



REGIONAL
SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

*Public health problems
in the coastal zone
of the East African region*

UNEP Regional Seas Reports and Studies No. 9

Prepared in co-operation with



WORLD HEALTH ORGANIZATION

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PREFACE

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions 1/ and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities.

Decision 8/13(C) of the eighth session of the Governing Council of UNEP called for the development of an action plan for the protection and development of the marine and coastal environment of the East African region. As a first activity in the region, UNEP organized in October and November 1981 a joint UNEP/UN/UNIDO/FAO/UNESCO/WHO/IMCO/IUCN exploratory mission which visited the eight States of the region 2/ in order to:

- assess each State's interest in participating in a future regional programme;
- consult with Governments with a view to identifying activities that may usefully be included as part of a comprehensive action plan;
- make a preliminary assessment of the environmental problems in the region, including the problems related to the environmentally sound management of marine and coastal natural resources and activities influencing the quality of the marine and coastal environment;
- collect available scientific data and information pertaining to the development and implementation of the action plan planned for the region; and
- identify national institutions that may participate in implementing an action plan once it is adopted.

1/ Mediterranean, Kuwait Action Plan Region, West and Central Africa, Wider Caribbean, East Asian Seas, South-East Pacific, South-West Pacific, Red Sea and Gulf of Aden, East Africa and South-West Atlantic.

2/ Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia, and United Republic of Tanzania.

(ii)

The findings of the mission were used to prepare the following six sectorial reports:

- UN/UNESCO/UNEP: Marine and Coastal Area Development in the East African Region. UNEP Regional Seas Reports and Studies No. 6. UNEP 1982;
- UNIDO/UNEP: Industrial Sources of Marine and Coastal Pollution in the East African Region. UNEP Regional Seas Reports and Studies No. 7. UNEP 1982;
- FAO/UNEP: Marine Pollution in the East African Region. UNEP Regional Seas Reports and Studies No. 8. UNEP 1982;
- WHO/UNEP: Public Health Problems in the Coastal Zone of the East African Region. UNEP Regional Seas Reports and Studies No. 9. UNEP 1982;
- IMO/UNEP: Oil Pollution Control in the East African Region. UNEP Regional Seas Reports and Studies No. 10. UNEP 1982; and
- IUCN/UNEP: Conservation of Coastal and Marine Ecosystems and Living Resources of the East African Region. UNEP Regional Seas Reports and Studies No. 11. UNEP 1982.

The six sectorial reports prepared on the basis of the mission's findings were used by the UNEP secretariat in preparing a summary overview entitled:

- UNEP: Environmental Problems of the East African Region. UNEP Regional Seas Reports and Studies Series No. 12. UNEP, 1982.

The overview and the six sectorial reports were used as the main working document and information documents for the UNEP Workshop on the Protection and Development of the East African Region (Mahé, Seychelles, 27 - 30 September 1982) attended by experts designated by the Governments of the East African region.

The Workshop:

- reviewed the environmental problems of the region;
- endorsed a draft action plan for the protection and development of the marine and coastal environment of the East African region;
- defined a priority programme of activities to be developed within the framework of the draft action plan; and
- recommended that the draft action plan, together with a draft regional convention for the protection and development of the marine and coastal environment of the East African region and protocols concerning (a) co-operation in combating pollution in cases of emergency, and (b) specially protected areas and endangered species, be submitted to a conference of plenipotentiaries of the Governments of the region with a view to their adoption (UNEP/WG.77/4). The conference is to be convened by UNEP in early 1984.

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INTRODUCTION

1. This document examines the public health problems in the coastal zone of the East African region. In the countries of this region, the increasing coastal population of residents as well as tourists has led to a heavier pollution load and resultant stress due to land-based pollution such as domestic sewage, industrial wastes, agricultural run-off and river drainage. The first of these is treated more fully in this report whilst the others are dealt with in the following reports pertaining to the mission:

- UN/UNESCO/UNEP: Marine and Coastal Area Development in the East African Region. UNEP Regional Seas Reports and Studies No. 6. UNEP 1982;
- UNIDO/UNEP: Industrial Sources of Marine and Coastal Pollution in the East African Region. UNEP Regional Seas Reports and Studies No. 7. UNEP 1982;
- FAO/UNEP: Marine Pollution in the East African Region. UNEP Regional Seas Reports and Studies No. 8. UNEP 1982; and
- IUCN/UNEP: Conservation of Coastal and Marine Ecosystems and Living Resources of the East African Region. UNEP Regional Seas Reports and Studies No. 11. UNEP 1982.

2. The scope of the publication comprises:

- review of factors determining the quality of environmental health;
- assessment of domestic waste treatment and disposal policies and practices;
- review of major problems in individual States of the East African Region.

3. The countries covered by the report are, on the mainland, Kenya, Mozambique, Somalia and Tanzania; two mini-states, Comoros and Seychelles; the small island of Mauritius; and Madagascar, an island as big as France, Belgium and The Netherlands put together. The heterogeneous nature of these eight States makes comparisons irrelevant in many respects. The differences in size, economic conditions, cultures, political and legal systems are the main reasons for the diversity of their problems. The general features, oceanography and description of the area involved are fully covered in the concurrent reports of the mission, to which should be added:

- IMO/UNEP: Oil Pollution Control in the East African Region. UNEP Regional Seas Reports and Studies No. 10. UNEP 1982.

FACTORS RELEVANT TO ENVIRONMENTAL HEALTH

Water supply services

4. The objective of all the Governments is to provide the total population of the country with an adequate water supply before the end of the decade and in special cases by the end of the century. It is assumed that "potable water supply" in an urban area means piped water supply to each house and indirectly that every citizen has access to sanitary facilities. Areas with a limited water supply have a greater solid content in the waste water; hence the water supply is an important factor in determining the quality of the waste disposed.
5. In the urban areas of the coastal zones about four fifths of the population have access to water supply: approximately two fifths are served by piped water supply through house connections and two fifths by public stand posts (see table 1).
6. In the rural areas only about a third of the population has access to reasonably safe drinking water. The facilities available are through public stand posts and individual wells.
7. The quality of the water supplied in rural areas is very seldom controlled by the authorities concerned. The principal reasons are the shortage of laboratory facilities and qualified personnel and scarcity of transport. In general, the water is bacteriologically suspect.

Epidemiological aspects

8. The most serious effect of the uncontrolled dumping of domestic wastes on human health is the transmission of diseases by either the consumption of polluted fish or shellfish or by direct bodily contact with pathogenic organisms in sea-water or on the beaches (see figure). Bathing in sewage-polluted sea-water can result in such ailments as eye, ear, nose and throat infections. Where faecal or bacterial contamination is also present, it can lead to more diseases especially when ingested. This is partly due to the ability of filter-feeding organisms such as oysters, clams, mussels and scallops to concentrate bacteria, and probably viruses, many times over their levels in the surrounding water.
9. The number of people living in the coastal areas suffering from diseases related to pollution caused by domestic liquid waste and solid waste is uncertain. In most of the countries visited, particularly in the rural areas, laboratory and clinical services are inadequate and in some places do not exist. A large number of cases, some fatal, are reported as unspecified diarrhoeal diseases (see table 2). In most instances, the causes were directly related to contaminated drinking water.
10. In many instances there is no regular laboratory test control of the beaches, rivers or water supply systems. Only when there are clear indications and outbreaks of a disease would such tests be carried out (see table 3). The absence of regular control by the health authorities is due to lack of laboratory facilities, shortage of staff and principally lack of adequate funds for overall regular control.
11. Medical statistics on the morbidity and mortality related to the coastal pollution are poor except for those connected with cholera outbreaks. Vibrio cholerae, the causative agent of cholera is not normally found in the marine environment but exists in sewage from communities where the disease occurs. It is

