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Pollution Prevention and Control Guidelines for the Coastal and Marine Environment of Kenya

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Pollution Prevention and Control Guidelines for the Coastal and Marine Environment of Kenya

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Cover Photo: Mombasa wastewater treatment plant at Kipevu

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Acronyms and Abbreviations

BOD	Biochemical Oxygen Demand
EACC	East African Coastal Current
ECC	Equatorial Counter Current
EMCA	Environmental Management and Coordination Act of 1999
ICZM	Integrated Coastal Zone Management
KMA	Kenya Maritime Authority
KWS	Kenya Wildlife Service
NEM	Northeast Monsoon
NEMA	National Environmental Management Authority
PPP	Public-private partnership
SC	Somali Current
SEC	South Equatorial Current
SEM	Southeast Monsoon
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
UNEP	United Nations Environment Programme
WRMA	Water Resources Management Authority
WWF	World Wide Fund for Nature

FOREWORD

The Kenyan coastal zone is endowed with abundant resources that are of great ecological significance and form a resource base for the economy of the region and livelihood to the community. The resources include coastal forests, coral reefs, seagrass beds, estuaries and sand dunes among others which form critical habitats for the productivity of the region. The success and sustainability of socio-economic activities dependent on these resources including tourism, fishing and maritime among others depend on maintaining a healthy marine environment.

The coastal zone resources are however under increasing pressure due to a rapidly growing population. Population growth has resulted in increased demand for goods and services, rapid urbanization, industrialisation and associated problems of solid waste and effluent discharge in urban centres. Expansion of agricultural activities in the rural areas has continued to open-up indeginous forest cover and riparian zones of rivers such as Tana and Sabaki river basins resulting in increased soil erosion throuh runoff. This pressure on the resources calls for a deliberate effort to alleviate adverse impact from pollution and ensure sustainable development.

The Environmental Management and Coordination Act (EMCA) of 1999 is the framework law on environmental management. The provisions of EMCA on pollution are being effected through the implementation of targeted regulations including EMCA (Waste Management) Regulations 2006, EMCA (Water Quality) Regulations 2006, EMCA (Wetlands) Regulations 2009 and EMCA (Noise and excessive vibration) Regulations, 2009. However, there is need for guidelines to assist the stakeholder in fulfilling or meeting the standards set by the EMCA regulations. It is against this background that pollution prevention control guidelines were developed to provide guidance to all stakeholders including the the general public to adopt best practice in their operations and attain the desired environmental standards.

The application of the guidelines will result in a coastal zone with healthy ecosystems that sustain socio-economic development as envisioned in Vision 2030; EMCA 1999; and the National Environment Action Plan. Specifically, the use of the guidelines will contribute to realisation of the objectives of the Integrated Castal Zone Management (ICZM) Action Plan; the National Land use Guidelines and Kenya Shoreline Management Strategy which have all identified pollution as one of the major issues facing the coastal zone and called for measures to be put in place to address the issue. It is anticipated that all stakeholders including government agencies, civil society; private sector and the geenral public will adopt, adhere to and implement these guidelines.

Mr. Ali D. Mohamed, CBS
Permanent Secretary, Ministry of Environment and Mineral Resources

ACKNOWLEDGEMENT

The coastal zone pollution prevention and control guidelines were developed through a highly consultative and participatory process coordinated by the National Environment Management Authority (NEMA) through the ICZM Steering Committee. Stakeholders including government lead institutions, NGOs, private sector players and experts played a significant role in preparation of the guidelines by providing invaluable information. Their contribution is highly appreciated.

Special thanks are accorded to Dr. Saeed Mwaguni who was the consultant engaged by NEMA to take the lead in drafting and preparation of the guidelines. His efforts to involve all the relevant players and experts in the preparation and delivery of the final guidelines to NEMA are very much appreciated.

I also wish to acknowledge the Deputy Director Coastal Marine and Freshwaters Sub-Department of NEMA for leading the process and all the NEMA staff who participated in the preparation of the guidelines. Special thanks also to the Board of Management of NEMA for providing policy direction throughout the process.

The financial support given by the government of Kenya, the Danish International Development Agency (DANIDA) and the European Union through the Regional Programme for the Sustainable Management of the Coastal and Marine Environment of the Western Indian Ocean (ReCoMaP) for the preparation of these guidelines is also gratefully acknowledged.

The guidelines come in handy to help stakeholders comply with set environmental standards by adopting and practicing measures that assist in prevention of pollution at source, promote re-use and recycling of waste material and disposal of waste in an environmentally friendly manner. A health and clean environment is a constitutional right for all Kenyans and therefore I urge all stakeholders including the general public to make good use of these guidelines to prevent and control pollution on the environment from their respective socio-economic activities.

Prof. Geofrey Wahungu
Director General, National Environment Management Authority (NEMA)

Executive Summary

Pollution is in the form of solid waste and effluent discharge is a major threat to the coastal and marine environment in Kenya. These guidelines have been developed to provide practical guidance to decision makers, managers, planners, developers, the community and other stakeholders to adopt best practices in their social and economic activities to enhance their level of compliance with set environmental standards.

In developing the pollution prevention and control guidelines, it was realised that there is need for deliberate efforts to prevent pollution at source, promote re-use and recycling of waste material, and as a last resort release or dispose waste in an environmentally safe manner. Thus the 4 Rs concept on waste minimisation i.e reduce, re-use, recycle and is apt and directly applicable to this undertaking. This calls for the incorporation of recycling and recovery technologies and waste minimisation in manufacturing processes. Pollution prevention and control has the overall objective of mitigating harm or damage to coastal and marine resources and ensuring sustainability of the environment and development. Pollution prevention strategies provide opportunities in addressing trans-boundary pollution issues, such as the import or export of hazardous waste from foreign countries.

