DEVELOPING ALTERNATIVE APPROACHES TO URBAN WASTEWATER DISPOSAL IN LATIN AMERICA AND THE CARIBBEAN[1]

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Rapid urbanization and industrialization in Latin America and the Caribbean has aggravated serious wastewater disposal problems in that region. This article describes some of the more promising methods available for dealing with these problems—including use of submarine outfalls, reuse of treated sewage effluent, and application of unconventional technology in poverty-stricken urban neighborhoods.

Introduction

...ation and Industrialization

Urbanization in Latin America and the Caribbean (as measured by population growth) is proceeding at an average annual rate in excess of 3.8%, while the area's total population (367 million in 1983) is growing at only 2.4% *(1)*. This implies that the rural population is stabilizing at around 116 million and the demographic explosion is being absorbed mainly by the cities. At present there are 286 cities in the area having more than 100,000 inhabitants; the population of these cities, where 46% of the area's people live *(2)*, is distributed as shown in Table 1. In addi..., there are over five times this number of smaller cities with 20,000 to 100,000 inhabitants.

Only about 43% of this great urban population has access to sewer systems *(3)*, and over 90% of the wastewater collected is discharged directly to receiving waters without treatment of any kind. In the slum communities that typically surround the urban centers, this difficulty is especially marked, and excreta disposal is a leading sanitary and health problem.

With regard to industrial waste, the Gross Domestic Product (GDP) of the countries in this region grew at 6.1% per year during the 1970s, while industrial manufacturing increased 7.7% per year during the same period *(1)*. As these figures suggest, notwithstanding the economic slowdown affecting these countries over the past two years, a major concentration of industry exists in the major metropolitan centers and is continuing its production activities. Industrial waste discharges, too often uncontrolled, commonly go untreated into sanitary sewers.

This concentration of people and industrial plants has created serious localized environmental problems, often with grave public health consequences. One characteristic of these problems in the region is that most of their impacts are limited to the same urban population that generates the wastes. External effects are minimal

Table 1. Distribution of the population of major urban centers in Latin America and the Caribbean, circa 1982.

Population greater than	Number of centers	Total population (millions)
100,000	286	167.6
500,000	58	114.9
1,000,000	28	93.7
3,000,000	8	60.8

Source: United Nations *(2)*.

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due to the relative geographic isolation of the large urban centers.

Even though the Economic Commission for Latin America (ECLA) estimates that 27% of all water resources investment goes for water supply and sewerage projects *(4)*, present levels of investment are insufficient. Just to maintain current levels of water quality in South America would require investments in treatment works and sanitary sewers on the order of 0.6% of the GNP of the countries involved *(5)*. This is much more than the total sum currently being spent on environmental sanitation.

Geographic Considerations

Realistic approaches to wastewater disposal in Latin America must take into account the geographic characteristics of the region. Four features in particular stand out: tropical climates in many areas; highlands (the *altiplano)* in others; extensive arid and semiarid zones; and the coastal or riverine locations of many cities.

Most of the region's people live in tropical climates. The major exceptions to this rule are found in Argentina, Chile, Uruguay, and portions of the Andean highlands in Bolivia, Colombia, Ecuador, and Peru. This circumstance strongly affects many important aspects of sewage disposal. Perhaps the most important public health consideration is that more pathogenic microorganisms are present, and many of these exhibit both increased virulence and increased persistence in the tropics. Also, the average rates of biochemical processes tend to be almost double what they are in temperate zones; this vital fact affects all phases of bacterial growth and respiration, waste decomposition, waste treatment, assimilative capacity, eutrophication, and so forth.

In the Andean highlands—where concentrated rural peasant populations often live in conditions of extreme poverty, poor sanitation, and prevalent diarrheal disease—the usual altitude of the populated areas ranges from 3,000 to over 4,000 meters. Here the normally low average daily temperatures slow down biochemical processes—the opposite of the above situation and one that, among other things, makes treatment processes less efficient. At the same time, because of the lower atmospheric pressure, typical dissolved oxygen saturation concentrations drop to 6-7 mg per liter, another fact that reduces treatment efficiency as well as the assimilative capacity of natural waterways.

Those concerned with environmental problems in the region must also consider distribution of the people, tillable land, and water resources—especially water resources. The reason for the latter emphasis is that while abundant humid ecosystems exist within the region, these generally have low population densities. In contrast, the 20% of the land that is arid or semiarid, with only 5% of the region's water resources, supports 60% of the population *(6)*. Therefore, use of these scarce water resources for waste disposal may severely limit their ability to perform other beneficial tasks.