Table 1 : Community Water Supply - comparison of services (1975 - 1979/80)

| Country | Year | URBAN POPULATION SERVED | | | | | | Rural population with reasonable access to service | | TOTAL | |
|------------|------|-------------------------|------|----------------------|------|-------------|-------|--|------|-------------|------|
| | | By house connections | | By public standposts | | Total urban | | Number '000 | % | Number '000 | % |
| | | Number '000 | % | Number '000 | % | Number '000 | % | | | | |
| Kenya | 1975 | 920 | 45 | 1095 | 55 | 2015 | 100 | 930 | * | * | * |
| | 1980 | 1775 | 60 | 1180 | 40 | 2955 | 100 | 2100 | | | |
| Madagascar | 1975 | 47.20 | 5.72 | 2.12 | 0.26 | 49.32 | 5.98 | * | * | * | * |
| | 1979 | 54.47 | 15.0 | 2.42 | 0.67 | 56.89 | 15.67 | * | * | * | * |
| Mauritius | 1975 | 111 | 29 | 250 | 65 | 361 | 94 | 466 | 97.5 | 827 | 96.5 |
| | 1979 | 121 | 31 | 246 | 62 | 367 | 94 | 487 | 94 | 854 | 94 |
| Mozambique | 1975 | 330 | 30 | 220 | 20 | 550 | 50 | 100 | 1 | 650 | 6 |
| | 1980 | 465 | 30 | 465 | 30 | 930 | 60 | 200 | 2 | 1130 | 9 |
| Seychelles | 1975 | 12.1 | 57 | 5.0 | 23 | 17.1 | 80 | 23.7 | 65 | 40.8 | 71 |
| | 1980 | 18.4 | 75 | 2.7 | 11 | 21.1 | 86 | 33.1 | 80 | 54.2 | 82 |
| Tanzania | 1975 | 264 | 14 | 1054 | 54 | 1308 | 68 | 2416 | 17 | 3734 | 23 |
| | 1980 | 546 | 25 | 1274 | 57 | 1820 | 82 | 4500 | 28 | 6320 | 34 |

From: The International Drinking Water Supply and Sanitation Decade Directory
World Health Organization (1981)

Figure showing points at which shellfish may become unsatisfactory for human consumption

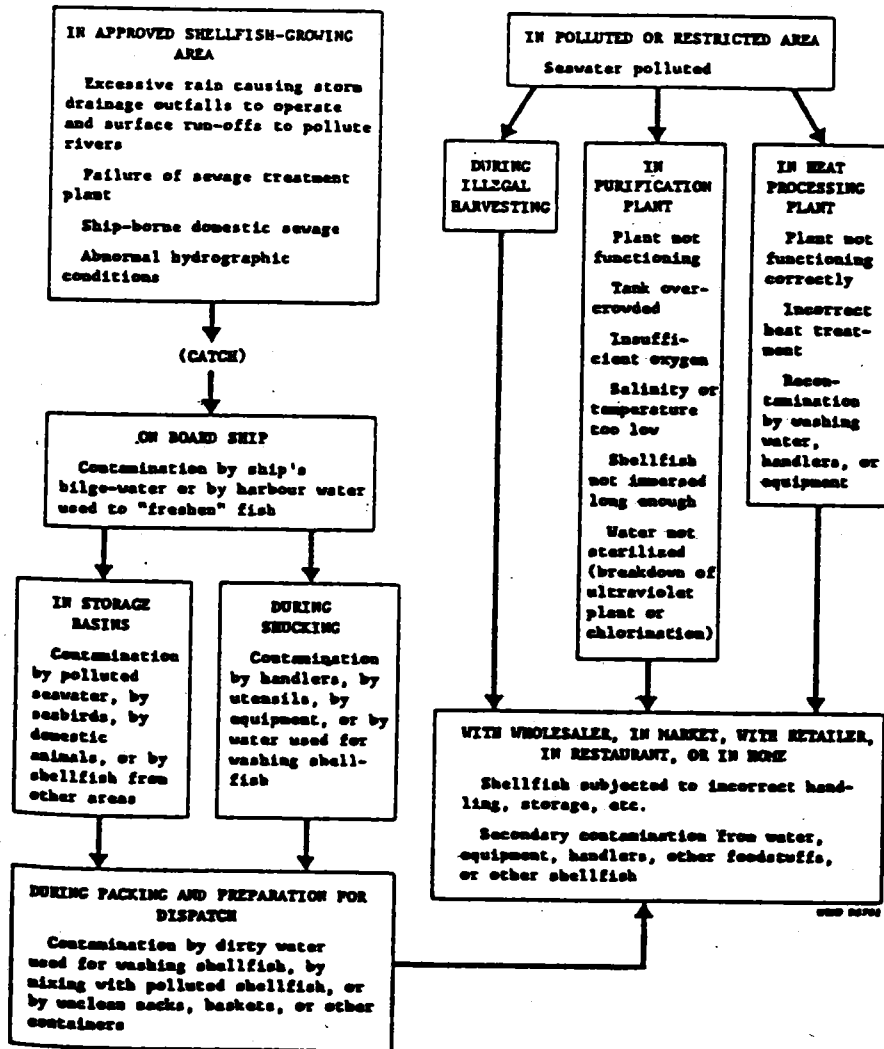


Table 2 Characteristics of Important Bacterial and Viral Shellfish-borne Diseases of Man

| | Etiological agent | Principal aquatic food animals involved as source of infection | Sources of infection for aquatic food animals | Mode of transmission to man | Disease in man and most common manifestations | Control |
|---------------------|---|---|--|--|---|---|
| Bacterial Infection | <u>Salmonella</u> spp. (a) <u>S. typhi</u> <u>S. paratyphi</u> (b) other spp. (e.g. <u>S. typhimurium</u> , <u>S. enteritidis</u>) | Shellfish secondarily contaminated by polluted waters or from improper handling | (a) Human faeces and water contaminated by human faeces (b) Human and animal faeces, polluted water | Ingestion of raw or insufficiently cooked contaminated shellfish | (a) Typhoid and paratyphoid fever septicaemia (b) Salmonellosis gastroenteritis | Proper sewage disposal; Hygienic handling; Adequate cooking and cooling Restriction of fishing or of harvesting in polluted waters; Relaying and purification of shellfish from polluted waters |
| | <u>Vibrio cholerae</u> | Shellfish secondarily contaminated by polluted waters or from improper handling | Human faeces and waters contaminated by human faeces | Ingestion of raw insufficiently cooked contaminated shellfish | Cholera: severe watery diarrhoea, vomiting, dehydration | Proper sewage disposal; Hygienic handling; Adequate cooking and cooling Restriction of fishing or of harvesting in polluted waters; Relaying and purification of shellfish from polluted waters |

(Table 2 continued...)

| | Etiological agent | Principal aquatic food animals involved as source of infection | Sources of infection for aquatic food animals | Mode of transmission to man | Disease in man and most common manifestations | Control |
|-----------------------------------|--------------------------------|---|---|---|---|---|
| | <u>Vibrio parahaemolyticus</u> | Shellfish | Organism occurs naturally in the marine environment | Usually from consumption of raw or inadequately cooked shellfish that have not been properly refrigerated | Diarrhoea, abdominal pain | Hygienic handling; Correct processing; Adequate cooking and cooling |
| Bacterial Intoxication | <u>Clostridium botulinum</u> | Fermented, salted, and smoked fish | Sediment, water, animal faeces | Ingestion of improperly processed fish or shellfish | Botulism neurological symptoms with high case-fatality rate | Correct processing; Cooking just prior to eating food |
| | <u>Staphylococcus aureus</u> | Shellfish secondarily contaminated from improper handling | Man - nose and throat discharges skin lesions | Ingestion of shellfish cross-contaminated after cooking | Staphylococcal intoxication: nausea, vomiting abdominal pain, prostration | Hygienic handling; Adequate cooling |
| Bacterial intravital intoxication | <u>Clostridium perfringens</u> | Shellfish secondarily contaminated by polluted waters or from improper handling | Polluted waters, human and animal faeces, sediment | Ingestion of cooked shellfish that have not been properly refrigerated | Diarrhoea, abdominal pain | Rapid cooling of food after cooking |

(Table 2 continued...)

| | Etiological agent | Principal aquatic food animals involved as source of infection | Sources of infection for aquatic food animals | Mode of transmission to man | Disease in man and most common manifestations | Control |
|-----------------|-------------------------------|---|---|--|---|---|
| Viral infection | Virus of infectious hepatitis | Shellfish secondarily contaminated by polluted waters or from improper handling | Human faeces and water polluted by human faeces | Ingestion of raw or inadequately cooked contaminated shellfish | Infectious hepatitis | Proper sewage disposal; Adequate cooking; Restriction of harvesting in polluted waters; Relaying and purification of shellfish from polluted waters |

