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On-Site Sanitation and Its Effects on the Recreational Waters of Nyali-Bamburi-Shanzu and Diani-Chale –Kenya

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Abstract
This paper presents the effect of on-site sanitation systems on the recreational waters of Nyali-Bamburi-Shanzu and Diani-Chale tourist destinations along the Kenya Coast to establish the level of contamination in these lagoon waters frequented by tourists for swimming, diving and snorkeling. Water oozing out along the beaches near hotels or a clusters of hotels and that of lagoons in front of the beach hotels were sampled for laboratory examination to determine the levels of contamination by nutrients and micro-bacteria. Nitrites and E. coli – indicators of recent contamination by human wastes were of major interest. The sampling and analysis spanned the whole year to capture the four tourist seasons and the wet and dry periods of the year. The results of analysis established the in-effectiveness of the on-site sanitation systems in containing human waste. Topology and rock formation promoted transportation of contaminants downstream for measurable levels of nutrients and E.Coli to be detected in the lagoon waters. Nutrients and bacteria levels were higher in the lagoons in the wet periods than during dry weather. This was linked to of diffuse pollution from surface run-off, leachates from dumpsite, and discharges of contaminated water into the lagoons. Specifically for Diani-Chale, the levels of contamination were observed to be in sync with the peak tourist season, where the higher levels could be explained on account of the large number of people (tourist plus local people), which increased significantly as the number of local people increased to cash in on the opportunities the industry offered during this period only to decline to low contamination levels during the low-tourist season when the tourists return to their home countries and the local people move to their rural homes for farming activities. Variation of contaminant levels as a pattern due to migration of the people was not observed in the NBS study area on account the area being more urbanized, people depend on other sectors for their socio-economic activities. Overall, the contamination levels in the two study areas are generally still low. However, with increasing urbanization and investments in the tourism industry, the problem may grow to unacceptable levels and action needs to be taken to address it as an emerging problem.
Keywords: Lagoon waters, on-water activities, on-site sanitation, human waste management, contamination, nutrients, micro-bacteria, E. coli

1. INTRODUCTION

The Kenya coast is a tourist destination of choice, with visits from many travelers, local and international: descending upon the area religiously. Nyali-Bamburi-Shanzu and Diani-Chale are the preferred localities in the visits, mainly because of their natural attractions. As a result, a number of beach hotels were built to offer accommodation to the increasing number of visitors. Not to be left behind, the local population, wanting to have a stake in the tourism industry, has rather more permanently also, descended on the two locations, investing in residential housing and commercial developments to cash in from the industry, , resulted in rapid urbanization, without support infrastructure for the management of human waste. Consequently, both the hotels and the human settlements have had to rely on on-site sanitation systems in the form of pit latrines and septic-tank and soakage pits for containing human wastes. These sanitation systems, it is feared, could be having negative effects on waters of the marine environment, where varied on-water activities take place. This study identified the sources of pollution and evaluated the pollution levels in the lagoons, where for tourists who had a beach agenda in their holiday plan, spend many hours swimming, diving, snorkeling etc.

The main sources of contamination to the lagoon water system identified include sewage, storm water, solid wastes and sporadic oil spills. However, sewage is considered to pose the single most significant threat to human health and to the sustainability of tourism and the human settlements. This notwithstanding, due to poor drainage –surface run-off is a significant source of diffuse contamination, introducing into the lagoons, excessive nutrients, micro-bacteria and suspended solids. Similarly, as each of the study areas, operate open solid waste dumps, leachates from these add to the water contamination problem. Informally disposal of solid wastes, contribute to water pollution from surface run-off depending on the size of the waste build-up as well as on local topography. The UK DOE, (1978), indicates that leachates produced from the waste dumpsites occur if there is a source of water equal to or greater than about 133 mm per meter of fill; and the contaminating ability from leachate can be some 10 or more times greater than for sewage, Xu and Braune, (1995). Rainfall in these two areas is adequate to provide the amount of water needed for this to occur. Compounding this, the Mwakirunge dump site in the N-B-S study area is overlain by over 100m thick impervious Jurassic shale outcrop of the Upper Mto Mkuu Geological Formation, which has weathered over the years to form a few metres of unconformable layer of impenetrable clay soil overburden on the surface, promoting horizontal flow rather that percolation of the leachates underground. With the site standing on a Foot Plateau, and sloping seaward, in an area sandwiched between two steep sided valleys to form the upper reaches of seasonal streams, with both surface and underground flows, draining into the Mtwapa Creek and Coastal Plains, presents a topography, suitable for contaminant movement and flows, directed downstream into the lagoon waters downstream. Thus contaminants leached from the Mwakirunge solid wastes are transported downstream either as dissolved substances or particulates via the groundwater channels along some inferred fault, or, through surface runoff. Topographical and geological conditions of this type do not occur in Diani-Chale, however, the coral basement underlying the area, indicates that the areas lagoon waters could also be suffering the same fate.

Tourism is the main stay economy for the two areas. As tourism travels have been advocated for many years through vigorous promotional campaigns, large numbers of people are travelling to various destinations of the world, with the two study areas being recipients of the same. However, the industry has created not only opportunities for national economies, but also, impacts on the receiving destinations, and the problem may be growing. Coastal water resources may therefore be getting impacted by the industry and its associated human settlements, Biliana and Knetch (1998).

Thus, the travels, promoted as a way of trade with other countries and highly encouraged, neglected the impact the movement of large numbers of people could have on the receiving destination, its environment and resources. Miller & Auyong (1991).

