# COUNTRY REPORT
# TANZANIA - ZANZIBAR

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# 1. INTRODUCTION

## 1.1 Location

Zanzibar is in the Western Indian Ocean ($39^o$ 05' E to $39^o$ 55' E and $4^o$ 45'S to $6^o$ 30') in the East African Coast. Zanzibar Islands are a state of the United Republic of Tanzania. The state is made of Unguja and Pemba Islands. Unguja Island (Fig. 1) is also called Zanzibar after the famous and historical town. Zanzibar Town is a historical town which was already serving as a trade centre for Arabs, Indians and Europeans in the middle ages. It also served as a gate way to East Africa.

## 1.2 Climate

The climate is mainly influenced by monsoons with two peak rainfall seasons. The long rains are from March to May while the short rains are from September to November. The average annual rainfall is 1600 mm and 1900 for Zanzibar and Pemba respectively. The water table on Unguja is very high and ground water infiltration is rapid. In heavy rains ground water recharge is immediate and surface runoffs are short and sharp[17]. Ground water intrusion in to the marine environment is predicted to be common especially in the western coast[18]. Few studies have been done on water quality, its management and policies (FINNIDA, 1991; Mohammed, 1991; Van Bruggen, 1990; Zanzibar Ministry of Water, Construction, Energy, Lands and Environment, 1992; Mmochi, 1998; Mohammed, 1997; Mmochi, 1997 and Louis Berger International Inc, 1996)

## 1.3 Population

In the last census in 1988, the population of Zanzibar was 640,575 growing at 3.2%. The population is now estimated at 800,000 in an area of 2450 $km^2$. About 200,000 people recide in the Zanzibar town**.**

## 1.4 Economic background

For a long time, cloves served as the main cash crop and foreign income earner. Recently, following farming of cloves in the Far East and consequent fall of prices in the world market, Zanzibar was forced to diversify its economy. The economy of Zanzibar dropped by 27% between 1976 and 1985. It grew at 2.5% from 1985 to 1990 (Zanzibar Ministry of Water, Construction, Energy, Lands and Environment, 1992). From 1985 to 1990 economic growth was recorded in construction (135%) and commerce and tourism (80%). There was a drop in agricultural outputs (8%), industry (38%) and transport and communication (63%). From 1980 to 1989 inflation was at 25%. The situation have improved since in agriculture especially after introduction of seaweed farming and transport and communication after liberalization of trade and privatization of some public utilities eg. Telecommunication, air and water traqnsport. The economic growth is thought to have continued upwards to date. There is now more emphasis on tourism, aquaculture, semi processing industries and diversification in agriculture. (Zanzibar Ministry of Water, Construction, Energy, Lands and Environment, 1992).

## 1.5 Water Consumption in the Townships

Zanzibar Town consumes about 68-105 litres per capita per day (l/c/d). Other towns with the percentage consumption rates in bracket are Wete (30-65), Chake Chake (28-69) and Mkoani (14-34). Domestic use accounts for about 70% of total water use in Zanzibar town while 30%

of all the water produced is unaccounted for (FINNIDA, 1991). If the quality of the groundwater is maintained there is enough water to meet all the estimated demands of 72,000 m3/d for Zanzibar urban areas until 2015. Unfortunately intakes of all urban water supplies are already biologically polluted and surface water supplies is not a viable alternative (FINNIDA, 1991). Chemical quality of public water supplies are considered good although the effect of agrochemicals is unstudied. Some chemicals that have been identified as pollutants are chromium (industrial waste), calcium, iron and manganese (natural sources).

**1.6 Land Use Structure**

Zanzibar Municipal area is 4424 ha. Of these the total built up area is 1945 ha. Residential area constitutes 43.5 % of the built up area. Of the residential area 73% is squater. About 50% of the residents of Zanzibar Town get water from communal taps.
The land use distribution is as shown in Table 1.

