Control of Infectious Disease Through Sanitary Improvements in The Comoro Islands

Volume 1

(Preparatory work - A methodology)

CONTROL OF INFECTIOUS DISEASE THROUGH SANITARY IMPROVEMENTS ON THE COMORO ISLANDS

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Civil Engineering, Division of Sanitary Engineering of the Delft University of Technology

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Moroni Comoro Islands

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PREFACE

I am given opportunity to carry out a field study in the Comoro Islands and prepare a technical report in partial fulfilment of the thesis requirement for the degree of Master of Science in Civil Engineering. This study consists of an assessment of the health problems in the study area through the use of medical health records, completed by laboratory examinations of samples of faeces and water samples. The building up of a general picture of the water- and excreta related disease burden may help guide future policy on the type and location of priority improvements as well as indicating the scale of the problem to those who allocate funds. A study of the local organisation and its administrative implications will be undertaken as to determine the allocation of responsibilities towards water supply, sanitation and primary health care. Critical information will be collected, needed for selection and design of sanitation systems. Such a survey will enable us to assess the needs to break the transmission cycle of water- and excreta related diseases and prevent the reinfection of the environment, especially man. Thus suggestions will be made for sanitary improvements.

It is hoped that the outcome of this study will be valuable to the agencies involved in the study area and of interest to central government, to bilateral aid donors and to international agencies.

1. INTRODUCTION

The Comoro Islands, an archipelago of four islands, lie between the East African coast and Madagascar. The population of about 500.000 inhabitants live under poor circumstances with a GNP of a capital of $210.-. Primitive fishing and agriculture give income to some people, others go out working in the industry which consists mainly of the preparation of crops for export together with handicrafts such as pottery. The unemployment is very high.

The four islands, named Grande-Comore (on which the capital, Moroni, is situated), Anjouan, Moheli and Mayotte, are volcanic in structure. Climate, rainfall and vegetation all vary greatly from island to island, with similar divergences in soil characteristics.

- On Grande-Comore, though rainfall reaches 8 M., there are no watercourses because the soil is particularly permeable. However, recent investigations have shown that underground sources exist in several places. Water supply is conditioned by the arrival of rains. A 50 Km. network, put into operation in 1977, supplies regularly more than 20.000 inhabitants of the town of Moroni. The remaining 150.000, living scattered around the island depend on open shallow wells and rainwater collected in cisterns. The pit latrine remains to date the most widely used technique for excreta disposal. Removal of waste and polluted water poses additional problems. Waste-water disposal is in septic ditches in a very permeable basaltic soil.

- In the three islands Anjouan, Mayotte and Moheli, the presence of watercourses makes the problem different. The presence of rivers allows the population to supply themselves directly with the consequent risks from pollution of this untreated water. The presence of an antiquated water system does nothing to help the supply of potable water. Storage reservoirs lack any form of maintenance. Where they exist, conduits are sited in the bed of the river so that during peak flows the pipes are filled with muddy water making use for consumption impossible. For those people who have to rely on open shallow wells, generally, no dispositions have been encountered to control and protect these wells. With regard to sanitation, the same holds here as in Grande-Comore. Moreover the totally clay soil demands a proper waste-water disposal.

It goes unchallenged that the lack of clean water resources, together with an antiquated water system and a poor sanitation, seem to be the main cause for the high incidence of tropical diseases such as gastro-enteritis and diarrhocal diseases, but also typhoïd and cholera are not uncommon. These diseases are rarely reported by the health authorities to save embarrassement. There was a recent mission (May 1983) by Geneva - based environmental health staff to the Comoros but in their report no health statistics are given, most probably because they were not available in the country (was their conclusion).

This study has a three-fold purpose:

- To assess the health problems that may be related to water supply and excreta disposal facilities. The question immediately raised is the following: How much disease in the area may be related to unsatisfactory sanitation and water supplies? An attempt to answer this question will enable the building up of a picture of the health problems that will indicate the needs.
- To determine the sources and mechanisms of contamination. Attention will be confined to microbiological contaminants which may cause infectious diseases, not neglecting that

chemicals in water may potentially cause disease (high fluoride or nitrate levels).

- To give suggestions for sanitary improvements. An evaluation of the existing system of water supply and sanitation will suggest which sorts of improvement are most urgent. With regard to sanitation, emphasis should be placed on dry systems, off-site treatment and disposal vs. on-site treatment. This is highly relevant where resources (time, money, expert manpower) are scarce. An attempt will be made to assess the health benefits of the above-mentioned systems.

This three-fold purpose leads to the following programme:

- Preparatory investigation of the study area, consisting of: gathering the information needed for the selection and design of sanitation systems.
  a. Geography; site conditions.
  b. Climatic conditions.
  c. Social-geography; population.
  d. Existing on vironmental sanitation.
  e. Socio-cultural factors.

- Discussion of diseases and mechanisms of water-related transmission followed by an attempt to measure the health problems through:
  a. Initial observation of medical records from health care facilities in the study area and assessment of the prevailing water-related diseases and how common and serious they are (incidence of reported disease; frequency of reported disease; incidence; prevalence; morbidity; mortality; letality; seasonal variations).
  b. Bacteriological examination of the well water and supplied drinking water using the membrane filter method with total coliforms, thermotolerant coliforms and faecal streptotocci as indicator organisms.

c. Determination of chemical and physical parameters of the drinking water; temperature and conductivity, if possible more.

d. Evaluation of the collected health data.

- Analysis of the institutional framework.
  - Allocation of responsibility and effectiveness of local level organization in providing the following services:
    a. drinking water supply,
    b. sanitation, street cleansing, drainage,
    c. medical establishment: the pre-requisites and constraints of primary health care,
    d. conclusions involving organisational and administrative options.

- Suggestions for sanitary improvements:
    a. improvements of the existing excreta disposal,
    b. choice of (low-cost) dry on-site excreta disposal treatment and re-use alternatives,
    c. suggestions for other improvements, based on new insight and intuitive understanding.

The work has to be done in co-operation with the staff of the Ministry of Public Works, the Ministry of Environment and the laboratory staff of the main hospital Moroni.

2. PREPARATORY INVESTIGATIONS

2.1 Study area (Comoros)

The choice of a sanitation technology has to be preceded by a reconnaissance survey of the study area, which aims at gathering a maximum of information needed for the design of sanitation systems. The following critical information items are to be dealt with.