This neglect is of concern since the two destinations are located in a coastal area where as studies have established in the developing world, the industry has impact on water quality, despite superior infrastructure to manage wastewater, UNEP/GPA, (2001). Therefore in the developing world, where sewage infrastructure is non-existent or inadequate, the magnitude of the problem, may be worse. Such a situation could be mirrored in the two study areas where it is feared that large volumes of untreated wastewater generated is being discharged into water bodies. A situation may be attributed to the rapidly growth of tourism and associated human settlements without matching infrastructure and services to manage the wastes generated, and therefore placing a burden on already inadequate existing facilities. The outcome of which is, inadequately treated waste discharged into water bodies, causing the deterioration of water quality. As tourism booms and coastal settlements continue to grow for mutual support, the problem will persist and become worse in a scenario where hotel establishments are found within short stretches of space between each other, and the crowding population in the human settlements immediate hinterland, continues to increase. Good water quality, which is necessary for the coastal ecosystem functions that promote aesthetic beauty and value of the coastal environment for thriving local communities and tourism development. The concern among stakeholders is that the situation may be affecting sustainable tourism development in the study areas.

Sewage introduces pathogens in water bodies and its link with water borne diseases is well established, WHO, (1999). The effects of poor water quality being numerous on national economies. The Global Program of Action, (GPA) on Municipal Wastewater Management identified poor sewage management practices in the coastal regions of the world as the major sources of water pollution, resulting in stress in the marine environment UNEP/GPA, (2001), and recommended for remedial measures. This is so because implementing sound practices in wastewater management may allow tourism to generate benefits that can lead to improvement in government services and facilitate the attainment of sustainable community development objectives.

This situation makes it worth-while to investigating the problem of water pollution in a coastal destination of a developing country on account that coastal dwelling and the tourist hotels largely do not have proper sewage management infrastructure and therefore resorting to on-site sanitation, where it is standard practice to dig soakage pits and pit latrines deep down to the water table, as in doing so, the pits would not fill up quickly, minimizing the costs of frequent emptying. However, behind this practice, is the risk of direct injection of contaminants into to groundwater aquifers and, by extension, transport of the same to waters of the marine environment.

As good water quality is cornerstone for a healthy population and for the recreation opportunities that tourists come to enjoy, the importance of protecting and maintaining good water quality cannot be over-emphasized. Water contaminated with sewage means decreased health to the people; it also means less recreational opportunities for tourists. Thus, for beautiful aesthetic experience, safe swimming, snorkeling and diving, the safe eating of locally caught seafood, maintenance of the mangrove, sea grass, fish, algae, and coral ecosystems, that the tourists come to see, maintaining good water quality is pre-requisite. Equally, drinking water devoid of pathogens minimizes the effects of water borne diseases.

Studying the problem is urgent on account that for the past many years, cultural practices for water supply in coastal areas have, in many cases, shifted from over-reliance on reticulated supplies to dependence on groundwater sources. Maintaining good groundwater quality is therefore prerequisite for sustaining both tourism and local communities as reticulated supplies become scarce. Similarly, a permeable geology and quick recharge of the bedrock, making coastal environments rich reservoirs of groundwater, is its curse, because; behind the quick recharge, is also the risk of contamination of the water resources. Just as the aquifers recharge quickly, they are also prone to quick contamination, with the spread of the problem to the marine environment, - not in doubt.

2. Research Methods

Nutrients and coliform bacteria do not naturally exist in water above certain levels. When found above these levels, it is usually as a result of contamination from human waste. E. coli and nitrites in particular, if found in water, is indicative of recent feacal contamination. Therefore, by measuring the concentration of total ammonia, faecal coliforms and faecal streptococci the quality status of water can be established. The ratio of faecal coliform/faecal streptococcus in particular, gives the level of contamination in bathing waters. Dangerous bacteria, viral and the pathogens cause waterborne diseases and therefore, by measuring the nutrient and micro-biological levels of a water source, the link between deteriorating water quality and sewage management may be established.

On-site sanitation systems are the most dominant methods for excreta disposal in the human settlements and in the beach hotels. The use of such systems pose potential threat to groundwater contamination and by extension, the contamination of the water in the lagoons through seepage and direct discharge from the systems. Such scenario has negative effects on the lagoon recreational waters of the marine environment. As water for recreational use must meet the general Environmental Quality Objective, (EQO) of guarding safety and health by being aesthetically acceptable, free from bacteria and free from toxic materials; water contaminated with human waste cannot guarantee this. Consequently, this study sought to establish the water quality status of the recreational water of the two tourist sites by sampling for laboratory analysis, the water seeping out along the beaches and discharging into the lagoons, and also the water from the lagoons to establish the presence of nutrient and micro-bacteria –the main indicators of pollution from human waste

The Nyali-Bamburi-Shanzu tourist destination (Figure 1), is located in the Kisauni District of the Mombasa County. Its inland boundary to the west is the new Mombasa-Malindi road, to the east, is the Indian Ocean and its immediate lagoons. Its north and southern boundaries are the Mtwapa and Tudor Creeks, respectively. Within the north-south stretch are to be found the Nyali, Kenyatta and Bamburi beaches that are very popular among tourists.

