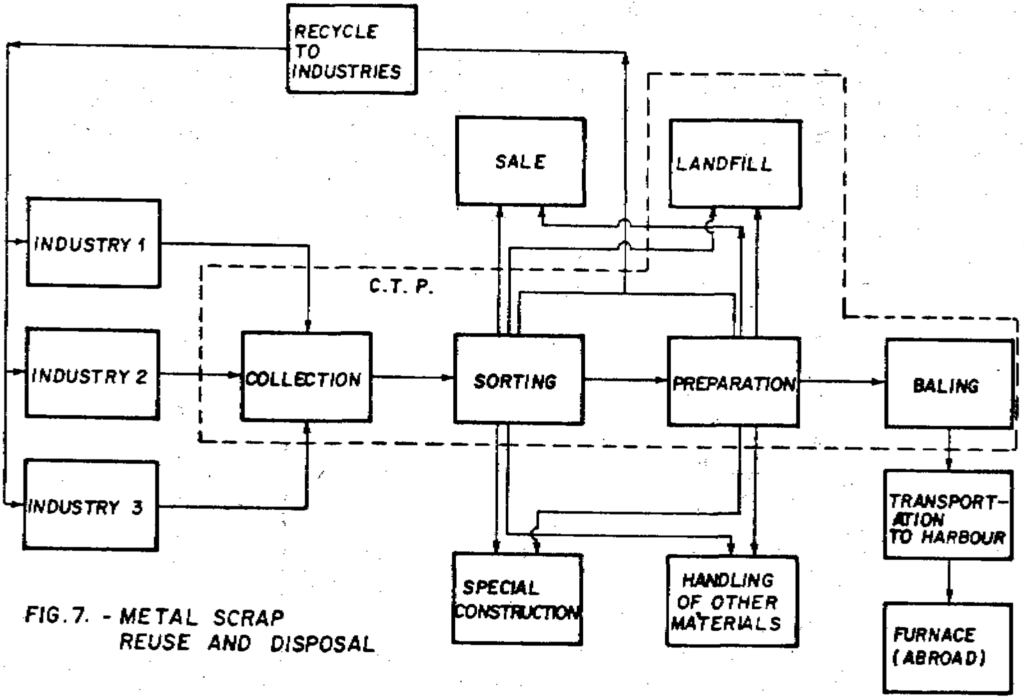

FIG. 7. - METAL SCRAP REUSE AND DISPOSAL

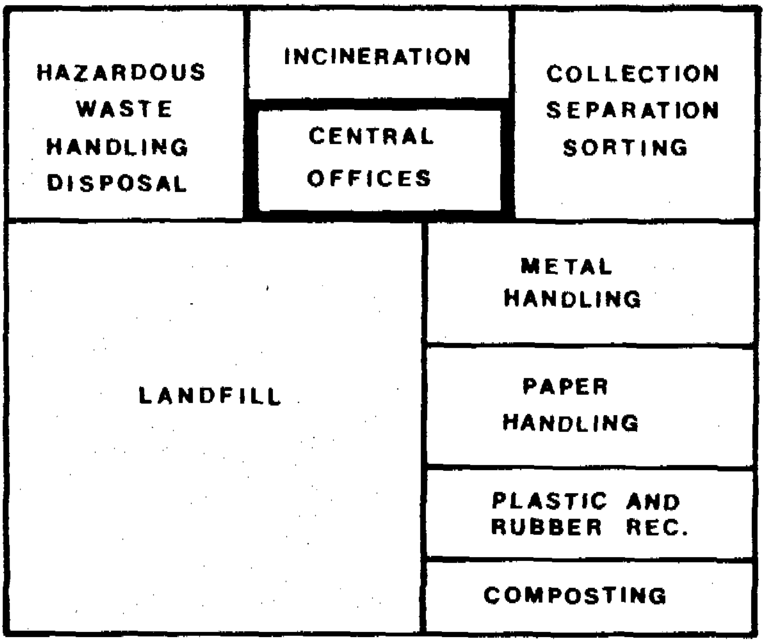

FIG. 8 CENTRAL TREATMENT PLANT

will be located in the selected disposal area, where the industrial general wastes will be collected and prepared for handling and disposal. The expected central handling plant and facilities should be located here namely the collection, separation, sorting system, the incinerator the metal and paper handling and preparation plant, the plastic and rubber handling and recovery plant, the composting section, hazardous waste handling store, disposal section and landfill area. The central office for waste management should also be here.

ACKNOWLEDGEMENT

The authors wish to acknowledge the Shuaiba Area Authority for funding the project SPP-4 based on which results this paper has be prepared. The authors also wish to thank the directors and specialist in the industries located in the ESIA for their kind help and interest in providing the data for their respective industries.

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VERMICOMPOSTING IN THE PHILIPPINES

Basil A. Rossi

President
Asian Recycling Association
P.O.Box 753, Bacolod City, Philippines

In Southeast Asia more than eighty percent of all collected solid waste is organic putrescible. This is an even more important percentage when it is realized that much of the remaining materials are removed by scavengers during the movement of the waste from its point of origin to the dumpsite. These are glass, plastics and metals. Therefore the organic fraction forms the bulk of waste and is therefore the most significant element to consider in waste disposal or recovery. It should also be realized that this organic fraction is the disease risk fraction in tropical areas.

Looking at the waste disposal picture we must then look at comparative costs of disposal--sanitary landfill and possibly incineration. Although with a very high level moisture content this is not really a solution. If we shift our viewpoint from waste disposal to one of resource recovery, we are forced to look at the end of a composted material.

The Philippines in common with most areas of the world has a massive soil problem. With fragile tropical soils to begin with and coupled with a high rainfall and high temperature factor, the most important problem after micro element depletion must be the organic matter levels. In nature, organic matter in tropical soils rarely has a chance to reach a humate level. The action of heavy rains and sun make this almost impossible. So if reasonable humus level is to be achieved, some method of introducing a complete replacement to topsoil is required. It is then for this reason that we have chosen to work with worm castings or vermicompost.

The harnessing of large quantities of earthworms to consume large quantities of agricultural and solid wastes began in the Philippines in 1978. Based originally on a Japanese system in turn based on concepts as old as Darwin and Aristotle, it has to rapidly and radically change to produce a system suitable to the tropics.

In the beginning the worm Lumbricus Rubellus was used, but it was found that Eisenia Foetida give better results both in feed consumption and breeding rates. The Japanese had introduced worm stock to waste in field conditions--that is, in open beds with soil as the base. We found that predators, ants and leaches resulted in poor results so initial breeding was achieved in clay "flower pots" Beds had to be sealed and moated with waste oil to keep them free of leaches that would kill, the worms or ants which, remove huge quantities of the protein.

The whole unit area required roofing to keep control of water. This was especially true of heavy rainfall areas of tropical Philippines. Still we had the advantages of a more or less constant 28 to 30 degrees C, ideal temperature for worm culture; also the advantage of low labor costs. Feed was never a problem as we had a choice between agricultural fibre wastes, a variety of manures or in the towns and cities, vast quantities of organic matter from solid wastes.

It took three years of basic research to reach a position of certainty as regards the entire system. Much of this tine was spent on surveying market potentials both in the Philippines and overseas. The Japanese had concentrated on production for two markets. The first was the home gardener (through supermarkets and garden shops) plus the glasshouse industry. The second was the field crop market. Obviously the first market was limited to a few thousand tons of pure castings per year. However, in the mid 1970's tests checked by the Tokyo Agricultural University concluded that Nitrogen or NPK blended with castings achieved notable increases in crops tested and resulted in lessening of N requirement by as much as 50% because the natural castings acted as a carrier and this produced "time-release" fertilizer.

This became even more important in the Philippines where up to 70% of chemical fertilizers are lost to either atmosphere or leached below or away from the plant root levels. We discovered that coating urea granules at 20% to 30% rate made nitrogen available over a period of eighteen weeks as against five weeks in straight chemical application. We used this system for both sugar and rice with good effect. As both industries are in economic crisis the idea of both lessening input costs and raising productivity was easy to sell.

WHAT ARE CASTINGS?

Castings are the end result of the feed (agri-waste) taken in by earthworms. They are the feces of earthworms. Castings are fine cylindrical excretions containing a considerable quantity of humus and are the finest (highest quality) top soil produced by nature. The quality of castings vary with the type of feed or wastes being fed to the earthworms. For example, earthworms can digest low nitrogen, high fibrous organic substances like straw and paper wastes. This will produce a good soil amendment; but an overall low quality castings. Earthworms can also digest aerobic sewage sludge which contains 4% to 6% nitrogen, the castings from this source will be of very high quality. The analysis of castings although variable show a high soluble calcium, potassium, sodium and phosphoric acid content. Most of the nitrogen is in the organic form as mucoproteins, peptides, urea, uric acid, allantoin and humic acid; the remainder as ammonia and nitrate nitrogen.

The recycling system designed produces a high quality casting having a total NPK content (dry weight) above 3% with some castings above the 5% NPK level. In some areas of the country this is high enough to be considered a fertilizer. The castings have a high cation exchange rate with a carbon to nitrogen ration under 20:1; excellent for good plant assimilation. The entire dry granular composition of castings is under 4.0mm with over 50% of the dry castings under 1.0mm.

The castings have a humus content above 20% (dry weight) of which better than 15% is humic acid. The humus portion of castings is responsible for stabilization of organic matter, binding of water to slow leaching, release of water during drought, and binding of metals for appropriate plant use. Humus also acts as a nitrogen recycling sink. It imparts a good texture and fertility to soil due to pore space and tilth, and most of all, acts as a plant growth hormone stimulant. As such castings are indeed a favorable organic soil amendment among gardeners.

Air dry earthworm castings have a density lower than potting soils due to the fine porous structure permitting air entrapment. Transportaion costs are thereby reduced. Castings, due to the mineral, nitral and high humic acid content, must be mixed 1.4 to 1.2 with low nutrient materials for making a good potting soil medium for seedlings and house plants. For soil amendment fertilizer use, castings are generally applied at the rate of 1.0 to 2.5 tons per acre depending upon environmental conditions and the crops grown.

Earthworm castings are also unique in that they are protected by a peritrophic membrane secreted around the castings during egestion. This membrane aids in the mineralization and time-release nature of castings. The earthworm comminutates the organic matter into very fine particles and as such fresh castings have a very high respiration rate. The microbial activity has been greatly increased due to the increase in surface area.

The castings of earthworm contain more fungi, actinomycetes spp. and cellutic type bacteria than if the organic matter is left alone in the soil without earthworms. As such, the earthworm castings are the foci for the dissemination of the beneficial microorganisms. So it is quite evident the great potential that castings hold for agriculture. Their potential marketing usages are varied and nearly limitless. Castings, for instance, can be combined and transformed with chemical fertilizers for modern large scale farming.

Earthworm excreta (castings) are a superior soil conditioning material. To summarize, worm castings: (a) exhibit low moisture levels which allows greater water retention, thereby slowing erosion when applied to the soil; (b) display a "natural time release" for releasing total nitrogen over a six week period; and (c) may be mixed and bonded with chemical fertilizer, forming a casting pellet, for large agricultural crops.

THE SYSTEM

We work on two systems. The first for quantities up to one ton per day of feed input is housed in clay pots (flower pots); and the second, for quantities of one to ten tons per day and above, is housed in beds.

The "pot system" is flexible and can range from a "household" situation where a family can keep from 10 to 1,000 pots in racks and feed each pot 6.5 kilos of feed every 45 days. The casting recovery is 40% dry weight castings for each ton of wet weight feed, so each pot can produce a revenue of US$5.00 per year when based on a casting sales value of UScents 30 per kilo. (The Japanese value their castings at between US$1.50 to US$3.00 per kilo).

The "bed system" requires a greater degree of technology as the greater surface area of a bed and the vastly greater number of worms (500 in each pot to 125,000 in an average bed--present problems of breeding, cooling and harvesting.

ECONOMICS

Economics largely depend on just what market is established, how ever, based on minimum values, one ton of waste (wet) produces 400kg. of castings valued at US$120 the cost of inputs does not exceed US$40 so the one ton of waste takes on a nett value of US$80 as against a $10 to $15 normal dumping cost. Thus a savings/gain of $90-95 per ton

The capital cost of bed system is such that initial requirements of US$20,000 is recovered in the ninth month of operation and expansion can comfortably be taken from cash flow. These figures do not take into account either the sale of worms as breeders or as protein.

As each ton of worms working produces a surplus of 35 tons of worms per year, a further income is assured.

For instance, a farmer or farmer-producer may conventionally use eight bags of urea per hectare valued at US$12 per 50 kg. sack; by coating four bags of urea with one bag of castings he will have a urea cost of US$48 plus US$15 for casting, a total of US$63 as against eight bags of urea at US$12 equals US$96. Thus, a saving of US$33 per hectare and a better crop as a result.

OTHER BENEFITS

A. Employment. In the Philippines, with labor rates of around US$2.50 per day we have massive unemployment. The systems employ 17 persons per ton of worms plus waste collection labor. The employment potential therefore is well above 100,000 for the country.

B. Foreign exchange savings/ earnings. Every ton of urea saved is a direct saving in foreign exchange. We are now exporting castings, so direct foreign exchange earnings are possible.

C. Vermicomposting is superior to conventional composting for the following reasons:

1. Turning of the compost is minimized; the movement of wet material is less.
2. Extended forced aeration of the compost is not necessary, as the earthworm movement channels oxygen into the compost.
3. It is usually not necessary to use bark chips or extraneous materials to prevent the compost from packing.
4. There is no need to maintain high temperature. Although a rapid temperature build-up is desirable for initiating thermophilic bacterial activity and destroying certain pathogenic bacteria, by using vermicomposting methods the maintenance of high temperature is neither necessary nor warranted.
5. Earthworms radically decreases pathogens present in the organic material. The environment and bacteria associated with earthworms facilitate the destruction of the coliform group and Salmonella.
6. Earthworms, in a proper mix, can digest large amounts of pulverized fibrous material. This allows cellulosic substances such as paper to be composted more quickly than is possible with conventional methods. Earthworms have the highest cellulase activity of any invertebrate.
7. A protein-rich animal may be cultivated on material once considered as waste since pulverized and properly mixed refuse is a food source for earthworms. Dried earthworm meal has an actual protein content better than 60% and has a higher percentage of sulfur-bearing and essential amino acids than meat meal. Earth

worm meal is comparable in quality to fish meal as a protein supplement.

8. Earthworm excreta (castings) are a superior soil conditioning material. Worm castings (a) exhibit low moisture levels which allow greater water retention, thereby slowing down erosion when applied to the soil. (b) display a "natural time release" for releasing total nitrogen over a long period; and (c) may be mixed and bonded with chemical fertilizer, forming a casting pellet, for large scale agricultural crops resulting in less run off in high rainfall areas.
9. Castings have a nitrogen content which equals or surpasses the original content of the undigested food due to volume reduction and carbon utilization.
10. Earthworm accelerates the degradation and stabilization of various sludges. This is possible because the surface area of the sludge is greatly increased as it passes through the earthworm. Earthworm stabilizes sludges as much as two and a half to five times faster than other methods. Earthworms return organic matter to the the ecosystem in a safe, sane and easy manner which is completely harmonious with nature.

Most important of all, the subject of vermicomposting could fall under any project: Treatment and Disposal of Domestic Wastes; Solid Wastes Management; Recycling and Non Waste Technology; Energy Production from Wastes; Management of Agricultural Residues; Appropriate Technology for Developing Countries.

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ACUTE TOXICITY AND PATHOLOGICAL CHANGES OF THE FISH *TILAPIA NILOTICA* EXPOSED TO DIFFERENT WASTES OF DYES PROCESSING

Samia G. Saad(1), Magda I. Zaki(2) and
Ahmed A. Hamza(3)

(1), (3) Professors at the High Institute of
Public Health, Alexandria, Egypt
(2) Assistant Professor at the Institute of
Oceanography and Fishery

INTRODUCTION

Ismadye is the biggest dye processing establishment in Egypt located at Kafr El Dawar near Alexandria.

The plant comprises several processing units for the manufacture of acid and alkaline dyes, Azo dyes, Naphthol and Sulphur dyes as well as intermediates and solvents used for the different dyes preparation. (Hakim *et al.*, 1979).

Both the Italian and Polish knowhow are used which created a vast array of chemicals in the final effluent. Inorganic salts and organic acids, amines, alcohols, aldehydes, esters and chlorinated hydrocarbons are among the toxic chemicals that could be present in the different departments' waste. The final effluent is a mixture of all the individual wastes and is subject to wide variations in quality from one hour to another. Since the dye production is fashion and mode dependent from the stand point of both the colour and the fiber used. The treatability of the waste has to be versatile and applicable to a wide range of characteristics present in the final effluent.

The antagonistic or synergistic toxic effects of those chemicals before and after treatment have to be evaluated in order to visualize the extent of toxicity removal by the well established methods of chemical and biological treatment. The toxic and pathological changes induced in fish reared in serial dilutions of the different departments effluents will indicate the extent of biological damage created by such waste when discharged raw to a body of water. This evaluation would be important in case certain effluents are highly toxic and their segregation would be mandatory to reduce the final effluent toxicity.

Tilapia nilotica is one of the most common species in the Egyptian drains, canals and fresh water bodies where the majority of industrial wastes are discharged without treatment. This supported its choice as a biotoxicity assaying organism.

The final effluent of Ismadye after being subject to a pH adjustment by addition of lime is tested as the initial raw effluent to be further treated for removal of colour and different chemicals. Chemical treatment using alum coagulation followed by active carbon adsorption was the recommended treatment to make the final effluent comply with the standards specified by the Egyptian law.

Materials and Methods

The final effluent of the plant as well as each dye processing unit was sampled and chemically analyzed for characterization following the Standard Methods for the Examination of water and wastewater (1979). The final effluent was subject to coagulation with 200 mg/1 alum for suspended matter and dissolved dyes precipitation as well as partial color elimination.

Adsorption using fine active carbon powder at a dose of 250 mg/1 at 200 r.p.m. for half an hour followed by sedementation for 1 hour and then filtration using a sand filter gave an effluent accepted by the standards.

Wastes generated from the departments processing Acid dyes, alkaline dyes, Azo Naphthol and azo-dyes were also sampled separately for chemical characterization as well as fish biotoxicity evaluation.

Trace metals were analyzed using Jarrel Ash 900 Atomic adsorption spectrophotometer as part of the activity carried by the project Assessment of Industrial waste pollution in Alexandria Metropolitan Area.

Serial dilutions of the different effluents were prepared as 100% raw waste, 50% waste and 50% dechlorinated water, 25%, 12.5%, 6.25% and 3.13 etc.... Dissolved oxygen was maintained at the saturation level, chlorides and pH were determined to eliminate leathality induced by their variations.

Tilapia nilotica with a total length of 4-6 cm and average net weight of five gms were collected from El Max fish farm, transferred to the laboratory and stocked in aerated rectangular tanks (255 liter capacity). Fish were fed daily during laboratory holding and acclimation period of one week.

The acute LC_{50} were determined in accordance with the standard methods (APHA 1976). Serial dilutions tested were 25% vol. of raw waste/vol. of water and its further dilutions down to 2.5 vol/vol. In each dilution Ten fish were tested and the experiment was repeated 5 times with different wastes effluents for 96 hours.

The dead organisms were examined to study the pathological changes inducing their mortality.

The survived fish spot in the aquarium after 96 hours of exposure were removed and preserved in Davidson's fixative. After 24 hours, fish were transferred to 50% ethanol for 2 hours and then 70% ethanol for storage.

Spots were dehydrated, infiltrated with paraffin and paraffin-embedded for sectioning sagittally and parasagittally at 7 um. Sections were stained with Mallory's and mounted for light microscopy.

Sections of gills, liver and the intestine of exposed fish to the raw and treated final effluents as well as different departments wastes, were prepared.

Results and Discussions

The waste effluents generated at Ismadyes when analyzed was not acceptable by all measures to the specifications given by the law governing the discharge of industrial wastes to drainage canal.

The waste was characterized by high variable colour density as well as high BOD, COD and volatile solids besides dissolved inorganic salts generated as byproducts of dye processing in the salting out operations.

Treatment of the waste was mandatory to remove the dissolved organics since the available treatment at the plant by addition of lime basically for pH adjustment is not sufficient for making the waste acceptable.

The need for assessing the treated effluent toxicity and pathological effects on fish like Tilapia nilotica normally living in the receiving body of water accepting this kind of waste gave a vivid idea about the removal efficiency of the treatment to be proposed.

The general characterization of the different basic departments as well as the final effluent before and after treatment are shown in table (1). Trace metals contents are also illustrated in table (2). Their removal during treatment was relatively achieved but the toxic effect of the combinations of minor concentrations of variable organics and heavy metals when biologically assessed showed noticeable toxic and pathological damage to the different organs of the fish. The LC_{50} values of the treated final effluent was 25% of waste by volume indicating moderate toxic effect as shown in table (3).

All departments raw effluents were highly toxic as indicated by the very short time of LT_{50} and the small concentrations of LC_{50}.

Although the treatment by alum coagulation at a dose of 200 mg/l followed by active carbon adsorption at 250 mg/l gave an effluent acceptable from the chemical point of view,yet even this applied tertiary, treatment did not eliminate the toxicity to the tested fish completely. This will dictate the need for assuring a dilution factor of at least 10 times the volume of the discharged treated effluent, as a dilution of 4 times can cause the death of 50% of the living fish in the receiving body of water.

A. Pathological Changes in the Respiratory System

The gills are among the most delicate structures of the teleost body. Their vulnerability is thus considerable because their external location and necessarily intimate contact with the water means that they are liable to damage by any irritant material, whether dissolved or suspended in water.

The Microscopic examination of Tilapia nilotica gills after exposure to different concentrations of different departments' waste revealed that extensive damage had occurred to the respiratory epithelium ranged from Complete denudation of the circulatory tissue of the lamellae to complete distortion of gills filament and lammellar organization.

Fish exposed to 12.5% of raw waste for eight hours should extensive damage to the respiratory epithelium and complete denudation of the circulatory tissue of the lamellae (Figure 2).

Tilapia nilotica exposed to concentration 25% for half an hour showed clearly complete necrosis and sloughing of the respiratory epithelium and complete denudation of the circulatory tissue of the lamellae (Figure 3). The gill filament and lammellar organization were completely distorted. After treatment of the waste the fish exposed to concentration 25% for 48 hours revealed complete denudation of the circulatory tissue of the lamellae (Figure 4).

Treatment increased the time for complete denudation but the effect was not completely removed at 25% waste concentration. This indicates the need for dilution of the treated effluent.

B. Pathology of Liver

Microscopic examination of Tilapia nilotica liver after exposure to waste of different departments at different concentrations, revealed liver alteration in fish ranged from moderate to severe fatty accumulation as indicated by vacuolation and necrobiotic changes of liver cells. These changes increased with time and concentration of exposure. Fish exposed to 12.5% of raw waste for 48 hours, showed parenchymatous extravasation in the liver indicating necrobiotic changes and extensive oil globule accumulation (Figure 5).

Increasing time of exposure to 58 hours at the same dilution increased destruction of cellular structure and necrobiotic changes of the liver beside fatty accumulation. Fish exposed to 12.5% concentration of the treated effluent for 48 hours showed extensive vacuolation and liver parenschyma probably due to abnormal accumulation of lipids and individual hepatocytes as shown in(Figure 8).

This proved that the causetive agents of liver parenchyma, were not even removed by active carbon adsorption which is considered as a tertury treatment. Further dilution showed be practised.

C. Pathology of Intestine

Intestinal degeneration of the villi in fish exposed to the different department effluents was revealed.

The distortion of mucosal epithelium and loss of brush border were the main features of villi degeneration in fish exposed to dilutions down to 25% of waste as shown in (Figure 10a, b, c). Fibrolyses appeared in wastes from departments producing Azo dyes and Naphthol dyes. This was coupled with complete destruction of the villi (Figure 11).

Dilution of the treated effluents decreased this effect. Those denoted changes are similar to those resulting from necrosis. Normal small intestine villi are shown for comparison in (Figure 12).

Recommendations

Ismadye final effluent presently discharged after pH adjustment is highly toxic and unacceptable for discharge to drainage water canals. The azodye and naphthol sulphur and intermediates department's raw wastes are highly toxic and their segregation is not recommended as they comprise the majority of the processing waste. Their mixing with wash and cooling water did slightly improve the toxicity of the final effluent treatment of this effluent using chemical coagulation at 200 mg/l alum followed by active carbon adsorption at 250 mg/l gave chemically acceptable effluent, yet its toxicity was moderate and the pathological changes it induced in the gills, liver and intestinal villi were not completely eliminated. Since those effects were diminished by dilution of the treated waste. It should be remembered that a dilution factor of at least ten times the discharged volume should be maintained all the time to minimize the waste damage to fish inhibiting the receiving body of water.

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TABLE (1)

SUMMARY OF CHEMICAL CHARACTERISTICS OF PROCESS EFFLUENTS FROM ISMADYES PLANT

Location		pH	Elect. micro	Cond. mho/cm	Turb. NTU	Sett.S ml/L	TS mg/L	SS mg/L	Cl$^-$ mg/L	Alk mg/L	BOD mg/L	COD mg/L
Azo	$\bar{X}$		4391		42.5	15.4	4257	546	1334	381	279	486
dyes	SD		1782		48.79	4.2	1598	276	1476	182	99	201
	R	7.5-	2000-		10-	11.5-	1933	234-	480	180-	120-	240
		10.1	7500		200	29	7531	1107	5700	800	528	1088
Naph-	$\bar{X}$		1927		54.1	9.2	1821	263	42	320	278	449
thol	SD		612		26.8	4.5	1044	248	286	185	110	179
dyes	R	7.1-	1350-		20-	2.7-	815-	44-	160-	160-	120	205-
		8.4	3500		100	15	3752	817	930	800	510	800
Sulphur	$\bar{X}$		2668		46	5.6	2201	241	985	159	201	330
dyes	SD		1957		53.5	3.5	834	197	477	83	61	91
	R	2.9-	1100-		6-	4-	1202-	34-	120-	75-	120-	210-
		6.6	7500		180	11	3759	700	1700	310	330	510
Inter-	$\bar{X}$		3440		43	8.4	1598	257	203	280	215	375
medi-	SD		269		48.6	3.2	597	152	211	86	86	124
ates	R	0.8-	1100-		6-	1.8-	1068	38-	60-	160-	106	200-
		0.1	7500		175	11	2032	583	700	400	400	640
Final	$\bar{X}$		6989		31.8	10.7	4124	383	1337	332	68	100
eff.	SD		1356		8.4	1.7	2185	324	1075	157	12	23
after	R	5.6-	2750-		20-	8-	950-	105-	480-	50-	30	60
treat.		7.8	7500		45	13	8030	1244	3570	500	80	160
Final	$\bar{X}$		6990		50.45	16	6838	690	1877	512	314	511
eff.	SD		1117		43.88	6.8	1778	422	135	246	96	143
before	R	4.3-	3600-		20-	10-	3750	169-	730	320-	185-	310-
treat.		5.2	7500		185	37	9865	1789	4100	1000	540	840

$\bar{X}$ Average of eleven observations (May 1982 - April 1983).

SD Standard Deviation.

TABLE (2)

TRACE METAL CONTENTS OF DIFFERENT PROCESSES AND FINAL EFFLUENT BEFORE AND AFTER TREATMENT

Location		Cu	Zn	ug/L Mn	Cr	Cd	Ni	Fe
Azo dyes	$\bar{X}$	340	190	1110	30	13	175	5390
	S	35	26	39	15	3	26	118
	R	420-385	185-240	855-1300	18-42	10-18	150-200	4300-6100
Naphthol dyes	$\bar{X}$	130	70	10	ND	6	132	94
	S	25	18	2	-	2	34	18
	R	98-155	65-83	6-14	-	4-12	118-155	80-110
Sulphur dyes	$\bar{X}$	2360	240	70	ND	17	146	5383
	S	85	50	15	-	2	32	185
	R	1980-3100	200-350	50-98	-	15-23	128-156	3400-6800
Inter-mediates	$\bar{X}$	150	70	40	ND	12	139	1093
	S	35	15	18	-	4	35	26
	R	120-175	42-88	32-56	-	6-24	115-210	980-1200
Final eff. before treatment	$\bar{X}$	2640	90	180	ND	10	103	620
	S	68	14	15	-	2	28	45
	R	1905-2850	85-148	164-220	-	8-14	98-156	430-720
Final eff. after treatment	$\bar{X}$	120	18	25	ND	ND	10	212
	S	28	3	3	-	-	3	45
	R	92-135	9-22	20-28	-	-	6-12	182-260

TABLE (3)

LC_{50} AND LT_{50} OF DIFFERENT EFFLUENT CONCENTRATIONS

		LT_{50}					LC_{50}
Process	Waste conc.	25%	12.5%	6.25%	3.13	1.6	
Intermediates		0.3 hr	0.7 hr	1 hr	24 hr	48 hr	1.5%
Azo dyes		0.05 hr	0.17 hr	0.25 hr	1.75 hr	2 hr	0.75%
Naphthol dyes		0.05 hr	0.25 hr	1.67 hr	1.75 hr	2 hr	0.75%
Sulphur dyes		0.25 hr	8 hr	> 96 hr	> 96 hr	> 96 hr	6.13%
Final eff. before treatment		0.5 hr	5.4 hr	24 hr	36 hr	48 hr	6.25%
Final eff. after treatment		48 hr	54 hr	96 hr	> 96 hr	> 96 hr	25%

Fig. (1) Section from normal gills of Tilapia nilotica from the control aquaria.

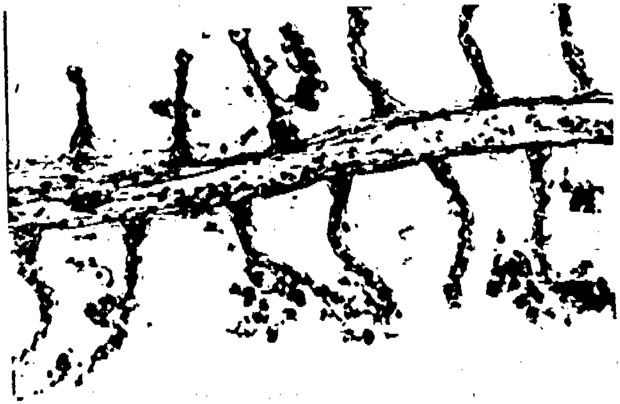

Fig. (2) Section from Tilapia nilotica gills exposed to 12.5% waste for 8 hours. Complete damage to the respiratory epithelium and complete denudation of the circulatory tissue of lamellae.

Fig. (3) Section from Tilapia nilotica gills exposed to 25% waste for half-an-hour showing complete distortion of gills filament and lammellar organization.

Fig. (4) Section of Tilapia nilotica gills exposed to 25% of treated waste for 48 hours revealing complete denudation of the circulatory tissue of the lamellae.

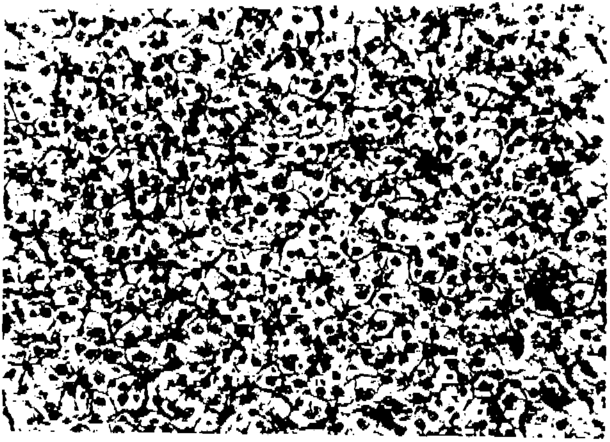

Fig. (5) Section from normal liver of Tilapia nilotica from control aquaria.