Table 1. Land use structure of Zanzibar Town

| Land use category | Area (ha) | Area (%) |
|---|---|---|
| Residential | 846 | 43.5 |
| Roads and squares | 165 | 8.5 |
| Special areas | 165 | 8.5 |
| Public open spaces | 108 | 5.5 |
| External communication | 103 | 5.3 |
| Colleges | 95 | 4.9 |
| Public utilities | 59 | 3.0 |
| Industry | 55 | 2.8 |
| Public buildings | 53 | 2.7 |
| Agricultural establishments | 33 | 1.7 |
| Commercial | 18 | 0.9 |
| Other areas | 247 | 12.7 |

Source: Modified from Zanzibar Ministry of Water, Construction, Energy, Lands and Environment, 1992.

## 2. PRESENT CONDITION OF WATER QUALITY AND POLLUTION

### 2.1 Water pollution

There is already a number of studies on water quality and its management and similar studies are now picking up (Table 2). Some of the studies were done in a snapshot manner with little regard to possible long term effects. In some cases questionable results have been given on the state of the environment and water quality in Zanzibar. Coliform counts done in a period of one month and only one sample per station have been used to explain the water quality (fresh and marine) without clear indication of distances from the sewage sources, outfalls and the position of the tide (Van Bruggen, 1990; Van Bruggen and Kivaisi, 1990)

There is a lack of information on the water pollution in Zanzibar though the few studies that have been conducted show that water pollution along Zanzibar coast is now a serious problem. According to Van Bruggen (1990) there was a positive correlation between faecal coliform and BOD which implies that the pollutants are of sewage origin.

There have been reports of periodic fish mortality in Mwanakombo and Zingwezingwe rivers draining Mahonda sugar factory and sugar cane plantation,[20]. The 3,000 acres sugar plantation produces an average of 6,000 tons of sugar per year. It also produces spirit. In the plantation there is a pesticide store. The Mahonda-Makoba drainage basin also contains rice farms, a rubber plantation and a cattle ranch.

In order to determine the causes of fish mortality in Mahonda-Makoba drainage basin water quality studies were done in the rivers in June and July 1996. The percentage oxygen saturations were the lowest in the trenches carrying waste water from the sugar factory. The values increased in the Makoba bay especially during the flooding tide. The lowest recorded percentage saturation was 76% and could not account for the fish mortality. The lowest percentage saturation was recorded in the trenches at a time when the sugar factory was in full production, the time during which fish mortality is known to occur. Concentrations of the dissolved inorganic nitrogen and dissolved inorganic phosphates were higher in the rivers and the trenches decreasing towards the Makoba bay. No algal blooms were observed in the bay and the concentrations could not account for fish mortalities. Pesticides are used only during outbreaks. However, the pesticide store in the plantation leaks. Fusel oil, a mixture of high molecular weight alcohols, a bye product of sugar fermentation is suspected to be the cause of fish mortality (Manager, Mahonda sugar factory pers. comm.). No complaint of fish mortality has been heard from 1995 to date perhaps because the farming and production activities have gone down because of economic problems.

In Cheju rice farms near Chwaka bay, an average of 1,500 to 2,000 acres of rainfed and irrigation rice farms are cultivated every year. According to the Plant Protection Department (PPD)[21], 5.5 tons and 155 kg of Basalgran (bentazone and dichlorprop) and malathion respectively were distributed in Unguja South Region alone compared to 14.5 tons and 630 kg respectively for the whole of Unguja. Most of the pesticides used in the Unguja South region are used in Cheju. The rest of the South region has perennial crops which are organically farmed without use of pesticides or inorganic fertilizers or are coral rag areas not used for agriculture. Fishermen from Mapopwe Creek of the Chwaka bay complain of disappearance of shrimps in the creek after first rains following application of fertilizers and pesticides in the Cheju irrigation and rainfed rice farms. The environmental awareness is rising but in some cases development has been so far ahead of environmental considerations and remedies are tending to be expensive. Since there is irregularity in data collection and inconsistencies in different reports regarding the quality of the environment, it is difficult to make the governments and communities embark in expensive remedies such as central sewage system. Zanzibar government is yet to develop sewage treatment facilities and although there is a central sewerage system in the stone town and some parts of the new town, the pipes discharge the sewage into the ocean untreated. Only 14% of the Zanzibar town house holds are connected to sewerage system and about 2.9 x $10^6$ $m^3$/yr of domestic wastes are dumped in to the sea untreated (Mohammed, Ngusaru and Mwaipopo, 1993). This is equivalent to 1421 tons of BOD, 3251 tons of COD 2627 tons of SS, 520 tons of N and 16 tons of P (Mohammed, 1993). Initially because of breakage in the pipes the sewage used to partly spill out in the town and discharge in the intertidal. The pipes have been repaired and lengthened to discharge into the sub-tidal.