The Diani-Chale tourist destination (Figure 2), on the other hand, is in the Kwale County. It has its north-south boundary bounded by rivers Mwachema and Mkurumudzi respectively, with the Mombasa – Tanga road, forming the inland boundary to the west. The Indian Ocean and its immediate lagoons constitute the eastern boundary. However, for both study areas, in order to capture important aspects that contribute to the study problem, the inland boundaries were extended to include the human settlements located in their immediate western boundaries.

Sampling was carried out throughout the year with a monthly schedule of a routine followed. The sampling strategy was to capture pollution data in all the tourist seasons. Samples were taken from along the beach during low tide for the seepages; while at the same time, recreational waters in the lagoons immediately after the beach in-front of a hotel, or a cluster of hotels, became the sampling points of choice as they represented areas with very high on-water activities. The sampling points consisted of transects between the beach and lagoon in front of the beach hotels and perpendicular along the shoreline to cover the study area.

The transect sections along the beach were stations that showed groundwater seepage. Due to its nature as an intrusion area, unlike the other sampling stations, which are out-flow areas, the Jomo Kenyatta Public Beach sampling point served as a control reference for recreational water quality. Maps of the two study areas showing sampling points for the recreational waters are given in Figures 3 and 4

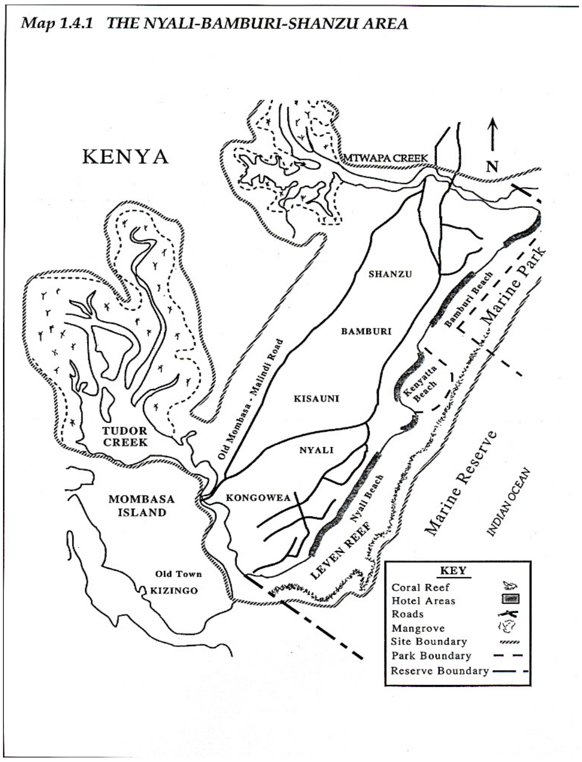

Figure 1: Map of Nyali-Bamburi-Shanzu study area, Source, CDA, (1996)

Figure 2: Map of the Diani-Chale study area, Source, CDA and IUCN, (2002)

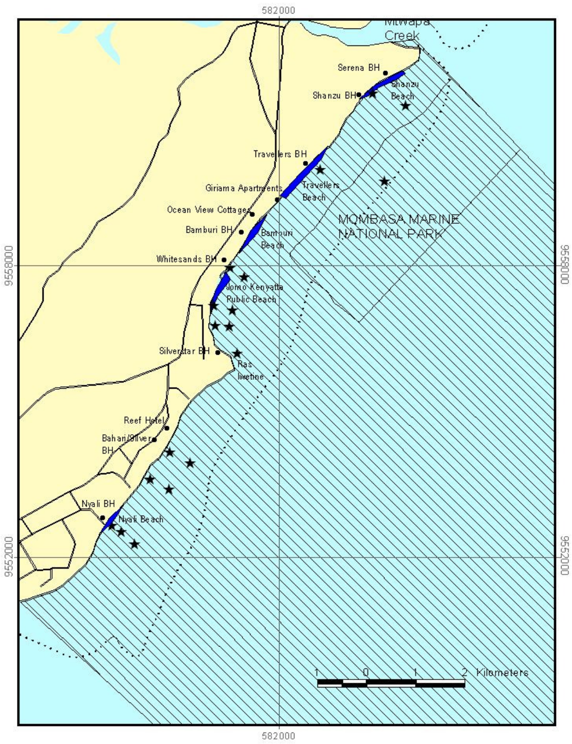

Figure 3: Sampling points NBS

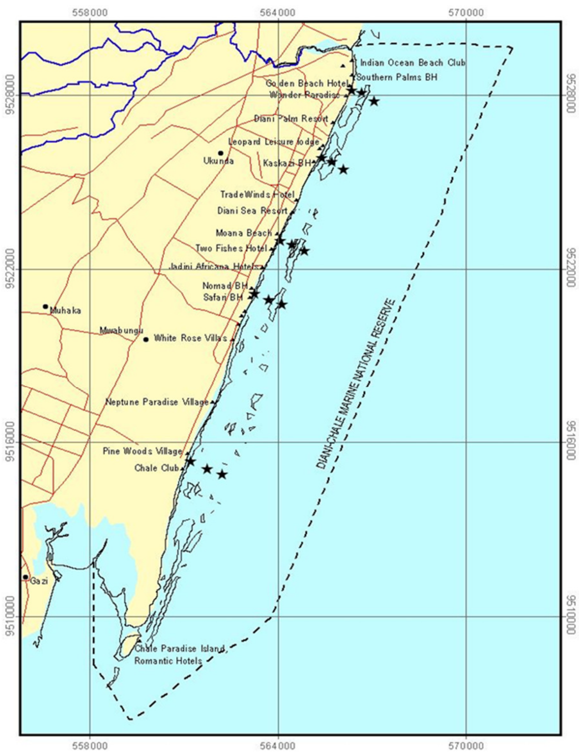

Figure 4: Sampling points Diani-Chale

2.1 Analytical Procedures

At each of the 5 sampling site, per study area, 2 replicate samples were taken per station monthly for nutrient analysis, with a similar number of samples taken for bacteriological examination. The samples were stored in a cool-box with ice before analysis in the laboratory within 24 hours of the sampling.