Finally, the coastal or riverine locations of many urban centers may dictate waste treatment and disposal choices. As Figure 1 shows, a significant number of cities with over 100,000

Figure 1. Urban centers in Latin America and the Caribbean with over 100,000 inhabitants.

people are situated along the coast or on river estuaries, suggesting that the option of establishing submarine outfalls is important. This point is particularly valid in the Caribbean zone. At the same time, interior cities are often located along rivers that in earlier periods adequately served the cities' water supply and waste disposal needs, but that today have insufficient capacity for these uses. This suggests that in such cases particular consideration should be given to some form of land disposal, and that increased attention should be focused on reuse.

Water Quality and Urbanization

A number of water quality problems are related to the characteristics of urbanization, industrialization, and geography described above. The following are among the more important:

- deterioration of water supply sources that every day become scarcer and more costly to develop in the face of an exploding demand;
- inadequate disposal of wastes—including increased domestic sewage that causes microbiological quality problems and concentrated industrial discharges that cause increased chemical contamination;
- indiscriminate reuse of raw sewage waters for irrigation in arid and semiarid zones with endemic waterborne disease;
- modification of the runoff regime and an increased impact of diffuse pollution related to deficient garbage collection, street-cleaning, and sewer services;
- increased demand for recreational opportunities by the urban population at the same time that the quality of available water resources is declining.

In addition to these problems—mostly specific to the big urban centers—a number of other water quality problems have emerged that are associated with the increased regulation and use of water resources. Among other things, there is a constant increase in the number of large reservoirs being constructed, and it is estimated that the volume of the region's total water storage capacity is growing at 10% annually *(6)*. Given this situation, the following problems are becoming more common and may have a significant impact on urban water use:

- eutrophication of water supply sources, especially tropical reservoirs *(7)*;
- increased breeding sites for disease vectors;
- reduction of the assimilative capacity of regulated streams where waste disposal competes seasonally with irrigation and energy uses;
- increased use of fertilizers and biocides in agriculture;
- salinization of arid and semiarid lands due to intensive irrigation projects.

Water and Health

It is well-established that water is an important vehicle for the transmission of many pathogenic microorganisms as well as organic and inorganic toxic substances. McJunkin *(8)* has classified the more important transmissible diseases in the Third World according to the role played by water in the chain of transmission as follows:

- Waterborne diseases (e.g., enteric and diarrheal diseases, typhoid fever, hepatitis);
- Water hygiene diseases (e.g., trachoma, shigellosis);
- Water contact diseases (e.g., schistosomiasis);
- Water vector diseases (e.g., malaria, onchocerciasis).

As a group, the enteric and diarrheal diseases present one of the most severe health problems in the region. According to PAHO data *(3)*, as of 1979 they were still the number one cause of infant mortality in many countries. (The overall extent of infant mortality in the Americas is indicated by the data in Table 2.) This situation is aggravated by the fact that only 72% of the urban population and 15% of the rural population have piped water supplies, while only 43% of the urban population and 2% of the rural population have access to sewerage.

Table 2. Infant mortality data for the Americas, 1979.

Subregion	Death rate per thousand children		Percentage of all deaths occurring among children	
	Under 1 year old	1-4 years old	Under 1 year old	1-4 years old
Northern America	12.9	0.7	2.4	0.4
Caribbean	20 5	0.7	10.5	3 0
Continental Middle America	50.9	10.4	28.4	15.4
Temperate South America	32.5	1 5	11.5	1 9
Tropical South America	36.6	4 2	24.0	10.5

Source: Pan American Health Organization, *Health Conditions in the Americas, 1977-1980, (3).*

In recognition of this problem, PAHO/WHO has stated that the goals of the International Decade for Water Supply and Sanitation are necessary conditions for improved levels of health in the region *(9)*. Accordingly, improved water supply and sanitation have become the top priority of the Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) and of PAHO's Environmental Health Program.

At the same time, it is important to note that progress made in controlling these water-related diseases is also contributing to increased life expectancy. During the period from 1960 to 1980 the average life expectancy in the region rose from 55 to 64 years *(10)*. This development, though certainly favorable, raises other environmental health questions; for in combination with increased industrial discharges it has resulted in increasing exposure of a progressively larger group of older people to greater risks of both chronic and acute toxic effects associated with chemical contamination.

Wastewater Disposal Issues

Water Pollution Control Policies and Programs

Water pollution control programs require the evaluation of receiving water quality based on prevailing and anticipated water uses and specific water quality objectives for each use. As a first step, a methodology is needed in order to establish a coherent set of water quality objectives for receiving waters. This methodology must be founded on sound scientific criteria, and must translate the in-stream objectives into water quality standards—usually discharge standards in the form of waste load allocations. The methodology used should also be based upon socioeconomic criteria (criteria that will do such things as minimize the sum of control costs plus pollution damages and that will also relate water quality to integrated water resource development) and upon technical-scientific criteria (including such things as mathematical models of water quality) that will deal with transport and decay mechanisms of pollutant discharges in the aquatic environment.

