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# **DISPOSAL OF COMMUNITY WASTEWATER**

**Report of a WHO Expert Committee**

WORLD HEALTH ORGANIZATION

GENEVA

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# CONTENTS

	Page
1. Introduction . . . . .	5
2. Significance of wastewater collection and disposal . . . . .	6
2.1 Public health aspects . . . . .	6
2.2 Environmental aspects . . . . .	8
2.3 Cultural and socioeconomic aspects . . . . .	9
2.4 Effects of population growth, urbanization, and industrialization . . . . .	11
3. Technical problems of wastewater collection and disposal . . . . .	12
3.1 Information and data collection . . . . .	12
3.2 Water-borne systems and alternatives . . . . .	14
3.3 Urban fringe and rural problems . . . . .	19
3.4 Wastewater treatment problems . . . . .	20
4. Management problems . . . . .	21
4.1 Relationship to water supply . . . . .	21
4.2 Economic aspects . . . . .	22
4.3 Financial aspects . . . . .	28
4.4 Manpower and material resources . . . . .	29
5. National planning . . . . .	30
5.1 Objectives and policy . . . . .	30
5.2 Manpower and material resources development . . . . .	32
5.3 Financing . . . . .	35
5.4 Legislation . . . . .	38
6. Community planning . . . . .	40
6.1 Master plans ; interrelation with land use and water supply planning ; staging . . . . .	40
6.2 Design criteria ; effluent disposal . . . . .	43
6.3 Preliminary surveys, design, and construction . . . . .	50
6.4 Nonconventional approaches . . . . .	52
6.5 Economics and financing . . . . .	58
7. Organization, administration, and management . . . . .	61
7.1 Regional management . . . . .	61
7.2 Combined administration of community water supply and wastewater disposal systems . . . . .	63
7.3 Role of health agencies . . . . .	67
7.4 Health education . . . . .	68
8. Research and development . . . . .	68
9. Conclusions and recommendations . . . . .	70

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ON DISPOSAL OF COMMUNITY WASTEWATER**

*Geneva, 25 September–1 October 1973*

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<sup>1</sup> Professor G. van R. Marais also represented the International Association on Water Pollution Research.

# DISPOSAL OF COMMUNITY WASTEWATER

## Report of a WHO Expert Committee

A WHO Expert Committee on Disposal of Community Wastewater met in Geneva from 25 September to 1 October 1973. Dr A. S. Pavlov, Assistant Director-General, opened the meeting and welcomed the participants on behalf of the Director-General.

### 1. INTRODUCTION

Since its inception the World Health Organization has been devoting attention and giving priority to problems connected with the paucity of basic sanitary services in the developing countries. In the formulation of the WHO long-term programme on environmental health,<sup>1</sup> in 1971, the need for basic sanitary services was re-emphasized, and special importance was attached to the provision of community water supply and the sanitary collection and disposal of community wastewater.

More recently, in 1972, the Twenty-fifth World Health Assembly in resolution WHA25.35 requested the Director-General, *inter alia*, to :

“ (1) prepare guidelines, manuals and codes of practice on the planning, design and management of community water supply and sanitation services, with emphasis on the public health aspects and particular attention to rural areas ;

“ (2) intensify the research and development efforts of the Organization in the light of the needs and possibilities of developing countries ; . . .

“ (4) give consideration to the related problem of wastewater disposal.”<sup>2</sup>

The importance of basic sanitary services and especially of community water supply and wastewater disposal was further stressed by the United Nations Conference on the Human Environment, held in Stockholm in June 1972, which recommended, *inter alia*, that “ water supply, sewerage and waste-disposal systems adapted to local conditions ” should be designated priority areas for research and that WHO should be the agency principally responsible for dealing with these questions.<sup>3</sup>

A survey of community water supply and sewage disposal conditions and needs was conducted by WHO in 1971 and 1972 in 91 selected developing

<sup>1</sup> See : *Off. Rec. Wld Hlth Org.*, 1971, No. 193, pp. 96-102.

<sup>2</sup> *Off. Rec. Wld Hlth Org.*, 1972, No. 201, p. 17.

<sup>3</sup> United Nations General Assembly (1972) *Report of the United Nations Conference on the Human Environment held at Stockholm, 5-16 June 1972* (document A/CONF. 48/14) p. 11.

countries, of which only 61 replied to the questionnaire pertaining to excreta and wastewater disposal. From these data it would appear that in urban areas only 28% of the population are connected to a public sewerage system, while 29%—i.e., 114 million people (1970 figures)—are not served by any sanitary system whatsoever. In rural areas 92%—i.e., 962 million people—completely lack sanitary facilities.

The significance of these figures is further underlined if a price tag is attached to the provision of the sanitary facilities at present lacking and if, in turn, the costs involved are compared with the meagre resources available to meet them. Another important problem is the lack of personnel with the necessary skills to plan, design, construct, operate, and manage the systems.

To overcome these basic problems WHO is endeavouring to intensify a sustained programme for the advancement and transfer of knowledge and for the development of methods designed to promote community water supply and wastes disposal. This programme aims at the collection and dissemination of information, the development of pilot studies and the demonstration of new methods, the formulation of guidelines for all types of activity relating to the provision of a specific sanitary facility, and the evolution of national policies and procedures for generalized programme implementation. Implicit in each of the above objectives is an element of education and training for all categories of national personnel, which is indispensable to attaining the established goals.

The terms of reference of the present Committee were as follows :

- (1) to review the most important problems of community wastewater disposal in developing countries ;
- (2) to define broad areas where there is a need for investigation, research, and promotion in respect of the scientific, technical, economic, social, and administrative aspects of such problems ; and
- (3) to formulate recommendations for national and international action.

## **2. SIGNIFICANCE OF WASTEWATER COLLECTION AND DISPOSAL**

### **2.1 Public health aspects**

The World Health Organization has always recognized that environmental deficiencies resulting from water and soil pollution cause disease problems of the first magnitude throughout the world. Human excreta are the principal source of the pathogenic organisms carried by water, food, and flies, which constitute the vehicles of transmission to susceptible hosts.

Specifically, the enteric diseases, including cholera, typhoid, dysentery, and the diarrhoeal diseases, and others of a viral nature (such as infectious hepatitis) are the leading causes of death and disability in areas occupied by more than two-thirds of the world's population. Schistosomiasis, a snail-transmitted disease caused by the pollution of streams, ponds, and irrigation ditches by human excreta, has reached endemic proportions throughout the tropics; while the disease is seldom fatal, it is severely debilitating and difficult to treat. Filariasis, transmitted by the *Culex fatigans* mosquito, is a direct consequence of improper waste disposal, since the mosquito breeds in standing pools of wastewater. Soil contaminated by human excreta results in worm infestations, including ascariasis, enterobiasis, and ancylostomiasis. The contamination of food crops through insanitary methods of irrigation, the use of nightsoil as a fertilizer and the pollution of waters used for harvesting shellfish can result in many enteric diseases. A growing problem for countries in the process of industrialization is pollution from industrial wastes; the adverse effects on health of such pollution are often difficult to assess and may be obscure in their causation, but their importance is nevertheless very real.

Recent outbreaks of cholera of the El Tor strain in areas not normally affected—e.g., parts of Africa and Europe—have again called attention to the perils of continued neglect of community water supply and wastewater disposal facilities. Enteric diseases are widely endemic in most of the developing countries and exact a heavy toll in mortality and morbidity. The number of cholera cases reported to WHO in 1971 reached about 162 000—the highest since 1953. Undoubtedly there was considerable underreporting; in fact reported cases represent only the tip of an iceberg of which the very substantial submerged part is made up of mild and asymptomatic cases that can cause widespread infection. In many areas of the world where cholera is not known to exist—e.g., Central and South America—enteritis and other diarrhoeal diseases are the leading or one of the leading causes of death. In 1969 a shigellosis epidemic in Guatemala caused more than 8000 deaths and spread in a pandemic form to many other Central American countries.

One of the most serious, if albeit indirect, public health consequences of the inadequate disposal of community wastewater in particular is the breeding of mosquito vectors of disease; it has been found that this breeding most often occurs in the highly polluted liquid wastes standing in roadside earthen drains or in concrete drains that were originally intended for stormwater disposal. Both of these types of open drain, as well as open pit latrines, are, unfortunately, highly suitable larval habitats for *Culex pipiens*, especially its tropical form, *C.p. fatigans*, which finds its optimum breeding conditions in water with a high degree of organic pollution. Where climatic conditions permit, *C.p. fatigans* breeds throughout the entire year and feeds avidly on man. This subspecies is the main vector of

Bancroft's filariasis and is found not only in large urban centres but also in smaller towns and villages in most tropical areas.

The rapidly accelerating unplanned urbanization that is occurring in the developing countries has greatly exceeded the ability of many of the cities concerned to provide adequate wastewater disposal services for the vast influx of new inhabitants. There is ample evidence that populations of *C.p. fatigans* have greatly increased in density as a result, and this is having particularly serious consequences in East Africa and South-East Asia, where the species in question is the main vector of urban filariasis. It is estimated that there are at least 200 million cases of filariasis in the world, and transmission appears to be increasing with urbanization.

Though very effective chemical larvicides have been developed, their use as a means of interrupting disease transmission would involve a continual and costly application of chemicals. The pursuit of research aimed at devising adequate prophylactic measures against filariasis is born of a despair that the environmental engineering solution—effective drainage and collection and disposal of community liquid wastes—may be beyond the reach of many a community within a foreseeable period. This is tantamount to treating the symptom rather than the disease.

The high incidence of enteric diseases in the developing countries and the increasing spread of filariasis are insidiously raising morbidity among vast sections of the population. They constitute serious deterrents to national progress in every direction. The provision of an adequate water supply, accompanied by appropriate wastewater disposal, could achieve a dramatic improvement in the situation.

## 2.2 Environmental aspects

A community wastewater collection system is an essential part of the overall objective of national housing programmes. The main objective should be to provide housing for low-income groups as economically and as rapidly as possible. In this context housing implies, *inter alia*, the provision of a plot and a shelter, together with a water supply and facilities for wastewater (sewage and stormwater) disposal. Though the shelter may fall short of regular housing standards, provided it is accompanied by water supply and wastewater disposal installations, such a dwelling is preferable from the community health point of view to more elegant housing that lacks these essential services.

The provision of low-cost housing is receiving increasing priority in the developing countries. Such housing programmes cannot fulfil their objectives if an adequate and safe water supply and proper wastewater disposal are not given due attention. No housing programme should therefore be embarked upon unless these amenities are included as an integral part of



the programme. In the case of industrial estates, adequate measures for the collection and disposal of industrial wastes are likewise important.

Wastewater disposal has a far-reaching effect on the environment. Pollutational discharges to receiving bodies of water create technical, biological, bacteriological, and aesthetic problems of varying degree, depending on the nature of the pollutants. Aquatic flora and fauna are affected. Aquatic recreational amenities are destroyed and potential health risks created. Extensive pollution of the soil by solid and liquid wastes exposes entire communities to enteric infections and helminthic infestations.

Along with the hazards of biological pollution, and the excess of chemical constituents that may occur naturally in certain water bodies, man is facing increasing perils from the discharge of chemical wastes. Hundreds of new synthetic chemicals are developed every year for domestic, agricultural, and industrial use. While some are known to be highly toxic, the long-term effects of others are yet to be determined. Ingestion is not the only route of exposure to these substances. Contact—for example, the recreational use of polluted water—is another possibility. Chemical pollutants may also influence man's health indirectly by disturbing the aquatic ecosystems or by accumulating in aquatic organisms used as human food.

### **2.3 Cultural and socioeconomic aspects**

It is difficult to place a precise value on the economic benefits of waste disposal, since it is an integral part of the social capital needed to secure a climate in which development can move forward. Social and economic development depends on a productive work force—that is, one not plagued by disease and disability, which result in inefficiency and a high rate of absenteeism.

Because of disease and premature death, the work force—i.e., persons in the age group 18–65 years—in a typical developing country is significantly smaller than that in a developed country; a far higher percentage of the population is young (below 18 years of age) and therefore dependent on the working population for support. When disease and disability are also taken into account, it appears that the work capability per million population of a developed country may be 3 times as high as that of a developing country; this does not, of course, take into account the availability of power and tools, which further aggravates the difference.

Man cannot live in dignity in the midst of his own wastes. Self-respect, comfort, and privacy are fundamental to social and cultural development: it is difficult, if not impossible, for the arts and other forms of culture to flourish among squalor and filth. Burgeoning urban growth, largely due to the influx of rural populations, poses a difficult and challenging problem to engineers and administrators in planning adequate waste disposal systems; the provision of these amenities must, however, have a high

priority, and aside from considerations of health and productivity, should be considered as a fundamental human right.

Man's environment exerts a latent influence on his thoughts and habits. His social and cultural development will respond to the removal of environmental deterrents to personal hygiene and community health. Water supply and wastewater removal are the minimum health needs for the urban dweller. Merely to provide him with a water supply and deprive him of the other facility may well be a sociocultural distortion. Between the elegant reception room and the primitive dry latrine in one and the same house there is a cultural gap of well-nigh a century.

Lack of appropriate wastewater disposal perpetuates the system of nightsoil conservancy in an urban community. In city centres and other crowded localities it may not be possible to install the nonservice type of household sanitary privy (such as the pit latrine, borehole latrine, aqua privy, water-seal (flush) privy, and septic tank latrine), and the use of the conservancy service latrine becomes a matter of necessity. Workers employed in servicing these latrines are exposed to a perpetual health risk. The sanitary precautions necessary to safeguard the health of the population against the inherent hazards of a conservancy system are seldom enforceable.

The operation of a conservancy system is decidedly vulnerable. Its fatal weakness lies in the employment of human beings in such demeaning work, to which its very beneficiaries attach a social stigma. The workers performing this service become hostile, sullen, and unwilling. Demands for higher wages and a decrease in efficiency are both inevitable. The conservancy system is the most inefficient of organized community services. To perpetuate it on the assumption that the requisite human labour will always be available is financially unsound and ethically untenable.

The provision of a water supply alone as the more important and urgent need has resulted in the concentration of domestic liquid wastes in house backyards, along street ditches, in low-lying open areas, and along various drainage courses. Roadside sullage drains become choked with every fall of rain and most often are transformed into elongated cesspools, brewing foul septic liquor. They also serve as convenient public latrines. Such insanitary conditions can create serious problems during an epidemic, particularly in communities where enteric diseases—cholera, in particular—are endemic. Open sullage drains with sluggish flows and foul stagnant liquid in crowded localities expose the population to severe mosquito infestation and consequently to serious health risks, particularly from filarial mosquitos.

Thus, if the provision of proper wastewater disposal facilities is postponed, the community is placed in a state of perpetual discomfort, preoccupied with fighting disease, and lacking a sense of wellbeing.

#### 2.4 Effects of population growth, urbanization, and industrialization

Rural areas of developing countries pose their own environmental health problems. Waste disposal facilities can generally be installed on the rural premises. A nonservice sanitary privy for each rural home is the *sine qua non* of rural sanitation. A pit or borehole latrine is inexpensive and practicable where subsoil conditions are suitable. As a single self-contained environmental health measure, it can yield spectacular results in the reduction of enteric diseases and helminthic infestations. Where such a simple remedy is not pursued the problems of rural health are compounded.

At the beginning of the 19th century, only 2% of the world's population lived in communities that could be classified as cities, and at the same time there were no more than 50 cities with populations in excess of 100 000. It has been estimated that by the end of the 20th century the world's population will have grown to 6500 million, of which about 50% will live in urban areas. In the developing countries, whose present total population is approximately 1800 million, 70% of the people are rural dwellers and 30% urban, but it has been further estimated that these percentages will be reversed by the end of the century if present trends continue.

The move towards urbanization is due to a combination of factors: improved agricultural methods and the concomitant reduction in the need for farm workers; industrialization of urban areas and the resulting job opportunities; opportunities for a better education and more entertainment; and, finally, the factor of gregariousness. There is, however, a very definite upper limit to urbanization and industrialization in terms of health and wellbeing unless provision is made for the basic needs—mainly a community water supply and sanitary waste disposal.

Water is indispensable for community needs, industrial progress, and national development. As the population grows and industry expands, the consumption of water increases considerably. In the same proportion, waters that have been used for domestic and industrial purposes must be suitably disposed of. Hence, the increase in population and the phenomenon of urbanization and industrialization create a growing demand for wastewater systems of increasing complexity, with significant economic consequences. This is an aspect that has been generally neglected and, in consequence, the backlog has reached considerable proportions.

It has been estimated that in the urban areas of the developing countries, as a consequence of population growth, urbanization, and increasing industrial development, the magnitude of the problem posed by the collection and treatment of wastewater may double every 10 years. In the developed countries, assuming a conservative growth rate of the service demand of, say, 4%, the magnitude of the problem tends to double every 20 years.

The unrestrained growth of cities and towns, especially in the developing countries, has fast outstripped the designed capacities for expansion of water supply and wastewater disposal installed barely 10 or 15 years ago. It has become necessary to provide services to areas not contemplated in the original projects and to enlarge the systems considerably. In the peripheral urban sectors, where the population migrating from rural areas has settled, the laying of sewers is particularly difficult because of the uncontrolled nature and great density of housing. It is often necessary to open pathways between houses and in some cases even to demolish dwellings in order to take the services to the inhabitants of these sectors.