2.1.1 Geography_site_conditions

- Situation of the study area.
- Topography.
- Geology, including soil stability.
- Hydro-geology, including seasonal water table fluctuations.
- Vulnerability to flooding.

2.1.2 Climatic_conditions:

- Temperature ranges.
- Precipitation, including drought and floods periods.
- Humidity.

2.1.3 Social_geography;_population:

- Examination of the most recent census,
  number, present and projected,
  density, including growth patterns,
  housing types, including occupancy rates and
  tenure patterns.
- Means of subsistence,
  income levels,
  locally available skills (managerial and technical)
  locally available materials and components.
- Means of subsistence,
  income levels,
  locally available skills (managerial and technical),
  locally available materials and components.

- Infrastructure,
  municipal services available, including roads,
  power,
  public health-care centres, health status of all
  age groups.

2.1.4 Existing environmental sanitation:

- Existing excreta disposal, sullage removal and storm drainage facilities.
- Existing water supply service levels, including accessability, reliability and costs.
- Existing treatment and disposal of municipal refuse (garbage and animal wastes).

2.1.5 Socio-cultural factors:

- People, organisations and administrative capability.
- People's perception of present situation and interest in or susceptibility to change.
- Marginal costs of improvements.
- Reasons for acceptance/rejection of any previous attempts at upgrading.
- Religious or cultural factors affecting hygiene practices and technology choice.
- Location or use of facilities by both sexes and all age groups.
- Attitudes towards communal or shared facilities.
- Attitudes towards resource reclamation.

3. EXCRETA- AND WATER-RELATED INFECTIONS DISEASE TRANSMISSION MECHANISMS

3.1 Introduction

For the purpose of collecting information, as well as interpreting it, a clear understanding of the transmission mechanisms of infectious diseases is required. The transmission mechanisms can help us to detect the pollution sources and hence, the particular improvement strategies needed for control of diseases, ranging from the construction or improvement of toilet to the choice of excreta disposal. This understanding is of utmost importance for it generates new insights on how to build better systems, and where to site them for the greatest effect.

A classification of water- and excreta-related* diseases is also required to assess the relevant diseases in the study area and the mechanism by which a disease may be transmitted from one person to another.

3.2 Infections Water-related Diseases

3.2.1 Classification of transmission mechanisms

A water-related diseas is one which is in some way related to water or to impurities in water. It is the merit of D.J. Bradley to have, for the first time, classified water-related diseases into categories which relate diseases directly to water. Four distinct water-related mechanisms, by which a disease may be transmitted from one person to another, are contemplated. The four mechanisms are defined and described below. This leads ultimately to the classification of infections.

(i) Water-borne mechanism

Truly water-borne transmission occurs when the pathogen is in water which is drunk by a person or animal which may then become infected. Potentially water-borne diseases include the classical infections notably cholera and typhoid, but also include a wide range of other diseases, such as infectious hepatitis, diarrhoeas, and dysenteries.

The term 'water-borne disease" has been, and still is, greatly abused so that it has become almost synonymous with 'water-related disease'. For the sake of a clear understanding, it is essential to stick at the definition given above. Another source of misunderstanding is the assumption that, because a disease is labelled water-borne this describes its usual, or even its only, means of transmission. It must be noted that all water-borne diseases can also be transmitted by any route which permits faecal material to pass into the mouth. Thus cholera may be spread by faecal-oral routes, for instance via contaminated food. It is essential to grasp that water-borne transmission is merely the special case of drinking faecal material in water, and that any disease which can be water-borne can also be transmitted by any other faecal-oral route. In formal terms, faecal material in water is a necessary basis for water-borne transmission but not sufficient on its own. This explains why, many water-borne diseases cannot be controlled with <u>only</u> the provision of safe water supplies.

(ii) Water-washed mechanism

A water-washed disease may be formally defined as one whose transmission will be reduced following an increase in the volume of water available coupled with improvements in domestic and personal hygiene. The term 'water-washed disease' stresses the fact that the disease transmission depends on the quantity of water used, rather than its quality. The relevance of water to these diseases is that it is an aid to hygiene and cleanliness, and its quality is relatively unimportant for this purpose.

Water-washed diseases are of three main types:

- Firstly, there are infections of the intestinal tract such as diarrhocal diseases, which are important causes of serious morbidity, especially among infants in poor countries. These water-washed enteric infections include typhoïd, bacillary dysentery, cholera and other diseases previously mentioned under water-borne diseases. These diseases are all faecal-oral in their transmission route and are therefore potentially either water-borne or water-washed. (Any disease which is transmitted by the pathogen passing out in the faeces of an infected person and subsequently being ingested.) A faecal-oral disease can either be transmitted by a true water-borne route or by an almost infinite number of other faecal-oral routes, in which case it is probably susceptible to hygiene improvements and is therefore water-washed. Investigations have shown that diarrhocal diseases, especially bacillary dysentery (skigello is), although potentially water-borne, were in fact primarily water-washed and were mainly transmitted by faecal-oral routes which did not involve water as a vehicle.
- The second type of water-washed infection is that of the skin or eyes. Bacterial skin sepsis, scabies, and fungal infections are extremely prevalent in many hot climates, while eye infections such as trachoma are also common and may lead to blindness. These infections are related to poor hygiene and it is to be anticipated that they will be reduced by increasing the volume of water used for personal hygiene. However, they are quite distinct from the intestinal water-washed infections because they are not faecal-oral and cannot be water-borne.

- A third type of water-washed infection is also not water-borne. These are infections carried by lice or mites which may be reduced by improving personal hygiene and therefore reducing the probability of infestation of the body and clothes with these anthropods. Mites cause scabies and are also promoters of asthma. There are two main louse-borne infections, both severe but rare diseases except in a few localities. They are epidemic typhus and louse-borne relapsing fever and both may be expected to decrease when more water is made available to people who are otherwise prevented from regular laundering of their underclothes.

(iii) Water-based mechanism

A water-based mechanism is one in which the pathogen spends a part of its life in an intermediate aquatic host (or hosts) such as a water-snail. All these infections are due to infections by parasitic worms (helminths) which depend on aquatic intermediate hosts to complete their life-cycles. The examples of diseases in this category are shistosomiasis, guinea worm and other diseases which are affected by excreta disposal.

