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# Qualitative Assessment of Marine Environmental Quality Along the Coast of Dar es Salaam, Tanzania

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***Abstract***

*This paper presents qualitative assessment of marine environmetal quality on the selected beaches and coastal areas including the port of Dar es Salaam. With the long-held misconception, the huge and resilient ocean could tolerate anything; ocean degradation has been happening for decades. From that ideology, this work came up with a research study with focuse on the qualitative assessment of the quality of marine environments along the coastline of the Dar es Salaam Region in Tanzania. In this paper field survey and observation, interviews, and questionnaires were employed to assess the situation. Results showed that, approximately 70% of the respondents visit the beaches frequently, showing their familiarity with the beach environments. However, 50% of the respondents have witnessed regular beach cleaning exercises, although they have commented that there have been inadequate cleaning efforts around the beaches. Additionally, all respondents commented that human activities in the study area are attributed to 90% of the environmental pollution. Also, from the methodology approached, this research work identified various anthropogenic activities contributing to marine environmental pollution on the coastline of the Dar es Salaam region, where the authors of this work propose measures such as clean-up campaigns, social media initiatives, educational programs, and the enforcement of laws and policies, aiming to minimize pollution and promote sustainable practices along the Dar es Salaam coast.*

***Keywords***: *Coastal Pollution, Anthropogenic Activities, Environmental Conservation.*

## 1.0 INTRODUCTION

Anthropogenic ocean damage has been occurring for decades, driven by the belief that the vast and resilient ocean could withstand anything (Reynolds *et al*., 2022). However, tangible evidence of human activities along the coasts now exposes the flaw in this belief. Only 13% of the ocean remains untouched by

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humanity (Li *et al*., 2024; Olivelli *et al*., 2023). The global population and consumption increase have led to unsustainable growth and practices in industries reliant on the ocean, such as fishing, land development, and oil and gas (Nchimbi *et al*., 2024; Packman *et al*., 2022). These industries not only impact the ocean's well-being but also have consequences for aquatic systems, environmental health, and societies globally (Galindo Montero *et al*., 2023; Munno *et al*., 2024; Wei *et al*., 2023).

The coast, extending from the coastline to the inland rise of land, represents a zone or strip of land marked by the level of high tide (Donato *et al*., 2024; Guggisberg, 2024). The World Health Organization defines coastal pollution as the introduction of substances or energy by humans into the marine environment, resulting in deleterious effects on living resources, marine life, human health, marine activities, water quality, and amenities (Abate *et al*., 2024).

Coastal areas play a strategic role in economic and ecological development, providing numerous benefits. (Bertolazzi et al., 2024) highlights disparities in services offered by the coastal system, such as climate regulation and recreational services. Additionally, it reveals that 40% of the world's population resides within 100 km of the coastline (Ullah *et al*., 2023). The coastal area is intricately linked to the morphology of the sea-land (Zhang *et al*., 2024). Despite its significance, the coastal area is subjected to harsh environmental impacts from both human activities and natural factors (Yose *et al*., 2023).

Efforts to address coastal pollution have been undertaken, but further action is required due to the positive impact of the coast on people's well-being and the national economy. Scholars such as Alomar *et al*. (2024); Hu *et al*. (2024); Jones *et al*. (2024); Micella *et al*. (2024); and Zheng *et al*. (2024) emphasize the necessity of raising awareness about the effects of coastal pollution. Various studies in Tanzania have assessed contamination levels in the coastal regions. For example, Machiwa (2010) examined microbial contamination, heavy metals, and persistent organic pollutants, comparing them with recommended environmental quality targets (EQTs) for the West Indian Ocean (WIO). Maione (2021) investigated the emergence of plastic pollution on tourist beaches in Zanzibar, Tanzania, revealing the impact of the tourism sector on coastal pollution in Dar es Salaam. However, these studies lack detailed information on the identified causes of coastal pollution. This study aims to provide a comprehensive examination of anthropogenic activities and their contribution to coastal pollution.