The slum areas within every urban community, the fringe populations living on the periphery and the "genteel" slums developed as town extensions all suffer in common from the lack of a safe water supply and wastewater disposal facilities and from insanitary conditions caused by stagnant wastewater. Their slum characteristics are manifestations of a social and cultural malaise stemming from such basic environmental deficiencies. The provision of a safe water supply and adequate wastewater disposal facilities can demonstrably transform the outlook and way of life and improve the civic status of the populations concerned.

The indiscriminate establishment of industries in urban zones brings about a significant increase in the volume of wastewaters, which in a short time may exceed the existing sewerage capacity and force an enlargement of these installations, with all the attendant difficulties. Moreover, the discharge of industrial wastewater into overloaded sewerage systems without adequate control may cause major problems. In those instances where municipal wastewaters are treated, the presence of some industrial wastes may complicate the treatment, especially if biological processes are used.

Unplanned urbanization and industrialization are fast adding several complexities to the problem of community wastewater disposal. Developing countries should tackle this problem before it assumes serious proportions.

### **3. TECHNICAL PROBLEMS OF WASTEWATER COLLECTION AND DISPOSAL**

#### **3.1 Information and data collection**

Since the inception, in 1971, of a cooperative programme established jointly by the International Bank for Reconstruction and Development (IBRD) and WHO, both organizations have given attention to the information and data required for the sound planning of all water management projects. For this purpose, guidelines have been developed, and although limited to water supply and wastewater collection and disposal, they also

have application in studies of broader scope. The assessment of this information has been characterized as a "sector study".

In its broadest outline, a sector study for wastewater collection and disposal should provide answers to the following questions :

(1) *Where does the country (or region) stand at present with respect to waste management, and what are the principal problems of the sector with respect to the local economic and social conditions?* This would require a survey of existing economic and social conditions, including the state of the public health, an inventory of existing facilities and services, and a review of existing technical and related studies, of the operational and administrative framework, of the national legislative, planning, and financial policy, and of the available material and manpower resources.

(2) *What is the outlook for the sector given existing planning and investment policies?* This would require a projection of future needs based on population growth, area development, and movements between rural and urban areas.

(3) *What are the national targets and the minimum sector goals or objectives?* This must be examined in the context of the objective of providing the maximum number of people with a safe water supply and adequate wastewater disposal services, but it must be recognized that this objective can only be achieved in stages over the long term. The Latin American goals for the 1960's as set forth in the Charter of Punta del Este,<sup>1</sup> and the Second United Nations Development Decade global goals for water supply for the 1970's<sup>2</sup> provide examples of such targets.

(4) *What are the strategies for meeting these goals and what are the constraints and obstacles?* This requires a knowledge of the sector problems and a determination of the additional studies needed, training and manpower requirements, legislative action, and sources of financing.

(5) *What order of magnitude of costs is anticipated?* This requires a local survey of costs for the planning, design, construction, and operation of wastewater collection and disposal services.

(6) *What are the relative priorities within the sector and what are the criteria for establishing such priorities?* Although priorities may be greatly

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<sup>1</sup> See: Pan American Health Organization/World Health Organization (1969) *Special meeting of Ministers of Health of the Americas. Final report and speeches (Buenos Aires, Argentina, 14-18 October 1968)*, Washington, D.C. (Official Document No. 89), p. 33.

<sup>2</sup> See Pan American Health Organization/World Health Organization (1973) *Ten year health plan for the Americas. Final report of the III special meeting of Ministers of Health of the Americas (Santiago, Chile, 2-9 October 1972)*, Washington, D.C. (Official Document No. 118), p. 48; World Health Assembly (1972) *Community water supply programme. Progress report by the Director-General (document A25/29)*, and resolution WHA 25.35 (*Off. Rec. Wld Hlth Org.*, 1972, No. 201, p. 17).

influenced by political considerations, nevertheless such factors as public health conditions, population concentration, tourism, industrial development, availability of local resources, and ability to sustain the services are among the major factors in the decision-making.

(7) *What are the feasible plans of action, in addition to the various institutional arrangements, and what is the impact of several different options?* This should cover alternative investment programmes based on sound tariff policy, and must relate to local budgetary contributions and national financing, as well as to foreign sources of capital (with the ultimate aim of achieving self-support).

The following information may be considered essential :

- (a) socioeconomic and cultural information, epidemiological data, and vital statistics ;
- (b) maps and plans of adequate scale with sufficient topographic detail ;
- (c) the appropriate portions of any available master or development plan ;
- (d) present population and future projections according to various types of growth pattern and the nature and density of population distribution ;
- (e) soil conditions ;
- (f) hydrological data, including water quantities, resources, and usage, and urban stormwater runoff ;
- (g) water quality : supply, wastewater, and effluent if treatment is available ;
- (h) reuse : requirements and potential ;
- (i) receiving waters : uses, quantity, quality, and location ;
- (j) availability of construction materials and manpower skills ;
- (k) economic resources and type and characteristics of financing ; and
- (l) evaluation of community awareness of the problem.

Additional guidelines for data collection are presented in the report of a WHO Scientific Group, *Techniques for the Collection and Reporting of Data on Community Water Supply*.<sup>1</sup>

### 3.2 Water-borne systems and alternatives

In the methodology of wastewater collection and treatment there is no evidence of the evolution of completely new techniques suitable for

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<sup>1</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1972, No. 490.

general application in developing countries. The low priority assigned to wastewater disposal problems has inhibited progress in this direction. Nevertheless, over the past decade appreciable advances have been made in adapting and modifying existing techniques and processes to provide innovative solutions. In the developing countries there is an encouraging trend towards the evolution of methodologies through research and development specifically aimed at solving problems peculiar to the situation in those countries.

In developed countries the methodologies are standardized to a degree : excreta collection is by means of the flush water closet of the pedestal type (with seat) or squatting type ; liquid waste is conveyed in sewers utilizing time-honoured design criteria with respect to self-cleansing velocities and pipe sizes ; and treatment technique is heavily oriented towards mechanical sophistication, automation, and power-intensive systems.

The transport of waste is by far the most expensive part of an overall system and is related to the type of ultimate disposal envisaged. Basically there are 4 different alternatives :

(1) Water-carriage system, which utilizes the hydraulic transport capacity of water flowing in a sewer or pipe, by gravity or under pressure.

(2) Air-carriage system, which uses an air-pressure difference by creating a vacuum that moves a solid/liquid plug in a closed pipe system.

(3) Nightsoil, bucket or conservancy system for the periodic transport of concentrated excreta (nightsoil) by special vehicles (tankers or animal-drawn carts) to the disposal site.

(4) On-lot disposal system, in which the wastes are not transported but disposed of locally by partial stabilization and infiltration at the site of generation. The waste-assimilative capacity of the subsoil with regard to percolation, and the availability of land, type of waste, and risk of groundwater pollution are constraints on the utilization of this method.

Each of these systems provides solutions in specific situations. Certain situations may call for a suitable combination of them. An example is the self-topping aqua privy system, in which the aqua privy is combined with a sewer and stabilization ponds.

### 3.2.1 *Conventional water-carriage system for waste disposal*

The water-carriage system is universally accepted to date as providing the best technical solution to wastewater disposal. It comprises essentially collection, transport, and treatment as distinct phases.

The liquid wastes from residential areas enter the system as sullage activities and from latrines (with mechanical or manual flushing). These wastes are transported by gravity in sewers laid at suitable hydraulic gradients. To ensure carriage of the high density inorganic materials

entering the sewer, such as sand, grit, and stones, minimum gradients provide self-cleansing velocities and are specified in design (0.6–1.0 metres per second), and minimum sewer diameters of 100–150 millimetres are adopted to prevent blockage.

Treatment of the liquid waste is effected by grit removal and settlement, followed by aerobic treatment (biological filter/activated sludge) and anaerobic digestion of the sludge; the degree of treatment required usually dictates the choice of treatment processes.

The system has certain handicaps, however, when applied in developing countries. It involves the use of an appreciable quantity of water. The cost of the regular flush and ablution units is fairly high. Where health education is rudimentary the latrine unit may be incorrectly used; units may not be flushed and blockages may occur owing to the use of cleaning materials other than toilet paper. In consequence a costly clearance service is often required to keep the system functioning. In flat terrain minimum gradients for self-cleansing velocities necessitate deep excavation, which increases the cost of trenching, particularly where shallow rock and high water tables are encountered. Lifting stations, where needed, involve the use of mechanical equipment and a power supply. From a hydraulic viewpoint, with a minimum sewer diameter of 150–200 millimetres the upper reaches of the sewers operate below capacity, so that special devices are needed for sewer flushing.

In small communities the capital outlay per unit capacity of the conventional treatment plants can be very high. Mechanical equipment, requiring a power supply and skilled supervision, is a necessary adjunct in such plants. Replacement costs are appreciable and breakdowns and delays are not uncommon. Chemical and bacteriological monitoring, though important, is rarely done. In small communities with insufficient resources the efficiency and utility of these plants may be impaired.

It is possible to overcome some of the problems enumerated above by innovative measures. India, for example, has developed a hand-flush latrine, draining to a sewer, that uses a minimum amount of water and is inexpensive to install. Similarly, Chile has developed a minimum domestic sanitary facility called the *caseta* (small house) that is based on the use of local materials and local labour.<sup>1</sup>

### 3.3.2 *Air-carriage/dual sewerage system*

In this system domestic wastewaters are divided into a “grey” portion (domestic waste), transported in a normal sewerage network, and a “black” portion (excreta), transported by vacuum suction in a small-diameter 50-millimetre pipeline. The quantity of water used for flushing the excreta

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<sup>1</sup> For further details of these types of facility, see page 53.



is only 1.2 litres as compared with about 10 litres for an ordinary water closet ; the overall saving in domestic water consumption is of the order of 30%. However, rather sophisticated technical equipment has to be installed and maintained. The small-diameter pipe carrying the “black” water is not restricted to normal sewerage criteria with respect to gradients or bends. There is a clear separation of “grey” and “black” waters and different treatment methods are applied to each category. The “grey” portion lends itself to biological treatment and suitable reuse more readily and economically than does the “black” portion. The applicability of the system in developing countries, however, need not be further considered, since even in countries at the highest level of industrial development it is practicable only in very special situations.

### 3.2.3 *Nightsoil, bucket or conservancy system*

Excreta is discharged into buckets on the family plot and then collected at random or systematically by manual labour. Transportation to the disposal site is by members of the family or by organized labour ; when the system is used on a larger scale, the nightsoil is collected by manual labour into mobile tanks and hauled by tractors to the disposal sites.

In unsewered city centres and densely populated fringe areas, the bucket system has had to be adopted as a necessary evil, despite its inherent health hazards. The system is labour-intensive ; its successful operation demands a highly organized labour force with competent vehicle maintenance, which makes it very expensive.

Owing to the obnoxious character of the wastes and the demeaning nature of the service, labour is difficult to recruit and retain. Without stringent control the system presents a continuous health hazard from spillage, direct contact with faeces, and fly and mosquito breeding at collection and disposal sites. In addition, initial capital outlay and recurring expenditure are entailed in the provision of open drains to convey the sullage, with the resultant problems of mosquito breeding and control. Nightsoil is sometimes used as a fertilizer, in which case it presents great hazards by promoting the transmission of foodborne enteric diseases and hookworm.

In India (as mentioned earlier), in order to reduce the insanitary conditions attendant on bucket latrines and the handling of the excreta, hand-flush latrines have been developed. Excreta is washed down small-diameter pipes or sewers to collection chambers (conservancy tanks) and emptied and hauled to the disposal site by vacuum tanker. However, the arrangement requires periodic emptying facilities and is expensive.

### 3.2.4 *On-lot disposal systems*

Logically on-lot treatment systems find application where the community is too dispersed to make a water-borne disposal system economic. They

can be constructed by individuals so that collective action by the community is not required. However, they have their limitations if they are installed in inappropriate locations. Their true costs have often not been assessed or compared with those of conventional systems.

There are a variety of on-lot systems, which are described below :

(1) *Pit latrines*. Pits are either hand dug or machine bored ; they may be open or have an appropriate seat installed and a structure erected over them. Their success, however, is dependent on favourable subsoil conditions. In hard and rocky soils they are costly and unsuitable, while in soft and sandy soils the pit walls may collapse, particularly with seasonal high water tables. When seepage from the pit is poor, the liquid accumulates and the useful life of the pit is reduced.

The life of a pit latrine ranges from about 2½ years to 8 years, the average span being some 5 years ; this implies that money and space must be provided for relocations in a housing scheme, if a water-borne system is not attainable during such a period. Furthermore, the minimum distance between the pit, the house to which it belongs, and the neighbouring houses should be about 7 metres, which calls for extra land reservation.

Pit latrines do not handle the household wastewater, which needs separate disposal where piped water is provided, otherwise insanitary conditions prevail around the house and promote mosquito breeding. If open to daylight the pit itself may invite fly and mosquito breeding.

(2) *Aqua privy*. The aqua privy system provides treatment of a simple septic tank type, without the need for a flush system. The excreta are received directly through a chute into the tank below, where the organic solids undergo anaerobic decomposition. The chute must reach the liquid level to ensure the satisfactory functioning of the system and to prevent odour nuisance and mosquito breeding. Usually the water used for cleaning the chute is sufficient for the purpose.

In principle the aqua privy provides an effective means of dealing with excreta. Anaerobic fermentation in the tank destroys much of the organic solids, and the small quantity of surplus liquid can usually be adequately disposed of in the soakaway. The system works satisfactorily irrespective of whether paper is used for personal hygiene or any other available material (such as sticks, stones, or corn cobs). These are retained in the tank and desludged periodically by vacuum tanker, the length of the interval between desludging operations depending on the size of the tank.

In practice, however, failures occur because of the omission to add water to maintain the seal ; the tanks eventually lose all liquid and become, in effect, pit latrines. The addition of water at intervals is a simple corrective, but needs personnel. Where the custom is to use water for personal hygiene the seal is automatically retained, the water use is small, and the aqua privy gives excellent service as an on-lot excreta disposal system. Failure

of the soakaways due to impervious soils, clogging of porous soils with organic matter, or seasonal high water tables are possible disadvantages, but can be avoided by intelligent design and operation.

As with the pit system the aqua privy system usually excludes the household sullage so as to minimize problems with soakaways.

(3) *Septic tank privy*. This is an improvement on the aqua privy, with the chute replaced by a regular waste closet or a hand-flush closet with a trap. The privy may be installed either on the septic tank itself, or located in the house and the discharge directed to the tank outside. Some septic tank systems are designed to deal only with latrine discharges, the treated effluent being led into soakaways, while the sullage is disposed of untreated in seepage pits. The more common system is to deal with both the sullage and the latrine discharges in the same tank, the effluent from the tank being disposed of in a soakaway or by other means. Separation of the sullage from the latrine discharge is not to be recommended.

Defective design of the tank may impair its efficient functioning; decomposition and settlement zones need attention in proper design; and access manholes should seal effectively, otherwise mosquito breeding may develop in the tank.

The dominant source of trouble with the septic tank system is failure of the soakaway to deal with the volume of liquid, owing to organic clogging of the soil, high water tables, unsuitable soil conditions, and related factors. The effluent eventually stagnates on the surface or seeps into the storm drainage.

Excavation of soakaways needs to be extensive if the soil is poor or impervious. In high-density areas it is not improbable that the excavation volume for soakaways will exceed the volume required for sewers.

### **3.3 Urban fringe and rural problems**

#### *3.3.1 Urban fringe problems*

In developing countries urban areas can often be divided into two entities—the regular city area and an unplanned fringe, squatter, or slum zone surrounding the city. In some instances the slums may be in the heart of the city.

These fringe areas, known locally as shanty towns, *favelas*, *villas miserias*, *barriadas*, *bidonvilles*, *bustees*, etc., comprise crowded hutments constructed of any available material in apparently random configuration. Within the settlements strong group association is often evident. Such groups usually have a common origin or are migrants from the same rural area. Shanty towns often extend beyond the city limits, spreading to privately owned land, where such construction may even be encouraged by landowners. Being illegal and outside the jurisdiction of the city authorities, these

settlements have no right to services and there is no public obligation to provide them. Eventually pressures may force their incorporation into the city ; in this fashion the city grows unplanned.

Water supply is minimal and there may be no provision for excreta disposal. The crowded hutments, narrow and meandering passageways and rudimentary streets built without regard to the lie of the land, and the minimal water supply all preclude, in most cases, the laying of sewers and the installation of individual water closets. Liquid wastes collect in cesspools of stagnant septic liquid or emerge in inefficient sullage drains. There is constant use of passageways and streets for excretory purposes. Mosquito and fly breeding is widespread. The slum and fringe areas constitute a reservoir of infection and the focus of diseases in an endemic and epidemic form. They pose a constant threat to the health of the entire urban community.

The forces generating fringe development may perhaps be expected to increase rather than decrease in the immediate future. The problem must be tackled realistically in urban planning as a whole, otherwise community health will be imperilled. It must be recognized that the prime responsibility of the community (as exemplified by the city or the state) in housing is the provision of land for occupation and an acceptable water supply and wastewater disposal system. Such considerations will highlight the merits of the "site and service" concept as an integral part of urban planning. Fringe areas are not an unexpected, self-generating phenomenon ; they are the byproducts of lack of planning or bad planning.