2.1.1 Nutrients

The water samples were analyzed for Ammonia, nitrates + nitrites and phosphates using the colorimetric methods. The ammonia concentration covers the non-ionized NH_3 and the ammonium cation NH^+_4 and reported as mg/l: (NH_4-N); Nitrite + Nitrate as {(NO_2^- + NO_3^-)-N} and orthophosphate (PO_4^{3-}-P). Methods modified from Parsons et al, (1984) and APPA 1995 were used for analyses. All chemicals used in these analyses were of analytical grade and the glassware acid-washed. Figure 5 shows the manifold used in the nutrient analysis.

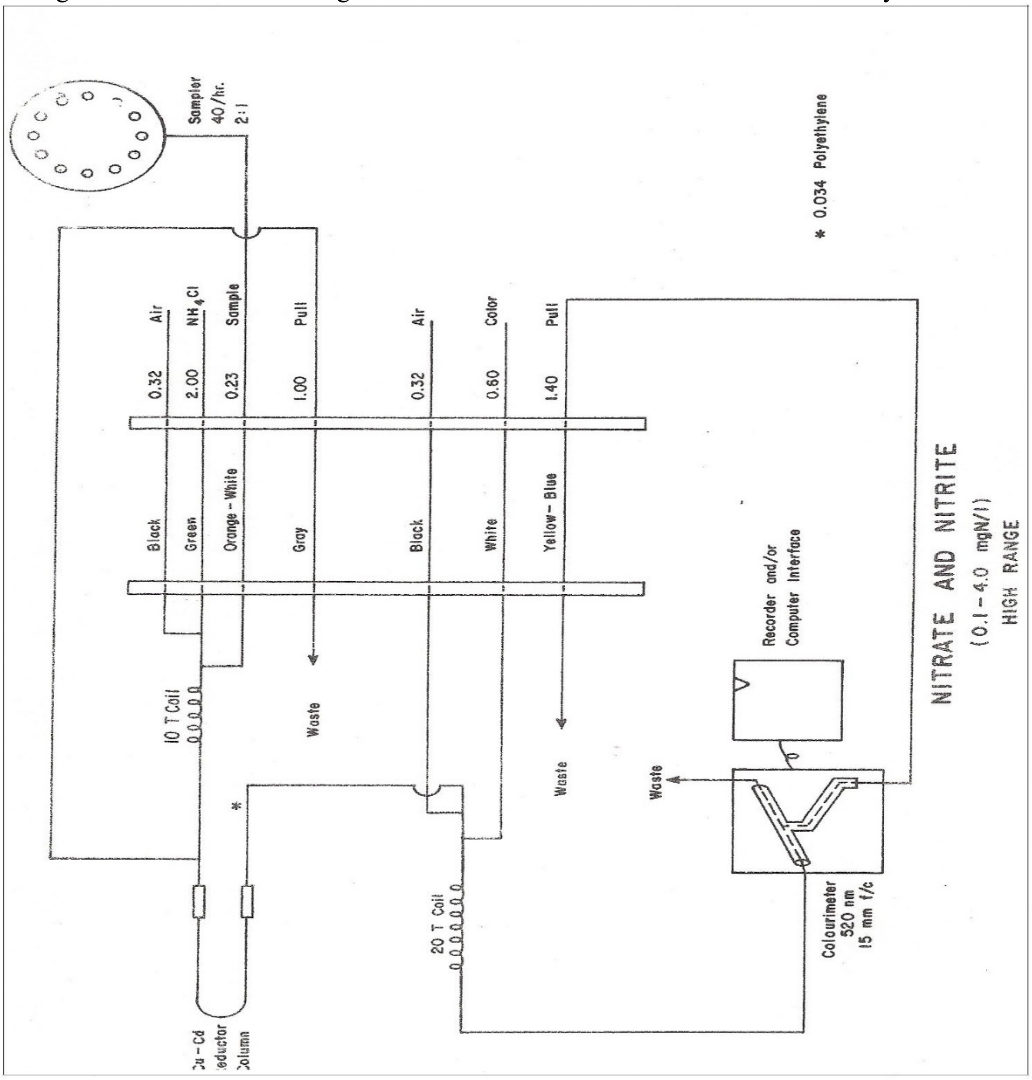

Figure 5: Manifold for Analyzing Ammonia, Nitrate & Nitrite and Phosphates in both fresh and sea water, Source APHA, (1995).

