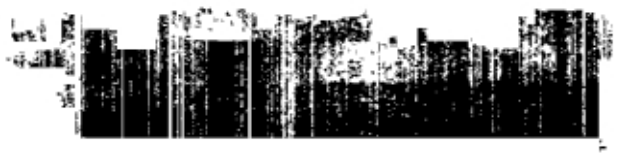

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1. EXECUTIVE SUMMARY

General

The environment of the islands of Zanzibar quite unspoiled, but at the same time very sensitive and there are risks to be taken into account in future development activities.

The Urban Water Supply Project will in its operations improve the environmental situation of Zanzibar. On the other hand the project may also create new environmental and health problems or add to the existing ones, if proper care is not taken.

The only feasible source for drinking water is ground water. No reliable surface resources exist.

Main problems

The main problems identified during the study were those related to the quality of ground water. Almost all the water intakes of urban water supplies of Unguja and Pemba are bacteriologically polluted, and therefore the networks as well. The pollution may also take place within the network due to pipeline leakages and unhygienic storage tanks. The microbiological pollution of drinking water can be considered the most acute water-related health problem for the public at the moment.

The chemical quality of the groundwater is generally good. One potential problem is the intrusion of sea water into the groundwater, but no alarming results were found at present. One chemical identified from the water samples of the Zanzibar Town supply scheme has been chromium, which may be due to chemical pollution from industrial waste waters. There is a potential risk of pollution of groundwater by agrochemicals.

There are also some other chemical aspects, such as the existence of calcium, which is mainly a technical and aesthetic problem, but may also be of significance to health. Iron and manganese are high in some sources.

There may be other potential negative effects brought along with the construction and other activities of the project, if the environmental aspects are not properly taken into account during the implementation.

Recommendations

The main aspects to be emphasized in the planning and implementation of the project are:

- the selection of sites for water intakes by taking into account the risks caused by industrial, agricultural, forestry and other human activities in surrounding areas and by taking into account the water quality results of the intakes

- protection of intakes by creating protection zones around them to avoid pollution of water sources, and also protection of all other open sources such as local shallow wells, which may pollute the groundwater sources

- chlorination of the water systems to ensure the microbiological safety of the drinking water

- continuous consideration of environmental issues and continuous environmental monitoring (including water quality monitoring) throughout the project

- increased environmental awareness among authorities, project implementators and communities

- planning and coordination of activities and cooperation with other sectors

2. INTRODUCTION

The purpose of this study is to provide information about environmental issues to assist in decision-making and implementation of the Urban Water Supply Project of Zanzibar, with the ultimate purpose of supporting in achieving the objective set for the sub-project " water resources and environmental development":

"To guarantee the adequate share of water resources for urban water supply and improve the environmental and health status of the Unguja and Pemba islands by improving water quality and to minimize any possible environmental deterioration due to the project activities."

From the environmental and health point-of-view the impacts of the water supply project are more beneficial than adverse, and the project will assist in solving some of the environmental problems already identified in Zanzibar. However, some negative impacts can also be foreseen, if proper care is not taken, concerning environmental aspects. They will be discussed further in the following chapters.

The study was carried out during the planning phase of the Urban Water Supply Project for Zanzibar. The following other studies were also underway at the same time:

- Water Resources Study
- Institutional Study
- Household Survey
- Physical Planning of Water Supplies
- Economic Plan

All these studies complement one another. Some aspects related to environmental questions, which are not thoroughly discussed in this report, are presented in other study reports (e.g. more detailed hydrogeological aspects are presented in the Water Resources Study, the Institutional Study will include aspects of education and planning, etc.).

The environmental study was carried out by Auli Keinänen, Environmental Hygienist from Plancenter Ltd. The consultancy assignment was for two months (see Terms of Reference, annex 1).

The present study can be considered a basic survey of environmental issues related to project activities. Further environmental studies will be needed, as recommended in chapter 6.

The data for the study was collected by visiting institutions, interviewing people, visiting field sites, analyzing water quality results, reviewing literature and working together with the personnel of the project and the Department of Water Development.

The following chapters will first give an introduction to the project as planned. After that an overview of the environmental problems of Zanzibar is given, followed by a review of specific problems related to groundwater quantity and quality. The last part of the report deals with future predictions and recommendations concerning environmental considerations during the project. The last two chapters give lists of institutions visited, persons consulted and literature reviewed.

The main concern during the study period has been to obtain as much groundwater quality data as possible during this stage - before starting the effective pumping of groundwater or before starting any other project activities. This provides reliable foundational data for following up any possible changes in water quality. Suggestions for water quality monitoring in the future are also included in this report.

3. PROJECT DESCRIPTION

3.1 Project Background

The Government of the United Republic of Tanzania has requested FINNIDA to consider financing the first implementation phase 1991 - 1994 of the Urban Water Supply Project of Zanzibar, which is a part of the overall Zanzibar Urban Water Supply Programme.

The planning phase of the project took place in 1989 - 1990 consisting of Financial Analysis, Institutional Study, Water Resources Study, Physical Planning and Environmental Impact Assessment. These different components are be compiled in the Urban Water Supply Development Plan.

3.2 Macroeconomic background of Zanzibar

The economy of Zanzibar is dominated by agriculture, principally the production of cloves. Due to many economic setbacks over the last years, the governmental and parastatal bodies have had difficulties generating sufficient revenue to meet expenditure needs. To improve the situation the Government commenced an economic recovery programme in 1987. The main targets of the programme are reducing subsidies on imported food and stimulating home production, controlling government spending, and developing the private sector, especially concerning non-agricultural sectors as well as liberalizing trade through the removal of state controls.

3.3 Project justification

The present water supply system is comprised of four urban schemes, one in the town of Zanzibar on Unguja island and one in each town of Pemba island (Wete, Chake Chake and Mkoani). The conditions of the schemes are poor and water quality is bacteriologically unsatisfactory due to pollution through unprotected intakes, broken pipes and unhygienic storage tanks. Distribution interruptions are common mainly due to power failures, and service coverage inadequate due to an insufficient quality of infrastructure and poor operation and maintenance. The inadequate water supply together with poor waste water and solid waste disposal systems cause a severe health risk to the urban population.

The four towns accommodate one third (about 230,000 people in 1990) of the whole population of the Zanzibar islands. The urban population is estimated to be almost 340,000 by the year 2000 and nearly 600,000 by the year 2015. This population development would lead to very densely populated urban areas with large

suburban fringe areas, which would mean enormous problems in terms of space and employment especially in the town of Zanzibar.

Successful urban water supply and sewerage development will establish economic self-reliance among the water organization and will also contribute significantly to the success of the national economic recovery programme, facilitating the development of tourism and industry. The project will make it possible to meet the future increased demands of water, as well as increasing skills and awareness among authorities, officials and the public. Water supply development will thus strongly contribute to the health and environmental situation of Zanzibar.

3.4 Institutional framework

The Ministry of Water, Construction, Energy, Lands and Environment of Zanzibar has, through the Department of Water Development (DWD), full responsibility for the provision of water supplies in Zanzibar. The DWD is the sole national authority for all water-related undertakings in the two islands.

The Competent Authorities of the two Governments for the implementation of the Project are the Ministry for Foreign Affairs of Finland, represented in Finland by the Finnish International Development Agency, FINNIDA, and in Tanzania by the Embassy of Finland in Dar es Salaam, and the Ministry of Finance of Tanzania. However, in matters pertaining to the substance of the project and not affecting the overall responsibilities of the Government of Tanzania, the Department of Water Development in the Ministry of Water, Construction, Energy, Planning and Environment of Zanzibar has the right to represent the Ministry of Finance.

The other organizations of Zanzibar involved in project implementation are the Municipal Council of Zanzibar and the Town Councils of Pemba, the Irrigation Department of the Ministry of Agriculture, the Commission for Land Use and Environment, the Institute of Marine Science of the University of Dar es Salaam, the Ministry of Health, the Ministry of Education, the Ministry of Trade and Industry, and the State Fuel and Power Company.

3.4 Objectives

The general development objective of the project is that of providing its beneficiaries with safe water in a sustainable, cost-effective way with minimum environmental risks, and to provide water authorities with long-term projections and proposals as well as

the institutional capability to effectively operate, manage and maintain the facilities.

The development objectives of each sub-project are the following:

Financial and institutional development

To contribute to the development of a clear-cut policy and strategy for urban water supply and achieve economic efficiency, as well as to improve financial performance, institutional capacity and the quality of human and material resources of the organization in charge of water supply. In addition, involvement of consumers regarding water issues will be encouraged.

Water supply development

To establish adequate and safe urban water supply systems appropriate to prevailing economic and functional conditions.

Water resources and environmental development

To guarantee the adequate share of water resources for urban water supply and improve the environmental and health status of the Unguja and Pemba islands by improving the water quality and to prevent any possible environmental deterioration due to project activities.

3.5 Project strategy

The first implementation phase 1991-1994 of the project shall concentrate on financial, institutional, human resources, community participation and environmental development, as well as on the verification of groundwater development plans and the development of preventive and corrective maintenance systems. The main emphasis in the beginning shall be on developing a tariff policy for the water organization. The technical part of this phase of the project mainly consists of the most urgent repair works and the technical planning for the following phases.

The project is divided into three sub-projects: economic and institutional development, water supply development and water resources and environmental development.

The target of economic and institutional development is that of gradually developing economically self-reliant water organization which shall be capable of effectively managing, operating and maintaining the water supply systems.

Providing urban water organization with the necessary management authority, financial independence and legal basis for operation is the responsibility of the political bodies and authorities of Zanzibar. The role of the project is to contribute by participating in preparatory committee work and drafting proposals and estimates with local experts and officials. The decision making responsibility lies with the Zanzibarian authorities.

Human resources development is part of institutional development. It is a continuous process of assessing the shortcomings in manpower and organization, which will be improved by training.

To solve the problems regarding the inadequacy of the contacts between the beneficiaries and water authorities and the lack of knowledge about water issues, the beneficiaries need to be informed, educated and motivated through an extensive community participation programme.

The implementation of the water supply development activities shall be based on revised water policies and guidelines of the Government of Zanzibar as well as on the action plan outlined in the Urban Water Supply Development Plan.

Groundwater development, including drilling and monitoring activities and the establishment of a coordinating system for groundwater utilization, shall be initiated already in the early stages of the first implementation phase. The construction and renovation programmes shall be devised in relation to the progress of the financial, institutional and human resources development components, subject to frequent reviews in connection with the annual work plans.

Development of the water quality and environmental monitoring facilities and capabilities shall be emphasized from the beginning of the first implementation phase and maintained throughout the project periods.

The capacities and facilities of the existing DWD water laboratory established during the planning phase shall be extended during the first implementation phase. Extensive water quality monitoring programmes are to be prepared and implemented. Special studies on groundwater pollution shall also take place.

4. EXISTING ENVIRONMENT

4.1. Data collecting methods

Persons and institutions that were consulted are listed in chapter 7. A review of literature is given in chapter 8.

Laboratory water analyses were conducted to obtain data on the quality of water. Much useful information was obtained during sample collection field trips by interviewing people (water users).

The initial results of the household survey done by the project were also reviewed to get ideas about the practices and attitudes of people regarding the use and quality of water, as well as to obtain information on the occurrence of diarrhoeal diseases.

Areal photographs were reviewed to locate possible environmentally high-risk areas.

4.2. Overall environmental conditions of Zanzibar

Various environmental studies have been carried out in Zanzibar during the last few years. Those studies - listed in chapter 8 - gave useful background data for this study.

4.2.1. Main environmental issues

According to Robert Smith (Z7), an environmental advisor for the Department of Environment, the top ten environmental issues in Zanzibar are those listed below. These issues and problems are very closely related one to another and almost all of them have either a direct or an indirect relationship to the activities of the urban water supply project.

(i) The rapid degradation of the coral rag lands

- shifting cultivation expands
- the town of Zanzibar demands unsustainable quantities of firewood and poles
- the western farm lands have deep soils and good rainfall, but erosion is increasing, especially in Pemba, as the protective clove trees disappear
- the coastal communities are increasing the amount of fishing, thereby also increasing pressure on the heavily exploited inshore reefs, and compounding the problem with physical damage to the coral

(ii) The need to regulate the water supply and monitor its quality

- Zanzibar has good groundwater resources but there are supply problems
- many rural communities depend on shallow wells, springs, ponds and streams, which are liable to contamination
- pipe breakages and technical problems contribute to urban shortages and contamination
- the administrative set-up, with many sectors having partial responsibilities, does not allow proper planning or management.

(iii) The need to regulate use, storage and disposal of chemicals

(iv) The problems of unplanned urban expansion

- construction in urban areas is chaotic, causing pollution problems, obstruction of open spaces, and annexation of land with a high value for agriculture, recreation, catchment protection, etc.
- small-scale industries outside their allotted zones cause similar problems
- many people need to be within a reasonable distance of their work-place and their fields, which leads to construction and/or cultivation in unsuitable places

(v) The effects of supplying poles, lime and sand for construction

- landscape degradation caused by quarrying; this is under supervision of the Forestry Department, but some collection of rocks and sand goes on at unauthorized private sites
- beach erosion caused by quarrying (removal of sand and coral rocks)

(vi) The need to bring coastal zone areas under integrated management, combining traditional uses, tourism and resource conservation

(vii) The need to monitor key coastal ecosystems, such as coral reefs and mangroves

(viii) The threat of environmental degradation by unplanned tourism development, stimulated by the Economic Recovery ID

(ix) The need for mechanisms to incorporate environmental factors into development planning and project assessment

(x) The need to raise environmental awareness and to develop national capabilities in environmental research and management

- Government sectors, development authorities and funding agencies
- techniques of environmental economics to be introduced into planning and evaluation

4.2.2. Environmental policy and legislation

The main authority on environmental issues in Zanzibar is the Department of Environment (under the Commission for Lands and Environment, COLE) with its four sections: Natural Resources Conservation, Pollution, Information and Education, and Planning and Evaluation.

Other major sectors with environmental concerns are the Department of Water Development, the Department of Agriculture (the agricultural policy emphasizes integrated land use planning and land conservation) and the Department of Forestry (the Five Year Plan includes the prevention of soil erosion, the protection of catchment areas and the establishment of forest parks, and also calls for the conservation and development of forest resources).

Zanzibar has a variety of legislation covering some, but not all, of environmental aspects.

Environmental considerations regarding water regulations include (according to Z15):

Cap. 73 of the Public Laws of Zanzibar (Public Health Act) provides for water resources in several sections, which regulate water-related procedures and disturbances.

In Cap. 79 of the Public Laws of Zanzibar there are provisions for the inspection and approval of fittings (sec. 118), the waste of water (sec. 119), penalties for pollution of water supply (sec. 124) and water related offenses (sect. 123).

The Ministry of Health analyses water samples, controls water-borne diseases and those water related disturbances that can affect the health of the population.

The Ministry of Agriculture and Livestock Development is in charge of irrigation projects. Water permits are required from the Water Department.

Some of the other environmental legislation is listed in annex 2.

The report of M.R. Solaines (Z15) gives recommendations for improving water legislation, including use of groundwater, protection from pollution, flood control, prevention of soil erosion, management of sewage, prevention of salinization and other environmental issues.

A report on issues has been prepared by the Department of Environment, proposing an environmental policy derived from an environmental seminar held in November 1989 and numerous discussions with different sectors. The suggested policy is based on the principle that the conservation of natural resources should become an integral part of the development of Zanzibar. It includes statements on inter-sectoral coordination, integrated management within ecological zones, environmental research, public participation in environmental protection, the reduction of the population growth rate, etc. It will be the role of the Department of Environment to promote and facilitate the implementation of the policy, coordinate sectoral activities and monitor the state of the environment. (Z7)

4.3. Specific environmental issues with direct relations to the quality and quantity of groundwater

4.3.1. Groundwater resources

Groundwater reserves are the only water resources to serve as urban water supplies for both Unguja and Pemba. These include boreholes, springs and caves. No reliable surface resources exist.

Groundwater is also needed for rural water supplies. Shallow wells are very important even in urban areas for replacing the piped water supply during power failures (in Pemba about half of the time) or when there are some other operational problems regarding town supplies.

Agriculture is a big user of groundwater for irrigation. Much coordination will be needed between the project and the Department of Irrigation.

Some rainfall data is given in annex 3, which gives some idea about the recharge of groundwater reserves. More detailed rainfall information is given in hydrogeological study report.

Some of the possible future problems regarding the increased use of groundwater is discussed later in this report.

Most of the groundwater areas are also major agricultural areas, where agrochemicals are used, as discussed in chapter 4.3.6.

4.3.2. Water and hygiene related diseases

Most of the health problems in Zanzibar result from or are caused by poor environmental conditions. They mainly result from factors such as socio-economic status, climate, cultural practices, poverty, rapid population growth and inadequate and unsanitary living conditions, including the inadequate quality of drinking water and insufficient personal hygiene habits.

The major health problems related to the quality of water are dysentery and other diarrhoeal diseases, as well as worm infestations. The last severe dysentery epidemic took place in Zanzibar during the first quarter of 1990. Other major diarrhoeal and worm diseases exist year round.

According to the household survey carried out by the project, 18 % of the people of the town of Zanzibar have had diarrhoeal diseases during the last 3 months. Most of the people (68 %) seem to be aware that these diseases can be related to drinking water.

The last severe cholera epidemics took place in Zanzibar 1978 and in 1983 in Pemba.

According to the test results, the bacteriological quality of the Zanzibar's town water supply is inadequate. Pollution takes place already at the sources and therefore spreads throughout the system. Even fecal contamination occurs.

There are also water-related diseases such as malaria and bilharzia, which are mainly due to stagnant water.

Malaria is the number one disease in Zanzibar and is affects a considerable number of people in urban and rural areas. Of all cases of diseases diagnosed in 1987, 32.2 % of them were malaria. It has been the major cause of death in Zanzibar Hospital (31.5 %) in the same year. (Z17).

Irrigation schemes can increase mosquito breeding and bilharzia. The storage of water at construction sites also provides breeding places for mosquitos. (Z7)

A third type of health risk is related to the inadequate disposal of refuse. The solid waste disposal system is not properly taken care of and the attitudes and habits of people should be changed to overcome this problem.

4.3.3. Quality of groundwater

4.3.3.1. Water quality monitoring

There has not been any regular monitoring of water quality in Zanzibar. The health department has done some monitoring earlier, but due to a lack of facilities they have not been able to establish any on-going monitoring system.

The need for water quality monitoring has been a big concern of the Department of Water Development and other authorities for years. The Department of Environment has also expressed its interest in having a joint environmental laboratory in collaboration with water and health authorities.

A small laboratory was established by the project on the premises of the Department of Water Development in June 1990 (during this study) and has been in full operation since the beginning of July. The results of the first analyses carried out in the laboratory are presented in this report (annex 4).

Some analysis of the quality of the waters of the town of Zanzibar was also done by the University of Dar es Salaam in April 1990 (a study ordered by the project). The results of that study are also discussed in this report. The study report of the University of Dar es Salaam is included (annex 5).

In addition to the results of the project laboratory and the University of Dar es Salaam, some old water quality results have been available from the years 1951, 1968, 1971, 1972, 1974, 1984 and 1985 (annex 6).

Both chemical and bacteriological quality was analyzed by the University of Dar es Salaam and the project laboratory.

The parameters analyzed were:

Project laboratory - color, turbidity, temperature (at certain points - not always), pH-level, conductivity, total dissolved solids, carbon dioxide, hardness, chloride, salinity, nitrate, nitrite, phosphate, fluoride, iron, manganese, chromium and

	nitrate, as well as total and fecal coliform bacteria
University -	temperature, pH-level, dissolved oxygen, oxygen saturation, biological oxygen demand, total solids, conductivity, chloride, nitrate, fluoride, calcium carbonate, sulphate, calcium, magnesium, cyanide, arsenium, cadmium, lead, chromium, iron, manganese, zinc and copper, as well as total and fecal coliform bacteria

The old quality data reports give results for Ph, alkalinity, hardness, chloride, nitrogen, oxygen and coliform bacteria.

Some studies have been done about the use of pesticides and fertilizers. In this study the use of these chemicals around the water sources and catchment areas was also surveyed. However, nothing definite can be said without a proper analysis of pesticides in groundwater. Some sampling has been done by the Forestry Project and by the University of Dar es Salaam, but no results have been obtained so far. It was also tentatively planned during this study to collect some water samples for pesticide analysis to be done in Finland. However, since this study has been made during the dry season, when there are no major pest problems and therefore no pesticides being used, it is of no use to collect water samples. The sampling and analysis has to be properly planned according to the time pesticides are applied and the type of pesticides used.