Table 3 : Incidence of Cholera and Poliomyelitis in the Countries
of the East Africa Region

| Country | Number of Cases Reported | | | | | |
|------------|--------------------------|---------------|------|------|------|------|
| | Cholera | Poliomyelitis | | | | |
| | 1980 | 1976 | 1977 | 1978 | 1979 | 1980 |
| Comoros | - | - | - | - | - | 3 |
| Kenya | 2808 | 210 | 290 | 1020 | 59 | 389 |
| Madagascar | - | 1 | 0 | 406 | 176 | 69 |
| Mauritius | - | 0 | 0 | 0 | 0 | 0 |
| Mozambique | 1212 | 8 | 22 | 65 | 48 | 66 |
| Seychelles | - | 0 | 0 | 0 | 0 | 0 |
| Somalia | - | - | - | - | - | - |
| Tanzania | 5196 | 14 | 157 | 90 | - | 91 |

From: WHO Weekly Epidemiological Records

highly contagious and persists in brackish water for variable periods. It is probable that shellfish serve as the vehicle of infection for this organism; raw shrimp has been identified as the source of one cholera outbreak.

12. Typhoid and paratyphoid fevers, caused by the organisms Salmonella typhi and S. paratyphi respectively, are the most common diseases associated with the consumption of shellfish, particularly raw molluscs, from sewage-polluted waters. Although the disease is usually contracted through the ingestion of contaminated shellfish and fish there are reports of instances where typhoid was caused by contact with a sewage-polluted beach or swimming in highly contaminated water.

13. Salmonellae are widespread in the environment due to contamination from human and animal excreta, and both warm and cold-blooded animals may serve as carriers without developing disease symptoms. Infection by this organism appears to occur most commonly in warmer climates. Shellfish taken from sewage-polluted water may contain salmonellae or may acquire them from contact with polluted water or soil, infected domestic animals, or food handlers.

14. Bacteria of the genus Shigella (Sh. dysenteriae, Sh. flexneri, Sh. boydii and Sh. sonnei), causing a bacillary dysentery, shigellosis, may be transmitted through food, water or, more commonly, through direct human contact. They survive for only a short time in the marine environment, but the infective dose is very low.

15. Other bacteria causing infections are Escherichia coli, Staphylococcus aureus, Clostridium perfringens, C. botulinum and Yersinia enterocolitica.

16. Viruses which multiply in the human alimentary tract may be found in considerable amounts in sewage and polluted water. There is evidence that, under some circumstances, virus particles remain viable in sea-water considerably longer than bacteria such as E. coli. Viral infectious hepatitis (type A) occurs as a result of consumption of shellfish taken from sewage-polluted water. Enterovirus infections are commonly spread by intestinal routes. Conclusive evidence that these may be transmitted by shellfish is lacking, although they have been identified in shellfish taken from sewage-polluted waters. Since enteroviruses are highly infectious, their presence in shellfish should be considered a hazard. They can survive for long periods in chilled and frozen oyster, and polioviruses were found to survive in oysters improperly processed and cooked.

17. Parasitic diseases from flukes and nematodes are not a major cause of concern but are an indirect source of infection from the consumption of improperly processed shellfish and fish.

Sewerage and excreta disposal

18. Several types of disposal systems are used in the region. The pit privy is especially well-suited to areas without a piped water supply. Bucket latrines are similar but are a greater sanitary hazard, and the disposal of night soil can create problems. This can be overcome by using the compost privy which converts the night soil into an end-product which can be used as a fertilizer.

19. Methods requiring water for their operation are the aqua privy, which receives excreta only, and the septic tank, in which all liquid wastes of the dwelling are treated. Both of these systems create an effluent for which adequate means of disposal must be provided. The effluent is septic in character and may contain pathogenic bacteria. Seepage from or overflow of these systems into the stormwater drainage system and through this into rivers, lakes or the sea is a problem that needs consideration.

20. In rural areas and in less densely populated urban areas possible methods of effluent disposal include seepage pits, sub-surface irrigation by means of open-jointed drain pipes and sand-filter trenches.

21. The above-mentioned are mostly individual systems but can be adapted for community use. Although it is cheaper to provide communal rather than individual latrines, these are more susceptible to neglect or overwork.

22. In relatively densely populated communities where there are well-developed water supply installations, a public sewerage system may be the most appropriate solution to the problem of liquid waste disposal. The collection of waste water from an entire community has the essential drawback of creating the problem of final disposal of large quantities of concentrated wastes and therefore some form of treatment is necessary.

23. Some alternatives for the final disposal of treated or untreated waste water, are:

- direct discharge to a watercourse or lake;
- discharge to the sea through a submarine outfall;
- land disposal for agricultural purposes; and
- other forms of reclamation, i.e. municipal or industrial re-use, use for recreation or fishing and groundwater recharge to prevent salt water intrusion or restore diminishing supplies (see also tables 4 and 5).

24. Marine dumping of sewage effluents is an easy way to dispose of wastes. However this solution can have long-term consequences for the health of coastal inhabitants and the coastal ecosystem.

25. About four fifths of the inhabitants of the urban areas are served by excreta disposal facilities, either by connection to the public sewerage system or through household systems (septic tanks) and in some places by pit-latrines. The proportion of people connected to public sewerage systems (about two fifths) has remained more or less stable for several years. With few exceptions, the increase in connections to public sewerage systems probably just keeps pace with the population growth in urban areas.

26. A few cities have sewers, but none has adequate sewage treatment nor effluent disposal facilities. In many cases the operation and maintenance of the urban public sewerage systems are not satisfactory and in one or two cases they are totally absent. For instance, in one of the States in the region nine stabilization ponds were constructed during the last decade but only one is working satisfactorily. The other eight have been left without maintenance and the sewerage effluents by-pass the ponds and flow directly to the sea or adjoining streams or rivers.

27. In the rural areas about 30 per cent of the population use pit latrines for excreta disposal, and a minority (about 10 per cent) use septic tanks. Pit latrines are an unsatisfactory method of waste disposal in several areas owing to the high ground water level. Large percentages of the rural population on the coastal areas practice open defecation on the beach and wash in the sea.

28. Stabilization (oxidation) ponds are an ideal way of treating sewage as the climatic conditions of the area are suitable for this form of treatment. They are a

Table 4 : Average reduction of coliforms present in sewage after treatment

| | Coliforms/100 ml | Approximate % reduction |
|---|------------------|-------------------------|
| Untreated | 10^6 | - |
| Primary treatment (sedimentation) | 5×10^5 | 50 |
| Secondary treatment (biological filtration, etc.) | 10^4-10^5 | 90-99 |
| Tertiary treatment (chlorination ^a) | 10^3-10^2 | 99.99 |

^a Assuming the efficient working of all stages of treatment.

Table 5 : Percentage reduction of bacteria by various sewage treatment processes

| Type of sewage treatment | Reduction in % of total bacterial count |
|---|---|
| 1. Sedimentation (dependent on sedimentation time) | 25-75 |
| 2. Trickling filters (dependent on filter load) | 80-95 |
| 3. Activated sludge treatment, high rate | 80-95 |
| 4. Activated sludge treatment, low rate | 90-98 |
| 5. Intermittent sand filtration | 95-98 |
| 6. Chlorination of raw or sedimented sewage | 90-95 |
| 7. Chlorination of biologically treated sewage, i.e., sewage treated by methods 2, 3, and 4 above | 98-99 |

Source: Imhoff, K. & Fair, G. M. Sewage treatment, New York, Wiley, 2nd ed., 1956.

useful method for growing communities where both funds and trained personnel are in short supply. In these ponds, beneficial organisms stabilize the waste water into a liquid that can be released to the environment without endangering man directly or affecting the environment adversely, and does not place an undue cost burden on a downstream user. They can be located where land is inexpensive, where there is a shortage of trained personnel and currency restrictions are in force.