2.1.2 Micro-bacteria

The micro-bacteria constituents analyzed in the recreational waters included E. coli, Total Faecal Coliforms and Total Faecal Streptococci.

i) Total Faecal Coliforms

The seawater samples taken under sterile condition were filtered through 0.45 micro-pore size membrane filters. The filters were then placed on the surface of m-FC agar contained in petri dishes and incubated at 44.5 ($\pm$) 0.2^0 C for 24 hours. Lactose fermentation causes colonies of faecal coliform to exhibit a characteristic blue colour. Residual chlorine, if present, was neutralized by adding thiosulphate to the sampling bottle before sterilization. Suspect or doubtful colonies were tested for acid or gas development with a confirmative test using MacConkey broth or brilliant green bile broth. The test procedure described in the Reference Methods for Marine Pollution Studies No. 3 Rev. 1 (UNEP 1983), was used.

ii) Total Faecal Streptococci

The principle of the method for the measurement of total faecal streptococci is the same as that for total coliform all through up to the filtration step. Thereafter, the filters are placed on the surface of KF agar containing TTC and incubated for 48 hours at 36 ($\pm$) 0.1^0 C. Pink to red centered colonies is considered to be faecal streptococci. The test procedure described in the Reference Methods for Marine Pollution Studies No. 4 Rev. 1 (UNEP 1983), was used.

3 Results and Discussions

The major sources of contamination to water resources of the study areas that have been identified include the on-site sanitation systems, solid waste disposal sites, and surface water run-off influences. From these sources of pollution, the contaminants of interest in the water resources were chosen as: the bacterial –*Total Coliforms, E. coli and Total Streptococci,* and the nutrients *ammonia, (nitrates + nitrites),* and *phosphates.* The results and findings for the recreational waters of both study areas are given and discussed in the sub-sections that follow:

3.1 Nutrient Concentration in the N-B-S Recreational Waters

The mean *nitrate + nitrite* concentration from the seepages along the beach are shown in Figure 6. It ranged from 0.48 –2.4mgl^{-1} nitrate + nitrite –N with the lowest concentration recorded in September, and the highest concentration occurring in January. In the lagoons, this ranged from 0.05 – 0.3mgl^{-1}, representing a dilution factor of 9 from the seepage values. The lowest and highest concentrations were detected in September and January, respectively. Along the reefs, Obura, D., (1996), reported nitrate + nitrite concentration ranges of 0.41 – 2.1µgl^{-1}.

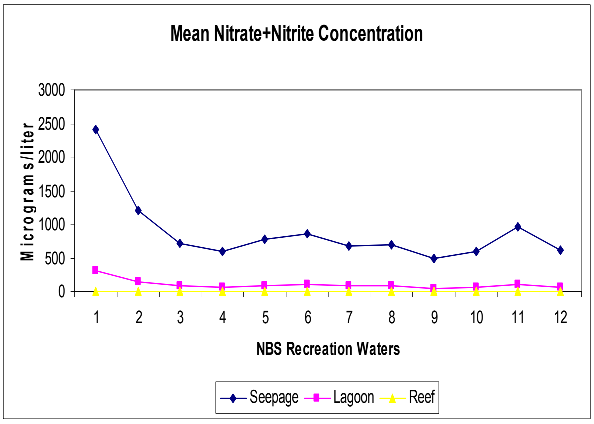

Figure 6: NBS Recreation waters, (2005)

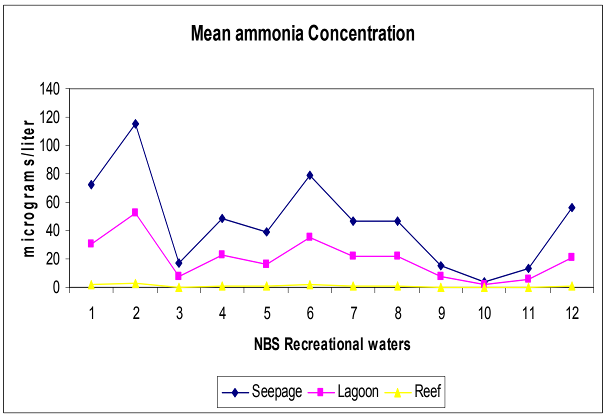

Figure 7: NBS Recreational Waters, 2005

The mean ammonia concentration in seepages along the NBS recreational beaches is shown in Figure 7. It ranged from 4.2 – 115.6µgl^{-1} of NH4–N with the lowest concentration detected in October, which is generally a wet month, and the highest in February, a dry month. In the recreational lagoons it ranged from 2.0 – 52.0µgl^{-1} of NH_4-N. As found in the seepages along the beaches, the highest and lowest concentrations were detected in the months of October and February. Along the reefs, Obura, (1996-7) doing some work for the Kwale Titanium Minerals Project, Kenya, (2000), reported the concentrations of ammonia ranging from 0.1 – 2.9µgl^{-1} NH_4-N., The mean phosphate concentration in the seepages along the beach was 18.1µgl^{-1} (±10.4 SD). The lowest recording of 5.7µgl^{-1} was made in February, with the highest of 42µgl^{-1} made in August as illustrated in Figure 8.

In the lagoons the mean phosphate concentration was 5.5µgl^{-1} (±3.2 SD), with ranges from 1.7 – 12.8µgl^{-1}. Again the lowest and highest concentrations were recorded in February and August, respectively. Along the reefs, Obura, D., (1996) recorded a mean value of 0.3µgl^{-1} (±3.2 SD).