Presented in Chapter 1 is an overview of the Key coastal and marine resources that are of great social and economic importance and the pressures that affect them. The resources include terrestrial and mangrove forests, coral reefs, seagrass lagoons and estuaries among others which form habitats that are critical to the productivity of the marine environment. Pollution constitutes a major threat to the resources. The main sources of pollution include wastewater and solid waste from urban centres and tourist facilities, waste effluent from industrial establishments and runoff from agricultural fields.

There is evidence to link pollution of inshore water areas by inorganic and organic contaminants to activities associated with agriculture, tourism, urbanization and manufacturing industries. The future outlook portends an increased threat of pollution to the environment and resources due to enhanced activities in the key sectors of the economy as the country gears towards meeting Vision 2030 objectives. A review of existing policy, legal and institutional framework reveals weaknesses in the largely sectoral policy frameworks on pollution management, inadequate enforcement of the law, and institutional weaknesses in pollution management.

Chapter 2 presents the objectives and principles that will guide the application of the pollution prevention and control guidelines. Listed in this section are the various socio-economic activities that form the main sources of pollution in the coastal area and require special focus.

Presented in Chapter 3 are the pollution prevention and control guidelines addressing the contribution of the various sectoral activities, namely industrial, tourism, municipal, agricultural, maritime, road, rail and aviation transport and mining. Other potential sources of pollution that have been addressed in this section include institutional waste, wastewater treatment facilities, and trans-boundary pollution sources. The activities that are potential sources of pollution and the type of waste have also been identified. Appropriate prevention and control measures of pollution from the various sources are presented.

Presented in Chapter 4 is monitoring and evaluation framework for the guidelines. The objective of the monitoring framework is to monitor and evaluate application of the guidelines.

CHAPTER 1: INTRODUCTION

1.1 Coastal and Marine Pollution

Major threats to the health, productivity and biodiversity of the coastal and marine environment result from land-based human activities. Most of the pollution load entering the sea from such sources as municipal, industrial and agricultural waste discharge and surface run-off, as well as atmospheric deposition, affects some of the most productive areas of the marine environment, including estuaries and near-shore coastal waters.

In coastal and inshore waters of Kenya, the contaminants which have caused the greatest concern are organic wastes from domestic and industrial sewage, microbial pollutants, and agrochemicals such as biocides and excessive nutrient loads, and toxic chemicals that include heavy metals, oil and petroleum chemicals and other industrial chemicals.

Considerable efforts have been made to manage the pollution problem in Kenya, through such regulations as the Environmental Management and Coordination Act (EMCA) (Water Quality) Regulation 2006, and EMCA (Waste Management) Regulations 2006. However, there is a lack of overall guidelines to manage pollution in the coastal zone. It is againt this background that the current guidelines were formulated. Prior to their formulation, it is however, important to understand the characteristics of the most affected areas and the driving forces causing the pollution problem along the Kenya Coast.

The guidelines are linked to national as well as regional consideration such as the requirements for a health and clean environment by the constitution; Vision 2030; EMCA1999 and the National Environment Action Plan. Application of the guidelines will specifically contribute to realisation of the objectives of the Integrated Castal Zone Management (ICZM) Action Plan; the National Land use Guidelines and Kenya Shoreline Management Strategy which have all identified pollution as one of the major issues facing the coastal zone and called for measures to be put in place to address the issue.

1.2 Overview of Coastal Zone Resources

The Kenya coastline extends for a distance of approximately 600 km in a south-westerly direction, with varying marine and coastal wetlands rich in biodiversity. The coastline is characterised by a fringing coral reef broken at places where rivers discharge and estuarine creeks open into the sea. The estuaries are typically fringed with highly productive and extensive mangrove swamps. In the nearshore areas between the mangroves and fringing coral reef are lagoons that harbour highly productive and diverse seagrass meadows.

The coastal ecosystems receive considerable quantities of riverine and coastal watershed discharge which include high loads of nutrients, sediments, suspended particulate matter, heavy metals and petroleum hydrocarbons associated with municipal wastewater and agricultural runoff that impact on the water and sediment quality, productivity, biodiversity and system functioning.

It is recognized that the systems are multiple use ecosystems providing various goods and services of ecological and socio-economic significance.

1.2.1 Climate and hydrological characteristics

Climatic conditions along the Kenya coast are dominated by the large scale pressure systems of the Western Indian Ocean and the two distinct monsoon periods, namely Southeast Monsoon (SEM) (April to September) and the Northeast Monsoon (NEM) (October to March). The rainfall is bi-modal, occurring during the inter-monsoonal period. The long rain season occurs in the period between March and June, and the short rain season occurs between October and December. Within the narrow coastal zone, rainfall ranges from 500 $mm.yr^{-1}$ in the relatively dry northern hinterland to 1150 $mm.yr^{-1}$ in the south coast region.

Hydrological conditions that influence the Kenya coastal zone are dependent on perennial and seasonal rivers (Figure 1). The major rivers are the Tana, which is the longest, and Athi-Sabaki that discharge into the Ungwana Bay and Malindi Bay, in northern Kenya coast, respectively. Tana River, with its source in Mt Kenya, has a total length of 850 km. It drains a catchment area of about 126,828 km^2 and discharges an average of 4,000 million m^3 of freshwater and 6.8 million tonnes of sediment, annually, with peak flows occurring between April and June during the long rainy season and between November and December during the short rainy season (Kitheka et al., 2005).

The Athi-Sabaki river is 650 km long and rises from the Aberdare mountain range with a catchment area of about 70,000 km^2. The Athi-Sabaki River currently discharges between 5 x 10^6 and 13 x 10^6 tonnes annually, having increased from 50,000 tonnes annually in the 1950's (Kitheka et al. 2003a). This increase in the sediment load has been attributed to catchment degradation as well as increase in the capacity of the river to transport sediments to the coast (Kitheka et al., 2005).