Water quality standards used in Zanzibar

Usually the WHO guidelines for drinking water quality are applied to urban water supplies in Tanzania.

Tanzania has its owns standards as well, (see "Tanzania Temporary Standards" for rural water supplies 1974), which allow much higher concentrations of chemicals than the WHO standards (see water quality tables, annex 4).

For example, the WHO guideline value for fluoride is 1.5 mg/l, since higher concentrations may cause coloring of teeth (and more than 3 mg/l may cause skeletal fluorosis). The Tanzanian standard for fluoride is 8 mg/l.

4.3.3.2. Quality of groundwater in Zanzibar

All the water intakes and some other potential sources around the town of Zanzibar and the towns of Pemba were analyzed both chemically and bacteriologically, as well as some local wells located near the intakes or in important groundwater areas. A detailed report of the environmental conditions and the quality of water for each of these sources is given in annex 4.

Almost all the water intakes of urban water supplies in Unguja and Pemba are bacteriologically polluted, and therefore also the networks. Even fecal pollution seems to take place. The sources are usually not covered or otherwise protected and therefore any kind of pollution is possible. The pollution may also take place within the network due to pipeline leakages and unhygienic storage tanks. The microbiological pollution of drinking water can be considered the most acute water-related health problem for the public at the moment.

The chemical quality of the groundwater is generally good. One problem is the intrusion of sea water into the groundwater and therefore special emphasis was placed on checking the salinity of water, but no very alarming results were found. In a few sources the conductivity and chloride levels were a bit high, but did not exceed the WHO or Tanzanian standards. However, the development of water quality along with the more effective use of groundwater must be carefully followed.

In Zanzibar the soil is generally very permeable (due to sand and coral) and therefore any waste materials or chemicals discharged into the ground without treatment can easily pollute the groundwater and thus create a health hazard. One chemical identified from the water samples of the Zanzibar town supply scheme has been chromium, which may be due to chemical pollution from industrial waste waters.

There are also some other aspects of chemical quality, such as calcium (very common in the waters of Unguja and Pemba), which is mainly a technical and aesthetic problem, but may also be of significance to health. Iron is high in some sources (most of them being local shallow wells). Possibly one of Pemba's intakes, Changaraweni near Chake Chake, must be rejected due to an iron problem, or other solutions must be found to treat it.

There is one source in Pemba, Kiguuni spring in Mkoani, where the fluoride level seem to be high. According to the caretaker of the spring there is no fluorosis problem (coloring of teeth) in the area. However, no proper interviews were done regarding this problem.

4.3.3.3. People's attitudes to clean water

Historically the groundwater sources and water supply of Zanzibar have had a very good reputation for cleanliness and good taste.

Also according to the first results of the project's household survey the quality of Zanzibar's water supply is considered good. Good water is described to be clear, colorless and without visible dirt in it. Tap water is usually considered clean. Obviously bacterial pollution is not known or understood. On the other hand people seem to trust that some "medicine" has been applied to the tap water. That is why people in urban areas do not care to boil their drinking water, which in light of the present situation would be very important.

4.3.4. Discharge of waste waters and solid wastes

The waste water and solid waste disposal system of the towns of Unguja and Pemba is at the moment poor, but some improvement will be brought about by the Sewerage and Drainage Project (a German project), which however will only begin with the Stone Town of Zanzibar. It may mean that no improvement to the situation will take place in the near future in the other parts of Zanzibar or in the towns of Pemba.

The situation is quite chaotic with no centralized sewerage system and blockages of sewers due to poor maintenance and misuse (drains are often used for garbage disposal places). Usually waste water is lead to the sea, which can be seen in the quality results of the sea water. However, often the waste waters do not reach the sea, but seep to the ground and are therefore causing a problem of groundwater pollution.

According to the study (Z1) carried out by the University of Dar es Salaam, the waters of the Zanzibar Channel near Zanzibar Town were found to contain high concentrations of fecal and total coliform bacteria (up to 7066 E.Coli per ml), which exceeds any standards given for swimming water. The Bwawani hotel area, Ras Shangani and Kiungani were the most polluted areas, which must be due to sewage outlets.

One source of pollution of sea water is the defecation habits of people - the fishing community in particular use the beaches for that purpose. Recommendations have been made by the Department of Environment to build public pit latrines on the beaches. Pit latrines may also be one source of groundwater pollution, which is an area to be studied further. Most households even in urban areas have pit latrines.

A verbal agreement has been made with the Department of Environment and the Institute of Marine Science to monitor the bacteriological quality of sea water at the new laboratory of the Water Department (project laboratory).

Some chemical pollution possibly caused by waste waters was also found in the studies: "The cause of heavy metal pollution of the mudflat near Bwawani Hotel might originate from the sewage which is discharged from two big sewage pipes near Bwawani Hotel. Investigations will have to reveal which industry is discharging heavy metals in the sewage system." (Z1)

4.3.5. Use and storage of pesticides and fertilizers

Some studies have been done on the use of pesticides and fertilizers; the use of these chemicals around the water sources and catchment areas was also examined during this study. However, nothing definite can be said about their effect on water supplies without proper studies and laboratory analysis of pesticides in groundwater.

Agriculture

One possible risk for the quality of groundwater is due to chemicals used in agriculture, especially rice cultivation, where obviously large quantities of herbicides are used to control weeds. Rice is cultivated throughout almost all of Unguja and Pemba islands and very often the cultivation is concentrated on areas where the main groundwater reserves are.

According to Smith (Z7) the use of chemicals does not follow any clear policy - the Plant Protection Unit is promoting a more systematic integrated approach to pest management, with detailed guidelines, but no official policy exists and many in the sector favor heavier pesticide use. Irrigation schemes are a focus for chemical use. Some experts claim that the weed problem is a direct consequence of the mechanized cultivation routines and would be better controlled by rotational removal of fields from production for a period of weed management. Herbicides and fertilizers are heavily subsidized.

The use of fertilizers is not high, and no clear signs of pollution (excess nitrogen) were found in the groundwater samples tested in the project laboratory. This should be further studied during the rainy season, when more chemicals are applied and the problem would be more obvious.

Forestry

In forestry-related activities chemicals are used only in nurseries, which limits the problem to a few small areas. However, the main tree nursery of Unguja, called Mwanyanya, is located just next to Bububu Spring, one of the most productive water sources of Zanzibar. Further investigations should be made to find out the extent to which the use of chemicals in the nursery may affect the quality of the spring water.

The use of pesticides and chemicals in tree nurseries takes mainly place in the rainy seasons.

Storage and disposal of chemicals

Storage of pesticides has also been found to be a high-risk matter.

There are rumors that large amounts of DDT have been dumped on the Town Council dumpsite, Marahvbi. If that is so, contamination of the groundwater may occur. (Z8) This has to be further checked.

According to the health officials of Pemba there has been a problem with malathion, which was supplied them for malaria control, but was found to be the wrong type and now needs to be disposed.

The soil next to the pesticide storage of Mahondo Sugar Factory has been found to be contaminated by the leakage of malathion, dieldrin and TCA (trichloroacetic acid). (Z8)

Many similar kinds of examples can be found. Therefore it will be important to test pesticide pollution of groundwater.

4.3.6. Chemical pollution from industry

Evidently the level of chemical usage in Zanzibar is not high. However there are some potential pollution risks -especially because there are no controls on the discharge of industrial wastes.

There are many small and medium scale industries in Zanzibar Town and its surroundings, most of which are not of environmental concern. A study has been done by the Institute of Marine Science (Z21) on the chemical use of the following industries: Cotex Ltd, Mahonda Sugar and Perfume Corporation, Mbweni Tractor Repair Workshop, Afrochem Ltd and Jitegemee Small Scale Industries.

Some signs of chemical contamination have been found both in the study carried out by the University of Dar es Salaam on the quality of sea water (Z1) and drinking water (annex 5), and the drinking water samples analyzed by the project laboratory (annex 4).

According to Z1 two sites were polluted with heavy metals (chromium, lead, cobalt and zinc): the mudflat in front of the Bwawani Hotel and another spot near the State Leather and Shoe Factory.

At Sebleni chromium, lead and even cobalt values are quite high. This pollution most probably originates from the Jitegemee Small Scale Industries. In the rainy season a small stream flows from the Small Scale Industries up to Sebleni pond. When there is no rain, the stream dries up somewhere midway between the factory compound and Sebleni pond. This indicates that most of the effluent of the factory seeps into the ground and can reach the groundwater. This phenomenon is common in Zanzibar: the effluent of the Cotex (Z) Ltd factory also seeps into the ground in a residential area west of the factory, due to blockage of the drainage channel.

Some chromium was detected in drinking water samples, but usually not exceeding the WHO standards.

The results indicate that there is some contamination, but not alarming amounts. However, it must be emphasized that in general chemical waste should not be discharged at all. If there is an urgent need to discharge chemical waste, then proper discharge should be arranged through the use of suitable piping. At present, most of the chemical waste seeps into the groundwater, which can endanger the quality of the drinking water in future. (Z1)

5. TRENDS IN ENVIRONMENTAL CONDITIONS

Some existing and possible environmental problems related to project activities have been discussed above. In the following chapters their magnitude and future predictions concerning them are discussed further.

5.1. Impacts of different uses of groundwater

The significant increase in the use of groundwater for future town water supplies, together with other uses such as irrigation and a probable increase in the use of water due to the development of tourism, may cause some problems in the future, as illustrated in figure 1.

The draw down of groundwater will first affect the shallow wells, which obviously will dry up. The compensatory measures for the rural people suffering from this development should be discussed.

The possible salinization of groundwater, as discussed before, will be another major problem in the effective use of groundwater. This will be followed up carefully by continuous monitoring of the water quality.

5.2. Water quality and health

Water quality problems have also been extensively discussed in earlier chapters and are summarized in figure 2.

The project will have mainly positive effects on this problem, except for salinization. Also the increased amount of domestic waste water due to expanded water supply systems may add to the already existing health problems due to poor waste water disposal. This should be avoided by coordination of the activities of the water project and the upcoming urban drainage and sewerage project.

Possible groundwater pollution by agrochemicals and industrial chemicals must be followed and action taken accordingly.

5.3. Other indirect impacts of the project

The construction activities of the project may have some indirect environmental impacts, such as landscape degradation and beach erosion due to the use of gravel and sand. Possible hazards to groundwater due to construction activities should also be taken into account. Creating water storage places at construction sites should also be avoided, as they can be breeding places for mosquitos.

The project may add to the problem of unplanned urban expansion by creating new job opportunities. It may also promote tourism, which again has its adverse impacts to the environment.

These and other possible risks, which might seem small at this stage, should be taken into consideration throughout the implementation of the project. The awareness of possible environmental risks must be increased among the authorities and project personnel.

Figure 1.

Problems related to increased use of ground water

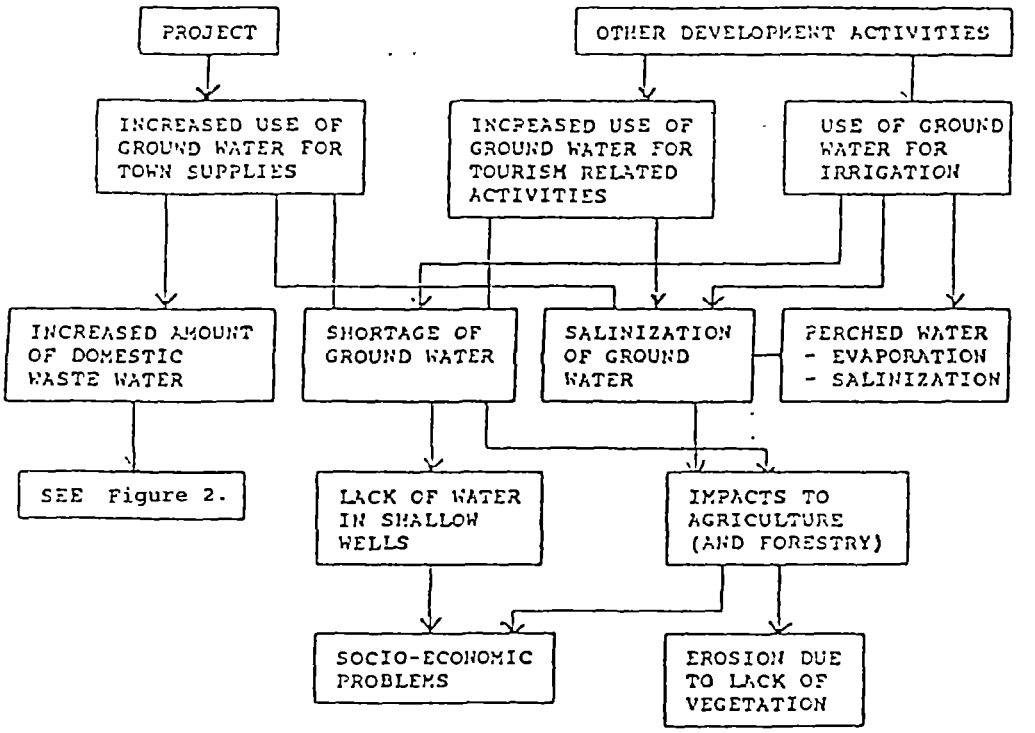
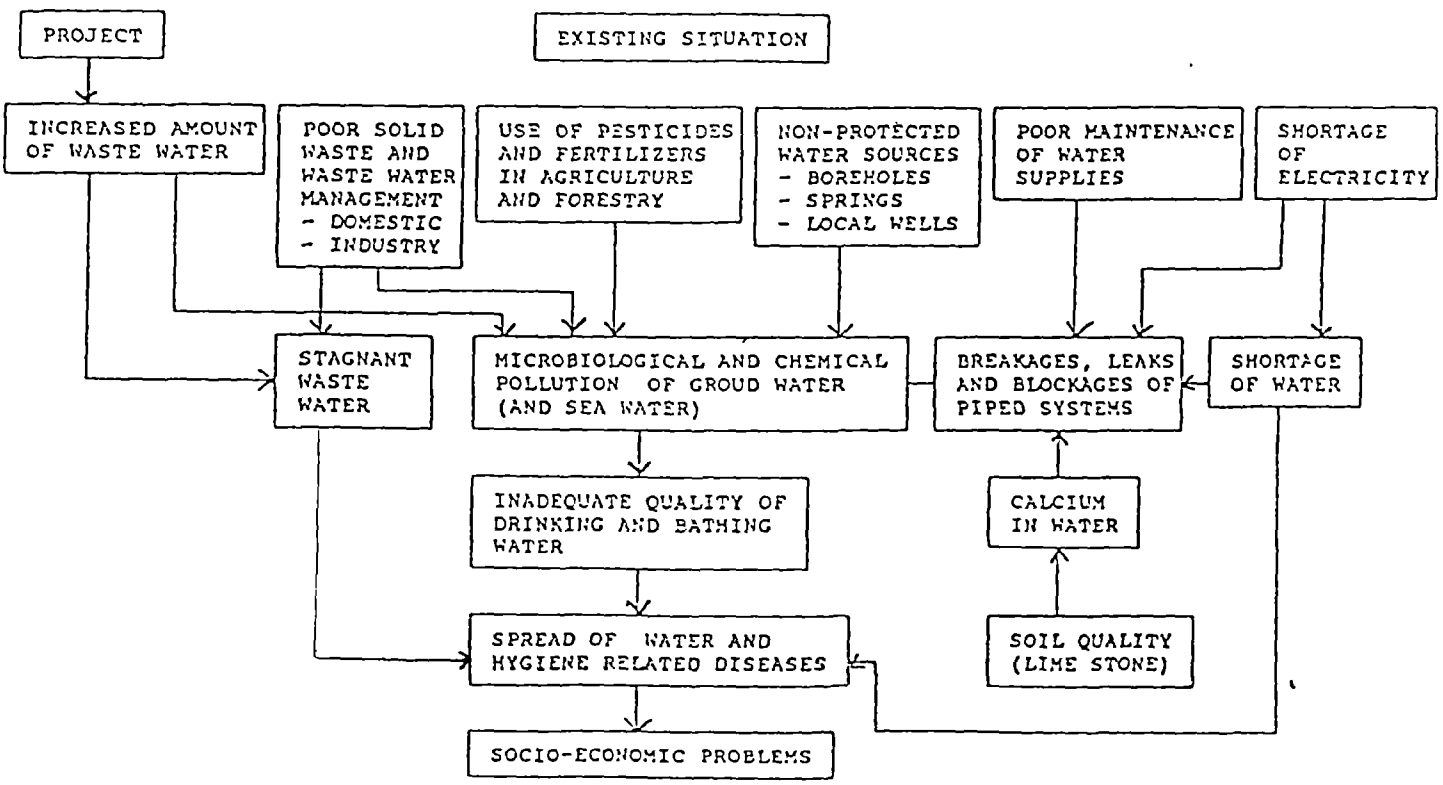


Figure 2.

Problems related to quality of water and health



6. SOLUTIONS AND RECOMMENDATIONS

This study will be followed by the following actions and recommendations:

Selection of sites for water intakes

1) Recommendations will be given for selection of intake sites vs. activities in surrounding areas (industry, agriculture, forestry, others).

2) Recommendations will be given on which sources are clearly not suitable or suitable only with certain treatment according to the water quality data.

3) Further comparison of groundwater areas and agricultural and forestry activities will be made and recommendations will be given on the protection of groundwater resources.

Protection of water sources

1) Recommendations will be prepared for protection zones for catchment areas of water intakes including recommendations for planting trees and other plants, structures for pit latrines and use of agrochemicals.

2) Guidelines will be prepared for protection of all open sources (standards for structures).

Chlorination of drinking water

1) Continuous chlorination will take place in the renovated water supply schemes.

Improvement of waste water and solid waste management

1) It should be guaranteed by the project that the improvement of drainage and sewerage systems is carried out simultaneously with that of the improvement of water supply systems.

Water quality monitoring

1) Water quality monitoring programme will be prepared and implemented.

2) The new water laboratory of Zanzibar will be enlargened to act as central laboratory. A bacteriology unit will be established in Pemba.

3) Sea water monitoring program together with COLE and the Institute of Marine Science will be prepared and implemented.

Proposed studies

1) Further EIA will be carried out:

   - analysis of the situation to be done during the rainy season

   - a more detailed and pragmatic environmental monitoring programme will be developed for the project in the early stage of the project implementation

2) A study on pesticide contamination of groundwater will be carried out (study to be done during the rainy season).

3) Following studies are also recommended:

   - studies on the spread of pollution of ground water (e.g. pit latrines - groundwater)

   - basic study on the quality of waste waters

   - study on waste water quality to be done (assessment of existing situation)

Environmental monitoring during project implementation

1) Development of industry should be followed in order to identify potential new pollutants in the future.

2) The extent of the use of pesticides and fertilizers should be followed up.

3) In all construction activities of the project the environmental aspects are should be taken into account (what materials are used, where they come from, is the sand from environmentally sensitive areas; do the chemicals used do any harm to the environment and people; mosquito breeding possibilities).

4) It will be followed up whether the project seems to encourage increased urban migration; what are the effects.

Increased environmental awareness

1) Increasing the environmental awareness of the following groups is recommended:

   - authorities and politicians
   - project/DWD staff - to be included in all technical training
   - school children
   - public
     - radio
     - TV
     - other

Sectoral co-operation and coordination between different projects

1) More co-operation is needed between the water sector and the following sectors: health, forestry, agriculture, tourism, education, environment.

2) Very close co-operation is needed between the urban water supply and the urban sanitation projects.

3) Coordination of activities of urban and rural water supply projects is needed.

Planning of activities

1) More emphasis should be given to planning of activities both within own organization and together with other sectors.

7. SOURCES OF INFORMATION

The members of the project team in Zanzibar and Pemba have made major contributions to this study, as well as the personnel of the Department of Water Development.