(iv) Insect vector mechanism

An insect vector disease is to be spread by insects which either breed in water or bite near water. Malaria, yellow fever, dengue and onchocerciasis (river blindness) are transmitted by insects which breed in water while the Gambian sleeping sickness (trypanosomiasis) is transmitted by the riverine tse-tse fly which bites near water. In practice, the vectors most closely related to domestic water supply provision are the Aëdes mosquito vectors of yellow fever and dengue which chiefly breed in temporary water containers, pots and jars, used to store water in the household where the supply is intermittent or has to be carried.

3.2.2 Discussion on the classification of infectious water-related diseases

Domestic water supplies affect diseases by four mechanisms:

mechanisms 1 : water-borne
mechanisms 2 : water-washed
mechanisms 3 : water-based
mechanisms 4 : water-related insect vectors.

The conventional generic or biological taxonomy of diseases classifies them according to the nature of the pathogens - the organisms which cause them. This classification is unhelpful to environmental health engineers, because it groups diseases in a way that has no bearing upon environmental interventions. For instance small pox is grouped with hepatitis and filariasis is grouped with Guinea worm.

For the purposes of assessing the impact on health of water supplies, through collecting information on the prevailing infectious diseases and interpreting it, a rather different grouping is convenient in practice. It is necessary first to list the chief water-related diseases and assign them to an appropriate category. Bradley has proposed that each disease be assigned to a category which corresponds to one of the four mechanisms listed and described above. This classification has the advantage of linking the diseases to the appropriate preventive strategies. However, this leads to the problem of having all faecal-oral diseases assigned to both the water-borne and the water-washed categories and so the categories cease to be mutually exclusive. In the reclassification of Bradley faecal-oral infections are all together in a special category which is water-borne or water-washed (category 1). Category 2 is reserved for water-washed diseases which cannot be water-borne; in other words the skin and eye infections plus diseases which are associated with infections of lice or infestations of fleas, ticks and mites. Each water-related infection can then be assigned to one of the following four categories:

(1) faecal-oral;
(2) water-washed;
(3) water-based; and
(4) insect-vectored.

The next table lists the major water-related diseases and assigns them to their category in addition to linking them to the type of organism which causes them.

3.2.3 Non-infectious vector-related diseases

These are illnesses associated with ingestion of water containing toxic substances in harmful concentrations. These may be of natural origin or man-made and are generally locality-specific.

Water-borne-chemical diseases are thus related to some chemical property of the water; as for instance cardio-vascular disease - is associated with water softness and high nitrate levels are associated with infantile cyanosis. Damage to the teeth and bones, is associated in some countries with high fluoride levels. On a global basis, these are not major problems in non-industrialized countries where infectious water-related diseases are a first priority. Nevertheless, it is better to rely on chemical analyses to detect dangerous levels of fluoride and nitrates, and to question consumers about sources that are not used for particular purposes because of high iron content or excessive salinity.

Table No. 1

Environmental Classification of Water-related Infections

Category	Infection	Pathogenic Agent
1. Faecal-oral (microbial infections) (water-borne or water-washed)	(a) Diarrhocal diseases	
	Cholera	B
	Bacillary dysentery (shigellosis)	B
	Amoebic dysentery (amoebiasis)	B
	E. coli diarrhoea	B
	Rotarvirus diarrhoea	V
	Gastroenteritis	B, V
	Enterovirus infections (some)	V
	'Diarrhocal disease'	B, V
	Salmonellosis	B
	Yersiniosis	B
	Giardiasis	P
	Balantidiasis	P
	(b) Enteric fevers:	
	Typhoïd	B
	Paratyphoïd	B
	Polymyelitis	V
	Hepatitis A	V
	Leptospirosis (Weil's disease)	B, S
	Ascariasis	H
	Trichuriasis	H

Table No. 1 (contd.)

Category	Infection	Pathogenic Agent
2. Water-washed	(a) Skin and eye infections and infestations:	
	Trachoma	"B"
	Conjunctivitis	B, V
	Other infections eye diseas	B, V
	Skin ulcers	B
	Scabies	A
	Other infectious skin diseases	B, V
	(b) Fevers spread by ectoparasitic insects	
	Louse-borne typhus	A -- R
	Louse-borne relapsing fever	A -- B
3. Water based infections developing in aquatic hosts		
	(a) Penetrating skin	
	Schistosomiasis (minary)	H
	Schistosomiasis (intestinal)	H
	(b) Ingested	
	Guinea worm (dracunculiasis)	H
	Diphyllobothriasis	H
	Fasciolopsiasis	H
	Paragonimiasis	H
	Others	H
	(c) Intestinal helminths (water-borne or water-washed)	

Table No. 1 (contd.)

Category	Infection	Pathogenic Agent
	Enterobiasis	H
	Trichuriasis	H
4. Water-related insect vector		
	(a) Biting near water sleeping sickness (trypanosomiasis) tse-tse fly	A -- P
	(b) Breeding in water	
	Filariasis mosquito	A -- H
	Malaria mosquito	A -- P
	River blindness (onchocerciasis) simuli um	A -- H
	Mosquito-borne viruses	
	Yellow fever	A -- V
	Dengue	A -- V
	Other arboviruses	A -- V

A =
B = bacterium
H = helminth
P = protozoon
R = riketsia
S = spirochaete
V = virus

As shown in the table above, it is convenient to start by classifying the relevant infections diseases into categories which relate to the various aspects of the environment which can be altered.

3.3 Infectious Excreta - Related Diseases

3.3.1 Introduction

The manner in which a community disposes of its excreta clearly has a strong impact on community health and a strong influence on the sanitary environment in which that community lives. All the diseases of the faecal-oral category, as well as most of the water-based diseases and several others not related to water, are caused by pathogens transmitted in human excreta, normally in the faeces. It must be emphasized that, especially in the case of excreta-related diseases, the lack of personal hygiene and cleanliness play an important part in the disease transmission.

Poor excreta disposal may cause pollution of drinking water sources.

A clear understanding of the possible interactions between excreta and health is required. This can be provided by a classification of excreta-related diseases. Such a classification is of more than academic interest since it enables the public health engineer to seek to modify the human environment in such a way as to prevent or to reduce the transmission of infectious diseases.

3.3.2 Excreta-related infections - a classification of transmission mechanisms:

An excreta-related infection is one related to human excreta (= faeces and urine). Some excreta-related infections, through the process of excreta contaminating drinking water sources, are also water-related infections and as such, can be controlled by improvements in water supply and hygiene but also by improvements in excreta disposal. Poor excreta disposal interact with the problems of water supplies. To understand the effects of excreta disposal on excreta-related diseases, a further classification is required.