The catchment areas of the Tana and Athi-Sabaki rivers are important agricultural lands that are the source of high riverine sediment loads due to poor land use practices. It is noteworthy that some of the tributaries of the Athi-Sabaki River draining through the City of Nairobi are heavily polluted. The degradation of water quality of both river systems is a potential threat to the health of the marine and coastal ecosystems, including beaches along the Kenyan coast.

There are a number of small river systems that emanate from within the coastal region of Kenya. These include the Ramisi River, whose catchment area extends into the Shimba Hills. The river discharges 6.3 million m^3 of freshwater and 1,500 tonnes of sediment annually into Funzi Bay (UNEP, 1998). Three seasonal rivers, Pemba, Mwache and Mkurumuji discharge 9.6 million m^3, 2.15 million m^3 and 1 million m^3 of water annually, respectively. River Mwache, drains a semi-arid catchment and discharges significant volumes of terrigenous sediments into Port Reitz Creek, causing degradation of the mangrove forest ecosystem within the creek, especially during episodes of heavy precipitation (Kitheka *et al*, 2003b). River Umba has its source in the Usambara-Pare Mountains in Tanzania and discharges 16 million m^3 of fresh water into the sea. Other small river systems and streams discharging into the sea include Mkurumuji, Kombeni and

Tsalu. The river discharges are major sources of freshwater and sediments entering the sea as shown in Figure 1.

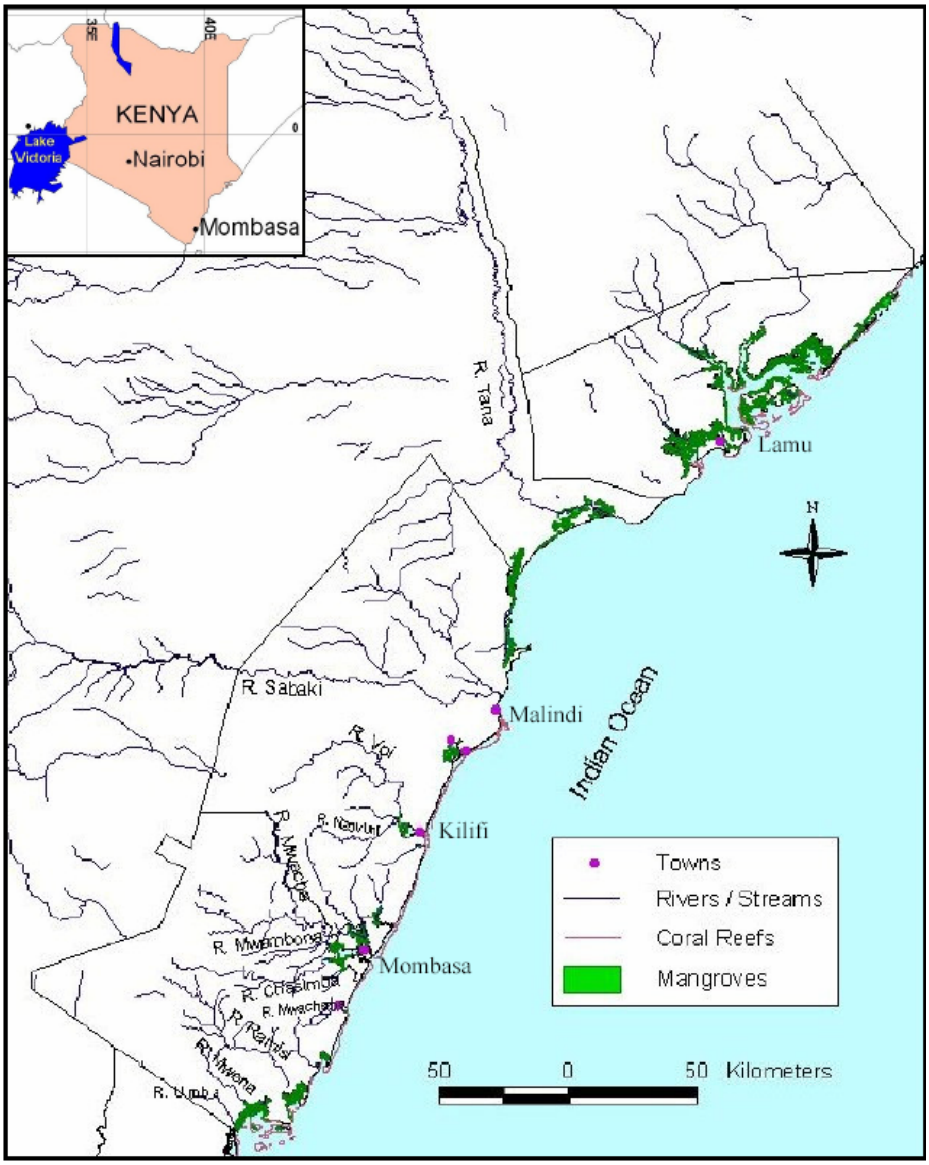

Figure 1.1: Coastal and marine ecosystems and drainage system

1.2.2 Oceanographic characteristics

In the inshore area, the local driving forces affecting oceanographic conditions include tidal and non-tidal currents, salinity and temperature variation, heat flux and long-shore currents generated by waves. The Kenya coast experiences semi-diurnal tides with a maximum tidal range of about 3.8 m. The rise and fall of the tide gives rise to flood and ebb tidal currents which vary in strength and magnitude depending on whether it is spring or neap. Differences in the strength of flood and ebb tidal currents are the result of geomorphological characteristics of tidal creek

systems and inlets which lead to either ebb or flood dominance (Kitheka 1996, Kitheka *et al*. 1996, Magori, 1997, Nguli, 1994, 2006, Odido, 1994).