29. The design of a waste stabilization pond depends on the treatment objective. A pond system is usually designed to receive untreated domestic or industrial wastes, but may also be designed to treat primary or secondary plant effluents, excess activated sludge or diluted night-soil. The ponds may be used to pre-treat wastes, to remove most of the biochemical oxygen demand (BOD), and to reduce the concentration of disease-causing agents. In waste stabilization ponds, the decomposable organic wastes are stabilized by micro-organisms and the numbers of disease-causing agents are reduced significantly, primarily due to the long detention period required for stabilization. An inspection of costs will show that it is considerably cheaper to treat waste water in stabilization ponds than by other methods, provided land costs are not prohibitive.

Solid waste management

30. The solid waste is composed of wastes from households, public buildings and hotels. It also includes solid waste from streets and gardens, wastes from small industries and garages, and sludges removed from waste treatment plants, septic tanks and from the redigging of pit latrines.

31. The collection and disposal of solid waste is a major problem and is frequently a major source of air, water and soil pollution. In most cases, the responsibility for solid waste collection and disposal lies with the municipality in urban areas and with the local council (where it exists) in rural areas. Nevertheless, with a few exceptions, the collection of solid waste in the region is more or less satisfactory. Lack of funds to replace old unserviceable vehicles is most frequently the reason for unsatisfactory handling of solid waste.

32. The disposal of solid waste in general is not carried out in a sanitary and efficient manner. In most cases the tipping sites are on the banks of rivers or on beaches near the sea, thus causing a threat to the environment. No special effort is made to salvage valuable materials, which would reduce consumption of scarce raw materials and preserve natural resources.

33. Solid waste management in the region faces two major problems:

- insufficient transport to disposal sites, mainly due to immobilization of vehicles caused by poor maintenance and inefficient organization of the labour force involved;
- inadequate control of the landfills resulting in leakage, open fires, free access for scavengers and illegal dumpings at the existing landfills as well as on private landfills.

34. The progress achieved by the increase in the number of people benefiting from excreta disposal facilities has improved the health conditions of the population, but as the volume of inadequately treated effluents in most cases has grown, pollution has greatly increased in rivers and coastal waters receiving these effluents.

Some general effects of pollution

35. The general effect of pollution stress on natural communities is to reduce the diversity of species by killing sensitive organisms or affecting their competitive interactions with others, resulting in a community of resistant and opportunist species. In extreme cases, pollution can result in the elimination of all non-microbial life. Excess nutrients can lead to eutrophication which, if severe, can cause anaerobic conditions to develop in the benthos. Large crops of green algae are then found decaying on the bottom, sulphurous smells are in evidence and there is an absence of diverse life forms. The important coastal breeding areas of pelagic species can be destroyed by such processes, and shellfish breeding grounds may have to be closed due to pathogenic content or tainting of food organisms.

36. Aesthetic degradation of coastal areas resulting from waste discharge is a major problem. The most visible wastes, such as surface films of grease, oil, wax or fats, or floating solids have a particular impact on aesthetic sensibilities, and for bathers such qualities as odour, clarity, taste and tactile characteristics are also important.

37. The pollution load reaching the coastal areas from rural domestic sources is negligible with the exception of widely practiced defecation on beaches. The estimated wasteload from urban sewerage systems is summarized in table 6. Due to uncertainties involved, no estimate is given for the wasteload from solid waste disposal practices.

WATER SUPPLY

38. The Comoros, a predominantly rural country, is composed of four islands with a total population of 400,000. Although there is sufficient rainfall, owing to a particularly permeable soil, water resources are scarce. The majority of the urban population is served by public stand pipes but the supply system is outdated. The presence of perennial rivers on Anjouan, Mayotte and Moheli, provides an adequate supply but the water is untreated. Contaminated water is a major cause of the widespread incidence of gastro-enteritis and similar illnesses. Where the population is solely dependent on the rain supply, drought has been a problem in the past few years. For example, in 1979, between October and December, the inhabitants of some localities were forced to tap the trunks of banana trees to supply their needs. Although new cisterns were built and old ones repaired, they are poorly maintained and are already being overworked due to the marked increase in population. This is especially noticeable in the dry season between May and October.

39. More than 12 per cent of the population of Moroni now has an adequate water supply. Anjouan, Mayotte and Moheli have watercourses but they are often sited near the bed of a river, leading to non-consumable, muddy water when the flows are very heavy. Settlements depend either on rain-water storage tanks or on wells which tap an underground reservoir of fresh water floating over salt water which seeps in from the sea.

40. In Kenya, the Ministry of Water Development, created in 1974, is responsible for: water supply for domestic and livestock uses; water conservation; sewerage and water pollution control; and water resource assessment and allocation. This has considerably improved the earlier situation where the responsibilities in the sector were distributed among many agencies and Ministries.

Table 6 : Estimated discharge of domestic sewage from major cities on the coasts
(estimated 20 kl/capita/year)

| Country-City | Population (Estimated) 1980 | Length of Coastline Expressed in Km. | Population Sewered % | BOD ₅ ton/yr. | BOD ₅ Km coastline ton/yr. |
|-----------------------|-----------------------------------|---|----------------------------|-----------------------------|---|
| Kenya | 15,300,000 | 500 | | | |
| Mombasa | 440,000 | | 88,000 20 | 1760 | 3.52 |
| Malindi | 14,000 | | | | |
| Lamu | 6,000 | | | | |
| Regional/Total | 460,000 | | 88,000 19 | 1760 | 3.52 |
| Tanzania | 17,540,000 | 800 | | | |
| Dar es Salaam | 760,000 | | 112,500 15 | 2250 | 2.81 |
| Tanga | 100,000 | | 10,000 10 | 200 | 0.25 |
| Lindi | 30,000 | | | | |
| Regional/Total | 890,000 | | 122,500 14 | 2450 | 3.06 |
| Mozambique | 10,200,000 | 2500 | | | |
| Maputo | 770,000 | | 77,000 10 | 1540 | 0.62 |
| Beira | 220,000 | | 55,000 25 | 1100 | 0.44 |
| Quelimane | 100,000 | | 10,000 10 | 200 | 0.08 |
| Nampula | 100,000 | | 10,000 10 | 200 | 0.08 |
| Pemba | 30,000 | | 3,000 10 | 60 | 0.02 |
| Regional/Total | 1,220,000 | | 155,000 13 | 3100 | 1.24 |
| Comoros | 400,000 | 350 | | | |
| Moroni (G.Comores) | 16,000 | | | | |
| Moheli | 4,500 | | | | |
| Anjouan | 10,000 | | | | |
| Regional/Total | 30,500 | | | | |

(Table 6 continued...)

| Country-City | Population (Estimated) 1980 | Length of Coastline Expressed in Km. | Population Sewered % | BOD ₅ ton/yr. | BOD ₅ Km coastline ton/yr. |
|---------------------------|-----------------------------------|---|----------------------------|-----------------------------|---|
| Madagascar | 8,500,000 | 4000 | | | |
| Tamatave | 60,000 | | 9,000 15 | 180 | 0.05 |
| Majunga | 70,000 | | | | |
| Tulear | 40,000 | | | | |
| Diego-Suarez | 45,000 | | 4,500 10 | 90 | 0.02 |
| Regional/Total | 215,000 | | 13,500 6 | 270 | 0.07 |
| Mauritius | 936,000 | 200 | | | |
| Port Louis | 250,000 | | 150,000 60 | 3000 | 15.00 |
| Plaines Wilhems | | | | | |
| Curepipe | 57,000 | | 40,000 70 | 800 | 4.00 |
| Beau-Bassin/ Rose-Hill | 72,000 | | 50,000 70 | 1000 | 5.00 |
| Phoenix | 36,000 | | 25,000 70 | 500 | 2.50 |
| Regional/Total | 415,000 | | 265,000 64 | 5300 | 26.50 |
| Seychelles | 65,000 | 600 | | | |
| Victoria | 25,000 | | 6,250 25 | 125 | 0.21 |
| Regional/Total | 25,000 | | 6,250 25 | 125 | 0.21 |
| Somalia | 3,850,000 | 3000 | | | |
| Mogadishu | 400,000 | | | | |
| Merca | 55,000 | | | | |
| Kismayo | 60,000 | | | | |
| Berbera | 50,000 | | | | |
| Regional/Total | 565,000 | | | | |
| GRAND TOTAL | 3,820,500 | | 650,250 17 | 13,005 | |

41. The Water Department Planning Division has formulated projects to improve the national water supply and sewerage sector. An engineering consulting firm has carried out studies specifically for the coastal province. These studies cover water supply, sewerage and solid wastes, pollution and management of the marine sector. The stages of the implementation of these proposed projects for the coastal municipalities are: Mombasa - final design; Malindi - preliminary design; Lamu - feasibility studies; and Kilifi - feasibility studies. External financial resources for the development programme have been obtained. The percentage of population served by water supply systems has increased on a regular basis and is the highest in the East African (continental) region. However, this is still only one third of the total population. In urban areas, house connections have increased to 60 per cent of the urban population, the other 40 per cent relying on stand posts. A Water Pollution Control Section within the Water Department is responsible for the preservation of the quality of the country's water resources.

