Sustainable water-pollution control technology in the South — issues and options

by Kenneth O. Iwugo

Untrammelled development, combined with its new role as the North's dumping-ground, has led to big increases in water pollution in the South. How should governments use their limited resources to tackle it?

IN THE LAST 50 years, low-income countries in sub-Saharan Africa, Asia, Latin America and the Caribbean, and the Middle East, have achieved political independence.

For these nations, political independence and liberation brought with it the inevitable quest for 'denied' development, which has resulted in rapid population growth, rapid and unplanned urbanization, unregulated exploitation of their rich mineral and other natural resources, unplanned industrialization, and ambitious agricultural-development projects.

Meanwhile, the current world economic recession, and the enforcement of stricter natural environmental regulations are 'forcing' industrialized countries to export toxic and persistent wastes to the South; where it is seen as a valuable source of money. This adds up to an increase in environmental degradation, in particular, of all types of water pollution.

Wastewater-disposal practices

The World Health Organization's Programme on Environmental Health has consistently published data and information reporting the increasingly poor environmental conditions, and the lack of environmental services (water-supply and environmental-sanitation infrastructures) in the South. The data suggests that the post-colonization 'developmental' efforts only exacerbated existing conditions.

The International Drinking Water-Supply and Sanitation Decade (IDWSSD) of 1981 to 1990 provided data which helped to quantify the magnitude of the water-supply and sanitation problems. The Decade gave impetus for increased water-supply and (basic) excreta-disposal facilities, but it did not address the problem of disposing of wastewaters from existing and proposed infrastructures.

All forms of land-based water pollution are on the increase in most developing countries (see Figure 1), mainly because there are no well-established technological, economic, legislative, and other regulatory instruments to control it, or they are not being implemented. Eutrophication is now a major problem in many countries because of uncontrolled, diffuse pollution sources.

The IDWSSD findings, and several earlier studies, revealed both the relative paucity of water-borne sanitation systems (sewerage, and septic tanks) and also their economic and technical inappropriateness in most areas. For example, in 1990, only about 13 per cent of the South's population was sewered, and this consisted mainly of the upper middle-income districts in the urban areas. The remainder, mainly in the low-income rural and unplanned urban areas, are served with low-cost communal water supply and sanitation services such as handpumps and public standposts (per capita cost of US$20 to $100), ventilated improved pit latrines, pour-flush latrines, and aqua-privies ($25-$50). Piped-water supply with house-connection installations are currently estimated at about $250 per head, while the corresponding constructional cost for piped sewerage with treatment is about $400.

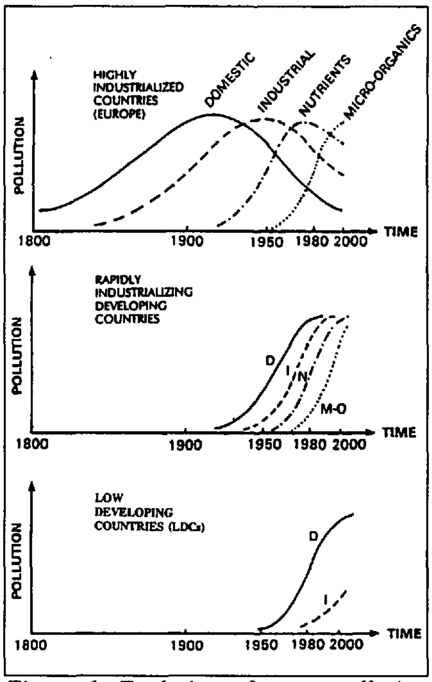


Figure 1. Evolution of water-pollution problems — North and South.

Water-borne sanitation

In developing countries, water-borne sanitation systems are characterized by:

- a low rate of household connections to sewers (typically less than 40 per cent of pipe-borne water-supply connections), resulting in under-use and regular malfunctioning — on new housing estates in Accra and Lagos most of the sewers are running at less than 30 per cent of their design capacity. The same trend has been reported in Mexico, Lahore, and Latin America;
- low volumetric capacity (typically less than $0.1 m^3$/capita-day) and medium organic-strength sewage (typically daily per capita BOD_5 of 40g to 55g); (the typical strength of British sewage is about 66g per capita per day, and for USA it is about 63g);
- small decentralized sewage-treatment plants with average flows of less than $1000 m^3$/day serving up to 10 000 people;
- extensive use of septic tanks, aqua-privies, and pour-flush latrines with the attendant problems of septage treatment and disposal;
- the prevalence of poorly operated and maintained conventional wastewater-treatment plants in sewerage systems;
- the paucity of appropriate, low-cost wastewater-treatment plants (such as waste-stabilization ponds, rotating biological filters, upflow anaerobic sludge blankets, and constructed wetlands);
- unregulated discharges of untreated, and unsuitably pre-treated, industrial wastewaters into open drains and

sewerage systems; and
- the discharge of leachates from unregulated and unattended waste dumps (landfills) into open drains and sewerage systems.

Effluent quality — requirements and targets

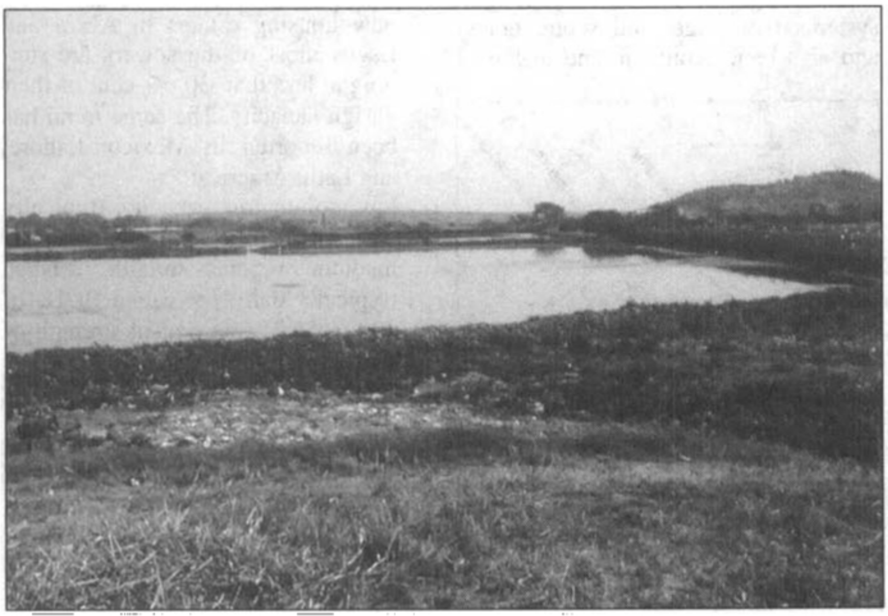
Dissolved-oxygen depletion and eutrophication are currently the most visible water-pollution problems in most developing countries. When adequate monitoring systems are established, pollution by industrial wastes may also be found to be a priority concern. In general, the bulk of the pollutants causing surface-water pollution result from diffuse (almost uncontrollable atmospheric emission and surface-runoff) sources.

Many operating wastewater-treatment plants are small and decentralized (housing estate-based) with an average flow of less than 1000m^3/d, or up to 10 000 population equivalent, which operate with varying hydraulic and organic loadings to which these plants can be very sensitive. For example, most of the conventional activated sludge variants (packaged extended-aeration plants, contact-stabilization plants, etc.) operating in various parts of Lagos were found to operate very poorly during the weekends when they received their peak weekly/daily loads, and were taking up to five days to recover.

Regular monitoring showed that the intermittent surge or shock discharges of about 0.2m^3 to 0.5m^3 high-strength organic wastewaters (BOD_5 of 250-600mg/l) from a few kitchen sinks and baths were sufficient to destabilize the performances of these packaged plant variants of conventional activated sludge plants serving five new Lagos estates, each housing less than 10 000 people, and with an estimated average daily sewage flow of 350 to 750.[3]

Developing countries, particularly in Africa and south Asia, lack effluent-quality standards and receiving water-quality standards or guidelines. Systematic and reliable data on sewage, sewage effluents, and river quality is also scarce. The available information on sewage quality from various countries suggests that small, domestic wastewater-treatment plants discharging into tropical surface waters will need to satisfy the following environmental quality objectives or standards:
- removal of biodegradable organic matter and suspended solids to the British Royal Commission Standards of 20mg/l BOD_5 at 20°C and 30mg/l of suspended solids, so that the resultant BOD_5 at 20°C of the receiving surface water does not exceed 4mg/l, and the dissolved oxygen does not fall below 4mg/l (45 per cent saturation) at 20°C;
- removal of ammoniacal nitrogen to less than 10mg/l so that the resultant concentration in the receiving water body is less than 2mg/l for total organic nitrogen (TON), including ammoniacal nitrogen;
- removal of total phosphorus to at least 5mg/l, so that the resultant concentration in the receiving water body is less than 0.5mg/l; and
- removal of heavy metals in sewage effluents to levels in which the resultant concentration of any heavy metal in the receiving water body would be less than 0.1mg/l.