### 3.3.2 *Rural problems*

Rural communities present their own challenging problems in the collection and disposal of excreta. Latrines are rare; open fields and house backyards are used for both urination and defaecation. However, the sparseness of the rural population is a factor in containing the spread of disease from wastes. Even where there is no sanitary provision, human wastes are dried by the sun and soil organisms may stabilize them to a certain degree. Nevertheless, some intestinal organisms remain viable for years in the dry state, and these constitute a lasting hazard. In areas where cholera is endemic the lack of latrines creates grave problems during epidemics.

### 3.4 **Wastewater treatment problems**

Regardless of the system adopted for the transport of domestic wastewater from the point of its generation, some degree of treatment is generally required before its disposal in the interests of protecting public health and the environment.

The technology of wastewater treatment has been developed in the industrialized countries, where the need for pollution control was first manifest. Their advanced stage of industrial and economic development implies high labour costs and a relatively small outlay on machinery and power. This capital-intensive economy is reflected in a treatment technology that employs extensive mechanization, instrumentation, and automation. When engineers from industrialized countries serve as consultants in developing countries they tend to draw from experience acquired in their own country and may recommend solutions that are not always in keeping with the economic, technological, or manpower resources of the developing country in which they are working. The project may be too costly to be implemented or, if implemented, may suffer from inadequate maintenance and technical supervision.

Many technical processes are currently available that are capable of producing an effluent of very high quality, which, in many instances, may not be necessary. A process, or combination of processes, is needed that can produce an effluent of a quality compatible with the uses to which the receiving body of water is to be put, or of a quality permitting reuse of the wastewater, as the case may be.

#### **4. MANAGEMENT PROBLEMS**

##### **4.1 Relationship to water supply**

In controlling the environment of urban areas for public health purposes, a safe and adequate public water supply generally has the highest priority, not only because of the part it plays in disease control, but also because of its aesthetic and cultural effects and the benefits it confers on industry, commerce, tourism, etc. But it is fallacious to assume that the provision of a safe water supply system will alone satisfy the major health needs of an urban community and ignore the complementary role of wastewater disposal. In the absence of the latter, the community faces greater exposure to parasitic diseases, and inadequate excreta disposal continues to be a major health hazard.

✦ The interrelationship of wastes disposal and community water supply, however, has an importance extending beyond questions of health and wellbeing. Both are an inherent part of good water management : they are the urban “ package ” of good water management planning and should be considered together in connexion with urban planning, systems planning, finance, and administration.

## 4.2 Economic aspects<sup>1</sup>

The benefits of wastewater collection and disposal programmes are difficult to separate from those attributable to adequate supplies of pure water and other aspects of sanitation. The combination community water supply, adequate waste disposal, and general sanitation forms the total sanitary concept essential to the health and wellbeing of communities. All three are indispensable in solving the problems that urbanization creates, and will continue to create, since—for better or for worse—urbanization is one of the predominant characteristics of the 20th century.

### 4.2.1 Costs

The cost of community waste disposal varies widely according to design criteria, labour costs, the availability of local materials, the methods and difficulties of construction, and related factors. For the provision of public sewers and sewage treatment, preliminary estimates based on a WHO survey of 61 developing countries mentioned in the Introduction (pages 5–6) indicate that the capital cost *per caput* of sewage disposal, inclusive of treatment facilities, ranges from US\$10 to US\$175, and that without treatment it ranges from US\$10 to US\$100. On the basis of experience in a number of countries it has been shown that the capital cost of conventional treatment may cost 5 times as much as the capital cost of stabilization ponds.

In addition to these costs, the individual householder has to make his own connexion to the system and provide the necessary household sanitary facilities, including water closet, bath, and wash basin at a cost approximately equivalent to the capital costs of the community system. A wastewater collection and disposal system may be regarded as one of the more expensive utilities needed by a community, and the most difficult and expensive to duplicate. It is also costly to maintain.

In the case of household systems, capital costs *per caput* have been estimated to range as follows : pit latrines US\$1–35 ; septic tanks, US\$4–62.

Operating costs vary with the type of treatment used. For a latrine system annual costs are practically nil ; for a conservancy system they may be quite high, equivalent to the annual debt charges plus the operating costs of a conventional sewerage system ; the costs of operating a sewerage system using lagoons are minimal (except for debt service and maintenance) ; the annual costs for a conventional system may currently run as high as 15% of the capital costs including debt service.

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<sup>1</sup> The Committee was greatly helped in its deliberations on economic and financial aspects by the unpublished report entitled "General Economic Principles for Sewerage Planning and Operation", which was kindly made available by the author, Professor J. W. Milliman, Director, Center for Urban Affairs, University of Southern California, Los Angeles, Calif., USA.

In any event, the costs of building and maintaining a community wastewater disposal system are substantial, and a great deal of attention must be given to an appraisal of these costs, as well as to planning for either the rate structure or the taxation scheme that will secure the requisite funds for repayment of the capital investment and for operation and maintenance at a high level of efficiency. Unfortunately, adequate operation and maintenance are often neglected; needless to say, the entire investment may be threatened and the entire objective missed if systems are not maintained and operated satisfactorily.

#### 4.2.2 *Benefits*

The benefits that accrue from innovations introduced in the early stages of development are judged very much on a personal impact basis. The modern yardstick of desirability—a favourable cost/benefit ratio—is only significant where the costs are reasonable and the benefits tangible and capable of clear and ready assessment; this last criterion cannot usually be met in the case of wastewater systems. Thus the value of the proposed works can have no more substantial basis than individual judgement or conjecture, nor can an intelligent estimate be made of the amount of money that can profitably be spent on their construction. For example, a stormwater drainage system has an observable benefit—the reduction of flooding. However, the duration, frequency, and degree of this benefit are sometimes so erratic that those meeting the cost can be pardoned if they question the value of the system in the light of the investment made.

A wastewater system reduces hazards to health and improves the aesthetics of living conditions. As a utility its value and necessity should be established in clear terms.

The benefits of a wastewater disposal system can be of 3 types: (a) the downstream benefits resulting from treatment of wastes before discharge into a watercourse; (b) individual benefits from waste removal as appreciated directly by households and establishments served by the collection system; and (c) collective benefits that accrue to the local neighbourhood and to the community as a whole through improvement of environmental health and aesthetics.

The identification of benefits is essential for economic analysis, because the total benefits derived from the wastewater system as a whole should exceed total costs. In addition, benefits directly related to individual parts of the system should be compared with separable costs attributable to separate parts of the system. For example, downstream benefits should be related to treatment costs, and often also to transmission costs. The collective and individual benefits should equal (or exceed) the costs of the collection system and perhaps some part of the transmission costs.

In certain cases, the benefits of treatment accrue to users of the water downstream and not to the people in the community actually provided

with sewerage. In other cases, where the wastewater creates a local nuisance or health hazard—for example, where it is discharged in lakes, estuaries, or groundwater—the benefits of different levels of treatment accrue to the users of the water themselves. This distinction is an important one to make, not only in an attempt to measure the benefits of alternative levels of treatment but, more importantly, in how to assess the costs of treatment (which may form a relatively large proportion of the costs of the total system).

The collection system confers most of its benefits locally—i.e., in the community served. Individual benefits can conventionally be measured by the willingness of households, establishments, and firms to pay for the removal of water-borne wastes from premises. These benefits are observed by the individuals concerned as the superiority of sanitary sewer systems over latrines, septic tanks, and other possible alternatives in providing for efficient waste disposal in a manner that promotes sanitation, health, wellbeing, and environmental aesthetics. It seems possible that greater attention should be given to the education of individuals and public officials about the benefits of connexion to public systems. With greater awareness of the benefits it is possible that the individual demand for sewers may increase.

Collective benefits—what economists term “a public good”—are, however, over and above the benefits as perceived by individuals. The collective benefits of wastewater systems, large or small, accrue in the form of better public health for the community at large, and in improved environmental aesthetics and flood protection.

A rational analysis of the 3 types of benefit referred to earlier is relevant.

(1) *Downstream benefits.* These are the benefits achieved downstream when the effluent is treated at the outfall. Downstream benefits may be related to any type of water use that is technically governed by the quality of the effluent at the outfall. Some of the benefits arise from instream uses of the watercourse; others are related to possible reductions in costs of treatment at downstream intakes because of improved water qualities. Extensive study of downstream benefits may or may not be warranted. If these benefits appear relatively slight in relation to upstream treatment costs, extensive study and quantification may not be necessary.

In some instances it seems likely that treatment measures should be deferred until they are justified by downstream development. Collection systems are built initially and minimum treatment applied with a view to installing higher levels of treatment at a later date, if required.

(2) *Individual benefits.* The individual benefits of a wastewater system are those that accrue to the individual household or enterprise. In many cases they are closely related to collective benefits. Individual benefits consist in the removal of certain types of waste from the premises. They



are a function of the superiority of sanitary sewers over alternative means of waste disposal, such as bucket latrines, pit privies, and septic tanks. The money saved on existing methods of waste collection, carriage, and disposal represents a benefit derived from the installation of sewers. This is another case in which knowledge of total benefits may not be needed, since we are really looking at the benefits and costs of sewerage *versus* those of existing waste disposal systems. The measurement of collective benefits would also involve some of these same comparisons.

Essentially, the superiority of a waterborne system can be seen in better health and sanitation, improved aesthetics, and a lower risk of operational failure. The health benefits can be measured by the value of the production that would have been lost as a result of sickness, by other types of prevention costs, by the saving of costs involved in the treatment of illness, and by the psychological satisfaction of consumers arising from a sense of wellbeing. There is a growing literature dealing with arguments for and against the various techniques of measuring health benefits,<sup>1</sup> but it seems to be generally accepted that the most useful measure devised is the present value of gross production lost. However, this benefit is useful only as a means of comparing alternative forms of health investment because it does not cover all health benefits.

Another approach to the measurement of individual benefits is not to explore these difficult problems of health and environmental quality and their relation to productivity, but to ask a much simpler set of questions. If there are local benefits—both collective and individual—we can ask what is the ability to pay and also the closely related question of whether the public is willing to pay. Conventional market surveys for many kinds of products and services are often used to estimate market demand. If a wastewater system is to achieve some sort of modified public utility status, the assessment of ability to pay, willingness to pay, and market demand will be helpful in estimating individual as well as collective benefits. In communities with a weak economy, however, the felt need may not satisfy the market demand methodology. Such special areas may form exceptions to the rule.

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<sup>1</sup> See, for example: Klarman, H. E. (1965) *The economics of health*, New York, Columbia University Press; US Public Health Service, Division of Public Health Methods (1964) *Economic benefits from public health services*, Washington, D.C. (Public Health Service Publication No. 1178); Weisbrod, B. A. (1961) *Economics of public health; measuring the impact of diseases*, Philadelphia, University of Pennsylvania Press; Winslow, C.-E. A. (1951) *The cost of sickness and the price of health*, Geneva (World Health Organization: Monograph Series, No. 7); World Health Organization (1973) *Interrelationships between health programmes and socio-economic development*, Geneva (Publ. Hlth Pap., No. 49); and World Health Organization, Regional Office for the Western Pacific (1961) *An estimate of the monetary value of improvement in public health due to proper disposal of organic wastes*. In: *Report on the First Zonal Seminar on Environmental Sanitation, 1956: The collection, disposal and utilization of organic wastes*, Manila (Document WPR/368/61).

Ways of assessing ability to pay are fairly clear-cut. What are the *per caput* incomes in the areas to be served? Usually, we find that higher *per caput* incomes not only indicate greater ability to pay, but also greater willingness to buy sanitary services and the general environmental amenities.

(3) *Collective benefits.* Collective benefits accrue to the community at large in the form of improvements in general public health and environmental quality. The risk of epidemics and contagion is decreased<sup>1</sup> and morbidity rates are lowered. Moreover, with the installation of sewers, foul smells are reduced, and the attractiveness of the environment is enhanced. In the past, and often at present, these types of collective benefit have served as the primary justification for installing sewerage. Their expected emergence, particularly in the form of improved public health, has also been used to justify large public subsidies for sewer construction and operation.

#### 4.2.3 *Economic analysis*

The objective of an economic analysis of a project is to determine the contribution that the project will make to the country, to the region, and to the people living in the project area, and to compare this with the economic outlay. Whereas a financial analysis may be said to relate more to the enterprise responsible for the project, an economic analysis, while taking full account of pricing policies and costs within the enterprise, extends the findings and attempts to interpret them on a much wider scale.

There are 3 main stages in considering the economic justification of sewerage projects. The first stage is to make as thorough a study as possible of the demand for the service reflecting expected economic developments and the effects of possible sewer charges on the ability of people to use the service. It is not uncommon that after completion sewer systems remain for many years only partially used, because of the unwillingness of householders to connect to the system. This may have been the result of a very high connexion charge, of high monthly charges, or a combination of both, or other special factors.

The second step in determining economic justification is to investigate whether the project is the least expensive means of providing the requisite service. In installing treatment facilities it is important to ensure that the degree of treatment proposed can be justified and that the least expensive method is employed. The questions of sewer dimension, selection of materials, and staging are equally important.

The third step is to test whether the project *per se* is worth carrying out by determining whether the benefits to the economy as a whole exceed its

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<sup>1</sup> It is possible that some part of the collective benefit may be regional or national (or even international) if risks of epidemics are reduced *outside* the local area.

costs by an acceptable amount—that is to say, the economic return on the project must bear some reasonable relationship to the benefits foregone by not being able to invest the resources concerned in other projects. In practice this calculation is extremely difficult for wastewater disposal projects for several reasons. First, where wastewater disposal is financed from general revenue, financial data yield absolutely no information as to the value placed on it by beneficiaries. Secondly, where compulsory sewer connexions are required as a result of municipal policy designed to enable the city to realize the benefits of the project investment, there can be no test of “willingness to pay” on the part of householders. If the choice of connexion were optional, such a test could be meaningful. Thirdly, where the price of service covers water supply and wastewater disposal, the benefit assignable to each becomes difficult to determine. About all that can be said in this regard is that willingness to pay for water supply plus wastewater disposal demonstrates that jointly the investment yields an excess of benefits over costs, but this does not answer the question of whether the investment programme would be improved if one of the components were omitted. Finally, the observed willingness to pay for wastewater disposal facilities by individuals will usually not fully reflect the total worth to society of such investments, because areas other than those directly served may also benefit from the facilities.

Subject to the foregoing reservations, it may be possible and desirable to calculate the incremental financial return of a project, since, in certain cases, this may give some idea of its economic worth. With this approach, the incremental revenues expected to be generated by the new project are taken as the sum total of the benefits. This return is the discount rate that equates the present worth of the project's construction cost to the present worth of the attributable net revenues (i.e., revenues less operating expenses before depreciation) over the economic life of the project. It normally represents at least a minimum estimate of the economic return and, if high enough, is in itself an indication that the project is economically justifiable without further analysis.

In view of the limitations of the incremental financial rate of return as an instrument of inducement in making investment decisions for wastewater disposal projects, other methods of project evaluation may be attempted. These may include an assessment of the savings in cost of disease, in construction costs of public systems over private, in incremental land values, and in costs of cleaning and maintaining private systems, as well as the advantages to be gained from the reuse of treated effluents for industrial and agricultural purposes, etc.

Any attempt to quantify benefits that may accrue with regard to public health, municipal cleanliness, and environmental improvement encounters the problem that reliable epidemiological data are frequently not available, and even when they are, the precise effect that a project may have on

the changing patterns of certain diseases is difficult to predict with accuracy. Nevertheless, there are cases in which costs can be determined. For example, where *Culex* mosquito breeding in sewage-polluted roadside ditches has been identified as the prime cause of filariasis transmission, the recurring costs of insecticidal treatment of the ditches can be measured.

There is evidence that in many cities sewage from high-rise buildings in high-density areas cannot feasibly be disposed of without access to public sewerage. To the extent that high-density and high-rise facilities can be shown to be economically justified, presumably the sewer system can be equally defended. Some attention has been given to the effects of sewer service on property values, and while at first glance this would seem to be a rather clear-cut example of the economic benefits to be derived, it proves difficult in actual practice to isolate the contribution attributable to the wastewater disposal system and to measure it. The argument that the public wastewater disposal system will prove more economic than individually constructed systems will have to be established on a case-by-case basis, since again density of population and individual costs would have to be taken into account. In some instances it has been possible to demonstrate that the cost of very frequent cleaning of commercial and private septic tanks has far exceeded the costs that would arise if a public system were installed. This is another facet that needs to be investigated on a case-by-case basis.

In those instances where treated wastes will be reused for agricultural and industrial purposes certain benefits can be quantified.

Because all the above-mentioned approaches to establishing economic benefits will frequently produce only limited results, the usual justification will therefore consist in examining revenue forecasts, and in making sure that the project is the least expensive means of meeting requirements. Studies must in all cases be supported by a conventional financial analysis in order to determine the effects on the enterprise's finances. If there are financial constraints that affect the ability of the enterprise to execute the project, either from its own limited capacity to generate and borrow funds, or from the unwillingness of government to provide the requisite finance, the scope of the project will have to be reconsidered, even when there is no doubt as to its justification.