The Dar es Salaam port receives and exports goods through various types of vessels, which can contribute to pollution. Domestic wastes from residents and the operation, repair, and maintenance of vessels pose significant contamination risks. Although studies have assessed contaminant concentrations in aquatic

environments, no current studies focus on identifying anthropogenic sources of marine pollution and assessing their associated effects around Dar es Salaam Harbour. This study aims to explore these sources, anticipate their effects on the marine ecosystem, and propose preventive and control measures. This study is therefore aimed at examining the anthropogenic activities of coastal pollution. To examine how anthropogenic activities, affect coastal pollution, the conceptual framework was developed and used in this study (Figure 1). Seven key elements were established in this study, namely: trading activities, dredging activities, extraction of coral polyps, boat maintenance, recreational activities, agricultural activities, and industrial activities.

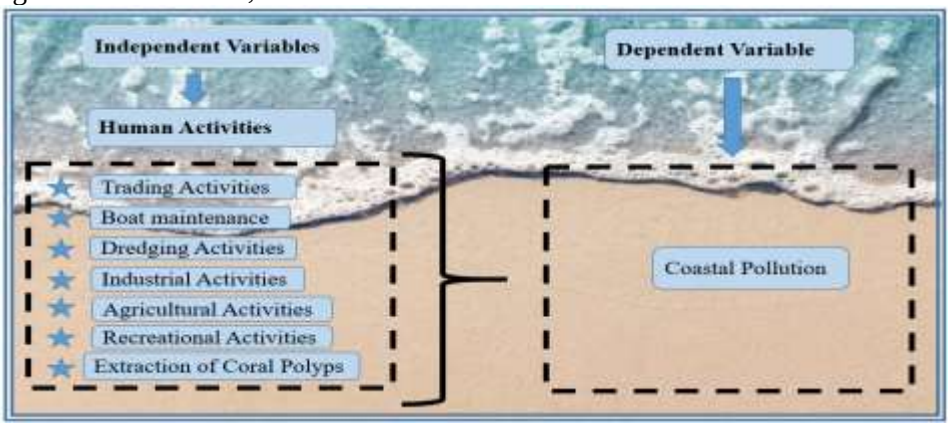


**Figure 1:** Contribution of human activities to coastal pollution

## 2.0 METHODOLOGY

The study employed a case study design and adopted qualitative research approach. The case study design was deliberately chosen due to its ability to provide comprehensive explanations of scientificbehavior. Furthermore, it facilitates the investigation and comprehension of intricate matters that were present in a specific region.

### 2.1 The study area

The study was conducted in Dar es Salaam Region with focus on the water of the Dar es Salaam harbour, stretching from the Aga Khan Hospital area (531843.79 East, 9248119.03 North) to the new Kigamboni Bridge (532801.84 East, 9241834.96 North), covering a coastline of approximately 9.45 km (Figure 1). The study specifically examined a 1.6 km section along the coastline of the harbour. The Tanzania Ports Authority (TPA) is responsible for the management and control of this area.

For the study, a sample was collected from five coastal sites along the Indian Ocean, situated in three different districts within Dar es Salaam city. These districts are Kigamboni (6° 49' 38.3844" S and 39° 18' 56.2068" E), Ilala (-6°47'42.00" S and 39°15'57.60" E), and Kinondoni (6.7053° S, 39.1127° E). The

five coastal beach sites were named as follows: Mikadi Beach (6°22'5.578" S and 34°53'6.702" E), Kipepeo Beach (6°51'5.556" S and 39°21'41.738" E), Sunrise Beach (38°10'33.1125" S and 92°47'3.679" E), Kunduchi Beach (6°40'52.514" S and 39°12'13.035" E), and Coco Beach (6°46'8.694" S and 39°16'55.993" E).

### 2.2 Data collection

The respondents were purposively selected based on the criteria that the respondents were frequently working on the coasts of the Indian Ocean. So, coastal users such as fishermen, boat drivers, tourist guides, beach visitors, and other knowledgeable coastal users were purposively selected. Generally, the collected data were thematically analyzed. The study used survey and observation, interviews and questionnaire approaches to gather the information. A total of 76 coastal users were involved in this study; from which 34 were interviewed and 42 responded positively to the questionnaires. In addition, observation, which involved a guide list and photographs taken were used.