The monitoring compliance rates should be negotiable and flexible but at least between 80 and 95 per cent of a minimum of 12 samples per year.



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Simpler wastewater-treatment technologies — such as this waste-stabilization pond in Lusaka — are proving to be as effective as conventional plants.

Adaptable systems

The last 15 years have seen tremendous advances in the process development and full-scale trials of several low-technology wastewater-treatment plants, such as waste-stabilization ponds, constructed wetlands (reed beds), rotating biological contactors, upflow anaerobic sludge beds, and biosand filters and their variants. These systems have also proved cheaper than conventional treatment plants.

Although the early full-scale trials were in the USA, Canada, UK, Norway, Denmark, Finland, Germany, Holland, Australia, New Zealand and South Africa, there have also been extensive trials in India, Brazil, Colombia, Kenya, Tanzania, Zambia, Zimbabwe and, to a much more limited extent, Nigeria and Ghana.

Most of these cheap, simple systems have the inherent capacity to substantially remove not only BOD_5 and suspended solids to generally acceptable low levels in sewage effluents, but also nitrogen and phosphorus compounds to the requirement levels suggested above. The urgent need would appear to be the generation of site-specific design data and information for the adaptation of these systems in communities where they are to be installed. Sequential development of these systems is also necessary in view of their relatively high cost (annual per capita cost of at least US$800) in communities where annual per capita GNP is much less than US$2000.