Once water quality objectives, discharge standards, and control policies are set, the next step in a pollution control program is to establish a monitoring system that will determine whether the standards are being complied with and a system of sanctions to deal with instances of noncompliance.

Obviously, a program of this type requires a sound legal foundation and an institutional infrastructure supported by sufficient human, technical, and financial resources. Therefore, key matters to be considered in developing pollution control programs in the region include modernization of legislation, institutional development, establishment of the necessary analytical framework together with corresponding information requirements, and human resource development.

Water quality legislation within the region varies greatly from country to country. In the past, the tendency has been to establish classification schemes for waterways based on prevailing uses, and to set uniform in-stream standards for each class of waterway. This approach has generally failed because of its inflexibility, its failure to provide a means of relating in-stream water quality to discharges, and its inability to deal with local economic issues. Another frequent problem has been the tendency to promulgate fixed standards and pecuniary sanctions within the laws themselves, rather than through an appropriate regulatory process defined by legislation. Such detailed laws quickly become outdated and ineffective, but are difficult to change.

In almost all Latin American countries the concept of water quality has traditionally been identified with public drinking-water supplies. For this reason the health ministries have been responsible for water quality control. This situation is beginning to change as comprehensive environmental protection agencies are established in a few countries such as Brazil, Colombia, and Venezuela, and as special water pollution control agencies emerge in others such as Mexico. Separate national agencies are now usually responsible for urban water supply and sewerage programs. Rural water and sanitation programs, however, are generally still assigned to the ministries of health.

Notwithstanding a rich and varied experience in Latin America with river basin management agencies, only a very few of these institutions have ever been assigned responsibility for water pollution control. Notable exceptions include the regional corporations established for the Cauca River and the Bogotá River in Colombia.

Water pollution control agencies often have institutional infrastructure problems, particularly in cases where salary scales are low, staff turnover is high, and there is an apparently contradictory lack of institutional demand for specialists; all of these conditions make it difficult to attract and retain experienced professionals. Furthermore, water pollution control agencies often lack a sound financial base for their activities, and this, besides affecting staffing, may also be reflected in a lack of adequate physical facilities such as laboratories, or, where these do exist, may result in insufficient resources for the operation and upkeep of such facilities.

With regard to the analytical framework, two related problems exist. That is, it is necessary to make an appropriate selection of the analytical techniques or models to apply to a specific water quality problem, and it is necessary to deal with the constraints imposed by limited availability or reliability of the data needed for analytical purposes. Too often the data required to calibrate, verify, and apply a water quality model are not readily available. Routine environmental monitoring of water quality for planning and control purposes is the exception, and where isolated studies have been carried out, the resulting data sets are often incomplete or inconsistent. As a result, those involved in model selection should carefully consider corresponding data requirements and should judiciously weigh the need for costly intensive data collection campaigns.

Finally, there is a great shortage of scientific and technical personnel required for carrying out water pollution control activities in the region, even considering the reduced institutional demand. Greater priority should therefore be placed on water quality planning and management in university programs, and more extension courses and in-service training programs should be offered for engineers practicing in this area. In this vein, the Pan American Center for Sanitary Engineering and Environmental Sciences in Lima, Peru, has been working intensively to promote specialized training activities and to produce instructional materials and manuals on water pollution control.

Investment Capacity

In recent years, a combination of economic circumstances has been adversely affecting the investment capacity of water and sewage agencies in the region. As a result, while the region's Gross Domestic Product grew at an annual rate of 6.1% during the decade of the 1970s and manufacturing grew at 7.7% per year, the recent worldwide economic recession subsequently caused these rates to fall to 0.5% and 0.7%, respectively, in 1981 *(10)*. At the same time, foreign indebtedness reached a point where the average foreign indebtedness in Latin America was US$505 per capita. Thus, the sharp downturn in industrial growth combined with the pressing need to refinance foreign loans has necessarily affected national water supply and sewerage investment programs.

Estimates made in 1980 of the worldwide cost of meeting the goals of the International Decade for Water Supply and Basic Sanitation averaged about US$30 billion per year (approximately US$5 billion per year for Latin America and the Caribbean). However, even in 1978 the investments actually made only totaled US$7 billion (US$1.5 billion in Latin America and the Caribbean). In other words, the Decade goals would require mobilizing many times the financial resources previously spent. In this connection, the track record for the first three years of the Decade is not promising. For example, World Bank loans for the water supply and sewerage sector decreased from $572 million in 1977 to only $441 million in 1982, with Latin America and the Caribbean being one of the most affected regions *(11)*. However, there are recent signs of a turnaround in World Bank lending in the sector.