To identify the anthropogenic activities taking place around the harbor water, primary and secondary data were collected. Primary data collection mainly involved field surveys and observation, interviews, and questionnaires. Also, in a few cases interviewing was conducted to get deep insight. The questionnaires were designed to get information on the different activities around the port as well as their associated effects on the quality of water. The questionnaires were given to ward environmental committee officers, TPA officers, fishermen, cooks at the port areas, and randomly selected passengers. In addition, physical observation around the Harbour area was done during the field campaigns to complement the information obtained from the questionnaire and checklist. Secondary data involved the review of different books, journals, and research papers.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Responses from Interviews and Questionnaires

The results of the number of visits of the respondents to various beaches are given in Table 1.

**Table 1:** Frequencies of beach visits per week

| Number of Visits (Frequencies) | Responses | | Percentages (%) | |
|---|---|---|---|---|
| | Interview | Questionnaire | Interview | Questionnaire |
| One time | 11 | 21 | 32 | 50 |
| Two times | 10 | 8 | 30 | 19 |
| More than two times | 13 | 13 | 38 | 31 |
| **Total** | 34 | 42 | 100 | 100 |

The interview results have shown that about 70% of the respondents (n = 34, 30+38) have been visiting the beaches two or more times a week. These results

implied that the respondents have adequate experience and trustworthy information about the beach environments. Results have shown that 50% of the respondents (n = 42, 19+31) have been visiting the beaches two or more times a week. It implies that the respondents have average experience and information about the beach environments.

Figure 2 indicates the responses of the interviewed respondents to the frequency of beach cleaning exercises. Only about 50% (n = 34) of the respondents (Figure 2a) have witnessed the beach cleaning exercise being conducted 3 times or more in a week. Similarly, only 20% (n = 42) of the respondents using the questionnaire (Figure 2b) have witnessed the beach cleaning exercise being conducted 3 times or more in a week. It implies that there exists inadequate beach cleaning along the surveyed beach sites.

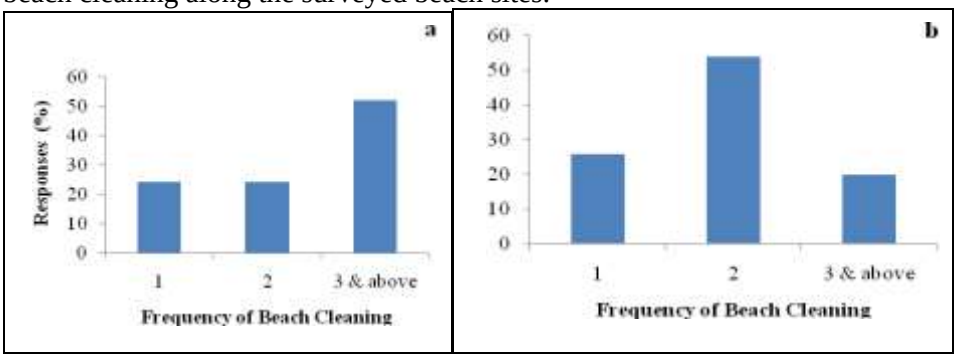


***Figure 2**: Frequency of responses from the interview (a) and questionnaire (b) on beach cleaning by the managing authorities*

Table 2 shows that all the interviewed respondents (n = 34) and all who filled out the questionnaire (n = 42) have witnessed a particular type of pollution along the surveyed beaches. This calls for immediate efforts to control and minimize pollution along the surveyed coastal areas. About 90% of the interviewed respondents (n = 34) agreed that the coastal pollution was due to anthropogenic activities. All interviewed respondents and those who filled out the questionnaire (100%, n = 76) agreed that anthropogenic activities are the source of pollution.

**Table 2:** Respondent's Responses Regarding Coming across Some Kinds of Coastal Pollution

| **Beach Name** | **Responses** | | **Percentage (%)** | | **Strongly agreed** | | **Agreed** | |
|---|---|---|---|---|---|---|---|---|
| | Interview | Questionnaire | Interview | Questionnaire | Interview | Questionnaire | Interview | Questionnaire |
| Kipepeo Beach | 8 | 9 | 23.5 | 21 | 6 | 7 | 2 | 2 |
| Coco Beach | 8 | 7 | 23.5 | 17 | 4 | 6 | 4 | 1 |
| Sunrise Beach | 7 | 9 | 20 | 21 | 5 | 3 | 2 | 6 |
| Mikadi Beach | 5 | 9 | 15 | 21 | 5 | 5 | 0 | 4 |
| Kunduchi Beach | 6 | 8 | 18 | 20 | 6 | 4 | 0 | 4 |
| **Total** | 34 | 42 | 100 | 100 | 26 | 25 | 8 | 17 |

