The Assessment of Water Quality and Pollution in Tanzania

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INTRODUCTION

The coastal area of Tanzania (Fig. 1) encompasses a number of habitats that include coral reefs, mangroves, seagrass beds, sand banks, wetlands and beaches, among others. In addition to being essential linkages in the overall functioning of the coastal area, these coastal habitats support various resources both living and non-living. In addition, for generations the coastal area has provided life support to coastal communities where such activities as fisheries and related activities have played an important role in the social and economic development of local communities. In recent years, coastal tourism and mariculture have immerged as being potentially among most important economic activities nationally. The well being of these habitats and resources and the various activities taking place within or near coastal waters depend, to a large extent, on good water quality.

However, expanding coastal populations and emerging industrial activities are exerting ever-increasing pressures on coastal waters thus negatively affecting water quality. As a result coastal pollution is increasingly becoming a major issue in Tanzania. Reports indicate that coastal waters fronting such cities and towns as Dar es Salaam, Tanga, Zanzibar and Mtwara are said to be grossly polluted. Furthermore, land-based activities such as agriculture, industry, and mineral exploitation have further contributed to the degradation of coastal water quality.

This report gives a summary of the available information about water quality and pollution in Tanzania.

Water quality research in Tanzania

Research in pollution and water quality does not have a long history in Tanzania. During a literature search preceding this synthesis, the earliest records found on this aspect were from the early 1970s. For example, a 1971 report by the Danish Isotope Center gives results of a feasibility study that assessed receiving water supply for Dar es Salaam. Another study by Steinbach (1974) reported on the relationship between industry and environment in the Msimbazi Valley drainage area. Ngoile *et al* (1978) discussed some aspects of aquatic pollution in Tanzania. These studies were followed, in the 1980s, by a number of investigations on different aspects of the environment (e.g. Shanmungam, 1981; Shanmungam, 1983;UNIDO/UNEP, 1982). Then beginning the early 1990s, there was an upsurge of publications on the topic making this period by far the most productive in terms of studies on pollution and water quality.

In Dar es Salaam, Kondoro (1997) assessed heavy metal (Pb, Cd, Zn, Cu, Cr) distribution along Msimbazi River. Mwandya (1996) determined the concentrations of heavy metals Pb and Cd in the soft tissues of *Saccostrea cucullata* in Ocean Road beach and Msimbazi Creek. Other studies in include that of Wekwe *et al* (1989) who assessed heavy metal content of several species of algae along the coast of Dar es Salaam. Heavy metal pollution was also studied by Machiwa (1992) who assessed anthropogenic input of Fe, Mn, Zn, Pb, Cr, Cd and organic carbon in Dar es Salaam coastal sediments. Machiwa (1992) also investigated the possibility of the occurrence of toxic materials (PCBs) and organic carbon and pathogenic microbes in the marine sediments off Dar es Salaam. In other studies, Lyantagaye (1996) invested the distribution of dissolved inorganic nutrients and dissolved oxygen in Mzinga Creek and Ocean Road coastal waters while Mamboya (1996) investigated

wet and dry season variations of those parameters in Mbezi Creek. Mlay (1994) assessed the interrelationship between environmental conditions and algal abundance and Chlorophyll *a* concentrations in the University of Dar es Salaam wastewater sedimentation ponds.

Several pollution assessment studies have been carried out in Zanzibar, mostly in the waters fronting the Stone Town in the Zanzibar Municipality. Among the earliest such studies is that carried out by Van Bruggen (1990) who measured water temperature, DO, conductivity, pH, BOD, COD, heavy metals and faecal and total coliforms. This study was commissioned by the Zanzibar Department of Environment to facilitate the formulation of the Zanzibar Environmental Policy. This study was followed by that of Mohammed (1990), who investigated pollution by industry and other users of chemicals in Zanzibar. Mohammed *et al* (1993) looked at the impact of pollutants (nutrients and coliforms) on the reefs fronting the Zanzibar Town. Another study was by Walvoord (1993) who measured baseline concentrations of dissolved nutrients, BOD, salinity and dissolved oxygen at 14 sites in the same area. Anderson (1994) carried out a two-week measurement of pH, dissolved nutrients, temperature, salinity, turbidity and dissolved oxygen at the Zanzibar harbour. Johnstone and Suleiman (1997) measured nutrient concentrations near the islets of Bawe and Chapwani (off the Stone Town). They also examined nutrient dynamics and community response to nutrient loading. Mmochi and Francis (1999) undertook a long term monitoring of water quality also in the Stone Town area of Zanzibar.

