- Maastricht Univ - Med School
- Prof E. Stobberingh
Ellen

WATER

THE SPRING OF LIFE

A Research on the quality of drinking-water in the Mantŝonyane area.

Marc Verhaegh
January 1990

CONTENTS page

CONTENTS CONTINUED

page

appendices

appendices continued

PREFACE

This survey is meant to give insight into the quality of drinking water of three different waterprovisions in Mantŝonyane Area.

Being a student doctor at St. James' Mission Hospital for a period of 4 months, most of my time was spent going into the fields to take water-samples.

All this would not have been possible without the help of a great number of people:

Zusters van het Heilige Hart, Zusters onder de Bogen, Stichting Nederland-Lesotho, for sponsoring the purchase of the water testing kit.

Dr. E.E. Stobberingh, of department of medical microbiology Rijks Universiteit Limburg, for supervising my research proposal, for arranging the purchase of the water testing kit, and for helping me find financial means to carry out this project.

Dr. Klaas-Jan Kamminga, P.H.C. Director of St. James' Mission Hospital Mantŝonyane, for supporting this project in many ways.

Ntate T. Lekhoaba, P.H.C. Supervisor, for informing me about the number and localisations of the spring protections, for organizing a time-frame and travel-necessities, and most important, for guiding and helping me with the sampling in the Mantŝonyane and Methalaneng area.

Ntate P. Petlane, P.H.C. Motivator Lesobeng, for guiding and helping me with the sampling in the Lesobeng area.

Mr. Kevin Mould, Village Water Supply Supervisor at Thaba-Tseka, for giving me useful information on Village Water Supply procedures.

I am also grateful to Mr. David Gittelman, technical officer of CCCD-project Maseru, 'me Madibata of Health Statistics Maseru, and miss Thérèsa

of Rural Sanitation Programme Maseru, for their advices.

I hope that this survey will contribute to the planning and management of succesful springprotection in the Mantŝonyane area.

Marc Verhaegh

January 1990

1. INTRODUCTION

1.1 Water supply and human health

Water is essential to man, animals and plants and without water life on earth would not exist. From the very beginning of human civilization, people have settled close to water services, along rivers, besides lakes or near natural springs. Indeed where people live, some water is normally available for drinking, domestic use, and possibly for watering animals. This does not imply, however, that the available source of water is convenient and of sufficient capacity, nor that the water is safe and wholesome. On the contrary, in many countries people live in areas where water is scarce. Often it has to be carried over long distances, particularly during dry periods. Scarcity of water may also lead people to use sources that are contaminated by human or animal faeces, and are thus dangerous to human health.

A few litres of water each day are sufficient for a person's basic food preparation and drinking requirements, depending on climate and lifestyle. Much larger quantities are necessary when water is used for other purposes such as peronal hygiene, cleansing of cooking utensils, laundry and house cleaning. Safe, adequate and accessible supplies of water, combined with proper sanitation, are surely basic needs and essential components of primary health care. They can help reduce many of the diseases affecting underprivileged populations, especially those who live in rural and urban fringe areas.

Safe drinking water is important in the control of many diseases. This is particularly well-established for diseases such as diarrhoea, cholera, typhoid and paratyphoid fever, infectious hepatitis, amoebic and bacillary dysentery.

It has been estimated that as many as 80 percent of all diseases in the world are associated with unsafe water and that each hour 1000-2500 children (under the age of 5) die from infectious or dirty water.
This association can take a number of different forms, and diseases may be grouped accordingly. (Table 1.1 Diseases related to deficiencies in water supply and/or sanitation.)

Table 1.1

Diseases related to deficiencies in water supply and/or sanitation.

GROUP	DISEASES	
. Diseases transmitted by water (water-borne diseases) Water acts only as a passive vehicle for the infecting agent. All of these diseases depend also on poor sanitation.	Cholera Typhoid Bacillary dysentery Infectious hepatitis Leptospirosis Giardiasis Gastro enteritis	
. Diseases due to lack of water (water-washed diseases) Lack of adequate quantity of water and poor personal hygiene create conditions favourable for their spread. The intestinal infections in this group also depend on lack of proper human waste disposal.	Scabies Skin sepsis and ulcers Yaws Leprosy Lice and typhus Trachoma Conjunctivitis Bacillary dysentery Amoebic dysentery Salmonellosis Enterovirus diarrhoeas Paratyphoid fever Ascariasis Trihcuriasis Whipworm (Enterobius) Hookworm (Ankylostoma)	
. Diseases caused by infecting agents spreaded by contact with or ingestion of water. (Water-based diseases) An essential part of the life cycle of the infecting agent takes place in an aquatic animal. Some are also affected by waste disposal.	Schistosomiasis (urinary & rectal) Dracunculosis (guinea worm) Bilharziosis Philariosis Oncholcrsosis Treadworm	
. Diseases transmitted by insects which live close to water (water-related vectors) Infections are spread by mosquitoes, flies, insects that breed in water or bite near it. These are especially active and aggressive near stagnant open water. Unaffected by disposal.	Yellow fever	mosquito
	Dengue + dengue hemorrhagic fever	mosquito
	West-Nile and Rift Valley fever	mosquito
	Arbovirus Encephalitides	mosquito
	Bancroftian Filariasis	mosquito
	Malaria (diarrhoea)*	mosquito
	Onchocerciasis*	Simulium fly
	Sleeping sickness*	Tsetse fly
. Diseases caused by infecting agents. Mostly contracted by eating uncooked fish and other food. *(Faecal-disposal diseases)*	Clonorchiasis	Fish
	Diphyllobothriasis	Fish
	Fasciolopsiasis	Edible plant
	Paragonimiasis	Crayfish

* Unusual for domestic water to affect these much

Source:
Saunders, J.; Warford, J.
Village Water Supply: Economics and policy in the Developing World.
Published for the World Bank by the Johns Hopkins University Press, Baltimore, 1976

- Water-borne diseases: are those carried by water that is contaminated with infecting agents from human or animal origin. When the water is drunk the infecting agents will be ingested and may cause disease. Control of such diseases calls for improving the quality of water.

- Water-washed diseases:diseases due to lack of water tend to be a serious health hazard. When people use very little water, either because there is little available or because it is too far away to be carried home in quantity, it may be impossible to maintain a reasonable personal hygiene. There may be simply too little water for washing oneself properly, or for cleaning food utensils and clothes. Skin or eye infections are thus allowed to develop, and intestinal infections can much more easily spread from one person to another. Clearly, the prevention of these water-washed diseases depends on the availability of and access to adequate supplies of water rather than its quality.

- Water-based diseases: do not spread directly from person to person. They are caused by infecting agents that for an essential part of their life cycle develop in specific water animals, chiefly snails and crustaceans. Over a period of days or weeks the parasite larvae or eggs mature in these intermediate hosts, and then are shed into the water. The matured larvae or worms are infective to people drinking the water or having contact with it.

Very important is the provision of adequate sanitation, including sanitary facilities for human waste disposal. All the water-borne and many of the water-based diseases depend for their dispersion on infecting agents from human faeces getting into drinking water or into food. The diseases chain of transmission may be broken as effectively by sanitary disposal of faeces as by the provision of safe and adequate water supplies.

Improvements in the quality of community water supplies will basically only affect the water-borne diseases such as bacillary dysentery, cholera, typhoid and possiblyschistosomiasis. Many of the diarrhoeal disease probably are more due to a lack of adequate quantities of water. Certainly skin and eye infections are in this group of water-related diseases.

1.2 Small community water supplies in developing countries

In the urban centres of developing countries community water supply systems of the type developed in industrialized countries can be suitable, with appropriate adaptions. Because of economies of scale and the large numbers of people to be served,the per capita investment and operating costs of urban water supply systems need not be high.

In most small towns and rural communities in developing countries, the prevailing water supply conditions are very different from urban installations. Usually the number of people to be served by such a water supply scheme is small and the low population density makes piped distribution of the water costly. The rural population often is very poor and particularly in subsistence farming communities little money can be raised. So the small communities are unlikely to be able to obtain the investment capital without assistance from the national government or from external donor or lending agencies.

Trained personnel for the operation and maintenance of the water supply scheme are generally not available in small communities.

One important factor is the requirement to use a technology that is appropriate for the local conditions. This technology will differ from the conventional one which was mainly developed for the larger water supply systems of cities and towns of developed countries. For small communities piped water supplies with house-connections are often not economically feasible. In such instances the realistic option is to provide a number of individual or 'point' sources: a spring tapping structure.
When the community to be served makes a contribution towards the construction costs of the water supply system, whether by payment of funds or through the provision of labour or construction materials, the capital investment can be kept low.

A small community water supply system need not be difficult to design and construct. The engineer should carefully select a technology which is simple, reliable and adapted to the available technical and organisational skills.

2. LESOTHO

2.1 Community and health status

The Kingdom of Lesotho is an independant country, landlocked by the Republic of South Africa. One third of the 30.500 km² is lowland (1500-1700m), the remainder is very mountainous and rugged. Some peaks reaching an altitude of 3500m. The population recorded by the 1987 census was 1.6 million. 60% live in the lowlands.
Transport and communication are the most difficult problems, roads being few and often not more than a track. Horses, 4-wheel-drive vehicles, off-road motorbikes and one's two feet are the most common means of transport. Lesotho has large climatic variations: summer temperatures in the lowlands reaching 40°C, while in the mountains the winter temperature can drop as low as -20°C. Snow can occur at any time of the year.
The avarage annual rainfall is about 700mm, of which over 75% falls in the warmest months of October to March. In about one year in five, however, extended summer droughts cause cropfailure and loss of cattle. This, together with the occasional hailstorms which damage crops, makes agriculture a risky undertaking.

Most of the population is very poor and ekes out a living by farming small plots of land, or herding cattle. A major source of income is provided by migrant labour in the mines of South Africa where an estimated 180.000 Basotho-men (about 50% of the male labourforce) are employed. This fact contributes largely to the problems of tuberculosis, alcoholism, violence and the break of families.

Another problem is the one of soil erosion, caused by the nature of the soil and rockformation, overgrazing, drought when followed by heavy rains and improper agricultural methods used on steep mountainslopes. Approximately 0.2% of the arable land (only 13% of the total surface of Lesotho is arable) is being lost annually.

Lesotho is one of the poorest countries in the world. The Gross Domestic Product per capita is 434 Maloti (=150 US$), while the Gross National Product is 822 Maloti. Taking into account that the incomes are higher in the lowlands, the average income of the mountain-people is less than these figures. About 50% of the population live below absolute poverty level. The Lesotho Government spends about 6% of its budget on health care. The under-5 years old morbidity rate is 140 per 1000 (14% of all live births die before the age of 5), and life expectancy is 51 years. The population growth is 2.7% per annum.

Health Services in Lesotho are furnished by 9 government and 9 private mission hospitals, each with a network of small clinics. While these Mission Hospitals provide almost 50% of the health services in the country, their importance is certainly not valued as its full worth by the Government in Lesotho.

2.2 Hospital and environment

St. James' Mission Hospital was founded in 1963 by the Anglican Church and is situated in the mountains in the geographical centre of Lesotho at an altitude of 2300m. It is connected with the capital Maseru by a 125 km road, partly tarred partly all-weather dirt-road, and to the east with de districtcapital Thaba-Tseka with a dirt road. Communication between the hospital and Maseru is done by 2-way radios, no telephone being available in the Health Service Area. The hospital has 57 beds and serves a population of 58.000 people (census 1987), living in small villages, scattered throughout an area of 2.000 km^2 . In the area there are 58 primary schools, 2 secondary schools and 2 high schools.

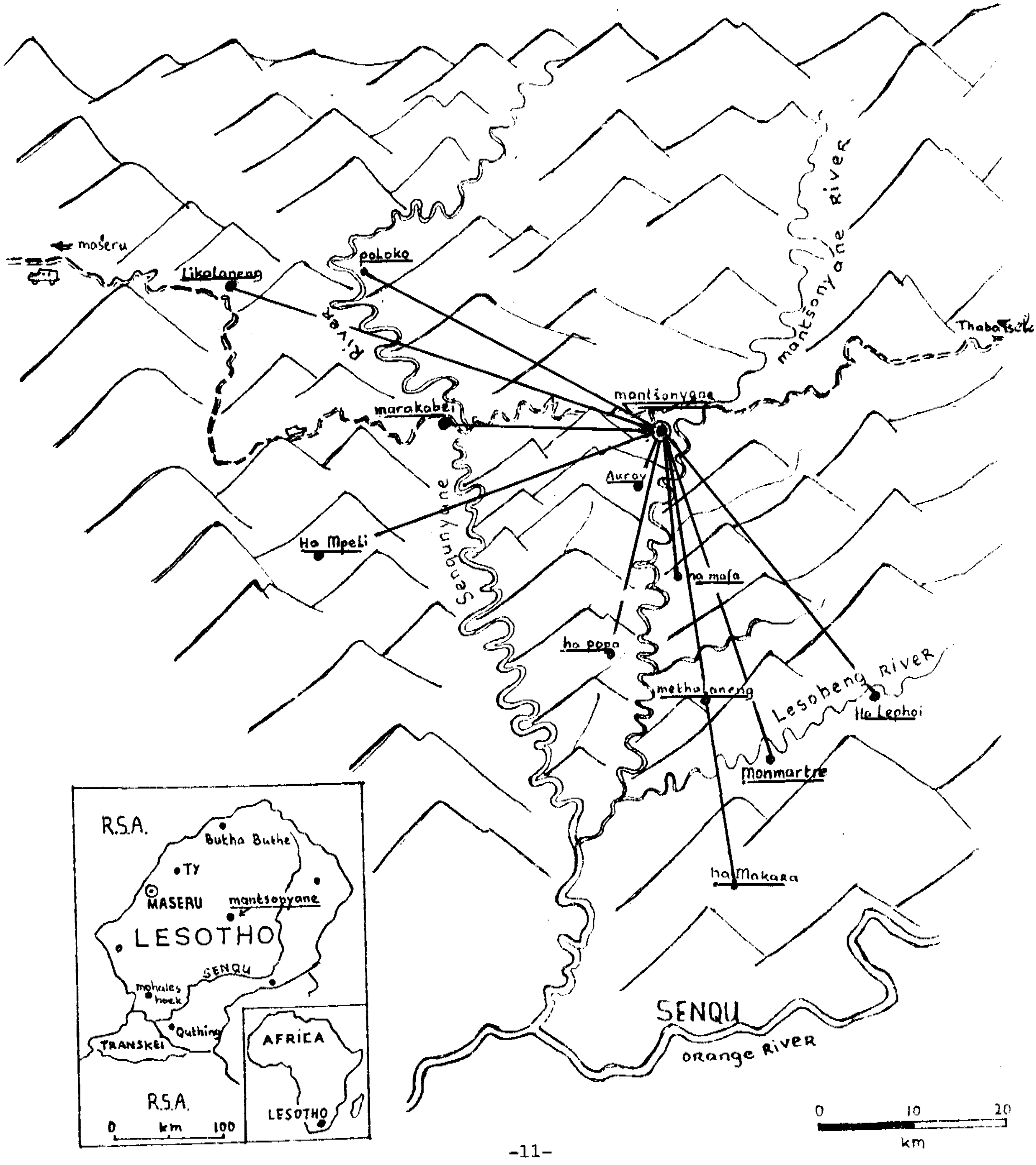
2.3 Health policy and health infrastructure

Many of the people in the hospital's catchment area (or Health Service Area) live at distances ranging from 4 hours to 2 days horse riding away. A network of permanent and semipermanent clinics has been set up to make health facilities more accessible for the whole population. There are currently 6 permanent clinics (open 24 hours a day, manned by a nurse or nurse-clinician plus other personnel and supervised by one of the doctors on a monthly basis), 2 semipermanent clinics (manned by a village health worker several days a week and supervised by the docter). One existing

Village Health Post and three under construction, these posts are manned by village health workers and supervised by a clinic nurse monthly. In line with the National Health Policy, the programmes are based on the Primary Health Care concept and the Alma-Ata Declaration of 1978.