Partly for the above reasons, various interrelated economic and technological issues in the area of wastewater collection, treatment, and disposal are receiving increased attention in Latin America. These include the following:

- Water and sewerage companies should achieve a greater degree of self-financing through the application of adequately designed tariff structures.
- Wastewater disposal systems need to be optimized using cost-efficient technology, eliminating unnecessary treatment, and making maximum use of the assimilative capacity of receiving waters and land treatment.
- Wherever possible, without endangering public health, reuse alternatives designed to convert wastewater into an economic resource should be considered.
- Conventional design and construction criteria and standards should be carefully reviewed and revised to achieve greater economies.
- Nonsewered disposal options for urban slum areas need to be demonstrated, along with the possibilities for community participation in construction and operating activities that could further lower costs.

While some of these approaches might be considered controversial in developed countries, and while their implementation would require that design engineers give up their routine conservative approaches, they represent the only hope for significantly extending wastewater and excreta disposal services to large segments of the urban population in Latin America. The rest of this article will discuss some of the more promising options.

Wastewater Disposal Alternatives

Wastewater Disposal in Coastal Areas

Of the 286 cities with more than 100,000 inhabitants shown in Figure 1, 76 are located along the coast or on river estuaries. This number increases many-fold when cities of 20,000 to 100,000 inhabitants are included.

A common practice in the coastal cities is to discharge untreated wastewaters to the nearest or most convenient water body, and sometimes only secondary considerations are given to the ensuing environmental consequences. Indeed, raw sewage discharges have often occurred very near bathing beaches, as happened in the case of the world famous Ipanema Beach in Rio de Janeiro, and as currently happens at or near the beaches of Montevideo, Lima, and most other coastal cities of the region. Such discharges entail potential health and ecologic hazards; they also create esthetic problems and may cause economic losses associated with reduced tourism.

In view of the vastness of the oceans, it is only logical that the residual liquid wastes of coastal cities should be discharged to the adjacent ocean waters. Nevertheless, in seeking to avoid the above-mentioned problems, a question arises as to whether the most appropriate means consists of conventional waste treatment, use of ocean outfalls, or a combination of the two. Latin America should not adopt, a priori, official policies established in some developed countries that advocate secondary waste treatment, unless there appears to be clear justification. Quite to the contrary, in an uncomplicated open-ocean situation, the approach of constructing ocean outfalls and providing pretreatment for floatables offers many advantages over conventional solutions using secondary waste treatment with discharge close to shore. For example, ocean outfalls designed to properly eliminate wastewaters can consistently achieve immediate dilutions on the order of 100 to one during the first few minutes of discharge, thereby reducing the concentrations of organics and nutrients typical of domestic wastes to levels that have no adverse ecological effects. This is far beyond the capabilities of conventional secondary treatment. Also, subsequent mortality of bacteria in the hostile ocean environment can further reduce the concentrations of pathogens to levels comparable to or below those achieved by chlorination of secondary effluents. An additional point favoring outfalls is the fact that biological treatment processes are often subject to upsets that can result in the direct onshore or near-shore discharge of raw wastes. Discounting structural outfall failure, which is rarely encountered with modern designs, if off-shore ocean outfalls were used, such discharges could not occur.

The unit construction costs of ocean outfalls under various conditions, according to projections prepared by Wallis *(12)* and updated by Ludwig *(13)*, are presented in Figure 2. Ludwig also performed further economic analyses demonstrating that for typical urban waste flows the

Figure 2. The estimated cost of submarine outfalls of varying diameters. The original data were provided by Wallis *(12)*, with the exception of the data on high density polyethylene (HDPE), and were subsequently updated by Ludwig *(13)*. The abbreviation "ENR" stands for the Engineering News Record Index.