The following institutions were visited during the study period to obtain information on different environmental issues:

- Ministry of Water (Zanzibar)
- Department of Health (Zanzibar and Wete)
- Department of Forestry (Zanzibar and Wete)
- Department of Agriculture (Zanzibar and Wete)
- Commission of Lands and Environment/Department of Environment (Zanzibar)
- Government Statistics (Chake Chake)
- Institute of Marine Sciences (Zanzibar)
- Municipal/Town Councils (Zanzibar, Wete and Chake Chake)
- V.I.Lenin Hospital/Laboratories (Zanzibar)
- Government chemist (Zanzibar)
- Tree nurseries of Mwanyanya (Unguja) and Konde (Pemba)
- Agricultural Research Centers of Kizimbani (Unguja) and Matangatuani (Pemba)
- Industry:
    - Cotex Ltd (textile factory), Zanzibar
    - Small Scale Industries, Zanzibar
    - Soda factory, Wete
    - Soap and coconut oil factory, Wete
    - Clove distillery, Chake Chake

A list of persons consulted is given below:

Mr. Foum	Principal Secretary, Ministry of Water
Dr. Hans van Bruggen,	University of Dar es Salaam
Dr. Uledi Mwita,	Director of Preventive Health Services and Health Education
Mr. Said Mohammed Said,	Health Inspector
Mr. Ali Moammed Shein,	Director of Laboratory Services, V.I.Lenin Hospital
Mrs. Ashok Ahmed Othman,	Chief Chemist of the Bacteriology Laboratory
Mr. Mzee Khamis Mzee,	Head of the Drainage and Sewerage Section, Municipal Council
Mr. Said Maalim,	Adm.Officer, Cotex Ltd
Mr. Said Monkia,	i/c Dying House, Cotex Ltd

Mr. Mohammed S. Said,	Production Manager, Small Scale Industries
Mr. Laamini Juma,	i/c Water Supply, Small Scale Industries
Mr. Massoud M. Hemed	Director, Department of Agriculture
Mr. Timo Laisi	Commission of Lands and Environment
Mr. Abdulrahman Salim Issa	Director of Environment, Department of Environment
Mr. Robert Smith	Advisor, Department of Environment
Mr. Issa Bedwi Issa	Chief Chemist, Hospital Pharmacology Department
Mr. Leroy Duwal	Project Manager, Forestry Department
Mr. Markku Siltanen,	Extension Adviser, Forestry Department
Mr. Tuomo Häyrinen	Advisor, Forestry Department
Mr. Daudi Rajab Toufiki	Project Manager, Forestry Department
Mrs. Khdija Mohammed Issa	i/c Nurseries, Forestry Department
Mr. Kassim Mandeweya	Forestry Department
Mr. Mohammed Salem,	Head of MOH, Pemba
Mr. Ali Fag Masudi,	Office Superintendent, MOH, Pemba
Mr. Bakaria,	Director of Town Council, Wete
Establishment Officer,	MOH, Pemba
Malaria Officer,	MOH, Pemba
Mr. Issa,	Municipal Accountant, Wete, Pemba
Mr. Ali,	Accountant, MOH, Pemba
Mr. Khalfan,	Representative of Preventive Section, MOH, Pemba
Mr. Sharif	Agriculture Department, Wete, Pemba
Mr. Ali,	Health Inspector, Chake Chake
Mr. Omar	Director, Clove Distillery, Chake Chake
Chemist,	Clove Distillery, Chake Chake
Mr. Saleh Mzee	Deputy Director of the Institute of Marine Science
Mr. Rashid Juma Hamad	Project Manager, Forestry Project, Pemba
Ms. Jokha Suleiman Ali	i/c Tree Nursery, Konde, Pemba

8. LITERATURE REVIEWED

Documents about the Project:

P1 Zanzibar Urban Water Supply Development Plan. Project Document. The United Republic of Tanzania/The Republic of Finland. September 1989.

P2 Sansibarin kaupunkien vesihuollon kehitys-suunnitelma. Matkakertomus 22.11.1988 - 9.12.1988.

P3 Zanzibar Urban Water Supply Development Plan. Mobilization and Inception Report. The United Republic of Tanzania/The Republic of Finland. December 1989.

P4 Zanzibar Urban Water Supply Development Plan. Progress Report 1st Quarter 1990. The United Republic of Tanzania/The Republic of Finland.

P5 Hydrogeology Field Visit Report. Zanzibar Urban Water Supply Project. December 1989-March 1990.

Literature about EIA and other general environmental data:

E1 Guidelines for Environmental Impact Assessment in Development Assistance. Draft 15.7.1989. FINNIDA.

E2 Driver, P. 1990: Environmental Impact Assessment. The World Conservation Union. Material produced for workshop held in Forssa, Finland, in April 1990. 28 p.

E3 Driver, P. 1990: The Assessment of Pollution and Ecological Effects. The World Conservation Union. Material produced for workshop held in Forssa, Finland, in April 1990. 27 p.

E4 Driver, P. 1990: Constraints and Opportunities for Sustainable Development in Tropical Environments. The World Conservation Union. Material produced for workshop held in Forssa, Finland, in April 1990. 17 p.

E5 Salminen, P. 1990: Constraints and Opportunities for Sustainable Development in Tropical Environments. Ymparistövaikutukset Suomen kehitysyhteistyössä. Material produced for workshop held in Forssa, Finland, in April 1990. 6 p.

E6 Kehitysyhteistyö ja ymparistokysymykset. FINNIDA. Luonnos. Tammikuu 1990. 161 p.

E7 Environmental Issues in Water Resources Management. DANIDA 1988.

E8 Hakulinen, K. 1982: Mtwaran-Lindin vesihuoltohanke ja sen ympäristökytkennat. Ulkoasiainministerio, Helsinki.

E9 The Environmental Impact of Development Projects. Selected Issues in Aid Evaluation - 2. Organization for Economic Co-Operation and Development. Paris 1989.

E10 Human Wastes: Health Aspects of their Use in Agriculture and Aquaculture. IRCWD News No 24/25. May 1988. 31 p.

E11 Mara D.D. and Pearson H.W. 1987: Waste Stabilization Ponds. Design Manual for Mediterranean Europe. WHO.

E12 Environmental Protection in Finland. National Report 1987. Ministry of the Environment. Finland 1988.

E13 Development of Environmental Health Manpower. Environmental Health Series 18. WHO 1987.

E14 Environmental Management of Urban Solid Wastes in Development Countries. A Project Guide. World Bank.

Environmental data about Zanzibar:

Z1 Van Bruggen, J.J.A: Assessment of Environmental Pollution on Zanzibar. University of Dar es Salaam. May 1990. 38 p.

Z2 Duncan, J.W.K: Report on Situation Assessment of Solid Wastes, Wastewater and Drainage Disposal in Zanzibar. Field Report. October 1987. 6 p. (unpublished report)

Z3 Surveying Report on Existing Sewerage and Drainage of Zanzibar Town. Municipal Council, Zanzibar. 10 p. (unpublished report)

Z4 Jiddawi, N.S. and Muhando, C: Summary of Marine Resources in Zanzibar. Zanzibar Environmental Study Series Number 1 of 1990. The Commission for Lands and Environment, Zanzibar. 21 p.

Z5 Development of National Marine Park System in Zanzibar Islands. University of Dar es Salaam, Institute of Marine Sciences, Zanzibar. 54 p.

Z6 Beentje, H.J: Reconnaissance Survey of Zanzibar Forests and Coastal Thicket. Zanzibar Environmental Study Series Number 7 of 1990. The Commission for Lands and Environment, Zanzibar. 34 p.

Z7 Smith, R.B: An Environmental Policy and Programme for Zanzibar. The Zanzibar Integrated Land Use Plan Project. The Commission for Lands and Environment. January 1990. 75 p.

Z8 Van Veen, R. and Oncedveld, G.D. 1990: Pesticides Wastes on Zanzibar. 30 p.

Z9 The Tropical Pesticides Research Institute Act 1979, Tanzania. 5 p.

Z10 The Pesticides Control Regulations 1984, Tanzania. p. 279 - 289.

Z11 List of Pesticides Registered in Tanzania, 1986. 22 p.

Z12 Dulski et al. 1987: Technical and Investment Report for Mineral Water Bottling Plant in Zanzibar, Tanzania. Samed-Gepol. Warsaw.

Z13 Johnson, J. 1973: A Review of Hydrogeology of Zanzibar Island. Development of Rice Cultivation and Extension in Vegetable Production, Zanzibar. FAO 1973.

Z14 Zanzibar Legislation Regarding Protection and Monitoring of Environment. Report by the Commission for Lands and Environment. Zanzibar 1989.

Z15 Solaines 1986: Mission Report to the Islands of Zanzibar and Pemba (on water legislation). Draft report from United Nations Department of Technical Cooperation, New York.

Z16 Edworthy, K.J. 1988: Review of Hydrogeology and Proposals for Future Development of Groundwater Resources. Development of Smallholder-oriented Irrigated Rice Production. Ministry of Agriculture. Zanzibar 1988.

Z17 Health Facilities in Zanzibar. Report by the Commission for Lands and Environment. Zanzibar 1989.

Z18 Hassan Z.S. and Omar H.A. 1989: Report of a Survey Done on the Perspective of Rural Women on Environmental Change in Paje and Bwenjuu. Environmental Studies for the Commission for Lands and Environment. Zanzibar 1989.

Z19 Report of a Survey of the Status of Selected Reefs and Intertidal Areas of Zanzibar Islands, Tanzania. FINNIDA/ZILUP Programme. The Commission of Lands and Environment. Zanzibar 1990.

Z20 Environmental Profile: Country Strategy for Strengthening Environmental Considerations in Danish Development Assistance to Tanzania. DANIDA 1989.

Z21 Mohammed S.M. 1989: Pollution by industry and other users of chemicals. Environmental Studies for the Commission for Lands and Environment. Zanzibar.

Z22 Rehabilitation and Improvement of Zanzibar Municipality Sewerage and Drainage Systems. Terms of Reference. Department of water. Zanzibar. April 1990.

Literature about water quality control:

W1 WHO Guidelines for Drinking Water Quality. Vol I - III. 1985.

W2 Standard Methods for Examination of Waters and Waste Waters. 15th Edition, 1980. APHA-AWWA-WPCF.

W3 The Bacteriological Examination of Water Supplies. Reports on Public Health and Medical Subjects No. 71. Department of Health and Social Security, Ministry of Housing and Local Government. London 1970.

W4 Water Supply Design Manual. Chapter 3. Water Quality. Ministry of Lands, Water, Housing and Urban Development. United Republic of Tanzania. 1986.

Other references:

O1 Guidelines for Project Planning. Draft April 1990. FINNIDA

Annex 1

Plancenter Ltd 9.5.1990

Zanzibar Urban Water Supply Development Planning

TERMS OF REFERENCE FOR A SHORT TERM CONSULTANCY FOR MS. AULI KEINÄNEN TO THE PROJECT 1.7.-31.8.1990

1. Introduction

The purpose of the short term consultancy of Ms. Auli Keinänen is to participate as an Environmental Specialist to the preparation of Zanzibar Water Supply Development Plan. Her major task is to carry out an Environmental Impact Assessment (EIA) study. To make it possible to carry out water quality analysis for the study (and the whole project) she will also establish a water laboratory and give necessary training in water quality control.

The purpose of the EIA is to analyze the possible effects of the project for the environment. It is not a one time study but should rather be an on-going process during the implementation of the project. In this stage a preliminary EIA study will be carried out to serve the planning purposes and to enable systematical assessment during the implementation of the project. The EIA will follow the lines of FINNIDA EIA strategy. The study required will not be a very large one and it will only concentrate on the most relevant issues.

2. Tasks

It is proposed that Auli Keinänen undertake a short term consultancy to the project in July- August 1990. Approximately one month will be required for the water quality control arrangements and one month for the EIA study.

The tasks of A.Keinänen will be:

1. Water Quality Control

- to establish a water laboratory (the equipment and materials are already purchased and rooms reserved for this purpose)
- to train necessary personnel to carry out water analyses
- make a plan for water quality monitoring

2. EIA study

- to carry out the study by working together with the present project staff and also in close co-operation with the relevant institutions/departments/ministries of the country to be able to follow the policy lines of the country and to utilize the relevant data existing in the country.

  The stages of the study:

  - determining the type of environmental impacts most likely to arise
  - determining the magnitude of impacts identified
  - determining the importance of the magnitude of the impacts
  - designing project modifications to avoid, minimize or compensate for important adverse impacts and enhance environmental benefits
  - to inform the other project staff, relevant authorities etc. of the likely impacts of the project, the options for minimizing adverse impacts & maximizing benefits and the proposed programme for monitoring impacts
  - to prepare a guidelines/check list for the use during the project implementation phase

3. Project Document

  - to participate in preparation of the project document

Annex 2

Environmental legislation of Zanzibar (extracted from Z7):

- The Act establishing COLE gives it powers to take action against people misusing land or causing environmental problems

- The Investments Protection Act of 1986 requires investors to minimize pollution "by providing acceptable sewage disposal arrangements" and to ensure that "the chemical, physical, biological substance and agents under their control are without risk to health".

- The Land (Distribution) Degree of 1966 makes any grant of land conditional upon good husbandry and soil conservation. However, there is no specific policy or legislation on soil conservation, which could guide the application of this law.

- Legal protection for forests and bush is provided by the Forest Reserves Decree and , on public land, byu the Woodcutting Decree

- The fisheries legislation revised in 1988 gives the possibility for good conservation of the marine environment.

- The Towns Act covered drainage and sewage disposal but this was repealed in 1986 by the enactment of the Local Government Act. Responsibility for these and other environmental matters was thereby handed over to local governments.

- The Public Health Act allows control of improper rubbish disposal and of acts which create mosquito breeding pools.

- Industrial wastes - solid, liquid or gas - are not adequately controlled by legislation .

- Toxic chemicals are now explicitly covered by legislation, but could come under the Dangerous Goods Act, which caverns the port handling, movement and storage of explosives and corrosive or inflammable substances.

- Air pollution is covered only by the Road Traffic Decree, which has a general provision against vehicles emitting "avoidable smoke or visible vapor".

- The repeal of the Towns Act has further weakened the controls over construction, which were already inadequate.

Climate and rainfall data

The climate of Zanzibar is influenced by the monsoon air flow coming in from Asia which constitute the trade winds over East Africa. During the months of December, January and February the trade winds are north easterly (northeast monsoon). From March to November they become south easterly (southeast monsoon). During February and March, the northeast wind changes to southeast and during October-November, the southeast wind changes to northeast. (FAO report information)

The rainy seasons occur during and just after the transition period of the trade winds. The rainy period from March to May is called the 'long rains' and the period from October to December is termed 'short rains'.
The onset of the long rainy season occurs in March with increased rainfall all over the islands of Unguja and Pemba. In April it reaches its peak, starting to peter out in May. From June to September the rains decrease steadily although there is some rain all over the island in June. Short rains start in October and fall all over the island in early November. In mid-December the short rains start to dissipate and there is very little rain during January and February. However, there have been peaks of rainfall in January, as well. For example in 1979 and 1989 the floods in Zanzibar town have been bad.

Generally the inland areas receive more rains than coastal areas.

Table __ . Long term average weather data at Zanzibar Airport adapted from the East African Climatological Statistics (by FAO)

	JAN.	FEB.	MAR.	APR	MAY	JUN.	JUL.	AUG	SEP	OCT.	NOV.	DEC.	MEAN	
Rainfall mm	75	74	136	388	241	60	49	42	47	90	207	156	1,565	Total
Mean Max. Temp. $0^{o}C$.	31.5	32.0	31.9	30.2	29.5	28 9	28.5	28 9	29.5	30 5	30 5	31.2	30.3	
Mean Min. temp. $0^{o}C$.	22.9	22.7	23 1	23.1	22.7	21.7	20.6	19.6	19.1	20 0	21 2	21.5	21.6	
Relative Humidity % at 06.00 hrs.	93	94	94	93	92	90	89	92	94	95	96	95	93	
Relative Humidity % at 15 00 hrs.	64	64	68	73	69	63	61	57	56	60	69	67	64	
Raindays 1 mm	7	5	13	18	13	7	6	7	7	17	14	12	116	Total
Mean Sunshine hours	7.8	8.0	7 2	5.5	6.7	7 5	7.3	8.1	8 3	8 3	7.6	7 6	7.5	
Daily Radiation Langlays m	448	438	427	372	391	408	409	425	448	446	423	432	422	
Class A Pan Evaporation	160	120	130	170	110	130	120	110	100	150	190	150	1,640	Total
Wind speed Knots at 15.00 hrs.	8	8	6	7	9	10	10	10	10	9	7	7	8	
Cloud Cover oktas at 15.00 hrs.	4 8	4.7	5.2	5.6	4.7	4.0	4.4	3.9	3 4	4 1	4 9	4.7	4 5	

The Table shows that due to the marine influence most of the weather parameters are fairly constant throughout the year

Figure 1. Total annual rainfall from 1974 to 1989 (Missing 1981) - Kisauni, Zanzibar Airport

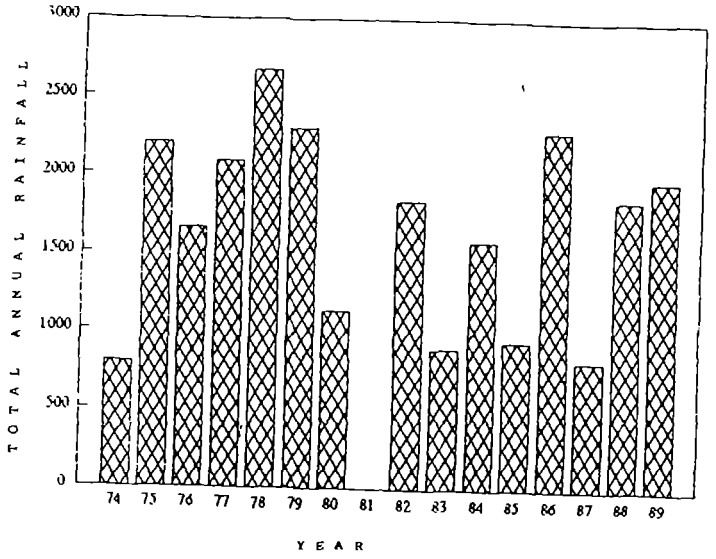


Figure 2. Average monthly rainfall from 1974 to 1989 (missing 1981) - Pemba, Karume Airport

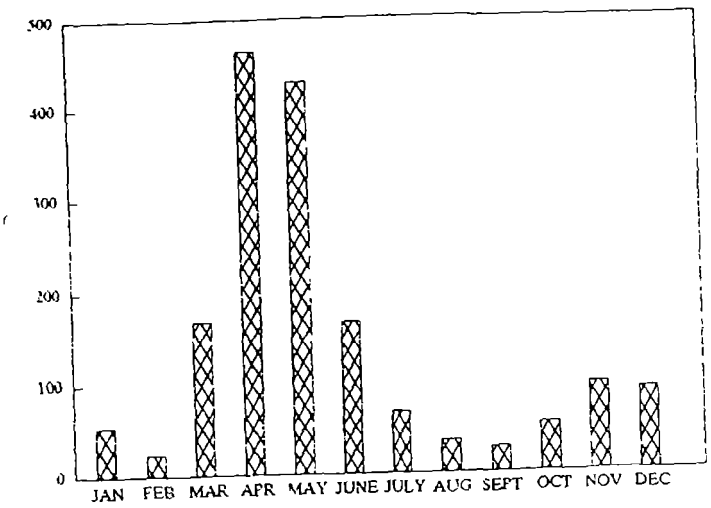


Figure 3. Long term average of relative humidity at Zanzibar.