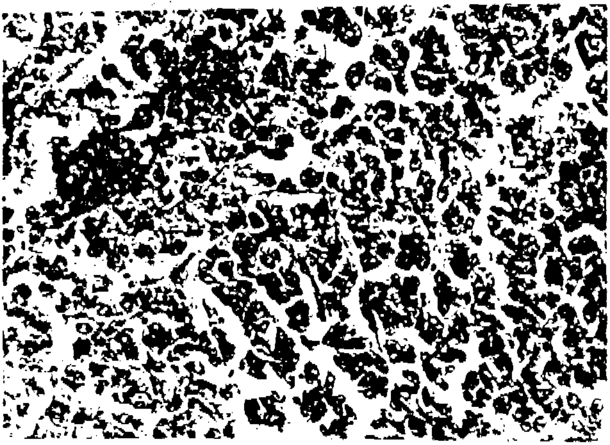

Fig. (6) Section from liver of Tilapia nilotica exposed to 12.5% of raw waste for 48 hours showing parenchymatous extravasation, necrobiotic changes and oil globules.

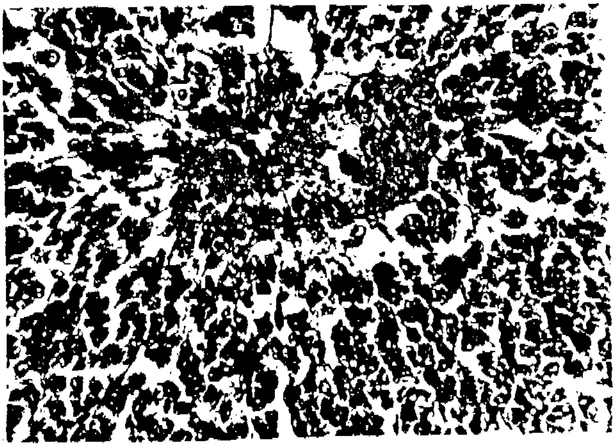

Fig. (7) Section from liver <u>Tilapia nilotica</u> exposed to 12.5% of raw waste for 58 hours, note destroyed cellular structure necrobiotic changes of liver and fatty accumulation.

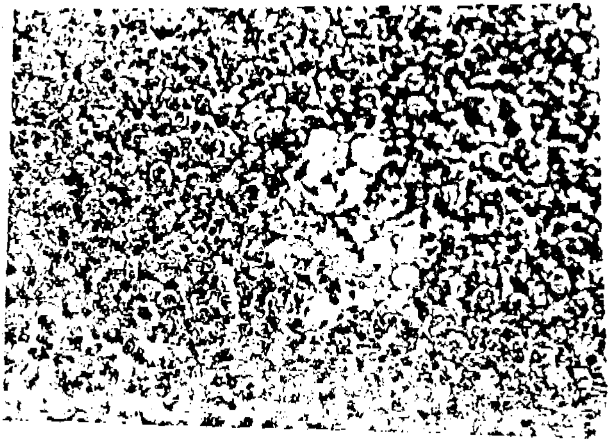

Fig. (8) Section of liver <u>Tilapia nilotica</u> exposed to 12.5% conc. treated final effluent for 48 hours showing extensive vacuolation.

Fig. (9) Section of normal small intestinal wall of Tilapia nilotica from control aquaria,note compact mucosal epithelium of villi.

Fig. (10) Section of small intestine from Tilapia nilotica exposed to 25% of raw final showing generation of villi of intestinal epithelium.

Fig. (11) Section of small intestine from *Tilapia nilotica* exposed to 12.5% of raw waste showing Fibrolyses with complete destruction of villi.

Fig. (12) Section of small intestine of *Tilapia nilotica* exposed to 25% treated waste for 48 hours revealing no changes from control.

EFFECT OF WATER POLLUTION ON FISH POPULATION OF LAKE MARIUT

Hamed Saleh
Institute of Oceanography
Alexandria, Egypt

Ahmed Hamza
High Institute of Public Health
Alexandria Univesity,Egypt

ABSTRACT

Fish population in lake Mariut consists mainly of *Tilapia zillii* Gerv, *Tilapia galilaea* Artedi, *Tilapia nilotica* Linn, *Mugil capito* Linn., and *Mugil cephalus* Linn. Until recently when the lake was relatively clear, these species were simaltanious.

The study showed that Tilapia zillii becomes abundant in the fish population as pollution of lake Mariut increases. This is attributed to the relative resistance of *Tilapia zillii* to aquatic pollution compare" with the other fish species surviving in lake Mariut; a finding supported by lower accumulation of pollutants on its gills.

INTRODUCTION

Lake Mariut was considered among the most productive lakes in Egypt (Saleh, 1961), He showed that the biological productivity of lake Mariut is more than three and half times that of lake Edku.

As a consequence of rapid industrial development in Alexandria in recent years and the uncontrolled disposal of industrail effluent in the lake, Pollution of the lake became significant mainly in areas close to sources of emission. El-Sharkawi et al (1978) proved that water pollution in lake Mariut causes considerable drop primary production, fish fertility, and length-weight relationship of the fishes. This study is carried to assess pollution with heavy metals, and its effect on fish population.

MATERIAL AND METHODS

Samples of water and fish were taken from eight different locations in the lake,. Length and weight of every individual fish was recorded. Specimens of gills and flesh were prepared for heavy metals analysis using Atomic Absorption Spectrophotometry (Jarrell Ash, Model 850).

Chemical characteristics and trace metals of water in different localities of the lake were measured according to the Standard Methods (1980) and correlated to accumulation of pollutants in fish.

RESULTS AND DISCUSSION

The physicochemical characteristics of water in different localities of lake Mariut varied according to the degree of pollution and sources of emission.

Appreciable pollution is found in the vicinity of discharge of El Nasr Refinery and Moharem Bey Complex as shown in Table 1.

Analysis of heavy metals in different localities of the lake showed that water in El-Nasr refinery drain, Merghim, and El-Mothalas contains considerable amount of heavy metals mainly lead (Pb) and Mercury (Hg),while at Moharem Bey locality water contains higher amounts of cadmium (Cd), Copper (Cu)and Iron (Fe). At all other locations water contains comparatively low amounts of heavy metals as shown in Table 2. These results indicate that heavy metals pollution is found in localities close to discharge of industrial effluents.

Statistical analysis of different fish species in the catch population of the different localities of the lake

TABLE 1: PHYSICOCHEMICAL ANALYSIS OF WATER IN DIFFERENT AREAS OF LAKE MARIUT (MAY 1983)

Parameters in mg/l

Locality	pH	Cl^-	SO_4^{2-}	Alk	T.H	Ca-H	Mg-H	Ts	SS	Vs	B.O.D	C.O.D	DO
Koubri Abu Khir	7.8	2500	530	600	1300	500	800	6301	897	1185	120	220	5
Fish Farm	7.2	1900	270	420	420	200	220	4599	200	1295	280	320	4.4
El Gharbia	7.6	2500	550	400	1300	520	780	6539	528	1207	120	240	4.9
Abu Azzam	7.9	2000	500	500	920	560	360	5570	916	910	120	220	5.2
Monarem Bey	7.8	2500	250	840	800	540	260	5933	229	1368	540	880	4.1
El Mothalas	7.5	2750	520	400	1200	480	420	6412	634	1399	180	260	3.5
Merghim	7.5	2750	500	300	1400	440	960	7091	1093	1554	224	300	5.3
El Nasr Refinery	7.3	3000	540	300	1500	620	880	18000	11975	2700	120	210	5

showed that Tilapia zillii is more abundant in the fish population of the polluted localities of the lake i.e there is a direct correlation between abundance of Tilapia zillii in the fish population living in water and its pollution level (Table 3). This proves that Tilapia zillii is resistant to aquatic pollution compared to other fish species e.g. Tilapia nilotica, Tilapia galilaea, Mugil cephalus and Mugil capito which either decrease or disappear in the fish population of the polluted localities in lake Mariut.

Measurement of heavy metals content in the gills and flesh of the different fish species living in a comparatively clean water of the fish farm showed that accumulation of heavy metals on the gills of Tilapia zillii is lower than that in its flesh, while the reverse occured in the other fish species (Table 4). This may be explained by the fact that the gills of Tilapia zillii permit the passage of heavy metals into its flesh by comparison with the other fish species living in the farm. However, heavy metals content in Mugil cephalus, Mugil capito, and Cyprinus carbio was considerably high which is attributed to their high conditions or fatness (Scott etal, 1972).

Previous research indicates that the accumulation of heavy metals in the aquatic organisms is positively correlated to heavy metals in the water environment (Portmann, 1972). Similar finding was confirmed for the fishes surviving in the different localities of lake Mariut (Table 5, 6, and 7). Keckes and Miettiment (1972) proved that the high accumulation of heavy metals on the gills of the fish causes its asphyxiation and death.

The previous results may explain the disappearance of Mugil cephalus, Mugil capito, and Cyprinus carbio from the fish population of the polluted water localities; taking into consideration that the fish farm is supplied with fries of the

TABLE 2: HEAVY METALS IN DIFFERENT LOCALITIES OF LAKE MARULT (MAY 1983)

Heavy Metals in mg/l

Locality	Fe	Cd	Cr	Pb	Cu	Ni	Mn	Zn	Hg	Sn
Koubri Abu El Khir	4.88	0.055	0.122	0.091	0.079	0.112	0.017	0.150	0.018	ND
Fish Farm	8.16	0.007	0.160	0.020	0.110	0.008	0.019	0.133	ND	ND
El Gharbia	5.54	0.059	0.147	0.020	0.148	0.112	0.018	0.143	0.011	ND
Abu Azzam	9.21	0.014	0.159	0.012	0.110	0.098	0.012	0.143	0.003	0.008
Moharem Bey	14.75	0.153	0.403	0.220	0.813	0.423	0.048	0.298	0.025	0.062
El Mothalas	12.65	0.091	0.360	0.713	0.216	0.432	0.020	0.123	0.067	0.080
Merghim	14.56	0.095	0.840	0.660	1.30	0.507	0.025	0.351	0.047	0.080
El Nasr Refinery	30.22	0.114	0.401	0.710	0.511	0.606	0.039	0.608	0.159	0.010

ND Not Detected

TABLE 3: PERCENTAGE OF FISH SPECIES IN THE CATCH POPULATION IN LAKE MARIUT (MAY 1982-JUNE 1983)

Fish Species in the catch population of lake mariut

Locality	Tilapia zillii	Tilapia galilaea	Tilapia nilotic	mugil Species	Cyprinus carbio	Other fish species
Clean						
Koubri Abu El Khir	35%	25%	40%	-	-	-
Fish Farm	23%	21%	22%	30%	4%	-
El Gharbia	40%	22%	34%	-	-	4% (clarias lazera)
Polluted						
Abu Azzam	44%	30%	26%	-	-	-
Moharem Bey	56%	35%	9%	-	-	-
El Mothalas	72%	20%	8%	-	-	-
Merghim	76%	12%	12%	-	-	-
El Nasr Refinery	95%	-	5%	-	-	-

TABLE 4: HEAVY METALS CONTENT IN THE GILLS AND FLESH OF FISH LIVING IN THE FISH FARM, LAKE MARIUT (MAY 1983).

Heavy Metals in mg/Kgm gills or flesh

Fish Species	Organ	Fe	Cd	Cr	Pb	Cu	Ni	Zn	Hg	Sn
Tilapia zillii	Gills	90.71	0.98	0.18	0.71	13.75	1.42	20.98	0.008	ND
	Flesh	141.56	1.22	0.31	0.75	22.07	5.22	30.09	0.019	ND
Tilapia nilotica	Gills	62.57	ND	0.42	0.69	16.95	0.73	12.44	ND	ND
	Flesh	108.70	0.328	0.28	0.36	13.43	0.49	12.58	ND	ND
Tilapia galilaea	Gills	97.28	2.31	0.34	3.61	13.75	8.21	16.02	0.021	ND
	Flesh	108.77	0.91	0.22	1.82	12.17	7.35	13.38	0.019	ND
Mugil cephalus	Gills	917.21	4.63	1.52	8.91	40.70	22.50	90.5	0.081	1.21
	Flesh	211	8.35	0.41	10.41	31.71	29.70	70.84	0.076	0.77
Mugil capito	Gills	122	ND	0.41	ND	37	9.14	14.78	ND	ND
	Flesh	90	0.93	0.48	2.1	10	1.35	16.90	ND	ND
Cyprinus carbio	Gills	565.02	ND	ND	8.16	10.69	2.40	37.63	ND	ND
	Flesh	178.46	0.27	ND	4.56	9.34	3.03	25.91	0.007	ND

TABLE 5: HEAVY METALS CONTENT IN THE GILLS AND FLESH OF <u>Tilapia zillii</u> SURVIVING IN THE DIFFERENT PARTS OF LAKE MARIUT (MAY, 1983).

Locality	Organ	Heavy metals in mg/Kgm gills or flesh								
		Fe	Cd	Cr	Pb	Cu	Ni	Zn	Hg	Sn
Fish Farm	Gills	90.71	0.98	0.18	0.71	13.75	1.42	20.98	0.008	ND
	Flesh	141.56	1.22	0.31	0.75	22.07	5.22	30.09	0.019	ND
El Gharbia	Gills	53.77	1.57	0.21	0.49	27.7	1.47	22.55	ND	ND
	Flesh	70.21	1.63	0.74	0.70	30.5	4.17	28.83	ND	ND
Abu Azzam	Gills	30.41	0.63	0.93	0.56	37.91	0.89	15.04	0.027	ND
	Flesh	106.21	0.75	1.58	0.94	136.84	0.91	18.45	0.059	0.09
Moharem Bey	Gills	419.21	8.67	1.74	2.12	136.8	7.05	147.82	0.012	0.114
	Flesh	358.42	3.08	0.84	1.33	49.5	2.78	108.45	0.016	0.232
El Mothalas	Gills	187	0.63	2.13	7.34	140.11	6.37	137.71	0.012	0.008
	Flesh	192	0.84	1.42	2.28	97.31	1.26	123.18	0.016	ND
Merghim	Gills	487.5	3.15	7.88	9.29	148.7	50.1	143.18	0.117	0.112
	Flesh	425	1.92	3.43	1.87	111.2	9.18	190.3	0.112	0.119
El Nasr Refinery	Gills	1009	3.64	4.19	12.31	34.31	48.2	237.11	0.127	0.12
	Flesh	990	2.17	2.15	1.9	9.43	9.84	101.49	0.117	0.87

TABLE 6: HEAVY METALS CONTENT IN THE GILLS AND FLESH OF <u>Tilapia galilaea</u> SURVIVING IN THE DIFFERENT PART OF LAKE MARIUT (MAY 1983).

		Heavy metals in mg/kgm gills or flesh								
Locality	Organ	Fe	Cd	Cr	Pb	Cu	Ni	Zn	Hg	Sn
Fish Farm	Gills	97.21	2.31	0.34	3.61	13.75	8.21	16.02	0.021	ND
	Flesh	108.77	0.91	0.22	1.82	12.71	7.35	13.38	0.019	ND
Koubri Abu El Khir	Gills	90.28	3.14	0.97	3.43	31.89	15.32	11.81	0.019	ND
	Flesh	77.42	1.47	0.41	2.87	19.96	7.64	7.82	0.023	ND
Abu Azzam	Gills	89.8	1.91	1.56	3.61	11.86	28.75	21.03	0.011	0.009
	Flesh	101.10	1.25	1.78	2.38	8.81	31.5	14.72	0.017	0.077
Moharem Bey	Gills	98.33	4.82	1.74	1.91	191.01	17.14	58.98	0.028	0.869
	Flesh	65.24	1.93	0.84	0.35	83.64	3.16	22.72	[illegible]	0.647
El Mothalas	Gills	177.56	6.67	4.53	17.11	123.75	33.78	125.31	1.35	2.08
	Flesh	146.49	1.35	1.55	3.15	62.38	10.43	70.68	0.18	0.73
Merghim	Gills	464.35	7.45	7.91	25.33	227.44	61.11	192.38	0.81	0.36
	Flesh	336.41	1.96	3.43	6.75	130.81	13.37	144.13	0.14	0.075

TABLE 7: HEAVY METALS CONTENT IN THE GILLS AND FLESH OF <u>Tilapia nilatica</u> SURVIVING IN THE DIFFERENT PARTS OF LAKE MARIUT (MAY, 1983).

		Heavy metals in mg/Kgm gills or flesh								
Locality	Organ	Fe	Cd	Cr	Pb	Cu	Ni	Zn	Hg	[illegible]
Fish Farm	Gills	62.57	ND	0.24	0.69	16.92	0.73	12.44	ND	ND
	Flesh	108.70	0.33	0.28	0.36	13.43	0.49	12.58	ND	ND
Koubri Abu El Khir	Gills	101.35	ND	0.63	2.44	24.41	0.95	5.28	0.005	0.216
	Flesh	40.91	ND	0.49	2.13	21.29	0.87	3.39	ND	0.183
El Gharbia	Gills	96.34	1.82	0.77	0.67	19.49	1.79	14.87	0.018	0.4
	Flesh	71.25	2.47	0.36	0.28	9.94	1.02	12.40	0.009	0.413
Abu Azzam	Gills	439.11	0.64	0.61	0.56	18.35	1.26	13.61	0.009	0.512
	Flesh	89.84	0.35	0.98	0.49	12.31	0.98	12.11	ND	0.316
El Mothalas	Gills	152.21	2.75	2.83	9.42	16.11	2.81	15.11	0.018	0.54
	Flesh	102.52	0.84	0.85	1.71	13.75	0.62	14.35	0.007	0.09
Merghim	Gills	304.18	0.31	3.97	9.29	137.91	4.45	45.[illegible]	1.26	0.711
	Flesh	177.14	0.04	1.32	1.84	73.21	1.33	30.91	0.91	[illegible]

TABLE 8: RATIO OF HEAVY METALS CONTENT (mg/Kgm) IN THE GILLS TO THAT IN THE FLESH FOR <u>Tilapia zillii</u>; <u>Tilapia galilaea</u>; <u>Tilapia nilotica</u> LIVING IN THE DIFFERENT PARTS OF LAKE MARIUT.

Locality	Fe			Cd			Cr			Pb			Cu			Ni			Zn			Hg		
	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g	T.n	T.z	T.g.	T.n
Fish Farm	0.6	0.9	0.6	0.8	2.5	-	0.6	1.5	1.5	1.0	2.0	1.9	0.6	1.1	1.3	0.3	1.1	1.5	0.7	1.2	1.0	0.4	1.1	
Abu Azzam	0.3	0.9	1.6	0.8	1.5	1.8	0.6	0.9	0.8	0.6	1.5	1.1	0.3	1.4	1.5	1.0	0.9	1.3	0.8	1.4	1.1	0.5	0.7	
Moharem Bey	1.1	1.5		2.8	2.5		2.1	2.1		1.6	5.5		2.8	2.3		2.5	5.4		1.4	2.6		0.8	2	
El Mothalas	1.0	1.2	1.5	0.8	4.9	3.3	1.5	2.9	3.3	3.2	5.4	5.5	1.4	2.0	1.2	5.1	3.2	4.5	1.1	1.8	1.1	0.8	7.5	6
Merghim	1.2	1.4	1.7	1.6	3.8	7.8	2.3	2.3	3	5.0	3.8	5.1	1.3	1.7	1.9	5.5	4.6	3.4	0.8	1.3	1.5	1.1	5.8	6.1

previous mentioned fihes. On the other hand, *Tilapia nilotica* and *Tilapia galilaea* considerably decrease in the polluted water localities of lake Mariut where water chlorosity is suitable for survival of such kind of fishes.

The affinity of the gills and flesh for accumulation of different metals varied with the nature ofmetal and was more pronounced as the pollution increased. i.e Accumulation of essential heavy metals e.g. Fe, Cu and Zn in the gills compared with that in flesh was lower than that of the nonessential heavy metals e.g. Hg, Pb, and Cd (Table 8). Such phenomena may explain the fact that the absorption and penetration of the essential metals through the gills is more than that of the nonessential heavy metals. This control of the different heavy metals penetration may be achieved by homeostatic process (Goodyear and Boyd, 1972., Cealey and Coleman, 1974).

However, the concentration of heavy metals in the fishes living in the different localities of lake Mariut was not an absolute reflection of the heavy metals concentration in the water environment. This probably means that the uptake and accumulation of heavy metals whether essential or nonessential in the fishes is both confusing and conflicting (McForlane , and Franzin, 1980).

As a general rule, the uptake and accumulation of heavy metals in the fishes living in the different localities of lake Mariut depend on both the character of the fish e.g. its ability to contol heavy metals penetration through its gills, its fatness... etc, and the physicochemical characteristics of the water environment e.g. its salinity, oxygen content, pH, calcium hardness, temperature... etc.

This means that the concentration of heavy metals in fish living in the different localities of lake Mariut are the result of complex intraction of many factors. This conclusion is supported by the work of other investigators (Wiener and Giesy, 1979, Giesy and wiener, 1977, Williams and Giesy, 1976).

CONCLUSIONS

The accumulation of heavy metals in the gills could be considered as the main cause of fish death living in polluted environment due to its asphyxiation. On the other hand, the flesh may contain considerable amount of heavy metals, without appreciable harmful effect on fish. Hence, Tilapia zillii is less vulnerable to pollution of the water environment compared with the other fish species living in the polluted water localities of lake Mariut. This was explained by the ability of Tilapia zillii to accumulate less amounts of heavy metals in its gills, compared with the other fish species and consequeutly its abundance in the polluted water localities of lake Mariut.

As pollution of lake Mariut spreads over wide area, Tilapia zillii is expected to dominate the lake, this would be a potential health hazard as it represents direct transfer of poisons from polluted water to the consumers.

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DYNAMIC METHODS TO DETECT RAW SEWAGE POLLUTION AND THEIR APPLICATION TO SHALLOW TROPICAL LAKES OF BHOPAL, INDIA

Salman S, Belsare D.K. and Ahmed A.M.

School of Biological Sciences,
Bhopal University, Bhopal 462026, India

ABSTRACT

In many parts of the world there is still a great shortage of drinking water. The reason mainly is that most of these tropical countries do not have perennial sources. It is therefore a must to store water by utilising the natural surroundings and constructing dams as man made reservoirs. One of the major problems that such stored lakes suffer are the inlet of pollutants from the overlying land above the surface of water, such as waste disposal, industrial chemicals etc. No dynamic method to quantify the exact spread of pollution is yet available. A man made lake in Bhopal, which has an area of 153 acres and is surrounded by 0.3 million people is taken for the present study. A model of this lake is made in the laboratory for proper study. Maximum depth of the lake recorded is 15 m. The input of the pollutant is from 3 main sources situated 120 apart, bringing in about 400 litres/s pollutants, the flow out of the lake is around 1200 litre/s.

Spread of pollution on surface is studied by three different methods namely, measurement of temperature as a means for bacterial growth, secondly measurement of B.O.D. content across the lake, and lastly growth of a plant called Myriophyllum in known and unknown samples of waters. A Pollution Index (PI-SBS-81) has been introduced. It is interesting to note that from the three methods used it is found that there is spot in

the lake around which the B.O.D. content is around 2, the temperature change is hardly recordable, and that the PI-SBS-81, comes out to be about 19.5 which also indicates that there is clean water around this area. This study was of extreme importance because during the year 1978-79 there was delayed monsoons which created a dangerous situation. The scientists were asked a number of times whether the water is good for drinking, and they could not reply with confidence. With these methods at hand, any lake and its pollution can be evaluated.

INTRODUCTION

It is interesting that with the population growth, and scientific advancements, the demand for more drinking water with better quality is increasing. As suggested by Anne Whyte (1977) the WHO intend to increase the adequate water supply in rural areas in developing countries from 12% to 25%. Also better standards for drinking water is realised, since the rural population is also aware now that most of the diseases are transferred or transported through drinking water. In hot and temperate climates the main source of water is through rain. The subsoil water is tapped through wells, and springs (White 1972). But during the hot season the temperature swells up evaporation losses may go up from 10% to 35%. Water table too recedes rapidly. With the result, one living in rural area is faced with dire difficulties.

On the other hand in urban areas where the population is dense, water requirements are comparatively more. Feeding larger number only makes the system more difficult. A number of man made lakes help to store water for domestic purposes. Most of these lakes are situated at a lower elevation surrounded by population. Sewage and other pollutants thus run into this water. One such example is of a lake in India at Bhopal. Fig. 1 shows the outline of the lake and other details. Other examples of large dams are Volta, Kariba, Kanji, Nasser, Bakhra Nangal and Chambal are a few examples. In Fig. 1, there are two lakes, the Upper Lake having an area of about 72 km which is only 20 m deep. The other lake is much smaller about 153 acres, with maximum depth as 12 m. Interestingly Hasler (1947) sited a similar example at Zurichsee at Zurich (Switzerland). This lake is also composed of two distinct basin Untersee (141 m deep) and Obersee (50 m).

For the city of Bhopal and an adjoining township of B.H.E.L., the total population is about one million, water is pumped from the Upper lake to the reservoirs situated about 15 km on the top of a hill. Water treatment plant is also kept on the same hill. The Upper Lake which is much larger is fed by river Betwa. In the year 1978-79, the monsoon rains delayed and due to this the water in the reservoir shrunk to just 15 square kilometers. This threatening situation made scientists to think of other alternatives, to provide drinking water to large population.

INVESTIGATION OF WATER POLLUTION

One of the alternative was to use the water of Lower lake for domestic use. Most of the scientists were of the opinion that this smaller lake is too contaminated and its water should not be used. Our group was of the opinion that there must be some spots in lake where the pollution could not have travelled upto. Three different methods were used to detect such a spot.

METHODS TO MEASURE WATER POLLUTION : FIRST METHOD: MEASURING POLLUTION BY MEANS OF TEMPERATURE CHANGE

As reported by Salman et al (1981) that large quantities of sewage were running into lake. There were three sources situated at 120° apart. Since experiments on the actual lake were difficult to perform, a model of the lake was made with the following dimensions. Maximum length 2.5 m, maximum width 2.5 m, depth 0.5 m, Sewage was then made to run into this lake. With the bacteria digesting the sewage temperature changes. This change of temperature was recorded on thermisters. Placed at regular intervals in form of mesh. About 648 thermisters were used to record temperature change and the pattern of spread of pollution. Thermister is a semiconductor like device, whose function is that with the temperature rise the resistance of the thermister keeps on falling.

$$R = R_0 e^k$$

and $$K = B\ (1/T - 1/T_0)$$

where R = Resistance at any temp. $T^{o}k$

R_o = Resistance at reference temp. T_oK

e = Base of the natural logrethim.

B = Constant (3400 to 3900).

The general equation of the cone can be written in this form -

$$An + Bn^2 y + Cn \; y^2 + Dn + E + F = 0$$

Where n and y are points on the cone, ABCDEF are constants depending upon the conic section, the focus and directrix.

Normal heat transfer equations with slight modifications were used to theoretically locate rise of temperature. The heat transfer equation is given -

By $Q = k \; A \; Dt_w$

where Q = Heat flux in (kW)

k = Thermal conductivity

A = Area of heat exchanger

Dt = Temperature difference in degree centi grade

S = Wall thickness in m

Value of constant $K = 0.5$ to 5 for water.

At the actual lake site two random lines which almost were at 90° to each other were chosen and temperature recordings at various depths were taken. For this experiment digital thermometer was used. Drifting of bacteria and its domain were also considered. These values were plotted. It is found that the theoretical values match fairly well with the actual thermometer values. It was also found that the ratio of cone angle to the largest distance is 0.125, the pollution is minimised.

SECOND METHOD OF ESTIMATION OF POLLUTION : BY MEASURING THE B.O.D. CONTENTS ON THE LAKE SURFACE

According to Pescord (1974) the sewage disposed into the lake should be 20/30 (20 mg B.O.D. 5 days/lit and 30 mg S.S./lit) as suggested by Royal Commission standards for the tropical countries. The values of B.O.D. are as follows:

Classification	B.O.D. 5 day/mg/lit.
Very clean	1
Clean	2
Fairly clean	3
Doubtful	5
Bad	10

There seems to be a close correlation between temperature change and B.O.D. contents. The value of B.O.D. contents range over large quantities, but then there is an over all arrangement with the figures indicating a zone of no pollution.

THIRD METHOD OF DETECTING POLLUTION

Salman et al (1982) have shown another dynamic method of measuring pollution by means of rate of growth of Myriophyllum (Water mill-foil). Since pollution is a complex mechanism with a number of parameters, it is always difficult to quantify it. With this method a pollution index has been evolved called PI-SBA-81. And PI SBA-81 is defined as the ratio of the intercept on the plotted curve, to the tangent drawn at the point when the curve becomes asumptotic to the tangent. Fig. 2 shows a typical growth curve with known pollutant concentration.

The equation for the rate of growth of the plant is given by -

$$y = a - a/e^{cx}$$

where y = Rate of growth of plant in vertical direction

a = Steady state value of growth

x = Time in days

c = Constant

Experimentally it is found that the plant growth rate, sewage water concentration, have a definite relationship, given by the above equation.

PI SBA-81 = 8.0/0.42

(5% sewage) = 19.5

For absolute pure water PI SBA-81 values range between 19 to 20 and for totally polluted water it ranges between 5 to 6.

APPLICATION

Three methods of detecting pollution were applied to Lower lake of Bhopal. From the different sampling sites temperature profiles and B.O.D. was estimated and the values are given in fig. 3 and 4. For estimation of Pollution Index samples were brought from the sites to the laboratory. PI (SBA-81) was calculated. The values are plotted in fig. 5.

It is interesting to note that the temperature change, B.O.D. and Pollution Index shows an area in the lake which is comparatively less polluted. This area in the lake is approximately 5 hectares.

These simple methods can be used to study the pollution content of shallow lakes polluted by domestic sewage.

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POLLUTION CONTROL İN THE İZMİR BAY

Ahmet Samsunlu

Vice President , 9 Eylül University

INTRODUCTION

Environmental problems have a close relation with urbanization. As it is true for all developing countries, there is a great migration from villages to cities in Turkey as well. This happens, because people have more chances to find jobs in larger cities.

Turkey presently is developing very rapidly, because of that all financial sources are allocated to economic development and new investments, and this has effected the urbanization negatively. Financial sources for overcoming the environmental problems are not available. Furthermore, the necessary organization for taking care of the environmental problems is not yet established. Financial and organizational problems are not settled, and therefore it is very hard to find a solution to the environmental problems. Today, the large cities of Turkey face the problem of understructure. In this paper, the existing situation in and around İzmir Bay will be summarized and preventative measures planned for the control of pollution in this area will be discussed.

URBANIZATION IN TURKEY AND İZMİR

The rural population in Turkey in 1960 was 7.3 million,while in 1975 it has become 17.2 million. Percentage of urban population has increased from 26% to 43%.

In Turkey there are 1654 municipalities, however, more than half of the population living in these municipalities have been settled in 48 large cities. Furthermore, half of this population is living in three big cities - İstanbul, Ankara and İzmir. The population of İzmir was 227,578 in 1950, 360,829 in 1960 and 520,832 in 1970. The average annual increase in population between 1960 and 1965 was 2.7%, and urbanization rate was 5.7%. Between 1975 and 1980, population increase rate was 2.1%, and urbanization rate was 4.5%. As can be seen, there is a decrease in the increase of population and urbanization rate.

The design population in the Sewerage Project of İzmir was estimated to be 1,625,000 in 1985, 2,200,000 in 1995 nad 3,035,000 in 2010.

THE POLLUTION IN İZMİR BAY

Rapid increase in population coupled with the insufficient wastewater collection and disposal systems have resulted in the pollution of İzmir Bay. This pollution has reached such levels that it has become dangerous for the public health. Beside the domestic wastes, industries are also contributing to the pollution by discharging their untreated wastes. The İzmir Bay has been polluted for years, and today this practice still continues. Increase in population, urbanization and industry has effected the amount and concentration of the wastewater discharged into the bay.

The main sources of the pollution of İzmir Bay are the domestic waste of approximately 1.5 million people, industrial wastewater and storm water. These sources and their relative strengths are given in Table 1.

Table 1. The Sources of Pollution of İzmir Bay and Their Relative Strengths

Source	%
Domestic and Industrial Wastes	50
Pollution from Streets	15
Pollution from Rivers	10
Artificial Fertilizers	10
Erosion	8
Balast Water	4
Pollution from Uncontrollable Sources	3

The amount of wastewater dischanged into the İzmir Bay has been increasing proportionally with the population and industry. As a result of urbanization the amount of storm water coming to the bay is also increasing. Storm water also carries the dirt of the streets as well as the fertilizers to the bay. The amount of pollutants carried to the bay by storm water is approximately 25-30% of the total pollutants. Since this kind of pollution originates from non-point sources, it is very hard to prevent it.