## 4.0 Anthropogenic Activities in the Beaches

### 4.1 Trading activities

The food and beverage business lead to environmental pollution due to the disposal of food waste and beverage cans along the sea coast. A response from the majority of the interviewees about trading activities along the study area's shore showed the increased of pollution on the environment. Based on the interview conducted, the anthropogenic activities contributed to the pollution in the beaches and coastal areas. Anthropogenic activities include small-scale trading activities, repairing of marine vessels, recreational activities, dredging activities, as well as agricultural activities. Selling and buying goods and services along the beaches are some of the human activities observed. These are a retail business establishment that serves alcoholic beverages, ice cream, and other soft drinks. The evidence was found in Kunduchi Beach where hotels around the beach serve coastal users around the respective beach. For example, improper disposal of glass bottles of beer, plastic bottles of soft drinks, sewage, and other wastes from food processing. The same situation was observed in Longoni Beach where ice cream, popcorn, and food sellers were selling along the coastal areas (Figure 3).

**Figure 3:** Vendors along the Coastal Area of Indian Ocean

The findings discloded that, “the remains of rotting fish lead to air pollution and cause a bad smell along the sea coast”; in other findings showed that,” fish remains lead to environmental pollution when they are thrown along the coast of the sea". An explanation provided by the vast majority of interviewees regarding how fishing activities along the study area's shore add to the pollution of the

environment. Various fishing activities were observed along the offshore Dar es Salaam coast such as hand gathering, spearing, netting, angling, and trapping. Some of these methods are prohibited by the government since they capture small fish and other aquatic animals such as molluscs, cephalopods, crustaceans, and echinoderms (Fisheries Act, No. 22, 2003). As a result, small fishes were left to rot on the coastal line shores contributing to pollution on the beach. In addition, fishnets and lines were left unattended along the coast at Mikadi Beach (Figure 4).

**Figure 4:** Netting for Fishing at Mikadi Beach

### 4.2 Dredging activities

Dredging activities associated with the removal of sediment and debris was observed to cause erosion and environmental degradation of the beach area (Figure 5). Such activities could result in coastal pollution and hence loss of biodiversity and ecosystem imbalance.

**Figure 5:** Dredging activities along Mikadi Beach

### 4.3 Repairing of marine vessels

Repairing of marine vessels was observed to use anti-fouling paints for coating vessels on the outboard to the hull of the ship or boat facilitating the detachment of subaquatic organisms and slowing the growth of marine species. Chemicals, pieces of wood, cleaners, oil bottle remains and other materials were observed around the areas (Figure 6). These wastes were found to be discharged along the coastline and could eventually cause coastal pollution.

**Figure 6.** Repairing of Marine Vessels at Mikadi Beach

### 4.4 Recreational activities

Recreational activities along the coast or beach tourism include swimming, snorkeling, scuba diving, sailing, fishing, and surfing. Swimming is one of the most popular forms of ocean recreation as was observed at Kunduchi Beach (Figure 7).

**Figure 7.** Recreational and business activities at Kunduchi Beach

It is widely accepted that tourism is one of the world's largest and fastest-growing industries. Historically, sandy beaches have played an important role as

locations for recreation and as attractions upon which tourism development has been based. These recreational sites along the beach had significant impacts on the environmental, social, and economic welfare of the people and nation associated with tourism development. It was observed that such areas accommodate some of the tourists and people who used to go for recreation at that beach litter and leave behind garbage like-plastic wrappers, and cigarette butts in the beach or surrounding environment.

### 4.5 Agricultural Activities

The transport of animals such as horses and camels cause environmental pollution by leaving excrement along the beaches. A response from a majority of interviewees regarding how agricultural activities along the study area's shore add to environmental damage. There is an increasing agricultural activity, particularly urban livestock keeping along the coast and beaches. A flock of sheep and cattle were observed walking along the Indian Ocean coast (Figure 8). Such animals could leave excreta that could cause coastal pollution by increasing the organic matter in the areas. The presence of hotels along the coasts and beaches could increase the amount of untreated waste along the coasts.