This means that St. James' Hospital is responsible for the implementation of curative and preventive services in the HSA (Health Service Area). This includes general curative services in clinics and hospital, promotionof latrine building and spring protection, maternal (mainly antenatal) care and family planning, immunizations against major infectious diseases, promotion of proper nutrition and health education.
The HSA hospital is supposed to act as the first referral level for the HSA, Health Centres being the first place people can go for curative services. Village health workers are the first-contact-people for patients in the villages, especially when a health centre is not nearby. They are able to treat simple conditions and to give first-aid, they refer patients if necessary to the health centres or to the hospital.

MANTŠONYANE HEALTH SERVICE AREA.



3. WATER SOURCES

3.1 Water occurence and hydrology

The first step in designing a water supply system is to select a suitable source or a combination of sources of water. The source must be capable of supplying enough water for the community. If not, another source or perhaps several sources will be required.

The water on earth, whether as water vapour in the atmosphere, as surface water in rivers, streams, lakes, seas and oceans, or as grounwater in the subsurface ground strata is for the most part not at rest but in a state of continuous recycling movement. This is called the hydrological cycle. (Fig. 3.1)

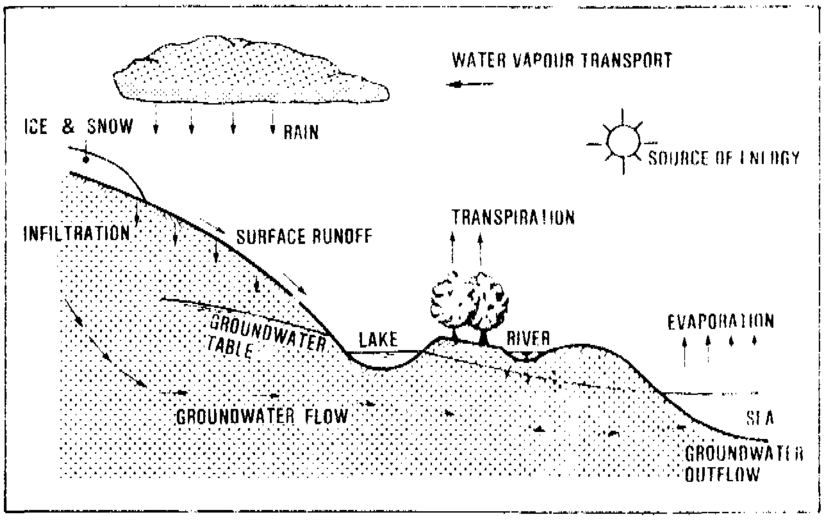


Figure 3.1
Hydrological cycle

The driving forces are the sun's energy and the earth' gravity. Water from the atmosphere falls to the ground as rain, hail, sleet and snow or condenses on the ground or on the vegetation. Not all this water adds to surface or groundwater resources, as part of it evaporates and returns directly to the atmosphere. Another part is intercepted by the vegetation or is retained on the ground, wetting the topsoil.

Water accumulating on the ground in pools and marshes is exposed to evaporation (evaporation occurs from any water surface. Transpiration is loss of water from plants. All plants take water through their roots; it is expelled through transpiration from the leaves). Part of the accumulated water flows as surface runoff towards streams, rivers and lakes. Another portion infiltrates into the ground. This water may flow either at shallow depth underneath the ground to open water courses, or it percolates further downward to reach deeper groundwater strata. Neither the shallow nor the deep groundwater is stagnant; it flows underground in the direction of the downward slope of the groundwater table. Sooner or later the water emerges again at the surface, either in the form of a spring or as a groundwater outflow in a river or lake. From the streams, rivers, lakes, seas and oceans, the water is returned to the atmosphere through evaporation. The whole recycling process then begins again.

By far the greatest part of the water on earth is found in the oceans and seas. However, this water is saline. The amount of fresh water is less than 3%, about two thirds of which is locked in ice caps and glaciers. The fresh water contained in the underground and in all lakes, rivers, streams, brooks, pools and swamps amounts to less than 1% of the world's water stock.

Most of this liquid fresh water is in the underground, an estimated 6.000.000 km^3 of groundwater up to 50 metres deep, and a further 2.000.000 km^3 at greater depth. Contrary to popular belief, the amount of fresh water in lakes, rivers and streams is small, about 200.000 km^3 of water. The atmosphere contains only 13.000 km^3 of water.

Water for domestic use may be abstracted from the hydrological cycle at various points:

- as roof drainage before it reaches the ground
- as ground catchment before it runs off or percolates downward
- as groundwater
- as springwater at the point of re-emergence to groundsurface
- as surfacewater in rivers and lakes

The process of developing the most suitable source of water for development into a public water supply largely depends on the local conditions.

Where a spring of sufficient capacity is available, this may be the most suitable source of supply.

3.2 Spring water tapping

Springs are found mainly in mountainous or hilly terrain. A spring may be defined as a place where a natural outflow of groundwater occurs.

Spring water is usually fed from a sand or gravel water-bearing ground formation (aquifer), or a water flow through fissured rock. Where solid or clay layers block the underground flow of water, it is forced upward and can come to the surface. The water may emerge either in the open as a spring, or invisibly as an outflow into a river, stream, lake or the sea (Fig. 3.2). Where the water emerges in the form of a spring, the water can easily be tapped. The oldest community water supplies were, in fact, often based on springs.

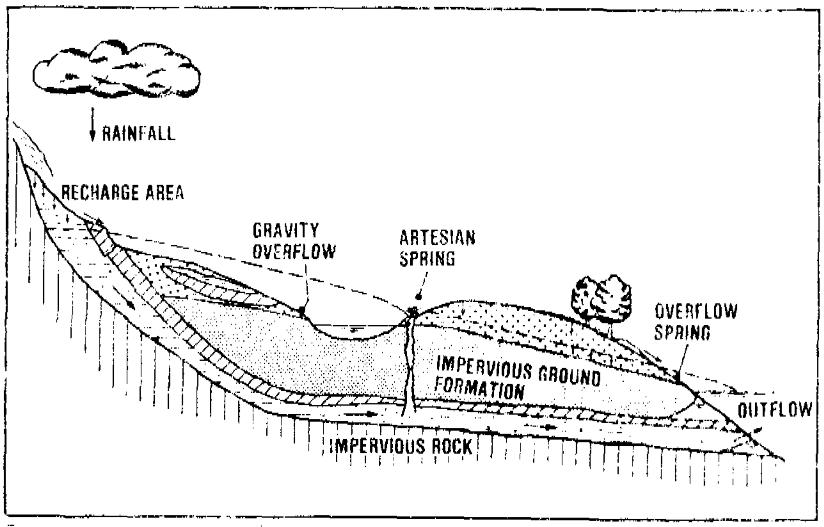


Figure 3.2
Ocurrence of springs

The best places to look for springs are the slopes of hill-sides and river valleys. Green vegetation at a certain point in a dry area may also indicate a spring, or one may be found by following a stream op to its source. However, the local people are the best guides, as they usually know most springs in their area.

Real spring water is pure and usually can be used without treatment, provided the spring is properly protected with a construction (e.g. masonry, brick or concrete) that prevents contamination of the water from outside. One should be sure that the water is really fed from the groundwater and not a stream that has gone underground for a short distance.

The flow of water from a spring may be through openings of various shapes. There are several names: seepage or filtration springs where the water percolates from many small openings in porous ground; fracture springs where the water issues from joints or fractures in otherwise solid rock; and, tubular springs where the outflow opening is more or less round.

4. IMPROVED WATER SUPPLY

Occasional water supply improvements have been carried out in Lesotho since 1937; these were mainly the protection of springs, primarily in villages with a reputed history of disease.

4.1 Village Water Supply

Village Water Supply construction only began in earnest in the 1960's. They started working in the Thaba-Tseka district in 1981 on a very small scale. Before 1981, some water protections were made by other organizations, but very few of these remain in good condition.

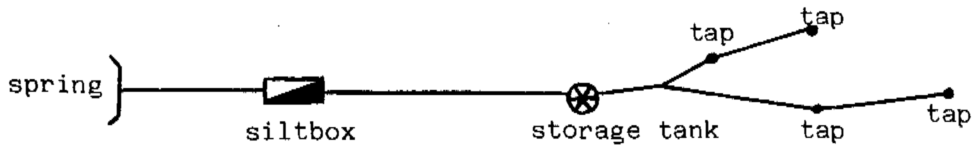
- A year by year account of the VWS constructions in the St. James' HSA
  1982 - Tholang (150 people)
  1983 - Makopoi (200 people)
  1984 - all east of Thaba-Tseka
  1985 - all east of Thaba-Tseka
  1986 - Ha Toka (850), Ha Lepoi (70), ..uray (800), Ha Nyane
  1987 - Ha Leronti (400 people)
  1988 - Methalaneng (900 people)-4 projects
  1989 - Methalaneng (1704 people)-7 projects

- A simple spring protection, without storage tanks or pipes should cost very little:

cement 250 kg	R 50,-
3 days skilled labour	R 72,-
3 metres steel pipe	R 19,-
sand and stones	local
village labour (45 man days)	-
Total	R141,-

For "building with stones and plastering" see appendix I.

- If storage and piping into the village are added, the cost can go very high. For an average sized village of about 300 people, a water system may look like this:



spring	R	140,-
pipe to siltbox	R	200,-
siltbox	R	600,-
pipe to storage	R	9.000,-
storage	R	1.500,-
pipes to taps	R	2.000,-
taps	R	400,-
		R13.840,- about R45 per person in the village

- The only money collected from the village is a small contribution to a maintenance fund which they will use to make repairs in the future. This contribution is usually 5 to 20 Rand per family, and is kept by the <u>village water committee</u> in a bank account (see appendix II: the important people in Village Water Supply).

- The water-minder; his work is to take care of the water supply system, and he is selected by the committee together with the Engineer or the VWS Supervisor (see appendix III).

- Village Water Supply policy and selection criteria:
  This is highly influenced by the persistence of villages contacting VWS and rural development offices (see appendix IV).

- In the past, regular checks were never made by VWS because:
  * shortage of staff
  * no maintenance budget
  * all water systems are less than 7 years old

In 1989 they started answering some old requests for maintenance. And in 1990 they plan to make a complete survey of existing systems. This is now possible because of a country-wide commitment by VWS to dedicate personnel and materials to maintenance.

4.2 St. James' Mission Hospital

- St. James' started constructing springprotections in 1981. The main idea was to protect only the spring itself, so without storage or piping into the village.

- Springprotection:
  * stones and cement
  * plastering inside
  * closed construction without a lid
  * a tap

- Costs: 100-150 Rand to pay by the village itself.

- Constructing periods:

  1982-1983 Mantšonyane area

  1983-1986 Lesobeng area

  1987-1988 Methalaneng area

- St. James' policy and selection criteria:

  Springprotections only are constructed on request of the villages.

- Last year (1988) St. James' did not construct any new protections at all because of:
  * almost no requests
  * no pipes available
  * shortage of staff

- There are no regular checks of the existing constructions.

5. WATER QUALITY AND QUANTITY

5.1 Water quantity

Depending on climate and work load, the human body needs about 3-10 litres of water per day for normal functioning. Part of this water is derived from food. The use of water for food preparation and cooking is relatively constant. The amount of water used for other purposes varies widely and is greatly influenced by the type and availability of the water supply. Factors influencing the use of water are cultural habits, pattern and standard of living and the cost and quality of the water.

The use of water for domestic purposes may be subdivided in various categories:
- drinking
- food preparation and cooking
- cleaning, washing and personal hygiene
- vegetable garden watering

As a tentative estimate, a water supply system for a more or less centralized community settlement would need to have a capacity of:
- about 0.3 l/sec per 1.000 people when the water is mainly distributed by means of public standpipes (25 litres per capita per day).
- about 1.5 l/sec per 1.000 people when yard and house connections predominate.

5.2 Water quality

The relationship between water quality and health effects has been studied for many water quality characteristics. An examination of water quality is basically a determination of the organisms and the mineral and organic compounds contained in the water.

The basic requirements for drinking water are that it should be:
- free from pathogenic (disease causing) organisms
- containing no compounds that have an adverse effect, acute or in the long term, on human health

- fairly clear (i.e. low turbidity; little colour)
- not saline (salty)
- containing no compounds that cause an offensive taste or smell

5.2.1 Microbiological aspects

The most important parameter of drinking water quality is the bacteriological quality, i.e. the content of bacteria and viruses. It is not practicable to test the water for all organisms that it might possibly contain. Instead, the water is examinated for a specific type of bacteria which originates in large numbers from human and animal excreta and whose presence in the water is indicative of faecal contamination.

Such indicative bacteria must be specifically faecal and not free-living. Faecal bacteria are members of a much wider group of bacteria, the coliforms. Many types of coliform bacteria are present in soil. Suitable indicator of faecal contamination are those coliforms known as Escherichia-Coli (E.coli), and faecal streptococci. They are capable of easy multiplication. When these bacteria are found in the water, fairly fresh faecal contamination is indicated and on that basis there is the possibility of the presence of pathogenic bacteria and viruses. Either one or both of these coliform and streptococci bacteria may be used as indicator organisms.

In almost all small community water supply systems faecal bacteria are likely to be found. It would be pointless to condemn all supplies that contain some faecal contamination, especially when the alternative source of water is much more polluted. Rather, testing of the bacteriological quality of the water should examine the level of faecal pollution, and the amount of contamination of any alternative sources.

Water samples should be collected in sterile bottles according to standard procedure. They should be kept as cool as possible. It is necessary to carry out bacteriological examination of samples within a few hours after sampling (keeping them at 4°C), otherwise the results will be quite unreliable.