#### **4.3 Financial aspects**

A community water supply distributes a commodity that can be sold, so that if the fiscal management is sound, funds can be generated for installation and operating costs, as well as for necessary extensions. On the other hand, since community wastewater collection and disposal are in part a service rather than merely the sale of a product, the financing of wastewater systems is much more difficult. The sale of wastewater for reuse and the

sale of sludge may help in the financing. The management of the wastewater, when rationally considered, is an integral part of the sale of water in the first place. Piping water into a house without piping out the wastewater is neither a complete nor a healthy transaction. A water supply provides a direct benefit to the user, who is generally required to pay for it; a wastewater system benefits not only the user but other residents, downstream from the community in question, and this further complicates the problem of financing. Lastly, regardless of their importance, wastewater collection and disposal have not enjoyed as high a priority as most other social capital needs, and planners and engineers have not always used sufficient ingenuity or produced an adequate rationale in their proposals for financing these schemes.

#### **4.4 Manpower and material resources**

The great variety of tasks involved in the problem of wastewater collection and disposal presupposes an integrated team of professional workers of various categories, among whom should be mentioned sanitary engineers, chemists, and biologists, who form the leading personnel, assisted in their work by middle level and auxiliary employees. The shortage of trained personnel is one of the major constraints in meeting objectives in this sector. Even with available funds to construct wastewater systems, there is often insufficient qualified manpower for their planning, design, construction, maintenance, and operation.

Another serious problem is the retention of technical personnel in the organization. It is not enough to provide extensive training: the organization must be so constituted as to retain the services of the personnel once trained. It is imperative to implement a series of measures to manage the human resources in a rational way, so that the work is made attractive enough to keep the staff required to deal with the increasingly complex problems in developing countries.

The establishment of autonomous organizations somewhat independent of government to deal with water supply and wastewater collection and disposal may improve the working conditions and provide better prospects for professional personnel. Developing countries can ill afford the drain of such personnel to industrialized areas, and this trend can only be reversed by providing positions that offer attractive opportunities.

Past experience has shown that very often project design, in spite of its sound engineering, has not properly taken into account local socio-economic conditions. A consequence of this lack of adaptation has been high costs that cannot be met by the population to be served. A working association of consulting engineers from the developed countries with reputable and experienced professional personnel in the developing countries is one way in which such difficulties may be overcome.

The poor financial resources available for community wastewater systems in most of the developing countries is no doubt a matter of grave concern. Of even greater concern, however, is the almost total lack of manpower preparedness in many of these countries to deal even with the fringe of the problem. Financial resources can be mobilized by tapping local, regional, national, and international potential when a programme has been decided upon. But the determination of manpower needs and the development of manpower resources to handle such a programme is a slow and laborious process. Vision and sustained effort over a period of years are required before each country can build up a modicum of skill, competence, and expertise in the engineering and managerial fields that alone can ensure national planning and implementation of efficient, effective, and profitable programmes.

Of equal importance is the insufficient employment of local material resources through lack of knowledge of their availability and potential usefulness. This deficiency results in the need to purchase material and equipment abroad at a comparatively high cost with scarce foreign exchange. A concomitant problem is the difficulty of servicing equipment of foreign origin and of acquiring the necessary spare parts.

## 5. NATIONAL PLANNING

### 5.1 Objectives and policy

That community health is the foundation of national prosperity is irrefutable. It may also be claimed that community wastewater systems are indispensable to the promotion of community health. In view of expected population increase and rapid urbanization and industrialization, together with the fact that unsatisfactory disposal of community wastewaters affects areas far beyond local communities, it is imperative that early government action should be taken in determining the extent of the problem and in planning and implementing efficient control measures.

Planning has been defined as "a process by which available data, needs, and resources are appraised and analysed, and used in preparation for change".<sup>1</sup> In aiming for certain changes, clear objectives are necessary. In broad terms, the primary objectives of a national plan for community wastewater systems are to safeguard public health, to promote environmental quality, to conserve water resources, and to control flooding.

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<sup>1</sup> World Health Organization (1970) *National environmental health programmes: their planning, organization, and administration. Report of a WHO Expert Committee, Geneva (Wld Hlth Org. techn. Rep. Ser., No. 439), p. 11.*

More limited targets need to be fixed as immediate steps towards the ultimate objectives, scheduled to be reached within a certain period of time. These immediate targets may be expressed in terms of health standards to be achieved or in terms of physical work to be carried out. The plan targets may also be oriented towards the removal of certain major problems and expressed in this way.

Planning for community wastewater systems is closely related to other social and economic objectives of government and must be integrated into the national socioeconomic development plan. Since community water supply and wastewater collection and disposal form indivisible components of a composite project and play a complementary role in the prevention of water-borne and filth-borne diseases, it is of the utmost importance that in any national planning, water supply and wastewater disposal should be treated as an integral unitary project with the implementation phased out suitably without any undue time-lag. This would secure for wastewater disposal its legitimate priority in the entire programme. It might also facilitate the acquisition of financial support for wastewater collection and disposal to the extent that water supply charges can be made to provide the funds for the complete water service, including proper handling of the used water.

Sector studies are exceedingly useful for a proper assessment of the status of wastewater disposal problems, on the basis of which the broad objective of the national plan and policy could be evolved. With the advent of country programming as the basis for preinvestment assistance made available by the United Nations Development Programme (UNDP), information on the water supply and wastes disposal sector will provide the best input for programming and priority setting.

Policies for community wastewater disposal must be made in harmony with other socioeconomic objectives. They must also fit into the political and administrative framework of the country, and should be flexible enough to be adapted to local conditions.

The formulation of policies should be based on an intelligent study of the nature, extent, and magnitude of the problems involved and on realistic priorities accorded to achieve the desired objectives. Constant reappraisal of alternatives and changing circumstances is necessary to modify policies if this should be required. Promotional policies calculated to help local authorities in establishing wastewater systems with technical, financial, and management assistance as needed are of the utmost importance. Such assistance should be designed to stimulate local initiative and exploit local resources to an optimum extent.

In general, special attention needs to be given to the following aspects :

- (1) Improvement programmes must be related to other government policies.

(2) Government agencies responsible for the execution of policies must be strengthened and given every facility to promote recognition and understanding of wastewater problems by the local authorities.

(3) Water resources and other environmental conditions must be monitored ; hence, surveillance requirements must be identified early in the formulation of wastewater policies.

(4) A realistic wastewater policy requires the backing and support of a large and well-informed section of the public. This is an important guiding principle in the many different attempts at creating new channels of communication between the various official agencies responsible for environmental planning.

(5) Maximum use should be made of locally available materials. This practice is often conducive to a considerable reduction in project costs.

(6) The safeguarding of hygiene should be the overriding principle in planning, design, and operation. Technological refinement and elaborate installations are of little importance. Economy and simplicity of design consistent with optimum health requirements should govern programme implementation.

In most industrialized countries, where the environment is heavily burdened by all sorts of pollution, wastewater systems have to be integrated with overall environmental planning. Discharge requirements are generally determined to fit into an overall plan for pollution load distribution and control for the receiving water. Additional pollution loads usually have to be taken care of by additional treatment plants and, in many instances, discharge standards are such that they may require additional treatment beyond conventional processes.

Even where no extensive treatment is required at present, provision should be made for monitoring the receiving environment before and after the introduction of the waste stream, and the possibility of further treatment should be left open until the environmental conditions warrant it.

The conscious and organized participation of the population in community improvement constitutes a factor of paramount importance in the provision of sanitary services, both in the rural areas and in the marginal urban sections.

## **5.2 Manpower and material resources development**

Large sums of money are already being spent on the construction of water supply and waste disposal systems in many countries. This expenditure will very likely increase substantially as urban and community



growth demand the provision of these essential services. In many instances the poor operation of systems already built is jeopardizing the investment and resulting in the need to replace equipment prematurely. This is a consequence of shortages of adequately trained staff. Few countries have well-established and on-going programmes for the training of all categories of personnel engaged in water and wastewater systems operations. As a result, in addition to the cost of building new systems, the cost of replacement of deteriorated systems falls as a burden that could be avoided.

Manpower planning involves the specification of personnel placement in relation to the siting and timing of operations. It also involves an assessment of the present availability of manpower, an analysis of its pattern of utilization and effectiveness, and an estimation of future manpower requirements and of education and training needs, so that the knowledge and skills necessary for adequate performance can be established and made available according to a predetermined schedule.

Manpower planning is not a single isolated exercise. Instead, it is a continuing process that should be initiated at the time of planning national or regional programmes.

Perhaps the most difficult task in manpower planning in environmental health and related fields is that of estimating future manpower requirements. Indeed, methodological approaches for gauging manpower requirements in these fields are yet to be defined. Countries should be encouraged to promote studies and investigations to that end.

Manpower development consists in the generation and utilization of skills. Once the decision has been taken to develop manpower, the next logical step is to carry out a survey of existing training facilities, including an assessment of the need for facilities additional to those already available and a determination of the means of financing training programmes.

Every country requires the establishment of a water supply and wastewater disposal training programme designed to meet the needs of the country and carried out on a continuing basis by competent staff who devote themselves full time to this activity.

The educational objectives of training programmes are of particular importance. They should be defined in measurable behavioural terms prior to the formulation of programmes, curricula, or course content. Educational objectives specify what the personnel will be capable of doing once they are suitably trained.

Training programmes and policies should make allowance for changes likely to occur in the functions and productivity of trained personnel. They should also take into account rising social expectations in all areas of living, promotional opportunities, and the means to attract potential candidates and ensure the retention of technical personnel.

The above basic principles should be given due consideration when

dealing with the problem of manpower for wastes disposal, not in isolation but in conjunction with an integrated programme of water supply, wastewater disposal, and general sanitation. Indeed, this important field requires an integrated team of professional and technical personnel of various categories who are called upon to perform a great variety of tasks. Lack of planning or poor planning for manpower requirements would result in an inadequate and inefficient service, and a poor return on the heavy investment required for these community health facilities.

The means of financing such a programme should be determined with the knowledge of existing and new arrangements required to cover the continuing training needs of the country. Water supply and wastewater disposal agencies themselves will in many instances be able to allot the funds necessary on an annual basis to do the work. In instances where funds fall short of requirements, governments should be approached to supplement the amount and to encourage the establishment of the programme. Where aid is needed to commence operations, international and bilateral agencies can be approached for loans, grants, and technical assistance.

The end result of this effort should be the creation of a training programme in which all existing and new staff participate and which will ensure that present and future investment will provide the maximum benefits.

It is seldom realized that the procurement of the much-needed finances for projects is perhaps less important and difficult than the building up of a well-trained, well-equipped, and competent manpower unit that can be depended upon to spend the allotted funds economically and efficiently and to secure maximum return on the investment. Manpower potential is fundamental to such national programmes. National policies should therefore be formulated in such a way as to develop the required manpower for the efficient implementation of the programme at the required pace, with adequate provision of funds and institutions to ensure the recruitment, training, and retention of the best available staff.

Of equal importance in this context is the need for a countrywide survey to identify and develop the material resources required for such a programme. The planning and design of projects will aim primarily at the optimum use of construction material or equipment that is locally available or can be generated locally by the judicious preplanning of basic industries dovetailed into the national programme. The use of imported materials and equipment should be minimized, if not avoided altogether.

Manpower and material resources are interrelated to a certain extent and their optimum utilization calls for vision and advance planning if developing countries are to achieve near self-sufficiency.

### 5.3 Financing

National planners today are faced not only with the need to assign scarce funds to the multitude of essential projects in every sector of the country's economy, but also with problems of the environment and ecology.

With few exceptions, the most pressing environmental problem confronting the developing countries is that of pollution of dwellings, agricultural lands, ditches, lakes, and streams by human wastes. This major environmental problem can be substantially resolved by the provision of properly designed and operated wastewater disposal systems. Since investment in such systems is well established in many countries as a priority requirement for the continuing development of urban areas and communities, the associated benefits to be realized in general environmental improvement will no doubt be of particular interest to those responsible for planning and the allocation of national resources.

Community waste disposal systems have traditionally been built with a view to disease control, aesthetics, convenience, and increased productivity, but difficulties have been encountered in justifying the necessary expenditure in purely economic terms. The complexities of cost/benefit and economic analysis have been discussed earlier. Investments in waste disposal, particularly in developing countries, must compete for scarce financial resources with other needs for social capital, and even though significant cost/benefit ratios are difficult to calculate, the provision of adequate sewerage facilities must rank high on the list of basic priorities in much of the developing world in the interest of overall national progress.

As a financial objective for sewerage projects, policies should be established that seek to generate revenues by direct user charges, which cover most of the costs of sewer service and which permit funds to be set aside to meet the expenditure on normal extensions of the system and to cover part of the costs of the next major expansion, where feasible. While this objective will prove difficult to achieve in many countries—particularly where wastewater disposal systems are being constructed for the first time—it nevertheless deserves to be kept as the goal for financial policy if sewerage operations are to progress and begin to meet the vast need for this service.

Because of the amount of money required for the construction of new systems and major expansions of existing systems, it will normally be necessary for wastewater disposal agencies to obtain loans or grants. Loans, including interest, must be repaid within specific periods. They can be made available from government revolving funds, supplemented by local loans raised on the open market, from international financing agencies such as the IBRD, from regional development banks, or under bilateral arrangements with many of the more highly industrialized nations.

Loans secured from international lending agencies have the added advantage of injecting into the financial operations, as part of the obliga-

tions of the receiving country, well-established norms of technical, administrative, and managerial practice and procedures, devised to ensure the efficient and economical operation of the system as a whole.

The receiving of grants offends against the concept of community self-financing, but in many developing countries with a low national income *per caput*, an element of subsidy by the federal or state government may be a real need to promote and sustain a national programme of wastewater disposal, at least in the initial stages. There is the risk that subsidies may sap local initiative and inhibit the growth of self-help. For that reason it is advisable to make it clear by policy decisions that subsidies should not be taken for granted and will be based on a searching analysis of local resources and potential for self-help. In any case, the financial elements of such wastewater projects will follow the same pattern as that of self-paying projects, so that sound practice and precedents will be established with regard to the general budgeting, accounting, and billing procedures, treating grants as only a part of the fund-raising resources.

The following alternatives may be considered in respect of grants :

(1) Where all the investment is covered by grants, such local grants obviously do not benefit all parts of the nation equally, and must in general be justified on the basis of promoting the general health and welfare of the nation. The scarce financial resources and the large number of competing needs may limit considerably any extensive wastewater programme on a national basis, if this programme has to depend solely on grants.

(2) Where part of the investment is financed through loans and part of it covered by grants, the participation of the government is intended in such cases to keep down debts to a level commensurate with the community's ability to repay. If the amount of government funds to be applied is reduced for a particular community other communities may be afforded the opportunity to gain similar benefits.

On the other hand, investment covered entirely by loans has been a successful system of financing both in developed and in many developing countries, particularly in Latin America. The communities to be served do not have to depend on the availability of grants, and the services will tend to be better managed as a result of an efficient cost-conscious approach, such as that applied to other public utilities—power supply, water supply, telephone service, etc.

One promising example is provided by Brazil, where the government has established a national revolving fund using social security funds for a plan to provide 60% of the total population with wastewater disposal systems within 10 years. The financing of water supply and wastewater disposal systems is secured on the basis of loans at reasonable interest rates over a period of 21 years with 3 years of deferred payment (construction time) without subsidies. The programme was initiated in 1971 and is

already showing good results, which may be attributed to the following factors :

- (a) official recognition of the problem and of the importance of its solution for the development of the country ;
- (b) the establishment of a national programme with policy decisions and financial provisions ;
- (c) the adoption of realistic design parameters to suit local needs, with considerable reduction of costs ; and
- (d) extensive training of manpower.

Historically, sewerage systems have been paid for out of general tax revenue. However, new innovations are necessary and desirable in the present context. A well-balanced financial programme might, however, make use of a variety of means : (a) *special assessments* for lateral sewers, the costs to be charged to property owners who will benefit directly ; (b) *general property taxation* for those areas of the system that will benefit the community as a whole ; (c) *service charges* to the users of the system based on quantity or strength of discharge or both ; and (d) *package financing* based on a combined water supply/sewerage system considering that both are an inherent part of sound water supply management. The last-mentioned arrangement, in which funds are generated through the sale of bonds or through a loan from a national or international agency to supplement local resources, is to be highly recommended.

While a community wastewater disposal system benefits the community as a whole, it must be recognized that special benefits accrue to those with direct access to the system, from the point of view both of convenience and of the resulting increase in property values. There are therefore convincing reasons for the application of a frontage assessment for laterals rather than an *ad valorem* tax on all property in the community. In developing countries, however—especially those that are least developed—*per caput* income is low and it will be difficult to obtain the necessary funding on an individual assessment basis, thus making community-wide or nation-wide financing more practicable. In any event, the financing of a proposed system is of such critical importance as to warrant detailed studies that take all the relevant factors into account.

One difficulty usually encountered in waste disposal projects is the capital charges that have to be met. Loans for such works should have a long life—preferably not less than 30 years—and the interest rate should be kept as low as possible. The influence of these two factors on the annual capital cost and therefore on the selection of one or another of the available solutions is quite important. For example, the reduction of interest on a 30-year loan from 5% to 4% decreases the annual capital charges by 11% ; at the same time, to reduce the life of a 5% loan from 30 years to 20 years increases the annual capital charges by 23%.