**Figure 8.** Animal grazing at Coco Beach

To minimize coastal and beach pollution, plausible measures are proposed. The local government authorities and institutions like the Colleges of Agriculture Science and Fisheries Technology (COAF) and Environmental Protection Agency (EPA) can plan clean-up campaigns, for example, along the Kunduchi and Saga coasts. Social media campaigns on cleanup may involve policymakers

in making better policies that will protect the coastal environment. Moreover, the campaign will aim to educate people on the need to protect the coastal environment. For example, active cleaning programs also include governmental and non-governmental organizations' cleaning programs and other youths-based cleaning campaigns. Furthermore, coastal users and Tanzanians at large should be educated on the need to protect the coastal environment; students should be taught from the lower level on the need to protect our coastal environment. Social media campaigning through (Facebook, Twitter & Instagram) is an important tool for addressing the effects of coastal pollution. Placing signs that act as a precaution against coastal pollution on ocean beaches will help people know that dumping waste on ocean beaches is prohibited. Placards such as those in Figure 9 help raise awareness of environmental and beach protection.


**Figure 9:** Placard on coastal environment

To manage wastes and coastal pollution, rules, principles, and guidelines should be instituted to enhance coastal conservation to ensure that the policy is used to influence behavior during various social activities. Moreover, coastal conservation agencies such as marine parks and reserves in Tanzania should implement the available laws to protect the coastal environment. Information on the sources and harmful effects of coastal pollution needs to become part of people's lives. The parliament should amend the laws that seem to be inactive in the fight against coastal pollution. For example, the adoption of Tanzania National Environmental Management Policy, 1997 (henceforth NEP) and other laws such as the Merchant Shipping Act, The Fisheries Act No 22 of 2003, the National Environment Management Act,' Tanzania Harbors Authority Act, "Territorial Sea and Exclusive Economic Zone Act, 5, Marine Parks and Reserves Act, 7 Mining Act, 8 and Petroleum (Exploration and Production) Act 9. These laws and policies help to protect the environment including the coastal environments of Tanzania.

### 4.6 Anthropogenic Activities around Dar es Salaam Harbour

During the field survey and observation, various anthropogenic activities were observed to take place around Dar es Salaam harbour most of them have the possibility of releasing some pollutants into the marine environment. Such activities are described hereafter.

#### 4.6.1 Painting and welding of marine vessels

Marine vessels require periodic maintenance including painting. Wastes resulting from marine paints require careful management to ensure they do not end up contaminating ground or surface water. During the field survey, it was observed that some residues of marine paints were not properly managed as per the requirements of sound environmental practice resulting in the possibility of polluting the water (Figure 10).

**Figure 10.** Poor Handling of Products (Left and Middle) as Compared to Proper Handling around the Harbour (Right)

About 81% of the respondents did not know where the paint buckets should be placed after using the intended inside products. Also, 7%, responded that wastes are collected in especially available containers according to the by-laws and orders from the authority. 5% claimed that they could just mix them with other solid wastes.4% of them admitted that paint containers are thrown into the ocean and 3% claimed that wastes being thrown elsewhere

#### 4.6.2 Loading and offloading of goods

During the loading and offloading of different commercial, agricultural, mining, and industrial goods there were a lot of spills of cargo observed, which suggests the absence of proper programs to handle the materials appropriately. Spilled cargo could contain metals, oils, grease, and Nutrients. For example, spills of fertilizers were observed which could contribute to increased nutrients in the water, particularly during the rainy season.

#### 4.6.3 Discharge of industrial effluents

The field survey observed discharges of untreated wastewater at Gerezani Creek (Figure 11) which are discharged into the sea. It was previously observed that most industries in Temeke Municipality discharge wastewater into streams and then into the sea around the Dar es Salaam Harbour area (Bryceson, 1983).

These effluents may pose a problem to available aquatic species that are sensitive to dissolved oxygen since the wastewater contains a lot of nutrients.

**Figure 11:** Discharge of Effluents at Gerezani Creek (Left) and Oil from Marine Vessel (Middle) and KOJ (Right)

Various activities at the harbour such as cleaning up engine rooms for marine vessels (tugs) and washings from workshops generate a lot of liquid waste. Most marine tugs are not equipped with waste reception facilities which would help in managing waste sand oils from engine washings. The survey identified uncontrolled disposal of wastewater which could affect water quality and living conditions at the Dar es Salaam harbour (Figure 11). At Dar es Salaam harbour, there is a Kurasini Oil Jetty (KOJ) that receives 750,000 metric tons of crude oil per year that are discharged from tankers into an offshore coupling pipeline located to the west of inner Makutumba Island.