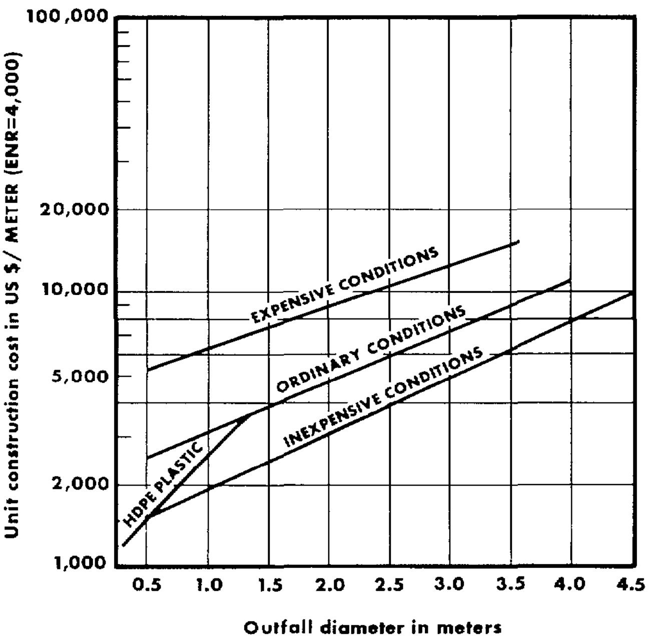
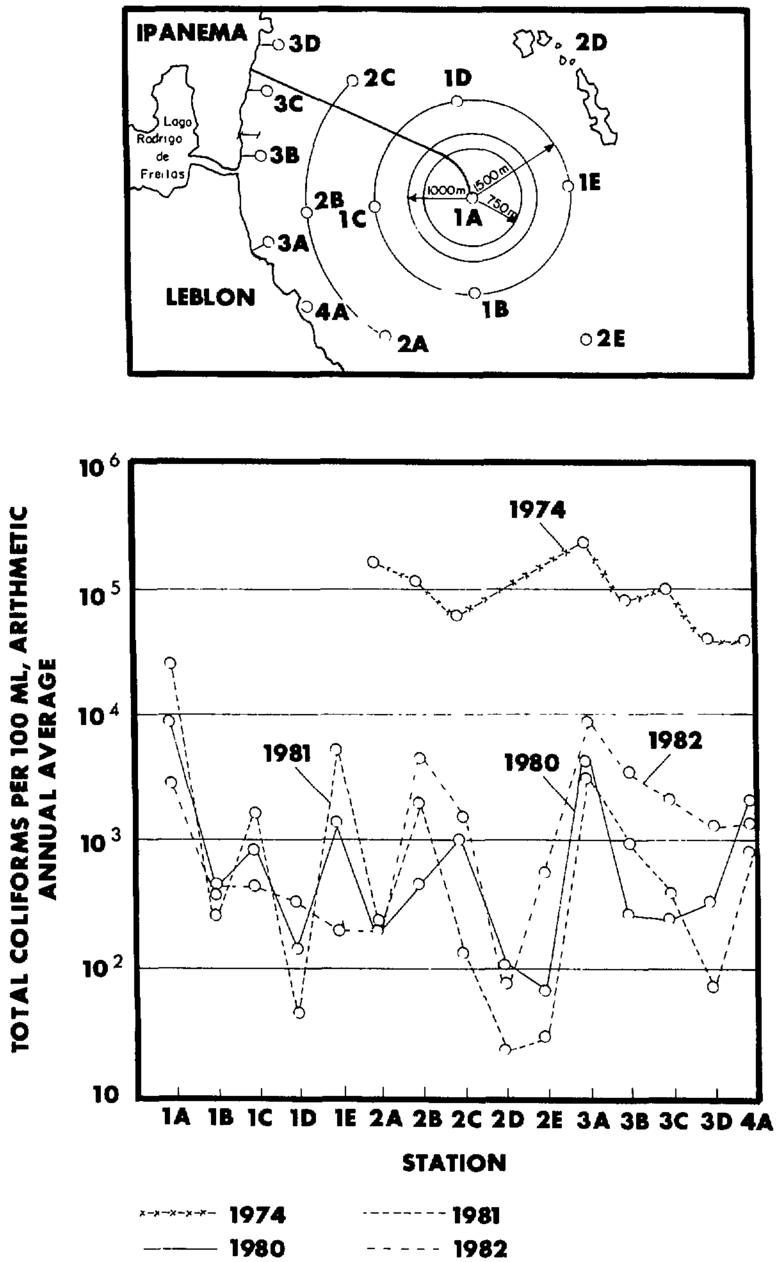


Figure 3. A map and chart showing sampling stations around the Ipanema Outfall and coliform counts (arithmetic annual averages) obtained from water collected at those stations in 1974 (before the outfall was constructed) and in 1980, 1981, and 1982 *(14)*.



lifetime cost differential between conventional secondary treatment on the one hand and conventional primary treatment with ocean outfalls on the other clearly favors the latter course. This conclusion is based on the knowledge that properly designed long ocean outfalls (three to five kilometers in length) discharging into tropical waters at depths greater than 20 meters will almost always meet both total and fecal coliform standards for bathing beaches. Limiting pretreatment to the removal of floatables only would make the comparison even more favorable for the ocean outfall alternative. Also, the recent use of more economical plastics in the construction of outfalls further demonstrates the viability of this alternative for waste disposal, especially for communities of small to intermediate size.