There are two methods for conducting tests on the levels of faecal coli and faecal streptococci in water: the multiple tube method for establishing the most probable number, and the membrane filtration method:

- In the multiple tube method small measured quantities of the water sample are incubated in 5 or 10 small flasks containing a selective nutrient broth. The most probable number of bacteria in the sample can be estimated on the basis of the number of bottles which show signs of bacterial growth.

- In the membrane filtration method water is filtered through a membrane of special paper which retains the bacteria. The membrane is then placed on a selective nutrient medium and incubated. The bacteria multiply forming visible colonies which can be counted. The result is expressed as number of bacteria per 100ml of water. The membrane filtration method gives rapid results which are easy to interpret and quite accurate. It can be carried out on site in the back of a vehicle. The multiple tube equipment is fragile and requires special provisions during transport.

In either of the methods the facilities for the incubation are the main contraint. The difficulty is the accurate control of the temperature. For faecal coli, incubation should be at an accurately controlled temperature of 44,5°C +/- 0,2°C.
If incubation with an accurate temperature control is not possible the recommended practice is that only faecal streptococci should be counted. For this caunt, incubation is required at 35-37°C which can be more readily provided.

The following bacteriological quality criteria are generally applicable for small drinking water supplies:

- Coliforms (average number present in the drinking water sampled) should be less than 10 per 100ml. ("Small Community Water Supplies - International Reference Centre for Community Water Supply and Sanitation")

- WHO claims that for individual or small community supplies, water should be condemned if it is repeatedly found to contain more than 10 coliforms per 100ml.

- Action is necessary if non-chlorinated drinking water contains more than 10 colonies per 100ml. ("Oxfam", Robens Institute at the University of Surrey, United Kingdom)

- The supply is heavily contaminated and requires immediate remedial action if the count exceeds 50 colonies per 100ml. (Water Testing Kit-users manual)

These guidelines should always be applied with common sense, particularly for small community and rural water supplies where the choice of source and the opportunities for treatment are limited. Also, it would be wrong to condemn a water supply if no better are available.

No bacteriological test can be substituted for a complete knowledge of the water supply system and the conditions under which it has to operate. Samples represent a single point in time and, even when samples are taken and analyzed regularly, contamination may not be revealed especially when it is intermittent, seasonal and random.

5.2.2 Turbidity

Turbidity in water is caused by suspended particles of matter such as organic material, bacteria, algae, clay, mud, lime or rust.
High levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria and exert a significant chlorine demand. The recommended guideline value is 5 T.U. (turbidity units), but levels should be preferably be less than 1 T.U. when disinfection is practiced.
Turbidity in excess of 5 T.U. may be noticeable (becomes visible to the human eye in a drinking glass) and consequently objectionable to consumers.

5.2.3 Temperature

Temperature affects the rates of bacterial and chemical reactions in water. It also controls the maximum levels of dissolved oxygen and carbon dioxide.

5.2.4 pH

The pH of natural waters is usually between 5,5 and 9. Readings outside this range may indicate pollution by strongly acidic or alkaline wastes. Water with a pH below 5 could constitute a health risk due to solubilisation of toxic heavy metals if they are present, and it could be carrosive. Chlorination is much less effective in water at a pH above 8.

5.2.5 Colour

Colour in drinking water may be due to the presence of coloured organic matter, e.g., humic substances, metals such as iron or highly couloured industrial wastes. Experience has shown that consumers may turn to alternative, perhaps unsafe, sources when their water displays aesthetically displeasing levels of colour. It is therefore desirable that drinking water should be colourless.

5.2.6. Taste and odour

Water odour is due mainly to the presence of organic substances. Some odours are indicative of increased biological activity, others may originate from industrial pollution.
Taste problems in drinking water supplies represent the largest single class of consumer complaints. Generally, the taste buds in the oral cavity specifically detect inorganic compounds of metals such as magnesium, calcium, sodium, copper, iron and zinc.

6. RESEARCH ON THE QUALITY OF DRINKING WATER IN THE MANTŜONYANE AREA

The aim of the study is to investigate the quality of drinking water of different water provisions in Mantŝonyane and surroundings:

- unprotected springs
- spring protections constructed by St. James' Mission Hospital
- spring protections constructed by Village Water Supply

Two aspects will be studied:

1. The water quality will be assessed:
   - macroscopic
   - with the help of a "water testing kit" (see appendix V)
2. Oriëntation on the local circumstances

With these figures it should be possible to show the differece in quality of drinking water between the three kinds of water supplies in Mantŝonyane and surroundings. Then the following questions could be answered:

- Is the water from the springs protected by the Village Water Supply less polluted than the water from the more primitive springprotections constructed by St. James' Mission Hospital?

- Is the water quality of the unprotected springs acceptable within the WHO standards?

These answers and the data of the local circumstances should lead to a proposal with regard to the planning and management of springprotection in the Mantŝonyane Area.

6.1 Design of the study

6.1.1 Selection

Visiting 60 water provisions with different kinds of protection. The selection will take place at random (see appendix VI).

- 30 unprotected springs
- 15 spring protections constructed by St. James' Mission Hospital
- 15 spring protections constructed by Village Water Supply

The Mantŝonyane Area (Series L50, sheet 2928 CB) contains 87 unprotected springs, 27 springprotections constructed by St. James' Mission Hospital, and 33 constructed by Village Water Supply.

6.1.2 Sampling procedure

Samples will be taken directly from the spring (in sterilized bottles).
- sampling from a tap: first open the tap and leave running for at least one minute before taking a sample. This ensures that any deposits in the pipe are washed out.
- sampling from an open well: with the help of a sampling cable; submerge the cup to a depth of 30 cm.

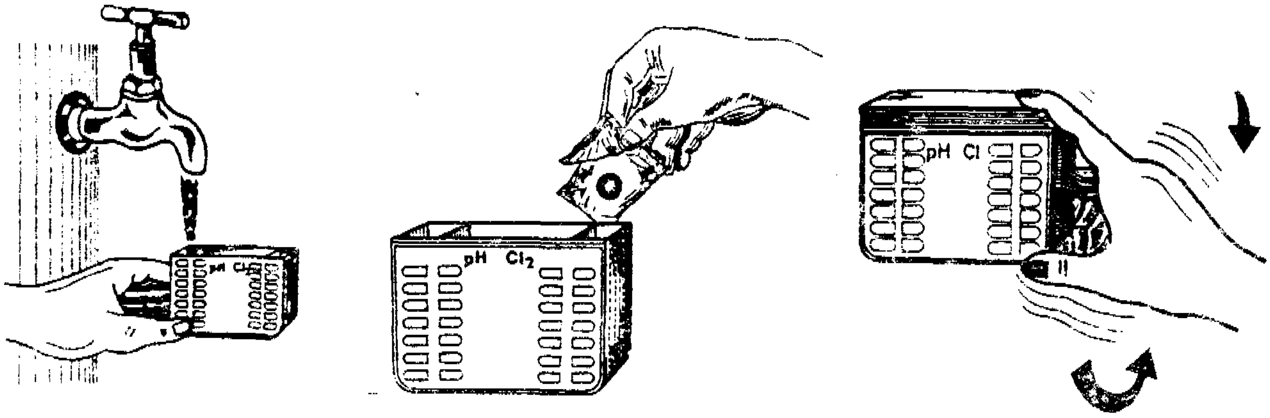
After that the water will be tested immediately by means of the "water testing kit".

6.1.3 Water quality

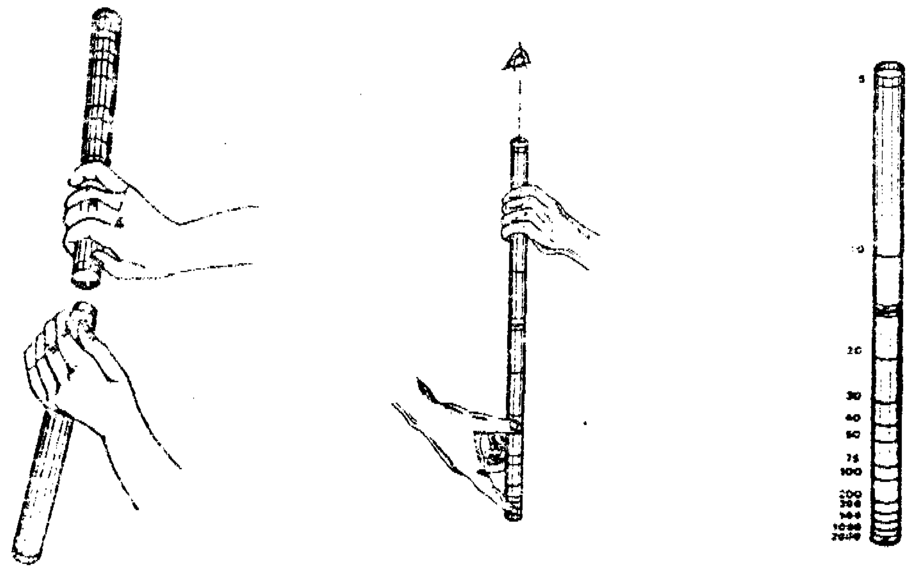
- macroscopic: colour, taste, odour.
- "water testing kit":

  * Analysis of pH: wash the comparator cells three times with water before filling it with the sample. Read immediately the pH concentration by holding the comparator up to daylight and matching the colour developed in the cell with the standard colour scale in the central part of the comparator.

The scale: 6.8 - 7.0 - 7.2 - 7.4 - 7.6 - 7.8 - 8.0 - 8.2.



* Analysis of turbidity: pour water sample into the tube from the sample cup until the black circle at the base of the tube just disappears when viewed from the top of the tube.



* Temperature test: put a thermometer for one minute in a covered sample cup.

* Faecal coliform analysis:

Volumes for faecal coliform analysis by the membrane filtration method:
- protected ground waters e.g. wells and springs.............100 ml.
- unprotected ground waters e.g. open dug wells and springs...50 ml.

For sample processing for faecal coliform analysis in the field and re-sterilisation of the filtration apparatus see appendix VII and VIII.

Once the last sample of the day has been taken, wait a minimum of 60 minutes before switching on the incubator (resuscitation time).

Incubate the samples for 14 to 18 hours (44°C +/- 0.5°C).

Once the incubation period is completed, count all the yellow colonies which have a diameter of between 1 and 3 mm. Do not count colonies which are transparant or red/pink. These bacteria do not ferment lactose.

In the end, convert the count into number of faecal coliforms per 100 ml.

$$\text{Faecal coli per 100ml} = \frac{\text{no. of faecal coli colonies counted}}{\text{no. of ml. of sample filtered}} \times 100$$

6.1.4 Oriëntation on local circumstances

- protected (St. James' - VWS) / unprotected spring
- quantity of water
- distance between the spring and the village
- number of latrines
- number of people using the spring

7. RESULTS

7.1.1 Unprotected springs

village	rain	time	turbidity (N.T.U.)	temp. (°C)	pH	faecal coli/ 100 ml
1. Lilomong (9)	+	14.40	<5	12	6.8	8
2. Tsirela (8)	+	15.15	<5	13	<6.8	1
3. Ha Letuka (24)	–	10.30	5	14	7.0	28
4. Matekane (22)	–	11.00	20	13	7.2	>200
5. Maloaloaneng (50)	+	12.15	<5	14	7.4	112
6. Moeaneng (49)	+	13.00	<5	17	7.2	>200
7. Ha Chejana (59)	+	14.30	<5	15	7.2	13
8. Ha Morumo (58)	+	15.45	<5	14	7.6	32
9. Ha Mothae (75)	+	10.30	<5	13	7.2	1
10. Ha Mothae (76)	+	11.00	5	13	7.4	23
11. Liphakoeng (77)	+	11.40	<5	14	7.2	2
12. Pontseng (85)	+	13.00	<5	13	6.8	1
13. Tsekong (84)	+	15.00	<5	14	6.8	105
14. Tlhakoaneng (68)	+	16.05	<5	13	7.0	62
15. Ha Kharmolane (54)	–	06.35	5	15	7.2	>200
16. Ha Motsiba (46)	–	07.45	5	14	7.2	14
17. Ha Nyolo (43)	–	08.25	<5	14	7.2	>200
18. Ha Phefu (29)	–	09.30	<5	16	7.2	19
19. Taung (28)	–	10.30	<5	14	7.0	75
20. Ha Khomari (35)	–	11.25	<5	16	7.2	3
21. Ha Sehlahla (33)	–	12.25	20	16	7.0	>200
22. Mapetleng (41)	–	13.40	<5	15	7.2	8
23. Makheaeleng (42)	–	14.10	<5	14	7.2	1

village	rain	time	turbidity (N.T.U.)	temp. (°C)	pH	faecal coli/ 100 ml
24. Ha Molupi (13)	–	11.00	< 5	14	7.2	> 200
25. Ha Ntoana (11)	–	14.45	< 5	16	6.8	28
26. Ha Mothibeli (14)	–	15.30	< 5	16	7.4	1
27. Hleoheng (16)	–	10.20	< 5	16	6.8	1
28. Hleoheng (17)	–	10.50	< 5	16	6.8	56
Extra:						
Ha Mafa (10)	–	16.30	< 5	15	6.8	38

During the sampling we found that the springs from Ha Rammuso (57) and Makhoaeleng (83) were protected by St. James' instead of unprotected. Therefore we only sampled 28 unprotected springs instead of 30.
The results of Ha Rammuso and Makhoaeleng are not included in any of the statistics!