Studies carried out outside the Zanzibar Town area include those by Kastner (1996) who compared nitrification rates in an unpolluted environments (a mangrove stand at Chwaka Bay and a beach at Fuji Beach) and a polluted beach (Stone Town, Zanzibar). Mmochi (1997, 1998) studied pesticide and nutrient pollution of ground water in the Chwaka Bay, Paje, Fumba and Mahonda-Makoba basins in Zanzibar. Mmochi *et al* (1999) assessed the quality and effects of groundwater outflow on the

near shore biota of Paje, Fumba and Makoba in Zanzibar. At Maruhubi, Machiwa (1999) measured lateral fluxes of organic carbon.

Many review studies have been carried out to assess the pollution problem especially in the Dar es Salaam area. Uronu (1995) analysed the development of the sewerage system in Dar es Salaam, from its construction in 1948 through its different extension phases in the 1970s. The report also assessed domestic sources of pollution along the coast of Dar es Salaam. Another review of the development of the sewerage system of Dar es Salaam was done by Martinez (1998).

Other reviews include that of Bryceson *et al* (1990) who assessed the state of the marine environment in the East African Region, including Tanzania. In another study, Bryceson (1981b) reviewed some problems of marine conservation with particular reference to Tanzania. A comprehensive review of the sources of pollution in Tanzania mainland was conducted by Mgana and Mahongo (1997), who quantified all major human activities that contributed to pollution of the marine environment. A similar kind of review was carried out in Zanzibar by Mohammed (1997) who investigated land-based sources of pollution affecting coastal, marine and associated freshwater environments on the islands. Other reports from Dar es Salaam are those by Bwathondi *et al* (1991) who compiled all available data at that time on pollution of the Msimbazi River and advised on the need for a comprehensive multidisciplinary research. Mashauri and Mayo (1989) discussed the potential impact of discharging raw sewage into the Indian Ocean. In Tanga, Shilungushela (1993) made an inventory of destructive activities to the marine and freshwater bodies in the Tanga region.

Most of the information on water quality and pollution in Tanzania comes from areas in or around major towns and cities. Consequently, Dar es Salaam, Tanga, and Zanzibar received the most coverage. In this regard, geographical coverage of water quality studies in Tanzania can be best termed as very poor. It can argued that the areas most affected by pollution are those that are located next to these densely

populated towns and cities, hence the studies. This is truly the case as has been shown by these studies. However, even in Dar es Salaam, Tanga, and Zanzibar, not all areas have been covered by these studies, both in terms of subject and geographic coverage. In Dar es Salaam, most studies have concentrated in the Msimbazi River and Creek and the harbour area, at the expense of other areas. The same can be said of Zanzibar and Tanga. In Zanzibar, the majority of water quality studies were carried out in the waters fronting the Stone Town in the Zanzibar Municipality. These include both baseline and monitoring studies. In Tanga, the studies carried out in that municipality targeted specific areas that are recipients of either municipal wastes or wastes from the local industrial facilities including a fertiliser factory (e.g. Munisi, 1998). However, a 1993 study by Shilungushela in Tanga looked at among other things, pollution emanating from the agricultural sector in the area. Hardly any other study has ha been conducted outside these areas. It is obvious then that there is a need to broaden the geographic coverage of water quality studies to other parts of Tanzania where virtually no information on this subject exists.

The subject area most covered by water quality studies in Tanzania is pollution emanating from sewage waste. This reflects the previously mentioned fact that most studies have been concentrated near major population centres and the nation's concern on sewage pollution. Fewer studies have looked at other sources of water quality degradation and their impacts on the natural environment and on human health. Studies have mainly focussed on nutrient loads and distribution, BOD and coliforms levels and other indicators of sewage pollution. Studies on heavy metal pollution and that emanating from organic compounds and agrochemicals are few and far between. Among the few studies of this kind include a study by Mmochi and Mberek (1998) who looked at trends in pesticide use and toxicity in Tanzania and those by Machiwa (1992a,b) which assessed pollution by heavy metals and other toxic material. Both Tanga and Dar es Salaam have relatively high concentrations of manufacturing concerns. Since few industries in Tanzania treat their wastes before they are discharged into the environment, it is obvious that these industries contribute significantly in the pollution loads. Given the current pace of industrial development

in the country and the fact that only few studies on industrial pollution have been done, it is important that more studies should be carried out to generate both baseline information as well as to follow trends on the impact of these wastes on the water quality.