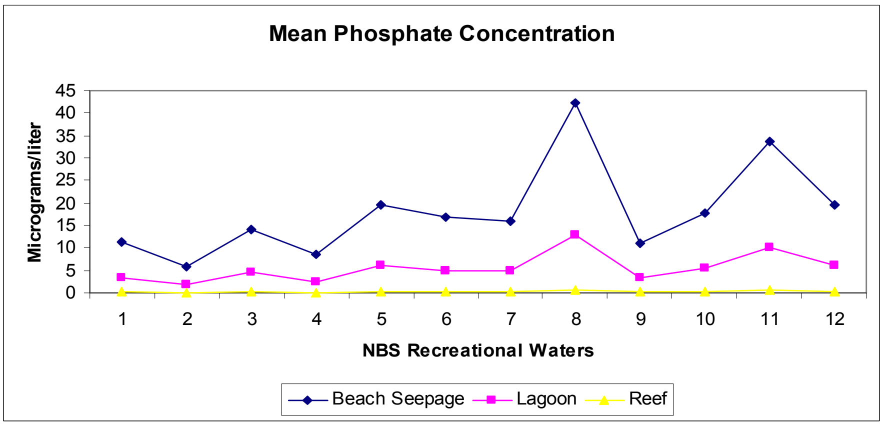

Figure 8: NBS Recreational Waters, (2005)

In this study area, the levels of contamination were higher along the mouth of the creeks: Mtwapa creek pouring into the Shanzu Beach, and the Tudor Creek, which pours into Nyali Beach. Contamination levelled-off from Mtwapa southwards along the beach, but the seasonal Hodi-hodi River, traversing the densely populated

Mtopanga settlements, just north of the Jomo Kenyatta Public Beach, elevated the contamination levels during the rainy season.

From the mouth of the Tudor Creek northwards, the creek waters carry plumes of pollutants from neighbouring human settlement into the Nyali Beach. Being somehow sparsely populated, it had been expected that nutrients levels in the groundwater sources of the Nyali area, would be low, but this was not the finding, because the area experiences additional contaminants carried down from the settlements located to its hinterland. Further north, the rapid urbanization occurring in the Shanzu, the neighbouring Shimo la Tewa Prison and Mtwapa Urban Centre: which without adequate sanitation systems, make the creek waters of Mtwapa recipient to large volumes of untreated sewage. Previous assessments have indicated that direct discharges of wastewater from the residents of Mtwapa and from the inmates and staff of the Shimo la Tewa Prison, constitute by far the most important sources of pollution to the Mtwapa Creek, CDA, (2007). Thus, located adjacent to the Mtwapa Creek, the Prison with 2,500 inmates and 1,500 staff members and their families generate about 400m^3 of wastewater per day with a pollution load of about 220kg/d BOD, which is discharged into the creek, Mwaguni, (2008). The plume discharge explains the high levels of nutrients detected in the Shanzu beach and lagoon

Dump sites in the study areas also contribute to the nutrient and bacterial loading into water bodies through leaching and flow, or, percolation into groundwater bodies. The flow of contaminated water in both study areas is enhanced by the eastward inclined topographic profile and the geological attributes of these study areas. The Mwakirunge waste disposal site, for example, lies on a basement of impervious geology and an angle of inclination tilted towards the human settlements downstream, towards the Indian Ocean. These attributes, enhance nutrient-laden surface flows towards the water sources of the lowland plains that eventually, recharge groundwater in the coral and sandy aquifers of the area with the consequences of injecting nutrient and bacteria laden effluents, undermining the quality of the recipient waters in the process. This problem is further compounded to a large extent by the on-site sanitation practices taking place in the human settlements.

3.2 Nutrient Contamination in Diani-Chale Recreational Waters

The mean *nitrate + nitrite* concentration in the recreational waters of Diani-Chale is shown in Figure 9. The highest mean concentration was once again recorded in the beach seepages. An average mean concentration of 312 µg l^{-1} of nitrate + nitrite –N was recorded, with ranges of 173-862µg l^{-1} recorded in September and January respectively in the seepages, December and January in the lagoon, and Sept and January, in the reefs. The highest concentration was recorded at the Nyali Beach, while the lowest was observed at Bamburi Beach

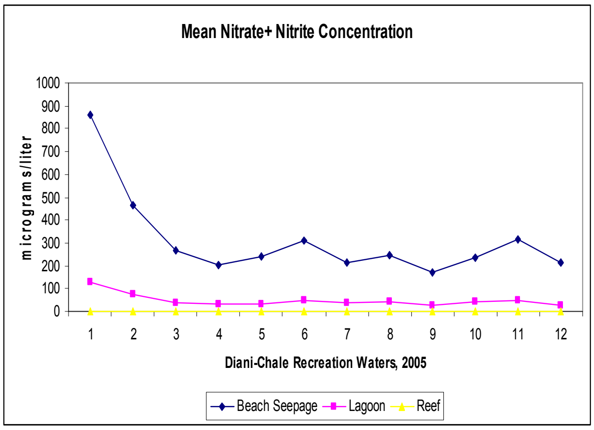

Fig. 9: Mean nitrate+nitrite concentration

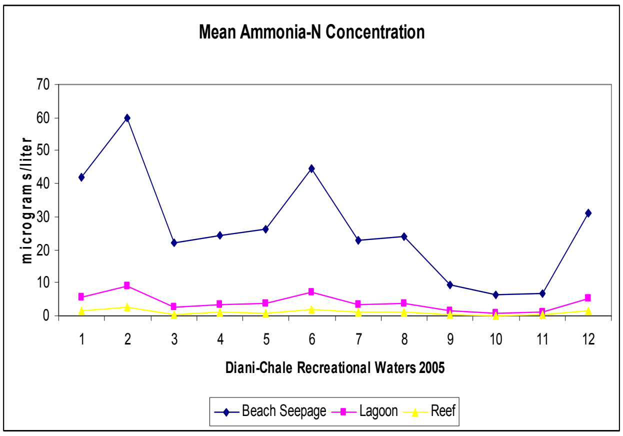

Fig. 10: Mean Ammonia concentration

Just as for the NBS recreational waters, the highest mean ammonium concentration was recorded in the seepages along the beaches. A mean value of 27µgl^{-1} with ranges of 6.4-60µgl^{-1} was recorded in October and February respectively.