(i) Faecal-oral diseases (non-bacterial)

Faecal-oral transmission occurs when the pathogen is in drinking water or food. Thus water-borne, food-borne and water-washed infections are closely connected with excreta-related diseases. Some of these infections, caused by viruses, protozoa, and helminths can spread very easily from person to person whenever personal and domestic hygiene is not ideal. Beside changes in excreta disposal methods, health education stressing personal hygiene and sanitary handling of food and drinking water must be given a high priority. This requires a substantial improvement in water supply and housing.

(ii) Faecal-oral diseases (bacterial)

Beside person to person transmission routes, the faecally contaminated food, crops or water sources play an important part in the transmission of faecal bacterial pathogens to man. Some of the pathogens in this category, notably campylobacter, salmonella and yersinia are also passed in the faeces of animals and birds. The same measures hold here as mentioned above for the control of these diseases.

(iii) Soil-transmitted helminths

This category contains several species of parasitic worms, such as hookworms, whose eggs are passed in faeces. The hookworm eggs hatch into larvae and under optimal environmental conditions (moist soil), they develop into infective larvae which reach the next human host by being ingested, for instance on vegetables, or by penetrating the skin or the soles of the feet.

The avoidance of faecal contamination of the floor, yard or fields will limit transmission. This emphasizes sanitary disposal of faeces accompanied by health education.

(iv) Beef and pork tapeworms

The most important tapeworms of man are transmitted to him via cattle and pigs. The tapevorms of the genus taenia require a period on the body of an animal host before re-infecting man when the meat is eaten without sufficient cooking.

The transmission of tapeworm infections is to be controlled by preventing pigs and cattle from eating untreated excreta. This can be achieved through a safe disposal of human faeces, attended by health education with emphasis on thoroughly cooking of meat prior to consumption.

(v) Water-based helminths

Man pollutes water with infected urine or stool containing schistozome eggs. All the water-based diseases already mentioned, except for Guinea worm, are caused by helminths which are passed in excreta and must then pass a stage in the body of an aquatic host, usually a snail. The schistosome eggs develop into infective larvae, once shed by the snail, re-infect man through the skin or when insufficiently cooked fish, crabs, crayfish, or aquatic vegetation are eaten.

Except for schistosma mansoni and S. haematobium, animal faeces are also a source of infection. This makes the control of schistosomiasis difficult and intricate, so that a combination of measures with great emphasis on environmental sanitation must be contemplated.

(vi) Excreta-related insect vectors

The culex pipiens group of mosquitoes, found throughout most of the world, breeds in highly polluted water and transmits filariasis in some regions. The transmission of this infection is only indirectly related to excreta disposal.

Flies and cockroaches which breed in faecally polluted water, carry pathogenic organisms on their bodies and in their intestinal tracts. This seems to be the case with anopheles (malaria) and aëdes (yellow fever). Yet there is uncertainty about their importance in spreading excreted fathogens. Flies have been implicated in the spread of eye infections. The integration of environmental sanitation as to avoid breeding habitats together with health education campaigns is a necessary combination for good results.

3.3.3 Classification of excreta-related infections

Before we can classify the excreta-related infections it may be helpful to comment on three epidemiological terms, latency, persistence and multiplication which are key factors in the transmission of excreta-related diseases.

Pathogens cannot infect man immediately after they have been excreted, but must first undergo a period of development in soil, pigs, cows, or aquatic animals. This property of excreta-related diseases is known as latency. Latency is the interval between the excretion of a pathogen and its becoming infective. The soil-transmitted helminths, the water-based helminths and the beef and pork tapeworms show this property. All bacteria, viruses and protozoa have no latency. Their nuisance value is great. The requirements of safe excreta disposal are far more stringent than for helminthic infections, except for 3 helminths which have no latency. Enterobius (threadworm); hymenolopis nana (dwarf-tapeworm) and strongyloides.

Persistence is a characteristic of each pathogen. How long a pathogen can survive after it has been passed in the faeces, indicates its degree of persistence. Short persistence means mostly direct transmission. More persistent pathogens may give rise to new cases in the long-run farther afield.

Multiplication of pathogens may take place in the environment or in the intermediate host under favourable conditions. For water-based helminths, a low level of faecal contamination may still be enough to maintain transmission, since one egg can multiply in the snail host to produce a thousand larvae. Virus and protozoa do not multiply outside their hosts. Bacteria may multiply under suitable conditions but multiplication in water is very rare.

Whether an excreted infection spreads to other persons, depends on the infective dose c.q. the number of pathogens excreted and their multiplication. As might be expected, the latent and more persistent organisms have 'longer' transmission cycles, and the efficacy of improved sanitation in controlling them depends on this cycle. For most of the excreta-related diseases, an improvement in excreta disposal is only one of several measures required for their control.

In the following classification, the chief excreta-related diseases are grouped and assigned to an appropriate category. This is done so, as to enable the environmental health engineer to relate these diseases to the various aspects of the environment which he can alter by means of engineering interventions.

Table No. 2

Environmental Classification of Excreta-related Infections

Category	Infection	Pathogenic Agent
1. Faecal-oral	Polyomyelitis	V
(non -bacterial)	Hepatitis A	V
Non-latent	Rota virus diarrhoea	V
low infectious dose	Amoebic dysentery	P
	Giardiasis	P
	Balantidiasis	P
	Enterobiasis	H
	Hymenolopiasis	H
2. Faecal-oral (bacterial)	Diarrhoeas and dysenteries:	
Non-latent	Campylobacter enteritis	B
Medium or high infectious	Cholera	B
dose moderately persistent	E. coli diarrhoea	B
able to multiply	Salmonellosis	B
	Shigellosis	B
	Yersiniosis	B
	Enteric fevers:	
	Typhoïd	B
	Paratyphoid	B
3. Soil-transmitted helmiths	Ascariasis	H
latent and persistent with	Trichuriasis	H
no intermediate host	Hookworm	H
	Strongyloidiasis	H

Table No. 2 (contd.)

Category	Infection	Pathogenic Agent
4. Beef and pork tapeworms latent and persistent with cow or pig intermediate host	Taeniasis	H
5. Water-based helminths latent and persistent with aquatic intermediate host	Schistosomiasis	H
	Clonorchiasis	H
	Diphyllobothriasis	H
	Fasciolopsiasis	H
	Paragionimiasis	H
6. Excreta-related insect vectors	Filariasis (transmitted by culex pipiens mosquitoes)	H
	Infections in categories 1 - 5 especially 1 and 2 which may be transmitted by flies and cockroaches	M

B = Bacterium
H = Helminth
P = Protozoon
V = Virus
M = Miscellaneous

4. ASSESSMENT OF THE HEALTH PROBLEMS

4.1 Introduction

The preceding discussion of diseases and of the mechanisms of water- and excreta-related transmission will provide the environmental health engineer with a thorough understanding of health problems, as far as they are related to the situation of water supplies, wastewater removal and excreta disposal.