The majority of the studies carried out so far looked at pollution loads *per se* and noticeably few have examined the impact of pollutants on the natural or social environments. Some of these studies are mentioned here. The first one was conducted in Tanga where Munisi (1998) investigated the effects of waste discharges from a fertiliser factory on intertidal floral communities. Other studies were carried out in the waters fronting the Stone Town of Zanzibar where Bjork, *et al.* (1995) observed a reduction in coralline algal caused by sewage pollution from the municipality. Johnstone and Suleiman (1998) reported increased community metabolism and gross production in the same area which they attributed to excess loading of nutrients through sewage discharge from the municipality. Machiwa (1999) examined the effects of sewage dumping on the levels and rate of mineralisation of organic carbon in sediments of a partly polluted mangrove stand in Maruhubi in Zanzibar. Kangwe (1999) studied the effects of mercury, lead and cadmium on calcification rates of the reefs building calcareous algae *Amphipora tribulis*. Other studies include that which looked at the impact of pollution on plankton biomass and composition at Kunduchi and the harbour area of Dar es Salaam (Lugenda, 1998) and port development in Tanzania and their impacts on marine environment (Shanmungam, 1981). Bryceson (1982) assessed the impact of effluent (domestic, industrial) disposal on the ecology of Dar es Salaam coastal habitats. Chande (1994) identified and assessed the magnitude of activities that had an impact on the marine environment. Shunula and Ngoile (1989) assessed the consequences of human activities on the marine environment of Zanzibar.

The State of Water Quality in Tanzania

Several studies have shown that in general the coastal waters in many parts of Tanzania are in a relatively pristine condition. The exception is coastal areas bordering major tows and cities that are recipients of untreated municipal and industrial wastes and those areas receiving agricultural wastes. These include the main coastal towns of Dar es Salaam, Tanga, Mtwara and Zanzibar. In Zanzibar, faecal coliform and total coliform levels of up to 70/100 ml and numerous thousands per ml of seawater respectively have been reported in the waters fronting the Zanzibar Municipality (Mohammed, 1997). Nutrient levels are also higher than normal for tropical seawaters indicating anthropogenic inputs. Concentrations of nitrate of up to 7.8 µ-at N/l phosphate of 4.0 µ-at N/l (Anderson, 1994) and dissolved ammonium levels of up to 28.6 µ-at N/l (Mohammed and Kyewalyanga, 2001) have been reported. Sewage pollution has been cited as principally responsible for increased cases of waterborne diseases on the islands. These include diarrhoea, gastro enteritis, cholera and dysentery.

Likewise, it has been reported that there is a proliferation of macroalgae in Tanga coastal waters due to excess nutrient loadings from discharges from a fertiliser factory and from the municipality (Munisi, 1999). Coastal pollution in Tanga is also attributed to discharge of effluents from sisal decorticating plants in the area. Up to twenty plants discharge their wastes onto the coast via the Pangani, Sigi, Mruazi/Mnyuzi and Mkurumzi Rivers (Shilungushela, 1993) some of which are heavily polluted (See Table 1 below).

In Dar es Salaam, domestic waste is the most serious source of pollution. The waste generated by 15% of the city residents who are connected to the sewer system is discharged into the sea untreated. As a result, the coastal waters, especially in vicinity of the Dar es Salaam harbour, are heavily polluted. Discharge of untreated sewage in Dar es Salaam has resulted in high faecal and total coliform levels in the same areas. The situation is made worse by a broken sewer pipe which discharges untreated sewage on sandy-mud flats near the harbour which is said to threaten invertebrates and fish (Bryceson, 1981, Bryceson *et al*, 1990). It has also been reported that chlorinated organic compounds are at alarming levels in the harbour areas as are heavy metals, Pb, Zn and Cu

(Machiwa, 1992). The harbour area also suffers from oil pollution from the refinery at Kigamboni, and industrial wastes from Keko, Chang'ombe, Kurasini, Mtoni and Temeke. These discharge heavy metal, pesticide, organic, and paint wastes into the nearby area (Bryceson, 1983).