Fresh water used in Zanzibar Town has been polluted as contained up to 723 cells per 100 ml of faecal coliforms (Kivaisi and Van Bruggen, 1990). The highest value was obtained at Mto Pepo water source where also reported to have been envaded by human settlements and activities. However, the there is a significance mitigation measure have been taken by goverment to improve situation such as removing buildings and premises constructed very close the water sources and also to fence the catchment area. At present , most of the chemical waste seep into the ground water which endanger drinking water quality especially because Zanzibar depend only ground water as a source of drinking water.

Regarding wastewater treatment, there is no central sewage or sewerage system in Zanzibar. The only sewerage system in Zanzibar is in the Zanzibar stone town serving 18.8% of the populationand dates back to 1920s). The rest of Zanzibar town and its suburbs are served by pit latrines (78.5%), cesspits and soakpits (2.7). The sewage from the Zanzibar stone town is emptied untreated in to the ocean off Zanzibar Town. Sewage from septic tanks and pit latrines are collected using vaccum disludge trucks and disludged in to the foreshore at high tide (FINNIDA, 1992).

Despite the inconsistency of the studies, there has been an increase in the incidences of communicable water borne diseases mainly cholera, dysentery and malaria Zanzibar (Mmochi, 1998).

Because of the inconsistencies, the Institute of Marine Sciences has decided to embark on a long term monitoring programme of water quality in the nearshore waters of Zanzibar Town. The programme was started in November, 1997. In the first bi-annual progress report, continuous monitoring for six months was done in the discharge areas covering the time before and after sewage pipes were re-constructed. The sewerage system of the Zanzibar stone town was being re-fitted and the outfall pipes elongated to sub-tidal. The parameters sampled for were, dissolved inorganic nutrients, suspended substances, oxygen, BOD, pH, salinity, temperature, total coliform and faecal coliform. Due to the importance of faecal coliform studies as result of rising incidences of water borne diseases, laboratory and manpower capacity for coliform analysis was developed during this programme.

Samples for dissolved inorganic nutrients (ammonia, phosphate, nitrate and nitrite), oxygen concentration, BOD, coliform and suspended sediments were taken. Salinity, air and water temperatures were measured at the time of sampling. Samples were taken 10 - 15 metres from the outfall at high tide. At low tide samples were taken at the water edge the shortest distance from the outfall. In some stations this was more than 400 metres from the outfall. Samples were taken twice a month once during the spring low tide and once in spring high tide. In March and April samples were taken at 0, 100 and 150 metres from the nearest point to the outfall.

The results of the study has shown a strong relationships between air water temperature and salinity. Water temperature was high than water temperatures in Bwawani, IMS and Forodhani (fig. 2) most of the time. Furthermore, water temperature tended to decrease to air temperature levels with time. In Africa House, Hospital and Kizingo the water temperatures eventually became lower than water temperature. The relationships between air and water temperatures are complicated. More intensive studies on heat transfer, weather and climate patterns are neccesary to draw definite conclusions. However, the variations may be behaving that way because of any one of the factors listed below.

- The coastline from Bwawani to Forodhani forms a shallow bay. During the day and especially at low tide it can warm more quickly by being heat by the underlaying land mass.