During a review of secondary data, it was previously observed that there was an oil spillage accident at KOJ (Figure 11). Also, there was no available data by that time, which indicated the magnitude and effects of oil spillages around the harbour area. In addition, there was no record found from the authority for oil spillage at the harbour. Similarly, smaller vessels such as tugs, pilot boats, and other harbour crafts are normally not fitted with oily/sludge tanks and oily water separators (OWS). The absence of these fittings causes operators of marine equipment to discharge oily water and other liquid waste into the harbour, therefore, degrading its water quality (Davis et al., 1989).

Similarly, the discharge of oily ballast and oily bilge water by vessels using the harbour can cause pollution. The effects can be detrimental to fish, shellfish, and other organisms particularly when they come into contact with the contaminated water. For example, oil adversely affects eggs and larval survival; adult fish may experience reduced growth, enlarged livers, and changes in heart and respiration rates.

From the field survey also discharges from food vendors that empty food remains and residues from cookware into the free channels and the ocean (Figure 12) were observed. Considering that there are about 200 food vendor groups off the harbour road, the effect of these discharges cannot be

underestimated. In addition, during the field survey, it was observed that various wastewater channels were directing their discharges into the ocean and as such the sources could not be easily traced.


**Figure 12:** A Food Vendor Performing her Duties along the Water Channel to the Ocean

This underestimated wastewater from these cooks and laundry entourages from food vendors as well as the presence of industries and urban runoffs could increase the levels of nitrates and phosphates in ocean water

### 4.6.4 Discharge and emission from maintenance and operations of marine vessels

During the field survey, it was observed that sandblasting is still conducted at the Dar es Salaam Harbour. These undertakings, which are performed during the repair of marine vessels and normal ship operations, could generate pollutants including metallic debris, oil wastes, bilge water, ballast water, and other residues. Out of 92 respondents who are involved in sandblasting processes; 72 (78.3%) prefer to clear the wastes directly into the ocean, and 11 (11.9%) use recommended methods for handling sandblasting specks of dust and sand.

Sandblasting dispenses sand or other media at high velocity to remove or clear coat, paint, rust, and other surface imperfections from metal surfaces. Sandblasting produces a lot of dust-containing pollutants which ultimately end up degrading the harbour water. This practice has been banned for use in the developed world due to its detrimental health effects but it continues to be practiced around the Dar es Salaam harbour. Since most auto body paint contains heavy metals, such as lead, chromium, and barium, sandblasting waste could potentially be harmful to human health and other living organisms that

depend on seafood as an alternative nourishment supplement. The wastes emanating from blasting contribute to the degradation of seawater quality.

The use of antifouling paints is a common mankind activity at the harbour for preventing estuarine or marine organisms from attaching to submerged surfaces or killing them should they succeed in attaching by relinquishing their grip and falling off. Severe damage to aquatic life has been caused by antifouling paints containing organic tin compounds such as tributyl tin. Careless application of antifouling paints can introduce significant chemical concentrations into harbour water degrading its quality.

Shipbreaking is also done at Dar es Salaam harbour in which the beaching method is used where a ship is cut into small recyclable scrap metals at the beach area. This activity pollutes the marine environment and exposes workers to health and safety dangers and terrible working conditions. The practice also renders the quality of harbour water seriously degraded.

### 4.6.5 Agricultural and fishing activities

The survey has identified urban agricultural activities that are conducted in streams that empty their water into the ocean. For example, vegetable cultivation along the Gerezani Creek that pours into the harbour (Figure 13); whereby the water coming from the creek could be carrying various pollutants (metals, nutrients, organic matter, pesticides, etc.).

**Figure 13:** Small scale agricultural activities adjacent to Gerezani Creek (L) and fishing around the Dar es Salaam Harbour (R)

Such pollutants can pollute the ocean, the organisms living in it, and those who consume them as food. The level of contamination in the rivers and estuaries due to agrochemicals in Tanzania has not yet been evaluated. However, detected contamination levels of polychloro dibenzodioxins and polychloro dibenzofurans (PCDD/Fs), metals and organic matter emanating from human activities call for immediate intervention.