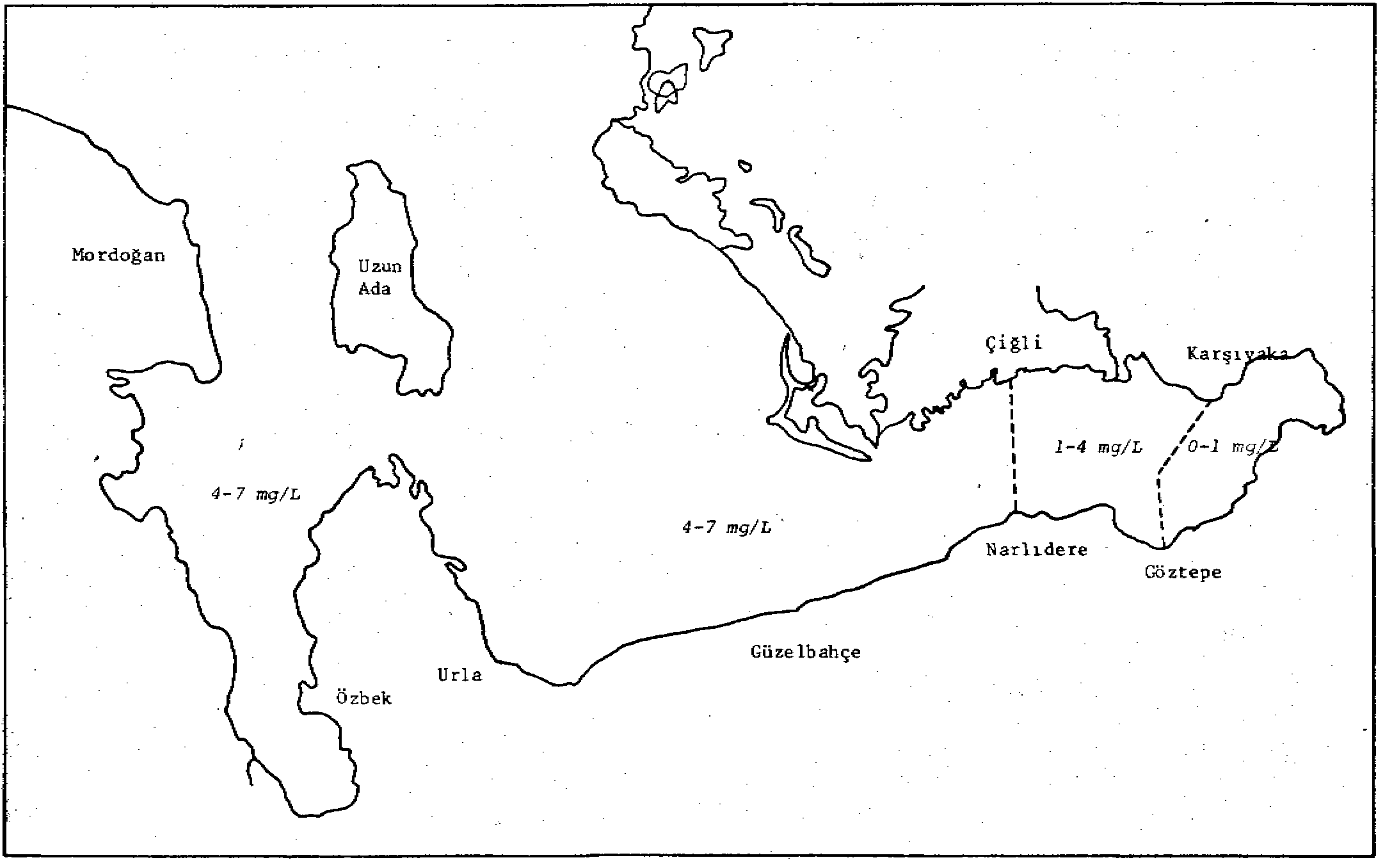
Industry has been developing rapidly in İzmir. The advantages of this development for İzmir and the Agean Region is undoubtful. At present, metal processing, food, oil, textile, alcoholic beverages, soft drinks, detergents, dye and machine industries are the main industrial groups existing in this area. These industrial groups help development of commerce, industry and tourism in the area, but at the same time they give rise to the environmental pollution poblems. To overcome this danger, municipality, governmental agencies and investigators should take the necessary precautions. Unfortunately, most of the factories mentioned above presently discharge their wastes either directly or indirectly into the bay without any pretreatment.

In order to better understand the extend of the pollution caused by industry, it is enough to examine Melez River which is the largest river in İzmir. This river springs in South Gaziemir and terminates in the İzmir Bay. At the source, the flow rate of this river is 10 L/sec. The assimilation capacity of this river is limited with the wastes of an equivalent population of 5,000. The BOD value of this river before entering the city is almost zero. At present, the wastes discharged into this river are equivalent to the domestic waste of 250,000 people. As a result of this, the pollution of the Melez River has been increasing continously, and the BOD value at the point of its discharge into the bay is 600-700 mg/L. This value reaches 5280 mg/L near the area where the leather factories are located. If these values are compared with the acceptable BOD values for clear rivers (0-4 mg/L) the extend of pollution can be understood more easily.

Another river which flows into the İzmir Bay is the Manda River. This intermittent river carries the surface waters only during winter. This river crosses the area in which the oil processing factories, Pinar Milk Factory, Efes and Tuborg Beer and Malt Factories and Ege University are located. After receiving the wastewaters of these institutions, Manda River reaches to the bay. The BOD value before entering the industrial region is about 1 mg/L, while at the point of discharge it is 60 mg/L.

Today, the bottom of the bay around Konak and Alsancak districts has been filled with waste solids, and bubbles coming out due to anaerobic decomposition can easily be observed. The "Red Tides" which occur during May and June are indications of very high pollution. Presently, 98 sewers are discharging directly into the bay and sewers inside the city are discharged into approximately ten rivers. The equivalent population (domestic and industrial) disposing their wastes into the bay can be approximated as two million people.

Mathematical models have been developed for the investigation of the pollution of İzmir Bay using BOD and dissolved oxygen (DO) values as controlling parameters. July is accepted as the most critical month, and values for these parameters have been determined in this month. As can be seen in Fig. 1 DO values at Bayraklı and Karşıyaka-Göztepe


Mordoğan
Uzun Ada
Çiğli
Karşıyaka
1-4 mg/L
0-1 mg/L
4-7 mg/L
4-7 mg/L
Narlıdere
Göztepe
Güzelbahçe
Urla
Özbek

districts vary between 0-1 mg/L, while in Karşıyaka-Göztepe and Narlıdere-Çiğli districts they are 4-7 mg/L. The DO values are below 4 mg/L in the inner and middle part of the bay and these locations can be considered as seriously polluted.

According to the world standards waters with a BOD value between 6 to 10 mg/L are considered polluted, while waters with BOD value between 0 to 6 mg/L are considered as clean waters. Waters with BOD values of 10 to 14 mg/L are heavily polluted. According to these standards, Melez and Manda Rivers are heavily polluted. In reality, it is questionable whether these waters should still be called as "rivers".

BOD concentrations in the İzmir Bay have been determined with the aid of the mathematical model mentionad above. Although the BOD values can not be considered as the best parameter for pollution indication in sea waters, BOD values obtained through this study are given in Fig. 2. As can be seen, BOD values are estimated to be 50-140 mg/L along the line connecting Karşıyaka and Göztepe, 30-50 mg/L along the line connecting Çiğli and Narlıdere, 10-17 mg/L between the lines Çiğli-Narlıdere and Güzelbahçe-Kokole Burnu and 7-10 mg/L in the remaining parts. These values show that the pollution at the inner and middle regions of İzmir Bay is critical.

PRECAUTIONS TAKEN TO PREVENT THE POLLUTION OF İZMİR BAY

The pollution of İzmir Bay is not the problem of the city of İzmir alone; it has gained importance for the whole Turkey. Because of that, solutions have been searched, and many projects have been developed. As a main precaution, collection and treatment of all domestic and industrial wastewaters before being discharged into the bay have been decided. For this purpose, Camp-Harris -Mesara Co. has prepared a project and a feasibility report between 1969-1971, sponsored by Turkish State Hydraulic Works (DSİ). However, because a long time has passed since that time, İlbank has asked Holfeeder-Su Yapı Co. to revise this project. This project has been completed in 1981. In the unit prices of 1981 the cost of this project was estimated to be 36,000,000,000 (36 billion) TL. This budget was approved in 1982.

According to this project, all domestic and industrial wastewaters are going to be collected by a main collector and brought to the treatment plant which is going to be built at Çiğli. After being subject to mechanical and biological treatment, the wastewaters will flow through a 12-km conduit to Gediz River and from there after travelling 13 km will reach to the outer bay (Fig. 3).

As a second alternative, the possibility of discharging these wastewaters through an ocean outfall at Tuzla has been considered, but due to the pollution of the bay the Gediz alternative has been preferred to the later one.

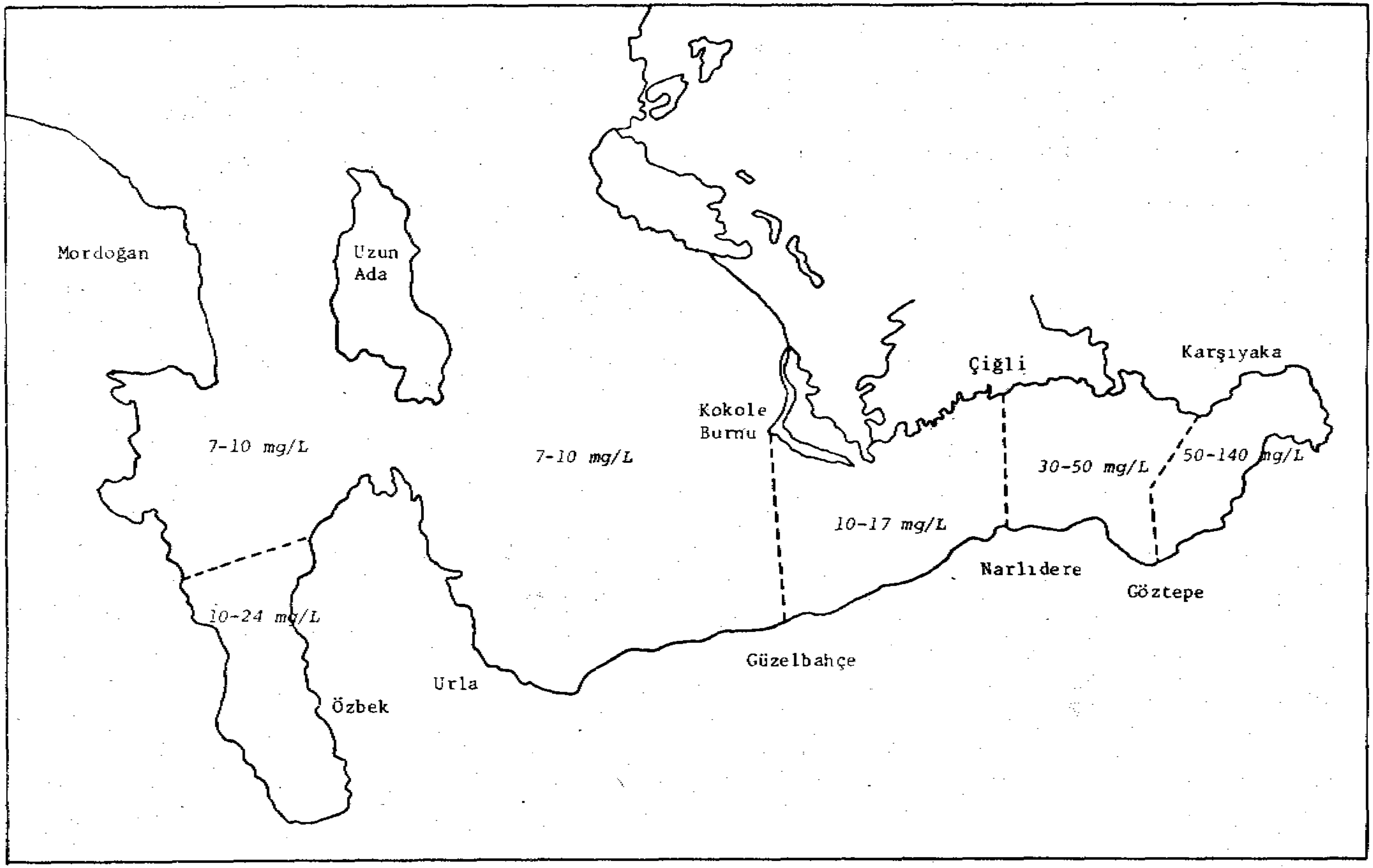


Figure 2. Biochemical Oxygen Demand (BOD) in İzmir Bay

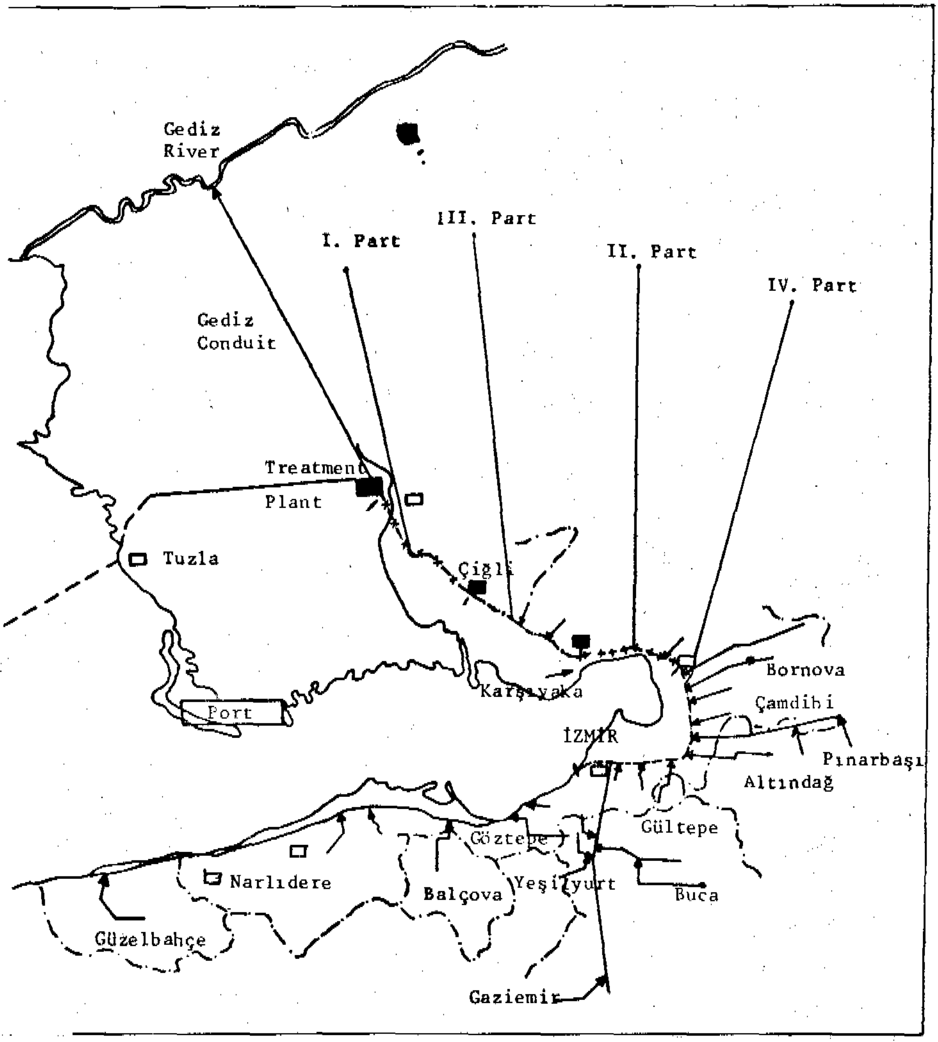


Figure 3. İzmir Sewarage Project - General Lay-Out

It is expected that the main collector will be constructed by 1995. After the collector is constructed the amount of pollutants discharged into the rivers will decrease considerably, and an appreciable improvement in the existing situation will be achieved. The reason for being optimistic for this project is the fact that İlbank in its 1983 investment program has allocated 37 billion TL for the completion of the collector and treatment plant between 1982-1990. Presently all the land purchases have been completed, and the construction of the collector from Gümrük to Çiğli, which is going to collect 75% of the total wastewaters, has started from four different points. This work which is going to contitue for four years will cost 9.8 billion TL. It is expected though that due to high inflation rate the cost will be considerably increased.

After this collector is completed the construction of Çamdibi-Pınarbaşı-Altındağ collector, The Melez Collector and the conduit from Çiğli to Gediz will start. Additionally, in the future, the Alsancak-Güzelbahçe Sewers, the pump stations and the treatment plant will be built. The realization of these works will be an important contribution to the rehabilitation of the İzmir Bay.

CONCLUSION

The environmental problems of İzmir due to rapid urbanization will be solved with the application of the project described. However, realization of this project will require the support of the public, the municipality and the industries. Legislation enforcing " the polluter pays " princple will facilitate the realization of this project. It should be mentioned, however, that the interest and the support of the central government is the most important factor. If the necessary finaucial support is provided, and the project advances according to the program planned, İzmir Bay will soon purify itself, and the city will again become an important touristic center.

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CONTROLLED RELEASE FORMULATION OF PESTICIDES TO DECREASE ENVIRONMENTAL POLLUTION IN DEVELOPING COUNTRIES

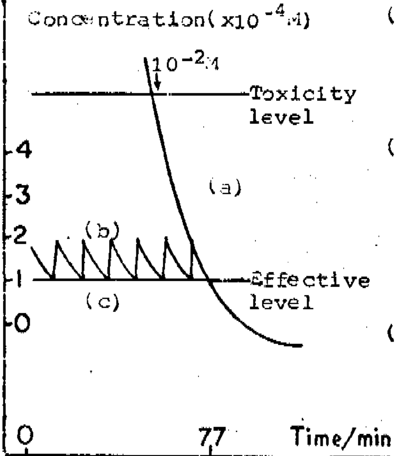
J.Shanker and U.C.Srivastava*

Department of Agricultural Chemistry
K.A.Postgraduate College, Allahabad, India
*C.M.P.Degree College, Allahabad, India

In the context of controlled release of Pesticides, the concept of exploiting metal Complexation has been developed and tested for the first time to increase the efficacy and decrease the environmental pollution in developing countries. Metal-Pesticide complexes have been synthesized between Mn(II), Fe(II), Co(II), Ni(II) and Carbaryl and Carbendazim pesticides in non-aqueous medium using reflux technique. Probable structural formulae for the complex have been reported on the basis of analytical and infrared spectral data. Cockroach (Periplaneta americana) mortality has been determined both for the free pesticides and their metal complexes containing same pesticide equivalence. The results indicate 10 - 30% reduction of Cockroach mortality from the same dose of Pesticides administered as metal complex, which work as controlled release formulation. The potential of metal-pesticide complexation as a "Controlled release" mechanism for pesticides is thus mooted.

Pollution is an inevitable consequence of men's existence on earth. Recent years have seen intense activity within all of these areas which has accompanied an increased public awareness of pollution problems. The use of chemicals to control our environment has increased markedly in the past few years and is now a significant factor affecting the quality of life. Two very important areas of application are in medicine and agriculture where the excessive and indiscriminate use of drugs and agrochemicals has often been criticized. However, using controlled release technique could make the application of bioactive agents safer and more efficient. Controlled release technology is an emerging technology that aims at an effective, safe and economic use of toxic chemicals in agriculture and public health with least projection to non-target biota and general contamination of the environment.

The dispensing of chemicals via controlled release techniques has grown in importance over the past 30 years, the original breakthroughs having been made in the pharmaceutical area. Controlled release implies a method of formulation that permits the optimum level of biological effector to be maintained over a period of time. Repeated dosage keeps the level above the optimum but employs more of the chemical, maintain the required activity (Fig. 1).



(a) A single dose is required to start at 10^{-2}M (higher than the toxicity level) in order to give 77 min of effective life.
(b) Repetitive addition with initial dosage of 2×10^{-4}M followed by six doses at 11.5 min intervals gives the same effective life as in (a) but with 92% saving in agent.
(c) Continuous addition must be at a rate of 10^{-7}ms^{-1} to maintain the effective level of 10^{-4}M.

Fig.1.Single repetitive & frequent dose of an agent.

A further problem is that the higher levels may cause toxicity. Ideal controlled release systems dispense the chemical at a rate that exactly balances the loss by dissipation.

One of the best and oldest examples of controlled release techniques is that of antifouling devices; these have been studied from antiquity. The first important experiments were carried out under the auspices of the Navy Board with HMS Alarm (1758) and revealed the effectiveness of copper sheathing as an antifouling agent. Humphry, Davy (1824) showed that the antifouling action of copper sheath is due to the slow dissolution of the metal.

The wide variety of controlled release techniques are now summarised in Table 1 (Williams, 1984). However there hardly seems to be any report on the use of metal pesticide complexation technique as a possible means for effective controlled release formulations. A recent communications from this laboratory has introduced a new concept of exploiting metal complexation as a controlled release technique (Shanker & Srivastava, 1982).

Microencapsulation :

Microencapsulation can be carried out via a number of processes whereby the agent becomes coated with a film, the agent is then released through several pathways as described in Table 1. A particle size of the capsules can vary from 1 to 5000 um and the coating materials for microencapsulation includes water soluble resins, waxes and lipids. A list of biologically active chemicals that have been encapsulated are given in Table 2.

Barett (1978) and Connick (1982) prepared the controlled release herbicides formulations based on alginate gel.

Polymer bound formulations:

Polymer-bioactive formulations have become increasingly used especially in areas outside pharmacology. The principle of controlled release from these formulations is that a bond to the polymer undergoes fission to release the agent at adesigned rate. Polymers that have been used include synthetic

Table 1. Controlled release devices

Device-technique	Release-action
Microencapsulation	1. Coating fracture by pressure, shear, abrasine or shrinking forces. 2. Coating degradation by melting or decomposition or by solution. 3. Diffusion
Hollow fibre	Evaporation
Polymer-agent formulations	Bond fission and diffusion
Compounding formulations	1. Diffusion-dissolution 2. Leaching 3. Exfoliation
Pro-pesticides	By chemical or biochemical action to release the pesticide.
Systemic techniques	The agent is taken up and distributed within the organism thereby rendering it toxic to the invading pest or pathogen.
Mechanical methods	1. Osmotic dispensing 2. Diffusion from sacks 3. Monitoring and pumping mechanically.

and naturally occurring. The ready availability of waste cellulosic type materials such as bark, sawdust or kraft lignin has led to investigation of their potential use as a matrix for herbicides used extensively in agriculture. These materials have the advantage of not only being biodegradable but also

Table 2. Uses for microencapsulated materials

Fertilizers
Fungicides
Germicides
Herbicides
Rodenticides
Growth regulators
Insecticides
Minerals
Nutrients
Pheromones
Vitamins
Repellents

contributing to the humus content of the soil. The herbicide 2,4-D is water soluble at neutral and higher pHs so it can readily leach out of the soil. By attaching the herbicide to lignin or to a cellulose by-product, an ester is produced that slowly releases the herbicide on hydrolysis (Cardarelli,1976).

Compounding formulations are those in which an agent is used with a 'filler' that is usually a polymer. Release of the agent from the compounded material is by three main processes : (i) diffusion-dissolution where the agent, which is soluble in the elastomer, diffuses to the surface and then escapes; (ii) when the agent is insoluble in the elastomer and is held mechanically, water may diffuse into the filler matrix and leach out the agent ; (iii) the agent is released following slow dissolution of the matrix in the solvent, usually water.

The best known examples of controlled release technology are in marine antifouling. Classical antifouling paint coatings contain a mixture of rosin and cuprous oxide. The rosin slowly dissolves by virtue of its acidic group and releases the copper salt by an exfoliation process.

Diffusion-dissolution is utilised in contact insecticide traps; the insecticide e.g. a pyrethroid is placed in a reservoir together with an insect attractant such as vanillin. The reservoir is placed between two plastic barriers and attached to a backing strip. The attractant and pesticide diffuse through the strip of plastic and the insect, attracked to the insect, is killed on contact with the pesticide.

Water-borne pests require special treatment because of the diluting effect of the medium. Aquatic weeds are killed by compounding certain herbicides, surface weeds such as water hyacinth and duckweed are effectively controlled with butoxyethyl-2,4-D incorporated into rubber and used with a flotation attachment.

Pro-pesticides :

Controlled release can be effected through the action of pro-pesticides which degrade to give active agents often at the site of action. The advantages of this approach are given in Table 3. The agriculturally important lethal synthesis is shown by 2-methyl-4-chlorophenoxybutyric acid (MCPB)(Tanquary and Lacey, 1973). This chemical is not itself toxic to plants but a controlled release mechanism operates whereby it is converted by β-oxidation within of most weed species to the herbicide MCPA (2-methyl-4-chlorophenoxyacetic acid) (Donaruma and Vogl, 1978).

The action of systemic fungicides and pesticides has some of the advantages associated with controlled release systems. Systemic agents can penetrate the plant cuticle and more through the vascular system. The advantages are that the agent is not lost from the plant by weathering and that all the new growth is protected. The action is selective in that the treated plant is unaffected and the treatment is economical in the amount used.

Mechanical dispensing in the field or in vivo can involve simple drip feed arrangements controlled by a variety of means. Another method is the macroencapsulation of the agent with a filler enclosed in a polythene membrane.

Table 3. The advantages of pro-pesticides

1. A sustained release can be maintained.
2. Absorption problems may be reduced.
3. Toxicity can be lowered for mechanical or agricultural use.
4. Passage through lipid membranes may be facilitated.
5. Stabilisation against metabolism or hydrolysis.
6. May be more acceptable to the environment.

Osmotic dispensing is achieved by formulating the agent with an 'osmotic' species such as magnesium sulphate. The mixture is held in a semipermeable membrane with an orifice of diameter 0.001 to 0.03 cm; osmotic pressure caused by entry of water through the membrane then squeezes the agent through the orifice at a controlled rate.

PRESENT INVESTIGATION

The Concept :

In the case of synthesised metal pesticide complex, there will always be a known equilibrium between the undissociated molecule and its components under aerial, enzymatic and hydrolytic action in the soil.

$$\begin{tikzcd} \text{Metal Pesticide complex} \arrow[r, shift left, "\text{Soil+}"] & \text{Metal ion+Pesticidal Factor} \arrow[l, shift left, "\text{Determinable equilibrium and release rate}"] \arrow[d] \\ & \text{Plants} \arrow[d] \\ & \text{Insects} \end{tikzcd}$$

Now as and when the free pesticide passes from the partially dissolved complex in soil to the plant as a systemic pesticide, and from the plants to the sucking insects, the equilibrium will be shifted towards the right causing more dissociation of the complex at a rate and to an extent depending upon the rate and the extent of removal of the pesticidal factor by the insects.

The metal complexation technique would have following advantages :

1. Controlled release of the free pesticide from the complex depending upon its stability constant, degradability and release rate in soil conditions.
2. Low residual toxicity since the pesticide would be used in a complexed form having a low dissociation constant.
3. Need-based action i.e. the free pesticide would be released more as and when the plant is attacked by insect where there is no pest,

attack the pesticide lies dormant in the soil in a less toxic complexed form.

4. By a suitable choice of low toxicity metal ions e.g. Fe, Co, Mn etc. the cumulative metallic residue shall not be deterimental to and shall rather add to the micronutrient value of the soil. Further metal ions like iron have been known to posses detoxification properties.

5. Least handling and pollution hazard since the complex would be in a non-volatile solid state as against the volatile organic pesticide.

6. Convenient systemic application and lesser problems of formulation.

7. Lower cost of application since the metal chosen would be cheap and the synthesis of the complex is relatively simple.

8. Unstable chemicals may be stabilised.

9. Less frequent applications necessary.

10. Liquid agents may be employed.

With these advantages in our imagination the carbamate pesticides were chosen as these are known to possess active metal binding sites consisting of nitrogen and oxygen donors. These donors have an affinity for binding with transition metal ions like Mn, Fe, Co etc. and are biologically important. The metal pesticide complex viz. Iron Carbendazim, Cobalt Carbendazim, Manganese Carbaryl and Iron Aldicarb were synthesized in non-aqueous medium using reflux technique (Anonymous, 1970). All the solid complexes decomposed without melting around 250°C. IR measurements were carried out on a Perkin Elmer grating infrared spectrophotometer model 577 in the range of 4000-400 cm^{-1} in CSI disc. The characteristic frequencies of the diagnostic value and tentative band assignment seems to suggest that in metal pesticide complexes the metal atom is coordinated to the carbonyl (-C=O) oxygen to the carbamate group and to N atom of the C-N group of imidazole ring.

Determination of cockroach mortality was done with a single dose of the synthesized complex such that the quantity of the carbamate complexed therein, is equal to the predetermined LD_{50} of the free carbamate. The % mortality data so obtained clearly indicate that metal complexation effects a significant reduction (10-30%). The effect being greater in case of cobalt complex than in iron and manganese complexes.

The synthesized complexes were also found to be quite stable in the soil in dry as well as moist conditions and were not generally detrimental to plant growth. It is therefore hoped that the stabilisation of the free pesticide by metal complexation would not only effect controlled release but also decrease the level of pollution of the soil and the environment by the otherwise free pesticide.

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REMOVAL OF COLOUR FROM PULP AND PAPER MILL WASTE BY MAGNESIUM SALT

A.K. Shrivastava*
S.K. Gupta*
M.V.S. Iyer**

*Reader in Civil Engineering,University of Roorkee, India.
**Lecturer in Civil Engineering, Government Engg. College, Rewa, India.

INTRODUCTION

Pulp and paper mill industry in India is nearly a century old. There has been tremendous expansion in the industry during the past thirty years and it is today one of the largest industries in the country. Our present installed capacity for paper and board is around 1.82 million tonnes per year and by the end of this century, we are likely to reach a figure of 4.25 million tonnes per year (Gupta and Sharma,1981).

The water requirements of a pulp and paper industry varies from 300-450 cubic meters/tonne of paper produced, depending upon its capacity, process, raw material, finish, product mix and availability of recycling facilities. Practically entire quantity reappears as effluent and contains fibres, lignin and their decomposition products, uncooked raw materials, clays, rosin, starch, gum, acid, alkali, salts etc. and the effluent is dark brown in colour.

Pulp and paper mill waste water are generally processed in biological treatment units for removal of biodegradable organic matter before discharge into receiving bodies of water. While biological processes are capable of producing effluents low in both BOD and COD, they typically accomplish very little towards colour removal while handling these wastewaters (Davis and Randal,1978).

A large number of these mills in India are located close to the rivers and discharge effluents with or without any biological treatment. The colouring material not only impair the beauty of the river but also inhibit the photosynthetic production of oxygen and could bring about a change in genetic code of living microorganisms in the river waters. Besides, these may chelate metal ions in water (Iyer, 1983) and may increase the cost of water treatment downstream the river. Further, since any colouring matter is a visible indicator of pollution, it affects the mental health and socio-economic growth of population in the area. The presence of colour in treated/semitreated/untreated pulp and paper mill effluents, therefore is of a constant concern to the industry and the regulatory bodies, all over the world.

SHORT RESUME OF PERTINENT PREVIOUS RESEARCH

A number of techniques for the removal of colour from paper and pulp mill wastes have been tried and are reported in the literature. These studies include Biochemical degradation, Chemical oxidation, Ion floatation, Ion-exchange, Soil percolation, Electrochemical process, Membrane filtration, Amine treatment, Radiation-exposure and chemical coagulation, but have not become economically viable for adoption in the Indian context since these techniques were mainly tried on biologically treated effluents and many of the pulp and paper mills in India do not have a biological waste treatment facility.