Msimbazi River and Creek are also among the most polluted water bodies in Dar es Salaam. The river and creek receives large quantities of untreated domestic wastes from the city's residents in addition to industrial wastes from various industries. The river and creek receive such pollutants as dyes and paint wastes and strong alkalis (from textile factories), oil and tars, (from vehicle depots and power stations), organic wastes (from breweries and meat plants). Other industrial and agricultural chemicals that pollute the river and creek include heavy metals, PCBs, cyanides, pesticides, and detergents (Bryceson, *et al,* 1982). Table 2 and 3 give pollution loads in surface and ground water sources respectively in Dar es Salaam.

Other coastal areas of Tanzania outside the major cities and townships though free from domestic wastes do suffer from input of agricultural wastes, including pesticides and fertilisers, via rivers and streams. Most major rivers in the country drain agricultural lands and deposit their waste loads on the coast. Unfortunately, this area of concern has not received sufficient attention in the literature. River discharges on coastal areas also carry with them industrial wastes. A case in point is Kilombero River, which transports wastes from the Mufindi Pulp and Paper Mill from the hinterland to the coast (Bryceson *et al*, 1990).

Vast amounts of sediment enter the coastal waters annually via the nation's river networks. Such inputs can be a result of natural events such as storm events and rains in upland areas, poor agricultural practices have been known to play a leading role in water quality degradation due to sedimentation (Bryceson, 1981). A direct consequence of sedimentation is the smothering of corals and other organisms lying on its path. Sedimentation also has a detrimental effect on social and economic potential of coastal waters causing the reduction of aesthetic value of the water thus

making it less attractive for such activities as tourism as well as for general recreational activities.

Recommendations

Not a single city or town in Tanzania has sewage treatment facilities. Invariably, waste from these cities/towns is discharged untreated into the environment, mainly into coastal waters via local sewer networks and rivers and through. In most cities and towns sewer networks are either nonexistent, inadequate or in an advanced state of disrepair. For example only about 15% of Dar es Salaam residents are connected to the city sewer network which was build in the late 1950's. The city has eight oxidation ponds, of which only four are in operation (University of Dar-es-Salaam, Kurasini, Mikocheni and Vingunguti). Over 80% of the households in the city use pit latrines and septic tanks. These frequently overflow, especially during the rains, contaminating water sources thus increasing health risks in the neighbourhoods.
The Zanzibar sewerage system which dates back to the 1920s serves only about 18% of the population. Like in Dar es Salaam, waste from the town's residents is dumped untreated in the nearby coastal waters. The same situation prevails in other towns along the coast.

For the long-term sustainability of the coastal zone ant its resources, it is important to develop better facilities including treatment plants. However, given the potentially huge investment requirements for secondary or tertiary waste treatment, it is recommended that there should be installed at least primary waste treatment facilities in the major cities to facilitate initial waste treatment before discharge. Tourist hotels and industrial plants should have their own onsite treatment facilities to reduce waste loads in the public sewer networks as well as avoid haphazard waste discharge.

The promotion of local awareness is key to the effective management of pollution and the health risk associated with the problem. For example, there should be formulated guidelines on the design and construction of wells and pit latrines with the view to reduce

pollution in peri-urban areas where these facilities are commonly used (Chaggu, 1993). The public should be advised on the health risks associated with using water from shallow hand-dug wells especially those facing the risk of contamination from pit latrines and should be discouraged from using such facilities. A monitoring program to study the fluctuation of ground water levels and quality should be initiated in areas where shallow wells and pit latrines are commonly used with the view to help in pollution and health risk management. The public should also be made aware of the health risks associated with seawater pollution such as the dangers of eating contaminated fish and shellfish and swimming in sewage contaminated waters.

There is a paucity of information on water quality for a large part of the coast of Tanzania. Such information is essential in setting up management strategies. To start with, priority should be given to filling up gaps in areas where there little or no data available before embarking on long term studies. Consequently short-term studies should take priority over long term monitoring programs. However, this should be decided on a case by case basis, as there are areas that urgently require monitoring of both pollution inputs and its effects on natural environment.

Pollution in Tanzania has yet to reach alarming levels. However, given the continuing population pressure and industrialisation in the country as well as the presence of some hotspots along the coast, necessary steps need to be taken to preclude further deterioration of water quality in the country.

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