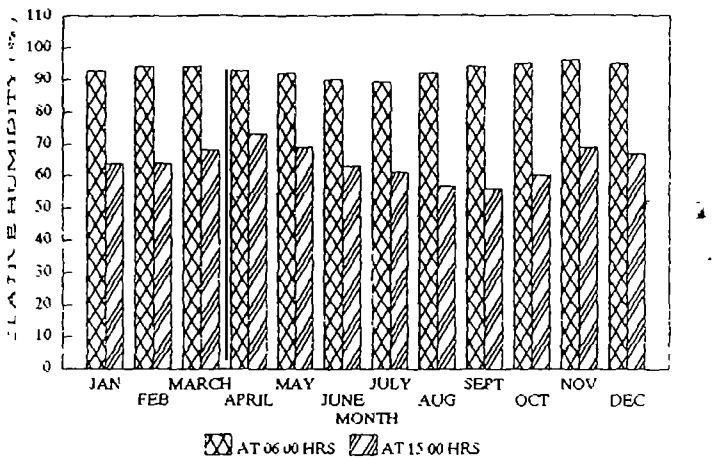
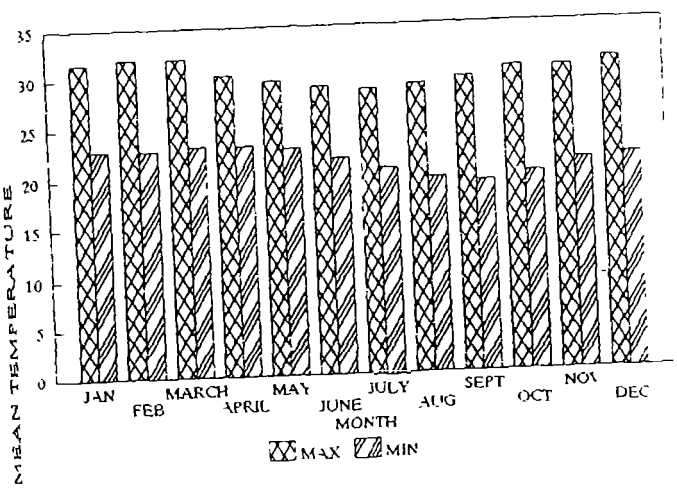


Figure 4. Long term average of temperature figures at Zanzibar.



Annex 4

QUALITY OF GROUND WATER SOURCES OF THE TOWNS OF UNGUJA AND PEMBA

1. Water quality in Unguja (tables 1 and 2)

The following chapters give a report of the environmental and water quality conditions of each existing and some proposed water sources of Zanzibar's town water supply, as well as the town supply network. The results of the University of Dar es Salaam are from April 1990 (rainy season, but drier than usual) and those of the project laboratory from July 1990 (dry season). The information on the environmental conditions of the sources has been collected during the field visits and from the Hydrogeology Field Visit Report (P5).

1) Mwembe Mchomeke boreholes Nos. ZA and ZD

The boreholes are situated about 10 km east of the town of Zanzibar on the Dunga road.

Both boreholes ZA and ZD were analysed by the University of Dar es Salaam and only the borehole ZA by the project laboratory.

The borehole area is surrounded by cassava, banana and coconut cultivation but there is no application of fertilizers. There are houses scattered in the borehole surroundings. Some of these houses have simple pit latrines. Cattle grazing is practiced in the area. The borehole is not closed.

According to both the results of the project laboratory and the University of Dar es Salaam the chemical quality of water is good. Bacteriologically the water is polluted, but no fecal pollution occurs.

2) Kianga borehole No. ZB

Kianga borehole is situated about 11 km north east of the town of Zanzibar and about 500 m east of Kianga village.

The borehole area is surrounded by cassava, banana and coconut cultivation, but no fertilizers are applied. There are few cattle grazing in the surroundings, but generally the environment appears reasonably clean. The borehole is open.

According to the test results the chemical quality of water is good as was the bacteriological quality during the dry season. According to an analysis done by the University of Dar es Salaam few coliform bacteria existed (no fecal coliforms) in samples taken in the rainy season 1990.

3) **Chunga borehole No. 9** (and 8)

Chunga borehole is situated about 10 km east of the town of Zanzibar, about 1.7 km north of Fuoni Main Road.

The borehole area is covered by cultivated vegetation (cassava, coconut palm, banana etc.) There are a few houses near by. There is some rice cultivation also around the area. Fertilizers are used on these fields.

According to a hydrogeological map of Zanzibar the Q2 waters in the Chunga area are simple mixtures of connate water plus local recharge water. High sulphates are recorded due to anhydride/gypsum lenses.

According to all the test results (June 1974, April 1990 and July 1990) the chemical quality of the water is satisfactory and the bacteriological quality unsatisfactory (no fecal coliforms, except in borehole No. 8 tested in April).

4) **Kaburi Kikombe boreholes Nos. 2 and 14**

The boreholes are situated within the town area about 3 km south of the town center and 600 m east of the main airport road.

The borehole area is covered by vegetation, coconut palms, cassava, etc. The recharge area is heavily populated. Some surrounding houses have simple pit latrines and some have septic tanks. About 100 m west of the borehole area there are rice plots situated in swamp area. Ammonium phosphate is used as fertilizer in the rice fields. (P5) There is no fence around the borehole area.

According to the hydrogeological map the ground water in Kaburi Kikombe consists of M3 waters which are simple mixtures of connate water plus local recharge water. The connate waters are typically the chloride rich waters trapped in Q3 sands. High sulphates are frequently recorded due to anhydride/gypsum lenses.

The borehole area is in a zone where sea water invasion is a natural phenomenon at deeper levels, and where good quality waters are due to the development of perched aquifers. (P5)

According to the laboratory results the water of **borehole No. 14** is quite saline (conductivity, total dissolved solids and chloride higher than elsewhere, but not exceeding standards). The bacteriological quality of the borehole is good.

The water of **borehole No. 2** is not as saline, but has excess iron and manganese in it (above all standards). The water is also bacteriologically polluted (but without fecal pollution).

5) Mbweni borehole

Mbweni borehole is located about 5 km south of the town of Zanzibar on the premises of a tractor factory near the sea. It is only a temporary source for the town water supply and will be replaced by other sources in future. The surroundings are not suitable for a water source and the borehole is not properly protected.

However, the chemical quality of water is not alarming, even though the chromium level exceeded the standards in the samples analysed in April 1990. Nitrates were also high, but not above standards. Bacteriologically the water is polluted (though no fecal pollution).

6) Bububu Spring

Bububu spring is situated about 7 km north of the center of the town of Zanzibar. The area is generally known as Mwanyanya. The spring source covers an area of about 30,000 m^2.

The western part of the spring area is covered by cassava, coconut and banana cultivation, and bamboo trees. There are several houses about 20 - 50 m from the spring sump. There is a tree nursery (Misitu nursery) about 250 m to the south east of the spring in the southern river band, which uses fertilizers and pesticides. The nursery may contaminate the spring water, but further studies would be needed to verify it.

The floods of the Bububu river are major sources of contamination for the spring. Flooding takes place almost every year - the worst flood took place in January 1989.

Laboratory results from tests on spring water are available for 1951, 1971, 1972 and 1990. All of them confirm that the chemical quality of the water is good. The most recent samples indicate that the water is bacteriologically polluted (fecal contamination occurs as well).

7) Mtoni Spring

Mtoni Spring, which supplies water for the town is situated about 4 km north of Zanzibar and about 0.5 km east of the shoe factory on the northern bank of Upepo River.

The eastern part of the spring area is covered by a mixture of natural and cultivated vegetation whereas in the western part there are small rice fields. There are houses with pit latrines along the banks of the river. The surroundings cannot be considered suitable for a drinking water source and a replacement or other solution should be found as soon as possible.

According to the results of the University, chromium levels of Mtoni have been higher than elsewhere (not actually exceeding standards, but almost reaching them). This might be due to the shoe factory or Cotex Ltd. Otherwise the chemical quality is satisfactory. Bacteriologically the water is polluted, but no fecal bacteria was found.

8) Kijoto Upele borehole No. 13

The borehole is situated about 7 km east of Zanzibar town, just near the Fuoni main road.

The area is covered largely by natural and cultivated vegetation. Rice plots are situated along Kijoto Upele Valley. Houses are built in the eastern part of the borehole area.

According to the hydrogeological map of Zanzibar the ground waters in the area are Miocene type waters, a simple mixture of connate water and local recharge water.

Water from this borehole has not been analysed at the project laboratory yet, since no water has been pumped recently. According to earlier results the quality is chemically satisfactory and bacteriologically unsatisfactory.

9) Zanzibar town network

Samples were also collected and analysed from one reservoir (Saateni) and five taps of the town supply, for which water is supplied from the above discussed eight sources. The taps selected for sampling were those from the offices of the Water Department and the Urban Water Supply Project, as well as the residences of the expatriates working for the water project.

The network water is of course in all cases a mixture of some of the above described sources. It is therefore no surprise that the water is bacteriologically polluted. In some cases the bacterial levels appear to increase in the network (e.g. the tap water of the Water Department must have its own source of contamination).

10) Dimani Caves

The Dimani Caves are not used as an urban water supply for Zanzibar at them moment, but are considered a potential source in the future.

The caves are located about 14 km southeast of Zanzibar and about 0.3 to 0.9 km from the sea shore.

There are palm, banana, cassava and various fruit crops around the area. The caves are easily reached by the inhabitants, who use the cave water for domestic purposes and even use the cave 'lakes' for bathing purposes. Animal grazing is also practiced in the area. It was also observed that people use the surrounding bushes for defecation. Especially during rains many contaminants are washed down to the cave sources.

In addition to possible problems of salinization and pollution, another fact which may hinder the effective use of this source is its religious reputation (it is in someway considered a holy place created by gods).

The chemical quality of the cave water seems to be satisfactory, but more analyses are required to confirm it. Bacteriological analyses have not yet been done by the project laboratory, yet. According to the earlier analyses the water is polluted, but surprisingly, not fecally.

11) Other springs and boreholes

Fuoni Spring is a small source of very little interest in terms of urban water supply. The spring, from where water is fetched by individuals from surrounding areas, is shaded by trees and bushes in marshy surroundings. According to the laboratory analysis, the water is exceptionally acidic (pH levels below the standards). The conductivity, total dissolved solids and hardness are very low. The water is bacteriologically polluted (no fecal contamination).

The **Bubwi Sudi boreholes Nos. 2 and 4**, as well as the **Kizimbani Dole borehole No. 1** are interesting due to their location in the major ground water area of Ujunga and within the major cultivated areas. The boreholes are mainly used for irrigation purposes. According to the laboratory results the chemical quality of the water looks "normal" and satisfactory. The water is bacteriologically polluted (no fecal pollution).

12) Local shallow wells

All the shallow wells (about 100) of the main ground water areas of Unguja have been selected for continuous monitoring of water levels and conductivity. Out of these wells 20 were selected for further quality monitoring (the first results have not yet been obtained for them all).

These are open wells located in rural areas, usually surrounded by houses and vegetation. The average depth of a well is about 10 m (varying between 5 and 20 meters).

The wells are divided here into six groups according to their locations: **Kisakasa-Jumbi** area (wells nos. 2 and 9), **Fuoni area** (wells nos. 34, 36 and 23), **Kidmigi-Kitumbi area** (wells nos. 54 and 63), **Kiboje area** (wells nos. 68, 69, 92 and 93), **Kizimbani-Machui area** (wells nos. 97, 103, 104, 109 and 97) and **Bumbwi Sudi area** (wells nos. 79 and 81).

The water of well no. 2 seems to be exceptionally saline with very high levels of chloride (above standards), conductivity and total dissolved solids. The conductivity and TDS of well no. 63 is also high. The pH-level of wells in the Kizimbani-Machui area is very low. Well no. 109 has exceptionally hard water. Nitrate levels are high in wells 63 and 109. Well 63 also has a high copper content. Concentrations of iron and

manganese are very high in well 104. Aside from this, the chemical quality of these wells appears 'normal'.

The wells are bacteriologically polluted (fecal contamination occurs as well).

2. Water Quality in Pemba

All the existing water intakes of the three towns of Pemba, as well as some sources (springs, boreholes and local shallow wells) due their proximity were selected for quality analysis.

Only the project laboratory has conducted analyses of samples from Pemba (except for the results of two analyses for boreholes C7 and C8 in 1959 and 1960). Therefore the amount of parameters checked is less than for samples from Unguja. The samples were collected during the dry season and therefore the results represent the best possible situation. During the rains waters are of course more polluted, since none of the sources are properly protected.

Chake Chake area (table 3)

1) Miembeni spring area

The Miembeni spring and water works are located at Chake Chake in a depression along the main road to Mkoani. The spring is the most important source for the town - people take water from it also when the supply system is not functioning. The spring area is in very bad condition with many sources of contamination.

There are at least two open chambers, from which people fetch water directly using unhygienic containers. They also wash and bathe near the well; the waste water from washing and bathing is stagnating around and obviously seeps into the soil and back to the source. The overflow tank, which appears very dirty, seems to lead the water back to the source as well.

The sewers for surrounding houses lead to the stream passing the spring (possibly in direct contact with the spring water).

According to the quality results the levels for water conductivity, total dissolved solids, hardness, and chloride are a bit high, but nowhere near the highest permissible levels. Nitrate and manganese levels were also quite

high. The water is bacteriologically polluted, but surprisingly no fecal pollution was detected.

One local well quite close to Miembeni Spring on the other side of the main road in **Bandalataka** was also checked. The well is in very heavy use, especially when the town supply does not function properly (i.e. almost all the time). The water level of the well is high (apparently the same water as in Miembeni). It is an open source with very unhygienic surroundings. People fetch water with various containers (usually rather dirty looking ones). Washing and bathing also take place at the well and the waste waters seep into the ground or stagnate around the well area.

According to laboratory results this water is also a bit saline (even more than Miembeni). Just as in Miembeni, nitrates are high here as well. Surprisingly, the water is not fecally polluted (total coliforms were not tested).

2) Kwapweza Spring Area

Kwapweza Spring is a new ground water source for Chake Chake town supply with future potential. The spring is situated in a valley about 5 km from the town. The intake is not properly covered and there are spider webs and dirt in the tank and water, and also a lot of fish. There are rice fields quite near by (fertilizers used).

The pH-level of the water is very high (exceeding even Tanzanian standards). Otherwise the chemical quality appears good. The water is bacteriologically polluted, but no fecal contamination took place at the time of sampling.

Five **local wells (Nos 1,2,3,24 and 25)** situated around the Kwapweza spring area were also analysed. The quality of water is chemically satisfactory, except for some concentrations of iron, manganese and copper, which nevertheless do not exceed Tanzanian standards. There is no fecal bacteria - other bacteriological qualities were not checked.

3) Changaraweni and Changuo areas

The **Changaraweni borehole** is situated along the Fidel Castro Hospital - Karume Airport road, about 9 km east of Chake Chake. There is some fencing around the area and the borehole is inside the pumping house, but not properly protected.

According to the laboratory results, the levels of conductivity, total dissolved solids and hardness are a bit high, but not higher than elsewhere in the area. The problem is the high iron content in the water (more than 2 mg/l, whereas the WHO standard is 0.3 mg/l and the Tanzanian standard 1 mg/l). Manganese levels also exceed the standards. Some treatment is clearly needed if the water is going to be used for drinking purposes. There is no fecal bacteria - other bacteriological qualities were not checked.

The **Changuo borehole C8** is located about 13 km from the town in Vitongoji. This borehole is said to contain high amounts of calcium, which precipitate in the pipes.

The area was surrounded by banana and cassava crops. There is a hospital close by (waste waters are led to the other side - toward Jamvini).

According to the quality results, the water is otherwise chemically similar to Changaraweni borehole water, except that there is no iron problem in Changuo. Water is hard (evidently due to calcium), but not much more than in Changaraweni. None of the chemical parameters analysed were above standards. There is no fecal bacteria - other bacteria was not checked for.

Another borehole in Vitongoni about 1 km west of Changuo is **Jamvini borehole C7.** This borehole has not been used recently. The water sample was taken during the pumping tests carried out in July. There are some rice fields close to the area. According to the laboratory results, the levels of conductivity and total dissolved solids, as well as hardness, are very similar to those at the Changuo borehole. The water in Jambini, however, has much less chloride. Some coloring occurs, perhaps due to manganese. The bacteriological quality was not analysed.

Three **local wells (nos. 4, 5 and 6)** in the proximity of the above boreholes were checked. The results show that the water of well no. 4 is very saline, which is not surprising, since it is very close to the sea. This water also has a high concentration of nitrate and copper. The chemical quality of other wells is very similar to the quality of the above-mentioned boreholes, as regards salinity and hardness. Fluorides in well no. 6 are exceptionally high. Fecal coliforms are present in wells 4 and 5.

Wete area (table 4)

1) Town area

The water quality of one local spring in Wete was analysed. The source is called **Miti Ulaya spring.**

The chemical quality of the water seems to be good (a bit high nitrate level). No fecal pollution occurred (total coliforms were not tested).

2) Gavani area

The **Gavani spring** is located in a valley about 1 km south of Wete. It is not further than about 60 m from the sea. Rice cultivation and cattle grazing takes place in the surrounding fields.

According to the laboratory results, the water is chemically good (no sign of salinity). There was some coloring and turbidity in the water. The water is bacteriologically is polluted (no fecal contamination).

Bubujiko spring, which is situated a few hundred meters west of Gavani, was also checked. There are rice fields quite near by and cattle is grazed around the spring area.

According to the laboratory results, the water is very similar to Gavani spring, except that levels of manganese seem to be higher in Bubujiko (0.3 mg/l, whereas the WHO standard is 0.1 and Tanzanian standard 0.05). There is no fecal contamination (total coliforms were not tested).

3) Bungumi area

Bungumi Spring is located in a valley about 5 km southwest of Wete and about 1 km from the junction of the Chake Chake - Wete main road. The spring area is surrounded by sugar cane and rice fields. Some algae grow in the spring water.

According to the quality results, the water is chemically good (actually not much different from Gawani water). There is no fecal pollution (no other bacteria was analysed). The quality of stream water passing the spring area looks quite different than the spring water.

Two **local wells (nos. 43 and 44)** were checked. They are situated along Wete Road, one close to Bungumi spring (43) and one close to Prison Farm

and other rice cultivations (stream water from this area was also tested). Only a few parameters were analysed. The conductivity of well no. 43 is remarkably lower than at the spring. The iron content is high in both wells and in the spring. The wells do not appear to be fecally polluted (total coliforms were not checked).

4) **Masipa area**

The third source for the Wete town supply is the **Masipa borehole**. It is located about 6 km west of Wete town. There are rice fields around the borehole area. The intake area is fenced, but the borehole is not covered.

According to the laboratory results, the water has high color and turbidity levels. Otherwise the water seems to be good (the chemical quality does not differ much from Gawani and Bungumi). The water is also good bacteriologically.

Three **local wells (nos. 35, 37 and 38)** in the close proximity of the Masipa borehole were checked as well.

Mkoani town supply (table 5)

1) **Mkoani town area**

The **Cogefar borehole** in Mkoani town (just on the shore of the Indian ocean) was tested. The levels of conductivity, total dissolved solids, chlorides and hardness were much higher than in other sources in the Mkoani area, but nevertheless lower than for example in Chake Chake boreholes (or Unguja). The nitrate level in the water was very high, as well as coliform bacteria (but no fecal coliforms).

Two **local wells (nos. 10 and 52)** in Mkoani town were also tested.

2) **Kiguuni**

Kiguuni spring is located in a valley which opens into the Indian ocean. The slopes of the hills around the spring are very steep and covered by vegetation. There is an open tank and a open well in the spring area (sources of contamination). No houses are located in very close proximity. There are rice fields close by.

According to the laboratory results the water contains a high concentration of fluoride (2.4

mg/l was measured, whereas the highest permissible level is 1.5). Unfortunately, the fluoride test could not be repeated due to shortages of chemicals (it will be carried out later). Otherwise the chemical quality seems to be good. No fecal contamination was found (other bacteria - total coliforms - were not tested).

3) **Changaweni**

Changaweni ground water source is situated 1 km from Mkoani town along the main road to Chake Chake. There are four boreholes around the area, two of which were in operation at the time of sampling. The area is surrounded by vegetation (e.g. banana). There are houses and open wells close by. The boreholes are not properly closed off.

According to the laboratory results the water seems to be chemically good. No fecal contamination seems to take place either (total coliform bacteria was not analysed this time).

Local well no. 51 close to Changaweni borehole was also tested.

4) **Mtambile**

Chemical samples were collected in June from three **local wells (nos. 7, 8 and 9)** in the Mtambile area. The conductivity and hardness as well as levels of total dissolved solids and chlorides seem to be higher in these sources (especially in well no.7) than in the sources described above. Not much more can be said about the quality, since only a few parameters were analysed.