The possibility of the use of Magnesium salts as coagulant was first introduced by Flentje (1927) when he demonstrated its use in combination with lime for better clarification efficiency in surface water samples. However, it was not until 1966, when Lecompte patented a process for using $MgCO_3$ as coagulant (plus lime) for removal of colours from wastewaters, that the potential of this chemical for colour removal was realised. However, since $MgCO_3$ was not available commercially and also since it was believed that the coagulant precipitates in the settling sludges and has to be replaced in each pass, the process could not receive acceptance in the industry. Further work in this aspect was conducted by Thompson et.al (1972) who suggested in-situ preparation of $MgCO_3$ by adding MgO to water containing $Ca(HCO_3)_2$ and suggested use of the make up water containing $MgCO_3$ as coagulant-rich water. In this study the authors also indicated the possibility of recovering the coagulant from the settled sludge. Researches were conducted later by Vincent (1974) and Oldham et.al (1978) who advocated the use of Mg^{++} ions on biologically treated kraft mill effluents. The authors also demonstrated the viability of recycle of $MgSO_4$ by carbonation of the settled sludge.

Limitation of the Existing Work in Indian Context

From the aforesaid studies, while it may be apparent that lime in combination with $MgSO_4$ is effective for removal of colour from biologically treated kraft mill wastes, the studies are,however, lacking in respect of behaviour of these coagulants on total mill effluents. It is apparently believed by the authors that a physicochemical treatment prior to the biological treatment would complement the same by removing a good fraction of suspended solids, COD & BOD etc., apart from removing the colour. Not only this, since no cost effective system of colour removal from pulp and paper mill presently exists in India (IS-5061, 1968), no specific standards for colour removal have been specified in Indian Code (IS-2490,1974) and this code prescribes that the colour should be removed as far as practicable before disposal of the treated effluents into a natural water course.

SCOPE OF THIS RESEARCH

Hence, the aim of this investigation was to study the efficacy of $MgSO_4$ in conjunction with lime on:

a) the colour removal pattern of the combined untreated effluents from a pulp and paper mill,

b) the characteristics of sludge including drainability and SVI,

c) to optimize the dosage of lime and $MgSO_4$ required to achieve a predetermined level of colour removal (90%) without sacrificing the quality of sludge, and

d) to report the cost of the above treatment as also the associated removals in suspended solids, BOD & COD etc. of the raw effluents and to compare its economic viability vis-a-vis coagulation in presence of lime alone.

MATERIAL AND METHODS

Composite samples of wastewaters were collected from a kraft mill located in western U.P. (India). This mill produces 185 tonnes of kraft paper/day; uses Eucalyptus as raw material and resorts to sulphate process for cooking the material. Presently no effluent treatment facility exists in the mill. The mill was chosen for the investigations to evolve a low cost for colour removal prior to biological treatment and its possible implementation in other pulp and paper mills.

The chemicals used in this study were commercial grade $MgSO_4$ and lime having percentage purity of around 50 and 60 percent respectively. The chemicals were sieved to remove any lumps etc. prior to their use.

Experimental Protocol

Experiments were mainly carried out in two phases, the first phase was aimed to arrive at the workable ranges of dosages of lime and $MgSO_4$, whereas in the second stage precise study of the aforesaid ranges was conducted to optimize these values. Coagulation studies were carried out using Aplab laboratory flocculator (type IE-55) in 6-unit jar stirrers. The dosages of coagulant and aids were taken ranging from 0-180 mg/l of commercial $MgSO_4$ and 1000-3000 mg/l of commercial lime. During the flocculation experiment, predetermined quantity of $MgSO_4$ stock solution (3%) was added and the jar contents were mixed briskly for 2 minutes at 100 RPM. Lime slurry was then added (5% concentration) and contents stirred briskly further for 2-minutes. The mixing speed was then slowed to 15-20 RPM and maintained for about 20-minutes for flocculation. The jar contents were then allowed to settle for 30-minutes. Samples of supernatent were taken for colour, pH, BOD, COD and suspended solids (S.S) analysis and the sludge samples were analysed for drainability and SVI. Colour measurements were made twice on each supernatent sample i.e. once at the observed pH and then at a pH of about 7.0, after neutralization with dilute H_2SO_4. While all the physical and chemical analyses were conducted in accordance with the procedure outlined in the Standard Methods (1980), for the purposes of estimation of sludge drainability, 100 ml of sludge was applied to a whatman 42 filter paper in a Buchner funnel and volume of filtrate (ml) collected over 30 minutes was expressed as percentage value, Randal et.al (1971).

RESULTS AND DISCUSSION

As mentioned earlier, the colour removal measurements were conducted twice on each coagulated and settled sample of wastewaters i.e. first at the observed pH and then at a neutral pH. It was recorded in all these experiments that the efficiency of colour removal increased by about 5-6% in each of the samples when the pH was adjusted to 7.0. Since the objective of the research was to explore the possibility of colour removal prior to any biological treatment, the colour removal values pertaining to neutral pH (amenable for biological treatment) have only been discussed here.

Figure 1 through 4 summarizes the results of a number of test run. It may be noted from figure-1 that lime alone has decreasing rate of return (in terms of colour removal efficiency) upto a concentration of 2100 mg/l, when only about 83% of colour removal could be achieved. Colour removal efficiencies higher than 90% however were achieved with lime dosage of around 3000 mg/l. While the various dosages of lime and $MgSO_4$ are predicting 90% colour removal, as is apparent from figure-1, however, the effectiveness of a small dosage of $MgSO_4$ with lime in achieving greater percentage of colour removal is distinctly exhibited by each of these curves. For instance, the curve, in the lower ranges of lime consumption, indicates that 90% colour removal can be obtained by:

a) 2900 mg/l lime alone

b) 1300 mg/l lime plus 60 mg/l $MgSO_4$

c) 1075 mg/l lime plus 120 mg/l $MgSO_4$ and

d) 1600 mg/l lime plus 180 mg/l $MgSO_4$

This leads one to believe that excessive dosage of $MgSO_4$ does not necessarily increase colour removal efficiency.

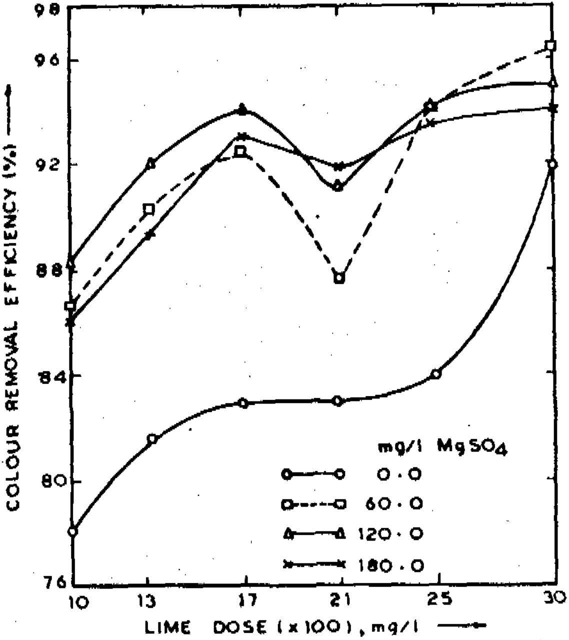

FIG 1: COLOUR REMOVAL EFFICIENCY Vs COAGULANT DOSAGES

The results of SVI of the waste samples with lime alone and after addition of $MgSO_4$ and lime in various combinations are shown in Figure-2. It is apparent from this figure that the SVI values are less than 100 in all cases suggesting good settling sludges. It may, however, be noted that at higher dosages of $MgSO_4$ (beyond 60 mg/l), the SVI values at all lime dosages studied, were greater than those for lower concentrations of $MgSO_4$ (0-60 mg/l), thereby indicating better sludge settling characteristics at lower dosages.

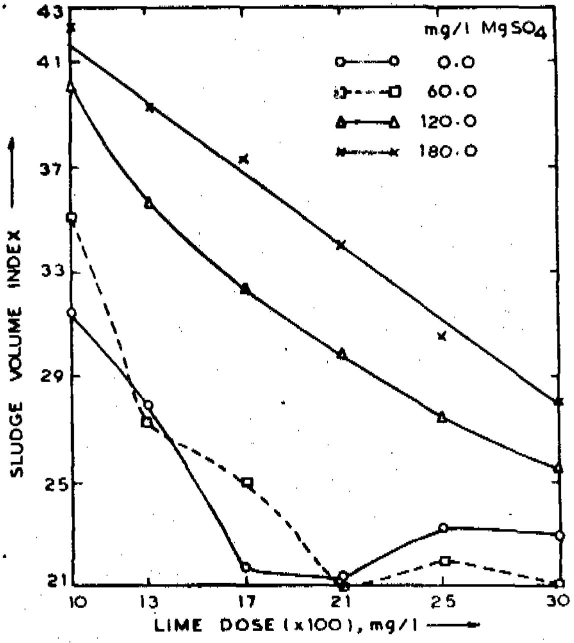

FIG 2 : SVI Vs. COAGULANT DOSAGES

A perusal of figure 3 reveals that drainability decreases with increase in lime dosage at a fixed dose of $MgSO_4$. This may be because of the fact that addition of extra lime produces denser sludges which have low water content and hence poor drainability. It was also recorded that the drop in drainability values was more pronounced at lower dosages of $MgSO_4$ (0-60 mg/l). At high dosages (> 60 mg/l) the drainability showed a linear variation with mild negative slope. Thus it may be inferred that from the point of view of improvement in drainability neither excessive lime dose nor excessive dosage of $MgSO_4$ are helpful.

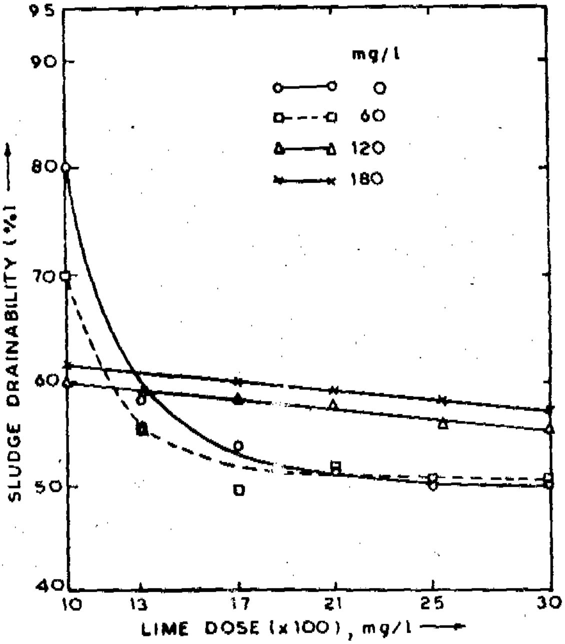

FIG 3: SLUDGE DRAINABILITY Vs COAGULANT DOSAGES

The data collected were analysed for the cost of chemicals required per MLD of wastewater and efficiencies achieved. The commercial cost of lime, $MgSO_4$ and H_2SO_4 were considered as 0.09 US $ per kg, 0.54 US $ per kg and 0.5 US $ per litre respectively. The results of cost of treatment with various efficiencies achieved for lime alone and lime plus 60 mg/l $MgSO_4$ are shown in Figure-4.

It may be noted from figure 4 that for achieving 78-82% colour removal, lime alone can be used economically when the cost may lie between 90-120 US $ per MLD of wastewater treated. The cost on chemicals increases rapidly when lime alone is used for obtaining efficiencies beyond 82% (US $ 270 per day for 90% colour removal). The curve also shows that the cost of chemicals on colour removal for the range 82% to 93% becomes less, if 60 mg/l $MgSO_4$ is also

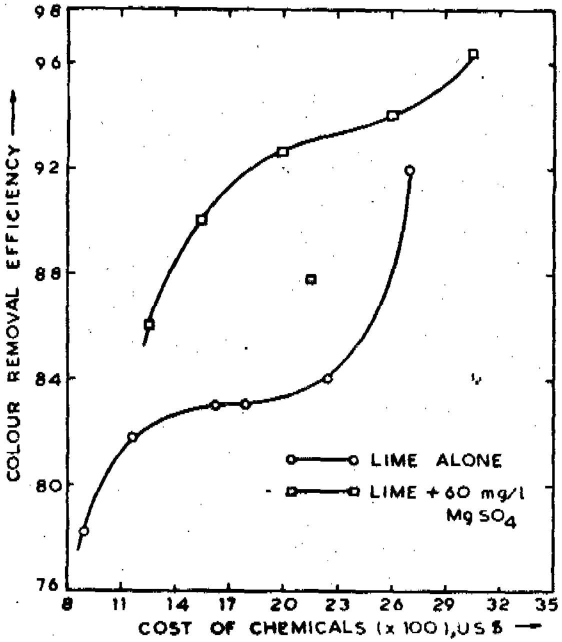

FIG 4: COST OF CHEMICALS PER MLD
Vs COLOUR REMOVAL EFFICIENCY

used in conjunction with lime. The curve has parabolic trend and cost varies from 120-230 US $ per MLD, being 158 US $ for 90% colour removal efficiency using 1300 mg/l lime and 60 mg/l $MgSO_4$. The removal of other parameters associated with this dose were also studied and are depicted in Table-1.

TABLE-1 CHARACTERISTICS OF WASTEWATER BEFORE & AFTER TREATMENT

S.No.	Parameter	Before Treatment	After Treatment
1.	Colour	2871	297
2.	pH	11.3	7.0
3.	Total solids, mg/l	3250	1430
4.	Suspended solids, mg/l	1245	415
5.	BOD, 5 day-20°C, mg/l	460	385
6.	COD	1450	696

The above table reveals that lime aided $MgSO_4$ (60 mg/l lime plus 1300 mg/l lime) has also been able to remove total solids by 44%, suspended solids by 68%, BOD by 17.5% andCOD by 52%.

CONCLUSIONS

On the basis of batch test results reported herein, following conclusions can be drawn.

1. The addition of relatively small concentration of commercial $MgSO_4$ (60 mg/l) reduces substantially the heavy dose of lime (from 2900 mg/l to 1300 mg/l) for effecting 90% colour removal.
2. The SVI of sludges formed at various combinations of lime and $MgSO_4$ were well below 100 indicating good settling characteristics. However, there was a remarkable increase in SVI values of sludges beyond a dose of 60 mg/l $MgSO_4$, indicating comparatively poorer sludges.
3. The sludges produced with lime alone (in lower ranges) had the best drainability; addition of $MgSO_4$ up to a dosage of 60 mg/l had no material difference on the results.
4. While working with lime aided $MgSO_4$, the pH of the settled effluent was found to lie between 10.0-11.5. A reduction of 5-6% in colour was observed after simply adjusting the pH to 7.0, which would be a prerequisite for further biological treatment.
5. From cost analysis, lime alone is found to be most economical for achieving 78-82% colour removal efficiency. However, for removal of colour in the range 82 to 93%, 60 mg/l of $MgSO_4$ used in conjunction with lime is a viable solution.
6. The cost on chemicals using 1300 mg/l lime plus 60 mg/l $MgSO_4$, plus the acid for neutralization per MLD of wastewater comes to around 158 US $ for 90% colour removal. Apart from the colour removal this coagulant dose also removes total solids by 44%, suspended solids by 68%, BOD by 17.4% and COD by 52%.

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GROUNDWATER POLLUTION DUE TO TANNERY EFFLUENTS IN NORTH ARCOT DISTRICT TAMIL NADU

M. SRINIVAS[*], G. TEEKARAMAN[**],And N. FAROOQUE AHMED[***]

The effluents discharged from the tanneries located in North arcot district have caused serious deterioration in the quality of ground water. Consequently, the quality and quantity of agricultural production have gone down significantly. The Electrical Conductivity (E.C) of the analysed samples is greater than 3 mmhos/cm, while the adjusted SAR is much greater than the maximum permissible 16. The Chloride content varies from 601.8 mg/1 to 3113.2 mg/1, far excess than the maximum allowable concentration of 355 mg/1.

oduction:

India has the largest population of cattle and goat in the world ustrial Researcher, April 1980: Table 1) which has provided it the natural ce of becoming one of the leading exporters of leather. The predominant ing areas in India are the Rajasthan, West Bengal and Tamil Nadu. During -79, India produced leather and leather goods worth Rs.1200 crores. Exports inished leather increased from 18% in 1974-75 to 55% in 1978-79, the r importing countries being the East European Countries, North America the Economic & Social Community for Asia & Pacific (Kothari's Economic & strial Guide of India, 1980-81)..

Tamil Nadu is the leading exporter of finished leather providing for of our country's exports of finished leather (Economic Survey 1980-81). Arcot District in Tamil Nadu has a dense concentration of tanneries ring more than 256 located on either side of river Palar (Soil Survey & Use Organisation, Vellore).

In the present paper, an attempt is made to assess the extent of damage d by the effluents of tanneries to the groundwater resources and agriculture.

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ophysicist, Action for Food Production, Geohydrological Investigation Team Hyderabad.

st.Chemist, Soil Survey & Land Use Organisation, Vellore.

st. Chemist, Soil & Water Testing Laboratory, Melalathur.

24 Samples have been collected from 7 affected areas and analysed for the various constituents. The areas affected by tannery effluents being known, suitable remedial measures for treatment of well water and reclamation of soil should be initiated immediately.

TABLE - 1

Livestock: World vis-a-Vis India

Item	World (1)	India (2)	2 as % of 1 (3)	Rank in the world
	(million heads)			
Cattle	1201	180	15	1
Buffalo	132	61	46	1
Goat	404	70	17	1
Sheep	1043	40	4	6

(Source: Industrial Researcher April 1980)

TABLE - 2

Export of leather & leather goods

Year	Rs.in crores
1974-75	165.30
1975-76	227-73
1976-77	306.00
1977-78	257-93
1978-79	350.40
1979-80	524.90*

* Provisional figure as per Economic Survey 1980-81, Government of India.

(Source:Industrial Researcher,
April 1980

nery Effluents:

There are mainly two types of tanning in vogue in North Arcot District, ., Vegetable tanning and Chrome Tanning. A large number of Chemicals are loyed during the various processes of manufacture of leather from raw ns and hides. The various processes of manufacture of leather include king, liming, de-hairing, deliming, oiling, pickling, dyeing and finishing. chemicals employed in the various stages are the chlorides and carbonates sodium, ammonia, and calcium apart from sodium dichromate, myrobalan ract and sulphuric acid. Organic dyes are employed by the finishing units. an average, 35 litres of effluents is produced for every kilogram of ished leather. Our country produces approximately 30 million pieces of es and 62 million pieces of skins. The quantity of effluent produced for e-fourth of this production contributed by the subject area is quite and is very toxic, containing various salts. Table 3 provides details haracteristics of tannery effluents.

TABLE - 3

Characteristics of tannery effluents

Parameter	Vegetable tanning	Chrome Tanning	Finishing units
pH	5.5 to 11.5	7.5 to 10.0	5.8
Total Dissolved salts(mg/l)	1680 to 26520	9000 to 20000	4400
Suspended Solids (mg/l)	160 to 6200	1250 to 6000	800
Chloride as Cl (mg/l)	500 to 7100	1900 to 26200	600
Sulphate as SO_4 (	80 to 2020	--	2040
COD	1000 to 10300	5100 to 7200	276

Source: LEPC Madras

Mode of disposal

The effluents are generally untreated and are discharged into the neighbouring fields and hitherto irrigation tanks. The effluents overflow these tanks which are in damaged condition (Table 4) to form stagnant pools and finally reach the Palar river course. During the course of movement to Palar, there is considerable amount of infilteration of the toxic effluent into the earth. The wells and borewells in the area thus tap the contaminated wa

TABLE - 4

Condition of tanks filled with effluents

Zone	Total No. of tanks	Overflowing	Damaged/Broken
1. Ammankuppam	4	2 (50%)	3 (75%)
2. Parnambut	122	79 (65%)	82 (68%)
3. Ambur	234	192 (82%)	89 (38%)
4. Vaniyambadi	45	32 (71%)	45 (100%)
5. Visharam	31	31 (100%)	15 (48%)
6. Arcot	13	13 (100%)	13 (100%)
7. Katpadi	18	18 (100%)	18 (100%)
8. Ranipet	186	154 (83%)	122 (66%)

(Soil Survey & Land Use Organisation, Vellore)

Drinking & Irrigation of Water Wells:

Table 5 gives the results of chemical analysis of water samples from well located in thetannery-affected zones. Table 6 gives the limits of constituents set for drinking water by World Health Organisation. From the two tables, it is evident that the water is highly un-suitable for human consumption. How the water from these wells has affected agriculture in the region can be understoo from a study of the results of chemical analysis in the light of irrigation water Criteria set by Food & Agriculture Organisation of the United Nations as given in Table 7. It cam be seen that the concentration of various elements

TABLE - 5

RESULTS OF CHEMICAL ANALYSIS OF WATER SAMPLES

Zone	Village	E.C. mmhos/cm	pH	Carbonate mg/l	Bicarbonate mg/l	Sulphate mg/l	Chloride mg/l	Sodium mg/l	SAR	Adjusted SAR
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Ammankuppam	a) Ammankuppam	7.0	7.0	150	1159	24.5	1539.9	947.6	10.87	38.5
	b) Ammankuppam	4.7	7.3	30	264	18.9	1362.8	657.8	9.44	24.54
	c) Veppur	2.1	7.4	30	183	10.1	584.1	264.5	9.56	12.22
2. Pernambut	a) Periathammal Chervu	4.0	7.3	30	244	23.2	1065.5	584.2	9.41	23.99
	b) Chinnathamal Cheruvu	8.7	8.8	60	488	20.4	2672.7	1320.2	14.91	46.22
	c) Erukkambattu	3.5	7.6	30	183	14.9	1044.3	561.2	10.61	13.30
	d) Pernambut	10.5	8.0	120	549	84.5	3115.2	1430.6	14.30	32.89
	e) Erikutti	2.4	7.8	30	264	39.5	637.2	358.8	7.61	17.50
	f) Pernambut	1.5	7.9	--	264	16.3	318.6	207.0	5.20	11.44
3. Ambut	a) Somalapuram	5.5	7.0	60	549	62.4	1469.1	814.2	11.31	32.99
	b) Thavozhi	5.0	7.6	30	427	59.5	1345.2	740.6	10.81	29.72
	c) Tharvozhi	6.0	8.0	60	610	99.4	1628.4	1025.8	13.64	40.92
	d) Govindapuram	2.5	7.3	--	366	83.5	601.8	354.2	7.19	14.39
4. Vaniyambadi	a) Thutipet	6.0	7.5	60	488	84.0	1539.9	913.1	12.41	31.03
	b) Vinnamangalam	3.5	7.0	30	305	103.7	796.5	133.4	1.52	4.41
	c) Udayandram	4.4	7.2	30	366	87.4	1044.3	457.7	5.72	16.87
5. Vishram	a) Talayancor	3.2	7.5	30	24.4	60.0	867.3	409.4	6.69	17.39
	b) Kathivadi	4.7	7.3	30	366	96.0	1026.6	713.0	10.95	29.01
	c) Visharam	--	2.4	30	183	24.0	619.5	372.6	8.22	18.08
6. Arcot	a) Villankuppam	5.2	7.5	30	244	61.44	867.3	409.4	6.69	17.39
	b) Uppupettai	2.7	7.3	30	305	8.64	1575.3	708.4	9.69	25.19
	c) Uppupettai	5.5	7.5	60	305	21.1	725.7	446.2	9.95	27.86
	d) Kukkundi	1.8	7.3	--	122	24.5	477.9	253.0	5.58	16.46
7. Katpadi	a) Katpadi	2.5	7.3	30	183	24.9	743.4	391.0	8.50	17.85

International Standards for Drinking Water

		Maximum acceptable range
Total solids	...	500-1500 ppm
pH	...	7.5 - 8.5
Calcium (Ca)	...	75 - 200 mg/l
Chloride (Cl)	...	200-600 mg/l
Sulphate (SO_4)	...	200-400 mg/l
Copper(Cu)	...	1.0-1.5 mg/l
Zinc (Zn)	...	5.0-1.0 mg/l
Iron (Fe)	...	0.8-1.0 mg/l
Organic Pollutants) (Carbon Chloroform extract)	...	0.2-0.5 mg/l
Chromium (hexavalent)	...	0.05 mg/l
Fluoride	...	1.5 mg/l

(World Health Organisation Standards accepted by Government of India)

*** ** ***

Quality Criteria for Irrigation Water

	No Problem	Increasing problem	Severe Problem
1. **Salinity**			
E.C.(mmhos/cm)	∠ 0.75	0.75-3.0	7 3.0
pH	Normal Range: 6.5 to 8.4		
Total Dissolved Solids (mg/l)	∠ 480	480-1920	7 1920
2. **Permeability** adjusted SAR	∠ 6	6-9	7 9
3. **Toxicity**			
Boron (mg/l)	∠ 0.5	0.5-2.0	2-10
Sodium (as adj.SAR) (mg/l)	∠ 69	7 69	--
Chloride (mg/l)	∠ 1 42	142-355	7 355
Bicarbonate (mg/l)	∠ 90	90-520	7 520

SRINIVAS

is much higher than the Standard values for agriculture. This clearly implies that the water in the tannery-affected zones has become highly unsuitable for both drinking and agricultural purposes as follows from the discussions in later sections.

Discussion of Parameters:

For the purpose of determining the suitability or otherwise of an irrigation water for raising crops, parameters analysed include E.C., Na, Mg, CO_3 & CO_3. The presence of these factors in unfavourable concentrations affects the rrigation water quality. Application of such water to agriculture gives rise o soil salinity and soil permeability problems. As crops basically depend pon water for proper growth, such a situation of salinity and permeability roblems causes several undesirable affects. Crop germination, soil aeration, nd diseases, apart from facilitating weed growth consequent on water stagna- ion are some of the problems that have realised. Yield is yet another actor that is seriously affected.

odium Hazard:

It is well known that Sodium in small quantities when present alone uses severe 'Sodium Hazard' to crop growth. However, crops can otherwise tole- te larger concentration when sodium occurs alongwith calcium and magnesium.

When drying of soil takes place during irrigations, a part of the carbonate d bicarbonate precipitates as Calcium-Magnesium Carbonate (Ca-Mg CO_3), thus moving Calcium and Magnesium from the soil. This process results in an crease of net Sodium concentration present in the soil, thus increasing the dium hazard.

The modified formula arrived at by taking into consideration the presence carbonate and bicarbonate is written as:

$$\text{Adjusted SAR} = \frac{Na}{\sqrt{(Ca + Mg)/2}} (1 + 8.4 - pHc)$$

Where pHc = (pK'2 - pK'c + p(Ca + Mg) + p(Alk).

SRINIVAS

The factors contained in pHc are available in some of the recent editions for various concentrations of Ca & Mg in the form of tables (reference 2). Th adjusted SAR is being employed increasingly as it is capable of predicting th permeability problem more correctly.

<u>Results & Analysis:</u>

The following major conclusions are drawn on the basis of the results of chemical analysis (Table 5) of water samples collected from wells located in tannery-affected zones of Palar basin:

The E.C. values of analysed samples are above 3 mmhos/cm in most of the places falling in the 'Severe Problem' range. Consequently, the germination o almost all the crops has been affected and yield severely reduced. The lowest E.C., 1.8 mmhos/cm and very few values lesser than 3, nevertheless, fall unde the 'Increasing Problem' range wherein the germination gets affected. Moderat salt tolerant varieties come up with reduced yield.

The SAR values more or less lie within the 'No Problem' range. Notwith standing, the agricultural production in the Palar basin has reduced to a fou within a span of 12-15 years, with as large as 40,000 acres of fartile land b coming unproductive(Soil Survey and Land Use Organisation, Vellore). The reas are better understood with the help of the adjusted SAR values listed in Tabl for the same samples.

From Table 7, we find that the adjusted SAR values should be below 9, more than 9 indicating severe damage to crops both in terms of yield and qual In North Arcot District, we however, find that the corresponding adjusted SA values for Irrigation water of E.C. more than 1.6 mmhos/cm range ffom 11.41 46.22 with only one favourable value, viz., 4.41, while the desirable limit should not exceed 16. This abundantly reflects the serious condition of groun water and soil. Again, the values for Chloride range from 601.8 mg/l to 311 mg/l, as against the maximum acceptable value of 355 mg/l for crops and 600 " for human consumption. Even the bicarbonate content is on the higher side of increasing problem ragge.

The effects of these concentrations is manifest on the crops as stunted growth, poor germination, staining, leaf burn, poor quality of grains, fruits etc. The fact that most of the farmers have stopped cultivating crop like Paddy and Sugarcane, and have taken to raising moderately resistant crops like maize and ragi, notwithstanding poor yield, adequately testifies to the deteriorated quality of the groundwater and soil.

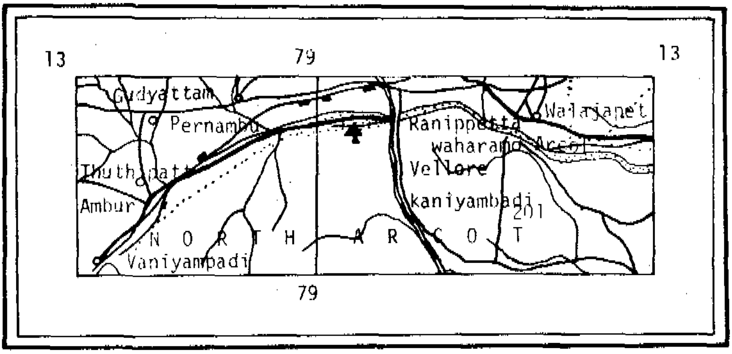
<u>Conclusions</u>:

Groundwater resources are observed to be depleting while the demand is ever increasing. Pollution of this basic commodity assumes greater importance in this context. The major occupation in India being farming, rendering of vast stretches of fertile land useless while the farmers take to other professions for livlihood, should be viewd seriously. Effect on health due to pollution adds an element of urgency to solution-finding.

It is therefore considered essential that pollution control measures are strictly followed by the tanneries. The people have to organise and push the administrative machinery to enforce rules. Even if a small fraction of the exports worth Rs.300 crores from North Arcot District are spent on pollution control and medical care, the erosion of fertile lands and non-availability of uncontaminated drinking water would not occur. The voluntary assumption of responsibility, very much wanting, on the part of the tanners would help find a decent solution to the effluent problem, which is believed to be more socio-economic than technical. The present analysis is considered relevant from this point of view.

SRINIVAS

LOCATION SKETCH



Railway broad gauge with station,
meter gauge
Main through routos road ist class
Stream non perennial

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AN APPROPRIATE TECHNIQUE FOR FLOW MEASUREMENT IN SMALL SEWAGE TREATMENT PLANTS

Percival R. Thomas

Department of Civil Engineering
University of the West Indies
St. Augustine, Trinidad, West Indies

INTRODUCTION

In recent years a number of small sewage treatment plants have been installed and also being planned to be constructed in many rural areas of the developing world. One of the fundamental requirements in the efficient management of these treatment plant facilities is the ability to measure the flow rates without any sophistication, and the common forms of flow measuring devices available are sharp crested weir, broad crested weir and Parshall flume. All these devices have their own advantages and disadvantages and they are by no means simple arrangements. Most of the large treatment plants are installed with a Parshall flume to monitor the discharge continuously. Although the advantages of a Parshall flume are low head loss and self cleansing capacity, it may not be economical to construct it at a small treatment plant in a rural area. This is because in many situations, the plant is too remote and too small to receive more than an occasional visit of inspection and flow monitoring. The other methods of measuring sewage flows involve the use of surface float, tracers and dilution gauging, but these are time consuming and require trained personnel at the site. The main requirements for small plants are reliability without frequent supervision or maintenance, simplicity and economy.

Taking into consideration the above factors, this study was carried out to develop a suitable arrangement in the form of a wooden hump for the measurement of discharge in the small treatment plant. Humps which were used are triangular in profile as shown in Fig. 1 with heights varying from 10cm to 25cm and the crest is rounded off with a radius of 2.5cm. Wastewater contains suspended and floating solids with water content greater than 99 percent and therefore in this investigation, water from a canal is used in a laboratory flume. The advantages of using humps are no moving parts, cannot get out of adjustments, easy construction, low cost, and long life when material chosen is resistance to corrosion and abrasion.