Needless to say, not all the infections discussed will be present in a given area. The first step is to select the relevant local water- and excreta-related diseases that are important in the study area. In the framework of this study, three survey methods will be used:

- the use of health service data,
- laboratory examinations,
- the questionnaire approach.

Usually, a combination of methods will be needed, but this depends highly on local circumstances.

4.2 The Use of Health Service Data

The study area will contain some health care facilities, comprising some or all of government hospitals, health centres and dispensaries, maternal and child health clinics, voluntary agency hospitals and clinics, and private practionners. It is useful to list and map these initially. The aim will be then to collect data from all the health services supplying some parts of the study area and to see which water- and excreta-related diseases are prevalent in the area considered and which of these constitute particularly important public health problems. The use of health records will enable us to give a general picture of water- and excreta-related disease, preferably for the two most recent consecutive years. This seems to be an easy task at first sight, but special problems arise when medical records are used: As a matter of fact, epidemiological work differs greatly from ordinary clinical diagnosis. Additionally, doctors and medical assistants are not primarily interested in the problem of water-supplies and excreta disposal and their health consequences. The question posed is the following:Which symptoms or diagnoses in the records are related to which water- and excreta-related diseases? Which entries in the record books may be placed in a general category of infectious diseases? This is a problem of standardization which can be obviated through considering groups of symptomatological entries which relate to a group of water- and excreta-related diseases. To this end, the following grouping of diseases is considered to be convenient in practice.

1. Faecal-oral infections (group 1)
   except helminths.
2. Skin and eye infections (group 2).
3. Parasitic worms (group 3).
4. Insect vector infections (group 4).

For instance, the following diagnoses in a hospital record are relevant for group 1.

Specific: cholera
typhoïd fever
parathyphoïd fever
bacillary dysentery (shigellosis).
amoebic dysentery (amoebiasis).
salmonellosis.
giardiasis.
balantidiasis

Non-specific: dysentery.
diarrhoea.
gastro enteritis.

It must be emphasized that to get usable information in a survey, it is important to maintain a critical and discerning attitude towards the accuracy of the records. It is also desirable to compile and discuss the records with specialist medical help.

4.3 Laboratory examinations

4.3.1 Bacteriological examination of drinking water from the shallow wells and the distribution system:

After the choice and collection of samples, laboratory testing can be done. Water is tested for bacteria which are excreted in large numbers by animals and humans and whose presence is indicative of faecal pollution. The possible bacterial contamination is examined using faecal coliforms (thermotolerant - largely comprising escherichia coli) and faecal streptococci as indicator bacteria. These two indicators meet the criteria of being specifically faecal and not free-living and being capable of easy enumeration. The greatest value of FS lies in assessing the significance of doubtful results from the FC count.

There are two methods for conducting tests on the levels of FC and FS in water: the membrane filtration and the multiple tube (most probable number) method. Which one of these two methods will be used, is dependent upon the equipment and materials available in situ.

In the membrane filtration method, water is filtered through a special membrane which retains the bacteria. The membrane is placed on a selective nutrient medium and incubated. The bacteria multiply to form visible colonies which may be counted by eye and the result expressed as a concentration per 100 ml. Direct counts of FC and FS can be made in 24 and 48 hours respectively and there is no need for confirmatory tests to check the species of bacteria.

FS requires incubation at 35-37°C, which is the temperature at which most hospital incubators operate, while FS requires incubation at 45°C. Whenever incubation at 45°C is not possible, the examination will be limited at a FS count.

Contrary to the WHO standards, according to which water supplies should contain zero E. Coli per 100 ml, bacteriological testing will be used to examine the amount of faecal pollution and rely upon incremental improvement.

4.3.2 Laboratory examination of faeces:

There are numerous methods for faecal examination, among which the formal ether concentration and the merthiolate iodine formalin concentration (MIFC) can be considered. Given the constraints of time and limited resources, we shall concentrate here on microscopic examination of faeces. A group of intestinal helminths and protozoa shed their eggs or cysts through the faeces, and therefore a single procedure of faecal examination with the microscope can provide information on the prevalence of amoebae, giardia, balantidium, ascaris, the hookworms, trichuris and the intestinal schistosomes. If laboratory facilities allow it, survey data on other diseases may be acquired through seroepidemiology, that is the search for antibodies to the parasites or microbes involved. Otherwise, for the purpose of this study, it will be sufficient to recognize at least the helminths.

4.3.3 The questionnaire approach

The results of any health impact study should be compared with the findings of other investigations. The questionnaire approach will be contemplated here. Such a study may demonstrate a specific disease problem, needing special attention. It may also show, for example, that a few families particularly troubled by a specific disease use a particular water source or have an unusually low water use level or live in a particularly unsanitary environment. The drawbacks of the questionnaire approach must be borne in mind to offset serious problems of precision and interpretation: the correct understanding of the question by the interviewee, the rapport and trust between interviewer and interviewee, the check on the accuracy of the results and to some extent the interviewee's memory are some of the drawbacks. Since it is clearly not feasible to carry out an investigation of each disease, the questionnaire approach will be contemplated for diseases which cannot be conveniently surveyed by other methods. This means only the diarrhocal diseases group, in which we include all diarrhoeas, gastroenteritis and dysenteries. These diseases constitute a major cause of death in all developing countries, and lead to frequent illness and impaired growth in children.

For the reasons given above, the only realistic recall period for diarrhocal disease is the past 24 hours. A provisional questionnaire follows.

If the results of a questionnaire are used, it is also necessary to be able to tell with reasonable certainty from the record of each case whether the patient comes from a household served by a water supply and excreta disposal facilities and what the activities around water are. To this end, additional information on water use and hygiene practice is needed. The questionnaire can therefore be extended to the following items:

- drinking customs,
- washing customs,
- activity around the excreta disposal facility.

Questionnaire

1. A passage of stool	Mother			Father			Child 1			Child 2			------
	1	2	3	1	2	3	1	2	3	1	2	3	
How many times have you passed stools since yesterday morning?													