7.1.2. Unprotected springs: local circumstances

village	no. of people using the spring	distance village-spring (in metres)	quantity (time in seconds for 1 litre)	no. of latrines
1. Lilomong (9)	25	300	–	3
2. Tsirela (8)	120	400	6	2
3. Ha Letuka (24)	150	500	42	4
4. Matekane (22)	42	250	–	0
5. Maloaloaneng (50)	100	200	–	0
6. Moeaneng (49)	20	200	–	0

village	no. of people using the spring	distance village-spring (in metres)	quantity (time in seconds for 1 litre)	no. of latrines
7. Ha Chejana (59)	350	120	–	0
8. Ha Marumo (58)	250	200	–	0
9. Ha Mothae (75)	178	75	–	0
10. Ha Mothae (76)	204	150	–	1
11. Liphakoeng (77)	60	150	–	0
12. Pontseng (85)	144	150	–	0
13. Tsekong (84)	90	180	–	0
14. Tlhakoaneng (68)	48	250	–	0
15. Ha Khanmolane (54)	72	550	–	0
16. Ha Motsiba (46)	102	300	–	2
17. Ha Nyolo (43)	120	150	–	2
18. Ha Phefu (29)	120	450	–	0
19. Taung (28)	36	50	–	0
20. Ha Khomari (35)	78	200	–	0
21. Ha Sehlahla (33)	66	50	–	0
22. Mapetleng (41)	96	100	–	0
23. Makheaeleng (42)	84	200	–	1
24. Ha Molupi (13)	120	800	–	0
25. Ha Ntoana (11)	54	200	–	0
26. Ha Mothibeli (14)	66	100	–	1
27. Hleoheng (16)	96	200	–	0
28. Hleoheng (17)	102	300	–	0
Extra:				
Ha Mafa (10)	250	350	–	3

7.2.1 <u>Springs protected by St. James' Mission Hospital</u>

village	rain	time	turbidity (N.T.U.)	temp. (°C)	pH	faecal coli/ 100 ml
1. Lihloaeleng (102)	+	10.00	<5	15	<6.8	0
2. Ha Long (107)	+	11.00	<5	14	6.8	39
3. Ha Long (108)	+	12.15	<5	12	<6.8	7
4. Ha Mokotana (111)	-	11.45	<5	15	7.0	3
5. Ha Mokotana (112)	-	12.15	<5	15	6.8	152
6. Ha Seoka (127)	+	16.55	<5	13	7.4	1
7. Ha Thebeeakhale (124)	-	11.15	<5	15	7.2	78
8. Ha Thebeeakhale (125)	-	11.45	10	17	7.4	>200
9. Ha Mohau (122)	-	12.25	<5	16	7.2	0
10. Ha Mohau (123)	-	13.00	<5	17	7.0	3
11. Ha Letsika (118)	-	15.45	<5	14	7.2	0
12. Topa (113)	-	09.20	<5	14	6.8	43
13. Topa (114)	-	09.50	<5	16	6.8	51
14. Shoella (115)	-	11.50	<5	12	7.0	2
15. Ha Mokolana (106)	-	14.15	<5	18	7.4	0
<u>Extra:</u>						
Makhoaeleng (83)	+	14.55	<5	16	7.0	2
Ha Rammuso (57)	-	16.30	<5	14	7.0	4
Ha Popa Clinic	+	14.30	<5	14	6.8	51

7.2.2 Springs protected by St. James' Mission Hospital: local circumstances

village	no. of people using the spring	distance village-spring (in metres)	quantity (time in seconds for 1 litre)	no. of latrines
1. Lihloaeleng (102)	90	120	4	1
2. Ha Long (107)	120	170	6	1
3. Ha Long (108)	156	500	–	1
4. Ha Mokotana (111)	60	50	–	2
5. Ha Mokotana (112)	174	200	10	4
6. Ha Seoka (127)	96	350	–	0
7. Ha Thebeeakhale (124)	96	195	8	0
8. Ha Thebeeakhale (125)	114	75	–	0
9. Ha Mohau (122)	72	300	38	0
10. Ha Mohau (123)	300	100	8	1
11. Ha Letsika (118)	115	250	14	2
12. Topa (113)	144	50	56	0
13. Topa (114)	48	150	4	0
14. Shoella (115)	60	750	8	0
15. Ha Mokolana (106)	84	100	8	0
Extra:				
Makhoaeleng (83)	114	75	–	0
Ha Rammuso (57)	78	300	6	0
Ha Popa Clinic	195	–	–	–

7.3.1. Springs protected by Village Water Supply

village	rain	time	turbidity (N.T.U.)	temp. (°C)	pH	faecal coli/ 100 ml
1. Mantŝonyane (207)	+	12.10	< 5	12	< 6.8	4
2. Ha Leronti (212)	-	12.50	< 5	18	7.4	0
3. Ha Toka (206)	+	12.50	< 5	13	< 6.8	2
4. Ha Sekharume (217)	-	08.30	< 5	15	7.0	18
5. Topa (219)	-	10.30	< 5	12	6.8	0
6. Shoella (227)	-	12.20	< 5	18	7.4	1
7. Matebeleng (221)	-	12.45	< 5	17	7.0	1
8. Ha Ntsilile (228)	-	13.20	< 5	13	6.8	3
9. Ha Ntsilile (229)	-	13.50	< 5	18	7.2	0
10. Ha Mahapela (222)	-	14.35	< 5	15	7.2	18
11. Methalaneng-Clinic (224)	-	15.20	< 5	18	7.0	0
12. Ha Mokhoro (210)	-	10.25	< 5	17	7.6	1
13. Ha Lethibella (205)	-	11.25	< 5	17	7.2	0
14. Sehlabeng-sa-Hae (218)	-	17.00	< 5	16	7.0	2
15. Methalaneng-School (213)	-	12.15	< 5	13	6.8	11
Extra:						
Ha Lepoi Clinic (232)	+	16.30	< 5	14	7.2	2
Montmartre (other protection)	+	10.55	< 5	14	7.2	15

7.3.2. Springs protected by Village Water Supply: local circumstances

village	no. of people using the spring	distance village-spring (in metres)	quantity (time in seconds for 1 litre)	no. of latrines
1. Mantšonyane (207)	100	-	10	toilets
2. Ha Leronti (212)	210	300	8	3
3. Ha Toka (206)	450	250	8	4
4. Ha Sekharume (217)	156	250	4	0
5. Topa (219)	18	150	18	0
6. Shoella (227)	108	300	4	0
7. Matebeleng (221)	168	50	4	0
8. Ha Ntsilile (228)	54	350	14	0
9. Ha Ntsilile (229)	66	150	8	0
10. Ha Mahapela (222)	200	250	3	1
11. Methalaneng-Clinic (224)	20	0	4	2
12. Ha Mokhoro (210)	336	100	6	2
13. Ha Lethibella (205)	36	500	14	0
14. Sehlabeng-sa-Hae (218)	72	50	6	0
15. Methalaneng-School (213)	218	50	8	0

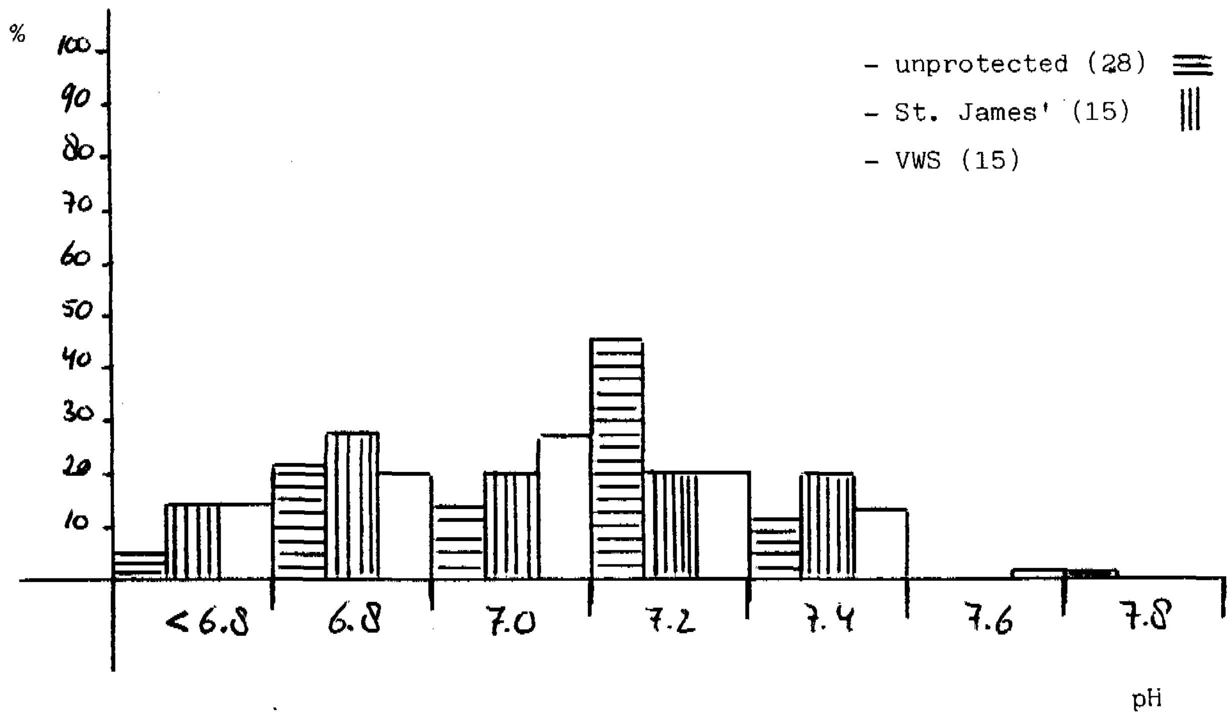
7.4 Synopsis

- Colour:
  According to the consumers and investigators all samples were defined to be colourless.

- Taste and odour:
  According to the consumers and investigators all the samples were "not offensive".

- pH:
  The pH of natural waters is usually between 5.5 and 9. In our sampling the pH was between 6.8 and 7.8.

unprotected:	$\bar{x}$ = 7.1	SD = 0,23
St. James':	$\bar{x}$ = 7.0	SD = 0,28
VWS:	$\bar{x}$ = 7.0	SD = 0,29



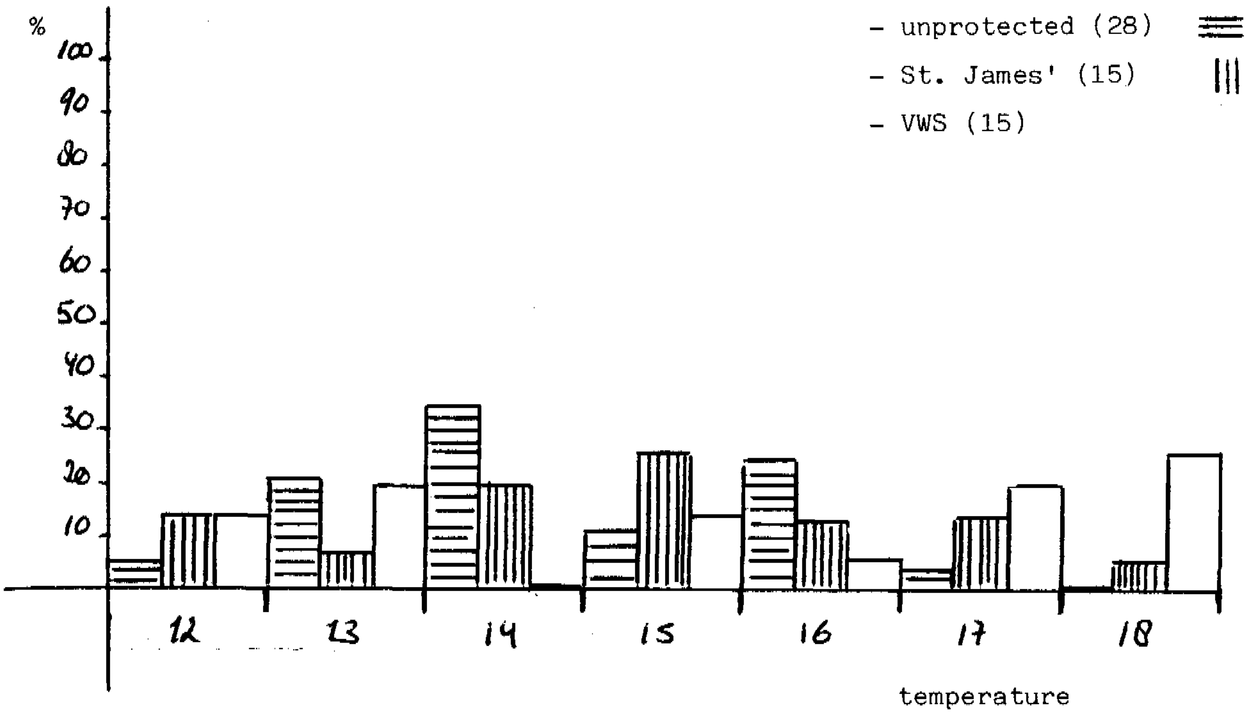
- Turbidity:
  Caused by suspended particles. The WHO (World Health Organization) recommended the highest desirable level for turbidity to be 5 N.T.U.

unprotected:	22 x	5 N.T.U.
	4 x	5 N.T.U.
	2 x	20 N.T.U.
St. James:	14 x	5 N.T.U.
	1 x	10 N.T.U.
VWS:	15 x	5 N.T.U.

- Temperature:

  In our sampling the temperature was between 12-18°C.

unprotected:	$\bar{x}$ = 14,4	SD = 1,3
St. James':	$\bar{x}$ = 14,8	SD = 1,8
VWS:	$\bar{x}$ = 15,5	SD = 2,3



- Faecal coliforms:

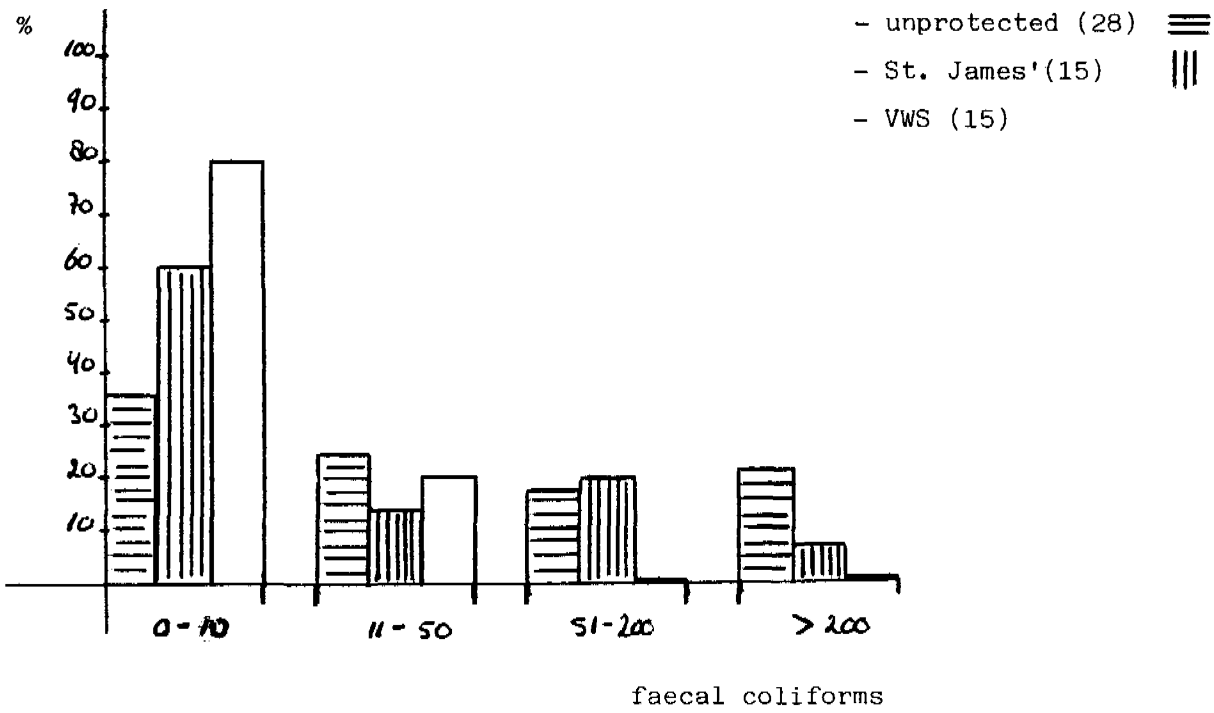
  The bacteria Escherichia Coli is an indicator of faecal contamination. This is the most reliable and widely accepted test of drinking water quality.