THEORY

The discharge over a rectangular weir is given by[1]

$$Q = C_d . \frac{2}{3} \sqrt{2g.}\ L.H.^{3/2} \qquad \text{..........(1)}$$

where
Q = discharge over the weir in m^3/s
L = length of the weir in metres
H = head over the weir including the head due to velocity of approach in metres
C_d = coefficient of discharge
g = acceleration due to gravity in m/s^2

$$\therefore \quad C_d = \frac{3\ Q}{2.\sqrt{2g.}\ L.H.^{3/2}} \qquad \text{..........(2)}$$

It can be assumed that the discharge Q over a hump weir is given by

$$Q = f\ (h,\ L,\ H_o,\ H_m.\ V_o,\ \rho,\ g,\ \mu) \qquad \text{..........(3)}$$

where
f = a function
h = height of liquid above crest
L = length of the weir
H_o = upstream depth of flow
H_m = height of hump
V_o = upstream velocity
ρ = density of water = density of sewage
g = acceleration due to gravity
μ = viscosity of water

By dimensional analysis using Buckingham's π - theorem eq. (3) can be written as

$$C_d = f_1\ \left(\frac{h}{L}, \frac{h}{H_o}, \frac{h}{H_m}, \frac{H_o g^{\frac{1}{5}}}{Q^{2/5}}, \frac{H_o \mu}{Q\ \rho} \right) \qquad \text{..........(4)}$$

where C_d is the coefficient of discharge which is a function $\frac{h}{L}$, $\frac{h}{H_o}$, $\frac{h}{H_m}$, Froude number and Reynolds number.

The approach velocity V_o may have a considerable effect on the discharge. In practice the velocity of approach is not uniform, particles nearer the surface of the fluid and the centre of the channel having a velocity greater than the mean value V_o. These particles undergo the least change in direction of movement when they pass over the hump. Since the velocity of approach of the particles has proportionately a greater effect on an increase in the flow over the hump, the effective head over the hump may be greater than the observed value, i.e. the actual velocity head may be equal to $\alpha V_o^2/2g$ and α has some value greater than unity. In this investigation α is taken as 1.1 for the calculation of velocity head.

EXPERIMENTAL SET UP

A German tilting glass flume of length 16m and breadth 0.4m was used for testing the humps. The flume was adjusted to give a bed slope of 1/1000. Initially a hump, 10cm in height was fixed approximately at the centre of the flume and water was allowed to pass through the flume from the inlet chamber. Baffles were used to prevent fluctuations in water level upstream of the hump. Water flowed over the hump and discharged on to a tank with a calibrated V-notch, downstream of the flume. For different discharge rates the corresponding heights of water over the hump and upstream depth of flow were measured under steady conditions. The above procedure was repeated for humps of heights 15cm, 18cm, 20cm and 25cm with the other parameters of the hump remaining constant.

OBSERVATION AND DEDUCTIONS

The flow parameters for the humps, of heights 10cm, 15cm, 18cm, 20cm and 25cm are given in Tables 1, 2, 3, 4 and 5 respectively in Appendix. Initially graphs of C_d, Vs. h and C_d Vs. h/H_o were plotted for the different humps. From the graph of C_d Vs. h (Fig. 2) it is observed that for the 10cm hump, the range of variation of the coefficient of discharge with height of water above the crest, is very small compared to the other humps. Therefore the 10cm hump gives the most accurate measurement of discharge under the test conditions adopted. It can also be seen that around the value of h = 5cm the coefficient of discharge for all the humps except the 20cm hump remained at a value of about 1.00. Thus it is possible to take 1.00 as the reference value for the coefficient of discharge and obtain the correction factors. The actual value of the coefficient discharge is very close to unity and some of the values obtained are slightly greater than unity due to minor experimental errors and approximations. The correction factor is a function of h/H_o and the variation of the correction factor with h/H_o for the different hump heights is shown in Fig. 3.

The variation of C_d with h/H_o for different humps is shown in Fig. 4 and it is seen that there is no uniform pattern in the variation among the humps. The behaviour of C_d with hump heights for different heads of flow is shown in Fig. 5 and there is a fairly uniform pattern for the various heads of flow. The pattern for the intermediate heads (2cm - 8cm) and for any hump (10cm - 25cm in height) could be interpolated.

Because of the very small range of variation of the coefficient of discharge with height of water above hump crest for the 10cm hump, a logarithmic plot of C_d Vs. h was obtained (Fig. 6). The variation of log C_d Vs. h is linear and the following mathematical model is obtained for the relationship between C_d and h for the 10cm hump.

$$C_d = 0.95h^{0.003} \qquad \ldots\ldots\ldots \quad (5)$$

CONCLUSION

From the various humps tested, the 10cm hump was found to have a fairly constant coefficient of discharge and hence it is the most satisfactory size for the range of values adopted. Also, the obtained mathematical model confirms that the coefficient of discharge remains fairly constant at different rates of flow for the 10cm hump. Furthermore, the results indicate that as the height of hump increases, the variation in the coefficient of discharge also increases. Therefore, it is seen that flow measurement at small treatment plants can be carried out simply, by installing a hump of about 10cm in height. A calibration curve should be provided where discharges could be read off directly in litres per second for varying heads. A correction factor of 95% could be used to obtain the actual flow or it may be even neglected because of the lesser degree of accuracy needed in a rural sewage treatment plant.

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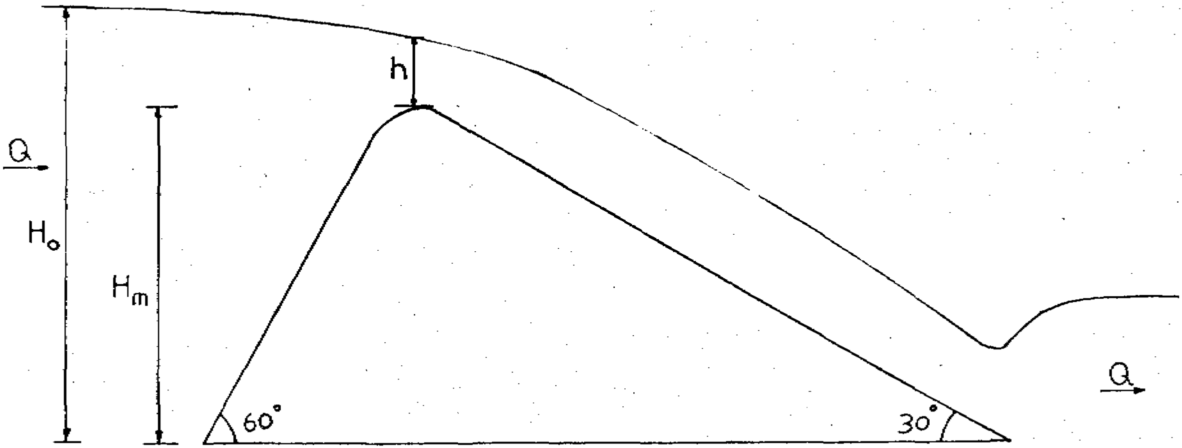


Fig. 1. Specifications of the hump

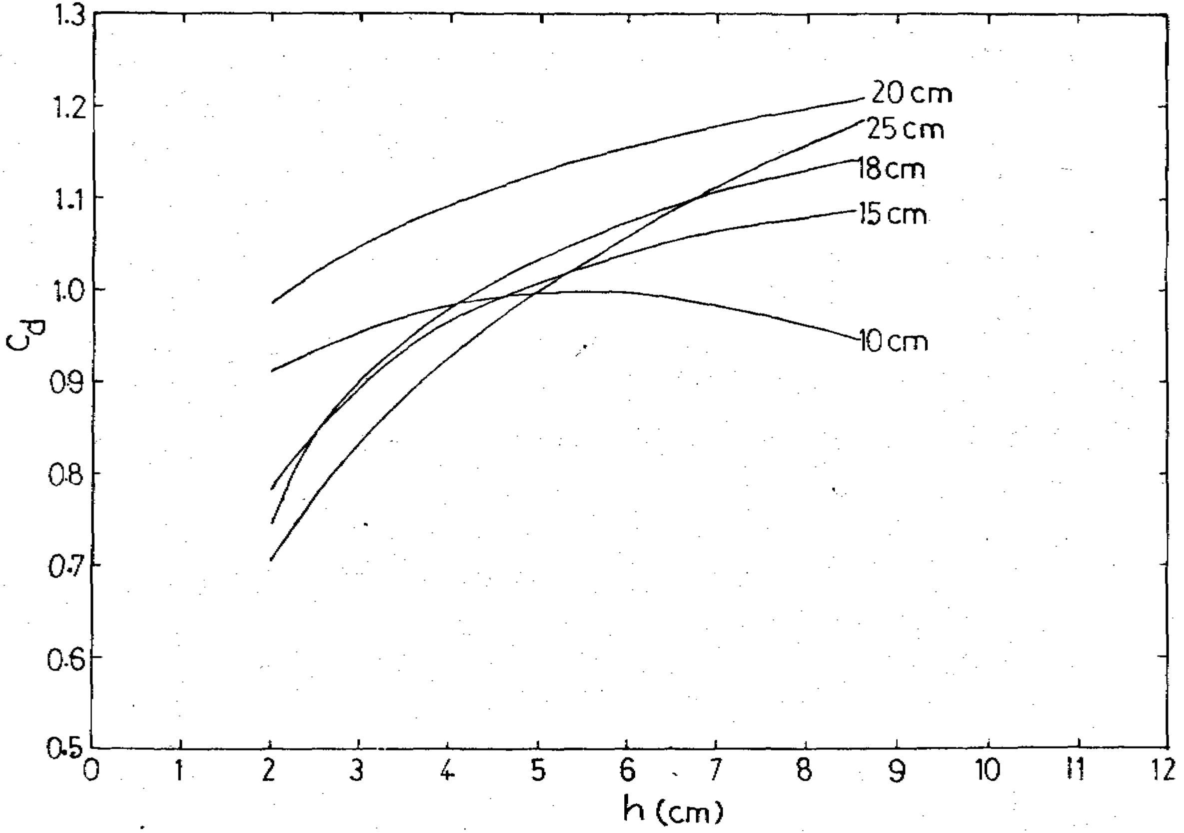


Fig. 2. Coefficient of discharge Vs head over hump

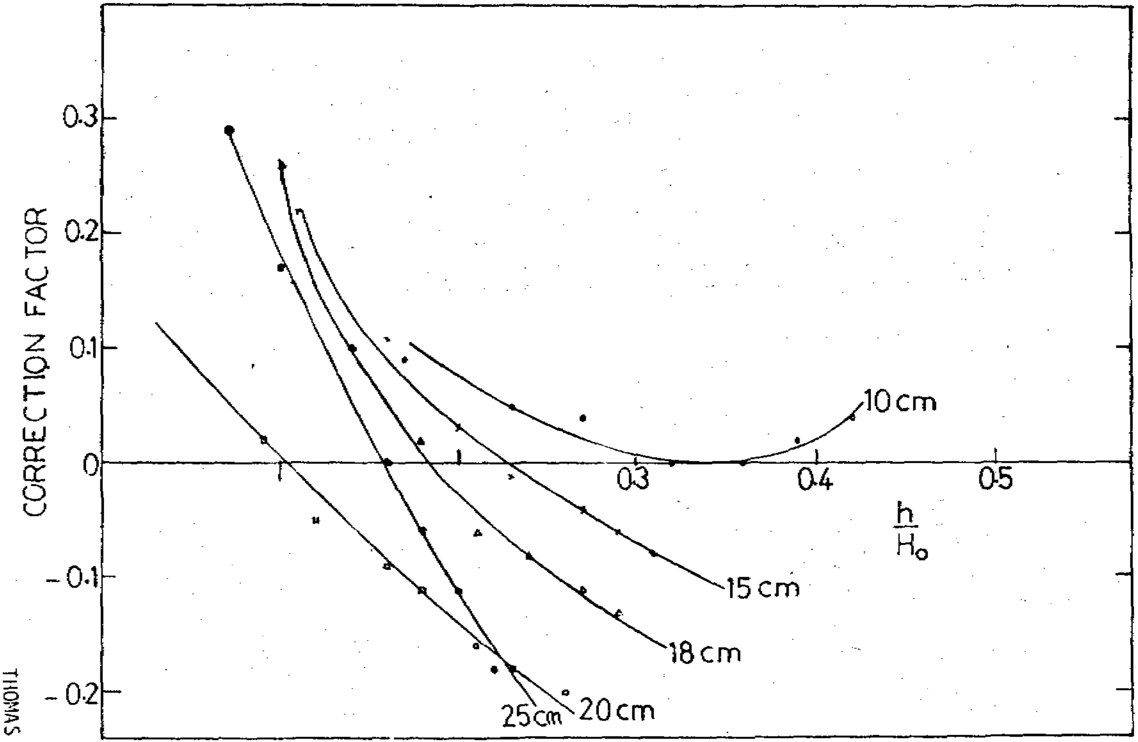
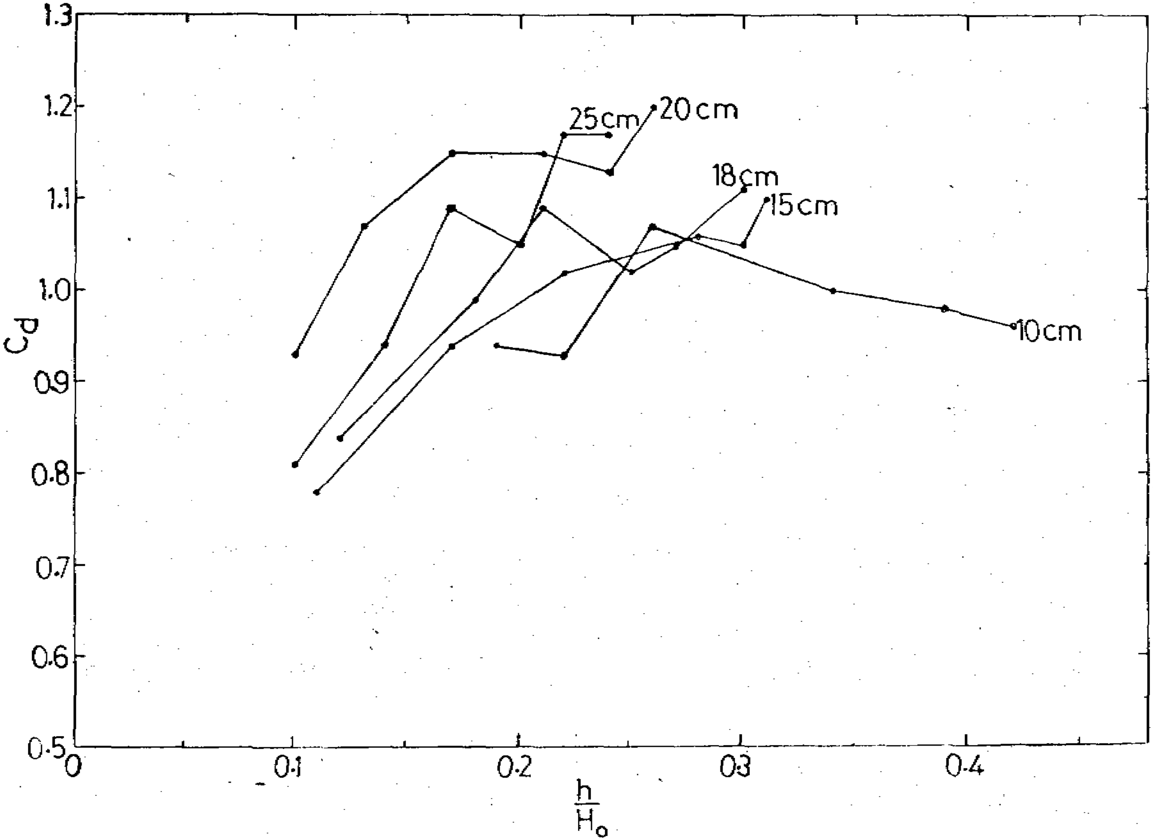


Fig 3 Variation of correction factor with $\frac{h}{H_o}$


1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
Cd
0
0.1
0.2
0.3
0.4
$\frac{h}{H_o}$
25cm
20cm
18cm
15cm
10cm

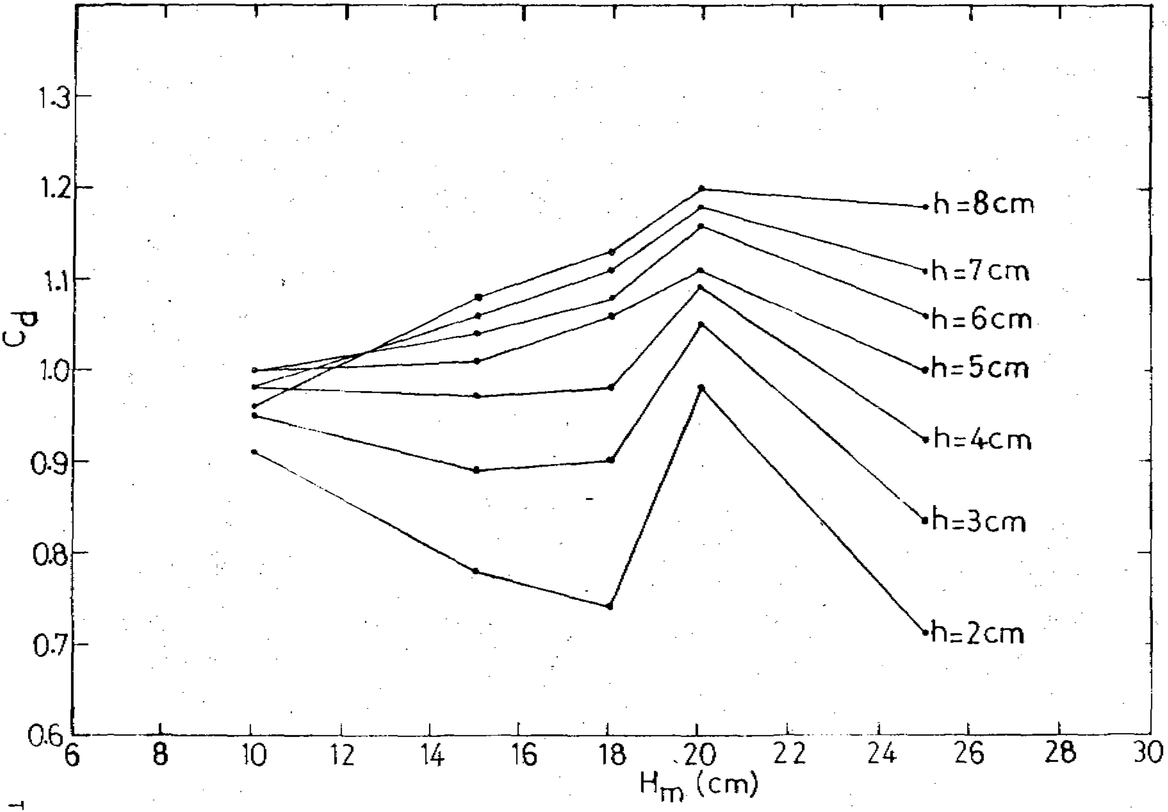
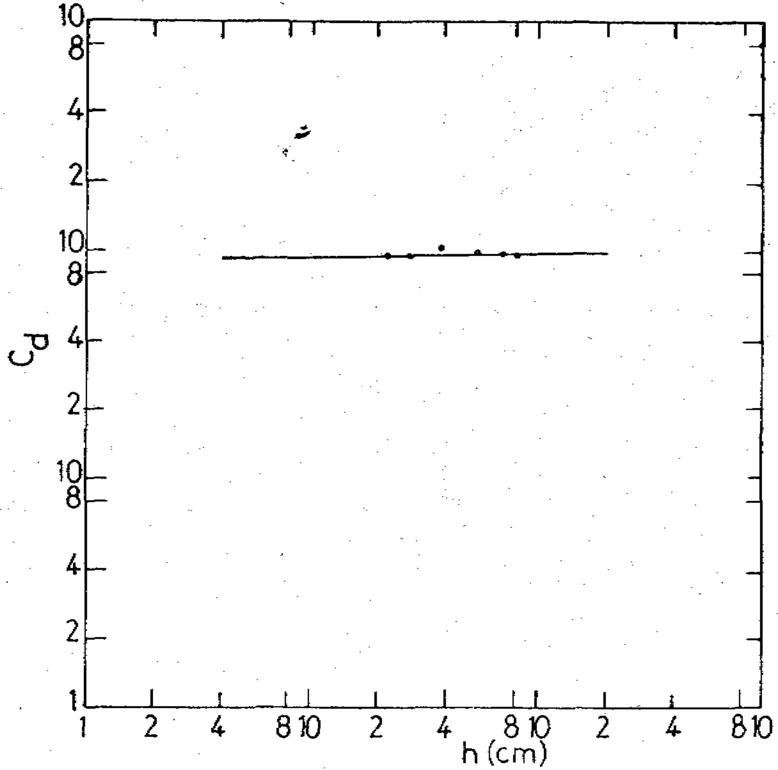


Fig. 5 Coefficient of discharge Vs. hump height


10
8
4
2
10
8
4
2
10
8
4
2
1
C_d
1
2
4
8
10
2
4
8
10
2
4
8
10
h (cm)

APPENDIX

Table 1. Flow parameters for hump of height 10 cm

Q (l/s)	h (cm)	H_o (cm)	$\frac{h}{H_o}$	C_d
3.96	2.3	12.2	0.19	0.94
5.31	2.8	13.0	0.22	0.95
9.91	3.8	14.5	0.26	1.07
17.75	5.6	16.5	0.34	1.00
23.22	6.9	17.8	0.39	0.98
30.58	8.1	19.3	0.42	0.96

Table 2. Flow parameters for hump of height 15 cm

Q (l/s)	h (cm)	H_o (cm)	$\frac{h}{H_o}$	C_d
2.63	2.0	17.5	0.11	0.78
6.80	3.3	19.1	0.17	0.94
12.03	4.6	20.8	0.22	1.02
21.24	6.4	22.9	0.28	1.06
27.38	7.4	24.6	0.30	1.05
32.56	7.9	25.4	0.31	1.10

Table 3. Flow parameters for hump of height 18 cm

Q (l/s)	h (cm)	H_o (cm)	$\frac{h}{H_o}$	C_d
3.96	2.5	20.6	0.12	0.84
9.91	4.1	22.9	0.18	0.99
15.43	5.1	24.1	0.21	1.09
21.52	6.4	25.4	0.25	1.02
24.86	7.0	26.4	0.27	1.05
35.40	8.4	28.2	0.30	1.11

Table 4. Flow parameters for hump of height 20 cm

Q (l/s)	h (cm)	H_o (cm)	$\frac{h}{H_o}$	C_d
3.85	2.3	23.4	0.10	0.93
7.65	3.3	24.5	0.13	1.07
13.59	4.6	26.7	0.17	1.15
20.39	5.8	28.2	0.21	1.15
28.15	7.2	30.2	0.24	1.13
33.98	8.0	30.7	0.26	1.20

Table 5. Flow parameter for hump of height 25 cm

Q (l/s)	h (cm)	H_o (cm)	$\frac{h}{H_o}$	C_d
4.53	2.8	28.4	0.10	0.81
9.63	4.2	30.5	0.14	0.94
15.49	5.3	31.8	0.17	1.09
22.37	6.6	33.5	0.20	1.05
30.58	7.6	35.3	0.22	1.18
37.38	8.6	36.1	0.24	1.17

ENVIRONMENTAL ENGINEERING MANAGEMENT IN DEVELOPING COUNTRIES

Percival R. Thomas

Department of Civil Engineering,
University of the West Indies,
St. Augustine, Trinidad, West Indies.

INTRODUCTION

In 1950, there were only 70 cities with a million or more inhabitants in the world. Today there are about 84 in the developed countries and 74 in the developing countries. By the year 2000, there will be 276 such cities in the developing countries alone.[1] Also, it is anticipated that by the turn of the century almost 80 percent of the world's population will be living in the developing countries and over one billion people will be added to the urban populations of the developing world. Many people in the developing world move to the city for employment and better life but, in today's swelling third world cities, the flood of new arrivals far outstrips the supply of jobs, particularly as modern industries put a premium on technology rather than manpower. In short, it will be virtually impossible to find employment for most of the new arrivals. They have no place to live and accommodation is sought in already crowded houses or by illegal squatter settlements. Generally, the squatter settlements are formed near sources of water irrespective of its quality. Rivers, streams, lakes and canals initially provide best conditions for drinking, bathing and washing clothes until they become polluted. These settelements also appear in the vicinity of garbage dumps and sometimes literally on top of them. All these people and many others living in developing countries lack reasonable access to adequate supply of safe drinking water and proper sanitation with problems particularly acute for urban fringe areas, and for countless small communities in the rural areas. As a result, the major causes of morbidity and mortality in developing countries are water-related and food-borne diseases, and out of these, the water-related diseases are responsible for a vast amount of ill-health, death and disability.

WATER SUPPLIES

The World Health Organization figures for 1980 show that among the urban population of the developing countries, only about 55 percent have house connections and an additional 20 percent have access to public standposts, about half of these supplies are intermittent. Of the rural population, less than a quarter have access to safe water, and hardly any of these have house connections. The following are typical sources of water used by the population:-

1. Rivers, streams, canals and lakes:- These present serious health hazards because they are usually polluted by the use of man and animal.

2. Open wells:- These are likely to create health hazards when they are poorly constructed, unprotected, badly located or too shallow. They may be contaminated by

   a. polluted ground water entering the well as a result from the location of the well too close to pit latrines, soakaways or refuse dumps.

   b. seepage from the surface may enter through the top few metres of the well lining, if it is not sufficiently water-tight near the surface

   c. objects thrown down the wells by children playing closeby and by vandalism

3. Sealed wells and boreholes with hand pumps:- when properly constructed and maintained, this is one of the best forms of supply as long as latrines are not polluting the water table. Usually hand pumps are prone to vandalism and mechanical failure.

4. Springs:- Although these provide clean water, the risk of contamination increases with the number of users especially where springs are left unprotected.

5. House connections:- These provide the ideal safe water supply but all cannot afford in most of the countries.

6. Standposts:- Standposts connected to the municipal supply are probably the most common source of drinking water in urban areas. But the number of standposts is usually inadequate. A shortage of standposts causes communal fighting and long queues, due to overcrowding. As a result, the people tend to look for other sources.

> Public standposts are badly connected and frequently damaged. Water is wasted by leaking taps and money is wasted in repeatedly repairing them. There are also the dangers of standing pools which soon become polluted. People sometimes wash themselves in these pools and children defecate close to the standposts. The provision of more public standposts does not necessarily increase community water use, but reduces the number of households using each. A standpost serving a small group of people is more likely to be looked after and less likely to be broken by overuse or vandalism.

In many developing countries, water distribution system is one of the main problems of the Environmental Engineers. As much as 60 percent of the water entering the system may be lost as leakage and the water pressure may be inadequate to reach certain areas. A number of unauthorised connections are made to water mains by individuals. Also, in many towns and cities, overloading of the system results in providing only an intermittent supply of water, which can have serious health hazards.

The main problem in many rural areas of African countries is getting the water to the houses. Mostly water is brought by women, boys and girls in dirty containers and also they use animals to carry them. Usually the source is a polluted well, stream, river or a public standpost. An extensive survey of the water use in East Africa[2] has shown that water carriers in rural areas spend a mean time of about 45 minutes per day collecting water and that in some communities up to 4 hours per day are required. Water is used from the same containers for drinking as well as for anal cleaning. Adults are quite ignorant of the dangers of drinking contaminated water and they prefer to collect water from a nearby polluted source rather than from a distant clean source.

For some communities, piped water supplies with house connections are not economically feasible. In such circumstances, the realistic choice is to provide a number of individual or 'point' sources, a protected well with a hand pump, a spring water tapping structure or perhaps a rain water collection and storage system. In certain towns and villages, a small water treatment plant and distribution of water through public standpost may be feasible. Although the process of water treatment offers a variety of technological choices, only a few of them can in principle fully meet the specific requirements of developing countries. One such method is slow sand filtration - a simple, efficient, cheap and reliable technique for the treatment of water.

SANITATION

Water supply and sanitation must go together with the Environmental improvement programmes. The provision of safe drinking water alone will often fail to produce substantial results in terms of public health improvement, if the community water supply is not supplemented by proper waste disposal systems. Normally in the developing world, sanitation programmes are not on par with water supply development and the situation is shown in Table 1 as given by the International Reference Centre for Community Water Supply and Sanitation[3]. This is attributed to the rapid population growth in the developing world.

If excreta disposal is neglected or inadequate, then there will be an open invitation for water-related diseases. In areas which are not serviced by municipal systems, people handle excreta disposal in many ways and the most common ones are

1. Defecation in open grounds and beaches: - This is a normal practice in rural areas of developing countries. The restricted sites of crowded cities, however, make this difficult in urban areas.

2. Bucket Latrines:- These are still popular in many towns and cities of developing countries because they are cheap. In certain Asian countries, manual labour is used for excreta collection from bucket latrines, and the society treats these men and their families as 'untouchable' low cast. As a result they are prevented from participating in religious, cultural and social functions with the majority population. Also, open buckets give rise to odour in the vicinity and attract flies and insects.

3. Wrap and Carry:- This is common where there are suitable places for dumping closeby which results in the area getting polluted.

4. Wet and Dry Pit Latrines:- This is probably the most common method of excreta disposal and many pit latrines are simply holes in the ground. Where water is used for anal cleaning there is a chance of contaminating water sources and also, ground water can be polluted particularly during rainy seasons.

Various other methods in use are overhung latrine, septic tank, aqua-privy etc.

Furthermore, communal latrines or toilets provided in many locations present a major environmental hazard due to lack of

Table 1: Percentage of Population adequately served

RURAL	1970(%)	1975(%)	1980(%)
Water Supply	14	22	29
Sanitation	11	15	13
TOTAL (urban and rural)			
Water Supply	29	38	43
Sanitation	27	33	25

individual responsibility. These are provided because of economy but the price is paid in the consequences of the resulting poor standard of sanitary conditions. Once a latrine is fouled by misuse or accident, the next user may have no choice but to foul it further. As a result, a chain reaction sets in and the latrine becomes unusable. Also, public latrines may be far-off from some houses and because of no proper access, people tend to avoid using them. To achieve even a minimum standard of hygiene, strict control and constant attendance of cleaners are required in addition to the users responsibility.

SOLID WASTES

In a developing country's environmental improvement programme, normally very little thought is given to the proper disposal of solid wastes and it needs to be integrated with the total environmental plan.

The most popular method among many municipal authorities is the uncontrolled or indiscriminate tipping which causes a revolting stink due to rotting vegetation, animal and faecal matter and create environmental problems. Also, this results in choking of drains and canals. Usually the garbage tips are crowded with men, women and children salvaging material and they are being competed by dogs, stray cattle and birds. Furthermore, municipal disposal systems are often inadequate, broken-down or inefficient due to out-of-date plant and vehicles. Rat and fly breeding are encouraged by heaps of rotting refuse, which will also aid mosquito breeding by rain water getting stagnant in cans, tyres, containers, etc. In addition, badly dumped refuse can pollute surface water and ground water after rainfall.

Controlled tipping (sanitary landfill) incineration and composting are three suitable methods of treating and disposing solid wastes if practised with care, and the appropriate method to be selected to suit local conditions.

ASSOCIATED DISEASES AND CONTROL

Control or elimination of water-related diseases depends on adequate sanitary disposal of human wastes and solid wastes and protection and purification of water supplies. The most common water-related diseases and their preventive strategies are given in Table 2.

Table 2: Water-related Diseases and Preventive Strategies

GROUP	DISEASES	PREVENTIVE STRATEGY
Water-borne diseases	Typhoid Cholera Gastroenteritis Infectious Hepatitis Dysentery	Improve quality of drinking water and excreta disposal facilities
Water-washed diseases	Scabies Leprosy Trachoma Conjuctivitis Diarrhoeal disease	Increase the quantity of water used. Improve hygiene
Water-based diseases	Schistosomiasis Guinea Worm	Reduce the need for contact with contaminated water. Control snail population. Prevent surface water contamination by excreta.
Diseases with water-related vectors	Yellow Fever Malaria Dengue Sleeping Sickness Filariasis	Destroy insect breeding sites. Improve surface water management.