The financing of wastewater disposal systems in fringe urban areas poses special problems. These areas usually house that part of the population with the lowest income but with the greatest needs. However, the methods available to raise the required sums at the local, national, or international level are the same as for wealthier areas. The only point to stress here is the importance of community participation in the work, and every effort should be made to secure it.

An effective method of local participation is the direct contribution of labour and in some instances of materials. Another form of direct contribution consists in payment of the labour required. The construction of a wastewater disposal system is usually a labour-intensive undertaking, in which local workers may well be employed under supervision. The expenditure involved in this part of the project represents a significant part of the total cost. In some countries contributions of labour have covered as much as 50% of the total cost.

Such a programme requires the mounting of a good health education programme ahead of the actual construction work and the creation of an acceptable community organization with responsible representatives able to take decisions on behalf of the entire community.

In one country it has been estimated that the adoption of this procedure using local self-help results in a saving of between 15% and 30% of the capital cost. The remaining percentage is financed in this instance by a legally established revolving fund generated by a levy of less than 10% on the bills for public service facilities submitted to property owners in the area concerned. The justification for this temporary service tax on water supply and sewerage is that people using such services are indirectly paying for the actual costs of illness and death which are attributable to insanitary conditions in areas not so served, and which will be reduced by the introduction of these amenities.

The levy remains in force till such time as the necessary monies are collected adequately to finance the revolving fund. During the first 4 years of a project, more expenditure is incurred in the construction and extension of public sewers and water supplies than in a programme of construction of sanitary facilities in individual houses. After the construction of the public sanitary services, the revolving fund will substantially increase its participation in house connexions, aiming to connect 80% of the population within a 10-year period.

#### **5.4 Legislation**

In establishing national objectives and policies for waste disposal, the necessary legislation must be enacted to promote and control the financing, planning, construction, and operation of sewerage systems. The legislation should preferably take into consideration the overall problem

of water quality management, or it may be limited to wastewater disposal alone. Depending on basic decisions made by the government concerned, the legislation may be sponsored by the department of public health, the department of public works, or the department of water resources of the national environmental protection agency. It should cover methods of financing and possibly the provision of funds, where these are necessary, as well as the establishment of standards and criteria, and regulatory functions.

While national standards may be the ideal, there may be such widespread differences between one part of the country and another that state or provincial standards may be preferable. In many instances there are distinct advantages if disposal systems are designed on a regional or watershed basis rather than being limited by political boundaries; provision for this should be made in the law.

The basic legislation should provide for authority to issue the requisite regulations. There are 3 guiding principles in formulating legislation :

- (1) Laws should guide and help people, and establish a trend of acceptance ; they should not be considered exclusively as restrictive and punitive.
- (2) Laws must be reasonable.
- (3) Laws must be enforced and obeyed.<sup>1</sup>

The legal arrangements for wastewater disposal systems should clearly define the responsibilities and scope of authority of the various government agencies concerned in this matter. They should also enable the responsible agency to extend its sphere of authority beyond political boundaries, if needs be—for example, in the case of operations in a river basin that may comprise several political units.

The national government agency responsible for developing community wastewater systems should have adequate power in the following fields of activity :

- (a) provision of wastewater and stormwater disposal facilities ;
- (b) control of the disposal of industrial wastewater ;
- (c) disposal and use of treated wastewater and sludge ; and
- (d) building of drainage and private sewers.

The application of practical measures for excreta and wastewater disposal in urban areas should be backed by appropriate legislation and regulations. Such regulations should promote the financing, planning, construction, and operation of wastewater systems in rapidly expanding

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<sup>1</sup> World Health Organization (1970) *National environmental health programmes : their planning, organization, and administration. Report of a WHO Expert Committee*, Geneva (*Wld Hlth Org. techn. Rep. Ser.*, No. 439), p. 29.

urban areas. Moreover, on the basis of local conditions and circumstances, they should establish the minimum design criteria and standards that are essential for the protection of health. This legal backing should promote the selection and implementation of the most appropriate and applicable combination of necessary sanitary facilities and of systems for the collection and disposal of excreta and wastewater. There should be no striving after perfection; efforts should rather be directed at devising the best possible scheme capable of immediate implementation.

It is not possible to suggest specific legal action covering all circumstances: each case must be studied in its own context.

## 6. COMMUNITY PLANNING

### 6.1 Master plans; interrelation with land use and water supply planning; staging

The purpose of planning the urban environment has been stated to be: "... the creation of the most favourable conditions of life for all the urban population, at work, at home, and at leisure".<sup>1</sup> The basic instrument for this planning consists in general town plans, in which the urban components, characteristics, and amenities are generally well defined: industrial, commercial, and residential zones; roads and streets; sanitary and other services; construction density and, consequently, population density; and the green zones and recreational and other areas necessary for the development and wellbeing of the town.

In town planning a series of steps are taken that are related to the problems under consideration here, such as the creation of areas of expansion capable of absorbing the extra population resulting from demographic growth and urban migration, measures conducive to the transformation or elimination of marginal urban sections, and delimitation of industrial zones.

On these bases it is possible to design the requisite sanitary services with a capacity sufficient for some expansion. The capacity to be provided initially is determined by the economics and feasibility of staging. In the event that funds are limited, the planner should also take note that in the tropics and subtropics, from a public health point of view, it is preferable to give priority to providing the housing lots with water and sanitation rather than to building the houses themselves, for whereas the occupier of the plot can always erect some form of shelter through his own endeavours, he cannot install the services. These ideas are inherent in "site and service" schemes, in which a plot, a way of access, and water supply and

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<sup>1</sup> World Health Organization (1972) *Development of environmental health criteria for urban planning. Report of a WHO Scientific Group*, Geneva (Wld Hlth Org. techn. Rep. Ser., No. 511), p. 8.



sanitation are provided by the community, and the shelter is the responsibility of the occupier.

In planning wastewater disposal systems a master plan is highly desirable. The systems must obviously conform to the community plan for land use ; they are directly related to the community water supply system and cannot be planned independently of it. Ideally, urban planning, water supply planning, and wastewater disposal planning should be integrated and all three should progress at a similar rate. There may be situations where water and wastewater disposal planning have to proceed without the benefit of a master plan, and there are other instances in which it may be desirable to move beyond a community's political boundaries, to cover a watershed or region that should be incorporated into the community's services.

The wastewater system will also have to make provision for treatment sites, both permanent and temporary, and for the disposal of grit and sludge and other byproducts of the treatment process.

The provision of sanitary services to an urban community is thus intimately connected with major questions such as land use and development, layout plans, demographic studies and control regulations, monitoring and surveillance of the surroundings, water pollution control and water resources conservation, public relations, and promotional activities.

Unfortunately, however, it is seldom that a single authority has control of all these interrelated functions. The responsibility for water supply and wastewater disposal systems is vested in different authorities, so that investment, planning, and pricing decisions with respect to the removal of wastewater from individual households and industrial plants are made independently of decisions on the city water supply. This fragmentation of public responsibility for the provision of water supply and of wastewater disposal facilities makes it difficult to adopt a systems approach to public investment decisions in the planning and operation of what is essentially a single physically interconnected system. It imposes a severe handicap in preparing master plans for wastewater systems, gives rise to problems in the design, construction, and operation stages that could otherwise be avoided, and makes financing and funding operations more difficult.

Prior to the provision of a piped-in water supply, domestic water needs can be met by public standpipes, individual wells, or water purchased by the bucket from water vendors. In these instances, the removal of wastewater from the premises is but a limited problem. Human wastes are then not disposed of by water-borne systems but instead by pit latrines, conservancy systems, or some other means. Clearly, important health hazards requiring public attention may be inherent in these situations. Yet in the absence of an organized water supply the problems of wastes disposal remain separate from problems of water supply.

However, once water is piped to a dwelling or a plant, the volume of water used becomes much larger and considerations of how to dispose of the wastewater become inseparably linked to the question of water supply. Of course, where a portion of the domestic water supplied is used for irrigation or lawn watering this statement needs to be modified. Water used for irrigation leaves the system either by evaporation and transpiration or by percolation into the ground. Only in special circumstances is it necessary to consider these "system" effects.<sup>1</sup>

Water piped into a dwelling unit or industrial plant must leave the premises in open drains, in sewers, or through septic tanks, which subsequently drain into groundwaters or into open drains. Wastewaters may be spent cooling waters or wastewaters carrying various types of organic or inorganic waste.

Although the systems aspects of water supply and wastes disposal may seem less apparent in the case of septic tanks they are still clearly present, especially when the water system is an urban one. Even with septic tanks the provision of a water supply needs to be coordinated with the method of disposal. Septic tanks and public drains, giving rise to large private investment (as does public concern for the quality of groundwater supplies), are just as surely part of the system as the transmission and distribution lines bringing water into the dwelling units. Optimum planning and operation require a systems approach to piped-out waters as well as to piped-in waters.

It is also obvious that some of the discussion concerned with a metropolitan approach to the planning and operation of wastewater disposal has an important bearing on the possibilities of adopting such an approach to the combined planning of water supply and wastewater disposal systems. It is possible that some of the problems of metropolitan water supply are separate from the problems of metropolitan wastewater operations. For example, the economics of scale and the optimum location for water production may not exactly coincide with the economics of scale and the optimum location for wastewater disposal systems. This problem and similar ones would bear investigation in particular cases. Yet it seems clear that the systems interdependencies are so marked that the considerations favouring a metropolitan approach for one part of the system would generally favour a similar approach for the other, often utilizing the same institutional framework or structure.

Economic and financial constraints may not allow the execution of all parts of a project at one and the same time, especially when water supply and wastewater disposal systems are dealt with together. It is therefore necessary to carry out the construction work in several stages, each stage

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<sup>1</sup> For example, surface percolation into groundwaters may be high in salinity and cause water quality problems downstream.

being complementary to the other and constituting part of a master plan for the whole project. In the staging process, due consideration should be given to priority areas. Priorities can be established on the basis of population density or problem areas. Target time schedules should be established for the execution of different parts of a project so that within a projected period the whole plan can be realized.

Each stage should provide a significant increase in the system capacity, which should not, however, become so large as to overcapitalize the system in the early stage of development. This may, of course, make the total project somewhat more costly in monetary terms, but more feasible economically and adapted to the needs of successive development stages.

## **6.2 Design criteria : effluent disposal**

### *6.2.1 Wastewater collection systems*

Design parameters for the elements of wastewater collection systems are generally based on empirical assumptions following well-established conventional analyses of local demographic studies and population growth, characteristics of wastewater quality and quantity, hydraulics of open and closed conduit flows, local hydrogeology, surface water inflow and groundwater infiltration, intensity and variations in water use, community customs and habits, material and manpower resources and requirements, and local constructional and operational limitations bearing on the design. For every given set of local conditions, there is one optimum economical design for a wastewater collection system. It is through his ingenuity and resourcefulness that the competent designer must strive to achieve the nearest approach to this optimum, using intelligent and meaningful adaptations of known technology and design criteria oriented to the realities of local situations. Manuals of sewer design and sewer system analysis as adopted in the developed countries are available for guidance in this regard. Each developing country must evolve and establish modifications to suit its own particular circumstances and needs. Economy with utility and simplicity with reliability must guide the design of such systems.

### *6.2.2 Wastewater treatment*

The treatment of wastewater is full of difficulties because of its effect on the environment and the resulting burden on other communities in the region. Industrial waste discharges add to the complexities of the problem. There is a variety of wastewater treatment processes ranging from the most elaborate to the most rudimentary. The choice of a process best suited to a particular situation calls for a discerning appraisal of the engineering, financial, and socioeconomic aspects of the problem, leading to a determination of the desired effluent characteristics.

The essential purpose of treating sewage and industrial wastes is to

reduce the concentration of polluting substances and organisms (solids, dissolved organic or inorganic compounds, and pathogenic agents such as bacteria, viruses, and parasites). Many different processes for reducing pollution are available. However, the process selected must apply the least expensive method that would yield the desired effluent quality and be suited to local conditions.

The simplest treatment is the removal of grit and floating materials through a combination of grit chambers and screens. Suspended solids, which may account for up to 40% of the biochemical oxygen demand (BOD), can be removed by settling tanks or by Imhoff tanks, which are often specially designed for the removal of oil and grease. Imhoff tanks have a built-in provision for sludge digestion as well. Sludge from primary settling tanks is stabilized in specially built sludge digestion tanks, where the sludge is both concentrated and stabilized; it must then be dried and disposed of. Secondary treatment, designed to remove organic material, can achieve 85–95% BOD removal through oxidation by means of biological trickling filters or the activated sludge process; both systems require final settling. Chlorination of the final effluent is designed to kill pathogenic organisms remaining in the effluents and may be desirable under certain conditions.

A treatment process particularly suitable for developing countries where sufficient land is available is the use of plain or aerated sewage lagoons. These may be used without primary settling and provide a complete form of treatment, well able to handle “shock” loads; properly designed lagoons have been used successfully over a wide range of latitudes throughout the world. A variation of the aerated lagoon is the oxidation ditch. The use of “earth filters” (spray irrigation or overland flow) may have definite advantages in arid or semi-arid regions.

Treatment by means of chemical precipitation may have little application in developing countries; sand filtration is limited to small treatment plants; and there is a variety of sophisticated processes that can be used where high effluent quality is desired.

Primary treatment includes screening, grit removal, and settling; oxidation processes provide secondary treatment; tertiary treatment where needed, is often referred to as “polishing”. Treatment may consist of one or a combination of these processes depending on the degree of treatment required and local conditions.

Economy and simplicity should be aimed at, and locally favourable features should be exploited. For example, in tropical countries, sunlight and higher temperatures increase biological activity. Consequently, the parameters for the design of stabilization ponds and lagoons can admit of higher rates of load application and shorter detention periods. Also, a labour-intensive economy dictates the need for such simple treatment in preference to the conventional highly mechanized treatment.

*Sludge disposal from wastewater treatment facilities.* The problem of sludge disposal was discussed by the WHO Expert Committee on Water Pollution Control in Developing Countries and the following statements, extracted from that Committee's report,<sup>1</sup> are reproduced herein for the sake of comprehensiveness :

If sewage is treated in oxidation ponds, no substantial problem of sludge disposal arises. However, if biological filtration or the activated sludge process is adopted, there will be a continuous output of liquid sludge, the disposal of which is often the most difficult part of the entire process of sewage treatment.

In countries with temperate climates . . . the method of disposal usually adopted in the past has been open-air drying on bottom-drained beds, the dried solid material being used by farmers as a soil conditioner or otherwise disposed of.<sup>2</sup>

. . . an increasing number of constituents of industrial effluents inhibit the micro-biological process of digestion. Furthermore, some wastes—particularly those containing nonferrous metals—render the dry sludge toxic to plants. A further disadvantage of this process is the fact that dried sludge usually has little economic value, at least in temperate countries where agriculture is well developed. It is possible that in a hot and arid country with a less well-developed agricultural system, sewage sludge might be of greater value as a source of organic matter for soil. The assessment would depend on local conditions . . . if sludge is to be used on the land, the admission of industrial effluents to sewers must be controlled, particularly if they contain substances that interfere with plant growth or (if digestion systems are used) substances that inhibit anaerobic fermentation.

Certain intestinal parasites are not entirely eliminated by mesophilic digestion and air drying, and are likely to be a serious health hazard in developing countries ; for this reason, it may not be possible to use digestion and air drying without a long period of storage. The same problem may be involved in the composting of mixtures of sewage sludge and household refuse, a method of disposal that is widely used in some semitropical countries. Much further information on these problems is needed.

If natural processes of drying, including prolonged storage, are ruled out, the only processes that can yield a product that can safely be used in agriculture are those employing some form of heat treatment. However, such processes are expensive to operate, as are such modern processes as wet combustion and incineration that entirely destroy the organic matter.

The WHO Meeting of Experts on the Reuse of Effluents also emphasized the complexity of the problems related to the proper treatment, disposal, and reuse of sludges resulting from wastewater treatment, but did not find it possible to discuss the question in detail within the scope of its report.<sup>3</sup> The present Committee endorsed the recommendation made in that report that WHO should carry out a separate study on this subject.

*Industrial wastes.* The composition of industrial wastes (which are becoming increasingly important in developing countries) varies widely,

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<sup>1</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1968, No. 404, pp. 26–27.

<sup>2</sup> To avoid unpleasant odours the sludge should first be anaerobically treated. This method has usually been retained since it is relatively inexpensive, but serious difficulties are now being encountered in its use.

<sup>3</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1973, No. 517, p. 36.

and no satisfactory classification is possible. However, wastes can be roughly classified into 2 main groups : those containing principally organic and those containing principally inorganic materials. Both may be present in suspension or in solution and both may be toxic and inhibit bacterial activity in the treatment process. In deciding whether a given industrial waste should be discharged into a sewer, the most important considerations are whether it will be a health risk to men working in the wastewater system, whether it will damage the system and interfere with its maintenance, whether it will interfere with the treatment process, and whether it will interfere with the quality of the effluent. Pretreatment at the industry site may be necessary before allowing discharge into the sewerage system. This is the reason why standards have had to be imposed on industrial discharges before they enter public sewers.