TABLE 1. WATER QUALITY DATA - UNGUJA - WATER SOURCES AND METHODS OF ZANZIBAR TOWN AREA (RESULTS OF PROJECT LABORATORY)

	DATE	COLOUR	TURBIDITY	TEMP.	pH	CONDUCTIVITY	TDS	CO2	HARDNESS	Cl-	SALINITY	NO2	NO3	PO4	F	Fe	Mn	Cr6+	Cu	TOTAL COLI-FORMS	E.COLI
		mg/l Pt	FTU	oC		us/cm	mg/l	mg/l	mg/l CaCO3	mg/l	ppt	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	/ 100ml	/ 100ml
INTAKES																					
M MLHOPEKE BH 7A	24.7	0	0	-	7.6	540	270	33	267	10	16	0 001	1.3	0.22	0.00	0.02	0.00	0.01	0.14	4	0
MANGA BH 7B	24 7	0	0	-	7.5	476	238	26	256	6	11	0.003	0.7	0.47	0.03	0.05	0.00	0.01	0.24	0	0
CHUNGA BH 9	24.7	0	0	-	7.0	582	291	53	302	5	9	0.003	1.1	0.66	0.17	0.03	0.00	0.01	0 43	12	0
MKWAJUNGOSE BH 14	24.7	0	0	-	7.4	944	472	32	284	111	195	0.009	3.1	0.33	0.00	0.10	0.10	0.01	0 12	0	0
MKWAJUNGOSE BH 2	24 7	59	12	-	7.6	740	370	28	250	61	107	0.003	1.4	0.17	0.65	1.35	0.20	0.00	0.17	84	0
MAMENI BH	25.7	0	0	-	7.2	616	308	24	258	26	46	0.002	5.0	0.79	0.43	0.00	-0.00	0.01	0.19	12	0
BUBUBU SPRING	25.7	0	0	-	7.1	601	300	40	293	8	14	0.003	1.2	0.35	0.23	0.01	0.00	0.01	0.00	43	0
MTONI SPRING	25.7	0	0	-	7.0	625	313	34	280	9	16	0.003	1.0	0.24	0.48	0.02	0.00	0.01	0.29	15	0
MJUJITO UPELE BH 13				-																	
METHODS																					
SAATENI-BUBUBU WEIR	1.8	0	0	-	-	604	302	64	-	6	-	0.002	0.1	0.21	-	0.02	0.00	0.09	-	-	-
SAATENI-MTONI WEIR	1 8	0	0	-	-	627	313	72	-	5	-	0.002	0.1	0.29	-	0.02	0.00	0.01	0 16	-	-
SAATENI RESERVOIR (UNDERS.)	1 8	0	0	-	-	616	308	66	-	3	-	0.003	0.1	0.35	-	0.07	0.00	0.00	0 20	-	-
TAP 1 (GULIONI)	9.7	0	0	-	7 9	577	290	29	286	29	51	-	1.0	0.65	0.46	0.01	0.29	0.00	1.62	21	1
TAP 2 (MAISARA)	16.7	0	2	-	7.9	574	266	4	235	9	16	-	1.1	0.02	0.00	0.13	0.00	0 01	0.11	5	0
TAP 3 (MTONI)	16 7	0	0	-	7.5	663	282	4	273	6	11	-	1.1	1.27	0.00	0.01	0.00	0.00	0.10	6	1
TAP 4 (MTONI)	16.7	0	0	-	7.8	631	293	4	246	6	11	-	1.4	0.22	0.00	0.01	0.00	0.01	0.14	TCN	0
TAP 5 (MAZIZINI)	16.7	0	0	-	7.1	941	474	8	231	117	206	-	2.6	0.68	0.00	0.19	0 00	0.01	0.18	0	0
OTHER SOURCES												-									
KIZIMKAZI DOLE BH 1	8.7	0	0	-	7.3	774	380	87	250	68	122	-	2.2	0.95	0.25	0.03	0.10	0.01	0.35	-	-
DIMANI CAVE	25.7	6	0	-	5.9	111	55	46	19	10	18	0.002	1.4	0.46	0.30	0.11	0.00	0.00	0.01	TCN	0
FUONI SPRING	26.7	0	0	-	7.1	495	247	17	241	7	12	0.000	1.2	0.33	0.65	0.14	0.00	0.01	0.09	0	0
BUMBNI SUDI BH 2	26.7	0	0	-	7.2	570	285	31	244	3	5	0.004	1.1	0.16	0.54	0.06	0.00	0.00	0.10	5	0
BUMBNI SUDI BH 4																					
WHO GUIDELINES 1984		15	5		6.5-8.5		1000		500	250			10.0		1.50	0.30	0.10	0.05	1.00	0 (3 OCCASIONALLY	0
TANZANIAN STANDARD 1974 (FOR RURAL WS)		50	30		6.5-9.2				600	800					8.00	1.00	0.50	0.05	3.00	1-3	0

TCN = TOO NUMEROUS TO COUNT (DUE TO OVERGROWTH)

Water Quality Survey, Summary of Laboratory results

Table 1

WATER QUALITY DATA, UNGUJA - LOCAL WELLS (RESULTS OF PROJECT LABORATORY)

	DATE	COLOUR	TURBIDITY	TEMP.	pH	CONDUCTIVITY	TDS	CO2	HARDNESS	Cl-	SALINITY	NO2	NO3	PO4	F	Fe	Mn	Cr6+	Cu	TOTAL COLI-FORMS	E.COLI
		eq/l Pt	FTU	oC		us/cm	eq/l	eq/l	eq/l CaCO3	eq/l	ppt	eq/l	eq/l	eq/l	eq/l	eq/l	eq/l	eq/l	eq/l	/ 100ml	/ 100ml
MTSHASAWA-JUMBI AREA:																					
WELL NO. 2	11.7	0	0	25.6	7.8	1470	735	-	252	286	509	-	1.0	0.49	0.00	0.08	0.00	0.01	0.33	TNC	0
WELL NO. 9	11.7	0	0	25.9	7.5	414	198	-	125	10	18	-	4.4	0.60	0.00	0.04	0.20	0.01	0.06	TNC	0
UNGUJA AREA:																					
WELL NO. 34	11.7	0	0	29.6	7.2	536	266	-	222	10	18	-	3.3	0.58	0.14	0.05	0.00	0.01	0.09	25	0
WELL NO. 36	11.7	0	2	27.0	6.6	149	75	-	69	12	21	-	0.7	0.30	0.00	0.03	0.00	0.01	0.04	TNC	0
WELL NO. 23	12.7	12	2	26.3	7.0	366	183	18	180	18	32	0.009	2.2	0.96	0.00	0.39	0.00	0.01	0.05	TNC	2
KIDIMNI-KITUMBA AREA:																					
WELL NO. 54	19.7	0	0	26.1	7.3	732	316		85	13	23	0.003	1.5	0.20	0.00	0.14	0.10	0	0.81	15	5
WELL NO. 63	13.7	0	0	26.2	7.1	1070	529		195	71	0.01	13.200	0.43	0.00	0.04	0.00	0.01	1.77	TNC	21	
KIBOJE AREA:																					
WELL NO. 68	14.7	0	0	26.1	7.2	633	309	-	38	5	9	0.020	1.6	0.40	0.00	0.00	0.00	0.01	0.03	-	-
WELL NO. 69	14.7	0	0	25.2	7.2	650	323	-	340	7	12	0.004	1.7	0.11	0.07	0.03	0.00	0.01	0.04	-	-
WELL NO. 92	14.7	0	0	26.0	7.1	590	299	-	333	12	21	0.003	1	0.04	0.05	0.02	0.00	0.01	0.11	-	-
WELL NO. 93	14.7	0	0	26.0	7.5	579	290	-	333	7	12	0.003	1.2	0.10	0.08	0.05	0.10	0.01	0.19	66	11
KIZIMBANI-MACHUI AREA:																					
WELL NO. 97	12.7	31	4	26.3	7.0	171	86	17	81	16	28	0.004	1.2	0.17	0.00	0.06	0.00	0.00	0.02	-	-
WELL NO. 103	16.7	-	-	26.7	6.2	154	76	-	53	42	74	0.003	0.3	0.05	0.00	0.05	0.00	0.00	0.05	-	-
WELL NO. 104	16.7	49	6	25.6	6.3	112	56	-	119	31	32	0.004	0.0	0.90	0.06	2.01	1.20	0.00	0.12	-	-
WELL NO. 109	14.7	0	0	25.9	7.3	942	472	-	450	51	89	-	13.4	0.12	0.11	0.03	0.00	0.01	0.03	TNC	65
WELL NO. 97	26.7	42	7		6.2	130	65	30	48	3	5	0.000	0.9	0.23	0.34	0.84	0.00	0.00	0.03	TNC	0
BUMBWI SUDI AREA:																					
WELL NO. 79	12.7	19	3	24.7	7.4	222	111	13	91	7	12	0.004	1.2	0.17	0.00	0.06	0.00	0.00	0.02	-	-
	26.7	17	3	-	7.4	245	122	14	87	8	14	0.003	0.9	0.08	0.44	0.11	0.00	0.00	0.01	TNC	0
WELL NO. 81	19.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	TNC	2
WHO GUIDELINES 1984		15	5		6.5-8.5		1000		500	250			10.0		1.50	0.30	0.10	0.05	1.0	0 (3 OCCASIONALLY	0
TANZANIAN STANDARD 1974 (FOR RURAL WS)		50	30		6.5-9.2				600	800					8.00	1.00	0.05	0.50	3.0	1-3	0

Table 2

Water Quality Survey, Summary of Laboratory results

TABLE 3 WATER QUALITY DATA PEMBA - CHAKE CHAKE AREA (RESULTS OF PROJECT LABORATORY)

	DATE	COLOUR	TURBIDITY	TEMP.	pH	CONDUCTIVITY	TDS	CO2	HARDNESS	Cl-	SALINITY	NO2	NO3	PO4	F	Fe	Mn	Cr6+	Cu	TOTAL COLI-FORMS	E.COLI
		mg/l Pt	FTU	oC		us/cm	mg/l	mg/l	mg/l CaCO3	mg/l	ppt	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	/ 100ml	/ 100ml
INTAKES:																					
MIEMBENI SPRING	26.6	5	1	28.1	9.1	914	462		302	86	151		7.5	0.18	0.29	0.03	0.10	0.01			
	27.7					877	439	118				0.007	10.6				0.04		0.07	TNC	0
KWAMEIA SPRING	26.6	16	3	27.8	9.7	602	302		278	15	26		0.6	0.36	0.80	0.29	0.00	0.00			
	26.7					588	294	82									0.20				
CHANGAWENI BH	27.6	19	13	27.7	6.7	903	452		399	56	98		0.6	0.57	0.41	2.18	0.40	0.00			
	26.7					862	431	144									0.10				
CHANGUO BH	27.6	0	0	28.2	6.9				418	60	105		1.0	0.65	0.23	0.02	0.20	0.00			
	26.7	0	0			902	452	108									0.10		0.62	15	0
JAMBINI BH 7	26.7	10	2			865	443	124	361	29	51		1.2	0.56		0.27	0.30	0.00	0.88		
CLOVE DISTILLERY BH	26.7	0	0			522	261	112					0.9	0.70	0.51	0.40	0.01	0.24		0.00	
NEAR MIEMBENI:																					
LOCAL WELL, BANDALATAKA	28.6	14	2						261	117	206		15.1	0.09	0.00	0.01	0.00				
	27.7	4	0			790	325					0.016	15.5					0.01	0.03		0
NEAR KWAMEIA:																					
LOCAL WELL NO. 1	26.6	17	2	28.0	8.9	173	83		0.04	18	32		1.2	0.23	0.00	0.11	0.00				
	26.7					186	93							0.14			0.20	0.01	0.02		
LOCAL WELL NO. 2	26.6	17	2	28.0	7.3	107	54		15	24	42		0.5	0.01	0.80	0.50	0.00				
	26.7					106	53												2.41		0
LOCAL WELL NO. 3	26.6	3	0	28.4	8.4	209	104		30	37	65		3.1	0.42	0.80	0.18	0.20	0.01			
LOCAL WELL NO. 24	26.7	7	0			166	83						0.4	0.16		0.02	0.00	0.00	0.02		0
LOCAL WELL NO. 25	26.7	2	0			641	320						1.0	0.35		0.12	0.10	0.00	0.16		0
NEAR CHANGAWENI AND CHANGUO:																					
LOCAL WELL NO. 4	27.6	10	1	28.1	6.6	2080	1050		1125	393	691		19.6	0.75	0.00	0.03	0.20	0.01			
	26.7	0	0		6.8	2060	1030							0.72		0.01	0.00		3.00		35
LOCAL WELL NO. 5	27.6	11	1	27.9	7.2	852	426		215	62	109		3.0	0.52	0.00	0.09	0.20	0.01			
	26.7	0	0		7.1	879	439							0.14			0.00		0.81		1
LOCAL WELL NO. 6	27.6	1	0	29.0	7.4	900	450		335	43	76		2.2	0.52	1.24	0.02	0.20	0.01			
	26.7	0	0		7.0	890	445							0.22		0.03	0.00		0.84		0
WHO GUIDELINES 1984		15	5		6.5-8.5		1000		500	250			10.0		1.50	0.30	0.10	0.05	1.00	0 (3 OCCASIONALLY)	0
TANZANIAN STANDARD 1974 (FOR RURAL WS)		50	30		6.5-9.2				600	800					8.00	1.00	0.05	0.50	3.00	1-3	0

TNC = TOO NUMEROUS TO COUNT (DUE TO OVERGROWTH)

Water Quality Survey, Summary of Laboratory results

Table 3

TABLE 4. WATER QUALITY DATA, PEMBA, MKOANI AREA (RESULTS OF PROJECT LABORATORY)

	DATE	COLOUR	TURBIDITY	TEMP.	pH	CONDUCTIVITY	TDS	CO2	HARDNESS	Cl-	SALINITY	NO2	NO3	PO4	F	Fe	Mn	Cr6+	Cu	TOTAL COLI-FORMS	E.COLI
		mg/l Pt	FTU	oC		us/cm	mg/l	mg/l	mg/l CaCO3	mg/l	ppt	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	/ 100ml	/ 100ml
INTAKES																					
GAMANI SPRING	27.6	23	7	29 0		520	259		238	24	42		0.4	0.10	0.46	0.19	0.10	0.00			
	26.7	12	2			535	267	86								0.34	0.10		0.06	21	0
BUNGUMI SPRING	27 6	11	2	28.1		494	247		252	17	30		0.3	0.17	0.80	0.30	0.10				
	26.7	6	7		7.1	532	266	84								0.31	0.06	0.01	0.07		0
MASIPA BH	27.6	71	13	29.0		508	255		261	22	39		0.3	0.08	0.52	0.37	0.10				
	26.7	0	2		7.2	562	281	86								0.15	0.06		0.05	0	0
IN TOWN																					
MITI ULAYA SPRING	26 7	0	0			496	249		156				4.1	0.24		0.05	0.10	0.01	0.01		0
NEAR GAMANI																					
STREAM	27.6	50	9	30.9		177	88		43	29	51		1.2	0.07		0.47					
BUBUTIKO SPRING	26.7	5	1			642	321	106	280	43	76		0.9	0.58		0.32	0.30	0.01	0.1		0
NEAR BUNGUMI																					
LOCAL WELL NO. 44	26.7	36	17		6.7	290	145							0.58		1.46	0.30	0.01	0.06		0
LOCAL WELL NO. 43	27.6	59	16			668	334						0.3	0.25		1.84	0.80	0.01	0.15		0
PRISON FARM STREAM	27.6	117	22	26.7		323	161		141	20	35		0.1	0.04	0.10	1.35	0.40				
NEAR MASIPA																					
LOCAL WELL NO 35	27.6	8	0	27.0		423	212		164	29	49		1.6								
	26.7	0	0			369	185							0.38		0.00	0.10	0.01	0.09		0
LOCAL WELL NO. 37	27 6	13	1	26 8		177	88		71	13	23		1.4								
	26 7	13	4			172	86						0.8	0.19		0.74	0.20	0.00	0		0
LOCAL WELL NO 38	27.6	9	4	28.0		522	261		102	96	169		8.9								
WHO GUIDELINES 1984		15	5		6.5-8.5		1000		500	250			10		1.50	0.30	0.10	0.05	1.0	0 (3 OCCASIONALLY	0
TANZANIAN STANDARD 1974 (FOR RURAL WS)		50	30		6.5-9.2				600	800					8 00	1.00	0.50	0.05	3.0	1-3	0

Water Quality Survey, Summary of Laboratory results

Table 4

TABLE 5. WATER QUALITY DATA - KENYA-MADAI AREA (RESULTS OF PROJECT LABORATORY)

	DATE	COLOUR mg/l Pt	TURBIDITY FTU	TEMP. oC	pH	CONDUCTIVITY us/cm	TDS mg/l	CO2 mg/l	HARDNESS mg/l CaCO3	Cl- mg/l	SALINITY ppt	NO2 mg/l	NO3 mg/l	PO4 mg/l	F mg/l	Fe mg/l	Mn mg/l	Cr6+ mg/l	Cu mg/l	TOTAL COLI-FORMS / 100ml	E.MH E COLI / 100ml
INTAKES																					
CHANGAMENI BH	27.6	17	4	26 8	6.6	203	101		64	14	25		0.7	0.2	0.27	0.28	0.10	0.00			
	26.7	5	13			117	88	70								0.49	0.01		0.04		0
KIBUNI SPRING	27.6	5	1	27 0	6.7	130	65		28	12	21		1.2	0.11	2.40	0.01	0.00				
	26.7	15	10		6.1	173	86	46											0		0
IN TOWN																					
COSEFAP BH	27.6	5	0	26.6	7.0	616	308		241	62	109		8.2	0 22	0.05	0.01	0.00	0.00			
	26.7	0	7		6.5	627	314		110			0.019	10.6						0.06	29	0
LOCAL WELL NO.10	27.6	14	3	26.2	7.2				124	29	51		1.1	0.08		0.37					
LOCAL WELL NEAR NO.10	26.7	0				482	241									0.01	0.00	0.00	0.03		0
LOCAL WELL NO.52	26.7	13	0			676	338						1.5	2.50	0.33	0.30	0.01	0.21		0	
NEAR KIBUNI																					
LOCAL WELL NO.51	26 7	34	7			412	206						1.1	0.29		0.60	0.40	0.01	0.07		0
KIAMBILE																					
LOCAL WELL NO 7	27.6	6	0	26.1	7.9	1136		428	138	243		5.1	0.67								
LOCAL WELL NO.8	27.6	5	1	26.0	7.9	157	329		267	35	62		0.8	0.34							
LOCAL WELL NO.9	27.6	16	3	25.6	6.7	154	227		113	68	120		1.4	0.12							
	27.6	9	4	28.0		522	261		102	96	169		8.9								
WHO GUIDELINES 1984		15	5		6.5-8 5		1000		500	250			10		1.50	0.30	0.10	0.05	1.0	0 (3 OCCASIONALLY	0
TANZANIAN STANDARD 1974 (FOR RURAL WS)		50	30		6.5-9 2				600	800					8.00	1.00	0.50	0.05	3.0	1-3	0

Table 5

Water Quality Survey, Summary of Laboratory results

Annex 5

WATER QUALITY STUDY REPORT

OF THE UNIVERSITY OF DAR ES SALAAM

JUNE 1990

FIRST DRAFT

THE QUALITY OF DRINKING WATER IN ZANZIBAR TOWN

A.K. KIVAISI
J.J.A. VAN BRUGGEN

JULY, 1990

Prepared for the Zanzibar Urban Water Supply Development Plan

FINNIDA **PLANCENTER**

THE QUALITY OF DRINKING WATER

IN

ZANZIBAR TOWN

A.K.Kivaisi,
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The Applied Microbiology Unit
Department of Botany, Faculty of Science,
University of Dar es salaam.

July, 1990

PREPARED FOR THE ZANZIBAR
URBAN WATER SUPPLY DEVELOPMENT PLAN

FINNIDA PLANCENTER

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1. SUMMARY

The general quality of the drinking water of Zanzibar town as well as the presence of toxic substances were examined. Compared to WHO and Tanzanian Standards, the water was in general fit for consumption, with only a few exceptions.

The water at Mbweni, Fuoni and Kiongoni local well was found to be polluted with very high levels of Chromium while Iron levels at Mchomeke, Kiongoni, Mtoni, Kijito Upele, Chunga, Dimani Cave, Mbweni, Fuoni and Mwera were higher than WHO highest desirable level. Manganese levels at Kijito Upele, Kikombe and Chunga also exceeded the WHO level The source of pollution of these water sources with heavy metals should be established and controlled.

The microbiological quality of the water was also investigated. All water sources except Kaburi Kikombe bore hole were found to be heavily contaminated with coliform bacteria (up to $\geq$ 23 cells per 100 ml) Of the functional water sources only Bububu spring was found to be contaminated with fecal coli bacteria, but at many consumer taps the water was contaminated with these bacteria.
On the basis of WHO recommendations, only the water from Kaburi Kikombe is suitable for drinking.