COMMUNITY PARTICIPATION AND HEALTH EDUCATION

In the recent past a number of evaluation studies have been carried out on water supply and sanitation projects and many of them have stressed the need of active community participation and support to achieve their goals. Before planning for environmental improvement, one must be unclouded on the expectation of success of a particular system. For this reason, it is necessary to enquire into the background, level of technology, and health literacy of the people before evaluating a system in any particular situation. The users may not be satisfied with the system provided, if it does not meet their requirements. Planners and Engineers often go to communities, install water supply systems and sanitation facilities and expect the people to use them with care for long periods of time. Usually the communities to be served are not consulted on matters, of planning, design, construction, use and maintenance of the facility. If the installations are not accepted and supported by the community, they are vulnerable to misuse, pilferage or vandalism. Failure of certain projects in some countries can be attributed to cultural, social and religious factors, often neglected by planners, because of no community involvement. Some of the examples are sons-in-law and mothers-in-law will not use the same latrine and the restriction in Muslim countries against defecating while facing Mecca.

It is to be realised that the community participation is not aimed at, to displace or override the responsibility of the planners or government agencies in the Environmental programmes. It is to supplement and help the professional planners in providing additional information on the realistic needs, wants and special characteristics of the society. Communities should be involved in allocation, planning, design, construction, operation, maintenance and administration of the project.

The degree of literacy in a country has a direct relationship to that country's health status and it is a fundamental prerequisite for ensuring that the community has access to basic health education to enjoy the benefits of the International Drinking Water Supply and Sanitation Decade. In addition to community involvement, the society should be taught how to use, protect and maintain their installations for healthful living. Simple instructions in water hygiene such as protecting it, collecting it and using it safely will enable the community to avoid preventable diseases. The water instruction should be followed by others, such as, personal hygiene, excreta disposal and, refuse collection and disposal.

CONCLUSION

Environmental Engineering Management in developing countries greatly concerns the engineering methods for the improvement of the health of a community by the provision of safe drinking water and proper sanitation appropriate for the local environment. Community participation and health education are indispensable elements in the evolution of environmental sanitation programmes especially in their formulation, implementation, maintenance and administration.

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ENVIRONMENTAL HEALTH IMPACT ASSESSMENT: A REVIEW OF ITS STATUS

Paul Tomlinson

Centre for Environmental Management and Planning,
University of Aberdeen, Scotland, AB9 2UF, United Kingdom

INTRODUCTION

As development has increasingly been recognized as a cause of serious health and ecological effects, so efforts have been made to develop health impact assessment (HIA) methodologies. Two fundamental difficulties have been encountered. First, there is a lack of epidemiological knowledge regarding dose-reponse relationships, and second, existing health impact data may be confidential, hence preventing the health component of environmental impact statements (EISs) using or presenting morbidity or mortality projections. As a result, the health component of EIA has been poorly developed. Environmental Health Impact Assessment (EHIA), can be seen as part of the EIA process, since both are founded with similar objectives, both have similar methods and techniques, and are faced with similar difficulties. Present day abilities to identify and predict are inadequate due to our limited understanding of ecological processes. EHIA is, therefore, built upon weak foundations, added to this EHIA has its own inherent difficulties which compound the problem. This is not to say that EIA and EHIA should be abandoned until the tools become available, since the knowledge gained by their present use, if the constraints are recognized, will be vital in the development of improved methods and techniques.

In order to resolve this situation the World Health Organization (WHO) has initiated numerous programmes which either provide fundamental data or develop additional methodologies. For example, in 1973 WHO established the Environmental Health Criteria programme to assess the health effects of pollution (Miller, 1983). WHO (Regional Office for Europe) have sponsored training activities and developed new methodologies and guidance manuals (ERL, 1983 and WHO, 1983a and 1983b).

The purpose of this paper is to highlight the need for environmental health impact assessment (EHIA) by examining some of the adverse health consequences of human actions, and to describe the stages in EHIA pointing out some of the issues surrounding the various methods and techniques. Finally a review of the state of the art of EHIA in relation to environmental health factors will precede a discussion of difficulties and future developments.

Before highlighting the need for EHIA, it is appropriate to present a few definitions.

DEFINITIONS

Public health management consists of prevention and avoidance of adverse effects on humans of biological, physical and chemical agents. Prevention involves the control of human/environmental interactions, consisting of both the physical and social environments, as well as the promotion of human well-being through individual and community behaviour. Primary prevention is strongly associated with both resource management and pollution control. Avoidance consists of organized community measures to remedy adverse effects after they have occurred.

Environmental health factors are those environmental factors recognized as having a strong health significance. Such factors are not, per se, agents of disease, however they may facilitate human contact with infection. Sensitivities to environmental health factors may vary from one individual to another. Groups of individuals at greatest risk are termed "risk groups".

Exposure is the term given to the intensity or duration of contact between a human being and the disease agent or environmental health factor.

Environmental health impact assessment (EHIA) - is the assessment of the consequences of a proposed action for those environmental health factors recognized as having direct or indirect health impact. In addition, EHIA also includes an assessment of the changes in human exposure, both in terms of numbers and intensity with due consideration of the high risk groups.

ADVERSE HEALTH CONSEQUENCES OF HUMAN ACTIONS

Problems of urban poverty, unemployment, inadequate housing, poorly developed urban infrastructure, rapid urbanization and industrialization are well known. In developing countries, these problems are exacerbated by climate, rapid population growth and the lack of resources to respond to the problems. Human and solid wastes that are not properly disposed of pose a severe problem to human health. Water supplies may be contaminated causing direct health risks, economic loss and impairment of water and ecological quality which may also pose problems for downstream users. Industrial wastes, often poorly controlled, are emitted, frequently next to residential areas. Hazardous wastes, such as poisons, inflammable materials, explosives, biologically active chemicals are often disposed on land leadnig to actual or potential groundwater or land contamination (Tabasaran et al., 1983).

Atmospheric emissions from industrial processes and transportation networks contribute to increased levels of particulates, hydrocarbons, suphur dioxide and other pollutants. Some cities are more susceptible to air pollution due to their physiographic and meteorological characteristics. Deaths from lung cancer have been increasing with air pollution appearing to be a significant factor. The hazards of air pollution have been well documented, for example, Doll (1978) suggested that the higher incidence of lung cancer in urban areas might be due to the presence of carcinogens and the effects of smoking. Kamat et al., (1980) found correlations between nitrogen dioxide, sulphur dioxide and particulates with colds and coughs.

Inappropriate allocaton of urban land for development is an important cause of environmental degradation. Development on steep slopes gives rise to soil erosion and the resulting sediment then pollutes water courses, impedes drainage systems and frequently increases the probability and magnitude of flooding downstream. Urban expansion into wetlands not only increases the risk of flooding, but may also threaten the livelihood of dependent communities either by increased contact with agents of disease or loss of a resource base such as a fishery. Overcrowding results in social and health problems, but improvements in medicine and greater awareness of disease vectors to some extent counteract these effects by reducing the severity of communicable epidemic diseases. The scale of urban health problems in developing country cities can be indicated by life expectancy data. this figure is estimated to be about 53 years in developing countries in contrast with 70-75 years in developed countries (Pearce, 1983).

While priorities in developing countries may be assigned to basic sanitary measures and waste management, pollution control is a closely related factor also requiring consideration. Indeed, WHO (1983c), has established the specific objective of the protection of human health from the adverse effects of environmental pollution and other environmental hazards. Other specific objectives outlined in the seventh general programme of work (1984-1989) include the promotion of human health through the support of member states in:

a) the provision of safe community water supply and sanitation;
b) the recognition and control of environmental conditions and factors in rural and urban development and housing;
c) protection from unsafe or potentially unsafe food through the prevention of health hazards associated with microbiological and chemical contamination and additives.

Developing countries suffer health burdens due to both poor levels of health care provision and the nature of the development process itself. In addition, the environment is often more fragile, either because of climatic conditions or heavy population pressures. As financial resources are limited, projects may be implemented hurriedly without sufficient attention being paid to assessment, prevention and mitigation of potentially adverse human health consequences. In addition, the lack of finance may even prevent serious adverse health impacts from being resolved. Careful study of environmental health considerations in the planning stages of development is crucial. Prevention may, in fact, be the only option available. In order to successfully implement a process of prevention, a mechanism must be developed which allows the rigorous identification of potentially adverse health impacts. This is the purpose of environmental health impact assessment.

When countries balance expenditure on economic development against public health investments, pollution control and environmental protection have often been seen as secondary needs. It is important to establish the reality of environmentally induced health hazards, and that expenditure on EHIA does have an economic return. It is difficult, but not impossible, to quantify the costs of health effects for example in terms of medical costs and working days lost. The costs of preventive measures can be more readily established. World Bank experience, since the early 1970's, has indicated a prevention cost usually between zero and 3 percent (Gushee and Abbasi, 1983). Indeed, early consideration of environmental health factors in the project planning stage can be achieved possibly at a very small cost. It is important that the costs of corrective measures are also estimated, since the costs of prevention have been found to be considerably less than those of correction.

Schaefer (1983) identifies ten desirable national health policy elements, one of which is a preventive stance (see table 1). As noted earlier, it is vital that projects and programmes are evaluated at the planning stage. It is even more crucial, however, that such evaluation does not occur in a vacuum. EHIA should be performed within the framework of more comprehensive reviews and projections of environmental health trends, in order to avoid the errors that can arise from incremental decision-making. For example, the cumulative consequences of urban development upon the urban and supporting agricultural and medical infrastructure must be given due consideration. The application of EHIA, in an EIA context at a national development plan level, could provide an opportunity to incorporate environmental health and resource management policies, into the development process, facilitating economic development without impairing public health or environmental quality. Indeed, if some of the land use planning techniques, such as overlay maps (see figure 1), were applied in the national plans, then many environmental threats to human health might be avoided and critical resources protected by the correct allocation of development land. Such "up-front" environmental planning could

Table 1 National Health Policy Elements

1. Linkage of pollution control with socio-economic development planning - public policy statements on pollution control should clearly pronounce those health and social values to be considered in the evaluation and decision-making processes.

2. Preventive Orientation - evaluation of projects and programmes should seek to minimize health effects at the planning stage.

3. Relative benefits orientation - recognition of inter-relationships between risk and cost and benefits during the assessment of development activities.

4. Comprehensiveness - pollution control policies should cover the full range of subjects pertinent to the country's situation. Concern for the acute, and sub acute short term and long term effects should be established within a priority scale for pollution control prgrammes based on relative severity, available resources and possible mitigating measures.

5. Basis for Co-ordination - pollution control policies must establish objectives and rules for coordination of information, evaluation, decision making and implementation.

6. Legal Structure and Process - policies may be expressed in law and it is desirable to assure comprehensiveness and consistency. Such laws should establish broad policy leaving subsequent easily modified regulations to provide the details.

7. Structures for policy monitoring and change - an intersectoral body to review and update policies in the light of development.

8. Role of health authorities - the role and responsibilities of the national health authority in relation to pollution control should be explicitly stated in national policies and in implementing legislation.

9. Public involvement - national policies depend for their motivation, support and implementation on public opinion and co-operation, consequently the development of needed attitudes and behaviours requires public education in health and pollution control.

10. International Aspects - National pollution control policies must address issues which are transboundary in nature such as where nations share a common resources eg: river basin, and in terms of international trade and the development of 'pollution havens'.

(Adapted from Schaefer, 1983)

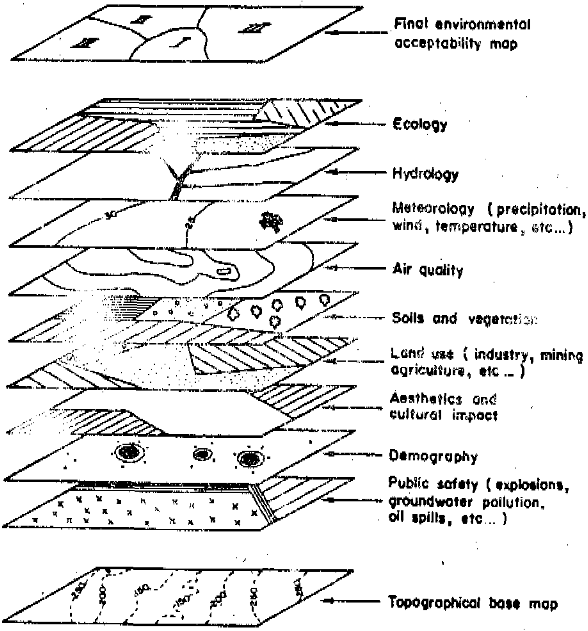

Figure 1. Schematic Representation of Overlay Mapping (From Pearce, 1983)

save time and money required at the project planning stage. The tiering of EIA and the accompanying EHIA is one mechanism to prevent individual projects experiencing protracted delay due to EHIA considerations. Tiering is the term given to the structured relationship between policy level environmental assessments and lower level plan, programme and project assessments. Ideally, the higher level assessments provide the wider framework for the more detailed and specific lower level assessments. For example, an assessment of urban development policy in relation to health may provide directives on which determine where industry may be safely situated in terms of potential hazards to health.

STAGES IN PROJECT EHIA

Over the years, a number of methods have been developed to assist in the process of identification, prediction, assessment and presentation of the findings and recommendations of impact studies, such as networks, matrices, weighting-scaling checklists etc. These methods, with a little adaptation, are applicable to the needs of EHIA, since it too seeks to assess the consequences of actions on environmental health factors. By such means it is possible to estimate the potential changes in the health situation and then assess these in terms of morbidity and mortality.

Project Screening

The first consideration in both the EIA and EHIA processes is the determination of whether an assessment is required. This activity is termed screening, since it screens out those projects not requiring consideration. Screening activities can be undertaken by a number of possible methods, such as positive and negative lists, matrices or checklists. Tomlinson (1984) provides a detailed account of screening methods. The purpose of screening is not to present a detailed investigation of potential impacts, but rather to provide an initial investigation of what are often termed "red flags". Such red flags provide early indications that environmental or health interests may be at risk.

Scoping

Scoping is the term given to the process of developing and selecting alternatives to a proposed action and identifying the issues once screening has identified the actions needing an EHIA. Essentially it is a procedure designed to establish the terms of reference of the assessment. It's aims are:

a) to identify concerns and issues requiring consideration,
b) to facilitate an efficient assessment process;
c) to enable those responsible for the assessment to properly brief the study team on the alternatives and impacts to be considered at different depths of analysis;
d) to provide an early opportunity for public comment;
e) to save on finance and time;

Scoping is not a discrete exercise, and may well continue into the planning and design stage as knowledge surrounding potential impacts improves. A more detailed account of scoping may be found in Tomlinson (1984).

Impact Identification

There is generally considerable overlap between scoping and impact identification, since scoping, out of necessity, involves some degree of impact identification. It is useful to distinguish between the words effect and impact. The former is used to describe a change of unknown significance, while the latter is used to define a significant change. The identification of possible effects arising from an action requires a systematic consideration of development/ environment interactions. The word systematic is to be stressed, as too often the obvious effects are identified only to overlook the indirect effects or inter-relationships between effects. It is important to also note that impact identification, although generally regarded as the identification of adverse impacts, should also identify positive impacts arising from the action, as these may out-weigh the negative ones.

The first stage in the identification of effects is to determine all the actions of the proposed development which may interact with the environment, and in particular with the environmental health factors. Checklists have been produced for various project types in which the individual project actions are itemized (for example, see table 2).

The second stage requires the identification of the potential effects from each of the project actions. Again checklists have been prepared (for example, ERL, 1983, see Table 3 and World Bank, no date). It is important not to use such checklists blindly, but rather to use them as the basis for the particular assessment. All too frequently, indirect impacts are overlooked, and in this context the use of networks is a very useful method (Bisset, 1983 and Canter, 1983).

During the identification of potential impacts other points require consideration:

a) effects may be reversible or irreversible, repairable or not repairable;
b) effects may arise in the long or short term, they may be continuous or temporary, and increase or decrease with time;
c) effects can be local, regional, national or global;
d) accidental or worst case analysis should be performed;
e) secondary development may be stimulated by the proposed project which may in turn cause health concerns;
f) the activity may establish a precedent ultimately resulting in greater environmental and health effects.

Table 2 *Checklist of possible components of water resource development and irrigation projects.*

Construction Activity eg: temporary access routes and accommodation;
introduction and re-emigration of immigrant workforce;
clearance of vegetation;
noise and dust.

Diversion of existing water courses.

Tunnelling.

Construction of dams.

Inundation of land to create reservoirs.

Operation of spillways

Operation of hydro-electric power generation.

Construction and operation of irrigation and drainage channels.

Irrigation of land.

Changes in agricultural practices eg: crops; methods of cultivation; intensity of cultivation.

Introduction or expansion of fisheries.

Relocation of communities.

Provision of water supply, effluent and waste disposal facilities in new and relocated communities and in temporary communities during construction.

Provision of infrastructure for permanent and temporary communities including: roads, jetties and other transport facilities; social services; utilities.

Water resource management measures including: level control; distribution of irrigation supplies.

Maintenance measures including: pest control; channel clearance.

Measures for health protection: of construction workers; of residents.

(Adapted from ERL, 1983)

Table 3 Checklist for Potential Health Impacts of Water Resource and Irrigation Projects.

A. Direct Impacts on People in the Project Area:

1. Will new diseases or new strains of the disease be introduced by immigrations of construction workers or new settlers? Will these affect new settlers or residents or both?
2. Will relocated communities be exposed to locally endemic diseases to which they have little or no immunity?
3. Will new settlers be exposed to locally endemic diseases to which they have little or no immunity?
4. Will food, waste or water cycles aggravate sanitation and disease problems?
5. Will housing and sanitary facilities become overburdened, misused or not used at all, leading to conditions conducive to increases in water washed diseases and spread of communicable diseases by the facal-oral route?
6. Will soil and water be contaminated by excreta, facilitating spread of communicable disease?
7. Will introduction of migrant workers cause increases in venereal disease among workers and subsequently residents?
8. Will new settlers and relocated communities be exposed to physical, social and cultural changes leading to psychological strains and traumas? These may include changes in lifestyle and employment.
9. Will changes in food supplies lead to possibilities of malnutrition, nutritional deficiencies or toxic effects?
10. Will effluents and emissions, or substances released intentionally into the environment (eg pesticides) pollute air or water or soil presenting a threat to human health?
11. Will irrigation of fields increase opportunities for human contact with water borne, water based and water related disease?
12. Will traffic in the area, and therefore road accidents, increase as a result of the development?
13. Will new industries and similar activities attracted to the area by growth, result in pollution of air, soil or water or noise, with subsequent impacts on human health?

Table 3 (Contd)

B. Indirect Impacts Through Effects on Disease Vectors

1. Will new vectors be introduced into the area from upstream as a result of hydrological changes?
2. Will new vectors be introduced into the area on vehicles, animals, transplanted plants, soil, etc?
3. Will existing vectors be infected or reinfected by contact with infected humans coming into the area?
4. Will the prevalence and distribution of existing infected vectors be changed by changes in the availability of suitable habitats for breeding and survival?

C. Direct Impacts on Workers:

1. Will migrant workers be exposed to locally endemic disease to which they have little or no immunity?
2. Will migrant workers be exposed to psychological strains and traumas from changes in living and working conditions?
3. Will workers be exposed to physical threats to the safety (injuries, deaths) or chemcial and physical hazards to health (toxic substances, noise, vibration, radiation, high pressures, etc)?
4. Will workmen be particularly exposed to contact with water and thus with water associated disease during their work?
5. Will workmen be exposed to dangerous animals during their work (snakes, scorpions, etc)?
6. Will adequate supplies of food be provided to prevent malnutrition and minimise spread of disease (eg by use of itinerant food vendors)?

D. Impact of Health Services:

1. Will health and other social services be overburdoned with consequent effects on health of residents and workers?

(From: ERL, 1983)

Impact Prediction

The objective of prediction is to determine the nature and extent of the impacts arising from the development. This information is then evaluated for its significance, and is used in the comparison of alternatives generated from the scoping exercise in order to determine the preferred alternative with regard to health and environmental considerations. The degree of sophistication of the predictive techniques employed should be relative to the information required. Simplistic worst case predictions may suffice in the majority of situations. If, however, expenditure on mitigation measures is required then a more refined technique may be necessary. The specific objectives of prediction are as follows:

a) to suggest how the environment - comprising both environmental and environmental health factors - will be affected by the project;
b) to indicate to environmental and habitat factors affecting diseases:
c) to predict the effects of change in these factors or disease vectors;
d) to predict the changes in exposure to health hazards;
e) to predict the consequences of changes in exposure on risk groups in terms of mortality and morbidity.

Before predictive techniques can be applied, a number of items of information are required, namely:

a) a description of the existing state of the physical, biological and human environment;
b) a description of existing trends;
c) the availability of and access to predictive techniques;
d) adequate knowledge of the dose response relationships.

The basis of prediction is information. ERL (1983) presented some information on ways of obtaining baseline information for EHIA, one of which was a questionnaire checklist (see table 4). While an array of techniques has been created to predict the effects a project may have on the environment, a number of difficulties arise, such as uncertainty as to their appropriateness for less developed countries, since they have generally been designed for a developed country application. Nevertheless, an extensive range of predictive techniques such as air pollution models, are being developed although their application may be constrained by the lack of an adequate environmental data bases.

Once the prediction of changes in environmental health factors has been completed, the task becomes one of predicting how these changes will influence disease vectors, toxins and pathogens etc. The degree of health risk posed by environmental health factors is, in part, influenced by the physio-chemical properties of the recipient environment. The toxicity of a pollutant may be reduced by specific

Table 4 Checklist of Questions on Obtaining Baseline Information

1. What are the major health problems current in the population, what is the level of infection and degree of resistance?

2. What are the environmental transmission pathways for existing diseases?

3. What habitats are important for breeding and feeding of disease organisms and vectors?

4. What are the life-cycles of important disease organisms and vectors?

5. What are the numbers, locations and characteristics of existing populations?

6. What existing information is available on local environmental and social conditions?

7. What time-period and geographical coverage are necessary for a survey of existing conditions to encompass important temporal and spatial variations?

abiotic properties of one ecosystem, while an equivalent dose may have potentially harmful effects in another (Babich and Stotzky, 1983). Table 5, for example, gives a list of physio-chemical factors that can affect toxicity. It is important to recognize the existance of high risk groups when performing the predictive exercises.

Formal techniques for the prediction of health impacts are poorly developed because of the lack of understanding and the large amount of uncertainty associated with the local transmission and exposure processes of environmental health factors causing ill health. The use of expert analysis is, therefore, necessary. Experience from the nuclear industries has clarified our understanding of pathway models in which interconnnected sub models provide a mechanism for assessing the pathways by which an environmental health hazard may affect man (see figure 2). The utility of such models lie in the prediction of either exposure concentrations or body burdens (Vaughan, 1983). Pathway models can be applied in two ways. The first is empirical, where measurements of concentrations in a real situation can be taken at two distinct parts of the environmental pathway. The data are used to develop a simple transfer factor that allows the prediction of similar chemical transfers in another situation. The second method of application relies upon laboratory generated data being used to predict exposure concentrations. This is the principal mechanism for estimating radiological doses (Vaughan, 1983).

Table 5 Physicochemical factors of an environment that can affect the toxicity of pollutants

pH (acidity/alkalinity)
E_h (oxidation-reduction potential)
Aeration status (aerobic, microaerobic, anaerobic)
Buffering capacity
Inorganic anionic composition
Inorganic cationic composition
Water content
Clay mineralogy
Hydrous metal oxides
Organic matter
Cation exchange capacity
Anion exchange capacity
Temperature
Solar radiation
Hydrostatic pressure
Osmotic pressure

(from: Babich and Stotzky, 1983)

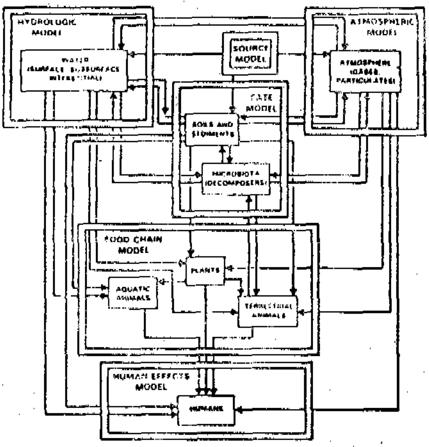

Figure 2 Example of a Pathway Model (From: Vaughan, 1983)

The next stage in the predictive exercise seeks to estimate changes in exposure to the environmental health factors. This is a complex activity, since not only is there a need for detailed information on social attitudes, but also it is likely that the social attitudes will be influenced by the project itself.

In order to estimate the health effects of changes in environmental health factors, the risk groups must be identified, enumerated and located relative to the sources of adverse environmental health factors. Health effects can then be estimated by combining the numbers of high risk persons, the degree of exposure to an environmental health factor, and a measure of the physiological response to that exposure. Those people with existing adverse health conditions are often particularly sensitive to other agents of disease, especially when acute effects are being estimated. Unfortunately, cost generally prevents the identification of direct dose-response patterns. The alternative is to use national prevalence data adjusted to local population characteristics. A number of techniques designed to calculate prevalence rates are discussed by Farley (1978).

Epidemiological studies are required to provide the essential information on the environmental dose-response relationships that relate changes in disease rates and mortality rates to environmental health factors. Attempts have begun in this direction, for example, the paper by Ware et al., (1981) describes some of the studies undertaken to quantify the effects of atmospheric sulphur oxides and particulates on health. Such studies have several important limitations which should be noted before the data is applied to EHIA predictions. These will be discussed later.

While some mathematical models are available to describe certain water related diseases such as malaria, they are generally only applicable to existing endemic diseases in specific environments. Consequently, recourse must again be made to the health experts.

Assessment

While the predictive phase of EHIA is crucial to the entire exercise, the interpretation and assessment of significance of the predicted effects is equally important. In this exercise, many of the EIA methods are applicable, some attempting to apply weighting factors to the impacts in order to reflect their general importance. While there are many papers and books on the general theme of assessment methods (for example, Canter, 1977; Rau and Wooten, 1980), and some in relation to developing countries, for example the Interim Mekong Committee, (1982 and Bisset, in press), the important issue is the evaluation of the predicted effects in terms of their significance. It is not the function of the EIA or EHIA analyst to determine the criteria of significance; that is the function of the politician or decision maker. Instead, the analyst should interprete the guidance given by policy statements, seek clarification where necessary, and apply these criteria together with expert analysis of the situation. The analyst must then present the following information in the impact statement. This should include answers to the following questions:

a) which risk groups are affected and in what way?
b) is the effect immdiate or long term, temporary or permanent?
c) is the situation reversible?
d) would the effect be controversial?
e) how much confidence is placed in the prediction, how likely is the event to occur?
f) would this establish a precedent?
g) are environmental and health standards and objectives being threatened?
h) are mitigating measures available and how costly are they to apply? The assessment should also address possible measures designed to mitigate adverse effects and enhance beneficial effects.

By the examination of these and other criteria the analyst is able to categorize the predicted impacts into groups, depending upon their relative importance. At this point a variety of EIA methods are available to weight the significance of the predicted impacts, such as scaling or weighting-scaling checklists. By similar methods it is possible to evaluate the various alternatives to the proposed action, including the no action alternative. Such numerical values are mutliplied by a weighting factor in order to allow the totalling of the individual impact scores and hence a simple numerical evaluation of the alternatives. A number of problems exist with such methods such as loss of information and possible failure to recognize red flagged impacts in a particular alternative. A more detailed account of the problems is presented in the papers by Bisset (1978 and 1981).

Presentation of Results

The entire objective of the EIA and EHIA exercises is to provide information for use in the decision-making processes. In order to do this effectively it is important that the findings of the assessment be conveyed in a useful manner.

The completed report or impact statement must present information on the expected impacts of the proposed action. It is essential that the impact predictions should be clearly worded. Authors should be careful in the use of words, such as may, might, would etc, which either describe the probability of an event occuring or the level of confidence to be placed in the prediction.

The magnitude, spatial aspects and duration of the effects should be recorded, as should the relationship the effect has with the various risk groups. the decision-makers' attention should be drawn to those impacts of critical importance. Finally, the methods of prediction and assessment should be stated, as well as recommendations for monitoring activities.

A number of EIA methods are available to present an initial summary of the predicted impacts such as a matrix with different shading to represent the degree of significance. It is suggested that the use of such visual aids greatly assists the decision-maker by drawing his attention to the important topics, while at the same time providing an overview of the assessment.

Monitoring and Auditing

Often in EIA studies, once a decision has been made on a specific project, then the entire purpose of the EIA is believed to have been fulfilled. Increasingly, this is being recognized as a limited perspective, since the subject of a post-project assessment provides a useful aid for future EIAs and EHIAs.

In the context of EHIA, monitoring can be appropriate at a number of distinct levels. First, monitoring activities may be designed to record changes in environmental health factors, such as level of pollution. The monitoring of air pollution can provide a timely warning of possible health hazards if an accepted relationship between levels of pollutant exposure and health effects is known. Unfortunately, such relationships often are not known. Thus health protection through pollution monitoring alone may be ineffective. Furthermore, pollutant monitoring provides only a partial basis for determining whether health is being affected (Goldsmith, 1981). For example, the intorduction of pollution into an unpolluted environment may elicit physio-social responses such as anxiety or annoyance, which may then aggravate disease. Waddington (1983) noted that there were two special requirements for environmental monitoring in relation to human health, namely:

a) it must involve the establishment of total body intake/dose;
b) it must provide information on pathways of agents of disease with potential effects on man.

To overcome many of the weaknesses of conventional environmental monitoring, a programme of epidemiological monitoring should be associated with those predicted impacts of greatest concern. Epidemiological monitoring has been defined by Goldsmith (1981) as the repetitive measurement or estimation of health effects of pollution exposures in a population for the purpose of estimating, at the earliest practical time, what needs exist to protect the health of sensitive populations and to monitor the effectiveness of such protective measures as may be implemented.

Auditing forms the other component of post-project assessment. Auditing is the term used to describe the action of evaluating the actual performance of an aspect of the EHIA and EIA. While a variety of audits can be identified (see Tomlinson and Atkinson, in press), the audit of predictive techniques provides the greatest return in terms of improving the science of EHIA and EIA. For audits to be successful, the differing levels of confidence in the predictive techniques and the data inputs should be documented. It is then necessary to evaluate the predictions in order to determine whether monitoring exercises would subsequently improve their accuracy. The concept of developing feedback loops for EIA has been investiaged by Aberdeen University, Scotland, and a number of papers describe its value as well as the difficulties, (Bisset and Tomlinson, 1983, Bisset, 1981 and UNECE, 1982).

THE FUTURE FOR EHIA; PROBLEMS AND POTENTIALS

EHIA, as the paper has outlined, has a number of very important objectives to attain, and is consequently receiving major support from the World Health Organization, United Nations Environment Programme, and many other international and national organizations. This support is showing itself in terms of training, information gathering activities, advisory functions and the development of new techniques to predict and manage the health effects of development.

A number of authors have suggested difficulties with EHIA, especially in relation to the need for improved scientific knowledge (De Werk Neal, 1978; Parke, 1983 and Cohen et al., 1983). These are listed below:

a) problems in the identification of health hazards;
b) limitations of epidemiology;
c) inadequacies in basic biological knowledge in the understanding of chemical toxicity and environmental disease processes;
d) limitations of analytical methods;
e) lack of understanding of biological defence and activation systems;
f) lack of identification of many biological receptors which act as targets for toxic reactions;
g) poor linkage between morbidity/mortality data and environmental exposure;
h) determination of what levels of exposure the general population may be exposed to without adverse health effects both at the present time and in the future;
i) isolation of the consequences of exposure to one environmental health factor from the effects of simultaneous exposure to many other factors;
j) inability to control exposure levels, population mobility and the difficulty in determining the history of previous exposure;

k) long latency periods between exposure and disease obscuring relationships between the two;
l) complexities in identifying exposure/disease relationships when either a single environmental agent may contribute to a number of disorders, or a single disorder may result from a combination of agents.

It is clear from this paper that EHIA has undergone some important developments, and that it is necessary and practical to commence its widespread application. Equally, before the quality of science in EHIA can be regarded as being satisfactory and the results from EHIA provide an accurate basis for action, much more research and actual application of EHIA methods is needed.