The partial results of a CEPIS survey now in progress indicate there are 26 existing outfalls longer than 1,000 meters in Latin America; eight of these are located in Brazil, five are in Venezuela, six are in Mexico, and five are in Puerto Rico. Of them all, the Ipanema Outfall is perhaps the best known, and its receiving waters have been extensively monitored *(14)*. This outfall services the southern zone of Rio de Janeiro, maintaining a present sewage flow of six cubic meters per second; its design flow, projected for the year 2000, is 12 cubic meters per second. It has a length of 4,325 meters, a diameter of 2.4 meters, and a diffusor that is 400 meters long (with 178 ports 17 centimeters in diameter) that discharges at a depth of 28 meters. Continuous water quality monitoring, conducted by the local water and sewage authority (Companhia Estadual de Aguas e Esgotos), has demonstrated significantly improved conditions since inauguration of the Ipanema Outfall in September 1975, as can be seen in Figure 3. Aside from coarse screening to protect the pumps, no wastewater treatment or chlorination is provided for the Ipanema Outfall effluent.

Chile and Venezuela have numerous outfalls of less than 1,000 meters. However, most of these are merely extensions of the sewer system and have not been designed according to modern criteria in order to optimize initial dilution of the effluent.

In general, dissemination of modern outfall design technology, which is presently limited to a few countries, is needed in the region. To this end, CEPIS is preparing a manual on the conceptual design of ocean outfalls that will address the interests of national water and sewage institutions within the region. This manual's primary objectives will be to provide a basic knowledge of submarine outfall design requirements and to develop national water and sewage institution capabilities to establish good terms of reference for contracting such projects and for adequately reviewing the quality of work during the proposal and execution stages.

Application of Water Quality Management Technologies

Water pollution problems within the region range from severe dissolved oxygen problems—as evidenced by extensive reaches of rivers with zero dissolved oxygen levels such as the Salí River in Argentina *(15)* and the Bogotá River in Colombia *(16)*—to bacteriologic contamination (e.g., in Peru's Rimac River—*17)*, to contamination with toxic substances (e.g., in Brazil's Paraiba River—*18)*. The key to solving these problems is development and dissemination of policy, planning, and control methodologies for water quality management. Within the context of the limited investment resources and competing priorities already discussed, it is evident that the assimilative capacities of the natural bodies of water involved must be utilized, and that the imposition of blanket levels of waste treatment without taking cognizance of this assimilative capacity will often result in excessive investment requirements. All this implies an urgent need to develop sound and efficient water quality planning models, in which design criteria are directed toward optimizing water use and protecting public health.

Mathematical models, which relate waste inputs to water quality in the receiving water body, can be employed to evaluate alternate engineering plans for control and management of water quality. Solutions that involve varying degrees of treatment (no treatment may be a legitimate option), relocation of the waste discharge points, low flow augmentation, in-stream reaeration, and regional treatment systems versus multiple plants are some of the specific alternatives whose influence on receiving water quality can be assessed by the application of water quality models.

The factors that influence the degree of complexity of the modeling effort include the water quality problem at hand, the characteristics of the water body, the availability of data on present and past water quality and waste discharges, the public health and environmental risks associated with the discharged contaminants, the range of alternative strategies and options available, and the time and funds available.

The climatic characteristics of the region require special consideration in the development and application of mathematical models. For example, the construction of artificial multipurpose reservoirs for potable and industrial water supplies, irrigation water, and hydroelectric power has accelerated in the region over the years. However, these reservoirs have generally been created without regard to the potential for eutrophication. The only simplified models available for the evaluation of eutrophication in lakes and reservoirs were developed from data on temperate lakes, and it has been concluded that these methodologies are not adaptable to the predominantly warm-water lakes of the region *(7)*. Therefore, CEPIS has initiated a regional project to develop simplified methodologies for the evaluation of eutrophication in warm-water lakes and reservoirs. At present, nine countries in the tropical and semitropical areas of the region are performing this research through investigations of 26 lakes. It is expected that the results will provide a tool not yet available for the planning of future reservoirs as well as for estimating the extent of corrective measures required to alleviate present problems.

The various countries' technical capacity for applying water quality management methodologies in the region is quite variable, ranging from state-of-the-art mathematical modeling capabilities (in several Brazilian institutions) to mere familiarity with the simple Streeter-Phelps dissolved oxygen model. CEPIS is therefore directing its efforts toward developing and training multidisciplinary study teams in a small number of national institutions that have the required technical capabilities and institutional resources to assume a leadership role in this area within the region. The objective is to achieve a multiplier effect in technology transfer through future horizontal cooperation between these experienced institutions and similar agencies in other countries in the early stages of initiating water quality control programs.

Another important role for CEPIS is to educate decision-makers concerning the practical usefulness of planning and modeling methodologies. A great deal of skepticism exists about this matter, and examples of successful case histories—such as the Cauca River project in Colombia *(19)* and the Guanabara Bay project in Brazil *(20)* are valuable illustrations of what can in fact be done. One compelling example outside of Latin America is the Washington, D.C., metropolitan area water resources optimization project, in which no major physical works were designed or constructed. The project's goals were accomplished solely by applying state-of-the-art water resources planning and management techniques so as to improve the aquatic environment while meeting future water demands. The end result of this undertaking was recognized by the American Society of Civil Engineers as one of the outstanding civil engineering achievements of 1983 *(21)*.