It is important to check the microbiological quality of the water regularly in order to advice the public on hygienic measurements to take In order to improve the quality of the water, covering of all boreholes and adoption of a good sanitation system are recommended.

2. ACKNOWLEDGEMENTS

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The Institute of Marine Sciences
The Geology Department

Special thanks go to Mr Bakari, Mr Saleh Mr. Mohamed and Ms Sanura for their assistance in sampling and to Mr Kimati for taking the major load of laboratory work.

Without financial assistance of the Finnish International Development Agency (FINNIDA) it would not have been possible to carry out the project.

3. INTRODUCTION.

Zanzibar is situated in the Indian Ocean off the coast of Tanzania and consists of the islands Unguja and Pemba. Unguja is the main island and is often called Zanzibar. (This study was done on the main island Unguja). In 1964 the two islands were united with Tanganyika to form the United Republic of Tanzania. Zanzibar has its own Parliament and Government.
The island has an area of 1600 km² and a population in 1988 of 375,539 people with an annual population growth of 2.3 % in rural areas and about 5 % in urban areas The population of Zanzibar town was 158,000 in 1988 according to the 1988 census

Zanzibar being a small island does not have big rivers and therefore depends on ground water for domestic use and drinking. Although there are many groundwater sources which include boreholes and springs only some are functional and the island, particularly the urban area, is at the moment experiencing a shortage of water supply.

In order to increase the supply, more water sources have to be brought into operation. Therefore, the Ministry of Water in Zanzibar, in collaboration with the Finnish International Development Agency (FINNIDA), has started a project to rehabilitate the distribution of drinking water on the island. The Water Department plans to incorporate more water sources into the distribution network and hence to increase the supply.

Prior to the start of the rehabilitation works it has to be known if the overall quality of the water is good. The quality of the water at the new sources had to be established in order to determine its suitability for incorporation in the existing distribution network, whereas the quality of the water at all points in the distribution network was examined in order to have a general picture of its suitability for domestic use.

This report gives an overview of the present quality of the water of all water sources and in the distribution system It can be used as a basis on which it may be decided which new sources to incorporate and measures to be taken in order to increase the supply and improve the quality.

4. OBJECTIVES OF THE STUDY.

The objectives of this study are:

1. To determine the physical/chemical conditions of the drinking water in Unguja island (at sources) with emphasis on the levels of toxic substances, substances which may affect health and substances affecting suitability for domestic use.

2 To determine the microbiological quality of the water from all sources and at all points in the distribution network.

3. To compare the quality of the drinking water in Zanzibar Island with WHO and Tanzanian Standards.

5. METHODS AND PROCEDURES.

The sampling and analysis was carried out basically in accordance with the Standard Methods for the Examination of Water and Waste Water, 16th Edition 1985, issued by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation [Ref 1].

5.1 Sampling Methods

In springs with no pumping facilities water samples were taken at 0-20 cm below the water surface. Water samples from taps were taken after allowing the water to run for about 5-10 min. The samples for the determination of Fecal and Total Coliform bacteria were collected in sterile 500 ml glass bottles, and samples for Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD) analyses were collected in 250 ml plastic bottles. For heavy metals analysis samples were collected in 50 ml plastic bottles with slender necks containing 1 ml concentrated nitric acid. Samples for the remaining analyses were collected in 1000 ml glass bottles.

5.2 Handling and logistics

Except for samples for heavy metal analysis, all samples were stored in a well insulated box immediately after sampling, and were subsequently transferred to the laboratory of the Pharmaceutical Division of the VI Lenin Hospital for analysis. Analyses for DO, BOD, Total Solids (TS), Conductivity , Chloride and Coliform bacteria always started within 4-5 h after sampling. The remaining analyses were done later in the laboratory of the Applied Microbiology Unit at the University of Dar es Salaam.

5.3 Physical Parameters.

Temperature and pH were measured at sampling sites. Conductivity and DO were measured in the laboratory.

Temperature.

Temperature of the water was measured at the sampling site in the shade with a thermometer.

Dissolved Oxygen.

DO was measured in the laboratory with a Cole Parmer Dissolved Oxygen meter and calibration was done against air.

Conductivity.

Conductivity was measured in the laboratory by using a WTW 56 Conductivity meter.
Calibration was done by using a KCL solution.

pH.

pH was measured at the sampling site by using a pH meter stick and a buffer of pH 7 was used for calibration.

Total Solids.

Total solid content was determined by evaporation of a sample in a weighed glass beaker and dried to constant weight in an oven at 105°C The increase in weight over that of the empty beaker represented the total solids.

5.4 *Chemical Composittion*

Heavy Metals.

The acidified samples were evaporated and dried at 105°C, followed by leaching overnight. The concentrations were determined by using a Flame Atomic Absorption Spectrophotometer (AAS) using an air-acetylene flame and various reference lamps.

Other Compounds.

Arsenic, Cyanide, Nitrate, Sulphate and Total Hardness were determined with Merck Testkits. Chloride was determined with a Hach Kit and Fluoride was determined with a selective ion electrode.

5.5 *Organic Pollution*

Biochemical Oxygen Demand

The Biochemical Oxygen Demand (BOD) was determined in special 100 ml bottles. They were incubated for 5 days at 20°C. The BOD was measured according to the Standard Methods (Ref.1. pp 525-532).

5.6 *Bacteriological pollution.*

The bacteriological pollution was determined by analysing the presence or absence of Fecal and Total Coliforms. These bacteria are indicator organisms for the presence of pathogenic bacteria.

Their numbers were determined by using the Most Probable Number Multiple Tube Fermentation method with ten test-tubes, each containing 10 ml sample and concentrated medium. The selective medium was MacConkey broth with Durham tubes to examine gas production (Ref.1, pp 870-874).

Fecal Coliforms.

Fecal Coliforms were determined after 48 h of incubation at 44°C. The presence of these bacteria in presumptive positive tests was confirmed by streaking onto Eosin Methylene Blue agar plates and subsequently incubating at 37°C for 24 h. The presence of single metallic green colonies confirmed the results.

Total Coliforms.

Total Coliforms were determined after 48 h of incubation at 37°C in MacConkey broth medium.

6. SAMPLING SITES

The sampling sites have been given a number and a name. An overview is given in Table 1 and a detailed description is given in Appendix I. All sites were sampled only once, except for sampling sites 7, 8 and 9. They were sampled several times more specificly for the coliform bacteria analysis.

Table 1. Names of sampling sites

Sampling Site	Name
1	Mchomeke B/H 1
2	Mchomeke B/H 2
4	Kianga B/H
5	Kaburi Kikombe B/H
6	Mtoni Spring
7A	Bububu Spring 1
7B	Bububu Spring 2
7C	Bububu Spring 3(Housed)
8	Kijito Upele
9	Chunga B/H 8
10	Chunga B/H 9
11	Dimani Cave
12	Mbweni B/H
13	Fuoni Spring
14	Mwera Police Station

Table 1. Names of sampling sites
Continued

Sampling Site	Name
15	Kiongoni Local well
16	Welezo steel reservoir
17A	Saateni Bububu weir
17B	- Mtoni weir
17C1	- Reservoir 1
17C2	- Reservoir 2
18	Water Department
19	Sogea
20	Muembe Njigu
21	Kibanda Maiti
22	Kilimani
23	Kiembe Samaki
24	Karume Techn. College
25	Mwanakwerekwe Police Station
26	Town Market
27	V.I. Lenin Hospital
28	Miti Ulaya
29	Bwawani Hotel
30	Feed Mill
31	Migombani School
32	Amani Hotel
33	Small Scale industries
34	Mambo Msiige
35	Mr Esa's residence (Mtoni)
36	Mr Yakoub's residence (Mazizini)
37	Children village
38	Mwanakwerekwe Mosque
39	Mfereji wa wima
40	Harbour
41	Kibanda Hatari
42	Kwahani
43	Mkunazini Cathedral
44	Michenzani Block 8
45	Michenzani Block 9
46	Kisauni
47	Ministry of Water
48	Mwanakwerekwe (Kijito Upele)
49	Muembe Madema
50	Mtwango FAO B/H

B/H: Bore hole;
Sampling site No. 3 was omitted.

7. RESULTS AND DISCUSSION

7.1 General

Overviews of BOD values, TS, conductivity and the presence of total and fecal coli bacteria in water distribution network in the island are given in Figures 1 - 5, respectively.

The complete set of data is given in the appendices:

Appendix I gives the description of the sampling sites and the observations done during sampling.

Appendix II gives the general physical and chemical data for all the sampling sites

Appendix III gives the data for the concentrations of heavy metals found in the drinking water

Appendix IV gives information on the presence of Total Coli and Fecal Coli in the drinking water.

Appendix V gives WHO recommendations on the microbiological quality of drinking water.

Appendix VI gives WHO and Tanzanian standards for drinking water.

Appendix VII gives WHO suggested frequency of sampling and analysis.

Appendix VIII is a Hydrochemical map of Zanzibar

7.2 Physical/Chemical data

Temperature, Dissolved Oxygen, Oxygen Saturation
The temperature of the water ranged between 25 and 30.5°C. By combining the temperature values with the DO values and assuming a Chlorinity of zero, the oxygen saturation was calculated. From Appendix II it can be seen that for all sampling sites the oxygen saturation is above 70%. This result implies that the water is not anaerobic.

BOD
On the contrary, the BOD values for most of the sampling sites are about 2-5 times higher than the Tanzanian Standard value. It is only sites 1, 15, 25, 45 and 48 which appear to contain desirable levels of organic matter. Lack of correlation between oxygen saturation and BOD values cannot be explained.

From Fig. 1, it can be seen that the amount of organic matter in the water distribution network of the island does not follow any clear pattern but varies from one sampling site to another. BOD values obtained for several points in the urban water distribution network appear to differ markedly. Since the water mixes

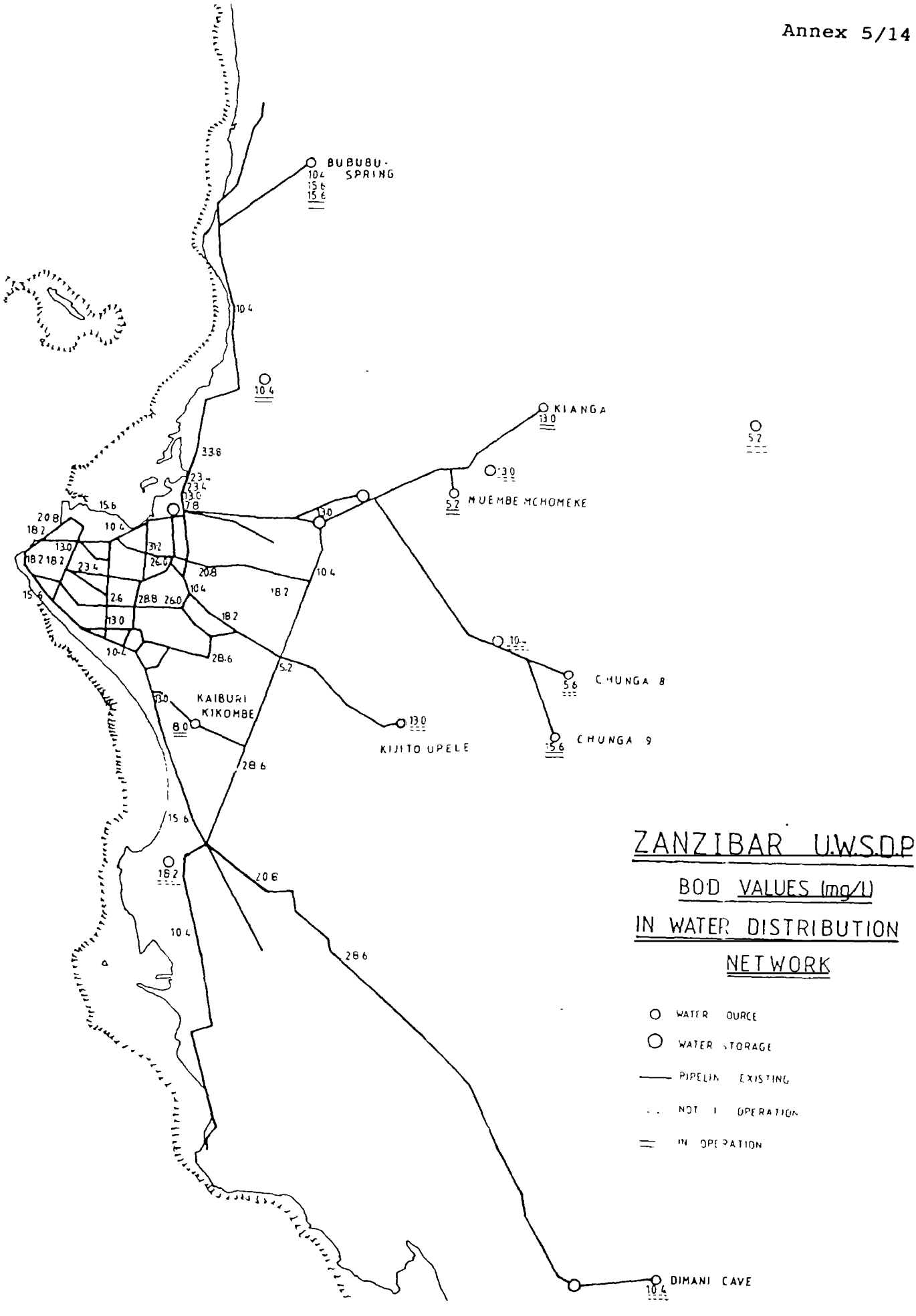

BUBUBU-
SPRING
KIANGA
MUEMBE MCHOMEKE
CHUNGA 8
CHUNGA 9
KAIBURI
KIKOMBE
KIJITO UPELE
DIMANI CAVE
ZANZIBAR U.W.S.D.P
BOD VALUES (mg/l)
IN WATER DISTRIBUTION
NETWORK
WATER SOURCE
WATER STORAGE
PIPELIN EXISTING
NOT I OPERATION
IN OPERATION

Figure 1.

at pipe interconnections. the organic matter content is expected to be rather constant in consumer taps. Unless the interconnecting pipes are damaged and thus allowing infiltration of organic matter, the variation in organic matter content in the water at urban taps cannot be explained.

pH
The pH values for all the sites except site number 13 were within the WHO and Tanzanian standards This site, Fuoni spring had slightly acidic water.

Total Solids
Total solids content values of the water from all sampling sites are well below the WHO maxium permissible level of 1500 mg/l. According to the Tanzanian standard of not more than 2000 mg/l. the water is excellent in this aspect. Of all water sources Kabure Kikombe, Fuoni spring, Mwera police station and Kiongoni have the highest values

According to Fig. 2, the TS content in the water distribution network varies widely. Whereas the variations of TS content in sources upstream are due to prevailing local factors, the marked variations in the TS content of the water at points after Saateni reservoirs is unexpected. This is because the water mixes in interconnecting pipes and thus should contain rather constant amounts of TS The only possible explanation to this variation is infiltration of solids at damaged points in the pipes.

Conductivity
The values for conductivity are within the range of 370-910 µS/cm Of all water sources examined Kaburi Kikombe and Kiongoni have the highest conductivities.

According to the FAO/UNDP/Kilimo Zanzibar Hydrochemical map No URT/73/024 of 1982 (Appendix VIII), the groundwater in Zanzibar town and coastal areas on both sides of Unguja island is infiltrated with seawater. Its conductivity is within the 500-1000 us/cm contour.

Fig. 3 shows that almost all the conductivity values obtained for the sampling sites in the above mentioned areas fit in the given range. Immediately after the marine contaminated area, is an area of non marine contaminated ground water with conductivity values in the range of 0-500 µs/cm. However, at many sampling sites in this area, the obtained conductivity values are higher than 500 µs/cm. This result indicates that there could be continued infiltration with seawater.

Chloride
The chloride value at Kaburi Kikombe is highest, again indicating that some infiltration with seawater might occur at this place. Nevertheless all values are lower than the WHO highest level of 200 mg/l.

Nitrate
Except for Kiongoni all values are very low.

Fluoride
All values are very low.

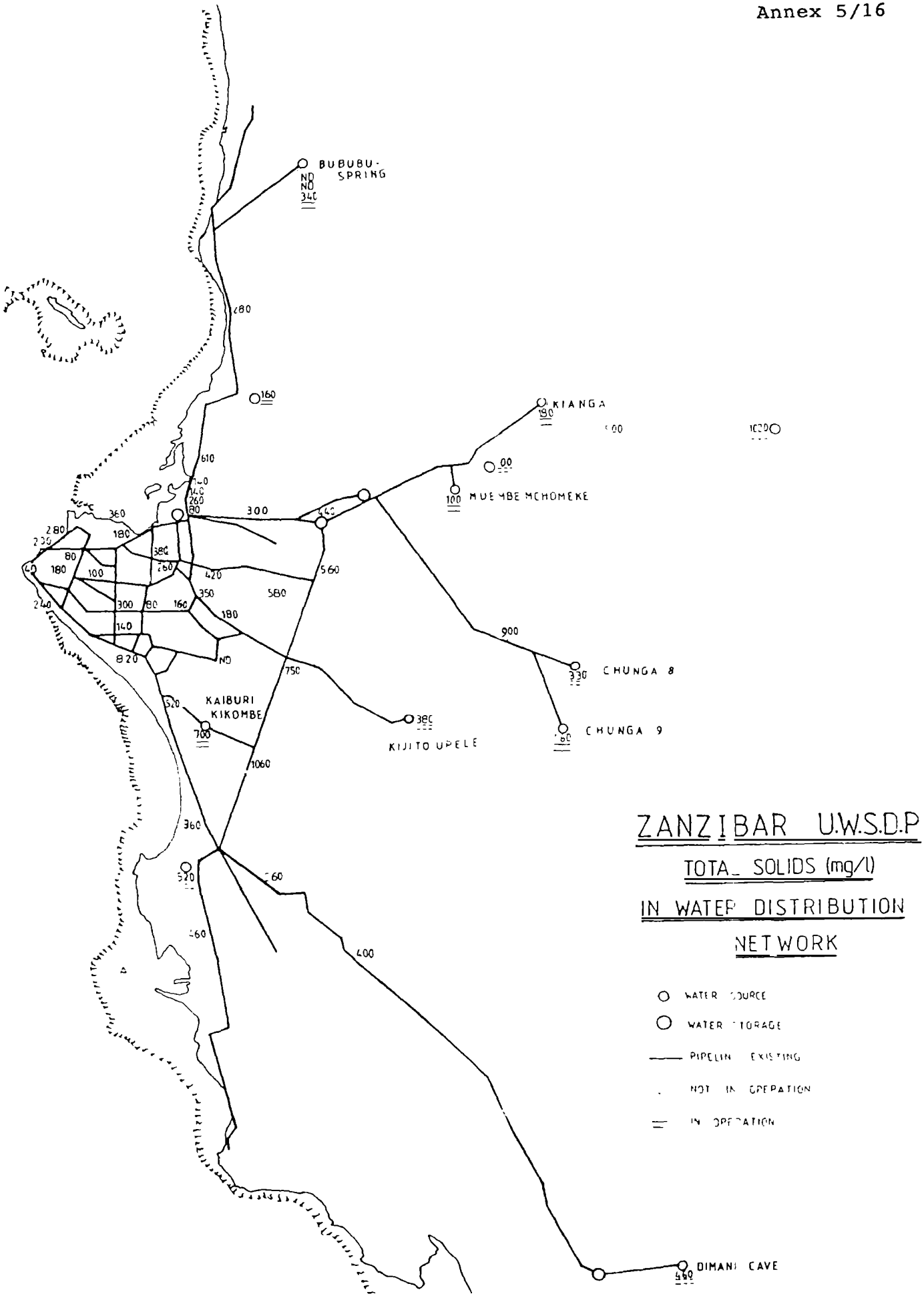

BUBUBU-
SPRING
ND
ND
340
KIANGA
190
MUEMBE MCHOMEKE
100
CHUNGA 8
330
CHUNGA 9
KIJITO UPELE
385
KAIBURI
KIKOMBE
700
ZANZIBAR U.W.S.D.P
TOTAL SOLIDS (mg/l)
IN WATER DISTRIBUTION
NETWORK
WATER SOURCE
WATER STORAGE
PIPELIN EXISTING
NOT IN OPERATION
IN OPERATION
DIMANI CAVE
460

Figure 2.