- The bay area (the area between Bwawani and Shangani) may be rich in trapped organic matter and the warming up may be associated with decomposition processes. This is supported by oxygen, BOD, pH and nutrient data. The biggest wastewater and runoffs pipe carrying wastes from the biggest food market and debris from the leading business streets empties at the Bwawani sampling station. Furthermore, most of the sewage pipes from the old stone town empties in the coastline from Bwawani to Shangani.

- The water circulation at Shangani, Africa House Hospital and Kizingo may be better than the rest the stations.

pH ranged from the lowest of 7.14 to 9.3. Similar studies by Van Bruggen (1990) showed a narrow range of pH from 8-8.4. Furthermore, there was persistence of low pH in Bwawani, IMS and Forodhani. The highest pH readings were in the better flushed areas from Africa House to Kizingo. Interms of seasonality December gave the highest readings while the lowest were in February. Total Dissolved Solids (TDS) were higher at low tides and low at high tides. In terms of seasons the lowest TDS were in November/December coinciding with the highest pH and the highest was in April. It may be reasonable to assume that some chemicals started contaminating the waters in harbour area (Bwawani IMS and Shangani) reducing the normal seawater pH and raising the total dissolved solids. Increase of TDS with decrease of pH suggests chemical pollution.

Oxygen concentrations and BOD were highly irregular both in the station and between seasons. Generally, the highest concentrations were in March. At Kizingo this reached 8.08m1/L indicating very high percentage saturation of oxygen normally associated with algal blooms. At Bwawani, IMS and Forodhani had the lowest oxygen concentrations especially at low tide. On the other hand the concentrations of oxygen at Africa House, Hospital and Kizingo were even higher at low tides in March. The phenomenon of high oxygen concentrations not associated with freshwater influx are indications of algal blooms. Interestingly, the concentrations of nutrients in March were not that high. The lowest concentration of oxygen was O at Bwawani during low tide. Generally oxygen concentrations were lowest in November/December while BOD was highest in March and April in the stations that were measured.

The first part of the study was used in establishing laboratory and manpower capability to coliform analysis. The samples whose results are presented here were collected by IMS and incubated in Water Laboratories, Department of Water Development, Zanzibar. However, from June arrangements for coliform analysis at IMS were completed and hence forth samples will be analysed at IMS. Sample analysis for coliform count were started in March before installation of or repair of the sewerage outfalls to the ocean and their lengthening to the sub-tidal. Coliform counts ranged from too numerous to count (TNTC) to zero. The Total coliform were too numerous to count at 10-15 m from the out fall at Bwawani, Forodhani, Africa House and Hospital. In Forodhani at about 10 m from the outfall, faecal coliform were also too numerous to count. The coliform count decreased seawards. However, the length of time involved is not enough to say much about the trends. The results agree closely with Van Bruggen (1990)

Ammonia and phosphate analyses showed high values at Bwawani especially in November and early December. The value were lower in the rest of the sites. The value also decreased in the late December and early January. It is interesting to note that at nutrients at Bwawani were highest at low tide indicating that the pollutants are coming in from land. At the rest of the stations high tide had higher concentration than low tide may be indicating a presence of high nutrient concentration pool that comes in and goes out with the tide. This may be consistent with the findings by Mohammed, Ngusaru and Mwaipopo (1993) that there is a current that passes between Changuu (Prison) and Bawe Islands flushing offshore as a product of Mbweni Peninsular to Shangani northbound current and Mtoni to Shangani southbound current. If such is the case, it may be expected to have a clockwisely circulating water pool between Mtoni-Shangani and the Shangani-Bawe/Changuu current. Likewise, an anti-clockwise circulatine water pool to the south. Such a pool will not flush out easly. If such is the case it will not be advisable to dump wastes in the area.

The results so far makes it difficult to link the decrease in nutrient concentrations and increase in oxygen concentrations and pH with either seasons or repairs that were then going on. It is unfortunate that we could not sample for nutrients continuously due to deffective spectrophotometer and lack of storage facilities. Samples for nutrients started to be taken again in July. It is however worth noting that the environmental parameters were the poorest at the outfalls improving gradually seawards.