42. The water supply systems in Madagascar vary from primitive to very sophisticated. The type of system serving a population is directly related to population concentration and the influence the population has on the administration.

43. The authorities have classified the water supply systems according to two categories: towns of more than 2,000 inhabitants and towns of less than 2,000 inhabitants.

44. There are 116 towns in the first category with a total population of 1,350,000 inhabitants. This represents 17.5 per cent of the Malagasy population. These towns have access to piped water supplies. In general, the volume and quality of the water supplied is satisfactory.

45. The population is supplied by private connections and public stand posts. The volume consumed is as follows:

| Type of supply | Number of connections | Volume supplied m ³ |
|---------------------------|-----------------------|--------------------------------|
| Private connection | 52,500 | 22,625,000 |
| Administrative connection | 3,000 | 8,000,000 |
| Public stand posts | 2,500 | 13,000,000 |
| <hr/> | | |
| Total | 58,000 | 43,625,000 |

46. The daily consumption for private connections varies from 100 to 270 litres/capita/day, including unaccounted-for water. The water supplied by public stand post varies in volume from 20-40 litres/capita/day. It is estimated that almost 90 per cent of the population of these towns has access to a water supply, one third through private connection and two thirds through public stand posts. The supply in several regions is very often interrupted.

47. Information and statistical data for towns in the second category of less than 2,000 inhabitants are very scarce, and it is difficult to have a clear appraisal of the actual situation. Almost 85 per cent of the Malagasy population lives in these secondary towns and villages. Five million live in villages of less than 500 inhabitants. This illustrates the dispersion of the rural population in small villages and the difficulty in supplying potable water systems.

48. These populations are supplied, if possible, by public stand posts and by individual or community wells and springs. It is estimated that less than 20 per cent have access to this type of water supply. There is a lack of co-ordination at all levels between the agencies responsible for these regions.

49. In Mauritius, the Central Water Authority is the sole agency responsible for the supply of water to the community. Mauritius is the only country in the region where almost the entire present population have access to a piped water supply, through private connections and public stand pipes. Unfortunately, in several areas, the supply is very often interrupted. The Water Authority is responsible for the collection, treatment and distribution of water for domestic, commercial and industrial purposes. The quality of the water is controlled by routine checks on the chlorine residual in the water supply system. Bacteriological checks are also made regularly by the Central Water Authority laboratory staff. Unaccountable consumption of water is very high in some places: for example, in the Port Louis area, only about half the water supplied to the distribution system reaches the consumers.

50. The Central Water Authority has a development programme covering: (a) major repairs and replacement of distribution systems; (b) extension and improvement of mains; and (c) distribution systems to cope with the additional water demands.

51. The population of Mozambique is approximately 10 million, of which one third is urban and two thirds are rural. The National Directorate of Water in the Ministry of Public Works is the agency that deals with water supply. It has responsibility for planning, co-ordinating, designing and building water supply systems through state enterprises. The Ministry of Health has responsibility for standards control of potable water. Health education and promotional work are carried out by the health authorities, whose activities are concentrated in the rural areas on water supply and pit latrine construction.

52. Only 15 per cent of the population is serviced by 150 water supply systems, i.e., 1,500,000 inhabitants of which 1,200,000 are in the urban areas. In 1975, just 1 per cent of the rural population had access to safe water; the percentage had doubled by 1980. The National Directorate for Water has set up a water supply action programme in parallel with the International Drinking Water and Sanitation Decade. The objective of the programme is to provide by 1990 water supply systems for 65 per cent of the expected population (making a total of 8 million inhabitants with adequate water supply). There is an emphasis on an initial improvement in rural conditions with the aim of establishing at least one source of water per 1000 people.

53. The water supplied to 70 per cent of the population of Mahé Island, in Seychelles, is treated; that supplied to 20 per cent of the population is untreated; and 10 per cent of the population receives water from rivers or wells. Legislation was drafted making the Seychelles Water Authority responsible for all water in Seychelles. Ground-water investigations have revealed storage of over 477.5 million litres.

54. The population is served by private connections and public stand posts. The average domestic water supplied to the population is 135 litre/capita/day. This includes 23 per cent unaccounted-for water. A comprehensive water supply study has been completed, covering the whole of Mahé. A minimum of 800 households in Mahé are converted yearly to drinking water supply networks.

55. The population of Somalia is estimated at 3.8 million, of which about a third live in 87 urban communities (Mogadishu alone accounting for half of them). The

remaining population is considered rural, 50 per cent of it being nomadic. Waterborne diseases are endemic in some areas and three quarters of the people harbour intestinal parasites. A third of the total population is served by public water supplies. In the urban areas, 60 per cent of the population is served. In rural areas, 20 per cent has access to public stand posts or public wells. About 67 per cent of the total population obtains water from unprotected sources.

56. There are plans to construct boreholes for rural water supplies as well as shallow wells and surface dams. Mogadishu, Hargeisa and Misimayo all have public water supply systems and extensions to these schemes will be undertaken in the early 1980s.

57. In Tanzania, in 1980, 82 per cent of the urban population and 28 per cent of the rural population had access to adequate drinking water. Some problems are encountered with water resources: surface waters are very turbid, whilst ground waters are highly saline and there is a high level of fluoride in some aquifers. In rural areas supplies are usually from shallow wells, deep boreholes, surface gravity and surface pumped supplies.

SEWERAGE AND SANITATION

58. There is no sewerage system in Comoros. Hotels, administrative buildings and a few houses have septic tanks. On the island of Grande Comore, this in itself is a problem as the septic ditches are in very permeable basaltic soil whilst on the other islands the soil is clay. As yet there is no pollution problem caused directly by sewage, but there is a litter problem in Comoros. The shore front is used as a disposal site and many are found adjacent to hotels. Children have been observed playing in the vicinity where human wastes are being discharged into pit latrines or in the open, which creates a sanitation problem. Many pit latrines are situated directly on the beach. As the water table is high, the siting of pit latrines has to be arranged so as to avoid contamination of the water.

59. Until early 1970, little or no attention was given to sewerage development in Kenya outside Nairobi. The Sewerage Division has been very active in promoting a national sewerage programme. This has facilitated increased financial support through the Ministry of Local Government for the undertaking of preliminary engineering and feasibility studies. At present, there are approximately 40 urban sewerage projects under the technical control of the Sewerage Division. These projects are funded from national and bilateral sources.

60. The Ministry of Health figures give the percentage of urban population considered as adequately served as 56 per cent. The rural population served by some sort of excreta disposal system is described as 'low'. It has been estimated that about 1.70 million have been provided with sanitation and about 2.77 million with pit latrine methods of excreta disposal.

61. With regard to the coastal zone, the main city is in the harbour of Mombasa. The existing sewerage system on the Mombasa Island is 25 years old and overloaded and discharges its wastes directly to the bay of Mombasa. Only 17 per cent of the entire population of Mombasa is currently connected to a centralized sewerage and treatment capacity, all in one section of Mombasa Island. Elsewhere septic tanks and soakage pits are used. Treatment of wastes in the municipal system is only primary (sedimentation). Liquid effluents are discharged about 0.5 km out to sea and sludges are trucked to the municipal dumpsite, a landfill in what used to be a

salt marsh or tidal flat, and spread. On the West Mainland of Mombasa, separate facilities do exist for hotels, houses and administration buildings, which use septic tanks or small treatment plants. Hotel capacities have expanded to accommodate more tourists but the sewage facilities have remained the same. Most of the population still uses pit latrines. The existing domestic liquid waste situation in Mombasa is critical and causes a public health hazard. A feasibility study has been carried out on construction of additional municipal sewage capacity for the West Mainland, however, and work is expected to begin in 1982.