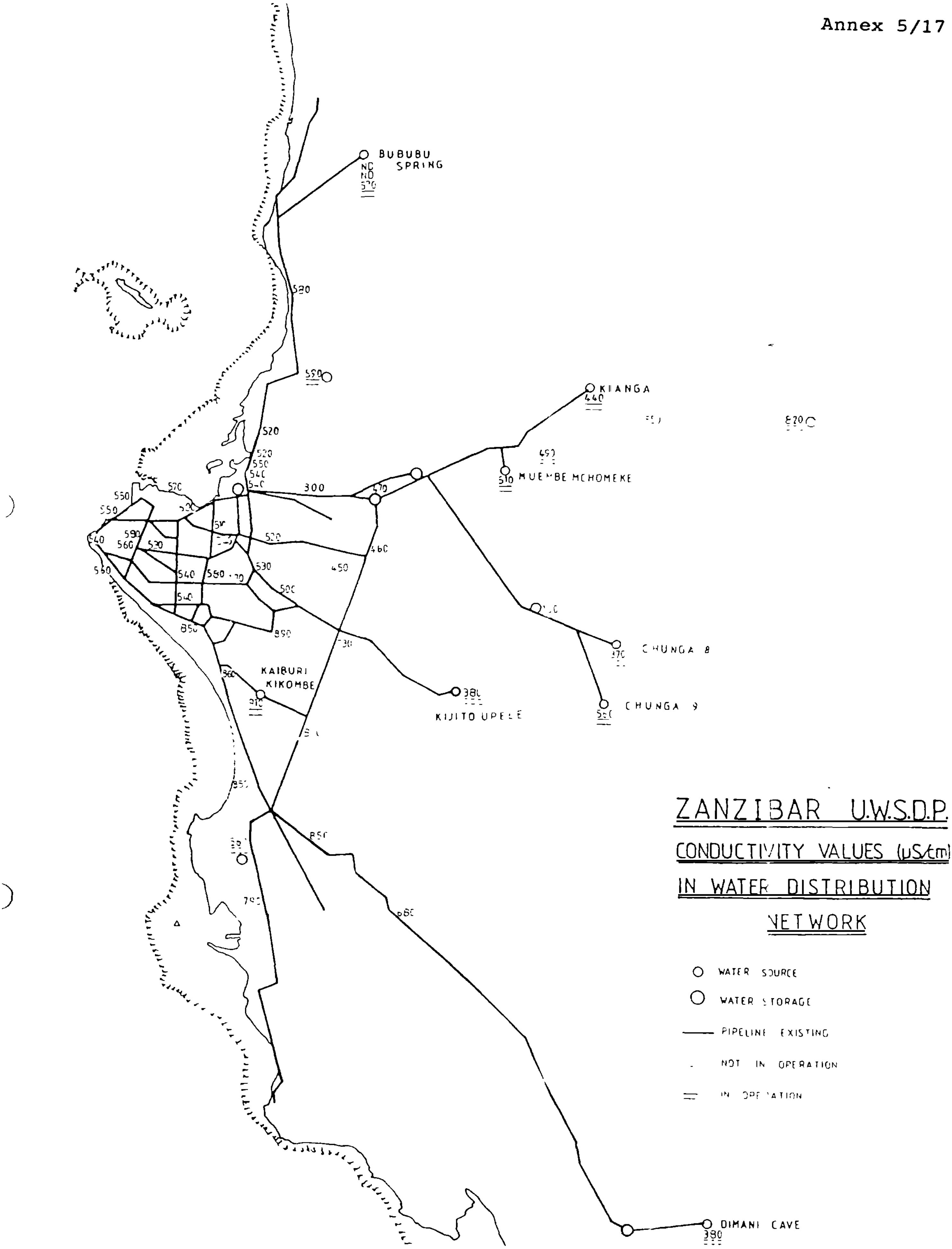

ZANZIBAR U.W.S.D.P.
CONDUCTIVITY VALUES (μS/cm)
IN WATER DISTRIBUTION
NETWORK
WATER SOURCE
WATER STORAGE
PIPELINE EXISTING
NOT IN OPERATION
BUBUBU SPRING
KIANGA
MUEMBE MCHOMEKE
CHUNGA 8
CHUNGA 9
KAIBURI KIKOMBE
KIJITO UPELE
DIMANI CAVE
520
300
450
530
550
560
540
590
380

Figure 3.

Calcium Carbonate
The WHO highest desirable level for Calcium Carbonate or total hardness is 100 mg/l Almost all sites have values higher than 100 mg/l, but the amount of $CaCO_3$ does not go beyond the WHO highest desirable level or the Tanzanian standard.

Sulphate
All values are well below the WHO highest desirable level.

Calcium
Most values are in between or lower than the WHO highest desirable level and the WHO maxiumum permissible level of 200 mg/l.

Magnesium
All values are below the WHO highest desirable level

Cyanide
Cyanide was not detectable

Arsenic
Arsenic was not detectable

7.3 Heavy Metals

In general the concentrations of heavy metals are low and both within the standards for Tanzania and the WHO maxiumum permissible level, but there are a few exceptions:
For **Chromium** the level is too high at Mbweni, Fuoni spring and Kiongoni local well. Mtoni is just at the limit.
The values for **Iron** are too high, if we compare with the WHO highest desirable level, for Mchomeke, Kianga, Mtoni, Kijito Upele, Chunga, Dimani Cace, Mbweni, Fuoni and Mwera, but they all are within the Tanzanian standards.
For **Manganese** all values are within the standards, but Kikombe, Kijito Upele and Chunga are above the WHO highest desirable level.
All **Zinc** values are good, only Kiongoni is about 50 x higher than other water sources but it is still within the standards.
For **Copper** all water sources have concentrations within the Tanzanian standards, but Kijito Upele and Fuoni spring are higher than the WHO highest desirable level.

Although the levels of heavy metals in the water are still in the range of Tanzanian standard it would be safer to establish the sources of pollution of **Chromium**, **Iron**, **Manganese** and **Zinc** at sampling sites with amounts higher than WHO highest desirable levels

7.4 Bacteriological Status

From Appendix IV it can be seen that water from almost all the water sources is contaminated with Coliforms. According to WHO recommendations (Appendix V) only water from site 5 is suitable for drinking. Sampling sites 4, 22 and 36 show very low values of Total Coli and no Fecal Coli is present. Of all water sources examined in our test sites no 1, 4, 5, 6 and 12 had the least microbiological contamination.
The poor quality of the water is probably due to the fact that most boreholes are open and hence subject to external pollution (people are throwing things, like dead animals, in the boreholes).
Another possibility is that since the sanitary situation in the rural areas is not good, rains bring feces into the water sources and maybe also water from pit latrines can seep into the groundwater in the vicinity of the water sources

Figs. 4 and 5 show how the microbiological quality of the water at the sources and reservoirs can affect the quality of the water at consumer taps.

Total coliform bacteria were found in almost all the water sources in operation. As a consequence the water at almost all the distribution points was found to contain the microorganisms.

Although only one functional source (Bububu spring) was found to be contaminated with fecal coliforms, the bacteria were present in water at most urban taps. A possible explanation to this observation is that part of the contaminated and non-contaminated water gets mixed up at Saateni and other reservoirs and thus contamination takes place of the entire water volume

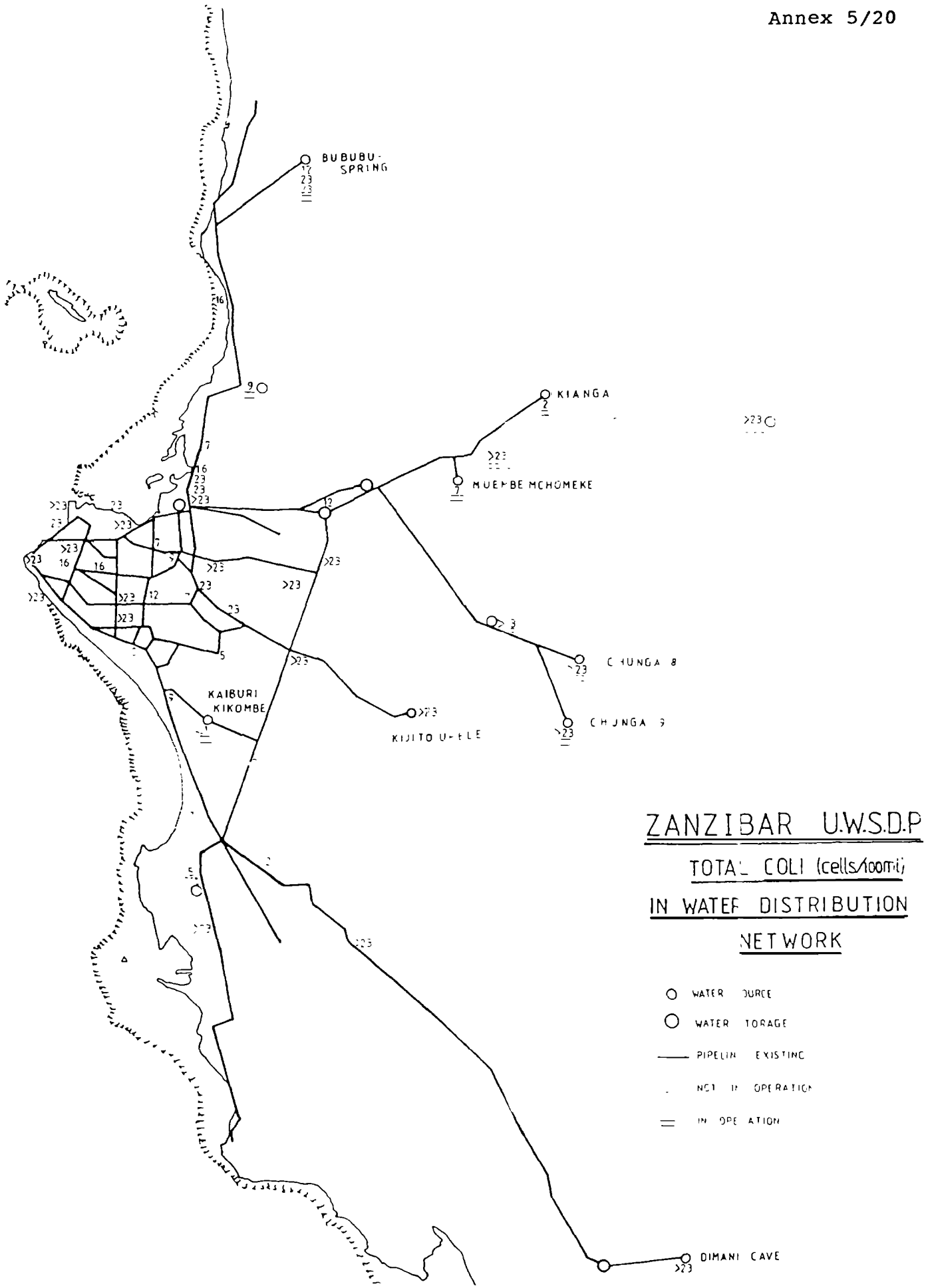

BUBUBU-
SPRING
KIANGA
MUEMBE MCHOMEKE
CHUNGA 8
CHUNGA 9
KAIBURI
KIKOMBE
KIJITO U-ELE
DIMANI CAVE
ZANZIBAR U.W.S.D.P
TOTAL COLI (cells/100ml)
IN WATER DISTRIBUTION
NETWORK
WATER SOURCE
WATER STORAGE
PIPELIN EXISTING
NOT IN OPERATION
IN OPERATION

Figure 4.

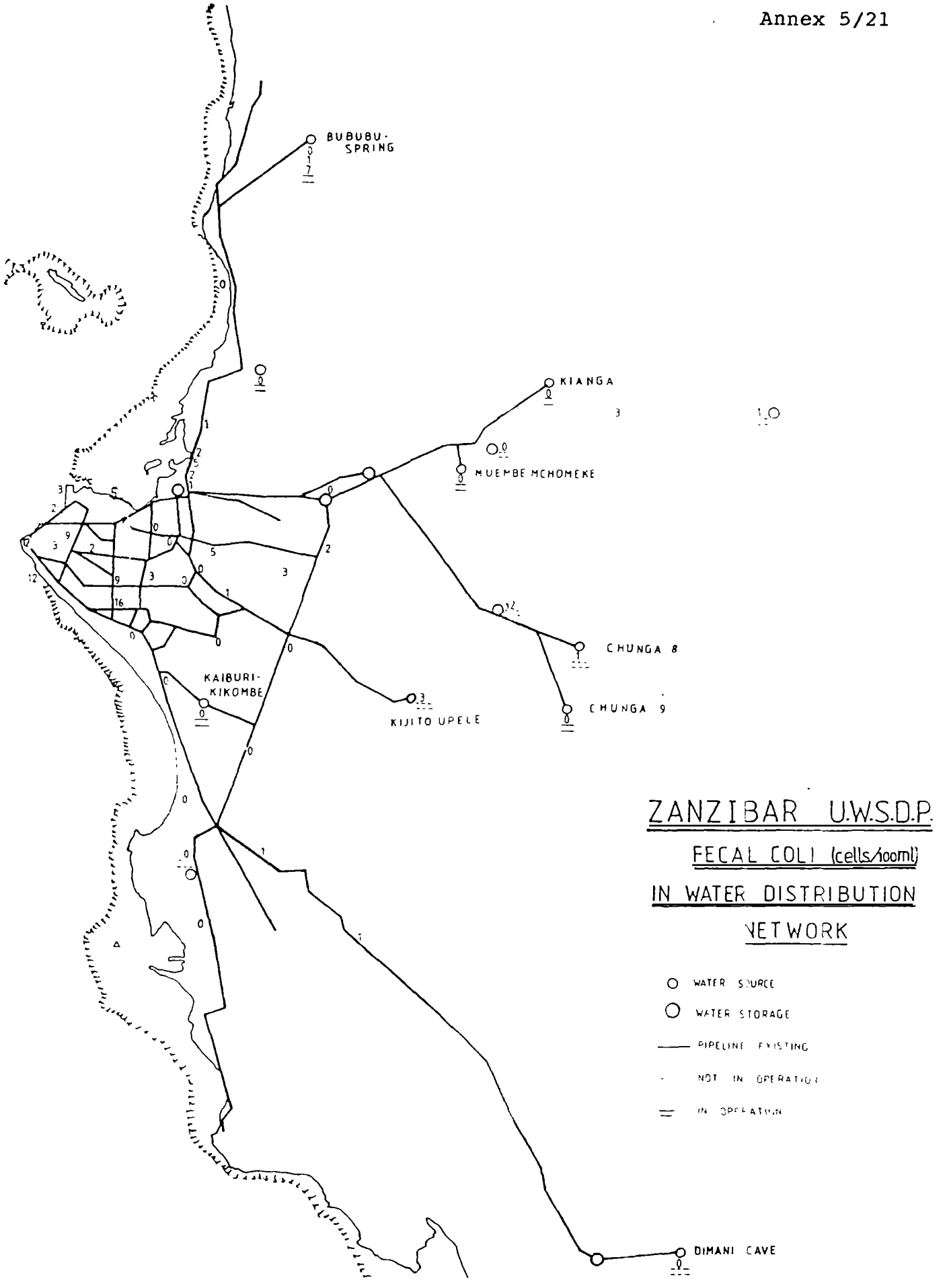

BUBUBU-
SPRING
KIANGA
MUEMBE MCHOMEKE
CHUNGA 8
CHUNGA 9
KAIBURI-
KIKOMBE
KIJITO UPELE
DIMANI CAVE
ZANZIBAR U.W.S.D.P.
FECAL COLI (cells/100ml)
IN WATER DISTRIBUTION
NETWORK
WATER SOURCE
WATER STORAGE
PIPELINE EXISTING
NOT IN OPERATION
IN OPERATION

Figure 5.

8. CONCLUSIONS

The results of this study demonstrate that most of the drinking water of Zanzibar town is contaminated with coliform bacteria and thus unsuitable to drink without boiling.

If the water would be free of microbiological contamination, then at most sampling sites it would be of excellent quality.

9. RECOMMENDATIONS

1. Open boreholes and wells should be covered in order to eliminate external pollution.

2. A good sanitation system should be adopted.

3. The presence of fecal and total coli in the water should be monitored frequently. See appendix VII.

4. New water sources should be sampled more frequently during subsequent service conditions in order to establish variations in quality under a variety of weather.

5. If repeated sampling and subsequent analyses demonstrate that coliform bacteria persist, a special investigation should be made of the water in the distribution system to determine the initial course. Occurrence of coliforms in successive samples calls for disinfection of the water.

6. The existing water distribution system should be checked for leakages in order to find out if infiltration from outside is going on.

10. REFERENCES

[1] Standard Methods for the Examination of Water and Wastewater (1985). 16th edition. Greenberg et al. (eds). American Public Health Association, American Water Works Association, Water Pollution Control Federation.

[2] Guidelines for Drinking Water Quality. Volume 1. Recommendations. WHO, Geneva, 1984.

APPENDIX I DESCRIPTION OF SAMPLING SITES AND OBSERVATIONS DURING SAMPLING

SAMPLING SITE Number	Name	OBSERVATION
1, 2, 8, 9, 10, 14	Mchomeke 1, Mchomeke 2, Kijito Upele, Chunga 8, Chunga 9, Mwera Police Station	These are open boreholes currently not in use. Before sampling a temporary pump was installed for test pumping. The water flowed with great force and was clear
4, 5	Kianga, Kaburi Kikombe	These boreholes are closed and have housed pumping installations The water was clear and samples were taken from taps
6	Mtoni Spring	Fast flowing water, a bit turbid Rain water was flowing into the housed part of the spring Samples were taken by dipping the sampling bottles.
7	Bububu Spring	Has two branches which join to form the main housed reservoir The water was clear and fast flowing. The site has pumping facilities.
11	Dimani Cave	A spring of clear water in a limestone cave in a remote area. Cows were seen grazing in the neighbourhood. The spring has pumping facilities.
13	Fuoni Spring	A very small water body shaded by trees and bushes in marshy surrondings The water is slow flowing and whitish in colour . Weak bubbling at several points in the bed of the spring was observed. Samples were taken by dipping
15	Kiongoni local well	Open and designed to collect rain water. Samples were taken from a tap coming from the well. The well has pumping facilities.
17A, 17B	Saateni · Bububu weir, Mtoni weir	Housed under one roof. Water was clear and sample water was drawn with a clean tin tied onto a rope
17C1	Reservoir 1	A very big housed reservoir. Water was brownish in colour. Samples were taken by dipping.
17C2	Reservoir 2	Closed with a heavy metal cover. The water was clear and had to be drawn up by a tin tied onto a rope.

APPENDIX I Cont. DESCRIPTION OF SAMPLING SITES AND OBSERVATIONS DURING SAMPLING

SAMPLING SITE		OBSERVATION
Number	Name	
18	Water Department	All of these sampling sites are urban taps mostly in the open The water from most of the taps except Bwawani Hotel was clear. For Bwawani sampling was done from a hose tube connected to the tap There appeared to be microbiological growth inside the tube and the water contained suspensions of the growth
19	Sogea	
20	Muembe Njigu	
21	Kibanda Maiti	
22	Kilimani	
23	Kiembe Samaki	
24	Karume Techn. Coll.	
25	Mwanakwerekwe	
26	Town Market	
27	V.I Lenin Hospital	
28	Miti Ulaya	
29	Bwawani Hotel	
30	Feed Mill	
31	Migombani School	
32	Amani Hotel	
33	Small Scale Ind.	
34	Mambo Msiige	
35	Mr Esa-s Res. Mtoni	
36	Mr Yakoub-s Res Mazi	
37	Children village	
38	Mwanakwerekwe Mosque	
39	Mfereji wa wima	
40	Harbour	
41	Kibanda Hatari	
42	Kwahani	
43	Mkunazini Cathedral	
44	Michenzani Block 8	
45	Michenzani Block 9	
46	Kisaumi	
47	Ministry of water	
48	Mwanakwerekwe (Kijito Upele)	
49	Muembe Madema	
50	Mtwango FAO Borehole	A closed borehole with pumping facilities. The water was clear and was flowing with great force while pumping.