## 6.0 Water Quality Analysis Techniques, Facilities and Equipments

6.1Water Quality Analysis Techniques

The general water quality analysis techniques used in Department of Water Development and Institute of Marine Sciences are shown below.

## Water sampling

1. Dissolved Inorganic Nitrogen (DIN): The samples are taken in 500ml plastic bottles where possible at about half meter below the surface. In such cases a shallow water sampler are used. The samples were immediately filtered and fixed using three drops of chloroform (Mmochi, 1993). Samples were stored in ice box and transported to laboratory where they are refrigerated at $4^oC$ and analysed within a week of sampling.

2. Samples for dissolved oxygen determination are taken by using a shallow water, water sampler and controlling the outlet tap such that a stedy weak stream carefully slunting the oxygen bottle until it fills to the brim without introducing air bubbles. The samples of about 125 ml (The exact volume of individual bottles are determined and used in the calculations) are treated with 0.5ml of MnCl solution followed by 0.5 ml of alkaline iodine solution (Parsons, Maita and Lalli, 1984) and restoppered carefully to avoid air trapping. The bottles are shaken 30 times in a rolling motion (Mmochi, 1993) to ensure proper mixing. They are then stored in dark places and transported to laboratory where they were stored at room temperature. The samples are analysed within 24 hours of sampling.

3. Samples for suspended sediments also known as suspended substances (Mmochi, 1993) or suspended solids (Patanaponpaiboon et al. 1996) are collected in 500 ml plastic bottles and treated with 3 drops of chloroform just like the DIN samples excluding filtration. The samples are stored at room temperature and analysed within one week of sampling.

## Analyses of samples

Temperature and salinity are measured in field by using normal thermometer and refractometer immediately after sampling while pH is analysed immediately on arrival from field by using Beckman pH metre standardized at pH 4,7 and 10. Oxygen and BOD are analysed by titration Winkler´s method (Parsons, Maita and Lally, 1984) modified as in Mmochi (1993). Dissolved inorganic nitrite and nitrates are analysed as in Parsons, Maita and Lalli (1984) by using Lambda Polynom 1201 UV/VIS spectrophotometer calibrated by blanks and standards for sea water. Suspended sediments are filtered in pre-weighed (W1) glass filter papers and dried at 80oC overnight (W2) to remove water and 450oC for six hours (W3) to burn out organic matter (Mmochi, 1993). The filter papers are then be treated with 1N HC1(W4) to remove carbonates. The differences in weights between W1, W2, W3, and W4 will give concentrations of total, organic, carbonate and silicic suspended matter respectively.

### 2.2 Water pollution control strategies and policies

The development of policies and regulations on water pollution control are undertaken by the persepectives departments, such as Water department, Department of Environment, Institute of Marine Sciences, etc. The following are main activies carried out regarding water pollution control strategies.

To execute water research programs.
Creation of water quality monitoring legislation.

Training water laboratory staffs.
Cleaning up chemical and pesticide wastes

### 2.3 Human resources

Department of Water Development is the most responsible organ in all activities related to public water suplies, and water pollution control. However Department of Environment, Institute of Marine Sciences, Zanzibar Municipal Council, Department of Public Health of the Ministry of Health and related institutions also play an important role on water pollution control. Departement of Water Development has established water laboratory which is able to conduct an analysis on some chemical and biological water quality parameters. Currently, water laboratory has five full employed technical staffs, one of whom holds a bachelor degree in science, other four were trained at the Water Resource Institute located in Dar es salaam and have full technician certificates (FTC).

Although, the present staffs are able to carry out their assignments, there is a need for them to be trained further in courses related Water quality analysis to upgrade their knowledge and skills and expose them to ever changing analytical procedures and technologies. In the Institute of Marine Sciences where marine water quality analysis is done, there are two laboratory dealing with water pollution. The laboratory are well equipped and many water environmental parameters can be anayzed. A part from normal chemical and biogical water parameters the laboratory can also analyse variety of pesticides, heavy metals and other environment parameters. It has good number of techicians and scientists at Msc and PhD levels.

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