2.	Father			Mother		
	Yes	No	No answer	Yes	No	No answer
Have you had watery stools since yesterday morning?						
	Child 1			Child 2		
The same question	Yes	No	No answer	Yes	No	No answer

3.	Father			Mother		
	Yes	No	No answer	Yes	No	No answer
Have you had bloody stools since yesterday morning?						
	Child 1			Child 2		
The same question	Yes	No	No answer	Yes	No	No answer

4. Did you call in these cases:	Yes	No	No answer
a doctor?			
a nurse ?			

a. If yes, did he/she tell you something about the cause?

Which cause:

Yes	No	No answer

b. If no, do you think that you know the cause of the diseases? Which cause:

Yes	No	No answer

c. Which of the following items would you think may be the cause of the diseases?

	Yes	No	May be	No answer
Nutrition				
Water				
Flies				
Contact with faeces				

It must be borne in mind that the administration of a questionnaire has to be done with the highest possible standard of care and is therefore time consuming. It is best to do the simplest survey possible.

4.4 Subsidiary Studies and Interpretation of the Results:

The studies discussed in the foregoing sections will give a measure of the present burden of water- and excreta related disease. In examining the question of whether or not the faecal-oral diseases in the study area are primarily water-borne rather than water-washed and in determing the disease transmission route, much insight may be gained through considering the seasonal variation of disease and investigating on outbreaks of epidemic disease. These subsidiary observations may throw up clues about water-related disease in the community and define the needs more precisely.

4.4.1 Seasonal distribution of disease:

Once data on the prevailing diseases in the study area has been collected from health records, the procedure consists of plotting the incidence of reporting of these diseases in different months of the year over the last few years. The annual plot should then be compared with a plot of both temperature and rainfall to expose any seasonality of the reporting of these infections. The resulting relationships may give indications as to the transmission routes of these diseases (water supply, flooded latrines, breeding habitats) and consequently the best ways to control them.

4.4.2 Outbreak investigation

The approach of a retrospective study of health records will be contemplated here. The procedure consists of plotting both in time and space the occurence of cases in a particular outbreak of a disease and to investigate whether these cases appear to be part of common source outbreaks due to water pollution. This is especially useful for uncommon but severe diseases such as typhoïd and cholera, whether they are epidemic or endemic. This represents a useful subsidiary study since it may indicate the transmission route of the disease (water-borne, person to person or water-washed) and why this came about. Especially in the case of outbreaks, the study can influence policy on the type of supply improvements needed and on their location.

4.4.3 Interpretation of health records

Once information has been collected on the prevailing infectious diseases in the study area, we need to assess how common and serious these diseases are. In other words, we need ways of measuring the features of diseases.

To this end two epidemiological terms, incidence and prevalence, will be introduced and discussed.

Incidence: is defined as, the number of new cases of a specified disease diagnosed or reported during a defined period of time, divided by the number of persons of the population in which they occurred.

$$\text{incidence} = \frac{\text{number of } \underline{\text{new}} \text{ cases}}{\text{population at risk}} \text{ (in a time period).}$$

The central difficulty in using health service records is to relate them back to a defined population. Since not all disease finds its way to the health care facility, the problem is compounded. To obviate this difficulty one has to define the catchment population through establishing a relationship between clinic attendance and residential distance from it. From the analysis of the health records, can the incidence of reported disease be measured.

Prevalence: is defined as, the number of persons sick or portraying a certain condition at a particular time (regardless of when that condition or illness began) divided by the number of persons in the population in which they occurred.

$$\text{Prevalence} = \frac{\text{total number of cases}}{\text{total of population}} \text{ (at a point or period of time)}$$

The same shortcomings hold here, as mentioned in the measuring of the incidence of reported disease. For both measurings, additional problems are:

- very often, the section of the population most involved in transmitting an infection shows little or no sign of disease;
- the tendency to report might change through time in the study area;
- the tendency to report might be different in different sub-areas in the study area.

To illustrate the measuring of incidence and prevalence an example is given below.

If fifty people in a village of five thousands people gets a particular illness in one year, and the illness lasts a week.

In a single visit, we shall, on average, only find one person ill we say, therefore, that such a disease has a low incidence with a few cases over a period of time (fifty in a year or an incidence rate of $\frac{50}{5000}$ = 1 per cent per year) and a very low prevalence (one person ill or a prevalence rate of $\frac{1}{5000}$ = 0,02 per cent), which is the number of cases at any one time. If the fifty people may be ill in the same week the prevalence would be temporarily high, though the yearly incidence would be unaffected.

5. ANALYSIS OF THE INSTITUTIONAL FRAMEWORK

5.1 Introduction

Environmental health engineering seeks to modify the human environment in such a way as to prevent or reduce the transmission of infectious diseases. This can be achieved through improvements in the field of water, sanitation and hygiene practice backed by intensive health education campaigns. The aim of this chapter is to study the existing organizational structure in the study area, in providing the above-mentioned services. Attention will be given to the precise allocation of responsibilities and the problems encountered in an administrative point of view. In studying the performance of the agencies involved, the following functions will be considered:

- policy-making and planning,
- programming and implementation,
- operation and maintenance,
- community involvement vs. community health education.

Organizational arrangements depend on local circumstances and therefore cannot be studied at distance. However, on a number of topics it may be appropriate to include here some more detailed discussion of particular practical points.

5.2 Allocation of Responsibilities towards Water Supply and Sanitation

Government agencies responsible for water supply and sanitation are institutionally located within a variety of different departments, ministries and autonomous bodies. One must start by defining the allocation of tasks and by determining what are the existing arrangements for managing water supplies and sanitation programmes.

The relevant questions hereabout are:

(i) Who owns the water supply and who is responsible for sanitation programmes? What are the legal provisions? The question of ownership must be extended to the responsibility for construction, operation and maintenance.

(ii) What are the present arrangements for managing the construction and maintenance of water supplies and sanitation facilities? How effective are they?

(iii) What is the amount of local initiatives and what incentive do they receive from the local organization?

(iv) Can the local organization respond adequately to community demands and has it established adequate controls upon local initiatives?

Health ministries, through their departments responsible for primary health care, may be able similarly to encourage a considerable depth of participation in small-scale water and sanitation projects. To what extent has this been attempted and what are the results?

When studying local organizations, it is necessary to include also questions about the linkages between local bodies and national bodies.