Wastewater Reuse

The large-scale reuse of untreated domestic sewage waters for irrigation is commonplace in many arid and semiarid zones of Latin America, and is very often performed without effective sanitary controls. This practice may pose substantial health risks for farm workers and for the population consuming agricultural produce from such areas. High rates of enteritis, other diarrheal diseases, typhoid, and hepatitis tend to be associated with these projects. Some examples of large-scale wastewater reuse are as follows:

• In Chile the *Zanjón de la Aguada* irrigation canal receives 80% of Santiago's domestic and industrial sewage. The wastewater from this sewage is used, together with the polluted waters of the lower Maipo River, to irrigate some 16,000 hectares of land near the city *(22)*. Of this land, an area of 6,200 hectares irrigated with four to six cubic meters per second of raw sewage water supplies the city with horticultural products.

• Mexico's Irrigation District No. 3 near Mexico City consists of 41,500 hectares irrigated with raw or mixed sewage. Other irrigation districts near the city also use raw sewage. Edible crops from these reuse sites have been found contaminated with fecal coliforms *(23)*.

• In Peru, 31 reuse projects have been identified along the country's desert coast, many of which use waste stabilization pond effluents. There are also some uncontrolled reuse sites in and around Lima *(24)*. Peruvian authorities are currently planning to reuse five to eight cubic meters per second of *treated* effluents to irrigate 5,000 hectares of desert land to the south of Lima.

As some of these examples suggest, the heavy concentration of populations in arid and semiarid zones of the region gives rise to an economic demand that is creating spontaneous and indiscriminate reuse. The responsible public health authorities must anticipate these economic pressures, and must plan for and implement adequate sanitary control measures. In addition to the risk of microbiologic contamination by bacteria, viruses, and parasites, there are potential problems of chemical contamination of edible crops, livestock, dairy products, and fish through the bioaccumulation of trace metals and toxic organic substances. Also, increased bacterial resistance to antibiotics is of concern, since reuse projects may create environmental conditions that favor the transfer of R-factor resistance among bacterial species. Clearly, then, there is a pressing need for field research aimed at evaluating sanitary strategies for controlling wastewater reuse.

Since 1977 CEPIS has been cooperating with Peruvian health agencies on a series of research projects dealing with the San Juan waste stabilization ponds in Lima and the reuse of treated effluents for agriculture and aquaculture, with the aim of evaluating the health risks of reuse and developing needed sanitary control measures for the protection of public health. The results to date show that the treatment provided by the multicell stabilization ponds is highly efficient, and that (through the adequate design of three ponds in series) effluents are obtained which meet common irrigation water quality criteria for parasites and indicator bacteria *(25)*.

The health, socioeconomic, and environmental benefits resulting from safe, controlled reuse projects are many; they include the recovery of arid lands for agriculture, creation of employment and settlement opportunities, increases in agricultural productivity that can help resolve protein deficits and improve nutrition, creation of a potential for increased recreational opportunities and amenities through establishment of parks and green belts, and development of a viable alternative to other forms of sewage disposal and their corresponding pollution problems. Collectively, these benefits suggest that reuse efforts may offer one way of financing sewage works.

Low-Cost Technology

The explosive urbanization in the Latin American countries has given rise almost overnight to peripheral communities that severely strain the ability of water and sewage authorities to provide even minimal services. As a result of these pressures, combined with limited financial resources, conventional sewer systems are often limited to serving the older inner-core city areas and the newer middle and upper class residential areas. Indeed, the bulk of the 57% of the urban population lacking sewers lives in these urban fringe slums. While many of the people involved may receive water through household or patio connections, they often lack basic sanitary facilities for excreta disposal or graywater drainage. Because the provision of conventional systems for these urban fringe areas exceeds the investment capacity of many large cities, only drastic revision of design criteria and sharp cost reduction is likely to offer hope of providing even minimal levels of service to these areas.

One innovative project of this sort is currently under construction in Cochabamba, Bolivia, a city of 240,000 inhabitants. New design criteria have been applied by the local water and sewage service in order to reduce sewer diameters, slopes, and manholes, thereby cutting costs. Additional economies were achieved by designing modular pumping stations. The collected effluents are to be treated in waste stabilization ponds and subsequently reused for irrigation. This integrated unconventional approach is expected to result in conventional standards of service for the population of Cochabamba at greatly reduced cost.