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TOXIC AND HAZARDOUS WASTE MANAGEMENT FOR INDUSTRIAL USERS-PRACTICAL APPLICATION

Ted T. Topolski
President, ETI Of North America
P.O. Box 7784 Overland Park, K.S USA

ABSTRACT

International industry is not only placed in a position of water discharge controls by the government regulatory agencies but most are caught in the catagory of being classified as hazardous waste generators.

Essentially this means the metal and chemical processing industry is responsible for the hazardous and toxic waste at their facility from the "cradle to the grave". This Requires a planned program of toxic and hazardous waste management.

The discussion of the paper will cover management of toxic materials including PCB's and other organics in waste water streams present at facilities. Record keeping, and the current impact of the health monitoring regulations in the USA suggested for industry. PCB destruction techniques, hazardous waste containment requirements and suggestions, contingency plans, and concluding with transportation, disposal, and facilities available for providing assistance in disposal Also, slide presentation and handouts will be given.

The paper will discuss ten (10) on-site environmental solutions to containing industrial environmental problems; 1) Incineration 2) Solar Evaporation 3) Acid Neutralization 4) Chemical Fixation and Chemical Treatment 5) Reclamation 6) Deep Well Injection 7) Land Farming 8) Consignment Burial - Secure Chemical Landfill 9) Chemical Detoxification 10) Dewatering Sludges.

A STUDY FOR THE MATHEMATICAL REPRESENTATION OF A BIOLOGICAL WASTEWATER TREATMENT SYSTEM

Orhan Uslu
Necdet Alpaslan

Dokuz Eylül University Engineering
Architecture Faculty
Environmental Engineering Department
Bornova-İzmir-Turkey

INTRODUCTION

Many efforts has been made for the mathematical formulation of biological wastewater treatment systems in the recent years. Such systems constitute of very complex and interrelated physical, chemical and biological phenomena, the mathematical formulation of which require very often substantial simplifications as can be seen by an examination of the publications in this field. Oversimplification of the processes lead to robust models with simple mathematical structures and solution procedures. On the other hand, such models may be inadequate to reflect the intricate mechanisms involved in the treatment systems. In this study an effort has been made to show that it is possible to construct models of increasing complexity containing relevant features of kinetic and mass balance approaches, which are still mathematically tractable. As the basic variables of the system wastewater flow ,substrate concentration, microorganism concentration and dissolved oxygen has been involved.

Activated sludge processes are among the major facilities employed extensively for the treatment of wastewater. The completely mixed systems are modifications of activated sludge processes and they consist of primary sedimentation, biological reactor and final sedimentation, all of which operate interdependently with each other. In certain cases, primary sedimentation may not be essential, thus the process design and operation can be investigated only for the biological reactor and the final sedimentation tank.

In the present, a dynamic mathematical approach is developed for the biological reactor and the sedimentation tank, considering the coupled relations between the two units. The differential equations governing the phenomena may be solved numerically by means of computer program. This model may be subjected to varying loads to observe the behaviour of the process and the effect of varying parameters.

Since the proposed model emphasizes the dynamic behaviour of completely mixed activated sludge processes, it gives more dependable results as compared to those of conventional steady-state relations. The variation of input and output is also considered so that decisions to be made through out the operation of the system can be more realistic. Consequently, it becomes possible to determine the effect of parameters which play a major role in the reactions. Furthermore, the wastewater disposal standards for the receiving environment may also be more realistically determined, since the stochastic behaviour with respect to both quality and quantity of the wastewater treated in the system can be analyzed.

The involvement of the dissolved oxygen concentrations as a variable into the model would furthermore allow the employment of this model by energy optimization studies concerning wastewater treatment systems.

MODEL DEVELOPMENT

Definition of the System and Mass Balance Equations

In the present study, the system for which the model is developed consist of two units, namely the biological reactor and the sedimentation tank as depicted in Figure 1 .

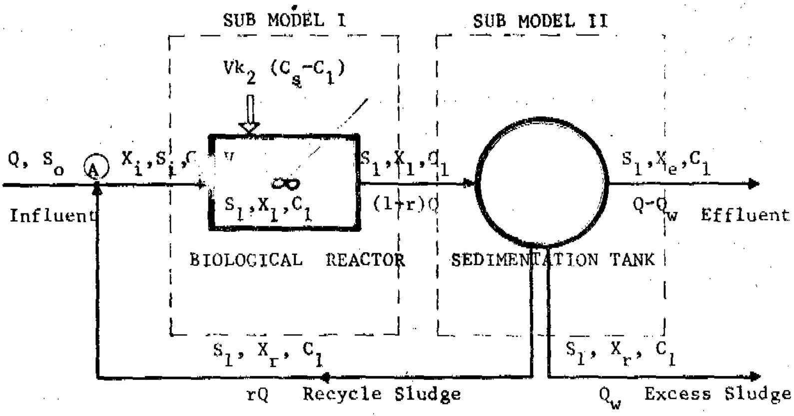

Figure 1 : Schematic Representation of the Biological Wastewater Treatment System

In the biological reactor, the substrate is consumed by microorganisms, and flocculated microorganisms are removed from the water in the sedimentation tank. To maintain the sufficient microorganism concentration in the biological reactor, a certain portion of the settled sludge is recycled from the bottom of the sedimentation tank back to biological reactor.

The proposed model is composed of two sub-models, one for the biological reactor and the other for the sedimentation tank. The processes occuring in two units of the system are completely different from each other; yet the units operate inter-dependently. In the biological reactor, the modified Monod function which considers both substrate and dissolved oxygen as limiting factors for the biological growth; and in the sedimentation tank, the Wallis equation which describes the drift flux are used as empirical relationships to define the phenomena besides the conceptional mass balance approaches (Alpaslan, 1983 and 1984). To develop the model of the system, it is necessary to define the "state vectors" at the intersection of channels and/or at the units of the system subject to input and output. Such a state vector may be defined as:

$$D = \begin{Bmatrix} Q(t) \\ S(t) \\ X(t) \\ C(t) \end{Bmatrix} \tag{1}$$

where for a certain time t, Q(t) represents the flow, S(t), the substrate concentration, X(t), the microorganism concentration (expressed as MLSS or MLVSS conc.) and C(t) dissolved oxygen concentration. The boundary condition for the state vector may be defined as:

$$D_o = \begin{Bmatrix} Q_o(t) \\ S_o(t) \\ X_o(t) \\ C_o(t) \end{Bmatrix} \tag{2}$$

which actually describes the input of the system. To obtain the state vectors at all critical points, the values of Q(t), S(t), X(t) and C(t) have to be calculated. This can be achieved by developing the mass balance equations at those points. A general description of a mass balance relationship may be expressed as:

$$\text{Accumulation} = \text{Input} - \text{Output} + \text{Production} - \text{Decay} \tag{3}$$

Considering the above relation together with Figure 1, the mass balance equations for Q, S, X and C can be written at respective points of the system as shown in the sequel:

a) Mass balance at point A :

$$Q : Q + Q_r = (1+r)Q \tag{4}$$

$$S : QS_o + Q_r S_1 = (1+r)QS_i \tag{5}$$

$$X : Q_r X_r = (1+r)QX_i \tag{6}$$

$$C : Q_r C_1 = (1+r)QC_i \tag{7}$$

b) Mass balance around the biological reactor :

$$Q : (1+r)Q = (1+r)Q \tag{8}$$

$$S:\ V\frac{dS_1}{dt} = (1+r)QS_i - (1+r)QS_1 - \frac{V}{Y}\hat{\mu}\frac{S_1}{K_s+S_1}\cdot\frac{C_1}{K_c+C_1}X_1 \qquad (9)$$

$$X:\ V\frac{dX_1}{dt} = (1+r)QX_i - (1+r)QX_1 + V\hat{\mu}\frac{S_1}{K_s+S_1}\cdot\frac{C_1}{K_c+C_1}\cdot X_1 - Vk_dX_1 \qquad (10)$$

$$C:\ V\frac{dC_1}{dt} = (1+r)QC_i - (1+r)QC_1 + V\alpha k_2(\beta C_s - C_1) - \gamma\frac{V}{Y}\hat{\mu}\frac{S_1}{K_s+S_1}\cdot\frac{C_1}{K_c+C_1}X_1 - k_{re}X_1V \qquad (11)$$

where $\hat{\mu}$ is the maxsimum specific growth rate, K_s, the saturation constant, Y, growth yield coefficient, k_d, the specific decay rate, r, recirculation ratio V volume of the biological reactor, γ, amount of consumed oxygen per unit substrate removal, C_s, saturation concentration of pure water under ambient conditions, α, correction factor for aeration coefficient for wastewater, k_2, aeration coefficient of the system for clean water, β, correction factor for the saturation concentration for wastewater, k_{re}, oxygen consumption per unit mass of microorganism by endogeneous respiration.

It is assumed that no biological reactions will take place in the sedimentation tank. As a consequence of this assumption and the relatively small magnitudes of the first and second terms of the right hand side of the eq. 11 in classical activated sludge systems, these terms will be neglected in further development of the mathematical model. Thus eq. 11 simplifies to

$$V\frac{dC_1}{dt} = V\alpha k_2(\beta C_s - C_1) - \gamma\frac{V}{Y}\hat{\mu}\frac{S_1}{K_s+S_1}\cdot\frac{C_1}{K_c+C_1}X_1 - k_{re}X_1V \qquad (12)$$

c) Mass balance at the sedimentation tank :

$$Q:\ (1+r)Q = rQ + Q_w + (Q - Q_w) \qquad (13)$$

$$S:\ (1+r)QS_1 = rQS_1 + Q_wS_1 + (Q - Q_w)S_1 \qquad (14)$$

$$X:\ (1+r)QX_1 = (rQ + Q_w)X_r + (Q - Q_w)X_e + \sum_{k=1}^{N} V_{s_k}\frac{dX_k}{dt} \qquad (15)$$

The last term of Eq. 15 defines the change of microorganism concentration in the sedimentation tank. For modelling purposes, the sedimentation tank is divided into N horizontal layers each with a volume of V_{s_k} .

Modelling of the Biological Reactor

A careful examination of the mass balance equations, derived in the previous section, reveals that Q, Q_r and Q_w are the known, whereas S_i, S_1, X_i, X_r, X_e and C_1 are the unknown values.

The derivatives dS_1/dt, dX_1/dt and dC_1/dt can be expressed as finite differences.

$$\frac{dS_1}{dt}\bigg|_j = \frac{S_1^j - S_1^{j-1}}{\Delta t} \tag{16}$$

$$\frac{dX_1}{dt}\bigg|_j = \frac{X_1^j - X_1^{j-1}}{\Delta t} \tag{17}$$

$$\frac{dC_1}{dt}\bigg|_j = \frac{C_1^j - C_1^{j-1}}{\Delta t} \tag{18}$$

where t is a time interval and j denotes the time step. By substituting Eq. 16, 17, 18 into Eqs. 9, 10,12 and after some algebraic manipulations one obtains the following relationships for S, X, and C.

for S:

$$\begin{aligned} &\{\frac{V}{\Delta t} K_s K_c - \frac{V}{\Delta t} K_c S_1^{j-1} - K_c Q^j S_o^j + K_s K_c Q^j\} S_1^j + \\ &\{-\frac{V}{\Delta t} K_s S_1^{j-1} - K_s Q^j S_o^j\} C^j + \{\frac{V}{\Delta t} K_c + K_c Q^j\} (S_1^j)^2 + \\ &\{\frac{V}{\Delta t} K_s - \frac{V}{\Delta t} S_1^{j-1} - Q^j S_o^j + K_s Q^j\} S_1^j C_1^j + \\ &\{\frac{V}{\Delta t} + Q^j\} (S_1^j)^j C_1^j + \{\frac{V}{Y} \hat{\mu}\} S_1^j X_1^j C_1^j = \\ &\frac{V}{\Delta t} K_s K_c S_1^{j-1} + K_s K_c Q^j S_o^j \end{aligned} \tag{19}$$

for X :

$$
\begin{aligned}
&\{-\frac{V}{\Delta t} K_c X_1^{j-1} - K_c r^j Q^j X_r^j\} S_1^j + \{\frac{V}{\Delta t} K_s K_c + K_s K_c (1+r^j) Q^j + K_s K_c V k_d\} X_1^j \\
&+\{-\frac{V}{\Delta t} K_s X_1^{j-1} - K_s r^j Q^j X_r^j\} C_1^j + \{\frac{V}{\Delta t} K_c + K_c (1+r^j) Q^j + K_c V k_d\} S_1^j X_1^j \\
&+\{-\frac{V}{\Delta t} X_1^{j-1} - r^j Q^j X_r^j\} S_1^j C_1^j + \{\frac{V}{\Delta t} K_s + K_s (1+r^j) Q^j + K_s V k_d\} X_1^j C_1^j \\
&+\{\frac{V}{\Delta t} + (1+r^j) Q^j - V\hat{\mu} + V k_d\} S_1^j X_1^j C_1^j = \frac{V}{\Delta t} K_s K_c X_1^{j-1} + K_s K_c r^j Q^j X_r^j
\end{aligned}
\tag{20}
$$

for C :

$$
\begin{aligned}
&\{-\frac{V}{\Delta t} K_c C_1^{j-1} - V\alpha\, k_2 \beta\, C_s K_c\} S_1^j + \{k_{re}\, V\, K_s K_c\} X_1^j \\
&+\{\frac{V}{\Delta t} K_s K_c - \frac{V}{\Delta t} K_s C_1^{j-1} - V\alpha\, k_2 \beta\, C_s K_s + V\alpha\, k_2 K_s K_c\} C_1^j \\
&+\{\frac{V}{\Delta t} K_s + V\alpha\, k_2 K_s\} (C_1^j)^2 + \{k_{re}\, V\, K_c\} S_1^j X_1^j \\
&+\{\frac{V}{\Delta t} K_c - \frac{V}{\Delta t} C_1^{j-1} - V\alpha\, k_2 \beta\, C_s + V\alpha\, k_2 K_c\} S_1^j C_1^j \\
&+\{k_{re}\, V\, K_s\} X_1^j C_1^j + \{\frac{V}{\Delta t} + V\alpha\, k_2\} S_1^j (C_1^j)^2 \\
&+\{\gamma \frac{V}{Y} \hat{\mu} + k_{re}\, V\} S_1^j X_1^j C_1^j = \frac{V}{\Delta t} K_s K_c C_1^{j-1} + V\alpha\, k_2 \beta\, C_s K_s K_c
\end{aligned}
\tag{21}
$$

The relationships 19, 20 and 21 constitute a nonlinear system of equations for the unknowns S^j, X^j and C^j which can formally be expressed as

$$f_i(S^j, X^j, C^j) = b_i \qquad i = 1,\ 2,\ 3 \tag{22}$$

A Taylor series expansion of the left hand side of eq. 22 up to and including the linear terms is

$$
\begin{aligned}
&f_i(S^j + \Delta S^j,\ X^j + \Delta X^j,\ C^j + \Delta C^j) = f_i(S^j,\ X^j,\ C^j) + \\
&(\partial f_i / \partial S^j)\, \Delta S^j + (\partial f_i / \partial X^j)\, \Delta X^j + (\partial f_i / \partial C^j)\, \Delta C^j
\end{aligned}
\tag{23}
$$

Starting with an approximation (S^j, X^j, C^j) at an iteration step, the changes (ΔS^j, ΔX^j, ΔC^j) can thus be obtained by substituting eq. 23 into 22 .

$$(\partial f_i/\partial S^j)\ \Delta S^j + (\partial f_i/\partial X^j)\ \Delta X^j + (\partial f_i/\partial C^j)\Delta C^j = b_i - f_i(S^j, X^j, C^j) \quad (24)$$

eq. 24 is linear with respect to the increments ΔS^j, ΔX^j and ΔC^j. The iterative solution of this system with

$$S^j = S^j + \Delta S^j \quad (25)$$

$$X^j = X^j + \Delta X^j \quad (26)$$

$$C^j = C^j + \Delta C^j \quad (27)$$

at each iteration step yields the solution of the original system (Eg. 22). The iterations are terminated when,

$$(\Delta S^j)^2 + (\Delta X^j)^2 + (\Delta C^j)^2 \leq \varepsilon \quad (28)$$

where ε is a specified positive upper bound for numerical accuracy.

However, to determine the S_i^j, X_i^j and C_i^j with the procedure mentioned above, X_r^j have to be given to the model as input. On the other hand X_r^j occurs after the X_i^j, i.e., first X_i^j enters the sedimentation tank and settles. The concentration at the bottom of the tank then becomes X_r^j. Therefore, it is necessary to solve the unknown values by an iterative procedure, using the sub-models for both biological reactor and the sedimentation tank. In other words, there exists an iteration cycle for the determination of X_r^j for all time steps (j= 1, 2,....).

Modelling of the Sedimentation Tank

In the sedimentation tank, the subsidence of particles is hindered by the large volumetric concentration of solids, so that deviations from Stokesian settling occurs. The extent of these deviations depends upon the limiting solid-flux at a certain section of the tank (Uslu, 1982). Therefore, the sedimentation sub-model is based on the concept of drift-flux and considers the hindered and flocculent nature of the settling particles. In the model, drift-flux is represented by the relationship developed by Wallis as given below (Wallis, 1969).

$$\emptyset = S\alpha\ (1-\alpha)^n \quad (29)$$

where $\emptyset$ represents drift-flux, S, the settling velocity of particles for infinite dilution; α; the volumetric concentration of particles; and n the Wallis coefficient.

In this study, the sedimentation tank is assumed to have a circular layout with a conical cross-section. For modelling purposes, two different zones in the tank is assumed, namely the one "above the feed plane" and the other "below the feed plane". Furthermore, two boundary conditions, that may be referred to as the "upper boundary" and the "feed plane" are introduced. The equations of the model are derived separately for those parts of the tank as summarized below:

a) Zone above the feed plane :

For this zone, a control volume representing a horizontal layer of thickness d_z at depth z_i is considered, where i denotes the number of the layer as seen in Figure 2.

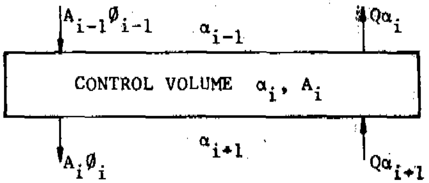

Figure 2 : Control volume for the derivation of the "above the feed plane" equations.

In the figure, A_i is the area at depth z_i, and Q, the bulk flow of the slurry. The volumetric balance for inflowing and outflowing solids may then be expressed as :

$$(Q^j\alpha^j_{i+1}+A_{i-1}\phi^{j-1}_{i-1}) - (Q^j\alpha^j_i+A_i\phi^j_i) = V_i\frac{\partial\alpha^j_i}{\partial t} \qquad (30)$$

where j-1 represents the time steps at which the values are known, and j, the steps where they are unknown. Introducing finite differences the right hand side of the above equation may be written as:

$$V_i\frac{\partial\alpha^j_i}{\partial t} \approx \frac{V_i}{\Delta t}(\alpha^j_i - \alpha^{j-1}_i) \qquad (31)$$

If eq. 30 is arranged by considering eq. 31 , the following expression may be obtained :

$$-A_{i-1}\phi^j_{i-1} + (Q^j + \frac{V_i}{\Delta t})\alpha^j_i + A_i\phi^j_i - Q^j_i\alpha^j_i = \frac{V_i}{\Delta t}\alpha^{j-1}_i \qquad (32)$$

b) Zone below the feed plane :

The control volume delineating the inflowing and the outflowing slurry for this zone is shown in Figure 3. The volumetric balance equations infinite difference form for this control volume may be written as :

$$-rQ^j\alpha^j_{i-1} - A_{i-1}\emptyset^j_{i-1} + (rQ + \frac{V_i}{\Delta t})\alpha^j_i + A_i\emptyset^j_i = \frac{V_i}{\Delta t}\alpha^{j-1}_i \qquad (33)$$

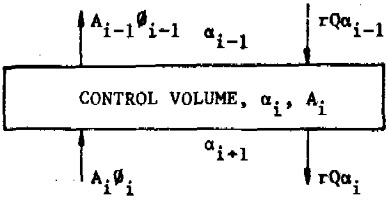

Figure 3 : Control volume for the derivation of the "below the feed plane" equations.

c) Upper boundary (i=1) condition :

At the upper boundary, the effluent overflows from the sedimentation tank with a volumetric concentration of α_1, and solids leave this layer with the settling rate of $A_1\emptyset_1$ as shown in Figure 4.

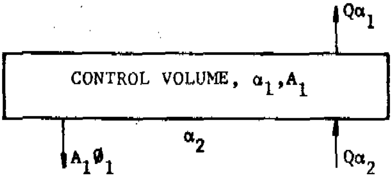

Figure 4 : Control volume for the derivation of the "upper boundary" condition equations.

The volumetric balance equation for this boundary condition may be written as follows :

$$-Q^j\alpha^j_2 + (Q^j + \frac{V_1}{\Delta t})\alpha^j_1 + A_1\emptyset^j_1 = \frac{V_1}{\Delta t}\alpha^{j-1}_1 \qquad (34)$$

d) Feed plane (i=m) condition :

Since the tank is assumed to be of a central feed type, the inflow enters the control volume with a volumetric solid concentration of α^* , at a rate of (1+r)Q. The outflow rates and concentrations may then be described as in Figure 5.

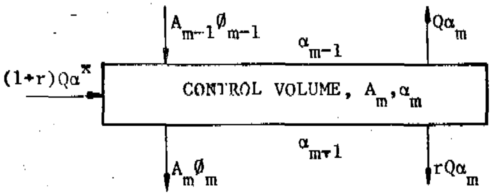

Figure 5 : Control volume for the derivation of the "feed plane" boundary condition.

According to Figure 5 the volumetric balance may be written as :

$$-A_{m-1}\emptyset^j_m + \{(1+r)Q^j + \frac{V}{\Delta t}\}\,\alpha^j_m + A_m\emptyset^j_m = \frac{V}{\Delta t}\,\alpha^{j-1}_m + (1+r)Q^j\alpha^{*j} \quad (35)$$

A careful examination of Eqs. 32, 33, 34. and 35 indicates that, the left hand sides of the mentioned equations contain only the unknown values of α^j. It should be noted that the drift-flux $\emptyset^j$ is also a function of α^j (see Eq. 29) and therefore, only the α^j may be considered as unknown values. Using a Newton-Raphson procedure the solution of α^j, and therefore $\emptyset^j$ can be achived.

CONCLUSION

With respect to input, output and reactions taking place within the system, the completely mixed systems reflect a dynamic character, that is, they are usually subjected to loadings which vary with time, and consequently, they exhibit a time varying response. In the design of these facilities carried out so far, this fact, although recognized, has been generally ignored or neglected. The conventional approach has been to define the steady state or the average loading conditions of the system through semi-empirical relations. Operating policy and process control are also dealt with in an empirical manner, and both the flexibility and the efficiency of operation have often used to be a function of operator ingenuity (Ott and Bogan, 1971).

By developing a dynamic model of the system the above mentioned limitations may be eliminated or at least may be decreased to the minimum level. With such a model, it will be possible to observe the response of the system to varying inputs, operating policies and process controls within a short period of time. Thus, decisions for both design and operation may be made on a much more realistic basis.

In this study a mathematical representation of a biological wastewater treatment system is elaborated emphasizing the inherent dynamic nature of such systems. Besides the conventional substrate and microorganism balances the dissolved oxygen has been involved as a main state variable into the system. It is thus possible to utulize this model in energy economy considerations.

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EDUCATIONAL AND MAN-POWER REQUIREMENT FOR ENVIRONMENTAL POLLUTION CONTROL LEGISLATION

Orhan Uslu
Aysen Müezzinoğlu

Dokuz Eylül Univ. Fac. of Eng. and Arch.
Env. Eng. Dept. Bornova-İzmir-Turkey

INTRODUCTION

Rates of exploitation of natural resources as well as environmental pollution due to waste disposal both have very serious dimensions in Turkey. Population growth rate which could not have been decreased in spite of widespread control programs all over the country and moreover the urbanization pattern add to the seriousness of resource exploitation and pollution problems. Nationel "development" which aims at tha public welfare create all these problems. Another group of side-effects of "development" which deteriorates the quality of life is the problems related with water and wastewater management as well as other municipal and industrial infrastructures. Various environmental problems taking part in these three basic groups are in contradiction with the basic principle put forth by the 1982 Constitution, Article No. 56 which translates "every citizen has the right to live in a healthful and well-balanced environment. It is the duty of both the state and the citizens to develop the environment, to protect the environmental health and to prevent environmental pollution".

As can be understood from this principle the state hold responsible all concerned including itself, people and establishments in order to avoid these contradictions. In parallel with Article 56 of 1982 constitution, an "Environment Law" has been passed by the Parliament on 11 August 1983. With this low a legal framework for preparing a valid environmental policy to protect and solve problems of pollution. It is hoped that with the help of this legal framework modern environmental science and technologoy, social and legal adjustments can be adapted in Turkey. Environment law foresees a number of regulations to be issued within one year to cover policy requirements and environmental standards.

Preparation, issuing, application and inspection of these regulations which are the essential elements of the Environment Law, as well as developing environmental protection techniques, project design and operating the waste treatment plants to be made effective under this Law require qualified manpower of different professional backgrounds such as, engineers, lawyers, ship crew, treatment plant operators, laboratory technicians, etc. This manpower requirement has been investigate mainly in view of the professional approaches and what needs to be done for the regulations to be issued.

Due to the multi-discihlinary character of the environmental issues, many different professionals are to bring about their own professions, methodologies and they must be combined to solve the environmental problems. That is why each group of different professions claim that it is their responsibility to deal with the environment and no other group can solve such problems. This professional shovenizm is further elaborated by bureaucratic practices and becomes a dangerous draw-back in the solution of environmental problems. Solution, however, lies in the togetherness of different groups of experts specially qualified for environmental matters coming from a diversity of professions.

2. REGULATIONS TO BE ISSUED ACCORDING TO THE ENVIRONMENT LAW AND PREVIOUS LEGAL STATUS

Until the Environment Law of August 1983, environmental problems were dealt with a large number of laws and regulations giving the power to various governmental bodies. The number of laws pertaining directly or indirectly to the environment has been found to be 118 and in Table 1.they are classified according to their subjects. Moreover it has been found that 38 regulations have environmental implications but have not been mentioned in Table 1.

Table 1 . Legal acts pertaining directly or indirectly to the environment (Ural, 1981 ; Akalan, 1983)

Subject	Number of Laws
Land and Soil usage	33
Protection of natural and historical environments	33
Water, water usage and pollution	22
Energy production and usage	8
General environmental issues	7
Traffic and noise	6
Air pollution	4
Solid wastes	3
Pesticides	2
TOTAL	118

Besides these summarized above, Environment Law is an integrating legal framework and must be followed by several new regulations summarized in Table 2. In this table topics to be dealt with as well as the reference article number have been indicated.

Table 2. Regulations to be issued until August 1984 according to Environment Law (Act No:2872)

Article No	Subject of the Regulation
8	Abatement against pollution (Media Standards and waste disposal methods)
9	Environment protection zones and their management
10	Environmental impact assessment methodologies and application
11	Techniques to be involved in effluent discharge and waste disposal, technological advancements, alternatives and efficiencies
12	Inspection of treatment and disposal
13	Production, importation, transport, storage and consumption of persistent chemicals
14	Noise abatement and standards
15	Methods of legal action against polluters to be followed by local administrators
17	Income and usage of environment fund
24	Penalties for ships and other sea vehicles

MANPOWER REQUIREMENTS OF THE NEW ENVIRONMENTAL LEGISLATION

To fulfill the new duties given to the state and the public by the new Environment Law, manpower duely educated to alleviate with environmental problems must be planned. Experiences have shown in the past that the most important element in environmental management has been qualified manpower sufficient in number to detect and solve problems. For example, this has been one of the most important reasons why "Water Products Law" Reg. 3 has not been e very successful achievement for water quality management. That is why we think that extensive education programs at several levels is a necessity to put Environment Law into action.

In this part of the paper manpower potential requirements has been qualitatively discussed for this purpose. Of course, unless the categories of manpower necessary for implications of Environment Law are described also by the number of people needed education planning is not complete. But given the data and information at hand, qualitative description is as far as one can go for the time being.

Qualifications of Manpower Required for a Good Environmental Management

In order to prepare and conduct a good environmental management plan, usually many experts from different professions or groups of professions are required must come together and work in harmony. In parallel with the new Environment Law an Environmental Management program must combine engineering, basic sciences, medical sciences, economics, social sciences, law, etc.

Data Collection and Evaluation for the Environment

In order to prepare a valid environmental management program, it must be based on a comprehensive data base. In order to do that one must continuously monitor, record, evaluate and publish environmental indicators such as physical, ecological, social, economic and aesthetic parameters. As an example pollution and resource exploitation can be shown as good physical indicators and ecological stability as another good indicator for ecological quality.

To obtain such relevant information a group of experts is necessary as well as suitable laboratories and similar facilities. Data collection also requires application of a good coordinating program. Coordination is especially important in this phase because of the danger of possible duplicate studies. On the other hand lack of data is on of the causes of unresolved environmental problems. For usable data generation a group of qualified technicians is also very important.

Evaluation of collected environmental data is a good step forward in defining the environmental quality, in setting environmental standards in preparing pollution abatement plans and their inspection.

Environmental Impact Assessment, EIA

In principle, projects aiming at social development must be discussed in view of the general acceptability as far as environmental values are concerned and they must be permitted for an environmentally sound and use, resource exploitation, production technology, etc. This need is put forward by the Environment Law and a decree must be prepared to describe the workability of the EIA. At the same time the Law states in favor of the "polluter pays" principle, thus mentioning the responsibility of polluters for measures aiming at prevention of pollution. Only with the condition that if these persons can prove they have taken all precautions to prevent pollution, they can be freed of legal charges. At the project stage an EIA report is required from its owner, which will help estimate the probable effects of this activity upon the environment, when different practices of other countries are taken into view it is seen that the EIA-report can only be helpful if it is prepared and evaluated by qualified professionals.

Decision-makers are well aware of the need of a standard guideline for evaluating environmental effects of development projects. By EIA-method screening the alternative projects can be made on an environmentaly sound basis, by taking into consideration the location and technology involved in each alternative. EIA requires a group of workers essentially coming from a diversity of professions so that the report covers all project components in relation to their effects on all environmental indicators. It also requires a homogenizing effort to put the different approaches of these experts into one single logical approach. Synthesis of the outputs of these different professions is a difficult job and special knowledge and experience is needed for homogenization. Especially at this stage experts that can see the problems on a makro level and at the same time can go into details of the projects are to be appointed for this synthesis work. Obviously personal abilities are of importance but an engineering bacground with special emphasis to the environment is a minimum education requirement for this EIA managers.

Engineering Services

Until now the importance of multi-professional team work and conceptualizing the environmental problems at a makro level have been largely emphasized. But as in all engineering applications, environmental technology requires a detailed work from a group of engineers related with it. Required Environmental Engineering services can be groupped into three categories as follows :

Planning engineer : Planning engineer bridges between the general environmental politics and detail generating field or project engineer. That type of a job requires a good environmental engineering bacground along with a basic experience in planning.

Project engineer : To treat the environmental pollutants, to dispose them in an approable way and to make them less objecttionable to the environment suitable technological applications must be made in projects. Water supply and sewerage system design, treatment of domestic and industrial waters and wastewaters disposal of solid wastes reduction of air pollutant emissions require specific project that must be prepared down to very minor details. Technological advancement in their countries with respect to these engineering areas must be followed and evaluated for suitability in this country. Such environmental engineering applications require a specialized group of educated and trained manpower. It is interesting to note that among the environmental engineering bureaus newly being established in this country. Some are made up of chemical, mechanical, even agricultural engineers.

Due to the multi-disciplinary character of the environment oriented projects several major engineering fields must find their specific share in these technologies such as civil, chemical, mechanical, electrical, electronic, computer, etc. For example in wastewater treatment plant design, prestressed concrete structures will make a good field of interest for a civil engineer; mechanical equipment selection and design for a mechanical engineer, corrosion control for a chemical engineer, automation and even micro-processor control systems for an electronic engineer etc. are important topics that requires special experienced engineers coming from these fields.