The mean *phosphate* concentration in the recreational water of Diani-Chale is presented in Figure 11. Average mean concentrations of 31, 9 and 0.3 µg l^{-1} were recorded in the seepages, lagoon and reefs, respectively. The lowest concentrations were recorded in February, while the highest were registered in August.

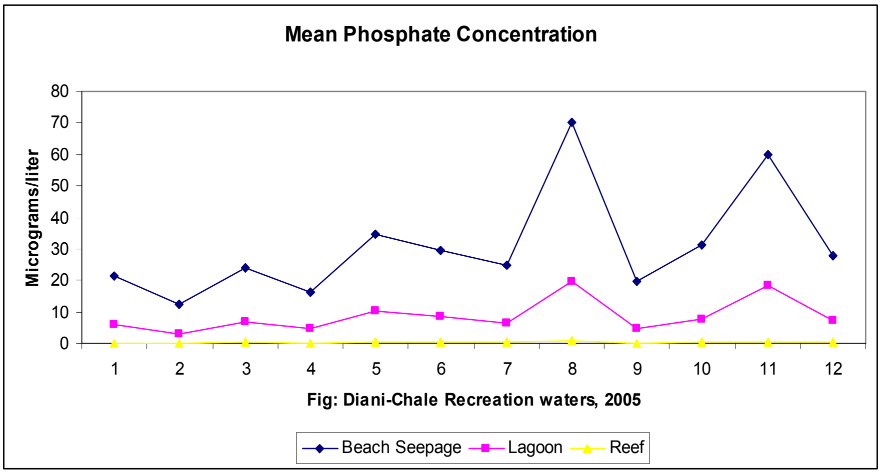

Figure 11: Diani-Chale Recreation Waters, (2005)

The yearly mean nutrient values showed moderate gradual increase with intensifying dry weather conditions. Thus in April, with the onset of the rains, the nutrient concentration in the lagoons shot up due to flushing-out of nutrients from the contaminated surface environment and percolation into groundwater sources. However, with continuing rainfall, the concentration of the nutrients dipped down as a result of the quick recharge in the coral groundwater aquifers. This circle repeated itself at the start and end of second dry and wet periods.

The increases in phosphate concentration in groundwater may be associated with detergents from wash-water discharges, originating from the households; while that of the other nutrients may be coming from the metabolism of human wastes. The increase in metabolic process is linked to increased human numbers, attracted to the dwelling homes fuelled economic opportunities fuelled by the tourism industry

Due to inadequate wastewater management infrastructure and practises, human waste disposed on land remains there to disintegrate through normal biological oxidation processes. This results in a contaminated surface environment, which reflects in the elevated nutrient concentrations captured at the on-set of the rains.

In addition to recharge to groundwater aquifers, decreased nutrient concentration during the wet weather may be explained on account or a recently flashed environment and reduced nutrient generation during the low tourist season due to reducing human numbers. This observation is more relevant in the Diani-Chale study area where the pull to the areas is to the greatest extent caused by tourism as a business. Comparison of the two study sites shows NBS to be more contaminated than Diani-Chale study area, emphasizing effects of the urban influence of the area when compared to the rather more rural, Diani-Chale.

The mean nitrate + nitrite contamination at the Control station for the study, the Jomo Kenyatta Beach sampling station is given in Figure 12.

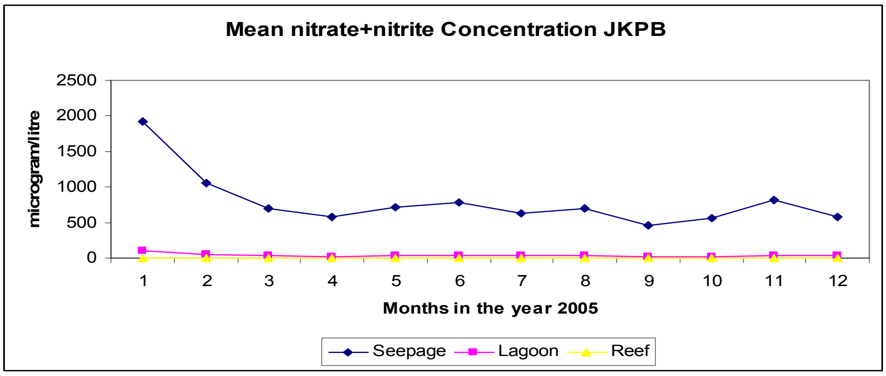

Figure 12: The Jomo Kenyatta Public Beach.

Here the mean nitrate concentration from the seepage on the beach, ranging from 0.58 mg l^{-1} to 1.93 mg l^{-1} was generally the same level as what has been recorded for the whole study area. However, in the lagoon, the influence of oceanic nature of the area comes into play, as at concentration levels of between 0.026 mg l^{-1} to 0.11 mg l^{-1} nitrate + nitrite detected, the nutrient concentration is way below what is recorded for the general study areas. Nutrient concentration in the Reef was however, comparable to what has been generally recorded for both study areas. Similar observations were obtained for both ammonia and phosphate concentration

3.3 Microbiological Contamination in Recreational Water Sources

The Total Faecal Coliform and Total Streptococci for in the recreational waters of the two study areas are presented in this sub-section.