However, even this approach is not affordable for many slum communities. New ideas have increasingly been put forward by international and bilateral funding and aid agencies—such as the World Bank, the U.S. Agency for International Development (AID), and Canada's International Development Research Center (IDRC)—which are seeking to explore "low-cost technology" options. Multivolume compilations of such options have been published by the World Bank *(26)* and AID *(27)*, and demonstration projects are springing up in Latin America. Some examples of the solutions being proposed are as follows:

- Construction of ventilated pit latrines, using community self-help labor, in slums of Guayaquil, Ecuador, where sewers are not technically or economically feasible.
- Promotion of an improved design for the Colombian pour-flush toilet with a hydraulic seal, which is being developed in collaboration with the Brazilian Technological Research Institute. This toilet utilizes only three liters (0.8 gallons) of water for flushing. The commercial production of the toilet is being explored with national manufacturers, and it is being installed in a large-scale demonstration project in Campo Grande, Brazil.
- Installation of lined pit latrines emptied by means of vacuum pump trucks or carts. Some 30,000 prefabricated units are being installed in a three-year program in Recife, Brazil, with community self-help labor. Under the terms of this program the user amortizes the cost of the latrine (about US$60) over a five-year period and pays a monthly service charge for latrine cleaning and maintenance. Up to one-third of the payment can be made in kind through contributions of manual labor and cement.
- Development of a demonstration project in Natal, Brazil, that uses unconventional sewers that tie into all of the houses on a block by means of 100 mm PVC pipe running underground through the back yards at a depth of 30-40 cm and that employ cleanout pipes instead of inspection manholes. The community contributes materials and labor, and also pays a monthly sewer fee. This demonstration project is also experimenting with three-liter pour-flush toilets, multi-house septic tanks, and waste stabilization ponds combined with a system for reusing treated effluent.
- Installation of communal sanitation facilities—including toilets, showers, and clothes-washing facilities—usually located at or near local schools or community centers.
- Use of neighborhood extended-aeration composting mounds in Haiti to dispose of mixed excreta and organic garbage in a manner ensuring adequate pathogen destruction.

It is important that these and other proposals and demonstration projects be carried through to completion and be subjected to complete evaluation regarding their technical and sanitary soundness, their economic feasibility, and their acceptance by the communities involved. To assist this process, CEPIS is coordinating a regional network of national water and sanitation institutions *(28)*, sponsored by PAHO and IDRC, whose aim is to gather and exchange technical information on appropriate technology experiences in Latin America and the Caribbean, and also compile a register of research, development, and demonstration projects in this area. CEPIS is also providing technical cooperation to national research groups that are seeking to develop proposals, obtain funding, and carry out demonstration projects.

It is felt that if solutions of this kind can be shown to work, and if they prove acceptable to urban fringe communities, improved sanitation may finally be brought within reach of many millions of the urban poor in places where present sanitary services are inadequate or lacking.

SUMMARY

The explosive rate of urbanization and industrialization in Latin America and the Caribbean has aggravated serious wastewater disposal problems. To address those problems, sound pollution control programs are needed—programs that are founded on a firm legal base and supported by an institutional infrastructure suitable for their effective operation. Such programs should make a point of employing technologies that are appropriate for the climatic and economic conditions prevailing in the areas they serve.

Promising methods for dealing with such problems include use of submarine outfalls with minimal pretreatment for cities along coasts and estuaries, maximum use of receiving waters' assimilative capacity (as determined through application of system management and water quality models), reuse of treated sewage effluent for irrigation, and the application of unconventional technology for urban slum sanitation. This article reviews those various approaches and describes the ongoing collaboration between national governments and PAHO's Pan American Center for Sanitary Engineering and Environmental Sciences (CEPIS) in the areas of research, information exchange, human resources development, and institutional development for the purpose of establishing a viable strategy and framework through which these major problems can be confronted and perhaps ultimately overcome.

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INTERNATIONAL CONFERENCE TO BE HELD ON THE ACQUIRED IMMUNE DEFICIENCY SYNDROME (AIDS)

An international conference on the acquired immune deficiency syndrome (AIDS) will be held on 15-17 April 1985 at the World Congress Center in Atlanta, Georgia. The meeting is being sponsored by the World Health Organization and by several major United States agencies—including the Centers for Disease Control, the National Institutes of Health, the Food and Drug Administration, the Health Resources and Services Administration, and the Alcohol, Drug Abuse, and Mental Health Administration.

The purpose of the gathering is two-fold: to review strategies for the prevention and control of AIDS; and to exchange information on screening and diagnostic tests for AIDS as well as on the epidemiology, virology, immunology, clinical manifestations, and treatment of the disease. Further information about the conference can be obtained by writing to: AIDS Conference, Building 1, Room 2047, Centers for Disease Control, Atlanta, Georgia 30333, U.S.A.

Source: See Caribbean Epidemiology Center, *CAREC Surveillance Report*, October 1984, p.5.