5.3 Policy-making and Planning

There has been until recently a greater concentration on water supplies to the relative neglect of sanitation. Now, it is increasingly being realised that sanitation and hygiene require more emphasis than they have been given. Determining the nature and the scale of the water and excreta-related disease problem in the study area will provide planners with some feel for the magnitude of the problem and generate material for both supporting the water programme and the sanitation programme. The occurrence of concentrated epidemies of disease may be the first signal which the planner receives which alerts him to intervene and to decide on the priorities the afflicted villages/communities should receive.

These insights will be taken into account when considering the national policy and planning. Inadequate policy formation is one reason why people other than the target population benefit, or why the services reach a more limited public than intended. Policy and planning should look forward over a period of several years, but at the same time they are of little avail if they are not followed in practice. If the latter is the case, an investigation is needed to find out why the official policy cannot be translated into effective action and what the presumable constraints are.

5.4 Programming and Implementation

Programming may be defined as a closer examination of planning, whereby short-term and small scale activities are analysed. These activities may be, for example, the construction of pit latrines in a sanitation programme or the drilling of bore-holes in a water programme. Through the drawing up of a specific work programme, one can measure the progress or the delays in achievements. The resulting observations may learn us much about the existing constraints in terms of shortages of manpower, of material, or of transport and these are often symptoms of major administrative inadequacies. The latter will provide some insight into practical problems of implementation.

For a better understanding, the following questions may be raised:

- Who was responsible for initiating the programme?
- How was the construction process arranged?
- How long did it take? What caused delays, if any?
- What technical expertise was used and where was it found?

- What service or money did self-help volunteers provide?
- What incentives were used to encourage volunteers?

5.5 Operation and Maintenance

It is increasingly being realised that operation and maintenance of water supply and sanitation systems require more emphasis than they have been given. Until recently, there has been a greater attention given to design and construction. It is, especially, necessary to emphasize preventive maintenance, since it is often ignored. The neglect of operation and maintenance is responsible for the many breakdowns and the unsatisfactory functioning of the overall system. The aim here will be to inquire about the occurrence of breakdowns. A summary description and comment on the operation and maintenance organization is needed.

It is also necessary to investigate how much the involved agencies know about the condition of its water supplies and sanitation systems. The following questions will be raised:

- What proportion of the installations were functioning as intended?
- Does the programme have appropriate policies and organizational arrangements for dealing with its operation and maintenance functions?
- Who is responsible for day-to-day operation, routine maintenances, emergency repairs?
- What are the main causes of breakdowns?
- Who do the users think is responsible for the maintenance of systems?
- What could be done to enhance a socially appropriate operation and maintenance plan?

5.6 Community Involvement vs. Community Health Education

As stated previously, health ministries, through their departments responsible for primary health care, may be able to encourage a considerable depth of community involvement in small-scale water and sanitation programmes. The assessment of likely disease transmission routes should lead to an understanding of which aspects of water use, hygiene and sanitation practices current in the community should be changed in the interests of health. Consequently, a campaign should be launched by health workers to persuade the whole population to adopt those changes in habitual practice which are deemed to bring about health benefits. As a matter of fact, the agencies responsible for water supplies and sanitation, will have to play an important part towards these goals. So, it is necessary to establish a framework within the agencies involved, whose task should be:

- to perform all the necessary liaison between the community and the respective agencies;
- to implement the community health education campaign, through discussing and encouraging in the community necessary changes in hygiene and sanitation practices;
- to help in community organization and steer it in the direction of involving disadvantaged groups;
- to support communities undertaking their own initiatives whether in water and sanitation or in other fields, according to their own felt needs.

The offer of support should include the regular monitoring of project performance and should take on the maintenance and repair of facilities. To provide feedback to the project itself but also to the current policy.

The suggestions, mentioned above, will be submitted to the agencies concerned in the study area. An attempt will be made to assess their feasibility.

6. SANITATION IMPROVEMENT

6.1 Introduction

Pit latrines are invariably the first organized toilet technology experienced by the population of the Comoros and remain to date the most widely used technique for excreta disposal in the urban as well as in the rural areas. Still, a number of 'experts' have suggested that this traditional sanitation arrangement should be replaced by a conventional water-borne sewerage system. There are several reasons why a water-borne sanitation system is inappropriate for the conditions of the Comoros. Pit latrines are not, of course, without problems. The principal areas in which difficulties are encountered in the construction of pit latrines are discussed here and how small-scale improvement could be made to the existing pit latrine system. For, the identification of an appropriate excreta disposal does not require the invention of new processes or devices but the design of improvements to eliminate problems that caused the abandonment of earlier arrangements. Re-use of wastes is not not traditional in the Comoros. Yet, it is deemed to be a considerable incentive towards the general improvement of public health and it is of great importance from an agricultural and economic perspective. In this study, we shall assess the feasibility of some kind of composting latrine and re-use options.

6.2 Inappropriateness of Water-borne Sewerage System

The conventional water-borne sewerage system, found in most European communities, is by far the most convenient for the user. A consideration of its requirements indicates that such a system would be not only unnecessary by completely inappropriate for the conditions of the Comoros. A number of critical items is reviewed here below.

Cost. The water-borne system would be financially unaffordable for most Comoran residents and would necessitate enormous government subsidy that would be an economically unsound use of resources. It is the most expensive of all sanitation systems and has a very high capital construction cost. An additional problem is that of the operation and the maintenance and the involved running costs. Experience has shown that conventional sewered systems are misused. Toilets become fouled, sewer pipes got broken during the self-building of houses, manhole covers disappear and rubbish is deposited in the sewers etc. Equipment is ordered from overseas for repairs and unacceptable delays are reported which are major causes of administrative inadequacies. The cost factor would be still further increased by the topography of the towns and the costs of sewage treatment. Consequently, the residents would be unable to cover the repayment and running costs by sewerage charges or additional taxes.

Sewer-buying. The installation of an underground sewerage system would be unacceptably disruptive and destructive to the construction of cities. For, it necessitates the demolition of a substantial number of houses since one has to dig large trenches in straight lines through existing, unplanned settlements. Such an undertaking would be politically and socially unacceptable. In addition, the construction of a sewer requires skilled personnel, which is in short, for the design and installation of drainage pipes. The employment of expatriate companies poses the problem of follow-up (repairs, maintenance etc.) and the cost factor involved.

Blocking. Where the problem of solid wastes has not been solved yet, blockages and a breakdown of water-borne sewerage systems are to be expected frequently.