  * more than 10 colonies/100ml : water is contaminated
  * more than 50 colonies/100ml : requires immediate action

unprotected : $\bar{x}$ = 64,0/100ml SD = 78,0

St. James': $\bar{x}$ = 38,6/100ml SD = 61,5

VWS: $\bar{x}$ = 4,1/100ml SD = 6,3



- Average number of people using the spring:

unprotected : 2993 ÷ 28 = 107 people

St. James': 1729 ÷ 15 = 115 people

VWS: 2212 ÷ 15 = 147 people

- Average distance between village-spring:

unprotected : 6775 ÷ 28 = 242 metres

St. James' : 3360 ÷ 15 = 224 metres

VWS : 2750 ÷ 15 = 183 metres

- Quantity of water:

unprotected : no taps

St. James' : 164 ÷ 11 = 14.9 sec/1 litre = 4,0 litre/minute

= 50 litre per capita per day

VWS : 119 + 15 = 7.9 sec/1 litre = 7,6 litre/minute
= 75 litre per capita per day

- Number of latrines:

unprotected : latrines in 8 of the 28 villages
St. James' : latrines in 7 of the 15 villages
VWS : latrines in 6 of the 15 villages

7.5 The quality of the building construction of the springprotections

7.5.1 St. James' Mission Hospital

1. Lihloaeleng: instead of a tap they use a piece of wood.
2. Ha Long: intact.
3. Ha Long: no pipe, no tap, the water is only partly covered.
4. Ha Mokotana: no pipe, no tap, the roof of protection is damaged.
5. Ha Mokotana: intact.
6. Ha Seoka: no pipe, no tap, roof of protection is damaged.
7. Ha Thebeeakhale: intact.
8. Ha Thebeeakhale: protection is totally destroyed.
9. Ha Mohau: several leakages, not streaming well (1 litre in 38 sec.)
10. Ha Mohau: intact.
11. Ha Letsika: no tap, roof of protection is damaged.
12. Topa: no tap, several leakages, not streaming well (1 litre in 56 seconds).
13. Topa: no tap (instead they use a piece of wood), roof of protection is damaged.
14. Shoella: intact.
15. Ha Makolana: no pipe, no tap, roof of protection is damaged.

7.5.2. Village Water Supply

15. Methalaneng School: tap is damaged.

The other 14 protections are intact.

8. DISCUSSION

8.1 Preface

In this study we visited 58 water provisions with different kinds of protection in the Mantŝonyane area, Lesotho (unprotected springs, springs protected by St. James' Mission Hospital and springs protected by Village Water Supply). We only took 1 sample of every spring, therefore the results are only a single point in time. They don't give complete knowledge of water supply systems.

Sampling was done during the month November 1989, which means the beginning of summer. Rainfall in Lesotho is associated with summer, furthermore there is a marked tendency for diarrhoeal disease and typhoid to peak in the wet, warm months.

According to a study in 1974 by Richard Feachem, on average, unimproved water sources have five times higher concentrations of faecal bacteria in the wet season than they do in the dry season.

Other studies have shown that pollution levels will peak within a few hours after heavy rain and that pollution will be especially high when rain has followed a dry period.

In this case water-borne transmission should peak directly following the first heavy rains which occur in Lesotho in October or November.

8.2 Water quality

- All samples were colourless and the taste and odour were qualified as "not offensive", according to the consumers and investigators.

- pH: There was almost no difference between the pH of the different springs. The average pH was 7.0.

- Turbidity: In only 7 samples of a total of 58 we found a turbidity > 5 N.T.U. (becomes visible to the human eye in a drinking glass).

All these samples contained more than 10 faecal coliforms/100ml. (4 samples contained even more than 200 faecal coliforms/100ml) This means that turbidity could be a reliable indicator of faecal contamination.

- Temperature: In our sampling the temperature of the water was between 12-18°C. The temperature of the springs protected by Village Water Supply ($\bar{x}$ = 15,5 °C) was higher than the springs protected by St. James' Mission Hospital ($\bar{x}$ = 14,8°C) and the unprotected springs ($\bar{x}$ = 14,4°C). A possible cause could be that sometimes we measured the temperature of water coming from a pipe or reservoir instead of from the spring itself.

- Faecal coliforms: This is the most reliable and widely accepted test of drinking water quality.

unprotected: $\bar{x}$ = 64,0 faecal coliforms/100ml
St. James': $\bar{x}$ = 38,6 faecal coliforms/100ml
VWS: $\bar{x}$ = 4,1 faecal coliforms/100ml

WHO claims that for individual or small community supplies, water should be condemned if it is repeatedly found to contain more than 10 coliforms per 100 ml.

If we follow the recommendations of WHO then:
80% of the springs protected by Village Water Supply
60% of the springs protected by St. James'
36% of the unprotected springs
is acceptable!

But according to many, these standards are far too stringent for developing countries and they would lead to the condemnation of the vast majority of their existing rural water supplies.

More sensible would be to apply the guidelines of the "water testing kit - users manual" that claims that a supply is heavily contaminated and requires immediate remedial action if the count exceeds 50 colonies per 100 ml.

If we follow the recommendations of the "water testing kit - users manual" then:

100% of the springs protected by Village Water Supply
73% of the springs protected by St. James'
61% of the unprotected springs
is acceptable!

This means that 0% of VWS, 27% (1 out of 4!) of St. James' and 39% (2 out of 5!) of the unprotected springs require immediate action!

8.3 Village Water Supply

Village Water Supply spring protections are superior to St. James' spring protections, and it gives almost maximum protection of the water quality. But there is more:

- an important issue of VWS is the convenience of the people. They are building a distribution system from the spring into the village.
- they see to community participation and responsibility through a village water committee and a water-minder (see appendix II and III).

8.4 St. James' Mission Hospital

The water quality of St. James' spring protections is better than unprotected supplies. A difference with VWS protections is that St. James' only protects the spring itself, without distribution system.

Unfortunately we found that in most cases the building construction of the protections was very poor. The stones are not well shaped, it is a closed construction without a lid, and the diameter of the pipes is too small.

10 of the 15 protections we visited were damaged! Most of these damages consisted of blocked pipes or taps. Many times the population damaged the entire construction in order to reach the water, having no knowledge of repairing the taps of the lidless construction.

On the other hand, we did not find any obvious relation between a damaged spring protection and its faecal contamination. Most likely contamination occurs through underground, unvisible leakages.

We also have to consider the fact that the protections of St. James' were built between 1982 and 1988, while the protections of VWS in the Methalaneng area were built in 1988-1989 (12 of the 15 elected springs by VWS came from the Methalaneng area).

Other studies claim that 3 years after initial construction, 2/3 of the public water supplies in rural areas of developing countries are no longer functioning, either because of a technical breakdown or because the population has lost interest, neglecting operation and maintenance.

Therefore frequent breakdown are by no means uncommon. It is necessary to learn from past mistakes and to recognize the causes of failure.

8.5 Unprotected springs

According to WHO recommendations ($>$ 10 coliforms/100ml) only 36% of the unprotected springs is acceptable.
For example if we take the Lesobeng area, which has almost nothing but unprotected springs (19 out of 28 samples were taken in this area), we find that 1578 people out of 2218 users of the elected springs are drinking "condemned" water.

These guidelines should always be applied with common sense, particularly for small community and rural water supplies where the choice of source and the opportunity for treatment are limited. Also it would be wrong to condemn a water supply if no better are available.

8.6 Water quantity

Lack of adequate amount of water especially has influence on water-washed diseases (table 1.1). As a tentative estimate, a water supply system for a more or less centralized community settlement would need to have a capacity of about 25 litres per capita per day. It appears from this study that water quantity is no problem factor for protected springs in the Mantŝonyane area:

St. James' spring protections: $\bar{x}$ = 50 litres per capita per day
VWS spring protections: $\bar{x}$ = 75 litres per capita per day

Note: again, these results were gained under "wet" circumstances.

8.7 Latrines

During this survey we visited springs used by 6934 people, having only 40 latrines available. This means that only 3,5% of the households currently have latrines! (one household = 6 persons = 1 latrine).

As a result human excreta are deposited on the surface, possibly causing increased faecal contamination of the underground waters.

9. RECOMMENDATIONS TO ST. JAMES' MISSION HOSPITAL

1. St. James' Mission Hospital must continue to protect springs. Especially in the Lesobeng area it is of great importance to start spring protection, maybe, as in the Methalaneng area, in coöperation with Village Water Supply.

2. St. James' has to improve the building construction of the spring protections:

   - to pay more attention to the shaping of the stones (appendix I)
   - to enlarge the diameter of the pipes to prevent blocking
   - to construct a protection with a removable lid on top
   - solid plastering, especially underground

3. The P.H.C. people of St. James' will have to train a person of the village as a water-minder (appendix III).

4. In the future there should be a complete survey of existing systems so that broken constructions can be repaired.

5. The springs in this study with more than 50 colonies per 100ml should be sampled again in the near future. If, again, they are found to contain more than 50 colonies per 100ml , immediate action should be taken (better protection, closing down of the spring).

6. If any typhoid-diagnosed patients should be admitted to St. James', their spring should be tested immediately by means of the water testing kit, so that action can be taken to prevent new cases.

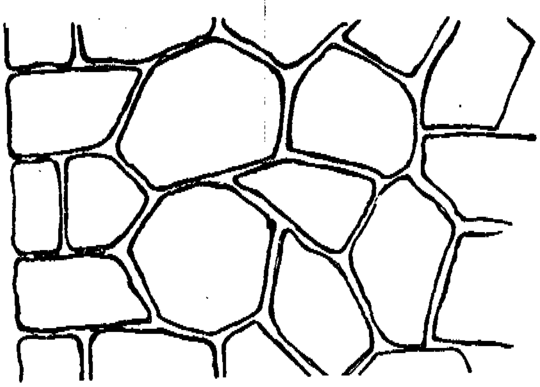
7. There should be a major change in excreta disposal practices: building more latrines.

8. Continue water testing, by means of the water testing kit, under different circumstances (for example dry / wet periods) to see if any changes in contamination occur.

Building with Stones

Uncoursed Rubble Stone Masonry

Only the cornerstones have level horizontal joints, all the other joints must be irregular.

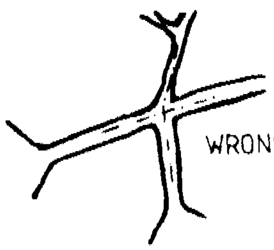


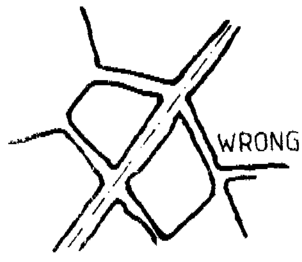
REMARKS: Different kinds of stone masonry have advantages and disadvantages, but for waterworks (tanks etc.) only uncoursed rubble masonry is recommended.

Sandstone can be used practically all kinds of stonemasonry, while other types of stone recommended are more different to shape for bonding. (e.g. dolerite).

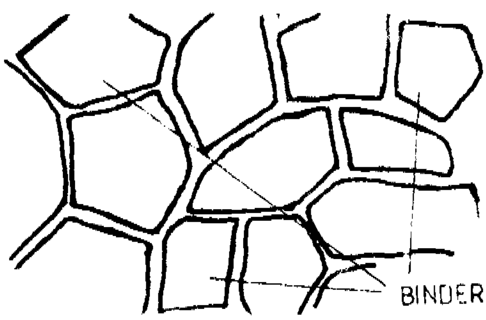
There are also different ways of shaping the front of the stone, but for waterworks we normally cut the face straight and even.

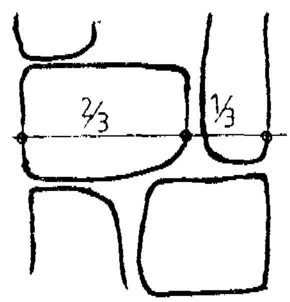
- 4 joints should never come together at the face of the wall. Straight joints longer than 2 stones should be avoided.



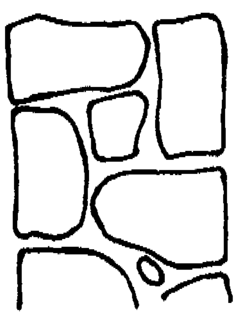


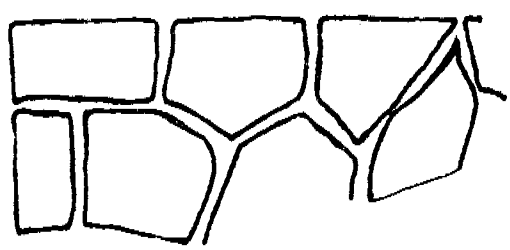
- Every third stone should be a binder. Length of the binders: min. 2/3 of the thickness of the wall.





- The top of the wall should be built with shaped stones which are properly bonded into the rest of the wall.





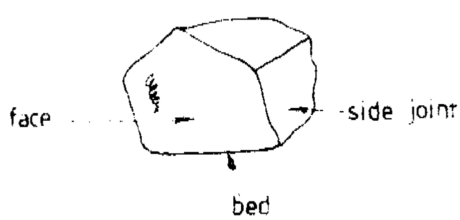
- The overlap of the stones should be a minimum of 10cm in all directions.

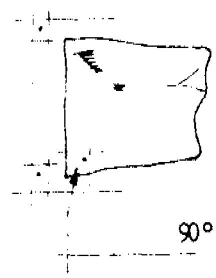
Shaping

- The stones should be broken into pieces which can be carried by one mason.

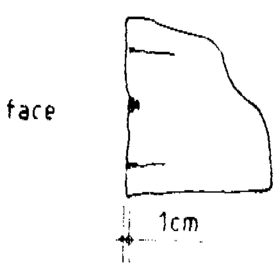
- Get the stones and choose the way you want to shape them.

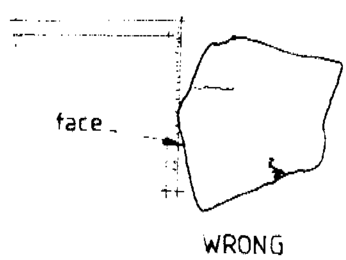
- Cut them roughly at all sides, if possible according to their natural shape. No angle face/joint should be greater that 90°.



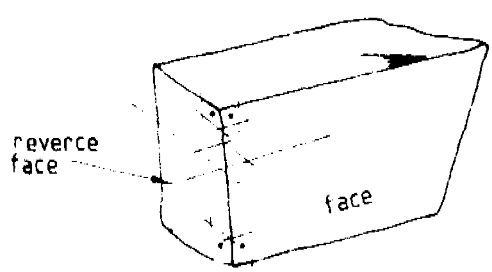


- Dress the face straight, check it with a square or a straight edge. (Depressions up to 10mm are allowed).