The major coastal current systems affecting the Kenya coast includes the South Equatorial Current (SEC), the Equatorial Counter Current (ECC), the East African Coastal Current (EACC), and the Somali Current (SC).

Sea surface salinity (SSS) and sea surface temperature (SST) show seasonal fluctuations along the Kenya coast. The salinity in the inshore water is normally affected by the freshwater input from rivers, resulting into relatively low salinities ranging from 5 to 34 PSU in estuaries (Kitheka *et al*. 2005, 2003a). The lowest salinity occurs during the long rain monsoon period when freshwater runoff is highest, whereas high salinity occurs in dry seasons when evaporation exceeds freshwater input especially in the shallow areas and in mangrove creeks and lagoons. Water temperatures range from 24 to 32 ^{o}C.

1.2.3 Coastal and marine ecosystems

The most important coastal habitats from both the ecological and socio-economic perspective include terrestrial forests, mangrove forests, coral reefs, seagrass lagoons and estuaries. The ecosystem health of these critical habitats determines not only the productivity of the inshore waters but also those of the continental shelf areas.

1.2.3.1 Mangrove swamp habitat

Mangrove swamps along the Kenyan coast cover an area of approximately 52,980 ha, with the largest stand (34,500 ha) found in the Lamu-Kiunga area (UNEP 1989, WWF 2001), followed by the Vanga-Funzi system (6980 ha) in the south, and Tana River delta system (4,180 ha). A significant mangrove cover exists in the Port Reitz and Tudor creeks in the Mombasa District, estimated at 1,575 ha and 1,465 ha, respectively. There are 9 species of mangrove trees and shrubs in Kenya with the most common being *Rhizophora mucronata* and *Avicennia marina* (Kairo *et al*., 2002). Rich in productivity and biodiversity, mangrove forests provide sanctuary to a variety of terrestrial fauna, which include many species of bird, large and small mammals (monkeys, pigs, hippos and buffalo), crocodiles and other reptiles. The Tana River delta and Mida creek mangrove systems exemplify this.

It is understood that a large majority of species found in mangrove areas dwell there on a permanent basis. In addition, many fish species and crustacea (e.g. prawns) spend their juvenile stages in this habitat. Mangroves forests also carry out other functions, notably the protection of the shoreline from agents of coastal erosion and the trapping of excessive terrigenous sediments brought in by rivers that may interfere with sensitive nearshore / inshore habitats, especially seagrass beds and coral reefs.

1.2.3.2 Estuaries

The Tana and Sabaki estuaries situated in Ungwana and Malindi Bays, respectively, are the only true estuaries along the Kenyan coast since they receive significant freshwater input throughout

the year (Kitheka, 2003a). The exception is the Mida creek where estuarine conditions are maintained almost exclusively by groundwater seepage from the adjacent Arabuko/Sokoke forest catchment area (Kitheka, 1998). Most estuarine areas are fringed by mangrove forests, which in turn contribute to their high productivity. The Sabaki delta has no significant mangrove vegetation fringing its shores because of high silt loads, but it is nevertheless an important feeding ground and features the highest concentration of bird species (37 species) along the Kenya coast (WWF 2001). The estuarine environment in the Malindi and Ungwana Bay support a high abundance of penaeid prawns.

1.2.3.3 Seagrass meadows

Seagrass beds occur in muddy and sandy areas and in lagoons between the mangrove and coral reef areas and exhibit high productivity and biodiversity. There are 12 species of seagrass that have been identified in Kenya, with the most abundant being *Cymodocea ciliata* and *Thalassia hemprichii*, which thrive in sandy areas on rock and old coral substrate (Isaac and Isaac, 1968, Ochieng and Erftemeijer, 2002). While the numbers of seagrass species present at various localities are yet to be fully documented, Uku *et al*. (1996) recorded 10 species at Diani in the southern coast of Kenya, with densities varying from 7.36 ±2.04 to 133 ± 40.07 g dw/m^2. The sea-grass habitat is ecologically important for a great variety of fish. Many fish species of commercial importance dwell in this habitat. Other fish species that use the mangrove areas as nursery grounds, use the sea-grass habitat as their grow-out area. This makes the habitat critical to the survival of these species. The sea-grass meadows also protect the coral reef ecosystem by trapping excessive silt and nutrients.

1.2.3.4 Coral reefs

Coral reefs along the Kenyan coast, which cover an estimated 50,000 Ha, are composed of coral reef flats, lagoons, reef platforms and as fringing reefs (UNEP 1998). The coral reef system is characterised by a fringing reef extending from the Kenya southern border with Tanzania to Malindi. Patchy coral reefs occur in Kisite-Mpunguti area in the south and Malindi-Watamu area in the north. Further north in the Lamu and Kiunga area, the coral system is composed of patchy reefs, atolls, offshore reefs and islands.

Marine protected areas act as reservoirs of biodiversity, which eventually filter out into the surrounding reserves and non-protected areas. The Malindi-Watamu Marine National Park and Reserve, a biosphere reserve of global significance, is characterised by a high biodiversity of corals. The fauna found in coral reef areas includes several species of turtle (e.g. green turtle *Chelonia midas*, hawksbill turtle *Eretmochelys imbricata*) and variety of coral fish species and molluscs.

1.3 Pollution Sources and Effects on the Resources

The main activities that are responsible for coastal and marine pollution are rapid urbanization, industrial activities including shipping, agriculture and tourism. These causes are described in detail in the following sections.

1.3.1 Population

According to the 2009 Population Census, there were 38,610,097 people in Kenya. Of these, 3,325,307 people resided in the coast region. The population distribution by County is presented in Table 1. In total, the coast region supports about 8.6 % of the national population. The population in the region increased from about 2.5 Million in 1999 to 3.3 Million in 2009, representing a 32 % increase between 1999 and 2009.