In certain areas bulky cleansing materials are traditionally common (corn cobs, cement bags, stones, sticks and mud-balls etc.) and these contribute to obstruct sewers. There is also evidence that manhole covers are removed and large objects are fed into the sewers. Even if the introduction of such a system should be accompanied by an education campaign, still is this no guarantee that the system operates smoothly.

Water use. There is no certainty that sufficient water is available to run such a system and, even if there were, this would be an extremely unproductive use of water that will always be at least a scarce resource. Except during the monsoon period which lasts three months each year, the country is arid for the rest of the year. Consequently, there are no flowing rivers into which to discharge the affluent of a sewerage system. Water-borne systems use large volumes of drinking water merely to transport wastes along pipes. This would be a dangerous squandering of an uncertain water supply.

The conventional water-borne sewerage, found in most European communities, has been designed to achieve two objectives:

(a) a reduction of organic matter or BOD (biochemical oxygen demand),

(b) a reduction and control of pathogens.

If it is clear that a water-borne sewerage performs a BOD-reduction by 98% so as to limit water pollution, it is by no means clear that the second objective is also achieved: Pathogens, including bacteria and viruses, are released with the effluent into water courses or infiltrate into the ground. This represents a pollution hazard for drinking water supplies and a hazard for public health in general.

The observations made above apply also to the septic tank and the aqua privy, which are merely derivatives of the conventional water-borne sewerage, based on the addition of water to turn it into waste-water disposal. A firm conclusion is that on no account should it be assumed that the conventional water-borne sewerage is a solution for the sanitation of the Comoros. Only dry systems of excreta disposal represent a potential for the Comoran conditions.

6.3 Problems of Pit Latrines

The problems of latrines can be divided into two sections:

(i) difficulties encountered in the construction of pit latrines related to soil and ground water conditions;

(ii) risk of contamination and the hygienic maintenance of pit latrines.

These are discussed below.

Soil conditions

Rocky ground. The digging of a deep pit in rocky ground becomes extremely difficult and it requires skilled workers with mechanical diggers. Consequently, the cost price becomes higher but the guiding principle is to build pits as large as possible instead of very small pits which would fill at a faster rate.

Sandy soil. Pit latrine construction in sandy soil is easy and cheap but some restrictions, if overlooked, result in pit collapse especially when heavy rains have destabilized the soil. These restrictions include the lining of the pit and the seepage of faecal liquors out of the pit into the surrounding soil. The conditions of sandy soil apply also to unconsolidated soils such as fine-grained alluvium or loam soils.

Ground water conditions

High water table. Where the ground water table is high, not only the construction of the pits becomes very difficult but they rapidly turn into a stinking cesspool. The latter may happen also with impermeable soil especially in the wet season. The pits are liable to cave in or to collapse even if a lining around the top of the pit exists. The pit provides a protected breeding ground for filth flies and culex pipiens mosquitoes (the vector of filariasis). In such circumstances a built-up pit may be appropriate.

Ground water contamination. The risk of ground-water contamination is always present but this depends highly on the structure of the sub-soil and on the location of drinking water sources. For a good evaluation, a knowledge of geologic, hydrogeologic and microbiologic aspects is required. Shallow wells are used for ground water recovery in areas of the Comoros. As a general rule, pit latrines should not be built within 15 M. of a well or other drinking water source (intermittent water main) and should not be located uphill from the water source. There should be at least 2 M. of soil depth between the pit floor and the water table or the rock surface (fissured rock or weathered rock). These guiding principles can be verified through a tracer investigation or regular well survey.

Hygiene and maintenance. The situation of the Comoros shows that increasing amounts of water are allowed to enter the pits due to:

- installation of showers in bathrooms allowing drainage into the pits,
- drainage of sullage into the pits,
- use of water for anal cleansing.

The result of this situation is that the natural drainage is unable to cope: Pits fill at a faster rate, the danger of pollution is increased, culex mosquitoes will breed in the pit if it turns wet, the soil on the platform provides a hatching place for hookworms, there is a risk of extremely offensive smells.

The conclusion of this present brief review is that many latrines do not meet minimal public health requirements. Consequently, a properly located, constructed and maintained latrine should satisfy the following requirements formulated by Ehlers and Steel and extended afterwards.

a. The top soil should not become contaminated.
b. There should be no contamination of ground water that may be abstracted from springs or wells.
c. There should be no contamination of surface water.
d. Excreta should not be accessible to flies or animals.
e. There should be no handling of fresh excreta, or when this is indispensable, it should be kept to a strict minimum.
f. There should be freedom from odours or unsighty conditions.
g. The technology should be such that the latrines can be constructed and maintained by the local community using local materials.
h. The use of water to dilute and transport excreta should, if possible, be avoided.
i. Application in existing high density areas should be possible.
j. The system should provide for proper use by children.

It goes unchallenged that many of the above criteria have a general applicability in a Third World setting but they highly depend on local circumstances.

REFERENCES

WHO (1983) Maximizing benefits to health. .... An appraisal methodology for water supply and sanitation projects.

Bradley, D.J. (1977) Health aspects of water supplies in tropical countries. In water, wastes and health in hot climates, ed. R. Feachem, M. McGarry, and D. Mara, London, Wiley.

Feachem, R.G. (1976) Infectious disease related to water supply.

Prof.Dr. J.Huisman (1983) Some aspects of excreta-related diseases - Municipal Health Service, Rotterdam.

APHA (1975) Standard methods for the examination of water and wastewater - 13rd ed. Washington, American Public Health Association.

Mara, D.D. (1974) Bacteriology for sanitary engineers, London, Churchill Livingstone.

WHO (1976) Surveillance of drinking water quality. Geneva - World Health Organization.

Feachem, R., Burns, E., Cairncross, A., Cronin, A., Corss, P., Curtis, D., Khan, M., Lamb, D. and Southall, H. (1978) Water, health and development, an inter-disciplinary evaluation, London, Tri- Med Books.

Isely, R.B. and Martin, J.F. (1977) The village health committee, World Health Organization, Chronicle 31, 307-315.

UN (1977) National systems of water administration, New York.

Chambers, R. (1974) Managing rural development. Uppsala, Scandinavian Institute for African Studies.

Wagner, E.G, and Lanoix, J.N. (1959)	Water supplies for rural areas and small communities. Geneva, World Health Organization.
Flintoff, F. (1976)	Management of solid wastes in Developing Countries, WHO Regional Publications, South East Asian Series, No. 1.
WHO (1971)	Solid wastes disposal and control, Technical Report Series, No. 484.