The question might be raised, however, whether industrial wastes should ever be allowed to mix with domestic wastewaters. The majority of industrial plants are situated within the boundaries of large cities or in adjacent areas. Experience gained so far proves that the combined discharge and treatment at a central plant dealing with wastewaters of different origins is preferable to separate treatment both from a technical and from an economic point of view, even if some difficulties need to be overcome. In order to protect the wastewater disposal system, effluent standards for industrial wastewaters discharged into municipal wastewater systems have been developed in various countries. Where an industrial effluent does not meet these standards it should be treated at the industrial plant before it joins the municipal wastewater system.

Finally, it must be borne in mind that in cases where industrial wastes are to be dealt with, the design of the treatment process needs careful attention. It is possible also that the attainment of the requisite standards for effluents to permit their reuse or discharge into natural water bodies might be more difficult in such instances.

### 6.2.3 *Final disposal ; reuse of wastewaters ; effluent criteria*

The final disposal of wastewaters must conform to the principles of comprehensive water resources management, particularly to those of water quality management. The latter is preferably regionally organized ; in most cases its activity covers a specific water basin (catchment area) or—where very large rivers are concerned—a river stretch. This management unit will establish “ effluent criteria ” for wastewater disposal into surface or subsurface aquifers.

In the case of controlled wastewater disposal, the following main types of disposal method can be distinguished : (1) discharge into surface or subsurface water bodies, and (2) reuse of wastewaters for agricultural, industrial, recreational, or municipal nonpotable purposes.

*Discharge of wastewaters.* Except for very large rivers and the oceans, where a piped outfall into the proper current (i.e., that which carries away wastes from the shore) might meet the "effluent criteria", in all cases some degree of treatment of wastewaters is necessary before discharging them to the water body in accordance with the criteria stipulated by the regulatory authority.

In the case of subsurface disposal—depending on specific soil and groundwater conditions—the infiltration method itself imposes a certain degree of treatment prior to disposal.

Whichever kind of treatment is adopted, the process results in a waste residue, such as screenings, grit, or sludge, that needs to be disposed of. The disposal site is generally on land, but the sea is also used for this purpose.

*Reuse of wastewaters.* The report of the WHO Meeting of Experts on the Reuse of Effluents (to which reference has already been made) examines in detail the problems and processes involved and may be consulted for detailed information on this subject.

*Agricultural reuse.* The oldest method of wastewater treatment and disposal is its reuse in agriculture. The quality of the wastewater is important for the health of the workers in contact with it and for the health of the consumers of the crops produced, as well as for the continued fertility of the irrigated area. The use of untreated sewage for irrigation, though still practised in some places, is a health hazard and should be avoided. Treated wastewater should not be used in the raising of greenleafed vegetables (lettuce, cabbage, celery, etc.), soft-skinned bulbs and rootcrops (onions, carrots, radishes, etc.), other salad vegetables (tomatoes, beetroots, cucumbers, sweet peppers, etc.), or any vegetables that are eaten raw.

*Industrial reuse.* Industries are resorting increasingly to the reuse of their own wastewaters, and municipal wastewater effluents from treatment plants are used as cooling water in industrial plants. Treated wastewater is being reused for various other purposes, in view of the shortage of water and the possible economies thus effected. In industrial reuse the main public health precaution required is to prevent cross-connexions between the pipes conveying the treated sewage and those carrying safe water for drinking and food processing. However, the microbiological hazards in recycling industrial wastes effluents are usually less severe than those resulting from the use of municipal wastewater.

*Recreational reuse.* Lately, treated wastewaters have been used for the development of artificial lakes intended for such recreational activities as boating, fishing, and even swimming. The water should be safe from the bacteriological point of view and free of enteric viruses and should have no deleterious effects on the users. It should be recognized that the health

risks involved in the reuse of wastewater effluent for recreational purposes are difficult to evaluate.

*Municipal reuse.* The reuse of wastewater can meet many municipal requirements, such as the watering of public parks and golf courses and street cleaning. In Singapore, for example, treated wastewater is used for flushing toilets in new housing estates. In all such cases the quality of the treated wastewater should be such as to carry no health risks to the persons handling it.

Other reuses of wastewater are found in fish farming, in the replenishment of groundwater, and in underground injection to repel salt water intrusion. In all these cases the quality of the water should conform to the criteria governing its suitability for the specific use.

The reclamation of water from wastewater effluents may not be economically attractive in the developing countries at present. It is likely to find favour, however, in areas where there is an acute shortage of water, such as in arid tracts, where the maximum use must be made of the available water resources.

*Evaluation of wastewater reuse.* As pointed out by the WHO Meeting of Experts on the Reuse of Effluents, there are several factors that must be considered before deciding on the economics of water reuse, such as the size and location of the system, the characteristics and composition of the wastewater, the degree of purity of the finished water, and the costs of the various alternatives.<sup>1</sup> As in the case of water supply systems, where the distribution system accounts for the major outlay, in a wastewater disposal system up to 75% of the costs can be attributed to the sewerage network. Treatment costs normally form 20–25% of the total expenditure.

Pollution control requirements are becoming more stringent all over the world. Treated effluents may have to comply with stricter standards in the interests of environmental protection. Further refinements for specific reuses may also be envisaged. Part of the cost of water renovation in such cases can possibly be charged to pollution control. As stated at the aforementioned WHO Meeting: “The benefits derived from the increased quantity of water available may well exceed the cost of obtaining it. At the very least the reclaimed water will help pay for the cost of treatment.”<sup>2</sup>

While economy of operation is an important consideration, if water is a scarce commodity and has to be obtained for reuse either directly or from the watercourse into which the effluent has been discharged, it may be cheaper to increase the level of treatment at the plant rather than to carry out water purification further downstream. This again is a decision that

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<sup>1</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1973, No. 517, p. 16.

<sup>2</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1973, No. 517, p. 17.



will be governed by the nature of the receiving water and its downstream use. Public health must be the dominant consideration in all cases.

*Effluent criteria.* Criteria for wastewater effluent are generally based on the level of quality at which the receiving body of water should be maintained or on the type of direct reuse of the wastewater.

The level of quality of various water bodies is a matter of governmental policy on water pollution control, depending on the nature and extent of water quality management necessary for comprehensive water resources conservation and use.

The standards imposed will generally be governed by the following basic measurements, which are used to determine the relevant aspects of the quality of a water body: dissolved oxygen, as the best single indicator of the general condition of a water body; biologically oxidizable matter (biochemical oxygen demand (BOD)) and chemically oxidizable matter (chemical oxygen demand (COD)); ammonia and Kjeldahl nitrogen, as a useful general index of the quality of a river water; organic matter, total, and in the form of suspended solids; pH value; inorganic solids, in particular calcium, sodium, and chloride ions, which are important in irrigation; temperature; bacteriological examination; and some other tests, such as those for hardness and the presence of metal salts, nitrate, and phosphate, which may be important individually, depending on local conditions.

After a decision on the quality of the recipient water body has been made, the responsible authority must determine the criteria on which the quality of the effluents of the wastewater systems should be based. This requires information on the nature, concentration, and volume of the effluents, as well as a knowledge of the flows in the water body.<sup>1</sup>

The establishment of standards is a very difficult and critical task, particularly in view of its important economic implications. Quality standards for water bodies and effluents have greater relevance at regional or local levels than at the national level, since they are conditioned primarily by the prevailing conditions in a specific area. However, some countries have developed standards for effluents and for the reuse of wastewater. Because of the cost and the economic implications of treatment, some countries may find it expedient to accept lower water quality standards in order to encourage industrialization and economic development.

It is also possible that effluent standards may vary from season to season throughout the year, and since full advantage should be taken of the natural purifying capacity of the soil and of rivers and lakes, the treatment process may be varied accordingly.

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<sup>1</sup> See: *Water pollution control. Report of a WHO Expert Committee*, Geneva, World Health Organization, 1966 (*Wld Hlth Org. techn. Rep. Ser.*, No. 318), p. 21.

### 6.3 Preliminary surveys, design, and construction

In the developing countries, the conditions and restraints limiting design are peculiar to each country. Each solution demands a pragmatic, common-sense evaluation of the situation, a willingness to adapt or modify existing techniques, and the courage to introduce innovations. The basic objective is to remove health hazards and promote community wellbeing at minimum cost. It is therefore essential to provide a system that is simple and reliable and suited to local customs and limitations, minimizes water consumption, mechanization, and power needs, reduces capital, operational, and maintenance costs, entails the minimum of supervision, and utilizes local material and manpower resources to the maximum advantage.

The siting of housing settlements, their internal layout details, plot frontage, and related factors have a significant bearing on the economy of the wastewater systems to be evolved for the settlements. A hard substratum, high water table, flat terrain, and high surface run-off would influence, singly or collectively, the cost of wastewater collection and disposal systems for the area. It is prudent to consider these aspects in the initial proposals for land use and housing development and make a judicious choice between available alternatives, in the interests of total economy.

Intelligent modifications of conventional design criteria, where feasible, may effect some reduction in costs. Increased spacing of manholes with the use of lampholes (inspection eyes) is an example. The savings in shallow sewers should be balanced against the need for extra lifting stations, sewer capacities should be limited to locally applicable peaking factors and infiltration water, the prevention of entry of inorganic grit and debris into the sewer system by suitable devices, the choice of traps to suit customer use and habits, the avoidance of mechanical flushing devices, where indicated, and foolproof plumbing guides to prevent misuse of the system are some of the design aspects in which ingenuity and foresight would pay dividends. Similarly, the wastewater treatment process should be selected only after a discerning analysis of the several alternatives adapted to local needs.

Generally speaking, a treatment system that is simple in concept and operation but capable of producing a satisfactory effluent with the minimum of expenditure is the one that should be chosen. This suggests that waste stabilization ponds, aeration cells, oxidation ditches, intermittent sand filters, and similar relatively simple systems may be preferred. Due consideration must, however, be given to land use alternatives, since some of the simpler systems require large tracts of land, often in areas that are eminently suited to agriculture or other uses.

The preliminary surveys to be initiated for wastewater systems should provide enough information to permit the efficient design and construction of the project, phased out in suitable stages for implementation. Reliable

data on the aspects discussed above would be desirable in this context. Such data would supplement the sector studies for national planning referred to earlier (see section 3.1, pages 12–14).

With the field data at hand, preliminary studies must be done to decide on the overall pattern for the wastewater system that would yield maximum benefits for the minimum investment, both at the outset and at subsequent stages. Given current limitations, it would be necessary to adopt a common-sense, economically sound approach in deciding on wastewater collection and disposal systems for urban areas. The population density and distribution patterns would indicate the choice of the particular system suited to different sectors within the same corporate limits. It may often be expedient to introduce “incremental planning” for an urban system, with solutions adopted for the different sectors to suit local factors and limitations—for example, a sewer system for the town centre and other crowded areas; a self-topping aqua privy system for the uncongested areas; on-lot disposal for the more sparsely populated areas; and, as a temporary measure, pit privies for the fringe settlements. The foremost objective is to eliminate hazards to community health from human excreta and community liquid wastes during the first planning stage, using the minimum investment necessary to achieve that end. Later on, the sewerage system can be extended to cover the entire corporate limits in successive stages as the community becomes better prepared to make proper use of the service. At all events, the conservancy system should be banished at the earliest opportunity.

As construction will most probably proceed in stages, important decisions will have to be made regarding the designed duration of the several elements of the project. While lateral or secondary sewers should be designed to have the same life-span as that of the sewer, temporary treatment facilities may be desirable and the plant or plants may be designed to last for periods as short as 10 or 15 years.

The design of wastewater treatment facilities calls for professional competence and experience. A decision on the nature and extent of treatment usually rests on the composition and flow conditions of the wastewater and on experimental evaluation of the various wastewater treatment operations, such as settling performance, response to biological treatment, and pH adjustment (owing to the unknown buffering capacity of the waste). The flow-through experiment is ideal but with experience the information gained by jar tests or batch-fed laboratory units may be sufficient for design in most cases.

The operational parameters can be checked by preliminary tests soon after construction—a basic and salutary procedure to confirm design assumptions and ensure proper operation. If operational characteristics are found to deviate widely from experimental ones, a suitable modification of the technology becomes necessary; such a contingency should be anticipated by proper budgetary provisions.

Certain special aspects of wastes treatment are important :<sup>1</sup>

(1) "Equalization" may form the most important unit operation : it adjusts pH values, contributes to the precipitation of colloids, and evens out organic compositions and shock flows.

(2) Sedimentation might be connected with equalization ; in many cases it is more appropriate to carry it out in a mixed basin.

(3) If "plain" biological treatment is indicated, stabilization ponds or lagoons should receive primary consideration.

#### 6.4 Nonconventional approaches

The disadvantages inherent in the conventional water-carriage system as far as developing countries are concerned have been referred to earlier. However, in assessing the suitability of a system for a particular application, it is important not to make a false assessment of the situation. Particularly in urban areas one should beware of so-called "cheap sanitation". When comparing systems, consideration must be given to the total costs involved—i.e., capital, operational, and full maintenance costs, the outlay required to combat such deficiencies as fly and mosquito breeding, recurrent expenditure on the digging of pits and soakaways, and the considerable cost involved in the mechanical haulage of bucket conservancy and septic tank contents. The space required for effective soakaways and their necessary relocation covers a considerable area ; in view of the fact that the sewer line can be laid along the backs of houses, excavation costs for soakaways or pits may be greater than for sewers ; in addition, there remains the cost of stone and cover materials. If soakaways can be successfully and economically excavated in a particular area, then that area is also suitable for the installation of sewers. Conversely, if a rocky terrain makes it costly to construct sewers, then the same is true for pit latrines. If all the expenses are capitalized, it may turn out that the apparently cheaper alternatives are costing the community more than the water-carriage system, and at the same time are giving an inferior service so that some health hazards still persist. The pursuit of nonconventional solutions should therefore be justified by the gaining of the objectives with greater economy in overall costs and greater simplicity in operation and management.

A brief review of some of the innovations and developments over the past 10 years gives an indication of the trends and of the variety of solutions that are available.

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<sup>1</sup> A series of unpublished documents entitled *Guidelines for the Control of Industrial Wastes* has been prepared by WHO. These documents are available free of charge, on request, from Community Water Supply and Sanitation, Division of Environmental Health, World Health Organization, 1211 Geneva 27, Switzerland.

#### 6.4.1 *Household facilities*

An example of a minimum domestic wastewater disposal facility—widely used in South America—is the prefabricated room with plumbed sanitary fixtures based on the use of local materials and labour. Designs are available either for attaching the facility to a house or for constructing it as a separate entity. Both types consist of a structure with roof and walls of asbestos cement, a concrete floor, water and sewer pipes, water closet, shower, laundry sink, and water meter, occupying an area of 2 square metres and costing about US\$ 180.

Another example of minimum wastewater disposal facilities for a water-carriage system comes from India, where the object was to transform the existing conservancy latrines to water-flushed latrines. The cost of the adaptation is about US\$ 23.

A still more elementary solution, in the form of a hand-flush latrine, has been tried in India, in cities without sewerage. Excreta only is washed through small sewers to collection chambers and conveyed to the disposal sites by tanker. This solution reduces the insanitary conditions attendant on bucket latrines and the collection of the excreta. The cost *per caput* works out at about US\$ 9.

#### 6.4.2 *Communal latrines*

The installation of public latrines is usually justified on the grounds of economy. However, communal latrines are rarely, if ever, satisfactory, no matter what system is provided. There is no individual responsibility. Once a latrine is fouled through misuse or accident, the next user may have no choice but to foul it further. Thus a chain reaction sets in and the latrine rapidly becomes unacceptable and even unusable. Communal latrines may be installed as far as 100 metres away from some houses; consequently, at night excreta may be deposited on the intervening ground, particularly if there is no street lighting. If the latrine itself is not well lit at night nobody uses it. A badly maintained communal latrine may be self-defeating.

To achieve a minimum standard of cleanliness, strict control and constant cleaning are required; each time a cubicle is used it must be inspected and cleaned if necessary. Sanitary paper must be provided otherwise blockages due to stones, sticks, leaves, and grass in the flush systems are frequent. Public latrines are of value mostly when they serve institutions such as railway stations, markets, hospitals, and sports stadiums, where organized control can be exercised.

The disadvantages of communal latrines may be overcome if the users, although numerous, all form part of a family. This situation is being turned to account in Ibadan, Nigeria, with the development of the “comfort station”, designed to cope with the human excreta problem in the heavily congested area of the old city, where a considerable part of the population

has no excreta disposal facilities. Only a meagre supply of potable water is available, usually from standpipes. The "comfort station" is built to cover the needs of a family group (which may consist of anything from 100 persons to more than 10 times that number). The system comprises separate aqua privies for men and women, individual showers for women, common shower units for men, urinals, and a washing counter. One toilet and 1 shower per 25 persons are provided. Laundry and shower wastes are disposed of along with latrine wastes in the aqua privy. The shower and toilet compartments have a maximum width of 3 feet and a maximum length of 5 feet 4 inches (about 0.9 m × 1.6 m). Squatting plates are standardized with 4-inch (100-mm) diameter down pipes. One clothes washing slab measuring about 2 feet 6 inches by 3 feet (about 0.75 m × 0.9 m) is provided for every 50 adult females. There is 1 urinal for every 50 male inhabitants.