Table 1.1: Population distribution in coastal Counties

County	Number of People 1999 Census	Number of People 2009 Census
Kwale	496,133	649,931
Mombasa	665, 018	939,370
Kilifi	825,855	1,488,052
Tana River	180, 901	240,075
Lamu	72, 686	101,539
Taita Taveta	246, 671	284,657
Total	2, 487,264	3,325,307
National Total	28, 686, 607	38,610,097

While precise data is unavailable, the rapid population growth in the urban centres within the coast has seen significant increases in population in the last ten years. The population for Mombasa for example has increased by about 41 % between 1999 and 2009. Trends in population growth indicate that the tourist destinations of Diani, Mombasa, Malindi and Watamu are experiencing rapid growth due to opportunities for employment in the tourism sector. This growth in population has severely stretched the ability of local authorities in the provision of infrastructure and other essential services, such as housing, adequate water and sanitation.

Population pressure is one of the fundamental threats to coastal and marine resources because of the increased demand for goods and services and means of livelihood. The associated rapid urbanization with changes in lifestyles characterised by high consumption rates, has resulted in increased generation of wastes and inadequate waste management practices that have negatively impacted on the marine environment, e.g. the dumping of municipal solid waste in mangrove areas in Mombasa and Lamu.

1.3.2 Urbanization

Mombasa is the largest coastal city with a population of 939,370 inhabitants (Population and Housing Census, 2009). The annual population growth rate of Mombasa is 4.03 % which is higher than the average population growth rate of the coastal region of 3.1 %. The provision of essential services such as potable water, sanitation, housing and infrastructure by the local authority has largely failed to keep pace with the increasing demand occasioned by rapid urbanization.

Mombasa is a source of huge quantities of domestic sewage which contribute high loads of Biochemical Oxygen Demand (BOD), nutrients, and microbial contaminants to surface and groundwater including coastal waters (Mwaguni and Munga, 1997). Municipal storm water runoff is a significant source of pollution to the marine environment contributing to BOD, suspended solid loads, nutrients and microbial contaminants. Elevated concentrations of nutrients (ammonia, inorganic nitrates, nitrites and phosphates) and total suspended solids have been observed in nearshore waters along the Mombasa tourist resort area of Bamburi-Shanzu (Mwangi and Kirugara 2001, Mwangi *et al*. 2003).

Inadequate municipal waste management practices have resulted in the contamination of surface and groundwater with potentially harmful micro-organisms, organic matter, excessive levels of nitrates and other nutrients, and suspended solids (Mwangi & Kirugara, 2001). The variation of nutrients in water in the tidal driven Kilindini harbour channel and Port Reitz creek has been observed not to be influenced by the system dynamics but attributed to direct input from land based sources. It is recognised that the Kilindini/ Port Reitz creek system receives large volumes of inadequately treated municipal wastewater from the Mombasa sewage treatment facility and municipal runoff, among other sources. On-site sewage disposal methods dominated by pit latrines and septictank/soak pit systems and solid waste dumps have been attributed with pollution of groundwater with microbial contaminants and excessive nitrates especially in the high-density housing settlements of Kisauni (Munga *et al*., 2006).

1.3.3 Industrial activities

Most of the manufacturing industries (over 90 %) in the coastal region of Kenya are located in the industrial area of Mombasa County, with an extension towards Mazeras and Mariakani Urban Centres and Kikambala in Kilifi County. Most of the industrial establishments in Mombasa County generally do not pre-treat their effluents before discharge, with the exception of a few which include the petroleum refinery. Some of the industrial establishments discharge their untreated liquid effluent into the municipal storm-water sewer system which drains into Port Reitz Creek. Other industrial establishments have been allowed to discharge their liquid effluent into vertical drains which tend to contaminate the groundwater refs. During floods and high tide, the vertical drains sometimes overflow and end in the marine environment. Earlier assessments of the pollution loads from industrial establishments, dominated by food processors and other agro-based industries, indicated high levels of BOD, suspended matter, and nitrogen compounds (Mwaguni and Munga 1997).

Solid waste from industries is usually not sorted before disposal at the Municipal dumpsites. Some of the industrial refuse is toxic and potentially hazardous to animal and human health (Mwaguni and Munga, 1997). For example, the petroleum refinery produces considerable

quantities of hazardous sludge contaminated with oil marcaptans, tetraethyl lead and rust, which is disposed of on agricultural land. Everaarts and Nieuwenhuize (1995) reported baseline data on heavy metals (Cu, Zn, Cd, Pb, Mn and Fe) in sediments and biota from shallow coastal waters and the continental slope (about 2000 m depth) along the Kenya coast.

Among the early studies that provided indications of the level of contamination of Mombasa inshore water areas were undertaken by Williams et al. (1997). Kamau (2001) reported the distribution and enrichment of heavy metals (Cu, Cd, Fe and Zn) in sediments in Port Reitz Creek, Kilindini Channeland Makupa Crees in Mombasa County. Elevated concentrations of Cu and Zn were found in sediments in the vicinity of a steel manufacturing factory and fish processing plant around the Mbaraki Creek in the Kilindini Port area (Kamau 2002). Elevated concentrations of Cd and Pb in water, sediments and selected fish species were reported in Makupa and Tudor creeks during the rainy season (Mwashote 2003).

1.3.4 Agricultural activities

Poor agricultural practices in the Athi-Sabaki and Tana River basins enhance soil erosion resulting in the discharge of high loads of suspended sediments into Malindi and Ungwana Bays. This has caused siltation in estuaries and mangrove swamps as well as smothering of coral reefs and seagrass beds. Siltation not only adversely affects the productivity and biodiversity of the various critical marine habitats, but also compromises the aesthetic/amenity value of the marine resources, which may cause negative impacts on coastal tourism.