62. The sanitation sector in Madagascar is directly related to the water supply sector. However, the agencies responsible for the two sectors are independent. The Ministry of Public Works is responsible for construction of sewerage systems in the main towns, and the Ministry of Health is responsible for sewerage systems in the villages. The operation and maintenance of the systems is the responsibility of the local authorities. They face difficulties due to shortage of staff, material, equipment and financing.

63. The sewerage and sanitation sector in Madagascar consists of the disposal of: rain-water, liquid wastes and solid wastes. The beaches and coast are already somewhat polluted.

64. Very few of the main towns, with the exception of the capital, Tananarivo (situated in the centre of the northern region of the island), have a sewerage system to dispose of domestic liquid wastes and rain-water. It is estimated that only 3 per cent of the urban population in the main towns are sewered. The rest of the population has individual sanitary facilities. Some facilities are still operating in the highlands, although their use decreases in direct proportion to the size of the small towns and is negligible in the coastal zones.

65. In the coastal regions, all the principal ports and bays in the vicinity of towns are generally highly polluted. The pollution is due to the disposal of untreated domestic and industrial liquid and solid wastes.

66. In the rural areas bordering the beaches, the population does not have any sanitation facilities. Most of the coastal rural population practices open defecation on the beach and washes in the coastal water. Pit latrines constructed on stilts can be seen offshore at sea and over rivers.

67. The level of cleanliness is high in Mauritius but there are some unsatisfactory environmental and sanitary conditions resulting from deficiencies in treatment of wastes by hotels. Certain hotels have insufficient septic capacity systems and these become overloaded especially during storm periods. One hotel is reported to discharge kitchen wastes directly into the sea.

68. The Ministry of Works in Mauritius is responsible for the two major sewerage systems in the island:

(a) The Port Louis System - most of the City of Port Louis is on the sewerage system and the sewage after screening is pumped out through two outfalls to sea:

(i) the Northern Treatment works and outfall at Roche Bois; and

(ii) the Southern Treatment works and outfall at Fort Victoria Cassis.

Before 1963 when the urban areas of Plaines Wilhems were provided with piped sewage disposal services, Port Louis was the only region in Mauritius where such services existed. Port Louis has had piped sewage disposal services since 1890. These services were occasionally improved but by the early 1960s, it was found that the system needed radical changes. The existing system was improved by providing intercepting sewers and new pumping stations and outfalls.

- (b) The Plaines-Wilhems System - this system covers certain areas in the Municipalities of Curepipe, Beau-Bassin/Rose-Hill and Phoenix. The sewage flows by gravity to St. Martin where, after screening, it is discharged to the sea near Pointe Moyenne in the west of the island.

69. In addition, there are a number of small areas which are not served by the two systems mentioned above. These areas include housing estates, hospitals, hotels and some industrial factories, and they usually have their own systems, such as individual sewage treatment plants, septic tanks and improved pit latrines.

70. The present per capita waste flow in the sewered areas of Port Louis, the capital city, is approximately 250 litres per day in dry weather. It is assumed that half of this volume includes a large amount of leakage from manholes, waterpipes and infiltration from rain-water drains.

71. In Mauritius, the design criteria for sewerage systems takes into consideration discharges from domestic, commercial and industrial areas (where appropriate) and the infiltration of rain-water.

72. The sewerage system of Plaines Wilhems covers two separate areas connected to a trunk sewer discharging to sea in the west of the island. The per capita sewage flow at present is 130 litres per second. This sewage flow is equivalent to about 100 litres per capita per day. One of the major problems for this sewerage system is infiltration, particularly in the Curepipe region. Approximately 70 per cent of the population of the Municipalities (115,000 inhabitants) are connected to the system. In contrast to Port Louis, the Plaines Wilhems sewerage system does not have much additional waste flow from industrial areas.

73. Apart from the areas covered by sewerage systems, alternative methods of disposal of liquid waste are:

- (a) individual septic tanks with soakaways or absorption pits for households and some commercial and administrative buildings;
- (b) pit latrines; and
- (c) improved pit latrines, of standard design and construction with water-seal units.

74. Sewage disposal by standard pit latrine, in common use at present, only partially meets standards and requirements of effective public health. However, with the improved type of pit latrine and "water-seal" unit modification, and an increase in the number of septic tanks in certain areas, better hygiene and sewage disposal should result.

75. Sewerage systems exist in four cities in Mozambique. In 1975, 10 per cent of the urban population was connected to the public sewerage system, 20 per cent had septic tanks and 30 per cent used buckets. None of the rural population had access to reasonable facilities. By 1980, in the urban population, 10 per cent had public sewage facilities, 50 per cent septic tanks and only 5 per cent used buckets. In

rural areas 5 per cent of the population has access to waste disposal. The principal cities are Maputo and Beira. The population of Maputo is approximately 800,000, 10 per cent of whom are connected to a sewerage system. This lacks a treatment capacity and simply receives wastes from residential buildings which themselves have septic tanks. The sewage and municipal wastes are discharged without treatment into Maputo Bay by ten outfalls located directly along the coastline. Septic tanks, soakage pits, aqua privies or pit latrines are used by the rest of the population.

76. The population of Beira is about 220,000. Less than a quarter of the population is connected to a sewerage system. Sewage is discharged directly to the sea. The rest of the population uses aqua privies, pit latrines and septic tanks. The use of pit latrines in this area is being discouraged, because the water table is too high. However, they are still used elsewhere and new and more efficient varieties of latrines have been designed. A low-cost sanitation system has been designed by the Public Health Engineering Division and is currently being constructed in the area.

77. Other coastal towns are: Quelimar, with a population of 50,000; Angola, with a population of 30,000; and Pemba, with a population of 30,000. All three towns have very small sewerage systems.

78. In 1977, 45 per cent of the urban population in Seychelles used septic tanks and 47 per cent pit latrines. In the rural area, 26 per cent used flush toilets and 70 per cent pit latrines. The rest of the population, both urban and rural, used bucket latrines, chemical latrines and nature. However, since 1980, bucket latrines are no longer in use.

79. An 8,000-person contact stabilisation sewage treatment plant serves approximately 30 connections in the commercial area of Victoria. The plant is under-utilized and discharges its effluent into the adjoining mangrove swamp. A disposal system for the northern part of Victoria is under construction and should be operational at the end of 1982.

80. 200 houses at Pointe La Rue Development are served by a 70 kl/d capacity extended aeration plant. The effluent discharges into the storm-water drain for conveyance through a lagoon beside the airport and into the sea.

81. Four major hotels on Mahé have their own aerobic treatment plants which discharge treated effluent into the sea. The airport has its own recently commissioned aerobic treatment plant for disposal of aircraft waste water and the waste from the terminal buildings.

82. Human excreta and other liquid wastes are disposed of using either treatment works, septic tanks, pit latrines or sea discharges. Usually, houses served by mains water are also served by an aqua privy or septic tank. This applies to the majority of North Mahé and part of South Mahé, and minor hotels and guest houses. Aqua privies and septic tanks are usually used in conjunction with separate soakaway and drainage systems for sullage, the septic tank only being used for night soils.

83. Septic tank effluent is a major potential source of pollution. This is because most septic tanks are inaccessible for emptying by a road tanker. Clay ground and small plots which are usually situated a short distance from a watercourse, lead to soakaway failures and short circuiting of septic tank effluent to the streams. The pollution effect is, however, minimized by the vigorous flushing action during the rainy season and degradation of the pollutants is accelerated by the high ambient temperature and the abundant sunlight experienced in Seychelles.