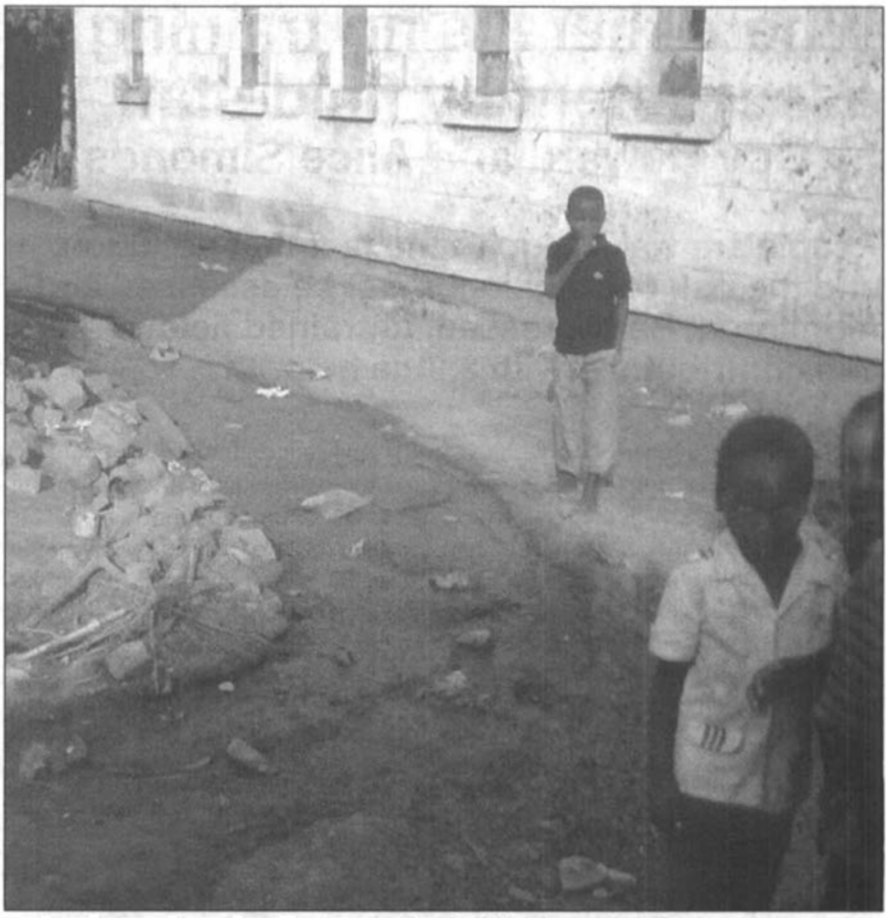
Stages of development

Depending on the volume of sewage flows, site conditions, and existing treatment facilities, a sewage-treatment facility for communities in the South can be installed and developed in four stages:
1. Install an anaerobic settling pond/tank or facultative pond, followed by either a constructed wetland (reed bed) or a grass plot. Operate and monitor continuously for at least five years (or until the facility is overloaded) both to assess performance, and to collect valuable design data.
2. Upgrade plant by adding an anaerobic pond or aerated lagoon, or a small trickling/percolating filter plant. Continue sewage and effluent monitoring in order to build up a valuable database for future plant upgrading and design.

3. When necessary, effect further plant upgrading by the addition of a compact, mechanical, extended aeration or oxidation-ditch plant. Continue sewage and effluent monitoring to build up the requisite plant-upgrading design data.
4. When necessary, provide (or convert the compact mechanical plant in stage 3) to standard activated sludge plant. Continue sewage and effluent monitoring for plant control and design.

NB A rotating biological contactor may also be a viable option for incorporation in stages 2 and 3; an upflow anaerobic sludge blanket may be an acceptable alternative to the anaerobic pond in stage 1.

Contrary to popular belief, land in the South may not always be cheap, nor readily available. A site should be selected both on the basis of likely future expansion, and on adequate environmental impact assessment (EIA). Apart from spreading the high capital costs of installations, another major advantage of this sequential approach is that it allows for the collection of realistic design data. Novel mechanical sewage-treatment plant use is also introduced in a gradual and systematic manner into an environment in which their use is not traditional, where there are few basic supporting infrastructures, and where operational and maintenance skills are lacking.



Both urban and rural pollution can lead to the loss of vital water resources — and it pays no heed to national boundaries.

Institutional and sustainability requirements

A basic capacity for intervention is required to enable any given system to deal with pollution problems, regardless of the specific problems facing a country, or the nature and degree of its socio-economic development. This capacity generally involves good and stable governance, policy formulation, information availability/dissemination, and co-ordinated implementation strategies and mechanisms.

Water-pollution-control technology problems in the South present the urgent need for:

- environmental legislation and standards — including monitoring and enforcement;
- adequate, sustainable infrastructure (regular water supply, vigorous town planning and urban renewal, and laboratory facilities);
- appropriately trained and motivated technical staff;
- the co-ordination of duties and responsibilities between different national agencies and organizations;
- the co-ordination of aid and assistance between different international development aid agencies; and
- vigorous research and development, including field-trials of appropriate-water-pollution control systems.

The resources to implement the necessary legislation will be limited. Legislation usually provides standards to control discharges and, in general, pollution-control standards are based on one, or a combination, of the following principles: Environmental Quality Objectives or Standards (EQO or EQS) which are based on toxicological effects; and Limit Values (usually related to the achievement of Best Available Technology (BAT) or BAT Not Entailing Excessive Costs (BAT-NEEC) which is based mainly on process-technology considerations; and Integrated Pollution Prevention and Control (IPPC).

The generally accepted administrative framework of pollution-discharge control is based on the 'polluter pays' principle.

Sustainability can only be achieved if Southern governments urgently put in place adequate mechanisms for adopting and implementing the effluent- and river-quality discharge standards based on the above principles. International agencies and regional economic organizations should gear their programmes towards catalysing national efforts aimed at capacity building and technology localization for water-pollution control. For example, the several water-quality and pollution-control directives of the European Union have helped to focus and give impetus to national programmes in several member states.

Perhaps particular pollution-control resolutions being adopted by some regional organizations could be made mandatory. The world has to acknowledge that water-pollution problems do not respect national boundaries.

Local and sustainable

The people charged with rehabilitating or developing municipal wastewater-treatment plants in the South must adopt a sequential approach, and use low-cost, appropriate systems. The need to encourage and promote research and development in GNP-related appropriate wastewater technologies and systems is very real. This would ensure the localization of the appropriate technology, and its sustainability. Shouldn't this 'technology localization' factor be a very high priority for the planners and implementors of any international aid project or programme?

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