High rates of deforestation in the Athi-Sabaki and Tana River catchment areas in the Central Kenya region, have also contributed to increased suspended sediments loads. The heavy sediment loads discharged into the Malindi and Ungwana bays are a potential source of agrochemicals, which may include excessive nutrients and pesticide residues. Contamination of water, sediment, fish and seaweeds with residues of lindane, aldrin, α-endosulfan, p,p'-DDD and p,p'DDT has been reported at several sites along the Kenyan coast (Wandiga, 2005). Levels of pesticide residues in sediment samples from the Sabaki River were found to be relatively higher during the rainy seasons which were attributed to seasonal usage of the chemicals associated with agricultural activities in the catchment areas. Recent trends in agricultural development point towards intensified activities within the Tana and Sabaki river basins. Intensified agricultural activities have witnessed the re-establishment of sugarcane plantations in the low-lying coastal area in the southern coast of Kenya.

1.3.5 Tourism

Coastal tourism is estimated to account for about 60 % of the national tourism industry revenue. Some of the large urban centres along the Kenyan coast attribute their rapid development to tourism. Such urban centres include Malindi, Watamu, Mtwapa, Ukunda and Diani. Tourism development and activities have impacted coastal wetlands and contributed to erosion of beaches (through construction of seawalls, etc). Tourism development is directly responsible for over-exploitation of marine resources, while poor waste management in tourist establishments and tourist satellite centres are responsible for degradation of water quality and the loss of aesthetic value of some beaches.

The promotion of mass tourism targeting the coastal area has exerted pressure on, not only the marine resources but also utilities, with the high demand for freshwater, estimated at between 300 and 500 litres per capita-day compared to a minimum requirement of 40 litres per capita-day (Visser & Njuguna, 1992). While estimated pollution loads due to beach tourist establishments are relatively low, there is always the risk of localized pollution hotspots which can be hazardous to tourists and is of public health concern (Mwaguni and Munga, 1997).

1.3.6 Outlook

The Kenya economic development blueprint, Vision 2030, envisions a 10% or higher economic growth rate in order for Kenya to attain middle income status. However, the high rates of industrialization are associated with environmental issues which include domestic and industrial waste management and pollution of the terrestrial and marine environment. There is need to address the effectiveness of strategies to manage and control environmental pollution and resultant degradation due to intensified industrial activities in particularly industrial areas in the coastal region.

Recent trends in agricultural development point towards intensified activities along the major river basins of the Tana and Sabaki rivers, targeting cotton and sugar irrigation schemes in especially the low-lying coastal region. These rivers discharge huge volumes of freshwater (estimated at 4,000 million and 2,000 million m^3 annually for the Tana and Sabaki, respectively) and sediments (3 million and 2 million tonnes annually, respectively) into the Ungwana and Malindi bays respectively (UNEP, 1998). Such discharges are not only a source of nutrients into the bays, but also potential sources of agrochemicals into the rich fishing grounds.

Toxic agrochemicals entering the marine environment through river discharge are a risk to the health and productivity of the estuarine areas, seagrass and coral reef habitats, with potentially adverse impacts on the socio-economic well-being of the fisher communities depending on them for their livelihood. The need to monitor levels of agrochemicals contaminating the marine environment and potential impacts on the same cannot be gain said.

1.4 Review of existing legal and institutional framework

Kenya has several policies, legislative and institutional frameworks for the management of pollution. Important existing policies in this direction include; (i) Land Policy (iii) Water Policy 1999 (iii) Mining policy (iv) Agricultural Policy (v) Regional Development Authorities Policy 2007 and, (vi) Occupational Heath and Safety policy.

In the legal front, important legislation for pollution management include; (i) The Water Act 2002 (ii) The Environmental Management and Coordination Act (iii) The Public Health Act (iv) The Forestry Act, (v) The Tana and Athi River Development Authority Act (vi) The Coast Development Authority Act (vii) The Physical Planning Act (viii) The Factory and Other Places of Work Act (ix) the Fisheries Act, (xi) the Wildlife Management and Conservation Act etc.

Also a number of institutions have been established with mandates on tackling the pollution problems. Such institutions include NEMA, Water Resources Management Authority (WRMA), County Governments, Directorate of Occupational Health and Safety, Physical Planning Department, the Regional Development Authorities, Kenya Wildlife Service (KWS), National Museums of Kenya (NMK) and Fisheries Department among others. This institutional framework notwithstanding, weaknesses in implementing activities abound in the form of inadequate capacity for enforcement and overlapping mandates.

National strategies and regulations include (i) The Environment Impact (Assessment and Auditing) Regulations (ii) EMCA (Water Quality) Regulations 2006, EMCA (Waste Regulations) 2006 (iii) Relevant sector strategies and regulations for agriculture, energy, trade, industry (iv) Poverty Reduction Strategy (v) Economic Recovery Strategy, and (vi) Vision 2030.

Despite adequate policy and regulatory instruments, pollution still remains a major problem in the coastal zone mainly due to weak enforcement.

1.6 Approach used to develop the guidelines

The strategy used in developing the Pollution Control Guidelines involved desktop study, liaison with relevant government lead agencies, NGOs and private sector institutions. Consultations were also held with the national Intergrated Coastal Zone Management (ICZM) Committee and the Pollution prevention Task Force constituted by NEMA. The final draft Pollution Prevention and Control Guidelines were presented and validated by stakeholders at national workshop organised by NEMA.