84. Many of these septic tanks, which were originally designed to serve three houses now serve an average of eight to twelve houses with the result that the septic tanks are overloaded and the effluent is very offensive and potentially dangerous to health. In general, the effluents from septic tanks flow directly to open drains or streams where the local population does its washing. The Victoria Hospital's liquid waste is discharged into septic tanks which also overflow into neighbouring streams and mangrove swamps. There is a project under way for treatment of Victoria Hospital effluent.

85. It is imperative that the hospital and houses in the areas north of the existing treatment works be connected to the new Port Treatment Plant which is under-utilized. Sea-front latrines should be abolished as they are a cause of pollution.

86. Litter can be seen in Seychelles. Disposal of wastes occurs along the beds of streams and they can be washed into nearshore waters in rainy periods. Houses are built close to the sea and surface run-off or soak-aways from septic tanks could be affecting the shore and nearshore waters. Outhouses are sometimes located directly over coastal waters as in Praslin and children are to be seen playing nearby.

87. The remaining residential premises on Mahé and the other islands are served by pit latrines for human excreta, with other functions such as washing being conducted in the nearest watercourse. Most of the major streams have washing restrictions near their estuaries. Approximately ten residences on Mahé and probably some houses on the other islands are served by sea-front latrines, consisting of a privy constructed to discharge human waste directly into the sea.

88. Urban sanitation in Somalia is the responsibility of the local councils technically supported by the Ministry of Health. There is no sewerage system in the country. In Mogadishu, the capital city, some 3,000 people use septic tanks, while from other premises raw sewage flows into an open drainage system and into the sea. In other urban and rural areas, pit latrines, cesspools, and septic tanks are in use to some extent.

89. A study has been carried out by a consulting engineering firm for the establishment of a Master Plan for "Main Sewerage and Surface Water Drainage" of Mogadishu. The scheme covers the greater part of Mogadishu and includes: main and minor sewers, surface water drains, septic tanks and other sanitation facilities, and a treatment plant (waste stabilization ponds).

90. The sewerage systems are to operate by gravity sewers leading to pumping stations in order to raise the flows, which would finally reach the treatment plant to the north-east of the city. The treated effluent is to be used for controlled irrigation. The surface water drains, in the first phase, cover two areas only in the central part of the city close to the sea. The market area is included in this phase. The waste stabilization ponds will be designed to treat the sewage flowing from the sewerage system. The treated effluent will be used for controlled irrigation, or discharged in the sea. Pollution of the coastal water by domestic liquid wastes or solid wastes is at present negligible.

91. The Ministry of Lands, Housing and Urban Development is responsible for sewerage and sanitation in Tanzania. The Sewerage and Sanitation Directorate is engaged in a number of activities in the sector. There are four major towns along the coast: Dar es Salaam, Tanga, Mtwara and Lindi.

92. Dar es Salaam is Tanzania's major port and has an excellent natural harbour. Over the last hundred years it has grown from a small coastal town to a major urban

centre and is currently the principal centre of commerce and industry in Tanzania. Although Dar es Salaam is the present capital of Tanzania, it is planned that Dodoma will become the capital in due course.

93. The majority of the urban and rural populations still use traditional pit latrines for excreta disposal. Twelve per cent of the urban population are served by partial sewerage systems while the remainder use septic tanks, soak-away systems and pit latrines.

94. The existing sewerage systems are of the 'separate' type. The system serving the city centre was constructed 25 years ago and comprises both gravity and pumped systems, the sewage flow being discharged through a 1 metre diameter sea-outfall pipe. Since the initial sewerage system has been installed, other areas have been sewered and connected to the city centre system. Sewage disposal for these additional sewered areas is by treatment in waste stabilization ponds and the effluent is discharged into inland watercourses.

95. These waste stabilization ponds have been provided to serve nine different sewerage systems. It is unfortunate that only some of the waste stabilization ponds are currently working well, all the others being either dry or overgrown with vegetation and therefore ineffective.

96. The municipal sewage system of Dar es Salaam, which relied on partial primary treatment by a pulverizer, has broken down and solid wastes are often found in the harbour area into which the system discharges by means of an underwater outfall. Areas outside the oldest section of the city, which are not served by centralized sewerage, generally use septic tanks in planned areas and pit latrines in the unplanned areas.

97. The existing sewers are in poor condition and completely obstructed in several places. There are seventeen pumping stations serving the city centre and the other sewerage systems. Only two are in good working order. Some of them have been out of operation for many years. This causes a surcharge of sewage in the sewers and overflows in the rain-water drains, rivers, harbour and beaches, causing serious pollution and creating a major risk to public health.

98. There is direct dumping of wastes from Msimbazi Hospital and surrounding settlements into the floodplain of the Msimbazi Creek. Anaerobic conditions have been noticed in the mangrove area just landward of Selander bridge at the sea-coast and considerable algal growth is observable at the edge of the sea off the mouth of the creek. Local residents harvest fish and benthic marine organisms in this area.

99. In view of the collapse of the sewerage system of Dar es Salaam, the Ministry of Lands, Housing and Urban Development commissioned a consulting engineering firm to establish a Master Plan for the sewerage and sanitation of the city of Dar es Salaam together with associated institutional studies. Some of the reasons for this general collapse of the sewerage systems and treatment plant have been lack of staff at all levels, inadequate equipment, and shortage of funds for satisfactory operation and maintenance. This Master Plan has now been prepared, and it covers the sewerage, sanitation, sewage treatment or disposal and institutional requirements of the city of Dar es Salaam (including the surrounding peri-urban and rural areas within the 1978 Regional Boundary) through to the year 2010. The report includes the following:

- (a) method of sewage collection;
- (b) feasibility of constructing further sea outfalls;

- (c) merits of effluent re-use;
- (d) short and long-term need for sewage treatment;
- (e) sewage treatment processes;
- (f) location of treatment works.

Various alternatives have been assessed to ascertain the least expensive solution.

100. The Master Plan has been divided into four stages, as follows:

| | Total Population in areas covered expressed in (1000) | Percentage served | | | Stage |
|-------------|---|-------------------|--------------|--------------|-------|
| | | Sewerage | Septic Tanks | Pit Latrines | |
| Existing | 932.3 | 12 | 10 | 78 | I |
| (1980-1981) | 1268.9 | 19 | 12 | 69 | II |
| (1985-1989) | 1642.4 | 25 | 10 | 65 | III |
| (1990-1999) | 2461.2 | 36 | 9 | 55 | IV |
| (2000-2010) | 3540.0 | 44 | 8 | 48 | |

At the end of Stage IV (2010) approximately 44 per cent of the new population will be served by sewerage systems. Of the remaining 56 per cent, 48 per cent will be served by low-cost sanitation systems and the remaining 8 per cent will be on septic tanks.

101. If the recommendations of the Master Plan are implemented, the problems of liquid and solid wastes disposal for the region of Dar es Salaam will be completely solved.

SOLID WASTE DISPOSAL

102. The majority of the Comoros population uses pit latrines. At present excreta disposal has negligible effect on pollution of coastal water round the islands, with the exception of the case of the rural coastal population which practices open defecation on the beaches and washes in the sea.

103. In Mombasa in Kenya, the Municipality is responsible for solid waste collection and disposal. A dumping site is situated on the edge of the sea and is not adequately managed. Local authorities are responsible for emptying septic tanks, cesspools and soakage pits. There is, regularly, a large volume of liquid waste collected from cesspools which is loaded into open drums and transported by truck. This liquid waste is discharged on to the solid waste dumping site, and leaches to the coastal water.

104. Uncontrolled dumping of toxic wastes such as outdated medicines is common. These are sometimes picked up by scavengers and resold on the black market. The wastes often carry infectious diseases which are easily transmitted by humans and animals scavenging on the dump site. Tourists and residents alike are subject to noxious odours from burning waste heaps and rotting litter. Toxic wastes may also

leach to the nearby coastal waters and infect fish, rendering them inedible. The public health situation caused by domestic liquid and solid wastes in Mombasa is a cause of concern for the Government, and it has given priority to the sewerage programme in the coastal zone.

105. According to the Ministry of Health, the following diseases occur in the coastal area: malaria, schistosomiasis, dysenteries, infectious hepatitis, cholera, and typhoid. All these diseases are directly related to the lack of potable water supplies and the absence of adequate sanitation facilities. The Government is making a special effort to face the challenge in organizing Kenya's health services to improve facilities and bring them within the effective reach of the rural population. Major constraints on development include shortage of finance and manpower.