The use of fertilizer along the harbour is considered to be high since 71% of the respondents claimed to use industrial fertilizer against 20% of respondents who use manure and 9% who do not apply any fertilizer in their farming practices respectively. The water coming from the creek could be carrying various pollutants (metals, nutrients, organic matter, pesticides, etc.) that can pollute the ocean, the organisms living in it, and those who consume them as food, especially sea fishes and vegetables from the seedlings and granges grown along the harbour.

The field interview with some of the fishermen has identified the continued use of ammonium nitrate fuel oil (ANFO) and other chemicals in fishing. This is correlated well with the recent government confiscation of fish at the Dar es Salaam fish market alleged of been obtained through illegal explosive fishing.

### 4.6.6 Poor solid waste management

It was also observed that there is dumping of solid wastes very close to the seawater around the Dar es Salaam Harbour area. The wastes originated from the port offices, storage yards, workshops, and social human activities at the harbour (Figure 14). As a result of a long storage time, these solid wastes could pollute soil through leachate, which might percolate and reach seawater through ground flow or be swept by surface water runoff into the ocean. About 62% of the respondents throw their waste haphazardly whenever they finish using and they do not know who will come to collect and dispose of them.

**Figure 14.** Poor disposal of solid wastes at Dar es Salaam Harbour

These pollutants could significantly contribute to metal and nutrient contaminants in the seawater. Similarly, plastics when broken down into small pieces may cause micro-plastic pollution in the ocean, which is dangerous to aquatic life.

## 5.0 CONCLUSION AND RECOMMENDATIONS

### 5.1 Conclusion

The preservation and sustainability of the coastal line are of utmost importance for the well-being of humans and other living organisms in coastal areas. Unfortunately, the researchers have identified that various human activities are posing a significant threat to the availability and attractiveness of beaches and other coastal resources, leading to coastal pollution and negative impacts on the ecosystem. One concerning observation from the conducted survey is the direct discharge of untreated industrial effluents into the Indian Ocean, which indicates a lack of compliance with environmental protection policies.

This qualitative assessment reveals a potential threat of marine pollution around Dar es Salaam Harbour, primarily due to inappropriate anthropogenic sources. While most of the pollutants originate outside the Harbour, there are a few instances of pollution caused by ship repair and maintenance, marine operations, tug engine room cleaning, fishing, untreated sewage discharges, illegal dumping of solid wastes, oil spills, sandblasting of marine vessels, loading and offloading of commercial goods, as well as painting and welding of marine vessels.

Based on the study results, it is recommended to conduct more systematic quantitative studies that focus on the physical, biological, and chemical levels of contaminants in and around the harbour, as well as their associated effects. This will help in gaining a comprehensive understanding of the pollution levels and their impact.

### 5.2 Recommendations

The study provides several recommendations first, regular inspections and audits by the National Environmental Management Council and other regulatory authorities to ensure adequate environmental management controls are in place to prevent pollution of the Harbour water from anthropogenic sources.

Second, Regular monitoring of maintenance and repair activities, cutting and grinding of metallic plates, marine vessels painting, cleaning of tugs engine rooms, welding, sandblasting, spills and leakage from the Central Mechanical Workshop, and waste dump sites within the harbour area to prevent metal pollution. Third, the development and implementation of a waste management plan by the management of Dar es Salaam Harbour to control different types of waste and prevent their disposal into the ocean. Fourth, the construction of sufficient latrines around the Harbour, connected to treatment systems, to comply with environmental laws and conventions on the prevention of marine pollution. Fifth, the implementation of a water monitoring program by the management of Dar es Salaam Port to proactively identify pollutants in the harbour water and take timely remedial actions. This program should include an analysis of oil and grease in water samples collected just below the surface, as well as a sampling of coastal sediment and floating objects for the determination of various pollutants. Last, further investigation is required to understand the response of biota and habitats in the harbour to predicted climatic changes and

the interactive effects of stressors on ecosystem functioning and services. This will facilitate the development of holistic risk assessments and integrated management strategies.

In summary, addressing the threats posed by human activities, improving waste management practices, implementing monitoring programs, and conducting further research are essential for the preservation and sustainable management of the coastal zone in Dar es Salaam.

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