- Select the stones which could be used as corners and shape the reverse face.



Rules for Building and Bonding

- Make an exact setting out of the building. Mark the inner and the outer side of the corners. If necessary erect profiles (beveled walls).

- Clean the foundation with a steel brush, wet it properly, if necessary roughen it by chiselling.

- Build the cornerstones inside and outside, make also the backfilling, then hang 2 lines on each side and build in the lines.

- Build up the corners about 1m high, then fill inbetween.

- Stones must always be cleaned (steelbrush) and watered before use.

- Always 2 masons should work on a wall, 1 inside and 1 outside the wall.

- Each mason must have sufficient stones ready, so that he can select the correct shapes.

- The faces and the inner part of the wall must be built at the same time.

- Stiff-plastic mortar should be used. Never fill the inside of wall with slurry mortar.

- The stones should be laid on a mortar bed and then knocked in the mortar with a hammer.

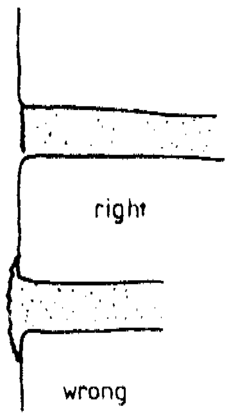
- Wedges on the face of the wall are not allowed.

- Joints should be 1.5 - 2.5cm thich (depending on the type of the stone).

Pointing

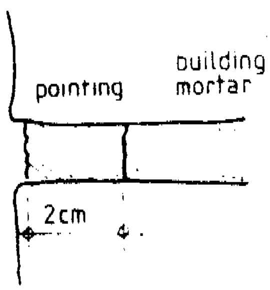
For uncoursed rubble stone masonry we normally use flush or keyed pointing.

flush pointing



It is normally used, where the wall be backfilled. It can be done after building, before the mortar has set. Be careful: Do not overfill the mortar as shown on sketch (b).

Keyed pointing



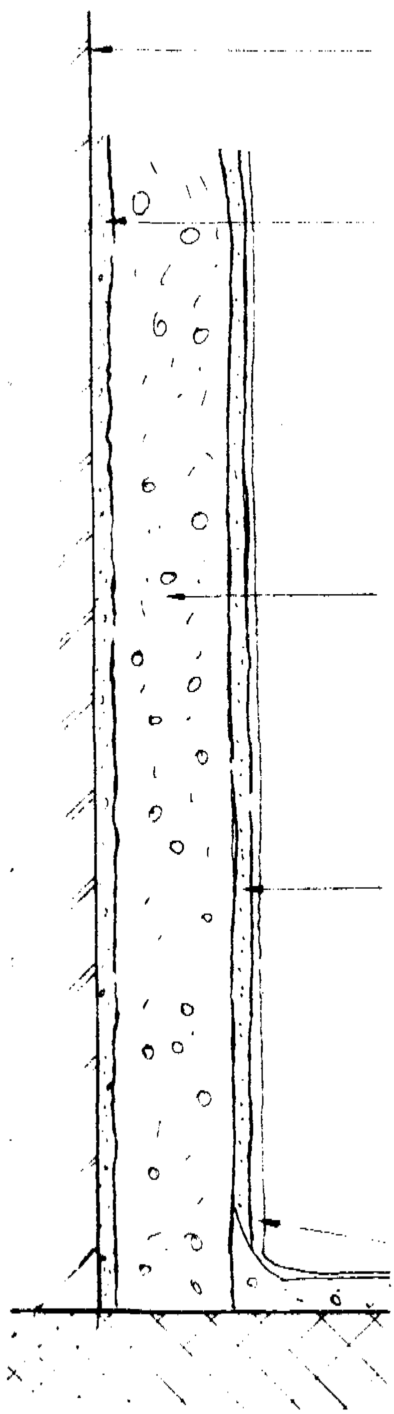
The joints are scratched out after building 2-3cm deep. They are filled with fine, rich mortar, about 2-5mm inside the stones. The joints are then carefully smoothed with the pointing trowel, so that the wall is properly sealed.

Remarks: When the pointing is done later, the joints have to be cleaned with a steelbrush and watered before applying the mortar.

Plastering

VWS structures are plastered in order to make them completely waterproof and get a smooth surface which can be cleaned easily.

The different coats and their functions



Walls
Surface must be rough, clean, dustfree and wet.

Spatterdash
2-3mm thick, it is the waterproof coat of the tank and the key for the rendering. Prepare a mortar slurry. If necessary apply two times. Allow to cure for 10 days.

Rendering coat
1.5-2cm thick. That allows the construction of a straight, flat surface. Do not float the rendering.

Setting coat
2-3mm thick. This makes a smooth surface and a key for the cement paste. This coat can be applied as soon as the rendering has set. Proper floating is required!

Cement paste
Apply immediately after the setting coat is floated. Apply it as a slurry, not thicker than 1mm.

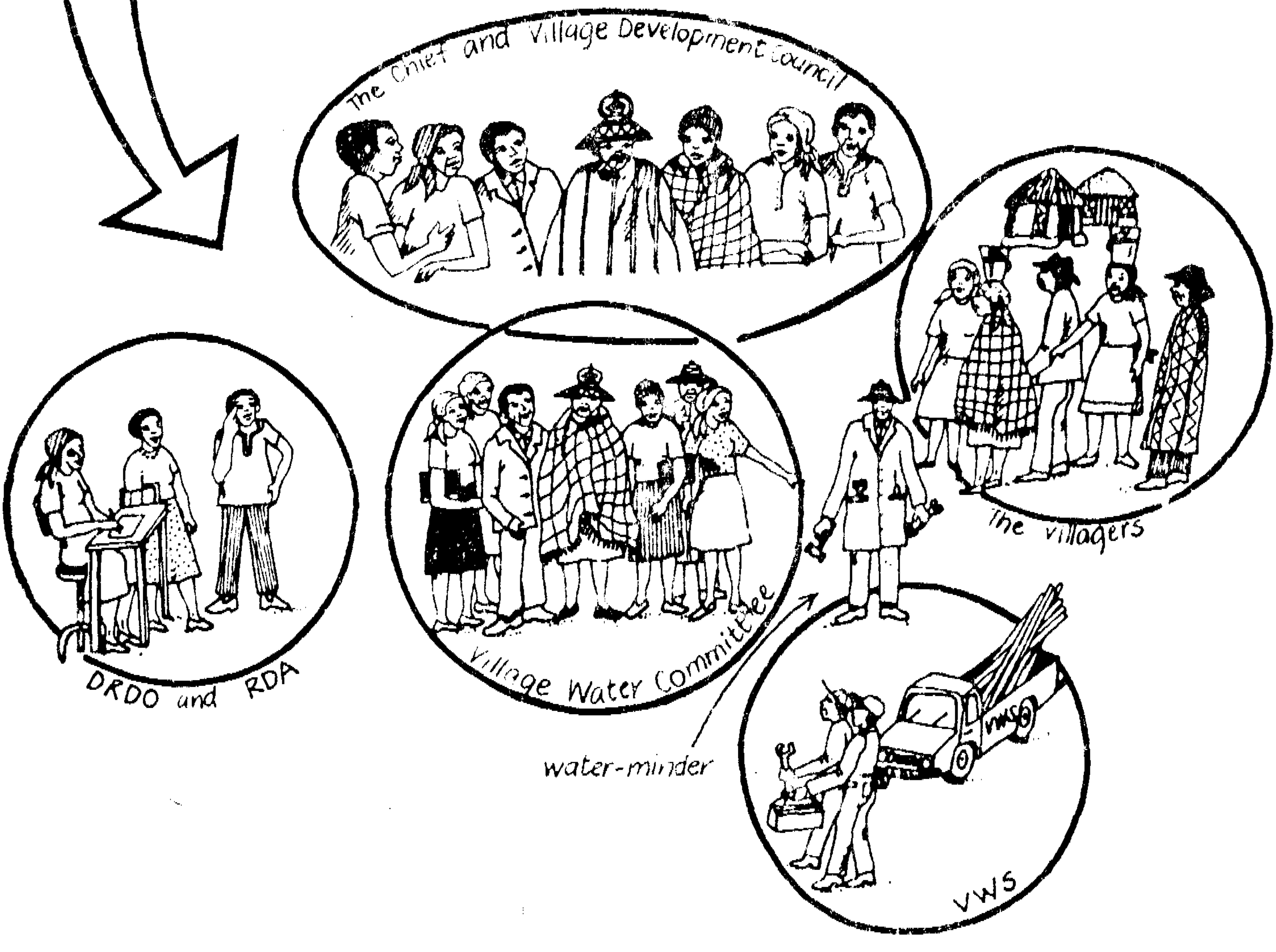
THE IMPORTANT PEOPLE IN VILLAGE WATER SUPPLY

In addition to you, the committee, there are four important groups which are responsible for the village water supply. The groups are:

- The Chief and the Village Development Council
- The villagers
- The Rural Development Office workers (DRDO and RDAs)
- Village Water Supply Section (VWS)

All these groups are linked by you, the Village Water Committee. Your committee is directly responsible to the chief and the Village Development Council.

Let us briefly look at the role of each group in the village water supply work. The picture shows your committee in the middle, working with all these people.



The Chief and Village Development Council

- The work of these people is to plan and coordinate all development activities in the village. All other development committees are responsible to the chief and to this council. For example: a community garden committee, a school committee, and a village water committee would all fall under the Village Development Council.

  The chief, with the assistance of the Village Development Council, must call all the pitsos, including one for election of the village water committee. They are the ones who should approach the government about new development projects for their village. They should also support the committee in organizing water supply work and enforcing rules.

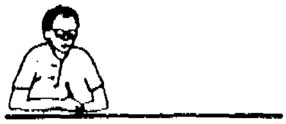
The villagers

- The villagers elect the water committee. This committee organizes the community in all the work that is involved with village water supply. For example digging furrows, shaping stones, and covering the pipes.

  Every household is supposed to contribute some money which will be used for maintenance of the water supply. The people should agree on the amount of money they will contribute for seabo and write it in their rules. The amount must not be less than what the Village Water Supply Section recommends for their system.

  The villagers are the owners of the water supply in their own villages. Therefore they are the ones who should take care of their water system.

Rural Development Office



The people who are directly responsible in this office are the District Rural Development Officer (DRDO) and the Rural Development Assistants (RDAs).

Their work is to explain government policies, to motivate the community for village water supply work, and to encourage those who seem reluctant.

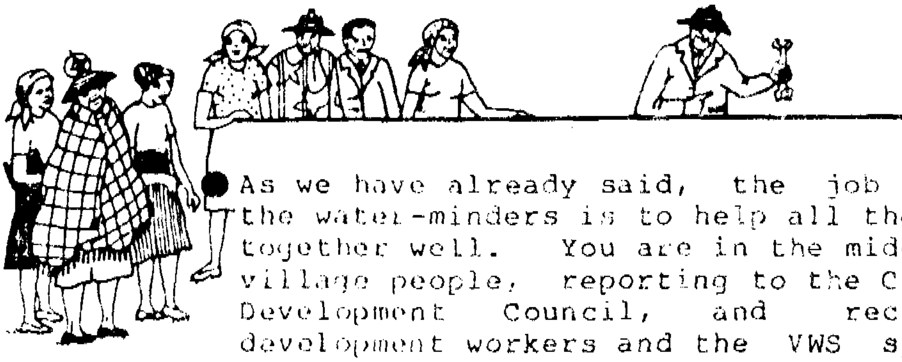
They will help you to make bylaws which are understandable and realistic. They can help you know how to organize the people for construction work, and how to keep good records of labour and money. In their office they keep a file in which they record all the information about your water supply system--like letters, financial reports and your bylaws-- so that they can give you any other help you may need.

Village Water Supply Section (VWS)

The Village Water Supply Section is called VWS for short. The people who work for VWS are specialists in water supply work. They may be masons, foremen, construction supervisors or engineers.

Their work in the village is to draw a proper plan for the system. Then they will work together with the people to construct the village water supply. They may also come back later to make repairs if anything is broken which the water-minder cannot fix.

The Village Water Committee and Water-minders



As we have already said, the job of the committee and the water-minders is to help all these groups to work together well. You are in the middle, encouraging the village people, reporting to the Chief and the Village Development Council, and receiving the rural development workers and the VWS specialists whenever they come. The whole work of organizing village labour for construction, collecting and taking care of the money, and then taking care of the system depends on you.

The next chapter gives the official policy of the Village Water Supply Section which guides their work in the villages. It also explains the "village selection criteria". This means the things which are considered in deciding which villages will get help soon in building their water systems. It is important for you to understand this policy, so you can explain about village water supply work to the people.

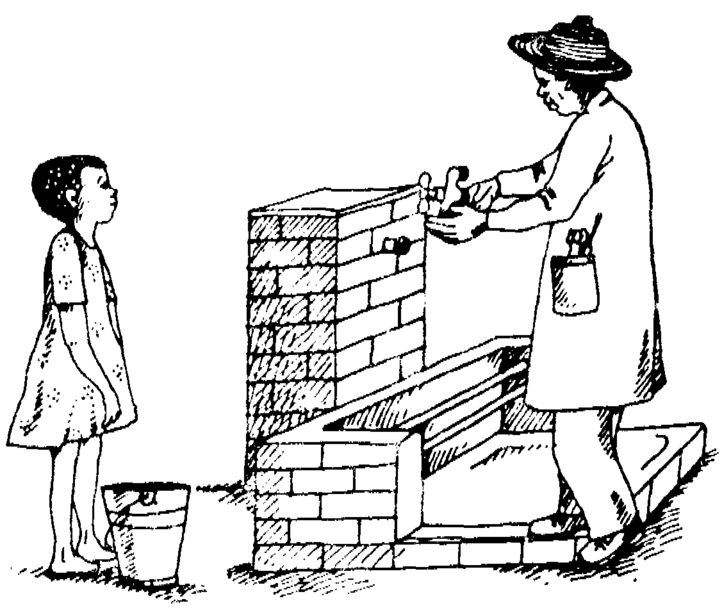
The Water-minder

This person does not have to be a member who attends all the meetings of the committee. But since his work is to take care of the water supply system, he should discuss his work with the committee and make decisions together with them. For example: suppose there is insufficient water. The water-minder will have to sit with the committee to agree about when they will open the taps and when they will close them.

Unlike other members of the committee who are elected by the villagers, he is selected by the committee together with the Engineer or VWS Supervisor.

The work of the water-minder is:

- to inspect the water supply system regularly to make sure that everything is clean, in good condition and working well.
- to send a report about the condition of the system to the Village Water Supply Office when required.
- to make simple repairs for which he has been trained. The committee should send people to help him if necessary-- for example to move stones or dig new furrows. They should also pay for materials needed for simple repairs
- to report major breakdowns to the committee, which will arrange for someone to report the problem quickly to the Village Water Supply Office or Rural Development Office.