3.3.1 Faecal Coliform & Streptococci in N-B-S Recreational Waters

Table 1, present a summary of the microbiological indicators of pollution recorded between January and December 2005 in the recreational lagoons the Nyali-Bamburi-Shanzu.

Table 1: Total Faecal Coliform and Total Streptococci, N-B-S study area 2005

Parameter	Beach		Lagoon	
	Dry	Wet	Dry	Wet
Coliforms no/100ml (± SD)	52±39.4	15±49.6	9±15.5	33.3±87.2
T/Faecal no/100ml (± SD)	17±22.0	10±37.2	4±10.5	20±48.5
T/Faecal Streptococci (± SD	582±690.4	355±561.2	408±655.9	450±682.6

3.3.2 Faecal Coliform & Streptococci in D-C Recreational Waters

Table 2 below, present a summary of the microbiological indicators of pollution recorded between January and December 2005 in the recreational beach waters of the Diani-Chale study areas.

Table 2: Total Faecal Coliform and Total Streptococci, Diani-Chale study area 2005

Parameter	Beach		Lagoon	
	Dry	Wet	Dry	Wet
Coliforms no/100ml (± SD)	29±45.2	9 ± 31.6	5±13.1	14±33.5
T/Faecal no/100ml (± SD)	10±12.8	5±15.9	2±10.5	9±51.3
T/ Faecal Streptococci (± SD)	351±620.3	299±552.1	190±474.2	244.5±515.8

3.3.3 Faecal Coliform & Streptococci in JKPB Recreational Waters

Table 3: Total Faecal Coliform and Total Streptococci, JKPB 2005

Parameter	Beach		Lagoon	
	Dry	Wet	Dry	Wet
Coliforms no/100ml (± SD)	49±37.9	13 ± 42.4	2±13.1	7±39.5
T/Faecal no/100ml (± SD)	15±19.1	8±25.9	1±7.3	5±31
T/ Faecal Streptococci (± SD)	561±645.3	215±486	89±110	104±148

At the Jomo Kenyatta Public Beach, samples taken from seepage on the beach yielded comparable results to those obtained in the other sampling stations within the study sites. However, the microbiological levels of contamination drastically diminished in the lagoon. This is explained in a similar way as for the nutrients given above. It is the Oceanic nature of the area, which quickly disperse the contaminants entering this water environment.

4 Conclusions

The infrastructure for human waste management in the two areas is inadequate. This is shown by the contamination levels in the waters of the marine environment. The nutrient and microbiological concentration in the marine environment were higher in Nyali-Bamburi-Shanzu than in Diani-Chale. And with both areas, lacking sewerage systems for human waste management, the higher concentration levels in the former is due to the larger number and density of on-site sanitation system. Also, with more pit latrines in the NBS area than Diani, the situation is worse for the former on account of the poorly constructed pit latrine, with some so shallow that they overflow during the rainy season. This compounds the water pollution problem as the more the people, the more the, on-site sanitation systems. The contamination levels varied depending on the location of the sampling site. The sites with human habitations, showed higher levels of contamination. Thus, with the increasing expansion of human settlements, it may come a time when there is no more room for the on-site sanitation systems, and both sustainability of the human settlements, and expansion of tourism may not be guaranteed. Tourists are known to have abandoned visiting some destinations on account of water pollution problems. The pollution problem is slowly creeping in in the two study areas and efforts are needed to remedy the situation. Kenya's policy on water supply and sanitation provision seems to provide the answer and, action is needed to operationalize the same effectively.

References

1. American Public Health Association, 1995: Standard Methods for the Examination of Water and Wastewater, 19th Edition, APHA, New York
2. Billian Sicin-Sain and Knetch, Robert W.,1998: Integrated Coastal and Ocean Management –Concepts and Practices, Island Press 517pp
3. Coast Development Authority, 1996: Towards Integrated Management and Suatainable Development of Kenya's Coast, Findings and Recommendations for an Action Strategy in the Nyali-Bamburi-Shanzu Area,

77pp.
4. Coast Development Authority and IUCN, 2002: The Riches of Diani-Chale, 32pp.
5. Coast Development Authority, 2007: A Constructed Wetland System for Sewage Management at Shimo-la Tewa Prison, EIA Report Submitted to NEMA
6. Miller, M. L. and Jan Auyong, 1991: Coastal Zone Tourism, A Potential Force Affecting Environment and Society, Butterworth-Heinemann Ltd Pp-75-99
7. Mwaguni, S.M., 2008: National Level Review of GPA Guidelines and the Status of Municipal Wastewater Management in Kenya, 86pp., Report Submitted to UNEP/GPA Wio-LaB Project
8. UNEP, 1983: Reference Methods for Marine Pollution Studies, No. 3 Revision 1.
9. UNEP, 1983: Reference Methods for Marine Pollution Studies, No. 4 Revision 1.
10. UNEP/GPA, 2001:Recommendations for Decision Making on Municipal Waste Water
11. World Health Organization, 1999: Guidelines for Drinking Water Quality 2nd Edition, Volume 3: Surveillance and Control of Community Water Supplies
12. Xu, Y., and Braune E., 1995: A Guide for Groundwater Protection for the Community Water Supply and Sanitation Programme, Department of Water Affairs and Forestry, Republic of South Africa