Water is supplied from a water storage tank with a capacity of about 3 gallons (approximately 14 litres) per head. The capacity of the aqua privy is designed on the basis of 4 cubic feet (about 0.1 m<sup>3</sup>) per person served. In each toilet running water is supplied through a tap. In the showers a tap is installed at a height of 2 feet 6 inches (about 0.75 m) above the ground to avoid excessive use of water. The overflow of the aqua privy is directed to a soakaway pit, which is provided with an emergency overflow in case it does not absorb the effluent wastewater. Piped water and electricity are metered and the cost is borne by the family group, which is also responsible for minor repairs. As a contribution to the construction of the facility the family provides the necessary labour.

In order to evaluate the utility of the "comfort station" described above, the Nigerian Government, in a UNDP-assisted project for which WHO is the executing agency, is carrying out a demonstration project in which the construction of 25 units is contemplated. It is expected that after construction a period of 12 months will have to elapse before the various aspects of the pilot project can be fully assessed.

#### 6.4.3 *Community systems*

The self-topping aqua privy system that has been developed in Zambia consists essentially of sanitation blocks with on-lot partial treatment of the wastewater in septic tanks or aqua privies, a water-carriage system to transport the local effluents in sewers, and treatment in a stabilization pond at the disposal site. A water supply, not necessarily piped, is essential for the operation of the system.

Each sanitation block comprises 1–4 units, with 1 unit per family. The block is located astride the common boundaries or corners of the plots it serves. Each unit comprises a latrine cubicle with an aqua privy squatting plate and chute, an ablution cubicle in which a shower can be installed, and a wash basin, covered by a roof. Where possible, piped water is supplied to

each basin and shower, though this is not essential. The wastewater from the washbasin and ablution cubicles drains directly into a tank underneath the building, thereby maintaining the seal around the chute.

The water-carriage system provides a network of sewers. The overflow from the tanks passes into a collecting sewer that runs along the centre block boundary of the plots (provided that regulations permit the laying of sewers in this location—i.e., that sewers are not restricted to the street area). Because no sand, stones, etc., enter the sewer and the digested organic solids are finely divided, the designed flow velocity can be reduced to 0.3 metres per second and the minimum sewer diameter to 100 millimetres.

Stabilization ponds deal with the daily inflow brought to the disposal site by the sewer system. The tank reduces the BOD by about 50%, and since the fermentation potential of the effluent is diminished no problems of rising sludge in the ponds are encountered during summer. Sludge and detritus banks do not form at the discharge point, since the sand is retained in the tanks, and the inlet discharge can be located next to the bank. Bacterial concentrations are reduced by about 99.9% by using 3 ponds in series, the detention time being 14, 7, and 7 days respectively.

The system is credited with several advantages. Each family must take individual responsibility for its own water tap, latrine, ablution cubicle, and wash basin. Although the units are grouped in a building, there is direct private access from each plot to the family's unit in the block. Simplicity of function is assured, since nothing beyond the normal household activities are required to keep the facility in working order, and only the most elementary hygienic practice is necessary to maintain cleanliness. With this system, all liquid wastes and excreta from the households are disposed of. It facilitates comparatively flat gradients and small sewer diameters, thus avoiding pumping even in flat terrain.

It would appear that sewers with a diameter of 100 millimetres, laid at gradients of 1 : 300, have been operated without blockages for a number of years. Excavation for sewers is minimized and the majority of sewer lines can be laid above the water table. It is reported that no system installed so far has needed pumping or lifting stations.

Piped water is not essential to each sanitation block. The aqua privies can be connected in series, receiving effluent from a communal washing point situated at the head of the sewer and supplied by hand-drawn water.

The system is also adaptable to different levels of sanitation. Where the aqua privy squatting plate is unacceptable a flush system discharging directly into the tank can be substituted. If indoor sanitation is required, a simple septic tank located outside the house receives the kitchen and toilet flush waters before they are discharged to the sewer.

A factor to be noted in the design and operation of the system concerns the use of sewers laid at flat gradients. In this case the design should ensure

that no inorganic grit enters the sewer via manholes ; this usually requires the use of heavy duty manhole covers to prevent the unauthorized lifting of covers for the disposal of trash into the sewer.

#### 6.4.4 *Fringe area problems*

Unplanned urban accretions constituting slum and fringe areas pose a constant threat to the entire urban community of which they form part. They become the focus of disease in times of epidemics. It is therefore imperative that these areas should not be neglected in respect of basic sanitary facilities.

Interim solutions alone can bring about some immediate improvement. Sewer lines can be extended as far as possible into the area. Supervised community latrines, similar to the "comfort stations" described above, can be constructed at suitable, selected points. A crew is needed to supervise the proper use, operation, and maintenance of the facility. Where the facility cannot be connected to a sewer, a septic tank can receive the wastes, and the effluent from the tank can be channelled in roadside drains. Existing earthen ditches should be replaced by concrete channels to facilitate flow and prevent the formation of stagnant pools. These channels should be covered by slabs in congested areas. The merits of a single sewer line in comparison with those of 2 roadside drains should also be studied. The liquid thus draining from the fringe area should be intercepted by oxidation ponds, 1 located suitably on each drainage basin. In general the aim should be to avoid local stagnations of liquid wastes and to provide some treatment at the outfall. Thus it is possible to find stopgap solutions for waste collection and disposal problems in fringe areas.

Finally, it should be noted that where the fringe development is not too crowded the construction of pit privies should be encouraged if the soil is suitable.

#### 6.4.5 *Rural problems*

Sanitary excreta disposal in rural areas is suffering total neglect in the majority of the developing countries. In most areas, however, the problem can be neatly solved. A sanitary household privy localizes on-site excreta disposal without contaminating surface water or groundwater ; there is no exposure to flies, and animals have no access to the privy ; odours and unsightliness are avoided ; and the facility is simple and inexpensive to construct and maintain.

If correctly located and designed, the pit privy and borehole privy provide a satisfactory means of rural excreta disposal. It is usual to provide a seat or squatting plate with a hole. Use of a waterseal hand-flush latrine costs a little more, but the latrine remains clean, and the excreta are completely out of view and inaccessible to flies. Water use is minimal, amounting to about 1½ litres per flush.



The pit privy is usually dug by hand and has a larger volume capacity than the borehole latrine. An important point in its favour is that it can be built without special tools—by the family itself, if guidance is available. The simplicity of construction and comparative cheapness are advantageous factors in its large-scale adoption as a semipermanent sanitary measure yielding enduring benefits in promoting the control of enteric disease in rural areas.

Alternative sanitary facilities, discussed earlier, are the aqua privy, with the chute or waterseal hand flush, and septic tanks. It is to be expected that the basic problem of human excreta disposal can find an inexpensive, easy, and acceptable solution in most rural areas by the installation of one or another type of nonservice sanitary privy in each rural household.

#### 6.4.6 *Treatment processes*

A system under investigation that may become suitable for institutional and isolated groups of buildings is to combine the septic tank with the rotating aerobic biological disc. The septic tank is given about 2 days' detention time and divided into 2 compartments. The raw sewage is discharged to the first compartment. At the outlet of the second compartment a set of slowly rotating discs is partially submerged in the tank contents, aerobic growth is promoted on the disc surface, and a relatively clear aerobic discharge is obtained. Power costs are minimal, since the discs virtually float in the liquid. If a second set of nitrifying discs is added in series to the first, and part of the effluent is recycled to the first compartment of the tank, a partially denitrified effluent is obtained.

#### 6.4.7 *Stabilization ponds*<sup>1</sup>

The development of the stabilization pond as a self-sufficient system of treatment has removed for small communities most of the difficulties posed by the conventional treatment plant. The capital and running costs *per caput* of stabilization ponds are distinctly low; mechanical equipment is usually not required; and only limited supervision is needed. With appropriate design the quality of the effluent from the bacteriological point of view can be as high as desired, and this quality can be maintained over a long period of time so that monitoring is required only occasionally.

In the developing countries the stabilization pond system has attained a position of major importance in controlling water pollution and bringing wastewater disposal within the means of most small communities.

Considerable research, development, and design data have been accumulated on stabilization ponds, to the extent that process design procedures are available for most types of environment in the developing world.

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<sup>1</sup> See also: Gloyna, E. F. (1971) *Waste stabilization ponds*, Geneva, World Health Organization (*Monograph Series*, No. 60).

Attention is drawn to a number of improvements in the stabilization pond method of waste treatment that have led to a substantial reduction in the primary pond area and an increase in the efficiency of faecal bacterial reduction.

(1) In small and medium-sized communities (up to 10 000 population) the raw sewage can be anaerobically pretreated in tanks (1 day's detention) instead of using open anaerobic lagoons. This increases the aesthetic acceptability of anaerobic treatment and allows the tank to be located near or on the housing site. With such pretreated effluents the size of the primary oxidation pond is reduced by about one half and the problem of rising sludge during hot weather is reduced.

Anaerobic pretreatment is also very advantageous when dealing with abattoir wastewaters.

(2) In large installations, where open anaerobic lagoons are used, recycling from the aerobic pond to the raw sewage influent line at rates of about 10–20% significantly reduces odours from the anaerobic lagoon.

(3) If secondary and tertiary ponds (with a detention time of 5–7 days in both cases) are operated in sequence with the primary pond, each successive pond will reduce the faecal bacterial content of its influent by about 90%.

The following problems in the design of stabilization ponds should be mentioned :

(1) In some countries, wastewaters contain high inorganic grit loads. This is due to the practice of using soil to scour cooking utensils ; moreover, sand from users' shoes is washed into the squatting plate during cleaning operations. Embankments of grit and organic material rapidly form around the point of discharge of raw water in the pond. When these conditions are encountered adequate grit removal would appear to be an essential prerequisite to further treatment.

(2) The growth of vegetation at the edge of the pond provides a favourable environment for mosquito breeding. Repeated removal of such vegetation creates a shallow underwater shelf, which exacerbates the problem. If the embankment is lined with slabs of concrete or some other material, maintenance and the need for mosquito control measures will be greatly reduced. Lining a strip at the edge of the pond from about 20 centimetres above to 20 centimetres below the water line has proved to be an economical measure and has given satisfactory service.

### **6.5 Economics and financing**

Basically, the object of a financial analysis of a wastewater collection and disposal project is to investigate the financial condition and policies of

the organization that is to manage, operate, and maintain the system ; to establish the sources of funds required to construct the system ; to estimate the effects of the project on the organization's future financial condition ; and to decide on the action required if any weaknesses or deficiencies become apparent from the analysis. The broader aspects of economics and financing have been discussed in detail earlier (see sections 4.2 and 4.3, pages 22–29).

#### 6.5.1 *Project financing*

Most new sewer projects and major expansions of existing systems are financed by loans, although a number of countries may make at least part of the funds available as equity contributions. In those instances where international and bilateral loans are obtained, the conditions vary. As a general rule, repayment periods of between 20 and 30 years have been provided for, with repayments frequently deferred until the construction is completed. In making estimates, interest rates may be calculated at 7–8%, but in some cases, concessionary terms may be granted by certain governments under bilateral arrangements.

The financial analysis of projects is concerned not only with establishing the most favourable sources and conditions of loans, but also with tailoring these to provide the most favourable terms for future repayments. The means by which funds will be generated to permit repayment while meeting the other costs is part of the task.

The funds required for future expansion need to be determined and their acquisition planned for in order to anticipate rate revisions and tax policies. This planning has to be done well in advance of actual construction in instances where either government loans or general revenue funds are needed and where the provision of such funds has to be reflected in national plans and budgets.

The end result of the financial analysis of a proposed sewerage project will be a plan showing monetary requirements and sources of financing based on projections of the income statements, the cash flow statements, and the balance sheets for at least 2 years after the project has been completed. Along with the financial analysis, accounting methods, personnel competence, policies, and procedures need to be examined, and the situation both present and future must be evaluated. Decisions can then be reached as to the actions needed to deal with critical areas.

#### 6.5.2 *Financial management*

A variety of arrangements for charging for sewer service exists, and even within a single country it is frequently found that different methods are employed. The following methods (more or less in order of preference) may be mentioned : direct user charge based on metered volume of water consumed (and, for industrial connexions, peak flows and strength of

waste) ; direct user charge based on a flat rate for houses and establishments of similar type ; connexion charges coupled with volume or flat rate charges ; property improvement tax usually coupled with volume or flat rate charges ; a general property tax ; general revenue ; or combinations of the foregoing. The financing of sewer services from general revenue, while by no means an uncommon practice, has the shortcoming that it places the sewerage organization in a constant state of uncertainty, because the funds are budgetary allocations and until the budget is approved, sewerage officials have no way of planning ahead. Of even more importance is that this practice deprives the personnel concerned of incentive to reduce costs and improve efficiency. Moreover, treasury officers will frequently cut maintenance costs when funds become scarce, and this leads to a rapid deterioration of equipment and jeopardizes the investment already made.

It has been stated that a direct user charge, based on metered volume used, is the method of choice because it is the most equitable means of charging. Those who use the most water use the sewer system to a greater extent for disposal of the wastewater. Also where water and sewerage are billed on the same statement, certain economies in billing and collecting will result. On the other hand, it must be mentioned that where water charges are already high, adding the sewer charges to the bill may create serious problems for management and could result in the financial collapse of both services if customers are unable, or refuse, to pay.

In instances where it is decided that the full costs of sewer service will not be collected as a direct assessment on the water bill, it is desirable to introduce at least a partial direct charge and thereafter to move as rapidly as possible towards placing the full costs on a direct user basis.

Charges that cover the full cost of sewer service imply charges that meet the costs of operation, maintenance, interest, and amortization. Such an arrangement will produce, for most systems, a positive though modest return on the capital employed. This is generally considered to be acceptable for sewerage operations, in contrast with water supply operations, where return on capital is a more important objective. In the case of new systems, finances from loan funds, and—where there are no existing facilities—debt service, will be the controlling factor, since loans will normally have to be amortized over periods much shorter than the depreciable life of the assets.

It appears that just as power and telecommunication utilities are usually better managed and financially stronger than water supply operations, it is also normally found that water supply utilities are in a more favourable position than sewerage services, in those instances where the two entities are separated. Although the backlog of investment needed for water supply is great, that for sewerage is many times greater. As in the case of power, telecommunications, and water, sewerage can be operated as a public utility and made to pay its own way, but the task is more difficult than for the other services. It will not be achieved without time and effort. The financial

analysis should result in judgements and decisions as to how far any operation can go and the best means of accomplishing this objective.

## **7. ORGANIZATION, ADMINISTRATION, AND MANAGEMENT**

### **7.1 Regional management**

The process of urbanization brings in its wake the need for an expansion of the system of public utilities. Water supply, wastewater and stormwater disposal, electric power, gas, and telephones are the utilities in greatest demand. The electric power, gas, and telephone systems are usually self-liquidating enterprises and in some instances profit-making. This does not usually apply to community water supply and wastewater disposal systems, which in many instances require government investment and subsidies—although water supply, if operated as a separate entity, is in less need of such aid. This is the reason why in the majority of instances wastewater collection and disposal services are administered by public institutions of a nonprofit-making character.

Independently of the character of the institution that will be responsible for wastewater disposal, the operation of the system calls for a well-equipped and efficient organization, which should provide the necessary engineering and managerial competence, financial soundness, and economic efficiency and also secure enlightened public acceptance.

Because of their successful record and the experience gained in their development, regional water systems are becoming increasingly common. Regional water organizations, which are usually based on catchment and distribution boundaries, have certain characteristics in common, whatever their objectives. They operate on a large scale, have a considerable degree of autonomy, and exercise control over the water resources of a natural region. Similarly, the development of regional management for wastewater disposal systems is likely to offer advantages, in respect of size of operations, to both developing and industrialized countries.

The area and extent over which a regional organization is given control must be carefully studied by the responsible authority in each country. So much depends on a variety of factors, such as the distribution of communities and population, the size of water bodies and basins, the state of development, and the system of government, that each case must be judged on its own merits. For some countries a central authority given powers over the entire national territory may be the appropriate solution; for others the local conditions may call for regional authorities either fully autonomous or subject to some degree of supervision by a central agency.

The attribute of autonomy is highly desirable in countries with well-developed political systems in which many interests are powerfully repre-

sented, as well as in areas where efforts are made to accelerate the progress of traditional communities by applying external pressures.

The concentration of a number of responsibilities and functions within the orbit of one authority offers important advantages of scale. An obvious advantage consists in facilitating the initiation and promotion of a national programme of wastewater disposal systems. Similarly, with a large-scale undertaking, the recruitment of specialists and the use, operation, and maintenance of better equipment are made more feasible. Such an organization would find it easier to select and employ well-qualified engineers, chemists, hydrologists, bacteriologists, etc., than would a number of individual small entities covering the same area. Large organizations are also more able to purchase equipment and operate it for monitoring and other purposes that are of interest to the area covered by the regional authority as a whole.

Among the other important advantages offered by wastewater management on a large enough scale, which are usually outside the scope of smaller entities, the following may be mentioned :

- (a) establishment of a technical and legal framework for effective operation ;
- (b) optimization of resources ;
- (c) optimization of financial policies ;
- (d) training and career development of employees ;
- (e) supply of materials and spares and development of stores ;
- (f) organization and maintenance of equipment ;
- (g) availability of up-to-date technical information ; and
- (h) initiation and development of new methods and promotion of knowledge by research and pilot studies.