CHAPTER 2: OBJECTIVES, PRINCIPLES AND SOURCE TARGETS

2.1 Objectives of the Guidelines

The pollution prevention and control guidelines aim to;

i) Minimize and control pollution;
ii) Stabilize and improve the quality of water in coastal areas;
iii) Protect essential coastal habitats and living aquatic resources from pollution;
iv) Support the integrity of coastal and marine environment resources.

2.2 Scope and Source Targets

The following activities and processes define the scope of the guidelines:

i) Industrial sector (liquid and solid waste)
ii) Hotel and Tourism sector
iii) Municipal sector (Municipal/domestic waste)
iv) Agriculture sector (agro-based processing industries, farming inputs, land development, livestock waste, disease control, aquaculture)
v) Maritime transport sector (shipping and ports)
vi) Road transport sector (used/waste oil, sludge, human waste)
vii) Rail Transport sector (used/waste oil, human waste)
viii) Aviation transport sector
ix) Institutional waste
x) Mining and exploration/ Exploitation
xi) Trans-boundary (exportation e.g. chemicals, toxic waste)
xii) Waste water treatment plants (operational guidelines)
xiii) Septic tank sludge disposal for urban centres without waste water treatment plants.

2.3 Guiding principles

The following principles will guide the application or use of the guidelines:

i) Polluter pays principle: The polluters of the environment and natural resources shall bear the full environmental and social costs of their activities.

ii) Duty of care: Any person producing, handling or managing hazardous substances, or related equipment, is ethically responsible for using the utmost care in that task.

iii) Recycle, avoid and minimize. This forms the basis for the adoption of an Integrated Pollution Prevention and Control (IPPC) approach in waste management.

iv) Precautionary Principle: Where there are credible threats of serious or irreversible damage to key environmental resources, lack of full scientific certainty will not be used as a reason for postponing cost-effective measures to prevent environmental degradation**.**

v) Application of best practicable environmental option (BPEO) technology. This relates to affordability of the technology for waste management.

vi) Application of Best Available Techniques: This can be defined as the most effective and advanced stage in the development of activities and their methods of operation, which indicate the practical suitability of particular techniques for a given operational context.

vii) The Proximity Principle: The disposal of hazardous wastes must take place as close as possible to their point of generation, recognizing that economically and environmentally sound management of some wastes will be achieved at specialized facilities located at greater distances from the point of generation;

viii) The Least Transboundary Movement Principle; Transboundary movements of hazardous wastes should be reduced to a minimum consistent with efficient and environmentally sound management.

CHAPTER 3: POLLUTION PREVENTION & CONTROL GUIDELINES

3.1 Industrial Sector

Industrial wastewater is a source of organic contaminants which exert a biological oxygen demand (BOD) to receiving waters, suspended particulate matter, nitrogen compounds, corrosive chemicals (acids and caustics) and toxic heavy metals (Mercury, cadmium, lead, chromium, copper, manganese). Contamination of surface and groundwater, as well as the marine environment with industrial pollutants compromises the water quality with potential adverse effects on ecosystems and public health (Mwaguni and Munga 1997). Gaseous emissions associated with manufacturing processes and operating industrial boilers may release toxic gases, such as, oxides of nitrogen and sulfur (NO_x and SO_x) and carbon dioxide (CO_2) which cause of acid rain and global warming. The disposal of industrial solid waste at municipal dumpsites is in most cases carried out in an uncontrolled manner, raising the risk of contamination of water bodies with potential pollutants through leachates. Open burning of these wastes and spontaneous fires also contribute to atmospheric pollution.

Thermal power generation and oil refinery plants release hot water from their cooling systems which are potential sources of heat pollution to receiving water bodies and having adverse effects on the biodiversity of aquatic systems.

Most of the salt for domestic and industrial use is produced by extraction from seawater through solar evaporation. However, solar-salt production has been characterised by extensive clearance of critical mangrove areas and is a potential source of salinization of groundwater. The resulting salinization is due to infiltration of saline water into otherwise fresh ground water.

The industrial sector provides identifiable point sources of pollution and clear opportunities to address the sources. These guidelines will enable industrial operators to reduce, reuse or recycle waste, and ensure that any waste disposed in the environment meets required standards in accordance with the EMCA (Water Quality) Regulation 2006, EMCA (Waste Management) Regulations 2006, and draft (Air Quality) Regulations. The major types of industries along the coastal region may be categorised as follows:

- Food processing industries
- Vegetable and animal oil and fats manufacturing
- Production of sugar from sugar cane
- Beverages manufacturing
- Textile manufacturing
- Leather products manufacturing
- Wood and wood products manufacturing
- Paper and paper products manufacturing
- Rubber and plastic products manufacturing
- Glass manufacturing
- Cement manufacturing
- Iron and steel manufacturing industries
- Petroleum oil refining and vending

- Chemical and chemical products manufacturing
- Thermal power Generation
- Salt manufacturing.
- Lead recycling

3.1.1 Sources of pollution

The main sources of pollution from manufacturing industries include,

- Spillages of petroleum, vegetable oil, liquid chemicals, during handling, transportation and storage (warehousing),
- Waste from manufacturing processes; liquid, solid and gaseous emissions,
- Solid waste arising from the manufacturing process.
- Gaseous emissions
- Leakages

3.1.2 Activities causing pollution and prevention and control measures

Table 3.1: Pollution prevention and control guidelines for industrial waste

Sub-sector	Activity	Waste type	Preventive and control measures
MANUFACTURE OF FOOD PRODUCTS			
Processing and preserving of meat (cattle, goats, poultry, pig, lamb, camel etc.)	Slaughtering and dressing	• Blood, bones and flesh remnants and offal • Feathers from poultry	• Isolate the killing area from dressing/skinning area • Segregate the wastewater streams • Collect the blood into a blood tank • Resuse bones, trimmings and blood to make blood/bone meal for animal feed, glues, ornaments, etc • Excess bones may be used to make glue. • Excess fats or lard to be used as raw material for soap making. • Offal and pauch manure can be used for biogas production or compost • Segregate waste types such as feathers and offal to be disposed of at designated dumping sites.
	Washing of	Wastewater	• Squeeze out the solids from