VILLAGE WATER SUPPLY POLICY AND SELECTION CRITERIA

1. The VWS helps people to construct their own water systems. It does not construct water systems for them.

2. The VWS provides the materials for construction, the transport of materials, and the skilled workers such as masons, foremen, supervisors and engineers.

3. The villagers contribute labour for construction as well as providing their own simple tools, storage space for equipment and materials, and accommodation for masons and foremen.

4. The villagers contribute money to a maintenance fund to pay for repairs if the system breaks down. The village should keep this money in a bank account.

5. In systems with diesel or electric engine pumps, the villagers must pay the monthly costs to keep the system running.

6. The engineers of VWS will make the decision about what type of water system to have in each village. This is because they have the technical knowledge and experience to know the best way to provide enough water in each location.

7. The location of water taps is decided by the Village Water Committee in consultation with the VWS engineer, according to the number and spacing of houses.

8. The people who plan the water system will try to have at least one standpipe for every 30 households in gravity systems.

9. In handpump systems they try to have one pump for every 20 to 25 households, if water can be located underground.

10. No taps will be placed in private homes or yards by the Village Water Supply Section.

11. When a water supply system is completed, it belongs to the people, not to the government.

12. At least two village water-minders will be selected by the Water Committee in cooperation with the VWS engineer and foreman. They will be selected and trained during construction.

13. The water-minders are responsible for basic operation and care of the system, as well as making simple repairs and reporting serious breakdowns.

Village selection criteria for district priority lists

About once in every two years each District makes a list of the villages in which new water systems will be built. These lists are made cooperatively by the District Rural Development Officer, the VWS District Engineer, and the District Development Council.

The following points help those people who are in charge to decide which villages should be on the priority list:

1. Genuine need

- Does the present water source often dry up because of drought?
- Is the present water source more than 500 meters from most households?
- Is the present water source unsafe because it is below village latrines or dirty dongas?
- Have there been cases of sickness because of bad water?
- Is there a school or a clinic which would also need this water?
- Are there at least 400 people in the lowlands, or 150 in the mountains, who would use the new supply?

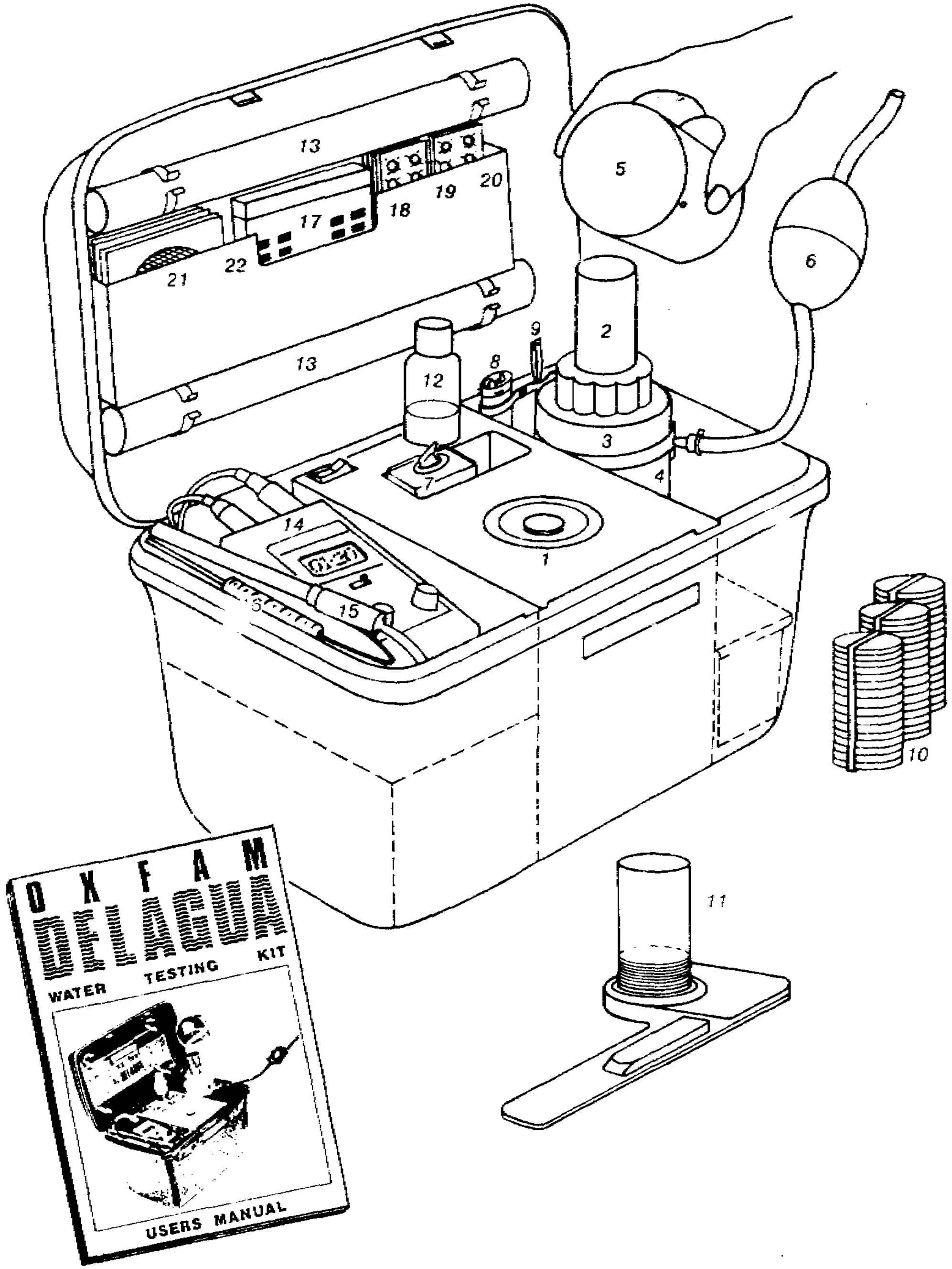
2. Community interest and willingness to work together

- Has a written application been made to the DRDO?
- Is there a Village Water Committee?
- Are the people willing to contribute labour and money?

3. Technical possibility of building a system in this village

- Can vehicles drive into the village to bring materials?
- Is there an adequate spring or supply of underground water?
- Would the cost of this system be reasonable?
- If possible, can a system be built without requiring expensive engines and pumps?

The Oxfam/DelAgua Water Testing Kit



Contents of the Water Testing Kit

(The bracketed numbers (1) to (24) in this list correspond to those in the diagram opposite.)

User's Instruction Manual

Equipment Box
Dimensions: 370 × 140 × 260 mm.
Weight: approximately 10 kg.
Construction: Polypropylene case with handle and hinged lockable lid. The case contains a built-in incubator and storage compartments for equipment.

***(1)* Incubator**
Capacity: 16 No. 55 mm diameter aluminium Petri dishes with carrier.
Temperature: 44°C.
Power supply: 12 volt from built-in rechargeable battery capable of 5 × 16 hour cycles or 12 volt vehicle battery via leads supplied.

Battery Charger
240 volt A.C. input, 12 volt D.C. output.

Filtration Equipment
(2) Filter funnel, stainless steel with locking polypropylene collar, 100ml capacity, graduated at 50ml.
(3) Filter base, aluminium.
1 No. O-ring gasket *(inside 3)*.
2 No. annular silicone rubber gaskets *(inside 3)*.
Membrane support disc, brass *(inside 3)*.
(4) Filter vacuum flask, stainless steel, capacity 500ml.
(5) Sample cup and cable, stainless steel, capacity 500ml.
(6) Suction pump, rubber.
(7) Methanol dispenser.
(8) Gas lighter.
(9) Forceps, stainless steel.
(10) 3 No. sets Petri dishes, 16 No. each, aluminium, and carriers, aluminim.
(11) 2 No. broth pad dispensers.
(12) Autoclavable media bottles for 1 batch of 500ml of broth.

Equipment for measuring turbidity
(13) 2 No. 30 cm plastic tubes to be push-fitted together; calibrated 5-2000 T.U.

Equipment for measuring conductivity and temperature
(14, 15, 16) Hand-held meter with conductivity and temperature probes.

Equipment for measuring pH and chlorine residual
(17) Comparator with permanent colour markings.

Consumables, 1 No. pack
- *(18)* 250 No. phenol red tablets, foil-packaged, for pH determination.
- *(19)* 250 No. DPD1 tablets, foil-packaged, for free chlorine residual.
- *(20)* 250 No. DPD3 tablets, foil-packaged, for total chlorine residual.
- *(21)* 200 No. membrane filters.
- *(22)* 2 No. sachets *membrane Lauryl Sulphate Broth* 38.1 grams each for 500ml broth.
- *(10)* 3 No. sets Petri dishes, 16 No. each, and carriers, aluminium.
- *(11)* 2 No. broth pad dispensers.
  200 No. broth pads *(inside 11).*
  1 No. set 3 No. gaskets.
  1 No. brass membrane support disc.
  Report sheet. Format shown opposite and on page 34 of User's Manual.

Packs of consumables and additional information on the kit can be obtained from:

DelAgua,
The Robens Institute,
University of Surrey,
Guildford GU2 5XH,
U.K.
Telephone: (0483) 572823 or 571281
Telex: 859331 UNIVSY G
Fax: (0483) 300803

Typical DelAgua water quality report

	1	2	3	4	5	6	7	8	9	10	11
1	Health Regi	on:	______		Water	Autho	rity:	______			
2	Date:	______									
3	Province:	______									
4	Community	______									
5											
6	Source	Time	Aspect	Taste	Turbi	Chlor	Chlor	temp	pH	Conduc	Coli
7	of			Odour	dity	free	total	ºC		tivity	fecal
8	Sample				NTU	mg/l	mg/l			uS/cm	/100ml
9											
10						.	.	.	.		
11						.	.	.	.		
12						.	.	.	.		
13						.	.	.	.		
14						.	.	.	.		
15						.	.	.	.		
16						.	.	.	.		
17						.	.	.	.		
18						.	.	.	.		
19						.	.	.	.		
20						.	.	.	.		
21						.	.	.	.		
22						.	.	.	.		
23						.	.	.	.		
24						.	.	.	.		
25											
26											
27	Sanitary Inspection Report										
28	Province:	______									
29	Community:	______									
30	OBSERVATIONS:										
31											
32	Source:	______									
33											
34	Treatment	______									
35	plant:	______									
36		______									
37		______									
38	Disinfection:	______									
39	Reservoir:	______									
40	Distribution:	______									
41											
42	UNSATISFACTORY RESULTS:	______									
43	RECOMMENDATIONS:	______									
44											
45	Date:	______			Inspector/		Analy st:	______			

appendix V.2

UNPROTECTED SPRINGS

1. Ha Muso
2. Lekhalong
3. Liphakoeng
4. Ha Makuoe
5. Hloahloeng
6. Phomolong
7. Ha Makhala
* 8. Tsirela
* 9. Lilomong
10. Ha Mafa
*11. Ha Nthoana
12. Ha Choko
*13. Ha Molupi
*14. Ha Mothibeli
15. Motse-Mocha
*16. Hleoheng
*17. Hleoheng
18. Matseng
19. Ha Ntsohoane
20. ..uplasi
21. Ha Ramotlau
*22. Matekane
23. Ha Poho
*24. Ha Letuka
25. Ha Mosiroe
26. Letlapeng
27. Masaleng
*28. Taung
*29. Ha Phefu
30. Phororong
31. Letlapeng
32. Ha Fisanne
*33. Ha Sehlahla
34. Lefikeng
*35. Ha Khomari
36. Manganeng
37. Ha Koona
38. Ha Sekhonyana
39. Kholokoe
40. Ha Makione
*41. Mapetleng
*42. Makhoaeleng
*43. Ha Nyolo
44. Ha Lali
45. Ha Mosa
*46. Ha Motsiba
47. Phomolong
48. Ha Seile
*49. Moeaneng
*50. Maloaloaneng
51. Ha Nokoane
52. Ha Lebusana
53. Ha Nang
*54. Kharmolane
55. Ha Motola
56. Thaba-Ntso
*57. Ha Rammuso
*58. Ha Marumo
*59. Ha Chejana
60. Ha Ngoato
61. Thoteng
62. Ha Mpeoli
63. Ha Sephoko
64. Tsekong
65. Ha Foofo
66. Ha Putsoa
67. Hleoheng
*68. Tlhakoaneng
69. Litsoeneng
70. Sekokoaneng
71. Mahooaneng
72. Tutulung
73. Tseng-la-Mataba
74. Bareng
*75. Ha Mothae
*76. Ha Mothae
*77. Liphakoeng
78. Meseeaneng
79. Ha Mpho
80. Ha Maseru
81. Likamoreng
82. Ha Tebeli
*83. Makhoaeleng
*84. Tsekong
*85. Pontŝeng
86. Thaba-Bosiu
87. Kholoaneng-ea Lehaha

* = selected springs

SPRING PROTECTIONS CONSTRUCTED BY ST. JAMES' MISSION HOSPITAL

101. Ha Muso
*102. Lihloaeleng
103. Lihloaeleng
104. Ha Mahlong
105. Makoetjaneng
*106. Ha Makolana
*107. Ha Long
*108. Ha Long
109. Ha Toka
110. Ha Mokotana
*111. Ha Mokotana
*112. Ha Mokotana
*113. Topa
*114. Topa
*115. Shoella
116. Bloubere
117. Ha Letsika
*118. Ha Letsika
119. Ha Khupiso
120. Qobacha
121. St. Peters RC Sch.& Ch.
*122. Ha Mohau
*123. Ha Mohau
*124. Ha Thebeeakhale
*125. Ha Thebeeakhale
126. Malimong
*127. Ha Seoka

* = selected springs

appendix VI.3

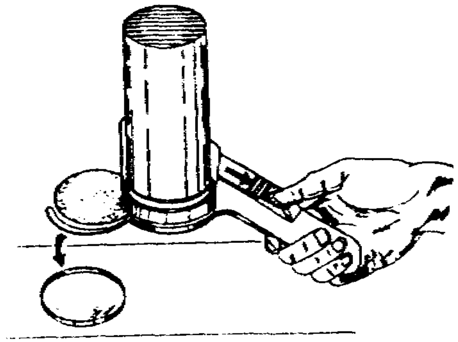
SPRING PROTECTIONS CONSTRUCTED BY VILLAGE WATER SUPPLY

201. Ha Kou
202. Ntsoenereng
203. Tiping
204. Ha Moshabata
*205. Ha Lethibella
*206. Ha Toka
*207. Mantŝonyane
208. Mantŝonyane
209. Ha Tsoarelo
*210. Ha Mokhoro
211. Ha Mokhoro
*212. Ha Leronti
*213. Methalaneng Sch.& Ch.
214. Ha Tita
215. Ha Tita
216. Ha Sekharume
*217. Ha Sekharume
*218. Sehlabeng-sa-Hae
*219. Topa
220. Topa
*221. Matebeleng
*222. Ha Mahapela
223. Ha Mahapela
*224. Methalaneng Clinic
225. Ha Marontoane
226. Ha Kou
*227. Shoella
*228. Ha Ntsilile
*229. Ha Ntsilile
230. Khohlong
231. Litenteng
232. Ha Lephoi
233. Ha Lephoi

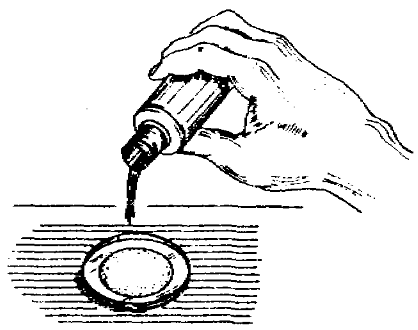
* = selected springs

Sample Processing for Faecal Coliform Analysis in the Field

1. Using the absorbent pad dispenser, place one pad into each petri dish (this is normally done in the laboratory before leaving for the field). If the dispenser becomes damaged the pads can be dispensed using the forceps.