Just as in the case of water and electricity supply, large-scale action can effect many economies in the planning, construction, and operation of a wastewater disposal system. Capital costs are high and many components of the system must be built to large sizes initially if construction costs are to be kept low. Moreover, it is quite likely that a regional treatment plant for wastewater will do the job far more cheaply than individual treatment plants and individual city outfalls. With a regional approach it is less difficult to decide precisely where treatment works should be located in order to minimize regional treatment costs. Such an approach may make it easier to ensure that a balance is achieved between downstream benefits and upstream treatment costs. The allocation of costs as between upstream and downstream users can therefore be made much more equitable. In many cases it may turn out to be less expensive to treat water downstream than upstream. Also, the entire region can be dealt with as a system and

modern methods of analysis used in the development of regional programmes.

An increase in size beyond an optimum level may, however, create some disadvantages—for example, a multiplication of management problems, especially with regard to communications (remoteness of head office from local employees and clients being a case in point), delay in the collection and use of information, lack of precision and promptness in reporting data, and remote control in technical and administrative spheres. However, some of the disadvantages of size have been diminished in recent years owing to significant developments in techniques.

Finally, a regional management can give the necessary impetus to the provision of better services to all users, and it is in a more powerful position to advise the government on the legitimate needs of the region it serves.

All the advantages of a regional approach are relatively well recognized. Yet this approach has problems and is sometimes difficult to put into practice. One rather obvious difficulty is that of persuading public authorities representing different parts of a region to agree about a common plan.

To summarize, then, the advantages and disadvantages that may be derived from regionalization depend on the prevailing circumstances. In some areas regionalization may be necessary in order to create a sufficiently large and powerful unit. In others there may already be adequate physical resources, but a reasonably autonomous body may be required to promote and conduct the operation for the better service of all users, and put forward its requests in the face of other demands made on the central government.

## **7.2 Combined administration of community water supply and wastewater disposal systems**

Water in its origin is a raw material of fundamental importance to health. When water has been used it becomes a problem. The supply of drinking-water and the disposal of wastewater are successive phases of the same process, which arises in response to the physiological needs of a community. The provision of community water supplies and the collection and disposal of the resulting wastewater are therefore closely related. In view of the experience gained in developing countries, this concept has served as the basis of an analysis of the advantages attendant on the combined administration of the services, mainly in large communities.

There are several important reasons why the administration and control of community water supply and community wastewater disposal systems should, if possible, be combined :

(1) Both are an integral part of the overall problem of the management of water resources.

(2) There is increasing recognition of the fact that supplying water is only a part of a cycle ; the full cycle consists of the collection, purification, and delivery of water, followed by the collection and treatment of the wastewater and its conveyance to a water body, which will often be the source of supply, at least in part, of another community.

(3) Payment for the collection and treatment of wastewater is an integral part of the water supply service, and water charges should include these costs.

(4) Plumbing details within the house and sanitary safeguards in the construction and operation of water supply and wastewater disposal systems must both receive careful attention to prevent pollution through cross-connexions.

(5) There are definite economies and other benefits to be derived from combined management, including an integrated layout of services and subsequent avoidance of conflict between the two systems.

(6) The combined administration of water supply and wastewater disposal systems offers great advantages from the technical, economic, managerial, and social points of view. When the two systems are administered independently for one or another reason these advantages are lost.

The water supply system always takes precedence, lower priority being given to the collection and disposal of the resulting wastewater. The pollution of the environment and the risks to health in a community that is provided with a water supply system but lacks a sewerage system are not sufficiently appreciated. Consequently, in almost all countries the proportion of the population served by water supply systems is considerably greater than the proportion provided with sewerage systems, and the difference between them in respect of the number of people covered by both services tends to be self-perpetuating, since when extensions or improvements are planned preference is always given to water supplies. In this regard the combined administration of both systems offers a considerable advantage, since the responsible agency cannot afford to ignore the deleterious effects on health and the environment created by the lack of sewerage.

The need for adequate protection of the sources of water supply makes it imperative to give attention to the proper collection and treatment of wastewater and other wastes in order to prevent or control contamination. For the same reason, any cross-connexions that may occur between the two systems must be detected and corrected as rapidly as possible.

A single set of drawings and topographic designs for the two systems, showing the latest developments in both, signifies economy. It also permits better coordination and eliminates the possibility of errors in the design and construction of new pipelines for water supply in relation to those for



the carriage of wastewater. Such an overall plan is of fundamental importance for the correct installation of all underground conduits, such as water mains, sewers, gas conduits; and power and telephone lines.

In general, technical resources can be developed with greater efficiency when they are common to both systems. All requisite resources, such as specialized personnel of different disciplines, equipment and supplies, pumps, valves, instrumentation in general, the facilities for analysis and control of quality, and laboratories for applied research, will be employed more effectively with a flexible administration that uses them as and when required within the system as a whole.

The financing problem is perhaps the biggest constraint in respect of the rational development of water supply and wastewater disposal systems at the tempo demanded by community growth. On account of inadequate rates and charges—particularly in the developing countries—the financial resources generated by the systems themselves often prove to be insufficient, so that, as mentioned earlier, the federal or central government is obliged to grant subsidies to the communities concerned. However, by ignoring wastewater disposal, officials have secured better prospects of solving the problem of financing water supply, and, in many instances, with the establishment of an adequate water rate, accompanied by proper administration, the water supply system has been made to operate on a self-sufficient basis. This has only postponed and accentuated the wastewater disposal problem, which, in any case, is inescapable. If wastewater disposal systems are administered together with water supplies, problems of finance have more possibilities of solution.

With a combined administration, the operational costs are lower; a combined billing for both services is usually more acceptable to users and produces greater revenues; if necessary, any excess returns generated by the water supply system can be used to compensate a deficit incurred in respect of the wastewater disposal system.

From the financial point of view another advantage of the combined administration of both systems is that it results in a reduction in the consumption of water. This is particularly true in countries that are short of water in certain regions. When the demand is great and the capitalized cost of the water supply is very heavy, a highly desirable practice (which is facilitated by a combined administration) is the reuse of wastewater in industrial or agricultural processes that do not require water of the highest quality. Thus wastewater can be sold under economically favourable conditions, and the use of scarce potable water for such purposes is avoided.

A combined administration requires greater supplies of equipment and materials, etc., which consequently can be purchased at a lower cost. To a certain extent, moreover, this factor promotes the planned development of local industries that will be furnishing the equipment and materials required for the operation of both systems.

There are also some inherent administrative advantages in combining the two services. In the first place, certain indirect costs, such as those connected with personnel, buildings, office equipment, and supplies, are reduced ; this is also true of accounting and supervisory activities, etc., as well as of general supporting services, such as warehouses, electrical and mechanical workshops, transportation, radiocommunications, and expansion of civil engineering works.

Personnel utilization is more efficient. This is easy to observe in emergency situations, which may require, at any given moment, a large number of workers to meet the needs. For instance, in areas where there is a great demand for personnel on account of flooding during the rainy season, or, alternatively, for additional works owing to water shortage in the dry season, the same employees can be used in these emergency situations and thus be occupied throughout the year.

It is also necessary to indicate that under a common administration the training of specialized personnel can be carried out more economically and more efficiently. Joint administration makes better use of scarce managerial resources. Furthermore, better career opportunities are provided for the professional personnel in the organization.

The combined administration of both services facilitates the establishment of policies such as coordination with other governmental organizations that render services to the community ; relations with their employees, with various government agencies, and with the public in general ; and action concerning town planning. In the last-mentioned case there is also the advantage that a single criterion can be applied in the provision of water supplies and wastewater disposal services to new lots or new residential developments in the community.

The administrative integration of both systems permits the proposal of joint solutions within a single juridical structure ; on the other hand, if the two systems are administered independently, it will be difficult to reconcile their individual interests when such questions arise as conflicts over water use, the different criteria governing water property regimes, and the urgent action needed to improve the environment or prevent its deterioration.

In countries where cultural patterns militate against the adequate use of water and proper wastewater disposal, the combined administration may promote favourable changes in public attitudes. It is very important that both the general public and the local authorities have a good understanding of the dual nature of water—i.e., on the positive side, its use for domestic purposes, for drinking, and for personal hygiene, and on the negative, its transformation into wastewater and a vehicle for industrial wastes that may be harmful to health and endanger the conservation of natural resources. Through a combined administration of both services contact with all members of the community is more direct. Thus it is possible to work out a joint programme for public health education that will bring about an

improvement of the environment and at the same time ensure the proper use of water inside the house.

Any conflicts that may arise can be dealt with on the basis of common interest. The sources of dispute include such questions as the material and social cost of the services ; the convenience and the comfort of using modern sanitary fixtures but at the same time avoiding water wastage ; the maintenance and cleaning of the plumbing systems ; and the periodic cleaning of choked lines.

A single organization with the necessary administrative facilities to provide information on the two systems and give prompt and adequate attention to users' complaints helps to stimulate in the community an attitude of understanding and cooperation towards both services.

Political decisions regarding water supply and wastewater disposal are also more productive if channelled through a single authority. Such an authority can participate effectively with national policy-making bodies on water resources conservation and allocation, control and prevention of water pollution, and related activities. Likewise, it is desirable that there should be good public relations with community leaders, institutions of higher education, professional societies, various groups and clubs, etc., and these are more likely to be achieved with a combined administration.

Although the final goal is to create a combined wastewater and water supply management, it should be recognized that there might be instances where such a solution is not the most appropriate under existing local conditions at a given time.

### **7.3 Role of health agencies**

In each country a decision has to be made as to the responsibility for waste collection and treatment—i.e., whether this service should come under the authority of the health agencies, the public works department, the water resources authority, the environmental protection organization, or some other body. In certain circumstances, divided responsibility as regards standards, construction, operation, and control may be unavoidable.

In some developing countries the ministry of health has played an important role in the promotion and construction of housing and water supply and wastewater systems. Lately, however, in most cases the responsibility for these services has devolved on other government agencies specially concerned with the development of the sector. Even so, the role of the health agencies is still important, covering such activities as promotion of the services, water quality control, wastes effluent criteria, training, health education, preventive action in emergency situations, and related functions. In many cases rural works and general sanitation are important activities of these agencies.

#### **7.4 Health education**

Health education plays a significant role, not only in the promotion of the sector services among the population, but also in the preparation and education of the people for the full and proper use of these utilities. To this end technological solutions of wastewater disposal problems should take into account behavioural patterns based on community practices and customs. With the aid of health education, acceptable methods should be evolved to bring about effective changes in current practices in order to promote personal and community hygiene.

Health education can be of particular use in creating mass awareness of the health risks arising from the lack of wastewater disposal facilities and in promoting community participation in the financing of such basic facilities. With equal effectiveness educational methods can be aimed at policy-makers, administrators, and other influential persons to obtain their support in the promotional aspects of wastewater disposal programmes.

Planning for health education should become part of environmental health planning, and attention should be paid to its proper development and implementation. It is important that the appropriate personnel concerned with wastewater disposal programmes should be conversant with the techniques and uses of health education and apply this knowledge in their work.

Health education aimed at schools should be given particular attention in wastewater disposal programmes. The provision of properly run hygienic facilities in schools, coupled with a programme of instruction on their use, will have long-term beneficial effects in helping to achieve appropriate wastewater disposal.

### **8. RESEARCH AND DEVELOPMENT**

In defining the areas for research and development in the field of wastewater collection and disposal, the Committee felt that research should essentially be oriented towards the adaptation of known technology to the specific needs of developing countries. Industrialized countries are confronted with many problems that require studies of a fundamental nature, which is not generally the case with the developing countries. There are many technological solutions at present available, and detailed information on the technologies concerned should be assembled into manuals and guidelines for distribution to countries where they can be successfully utilized. In this context, assistance should be provided for the field testing and adaptation of known technology.

Facilities and procedures currently available for the selective collection, storage, and dissemination of technical and scientific information on waste-

water collection and disposal, particularly with regard to the developing countries, are deficient and haphazard. Although there has been a good deal of discussion concerning the possibility of using computers or other sophisticated modern techniques for this purpose, most of the information available from Member States is in the form of technical papers or reports.

The Committee was provided with information on the WHO programme for the advancement and transfer of knowledge and the development of methods in the field of community water supply and wastes disposal<sup>1</sup> and recommended that this should be continued and expanded. The establishment of international reference centres is an important step towards improving the availability of information on various aspects of environmental health problems. Thus the WHO International Reference Centre for Wastes Disposal should receive continuing support, and the affiliated network of collaborating institutions should be extended in order to provide access to those countries not yet represented. Moreover, every support, governmental and otherwise, should be given to the collaborating institutions in order to strengthen their work and usefulness, both at the national and at the international level.

The Committee reviewed the specific activities and projects for research and development proposed by the Meeting of Directors of Institutions collaborating with the WHO International Reference Centre for Wastes Disposal, particularly those relating to wastewater disposal, and endorsed the priorities assigned. The Committee also referred to previous suggestions pertaining to research on wastewater problems put forward by other expert committees—more specifically the recommendations of the Meeting of Experts on the Reuse of Effluents: Methods of Wastewater Treatment and Health Safeguards,<sup>2</sup> to which it fully subscribed.

In summary the Committee emphasized the need for specific research activities in the following main areas :

- (a) alternatives to the water-carriage system ;
- (b) reuse of wastewater ;
- (c) removal of deleterious substances ;
- (d) new criteria for the control of effluent quality ;
- (e) manpower and managerial development ; and
- (f) low-cost collection and disposal systems.

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<sup>1</sup> See : *WHO Chronicle*, 1973, 27, 430.

<sup>2</sup> *Wld Hlth Org. techn. Rep. Ser.*, 1973, No. 517.

## 9. CONCLUSIONS AND RECOMMENDATIONS

### 9.1 Conclusions

The Committee drew particular attention to the following points :

(1) The importance of proper waste disposal in relation to public health and environmental aspects has been emphasized by the growing incidence of enteric diseases in general and cholera and typhoid in particular. As regards the parasitic diseases, the areas in which filariasis is endemic are steadily increasing, owing to the absence of proper facilities for wastewater disposal.

(2) An integrated approach should be adopted in dealing with community water supply and wastewater disposal. Planning and implementation should provide for a rational stage-by-stage development of the two facilities to achieve the objective of community health and wellbeing.

(3) There should be recognition of the importance of formulating national programmes that establish targets and determine policy with regard to programme implementation and the development of the necessary financial, material, and manpower resources.

(4) In order to extend the facilities of wastewater disposal systems to the maximum number of people with the limited resources available, special attention should be paid to reducing the cost of the systems.

(5) Fringe areas of urban communities should be provided *ad interim* with inexpensive waste disposal systems as part of the urban system. Since the nightsoil conservancy system is undesirable from the sanitary, social, and cultural point of view, the aim should be to terminate this system as soon as possible.

(6) Discharge of industrial wastes should receive special attention in the context of proper community wastewater disposal and as an integral part of the problem of total water resources conservation and management.

(7) Wastewater collection and disposal should be considered in the initial planning of settlements. It should be given a high priority in, and be coordinated with, land use plans, town planning, housing, and water supply.

### 9.2 Recommendations

The Committee recommended that :

(1) Effective techniques for collecting and reporting data on wastewater disposal systems should be considered a prerequisite for sound planning.

(2) Master plans envisaging feasible development in stages should be established on a community basis.

(3) An effective organization should be established at the national, state, regional, or local level, as appropriate, for the efficient management of the facilities, with the emphasis on a central agency to plan and operate water supply and wastewater disposal systems.

(4) Realistic design criteria, appropriate solutions to local problems, and ways of developing inexpensive materials and methods of construction should be devised.

(5) The exchange and dissemination of knowledge should be improved, and research aimed at ameliorating existing procedures should be stimulated in order to secure economy and efficiency.

(6) The financing of wastewater disposal systems should be integrated with that of water supply systems in the interests of obtaining higher priority for wastewater systems and better public acceptance of them. The wastewater disposal system should, as far as possible, be self-financing, government subsidies providing the initial impetus, if required. A combined management will facilitate common billing and collection procedures and effect a considerable saving in overhead administrative expenses and an improvement in manpower utilization.

(7) International lending agencies should play a special part in promoting the concept of wastewater disposal and water supply as an integrated project and in establishing innovative procedures for the further advancement of these related facilities.

(8) Health agencies should continue their activities in the monitoring and surveillance of water quality and environmental pollution.

(9) Health education should be regarded as exerting a significant influence on the promotional aspects of the programme, creating an awareness of the importance of the proper utilization of these facilities and their beneficial effect on community health.

(10) The IBRD/WHO Cooperative Programme, which is concerned with the execution of national sector studies for water supply and wastewater disposal systems, should be intensified and strengthened. The close interrelationship between community water supply and wastewater disposal systems and the complementary nature of the benefits they contribute to community health and wellbeing emphasize the need for an integrated study of these related facilities as a unitary system. The sector studies are of great value in formulating national plans for community water supply and wastewater disposal and in justifying preinvestment studies on which to base requests for loans from the IBRD, regional banks, and bilateral aid agencies for project implementation.

(11) WHO should assist the developing countries by disseminating information, identifying problems, and stimulating research aimed at finding a solution to those problems. The network of reference centres and collaborating institutions already established in the field of wastes disposal has a great potential and the area of collaboration should be extended. Developing countries should take advantage of this network and strengthen the national institutions that are collaborating in the programme.