APPENDIX II GENERAL PHYSICAL AND CHEMICAL DATA

Sampling Site	Temp. °C	pH	DO mg/l	O_2-Sat. %	BOD mg/l	TS mg/l	Cond. µS/cm	Cl mg/l	NO_3^- mg/l	F mg/l	$CaCO_3$ mg/l	SO_4^{2-} mg/l	Ca mg/l	Mg mg/l	CN mg/l	A_m mg/l
1	27.5	7.6	7.0	89	5.2	100	510	8	0	0.14	160	50	79.9	19.81	0	0
2	27.5	7.1	7.1	90	13.0	100	490	8	0	0.11	249	110	90.1	5.18	0	0
4	27.5	7.4	6.5	81	13.0	180	440	7	0	0.06	124	80	83.5	4.72	0	0
5	29.0	7.4	6.4	83	8.0	700	910	100	0	0.06	160	50	131.8	16.24	0	0
6	27.5	7.0	7.3	93	10.4	160	590	10	5	0.15	124	60	112.7	11.83	0	0
7A	ND	ND			10.4	ND	ND	ND	ND	ND	ND	ND	90.0	14.53	0	0
7B	ND	ND			15.6	ND	ND	ND	ND	ND	ND	ND				
7C	27.0	7.2	6.0	75	15.6	340	520	9	0	0.08	142	50				
8	28.5	7.7	7.0	88	13.0	380	380	10	5	0.18	142	50	54.1	14.19	0	0
9	27.5	7.3	5.9	75	5.2	380	370	7	0	0.10	160	50	75.9	8.87	0	0
10	27.5	7.2	6.3	75	15.6	460	560	7	0	0.10	195	50	109.0	3.86	0	0
11	27.5	7.4	6.3	80	10.4	460	380	82	0	0.01	142	80	103.0	9.41	0	0
12	29.1	7.0	5.8	75	18.2	520	560	21	20	0.01	124	90	117.1	3.45	0	0
13	27.5	5.8	7.1	91	10.4	900	100	9	5	0.08	35	50	5.1	1.31	0	0
14	28.0	7.1	6.8	87		900	550	10	0	0.08	106	50	102.8	4.1	0	0
15	29.0	6.9	9.0	117	5.2	1020	820	71	40	0.10	249	80	141.9	9.47	0	0
16	28.0	7.7	7.4	94	13.0	440	470									
17A	27.0	7.1	7.1	89	23.4	140	520									
17B	27.0	7.0	7.1	89	23.4	140	550									
17C1	27.0	7.0	7.1	89	13.0	260	540									
17C2	27.0	6.9	7.1	89	7.8	80	540									
18	28.5	7.6	7.5	97	10.4	180	600									
19	28.0	7.2	7.5	96	18.2	180	500									
20	30.5	7.5	7.2	97	10.4	350	530									
21	29.2	7.2	7.7	100	20.8	420	520									
22	29.5	7.0	7.3	96	10.4	820	850									
23	28.9	7.0	7.5	98	20.8	260	850									
24	28.5	7.3	7.5	97	10.4	460	790									
25	29.2	7.3	7.3	94	5.2	750	730									
26	28.0	7.5	7.4	94	13.0	80	580									
27	30.0	7.5	7.5	99	15.6	240	560									
28	27.0	7.2	7.5	94	31.2	380	510									
29	29.0	7.5	6.8	88	15.6	360	570									
30	27.0	7.3	7.3	91	33.8	610	520									
31	25.0	7.3	7.3	88	13.0	520	860									
32	30.0	8.4	7.0	92	18.2	580	450									
33	30.0	7.8	6.9	91	10.4	560	460									
34	29.5	7.6	7.2	95	18.2	40	540									
35	29.0	7.4	6.6	86	10.4	280	580									
36	28.0	7.2	7.5	96	15.6	360	850									

APPENDIX II GENERAL PHYSICAL AND CHEMICAL DATA
Continued

Sampling Site	Temp. °C	pH	DO mg/l	O_2-Sat. %	BOD mg/l	TS mg/l	Cond. µS/cm	Cl mg/l	NO_3^- mg/l	F mg/l	$CaCO_3$ mg/l	SO_4^{2-} mg/l	Ca mg/l	Mg mg/l	CN mg/l	A_s mg/l
37	29.0	7.2	7.5	97	28.6	1060	850									
38	27.0	7.6	7.6	95	28.6	ND	890									
39	27.0	7.2	7.7	97	26.0	260	540									
40	29.5	7.7	8.0	105	20.8	280	550									
41	28.0	7.3	7.5	96	26.0	160	470									
42	28.0	8.1	7.6	97	28.8	80	580									
43	28.5	7.5	7.0	88	18.2	180	560									
44	30.0	8.0	7.3	96	23.4	100	530									
45	28.0	7.5	7.4	94	2.6	300	540									
46	27.5	7.2	7.7	98	28.6	400	680									
47	28.0	7.7	7.7	98	18.2	200	550									
48	30.5	7.7	7.0	94	5.2	620	490									
49	27.0	7.4	7.4	93	13.0	140	540									
50	27.0	7.5	7.2	90	7.8	320	590	10	0	0.18	303	50				

DO: dissolved oxygen; O_2-Sat.: oxygen saturation; BOD: biochemical oxygen demand; TS: total solids; Cond.: conductivity; Cl: Chloride; NO_3^-: Nitrate; F: Fluoride ; $CaCO_3$: equivalent of Total Hardness; SO_4^{2-}: sulphate; C_a: Calcium; M_g: Magnesium; CN: Cyanide; A_s: arsenic.

APPENDIX III CONCENTRATIONS OF HEAVY METALS

Heavy Metals in water (mg.l^{-1})							
Sampling Site	Cd	Pb	Cr	Fe	Mn	Zn	Cu
1	0.011	<0.005	<0.005	0.037	<0 005	<0 005	0.014
2	0.006	<	0.01	0.169	0 023	0.019	0.01
4	<0.005	<	0.021	0.4	0.018	<0.005	0.02
5	<0.005	<	0.029	0.082	0.146	0.016	0.031
6	<0.005	<	0.052	0.192	0 043	0.025	0.011
7	<0.005	0.009	0.011	0.096	0.035	<0 005	0.042
8	<0.005	0.008	0.032	0.153	0.064	0.018	0.071
9	<0.005	<	0.05	0.029	0.095	0.266	0.028
10	0.008	0.05	0.038	0.173	0 012	0.017	0.019
11	0.005	<	0.042	0.171	0 038	0.022	0 019
12	0.008	0.01	0.081	0.174	0.008	0.089	0.016
13	0.009	<	0.073	0.183	0 028	<0.005	0 066
14	0.006	<	<0.005	0.141	0 041	0.028	0 025
15	0.009	<	0.066	0.104	0 02	1.478	0 026

Cd: Cadmium
Pb: Lead
Cr: Chromium
Fe: Iron
Mn: Manganese
Zn: Zink
Cu: Copper

APPENDIX IV PRESENCE OF COLIFORMS

Sampling site	Total Coli (cells/100 ml)	Fecal Coli (cells/100 ml)
1	7	0
2	>23	0
4	2	0
5	<1	0
6	9	0
7A	12	0
7B	23	1
7C	23	7
8	>23	3
9	>23	1
10	>23	0
11	>23	0
12	5	0
13	>23	12
14	12	3
15	>23	1
16	12	0
17A	16	2
17B	23	5
17C1	23	2
17C2	>23	1
18	>23	5
19	23	1
20	23	0
21	>23	5
22	2	0
23	12	1
24	>23	0
25	>23	0
26	>23	9
27	>23	12
28	7	0
29	23	5
30	7	1
31	9	0
32	>23	3
33	>23	2
34	>23	12
35	16	0
36	3	0
37	7	0
38	5	0
39	9	0
40	>23	3
41	7	0

APPENDIX IV PRESENCE OF COLIFORMS
continued

Sampling site	Total Coli (cells/100 ml)	Fecal Coli (cells/100 ml)
42	12	3
43	16	3
44	16	2
45	>23	9
46	>23	1
47	23	2
48	4	2
49	>23	16
50	16	0

APPENDIX V MICROBIOLOGICAL QUALITY OF DRINKING WATER: WHO RECOMMENDATIONS

Water Supply	Fecal (Coli, cells/ml)	Total
Piped Water	[A]	[A]
Treated water entering the distribution system	0	0
Untreated water entering the distribution system	0	0
Water in distribution system	0	0
Unpiped Water Supplies	0	0[B]

[A] In 95-98% of the samples examined throughout the year when sufficient samples are examined.

[B] Coliforms should not occur repeatedly; if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found

APPENDIX VI: WHO AND TANZANIAN STANDARD FOR DRINKING WATER

Substances	Unit	WHO highest desirable level	WHO max permissible level	Tanzania standard
Toxic substances				
Arsenic (as As)	mg/l	--	0.05	0.05
Cadmium (as Cd)	mg/l	--	0.05	0.05
Cyanide (as CN)	mg/l	--	0.05	0.20
Lead (as Pb)	mg/l	--	0.10	0.10
Mercury (total as Hg)	mg/l	--	0.001	----
Selenium (as Se)	mg/l	--	0.01	0.05
Chronium (as Cr)	mg/l	--	0.05	0.05
Substances that may effect health				
Fluoride	mg/l	--	0.8	8
Nitrate	mg/l	--	45	100
Substances affecting suitability for domestic use				
Colour	mgpt/l	5	50	50
Turbidity	JTU	5	25	30
Total solids	mg/l	500	1500	2000
pH	pH unit	7.0-8.5	6.5-9.2	6.5-9.2
Anionic detergents	mg/l	0.2	1	2
Mineral oil	mg/l	0.01	0.30	--
Phenolic compounds (as phenol)	mg/l	0.001	0.002	0.002
Total hardness	mg/l$CaCO_3$	100	500	600
Calcium (as Ca)	mg/l	75	200	--
Chloride (as Cl)	mg/l	200	600	800
Copper (as Cu)	mg/l	0.05	1.5	3.0
Iron (local as Fe)	mg/l	0.1	1	1.0
Magnesium (as Mg)	mg/l	30	50	--
Manganese (as Mn)	mg/l	0.05	0.5	0.5
Sulphate (as 504)	mg/l	200	400	600
Zinc (as Zn)	mg/l	5	15	15
BODS	mg 02/l	--	--	6
Permanganate value	mg 02/1	--	--	20
Toptal nitrogen exclusive nitrate	mg/l	--	--	1 0

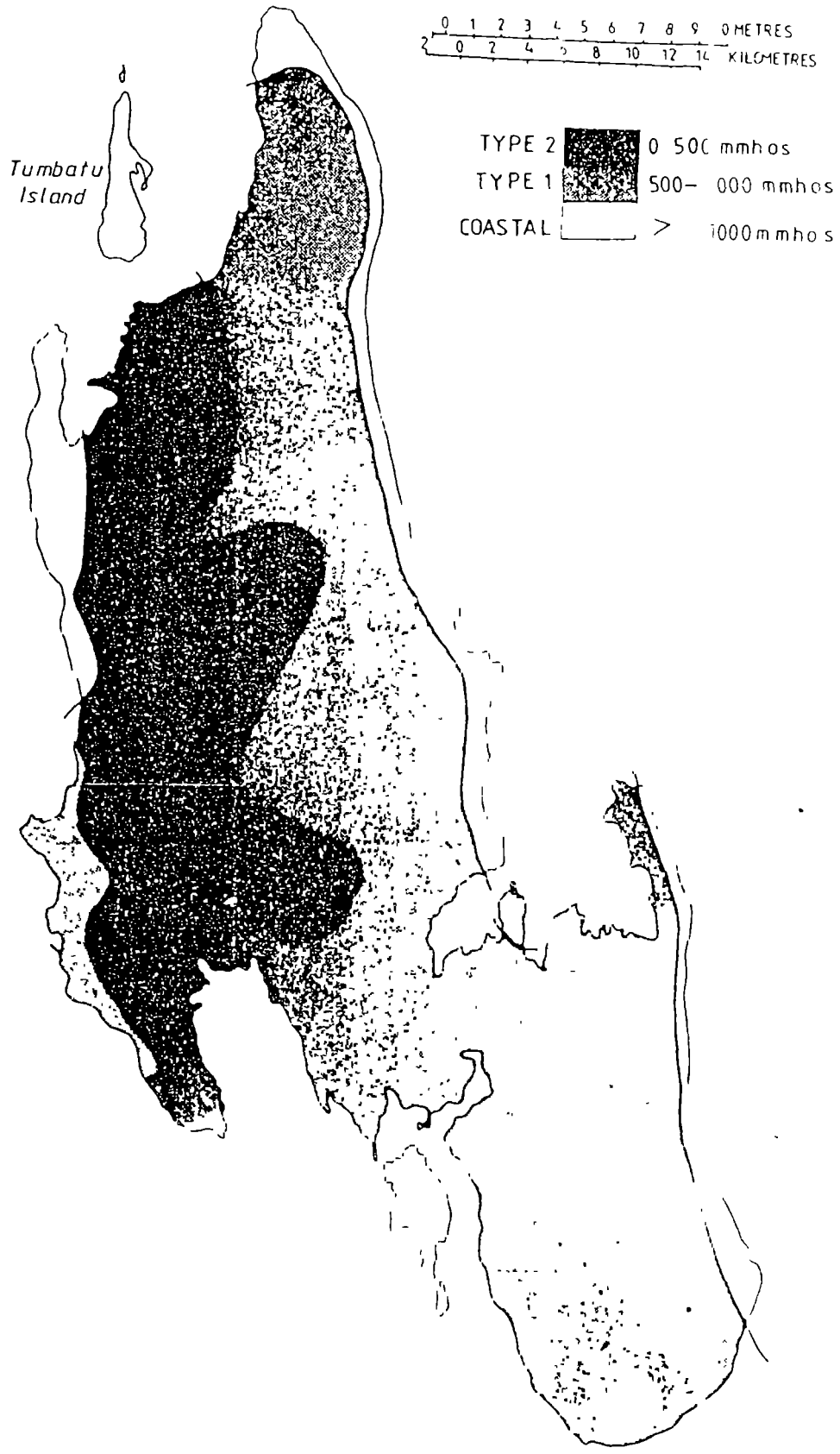
Zanzibar is currently using Tanzanian Standard except for Fluoride, Cyanide and Colour for which the values 1.00, 0.05 and 10 are respectively used.

Source: Coast/DSM Regions Water Master Plan, Vol. A 1979.

APPENDIX VII: MINIMUM FREQUENCY OF SAMPLING AND ANALYSIS OF DRINKING WATER ADVISED BY WHO.

Population	Minimum number of samples
≥ 5000	1 sample per month
5000-100,000	1 sample per 5000 people per month
≥100,000	1 sample per 10,000 people per month

FAO/UNDP/KILIMO - ZANZIBAR
URT/73/024
HYDROCHEMICAL MAP
DECEMBER 1982



ZANZIBAR URBAN WATER SUPPLY
WATER QUALITY DATA

Source	Name and Number of Borehole	Appearance of Colour in mg pt/l	ph (unit)	Total Solid (ppm)	Alkalinity mg/l	Chloride mg/l	Nitrogen mg/l	Oxygen mg/l	Coliforms per 100 m/s	Remarks
Borehole	Chunga-Fuoni No. 8	Bright, clear Colourless & free from sediment	7.2	320	Carbonate-Nil Bicarbonate-301	9.2	In free and saline NH3 - Nil In albuminoid ammonia - Nil In Nitrites - Nil In Nitrate - 0.65	0.3	25/100 ml	The water is satisfactory as judged by the chemical results on 20th June 1974 and unsatisfactory according to the recognised classification. For bacteriological analysis 22nd June 1974
Spring	Mtoni	-	-	-	-	-	-	-	-	-
Borehole	Kijito Upele No. 13	In 4th Sept 1985 Colourless with sediment	7.2	215	180	10	In free and saline NH3 - Nil In albuminoid ammonia - Nil	-	-	Chemically the water is satisfactory No bacteriological Analysis
		In 27th Nov. 1985 Clear & Colourless	7.4	265	255	49.4	In free and saline NH3 - Nil In albuminoid ammonia - Nil			The sample is satisfactory No bacteriological Analysis
Borehole	Kaburi Kikombe No. 14	-	7.2	-	266	26.1	In free ammonia - 0.6	-	-	-
Borehole	Kaburi Kikombe No. 2	-	-	-	-	-	-	-	-	-
Borehole	Kaburi Kikombe No. 10	Bright, Clear & free from sediment	7.4	520	Carbonate - Nil Bicarbonate-Nil	22.4	In free and saline - 0.029 In albuminoid ammonia- 0.015 In Nitrites - Nil In Nitrate - 0.65	0.55	-	The figures for free and saline NH3 arouses suspicion as to the samples purity and special attention should be paid to its bacteriological contents on 12th November 1974 No bacteriological Analysis
Borehole	Kianga No. 78	-	-	-	-	-	-	-	-	-
Cave	Dimani	Bright, clear Colourless & free from sediment	7.3	480	Carbonate - Nil Bicarbonate-271	144	In free and saline NH3 - Nil In albuminoid NH3 - Nil In Nitrites - Nil In Nitrate - 0.90	0.03	180/100 ml of sample	Highly satisfactory according to the recognised classification for bacteriology examination on 13th May 1985 while for chemical analysis the water is wholesome on 6th Dec. 1968
Borehole	Jangamizini Fuoni No. 9	Bright, clear Colourless & free from sediment	7.4	280	Carbonate - Nil Bicarbonate-229	3.2	In free and saline NH3 - Nil In albuminoid NH3 - Trace In Nitrites - Nil In Nitrate - 0.55	0.1	180/100 ml of sample	Unsatisfactory according to the recognised classification on 14th Aug. 1974 while for chemical analysis the sample is wholesome on 14th August 1974
Spring	Bububu	Bright, clear Colourless & free from sediment	7.0	310	Carbonate - Nil Bicarbonate-253	23	In free and saline NH3 - Nil In albuminoid NH3 - Nil In Nitrites - Nil In Nitrate - 0.91	0 5	Nil	Highly satisfactory according to the recognised classification for bacteriology examination on 23rd August 1972. For chemical analysis the water is wholesome on 25th March 1971
Borehole	Mwembe - Mchomeke	-	-	-	-	-	-	-	-	-

Annex 6/1

APPENDIX A

Chemical Analyses of Samples of water collected from Chem Chem and Bububu artesian springs and Dunduki surface spring in Chemical Laboratory, Zanzibar by Acting Government Chemist, M.A. Shatry.

(1) Chem Chem Spring drawn on 21st April, 1951.

The sample was clear, bright, colourless, tasteless and free from sediment.

Total Solids (dired at 105°C)	36.0 parts per 100,000
Alkalinity as CaCO3	30.65 " " "
Total Hardness as CaCO3	29.50 " " "
Chlorides as NaCl	1.65 " " "
Nitrogen in free and saline ammonia	0.001 " " "
" in albuminoid ammonia	0.001 " " "
" in nitrates	0.002 " " "
" in nitrites	nil
pH (Calorimetric)	7.1
Oxygen absorbed from Potassium permanganate in te. minutes at 100° C	0.001 " " "

(2) Bububu Spring drawn on 21st April, 1951.

The sample was clear, bright, colourless, tasteless and free from sediment.

Total solids (dried at 105°C)	35.0 parts per 100,000
Alkalinity as CaCO3	27.38 " " "
Total Hardness as CaCO3	31.50 " " "
Chlorides as NaCl	1.77 " " "
Nitrogen in free and saline ammonia	0.001 " " "
" in albuminoid ammonia	0.001 " " "
" in nitrates	0.001 " " "
" in nitrites	nil
pH (Calorimetric)	7.5
Oxygen absorbed from potassium permanganate in ten minutes at 100°C	0.003 " " "

(3) Dunduki Spring drawn on 15th August, 1951, by W. Chatken Tanganyika Geological Survey.

The sample was clear but very slightly turbid, bright, colourless, tasteless and free from sediments.

pH (Calorimetric)	5.7
Total solids (dired at 105°C)	10.0 parts per 100,000
Alkalinity (CaCO3)	3.5 " " "
Total Hardness (CaCO3)	3.5 " " "
Chlorides (NaCl)	0.83 " " "
Nitrogen in free saline ammonia	0.001 " " "
" " " Albuminoid ammonia	0.008 " " "
" in nitrate	0.001 " " "
" in nitrite	nil
Oxygen absorbed from potassium permanganate in ten minutes at 100°C	0.050 " " "