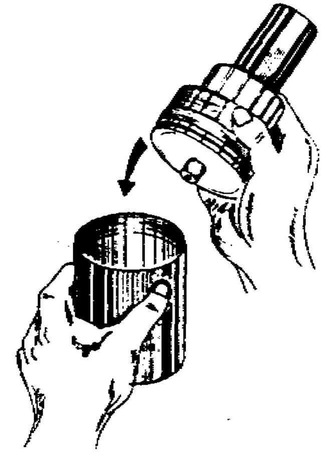


2. Pour enough culture medium to soak the pad in excess, onto the absorbent pad in the petri dish (approx 2.5ml). Replace the bottle cap immediately. Do not allow the bottle neck to come into contact with any external objects. Immediately before processing a sample, drain off most of the excess medium by inverting each dish with the lid removed. However, always ensure that a slight excess remains to prevent drying of the pad during incubation.



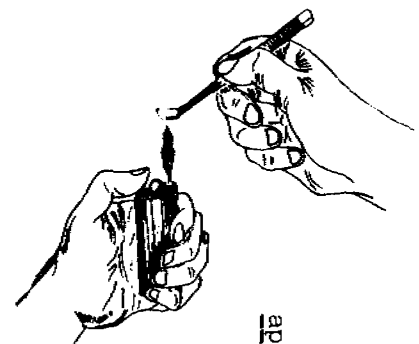
Once the bottle of culture medium has been opened it is recommended that the contents are used within a period of one day. It is not advisable to use the medium in one bottle over several days since this can lead to contamination.

3. Remove the sterile filtration cup from the filtration apparatus. Push the filtration apparatus firmly onto the vacuum cup (the rubber sealing ring may need some silicone grease). Place the assembly in an upright position in a convenient place in the kit. Do not place the apparatus on the ground where it may become soiled.

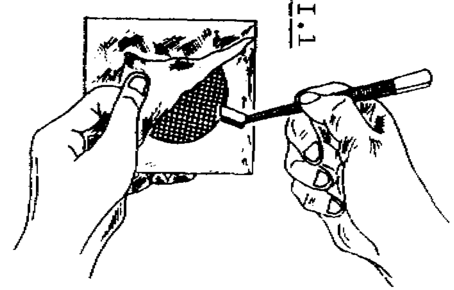


4. Unscrew the plastic collar and filtration funnel in order that these may be easily removed. Do not place these on any surface other than the filtration base.

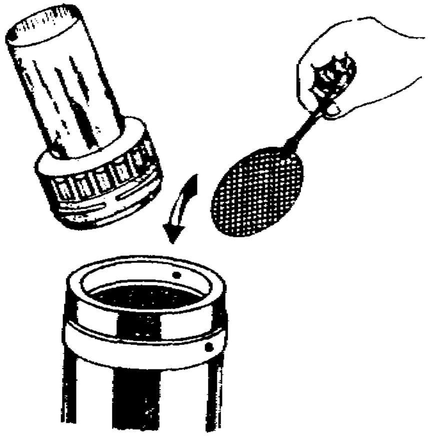
5. Flame the tips of the forceps with the lighter.



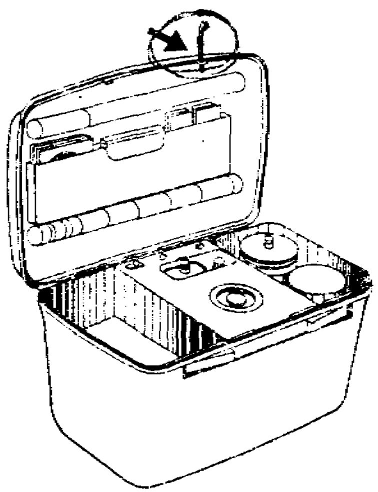
6. Using the sterile forceps, carefully remove a sterile membrane filter from its packet. Hold the membrane only by the edge.



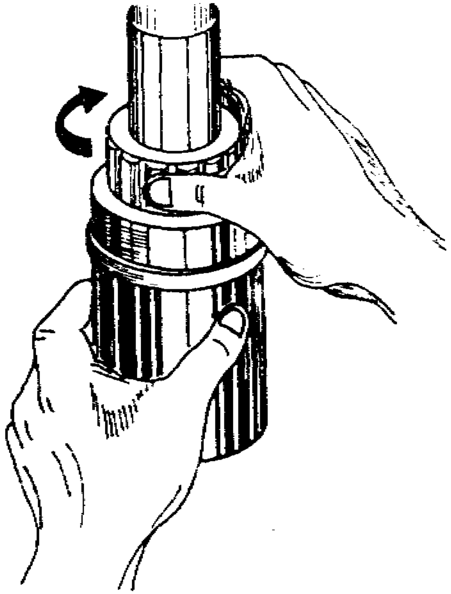
7. With one hand lift the filtration funnel and plastic collar above the filtration base. With the other hand holding the forceps, place the membrane filter (grid side uppermost) onto the bronze disc filter support. Replace the funnel and collar immediately without allowing them to come into contact with any external objects.
It is normally convenient to hold the funnel between the thumb and forefinger which ensures that the collar will not slip off and that the fingers do not come into contact with the interior surface of the funnel.



8. Place the heel of the forceps into the test kit case as indicated. This ensures that the tips are kept away from all sources of contamination whilst analyses are in progress.



9. Screw the plastic collar down tightly to hold the membrane and to provide a water tight seal.

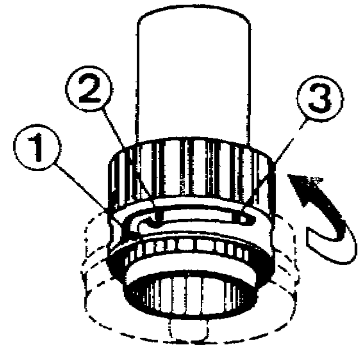


Note: The plastic collar has three adjustment positions:

1. Fully tightened – the funnel forms a tight hermetic seal between the membrane support and the membrane filter. This is the position for filtration.

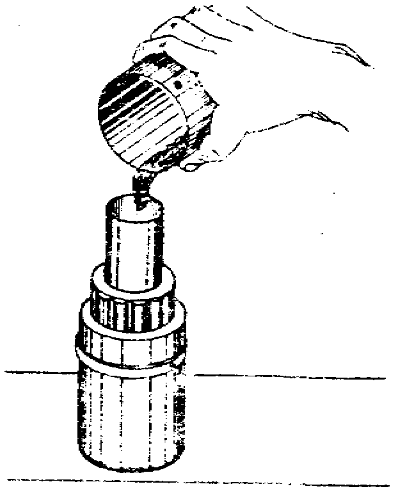
2. Loose but not free – All interior surfaces are exposed to the atmosphere. This is the position used when sterilising the apparatus.

3. Completely free – The apparatus can be dismantled when in this position.

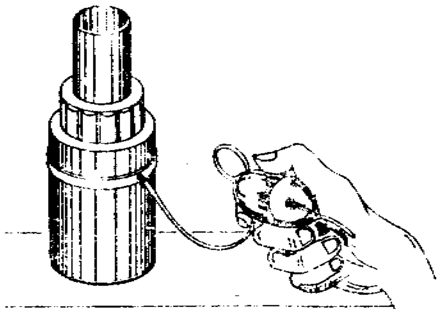


10. Rinse the sterile sample cup once with the water to be sampled and then fill the cup with the water. Take care not to allow external contamination to enter the sample cup eg. dirt and debris.

11. Pour the sample into the filtration funnel up to the appropriate mark (10, 50 or 100ml) engraved on the internal surface of the funnel. Take care not to allow external debris to enter the funnel.

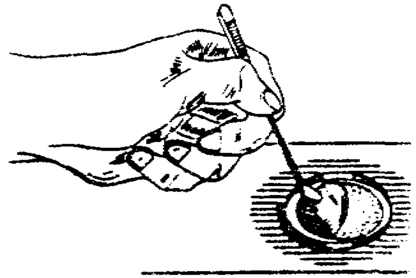


12. Insert the plastic connector of the vacuum pump into the vacuum connection on the filtration base. Squeeze the pump bulb several times to draw a vacuum and squeeze as required to draw all the water through the membrane filter. When all the water has passed through the filter, disconnect the pump from the filtration apparatus.

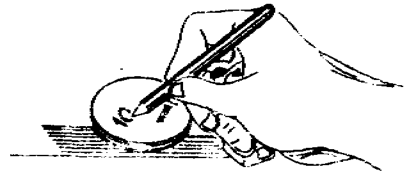


13. Unscrew the collar and remove the funnel and collar with one hand. Using the forceps in the other hand, lift the membrane carefully from the filtration base. Hold the membrane by the edge only.

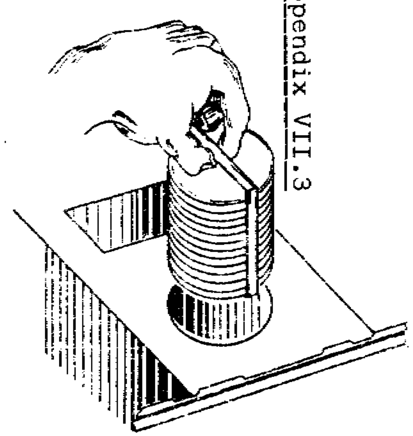
14. Remove the lid of a pre-prepared petri dish and place the membrane (grid side uppermost) onto the absorbent pad soaked in culture medium. Start at one edge and lower the membrane gently so as to avoid trapping bubbles under the membrane.



15. Replace the lid of the petri dish and mark the lid with sample information eg. volume, source, time or a code which relates to details on the daily report sheet. A wax pencil or marker pen is suitable for this purpose.



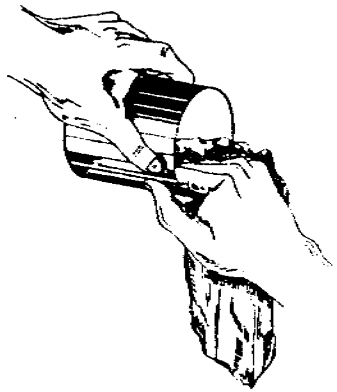
16. Place the petri dish with the lid uppermost into the carrier and return the carrier to the incubator pot. Replace the incubator lid.



Re-Sterilisation of the Filtration Apparatus

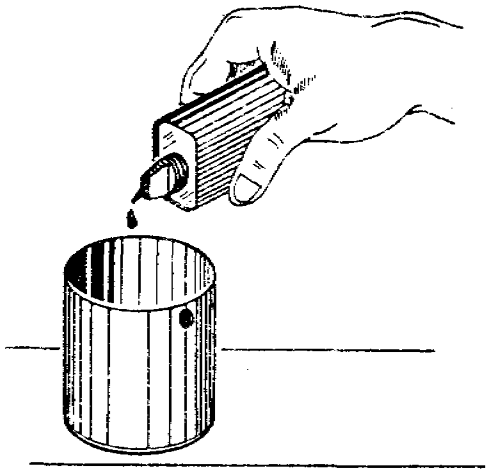
The sample cup and the filtration apparatus must be re-sterilised between samples when analysing water from two different sources.

1. Carefully dry the sample cup and the filtration assembly with a clean, dry towel or tissue.

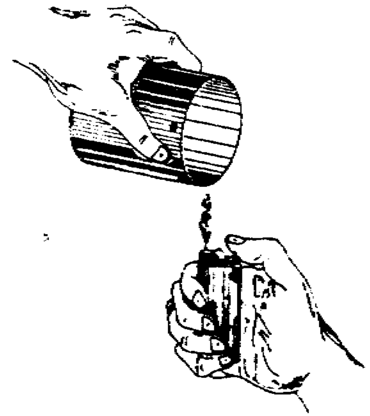


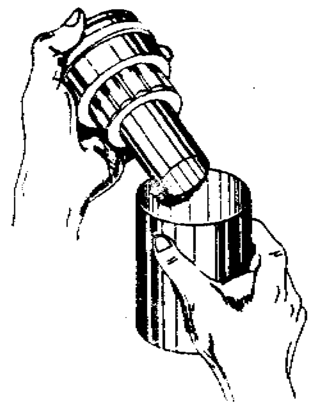
2. Using the plastic collar, secure the filtration funnel in the second position (see page 17) to allow the sterilising agent to penetrate.

3. Pour 1ml (approximately 20 drops) of methanol into the sample cup.



4. Carefully ignite the methanol in the sample cup using the lighter. **Caution** Keep the mouth of the cup away from your face. Place the cup on a flat surface which will not be harmed by heat.





5. Allow the methanol to burn for several seconds and when almost completely burned up, place the filtration apparatus over the sample cup and push firmly into place to form a tight seal.

The methanol burns in the absence of excess oxygen to form formaldehyde vapour which disperses throughout the filtration apparatus to sterilise all internal surfaces.

6. Keep the filtration apparatus in the sample cup for at least 15 minutes before using to process a sample.

It is convenient to sterilise the filtration apparatus immediately after each analysis and to keep the filtration apparatus in a sterile condition during transport and storage. In this way, the filtration apparatus is always ready for use and time is used in the most efficient manner.

The use of too much methanol will result in a residue being left in the sample cup and filtration apparatus after sterilisation. The ideal volume of methanol to use will be determined in the light of experience.

REFERENCES

- Feachem, R. Water, Health and Development. An interdisciplinary evaluation. (1978).

- Huisman, L. Small Community Water Supplies. International Reference Centre for Community Water Supply and Sanitation. (1981).

- WHO. Guidelines for drinking-water quality. Volume 3. Drinking-water quality control in small-community supplies. (1985).

- M.B. Consulting for US..ID, Maseru. Village Water Supply Management Handbook. (1987).

- Village Water Supply Section. Instruction Manual for Mason. (1988).

- OXF..M. Delagua Water Testing Kit, users manual. (1988).

- Year Report 1988. St. James' Mission Hospital, Mantŝonyane.