Operating engineer : Plants aiming at protecting the environment must be operated under the responsibility of engineers speci specially trained for the plant and for the environment. It might be understood from the discussions above, that such plants might be a complex one and usually requires attention of an expert engineer for efficient operation. Therefore operating engineer must be capable of running the plant smoothly and continuously and at the same time he must know what to do when adverse conditions occur. In this country very few treatment plants are in operation, yet, and they are not run by environmental engineers. That is why even these few plants no matter how expensive they have been, how much foreign expertise and know-how have been transferred for their erection are not in good working conditions. Only knowledgeable and specially trained operating personnel must be involved in these plants.

Environmental technology is being produced in this country, too, but its success largely will depend on specially trained operators and operating engineers.

Inspection

Along with the Environmental Health inspection services connected with the Ministry of Health and the municipalities, an inspection mechanism must be established in order to implement successfully the Environment Law and its regulations and decrees. Municipalities which might have been considered good focal points for all the environmental inspection services are not, however, equipped with "environmental protection and pollution prevention" units. If well established units can be founded for langer municipalities and if these unit can employ qualified environmental engineers, technicians and inspectors, municipalities can be good focal points for environmental inspection, indeed. Thus, the environment inspection teams can be utilized for local data collection and evaluation, which is a good starting point for successful environmental management (Engin, 1982). Of course it might, still be discussed if the municipalities can constitute good focal points for inspection work. But we think that in order to base local programs on real data, inspection must be planned at the urban planning - engineering foregrounds. Thus municipal - infrastructure engineers and architects specially experienced in environmental problems must be held responsible for local inspection programs. Inspector and technician level manpower must also be sufficient for this duty both by qualities and quantities.

RESULTS

Planning of manpower which is required by legislative regulations and the educational program adjustments which should be achieved under this plan are expressed above. In our opinion, in the educational programs of professional disciplines which are related to environmental issues, a similarity among the offered courses should be provided to enable the educated people who specializes in different fields, understand each other. These classes may be more than one in proper professions and if it is needed it may be altered into an optional education program. On the other hand, in this spectrum of disciplines, there are only quite a few number of professions which cover the solutions of environmental problems. Environmental engineering is on the first line among them. We think that solutions to the environmental problems should be looked for from the platform of engineering. Since, most of the problems arise from technological applications, engineering provisions are necessary. On the other hand, environmental engineering program should based on considering multi - disciplinary character of the matter. Because of this reason, environmental engineering undergraduate program which based on fundamental engineering courses is overloaded. This program is modified by different environmental engineering departments which exist in the country, but all of these departments seem locking of planning and management functions compared to projecting duties. It is possible to discuss the availability of couple of courses which are taken into the program such as urban planning, environmental management, environmental law, to meet the country's needs. But, it is known quantitatively that this type of courses which provide broad horizons are difficult to be offered more than the present situation. On the other hand, employment problems do not let the environmental engineering to be disintegrated particulary from civil engineering. For example, environmental engineers do not have a unity to establish a chamber yet. Because of this reason, graduated environmental engineers have to join civil engineering chamber to have the right to sign on the projects. Minimum requirements of standard educational program of Civil Engineering which is approved by higher educational council are provided to keep this right.

Consequently, despite many researchers who claim the hazards and negative points of rapid improvement and having responsibility of environmental engineering on the solutions to the environmental problems of the country, (Ar and Kuleli, 1983) this discipline is the easiest professional branch to be shaped into the desired multi-disciplinary environmental approach. Although, required and elective courses whihc would satisfy an engineering student qualitatively, should be taken into educational programs as much as possible. If this goal is met, an environmental engineer may play a key role among the other specialists who put their own efforts into the field, unless he or she grasps basics of the necessary mechanisms of multi-disciplinary environmental management approach such as technics, planning, education, fundamental science, medical science, law. Perhaps, it should be stressed the importance of personal skill and talents of the engineers who will take this duty, In addition, like in any other profession, an on site work is necessary in environmental engineering. The other professional groups which will take duty on environmental management should take take similar environmental courses and if it is possible, after finishing environmental options, they should be hired.

Special emphasis should be given to develope technical manpower and during the studies a coordination among them should be maintained.

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SAVING IN ENERGY AND MATERIALS BY DOSING SPENT ALUMINIUM ANODISING BATHS IN SEWAGE TREATMENT PLANTS

Dirk Wilms, Bambang Purwanto, André Van Haute

Katholieke Universiteit Leuven
Institute of Industrial Chemistry
de Croylaan 2, 3030 Heverlee, Belgium

INTRODUCTION

The addition of low doses of aluminium salts (5 to 20 g Al/m^3) to the wastewater at the inlet into the primary clarifier results in an enhanced settling of suspended solids, in an important removal of phosphates by precipitation as $AlPO_4$ and even in a lowering of the concentration of dissolved organic matter by adsorption on the flocs of aluminium hydroxide. As a consequence, the sludge loading in the biological stage is lowered which results in an improved quality of the effluent and, more important, in a reduced energy consumption for aeration. These advantages are, however, impaired somewhat by the production of higher quantities of waste sludge that have to be treated and disposed of. The aluminium compounds most used in the flocculation of wastewater are $Al_2(SO_4)_3$ and $NaAlO_2$. For wastewater treatment, those compounds need not to be pure products, as long as the impurities do not have an influence upon the treatment or on the quality of the effluent.

The baths used for pickling and anodising of aluminium surfaces are particularly interesting in this respect, since they contain relatively high concentrations of aluminium salts, have an almost constant composition and are on their own a waste product that has to be treated before disposal (neutralization and dewatering of the precipitated $Al(OH)_3$).

In Belgium there are more than 70 rather small anodising factories. The treatment of the spent baths is, in the light of the small scale of the works, very expensive. Therefore, it is an important advantage that these baths can be applied directly, without any special pretreatment, to the primary flocculation of wastewater in a nearby plant where domestic wastewater is treated.

The average characteristics of those spent baths are :

		Pickling bath	Anodising bath
$Al_2(SO_4)_3$	(g Al^{3+}/m^3)		13 - 18
$NaAlO_2$	(g Al^{3+}/m^3)	30 - 80	
Density	(g/ml)	1.13 - 1.35	1.17 - 1.19
pH		11.5 - 12.2	0.19 - 0.24
H_2SO_4	(g/l)		170 - 195
NaOH	(g/l)	45 - 150	

The feasability and the optimal conditions (dosis, pH of flocculation, composition of the mixture of aluminium salts) for primary flocculation of domestic wastewater have been studied as a first stage in a number of jar tests and in a series of continuous runs on a pilot plant scale (Alaerts et al., 1982[1]). From these experimental results and from economical considerations (Alaerts et al., 1982[2]) it was concluded that the optimal Al^{3+} dosis was about 10 g/m^3, and that if an appropriate mixture of acid aluminium sulphate and alkaline sodium aluminate was used, there was no need to correct pH, which is advantageous in practice.

To test these optimum conditions on a full scale, a sewage treatment plant has been searched that can easily be adapted in such a way that the whole treatment is splitted up in two equal parallel parts : one half of the installations would work in the classical way, whereas in the other half the normal pre-sedimentation stage would incorporate a flocculation step.

In cooperation with the engineering office De Koninckx, N.V., of Antwerp, which also designed the necessary adaptations, the sewage treatment station "Schijnpoort" in Antwerp was chosen. This treatment plant has a design capacity of 325,000 p.e. ; the actual BOD-load is 365,000 p.e., whereas the hydraulic load has increased in time to 600,000 p.e. or 90,000 m^3/day.

The conventional system consists of a presettling, biological treatment with activated sludge and aeration by mammouth rotors. The waste activated sludge is added to the incoming sewage so that it is withdrawn together with the primary solids. The mixed waste sludge is thickened, digested anaerobically, press-filtered and incinerated.

During the runs, that lasted almost two months, the concentrated solutions of recuperated aluminium sulphate and sodium aluminate were pumped from two 25 m^3 containers by two metering pumps to the inlet channel before the primary settling tanks of one half of the plant. As the pumping rate was made proportional to the incoming flow, a constant dosis of 10 g Al^{3+}/m^3 wastewater has been applied during the whole experimental period, and a constant composition of 60 mol % $Al_2(SO_4)_3$ and 40 mol % $NaAlO_2$ has been installed.

The impact of dosing Al^{3+} salts on the treatment efficiency could be evaluated by comparing the quality of the primary and secondary effluent in both parts of the plant. Therefore 24-h mixed samples have been taken daily on 5 points : one sample of the incoming sewage (common for the two parts of the plant) and seperately for both parts a sample of the effluent after primary and one after biological treatment.

RESULTS

Water treatment

Table 1 shows the averages of the experimental results of the jar tests, the pilot plant runs as well as the runs on full scale. One can see that there is a great similarity between the results from the three kinds of experiments, which is very important since from it one may conclude that the optimalisation of the parameters can be done perfectly well on laboratory scale, which is a much more convenient way.

In a large number of jar tests the specific influence of the composition of the flocculant (pure aluminium sulphate, pure sodium aluminate or mixtures of both salts), of the flocculant dosis and of the pH of flocculation, have been investigated.

As can be seen from table 2, the effluent quality of a wastewater flocculated with an equimolar mixture of aluminium sulphate and sodium aluminate, improves on increasing the flocculant dosis. Generally speaking, the greatest effect is obtained by applying the smallest dosis. For COD-removal there is no much gain in increasing the dosis above 20 g/m^3 Al^{3+}, whereas the removal of suspended solids and of phosphates decrease further by increasing the Al-dosis. The amount of sludge produced increases steeply with the Al-dosis too.

The influence of Al-dose and flocculation-pH on COD removal has been studied on a number of wastewater samples. Both $Al_2(SO_4)_3$ and $NaAlO_2$ salts have been studied and the results are shown in table 3. Under some circumstances the COD after

Table 1. Effect of Al^{3+} (10 g/m^3 as 60 mol % $Al_2(SO_4)_3$ and 40 mol % $NaAlO_2$) on removal of BOD, COD, TSS and Phosphorus from sewage effluent : comparison of data

		COD			BOD			TSS			PO_4^{3-}		
		In	Out	Removal	In	Out	Removal	In	Out	Removal	In	Out	Removal
		(mg/l)		%	(mg/l)		%	(mg/l)		%	(mg P/l)		%
Jar Tests	without	243	226	7				80	76	5			
	with Al^{3+}	243	137	44				80	27	66	41	12	72
Pilot Plant	without	249	329	0				66	107	0	37	29	23
	with Al^{3+}	249	148	41	125	68	46	66	27	59	37	16	58
Schijnpoort	without	299	260	13	149	141	5	115	85	26	8.3	11	0
	with Al^{3+}	299	180	40	149	95	36	115	46	60	8.3	2.3	72

Table 2. Reduction of COD, TSS, and ortho-phosphates and sludge production as a function of the Al^{3+}-dosis

Al^{3+}-dosis ($g\ Al^{3+}/m^3$)	COD (g/m^3)	TSS (g/m^3)	PO_4^{3-} (g/m^3)	Sludge-amount (g/m^3)
0	250	73	34	67
5	159	47	22	114
10	143	29	13	142
15	131	20	7	165
20	119	22	3	185
30	120	14	1.3	217
40	118	12	0.5	260
80	111	8	0.1	386

flocculation becomes lower than the COD one would obtain by filtraton. From the table one can see that the influence of pH is most pronounced at low dosis of flocculant, and that for a given flocculation-pH and a given dosis the COD-removal with aluminium sulphate is generally 10 to 20 % better than with sodium aluminate.

Table 3. Ratio of COD after flocculation to COD after filtration as a function of flocculation-pH and dosis $Al_2(SO_4)_3$ or $NaAlO_2$

Dose $Al_2(SO_4)_3$ $g\ Al^{3+}/m^3$	pH=7	pH=8	pH=9	Dose $NaAlO_2$ $g\ Al^{3+}/m^3$	pH=7	pH=8	pH=9
0	1.86	1.64	1.24	0	2.00	1.84	1.37
5	1.18	1.08	0.98	5	1.37	1.45	1.41
10	0.98	0.98	0.92	10	1.24	1.25	1.41
30	0.84	0.87	0.90	30	1.06	1.14	1.16

The influence of Al-dose and flocculation-pH on removal of suspended solids is shown in table 4. Here also the lowest TSS-values after flocculation are obtained with the highest Al-dose and at the lower pH-values. $NaAlO_2$ seems to perform better than $Al_2(SO_4)_3$, except at pH 9.

Although pure aluminium sulphate gives better results than sodium aluminate, the application of a mixture of both aluminium salts is considered since both aluminium compounds are wasted in the aluminium anodising industry, and since the application of aluminium sulphate alone may necessitate a pH-correction.

Based on the pilot plant results a mixture of 60 mol % aluminium sulphate and 40 mol % sodium aluminate and a dosis of 10 g Al^{3+}/m^3 has been chosen for plant operation.

As shown in Table 1 :

The COD removal efficiency by sedimentation alone was on average 13 % whereas by primary flocculation the COD removal efficiency varied between 23 and 61 % with an average of 40 %.

A similar result was observed for the BOD removal : the efficiency varies between 23 and 69 % with an average of 36 %, to compare with 5 % removal by sedimentation alone.

The average removal of suspended solids by sedimentation was 26 %, whereas by flocculation this varies between 39 and 89 %, with 60 % as an average.

Table 4. Suspended solids concentration (g/m^3) after flocculation as a function of flocculation-pH and dosis $Al_2(SO_4)_3$ or $NaAlO_2$.

Dose $Al_2(SO_4)_3$ g Al^{3+}/m^3	pH=7	pH=8	pH=9	Dose $NaAlO_2$ g Al^{3+}/m^3	pH=7	pH=8	pH=9
0	133	133	120	0	87	89	56
5	102	89	84	5	44	71	80
10	62	51	64	10	25	53	102
30	22	24	42	30	11	16	67

By sedimentation there was no removal of orthophosphates observed ; with the addition of 10 g/m^3 Al^{3+} 57 to 97 % of the phosphates are precipitated, with an average of 72 %.

Sludge production

As the flocculation of raw wastewater with Al^{3+}-salts results in an important increase in the removal of COD, suspended solids and orthophosphates, it is evident that the amount of sludge produced will increase too.

First, there is the production of an extra amount of "chemical sludge" in the form of aluminium phosphate and aluminium hydroxide. Then an extra amount of primary sludge is formed, that is the difference between the suspended solids load of the incoming sewage and of the effluent from the primary settling tanks. On the other hand, due to the increased removal of organic material by flocculation, there is a reduced production of excess activated sludge.

Plant scale experiments confirmed that there is an excess production of sludge ; by addition of 10 g/m^3 Al^{3+} the amount of sludge produced is 20 % higher than produced by the conventional treatment. The amount of sludge per m^3 of the wastewater is :

		conventional	flocculation with 10 g/m^3 Al^{3+}
primary	(g/m^3)	30	70
excess activated sludge	(g/m^3)	110	60
chemical sludge	(g/m^3)	-	40
Total	(g/m^3)	140	170

CONCLUSIONS

Primary flocculation of wastewater with 10 g/m^3 Al^{3+}, as a mixture of 60 mol % aluminium sulphate and 40 mol % sodium aluminate results in :

- 30 % more removal of BOD in the first stage
- at least 35 % more removal of COD in the primary settling
- a removal of 70 % or more of the orthophosphates.

In the conventional primary treatment the phosphate removal is practically zero.

The production of a better primary effluent makes it possible to decrease the volume of the aeration tank by at least 30 %. The energy consumption also decreases of approximately 30 %. This means for a sewage treatment plant of 100,000 p.e. an energy saving of 500,000 kWh per year, which is, by all means, not negligible. Primary flocculation may also be advantageously applied in cases where a treatment plant is systematically overloaded : the provision of a primary flocculation, which does not mean an important investment, can give the plant a relief so that an effluent can be produced that again meets the required standards.

In both cases one must be able to handle the extra amount of sludge. For the dose of 10 g/m^3 Al^{3+} this represents approximately 20 % more sludge, compared with the conventional treatment.

An elegant and profitable method to dispose of spent concentrated baths from the aluminium anodizing industry consists in dosing these liquors in sewage treatment plants, especially these that are temporally or constantly overloaded, provided of course that these plants have space capacity for handling the excess sludge.

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A NEW APPROACH TO IMPROVE THE FILTRATION AND DEWATERING STEP USED IN RECLAIMING WASTE COAL

Ülkü Yetiş, Ali Başaran

Middle East Technical University

Department of Environmental Engineering, Ankara, Turkey

INTRODUCTION

Energy is essential for development. One of the main sources of energy worldwide is coal. During its production however, thousands of tons of waste coal are generated every year at the mines. This portion consisting mainly of fine particles has a high ash and sulphur content and needs to be rid of them before it can be used. One of the ways commonly used for reclaiming the waste coal is washing followed by vacuum filtering of the coal slurry and heat-drying of the filter cake. Two of the major drawbacks of this method are: 1) it is an energy-intensive operation; and 2) the heat drying step causes air pollution problems.

To improve the process, the filtration step must be improved so that the moisture content of the filter cake, and in turn the heat drying cost is kept at a minimum. Since the particle size and particle size distribution are two of the important variables affecting the filtration and dewatering of fine coal slurries, effects of these variables were investigated in this study by using different fractions of fine coal obtained from Pittsburg Seam-Bruceton Mine (USA). *In addition, change in specific cake resistance, porosity, permeability,* and the moisture content of the filter cake with changing particle size were also studied. Based on the results obtained in this study some recommendations are made for making the process more efficient and in turn economically more feasible.

BACKGROUND

Fine coal fraction of a coal stream is that fraction which contains particles less than 500 μm. This fraction is cleaned and recovered to reduce the loss of coal. When this fraction is subjected to wet cleaning process it results in a coal-water slurry. The resulting slurry is dewatered afterwards, and a filter cake which has high moisture content is formed. Therefore, the problem faced is the reduction of the final moisture content of the coal filter cake. This is possible through a better understanding of the parameters affecting the filtration and dewatering process.

One of the most important parameters in this regard is the particle size. Particle size distribution also affects the process to a great extent. In a literature review on filtration and dewatering of fine coal slurries, Gala and Chiang[1] also emphasize the importance of these parameters in the filtration and dewatering of fine coal slurries. In another study, Gala et al.[2] point out that it is harder to dewater the cakes having more fines in it. Fine particles decrease the average particle and pore size and this results in lower filtration rates.

Besides these recent studies, there are also some other works on this subject. Fuhrmeister[3] observed that as the percentage of fines increases, the final moisture content of the coal cake also increases. Another similar work was done by Gray[4] and he found that increases in fines increase the porosity, so that more water is held by the coal filter cake. Gray also found that the dewatering can not be greatly improved until the proportion of fines falls below a certain value.

Recently, Leininger et al.[5] worked with ultrafine particles and they observed that the moisture content of the filter cake does not change if the amount of ultra-fines is increased while the slurry concentration increases. Increase in slurry concentration contributes through better filtration and dewatering, but the increase in the proportion of fines diminishes this positive effect.

In view of these drawbacks, an extensive work about the effect of particle size and particle size distribution on the filtration and dewatering of fine coal has been done in this study.

MATERIALS

This work was carried out using coal from Pittsburgh Seam Bruceton Mine. Two different batches of -32 mesh size (run of mine) coal were tested. Different size fractions (-200; -100+200; -100; -32+400; -32+100 mesh) were obtained from -32 mesh coal by sieving.

The particle size distribution he -32 mesh size coal samples were determined[6] by using a Leitz O plan microscope and an Omnican Image Analyzer. Results are wn in Figure 1.

For preparing coal-water slurries, distilled water was used.

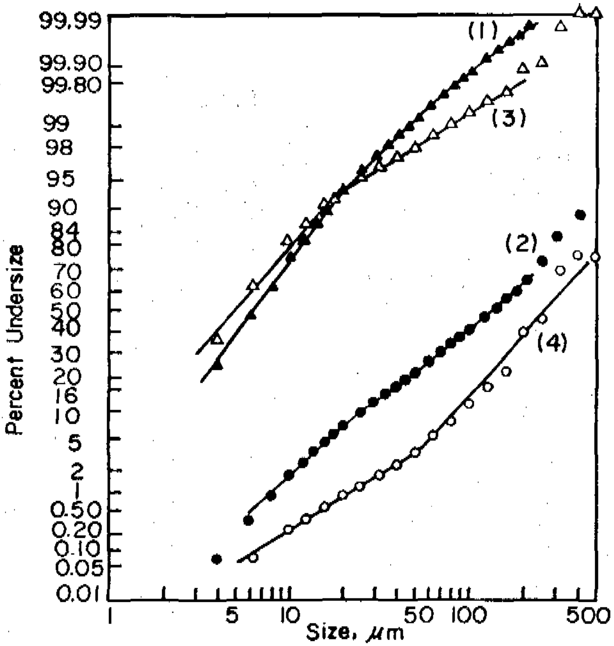

Fig. 1 . Particle size distributions. (1) number first batch; (2) volume first batch; (3) number second batch; (4) volume second batch.

APPARATUS AND PROCEDURE

Experiments were carried out in a filtration unit made of a cylindrical Plexiglas box with metal top and base, and a Plexiglas cylinder in which the filter cake is formed. As it is shown in Figure 2, filtration unit contains a load cell-transducer system (supplied by Gould-Statham Company, USA), over which a container for filtrate collection is placed; as the weight of filtrate collected increases, the load cell causes the transducer to give electrical signal to the recorder. That way, the rate of filtrate is recorded precisely.

The seepage of the filtrate around the periphery of the coal filter cake is prevented by covering the inside surface of the cylinder with a rubber sleeve and applying vacuum to it. When the

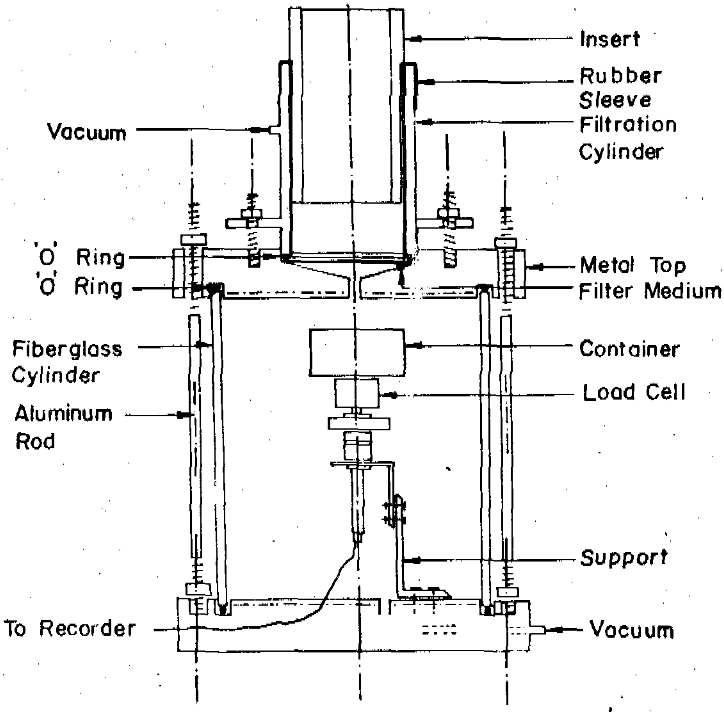

Fig. 2 : Assembly of the filtration unit.

filter cake is formed (at the end of filtration period) the vacuum is released from the sleeve. This causes the sleeve to expand around the filter cake and prevent the leakage of the filtrate.

Coal-distilled water slurries are prepared by mixing known amounts of coal and distilled water. Then, the slurries prepared are transferred into the filtration cylinder, and the vacuum provided by a pump is applied to the unit. Whatmann # 1 paper, supported on a wire mesh screen, was used as the filter media. The amount of filtrate is recorded continuously until the flowrate of the filtrate coming out of the filter cake is very low. This period was set as fifteen minutes.

At the end of fifteen minutes, the filter cake is removed its diameter and thickness is recorded and the filter cake is dried to constant weight.

Thus, the final moisture content of the filter cake is determined . The cake permeability and the specific cake resistance are determined by the application of parabolic filtration equation[7].

RESULTS AND DISCUSSION

In this section, the results from the experiments carried out with 0.33 kg coal/kg water slurry concentration at 67 kPa vacuum are given. The thickness of the filter cakes was about 0.02 m. All the parameters except the particle size were maintained constant during the experiments.

Effects of Particle Size Distribution

Particle size distribution was examined by working with the same size, but different batches of coal having different size distributions. Particle size distributions are given in Figure 1. As can be seen from the Figure, the difference in size distribution is not appreciable. However, Table 1 shows that this little difference makes appreciable changes in filtration and dewatering characteristics. The filter cake of first batch of coal is less permeable than that of the second batch. Since the fraction of big particle is lower in the first batch, it offers more resistance to flow. As it is seen from this Table the filtration period is 15 seconds (all the values given are the arithmetic means) for the first batch while it is 9.5 seconds for the second batch. Also, the specific cake resistance changes from 2.92 x 10^9 to 2.17 x 10^9 m/kg from the first to the second batch. This change is due to the contribution of the fines to the resistance. More fines in the first batch increases the cake resistance appreciably

Table 1. The Filtration and Dewatering Characteristics of the Fine Coal for different batches

	1 st batch of -32 mesh	2 nd batch of -32 mesh
Filtration Time, sec	15	9.5
Average Porosity	0.487 (0.008)*	0.534 (0.020)
Specific Cake Resistance, 10^9 m/kg	2.92 (0.74)	2.17 (0.29)
Permeability, darcy	0.533 (0.126)	0.789 (0.131)
Moisture Content of the Cake	25.46 (0.59)	24.65 (1.75)

* The values given in parenthesis are the standard deviations.

Table 2. Effect of Particle Size on Filtration and Dewatering

Particle Size mesh	Cake Formation Time, sec	Average Porosity	Specific Cake Resistance, 10^9 m/kg	Permeability, darcy	Moisture Content, % kg water/kg coal
-32	15.0	0.487 (0.008)	2.92 (0.74)	0.533 (0.126)	25.46 (0.59)
-100	16.5	0.491 (0.026)	5.45 (0.92)	0.282 (0.050)	26.90 (1.66)
-200	29.8	0.525 (0.015)	13.20 (3.49)	0.127 (0.028)	30.94 (1.86)
-400	33.3	0.567 (0.007)	23.67 (4.32)	0.075 (0.012)	39.93 (2.12)

The values given in parentheses are the standard deviations.

even though the difference in size distribution is not great.

Effect of Particle Size

The experiments with different size fractions of coal has shown that the particle size is a very important parameter in filtration and dewatering of fine coal. Table 2 gives the filtration and dewatering characteristics of the -32, -100, -200 and -400 mesh size coals. As the particle size decreases, the filter cake becomes more porous and at the same time, less permeable. More porous means more trapped moisture, and less permeable means higher resistance to filtrate flow or longer filtration time. The filtration time doubles from -32 to -400 mesh size while the moisture content increases about 21 percentage points. However, as it is shown in Figure 3, the change in moisture content is non-linear with changing particle size. The

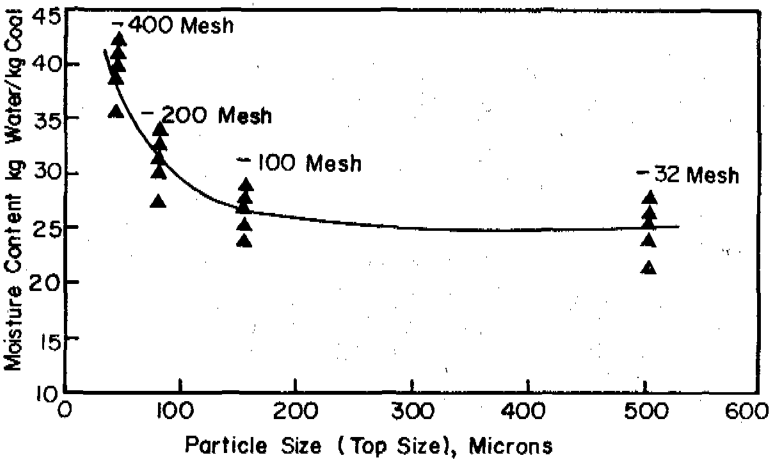

Fig. 3 . Effect of particle size on moisture content of the filter cake.

Table 3. Effect of Removing Fines from -100 Mesh Coal

Particle Size mesh	Cake Formation time, sec	Specific Cake Resistance x 10^{10}, m/kg	Permeability darcy	Final Moisture Content,% kg water/kg coal
-100	16.5	5.45 (0.92)	0.282 (0.050)	26.90 (1.66)
-200	29.8	7.32 (0.75)	0.127 (0.028)	30.96 (1.86)
-100+200	11.5	2.35 (0.47)	0.759 (0.345)	20.35 (1.59)

The values given in parenthesis are the standard deviations.

sharp increase in moisture content occurs when the size becomes smaller than -200 mesh (75 μm). Based on this result it can be concluded that the particles smaller than 75 μm mainly contribute towards the large increase in moisture content in coal filter cakes. Another important parameter which had to be investigated was the effect of ultrafine particles.

In Table 3, the effect of removing the particles smaller than 200 mesh size from -100 mesh size coal was shown. Removing that fraction causes a 6.5 percentage points decrease in moisture content. The increase in filtration rate can be observed from the filtration time. The filtration times for -200 and -100 mesh size coal are about 30 and 16.5 seconds respectively. The removal of particles smaller than 200 mesh size from -100 mesh size coal decreases the filtration time from 16.5 to 11.5 seconds. This means higher filtration rates are obtained with the removal of fines. The same conclusion results from the comparisons of specific cake resistances and permeabilities, too.

Table 4 also shows the effect of particle size on filtration and dewatering. Here, the particles smaller than 100 mesh and the particles smaller than 400 mesh were removed from the first and second batch respectively. The removal of fines improved the filtration and dewatering as it was observed from the filtration and dewatering characteristics. Five percentage points decrease in moisture content is obtained by the removal of particles smaller than 400 mesh size from -32 mesh size coal. The same change in particle size provides the specific cake resistance to fall from 2.17 x 10^9 m/kg to 1.980 x 10^9 m/kg. The removal of fines causes an increase in average particle size and also in average pore size. (As indicated in Table 4 the porosity decreases from 0.534 to 0.515). These changes in filter cake structure cause an improvement in filtration and dewatering characteristics, and the filter cake becomes more permeable which in turn results in higher filtration rate (2 seconds decrease in filtration time); and less porous which, in turn, results in higher dewatering rate (5 percentage points decrease in moisture content).

If the amount of fines removed is increased and the particles smaller than 100 mesh size are removed from -32 mesh size coal then

Table 4. Effect of Removing Fine Particles From -32 Mesh Coal

Particle Size mesh	Filtration time, sec	Average Porosity	Specific Cake Resistance, 10^9 m/kg	Permeability darcy	Moisture Content, % kg water/kg coal
-32+100 (1st batch)	17.5	0.486 (0.038)	2.41 (0.63)	0.597 (0.033)	18.66 (0.97)
-32 (1st batch)	15.0	0.487 (0.008)	2.92 (0.74)	0.533 (0.126)	25.46 (0.59)
-32+400 (2nd batch)	11.5	0.515 (0.033)	1.98 (1.49)	0.791 (0.402)	20.94 (2.40)
-32 (2nd batch)	9.5	0.534 (0.020)	2.17 (0.78)	0.789 (0.131)	24.65 (1.72)

The values given in parenthesis are standard deviations.

the changes in filtration and dewatering characteristics are more appreciable. A 6.8 percentage points decrease in moisture content is obtained while the decrease in filtration time is 2.5 seconds. In this case, the variation in particle size is reduced, because most of the small particles are removed. And this results in more improved filtration and dewatering characteristics. However, a comparison between -32 + 100 and -32 + 400 mesh size coal will not be accurate since their batches are different.

CONCLUSIONS

1. Particle size and particle size distribution have great effect on filtration and dewatering of fine coal. Increasing average particle size, increases the average pore size and this results in improved filtration and dewatering.
2. The increase in moisture content is drastic between - 100 and -400 mesh size. But decreasing the size from -32 to -100 mesh does not create a big difference in moisture content.

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