106. The collection and disposal of solid wastes in Madagascar is carried out only in the principal towns. The collection of waste is the responsibility of the municipality concerned. In a few towns the local authorities have adequate control of the dumping sites and the disposal of solid wastes is satisfactory.

107. In small towns and rural areas, collection and disposal of solid waste are unavailable. In coastal areas, the population dispose of their solid wastes on the beaches or in the sea.

108. Laboratory facilities for control/analysis of pollution in coastal waters are available at Nosy-Bé. This laboratory is one of the best in the region for monitoring of coastal water quality. It could usefully have additional qualified staff and equipment. Shortage of funds is a major constraint on the operational efficiency of this laboratory.

109. Port Louis, in Mauritius, has a population of 250,000, including the 60,000 to 70,000 employees in the major industrial and commercial areas who commute to the city. According to the municipal authorities 100 tonnes of solid waste is collected daily and deposited on the principal six-acre tipping site near the Port of Roche Bois.

110. The collection of solid waste varies in frequency according to area, from daily to once a week. The collection is carried out by an estimated twenty tipper trucks, covered trailers, open trailers and tractors. The dumping site is on the edge of a river and near the sea. From the viewpoint of public health, it is unsatisfactory. Alternative sites are being explored by the local authorities. It was suggested that in the selection of the dumping site consideration should be given to a location within a reasonable distance from the centre of Port Louis, in order to avoid high costs in time, petrol and mileage and to reduce pressure on the Roche Bois site.

111. A solid waste management study covering all the municipalities of Mauritius is currently being carried out. The present situation could be improved by progressively implementing the recommendations contained in the study.

112. The solid waste collection and disposal in the main cities of Madagascar is the responsibility of the municipality's Executive Council. Maputo's solid waste collection may be usefully cited as an example. This city is by far the cleanest of all the cities in the East African region. The result is achieved with a minimum of equipment and vehicles. There are 36 trucks for scavenging operations, of which only four are in working condition at any one time. The Executive Council uses the four trucks 24 hours a day, with three drivers per truck each working an eight-hour shift. The dumping site is inland, but unfortunately, it does not altogether meet adequate health standards.

113. On Mahé in Seychelles most refuse is disposed of at controlled tips, the one at La Retraite being the largest. On other islands refuse is either buried or disposed of in swamps. In Victoria and certain rural areas, household refuse is deposited in public bins located along the roads. Where this facility does not exist, refuse is either burned or buried. Refuse from the bins is transported in properly designed trucks for disposal at the La Retraite dump. The dump has been constructed to provide land reclamation but constitutes a minor pollution problem in the immediate vicinity.

114. A study of wastewater facilities calls for the implementation of a two-phase programme, Phase 1 covering the northern area of Victoria (1981-1985) and Phase 2 covering the southern area (1984-1988). This sewerage plan, if implemented fully, will provide services for the whole of the population of Victoria town (25,000).

115. It is a fact that there is no evidence of extensive coastal pollution caused by liquid and solid wastes. On the other hand, it is very important that the recommendations for future action should be implemented as soon as possible.

116. Previous surveys conducted along Seychelles coastlines have shown that little pollution is caused by liquid and solid wastes. A study conducted in 1979 showed that the sea-front of the Le Rocher industrial area, Mahé, has no appreciable pollution other than a slight turbidity of the water, which could be caused by land-fill operations. Minor complaints are occasionally received from people in the Bel Ombre area, who report obnoxious smells from land-locked waters. This problem solves itself when the river breaks through to discharge directly into the sea during the rainy season.

117. The Health Inspectorate ensures that wastes are properly disposed of without causing pollution of water courses. The Conservancy Section ensures that public and private bins are emptied regularly and manages the disposal of solid wastes at the La Retraite dump. This section is also responsible for de-sludging those septic tanks that are inaccessible by road tanker. The Seychelles Water Authority gives advice to the Planning Authorities on the disposal of sewage. It is responsible for the operation and management of the public sewerage systems serving Victoria and Pointe La Rue.

118. Solid wastes in Somalia are collected and deposited on an uncontrolled dumping site near the beach in the vicinity of the slaughter-house. The Ministry of Health is responsible for water quality control. However, control is not carried out on a systematic basis. New equipment for the public health laboratory in Mogadishu is being provided, and with additional staff, will ensure more regular chemical analysis in addition to bacterial testing.

119. In Tanzania, the existing municipal solid waste collection and disposal systems are totally inadequate. The city council is very short of funds to support this sector, and this results in very limited facilities to collect and dispose of solid waste on the official dumping site at Tabata. There are numerous unofficial dumps around the town, creating potential health hazards. The official dumping site at Tabata is now filled beyond an acceptable capacity for the maintenance of sanitary conditions. New areas are being explored for alternative sites.

120. A new public health laboratory has been established in the Ministry of Health building. At present, there are over 20 professional and technical staff, but within a few years, there will be about 75 staff members. The laboratory's main objectives are:

- (a) to perform routine analysis (bacteriological, mycological, toxicological and others);
- (b) to train laboratory staff - from technicians of different levels to university students;
- (c) to control the quality of drinking water and foodstuffs in the 10 provinces of the country; and
- (d) to undertake research.

121. The laboratory is well equipped with sophisticated scientific equipment and has a highly qualified scientific staff. There is a plan to create 10 secondary laboratories in the country for the control of water quality and liquid wastes.

122. The laboratory has already undertaken water supply studies in Maputo and in the neighbourhood of the capital. Recently, this laboratory has completed a study to assess the pollution of the Bay of Maputo. Tables 2 and 3 illustrate the results obtained, indicating the number of coliforms detected at different points in the bay.

CONCLUSIONS AND RECOMMENDATIONS

123. Environmental health problems are clearly related to the level of economic development of the States covered by this study. In general, the major problems are caused by the lack of adequate potable water supply, by the absence of sewerage or sanitation facilities, by the congestion of urban areas, and by the high incidence of parasitic and communicable diseases.

124. The major constraints have been the lack of good planning and inadequate management, the absence of adequate operation and maintenance organization and the very poor co-ordination between the different agencies responsible for the sector. As far as legislation is concerned, it appears that some countries have the appropriate legislation but not the means to enforce it; for others, the absence of legislation is a major obstacle to the implementation and follow-up action by the responsible authorities. Last, but not least, the great shortage of qualified staff and technical personnel at all levels of the administration is a serious problem. In most cases, the Government concerned has not been able to provide funds for the repairs and replacement of equipment.

125. The cause-effect relationship for the water-associated communicable diseases and their occurrence in East Africa are largely well known. Remedial action leading to improved health conditions of the coastal population must include all sectors that provide a potential pathway for the vectors in question. Thus, national programmes on water supply, excreta disposal and solid waste handling have to be supported by proper stormwater discharge schemes as well as food sanitation programmes and public education.

126. In the light of the considerable efforts undertaken nationally and supported by the international community, the regional dimension of the East African programme may provide a forum for jointly promoted research on the crucial pollution problems of the human environment. In particular, the International Water Supply and Sanitation Decade, 1981-1990, is expected to allow for measureable improvement of sanitary services in the region. Closer regional co-operation thereunder may be

beneficial and provide for a more widespread application of appropriate technical solutions.

127. It is recommended that the States of the region strengthen their national efforts to ameliorate the public health situation and to provide an adequate supply of safe drinking water as well as sanitary facilities for excreta disposal. Relevant activities under the International Drinking Water Supply and Sanitation Decade should receive additional support on a regional basis.

128. It is suggested that a regional approach to the public health aspect of coastal water pollution be adopted to reduce the health effect from polluted bathing beaches and contaminated seafood.

129. It is proposed to conduct a more detailed survey by individual country on the actual sanitary situation of the population living along the coastline. Special programmes may be developed on a regional basis for them, taking into account the national target set for the Decade and the technical and financial requirements to achieve them.

130. It is also proposed to develop common guidelines for the sanitation aspects of tourism installations in coastal resort areas, including drinking water quality, sanitation and food safety.

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