Sub-sector	Activity	Waste type	Preventive and control measures
	products	contaminated with blood and pieces of flesh	the products • Minimise use of water • Apply counter current flow rinsing of produtcs • Screen the waste water to rid it off coarse solids • Sediment the waste water to remove the solids • Wastewater taken to waste water treatment plant • Reuse the effluent
	General cleaning, cleaning premises	Wastewater with detergents	• Minimise use of water through scrapping • Channel wastewater to the treatment plant
Production of hides and skins as part of slaughtering	Trimming and fleshing	Fleshings, fat and hide trimmings	• Fleshings, fat and trimmings may be used to make animal feed or tallow • Biodegradable organic waste may be used for biogas production.
	Salting or brine curing of hides for preservation and storage..	Excess salt or brine	• Excess brine can be captured, mixed with fresh brine and reused. • Adopt low-salt hides and skins preservation or curing methods. • Install a brine tank for collection of leachate from the skins • Adopt alternative salt-free methods of preservation, such as chilling followed by treatment with biocide; chemical treatment within an hour of slaughter; adopt alternative green methods of preservation, such as chilling hides immediately after slaughter using cold water, ice or dry (CO_2)
Processing and preserving of fish,	Shelling (oyster shucking), scaling	Shells, scales, bones and flesh	• Shells, bones and flesh remnants can be used to

Sub-sector	Activity	Waste type	Preventive and control measures
crustaceans and molluscs	and filleting	remnants	make high calcium fishmeal for human consumption or animal feed. • Scales can be used for compost manure or • Scales to be separated and disposed of at designated dumping site.
	Washing of products and packaging material	Wastewater contaminated with blood and pieces of flesh	• Screen waste water of solids • Pass waste water through oil-water separator • Channel waste water to a treatment plant • Treated wastewater can be recycled for general cleaning
	General cleaning, cleaning premises	Wastewater with detergents	• Minimise use of water through scrapping • Channel wastewater to the treatment plant
Processing and preserving of fruit and vegetables	• Washing • Peeling and cutting of fruits and vegetables	Waste water Peelings Fruit kernels and cores Vegetable remnants	• Counter current flow of washing water • Waste material can be used to supplement animal feed, e.g. for swine. • Waste material can be used to generate biogas • Unused waste material can be composted.
	Preparation of juices fromfruit pulp	Waste fruit and vegetable fibrous material	• Can be used for animal food • Unused waste material can be composted. • Unused waste material can be used to generate biogas
	Washing of canning or packaging material	Wastewater	• wastewater treated before discharge. • Treated wastewater can be recycled for use for general cleaning
	General cleaning of premises	Wastewater with detergents	• Minimise use of water through scrapping • Channel wastewater to the treatment plant

Sub-sector	Activity	Waste type	Preventive and control measures
	Packaging material	Solid waste	• Minimize packaging and use of packaging materials • Recycle waste packaging materials • Reuse wherever possible
Manufacture of vegetable and animal oils and fats	Oil extraction and refining	Cake or meal of oil kernels, oil nuts and oilseeds	Oilcake can be used for manufacture of animal food. Oilcake can be used for biogas production.
	Bleaching	Spent earth – solid waste	• Collect the leachate • Dispose at the landfill
	Loading, discharging, and storage	Oil spillages during handling	• Containment of leaks and spillages of oil products, e.g. bunding to contain spills or leakages. • Provide spillage collection sumps during un/loading of products • Compliance with rules and regulations governing the design of storage facilities • Ensure regular maintenance of the systems
	General cleaning, cleaning premises	Wastewater with detergents	• Minimise use of water through scrapping of the solid matter • Install oil-water separator • Channel wastewater to the wastewater treatment plant
Manufacture of dairy products	• Spillages during decanting • Leakages along processing lines	Wastewater	• Provide collection sump at product offloading point • Ensure regular maintenance

Sub-sector	Activity	Waste type	Preventive and control measures
	Washing of canning or packaging material	Wastewater with detergents	• Install wastewater treatment plant • Low BOD wastewater to be treated to at least primary level before discharge. • Treated wastewater may be recycled for use for general cleaning
	General cleaning, cleaning premises	Wastewater with detergents	• Minimise use of water through scrapping where possible • Install oil-water separator • Channel wastewater to the wastewater treatment plant
	Packaging	Waste material	• Recycle waste material • Redesign packaging • Initiate return scheme for containers
Manufacture of flour (grain milling) products	De-husking	Grain husks	• Husks and/or chaff can be used for animal fodder. • Dry unusable chaff to be composted • Use for energy production
	Dry flour milling	Fugitive dust	• Seal leaks along the system to minimise wastage. • Install appropriate air pollution control system e.g. cyclones, fabric filters, among others • Install appropriate fugitive dust suppression systems.
Manufacture of starches and starch products from cassava	Peeling and cleaning	Peelings, woody parts and wastewater	• Degradable organic matter can be used to produce biogas for heating • Wastewater to be taken through treatment plant • Treated wastewater can be recycled.
	Starch extraction	Fibrous pulp and wastewater	• Solid waste and wastewater to be treated as above
	Drying and packing	Dust	• Control moisture content of dry starch to minimise dust

Sub-sector	Activity	Waste type	Preventive and control measures
			production
Manufacture of bakery products	Production of bakery products	Solid waste from dough droppings, waste packaging materials and returned stale products	• Use the by-products as animal feed • Unused solid waste products (packaging)to be disposed of at designated dumping site.
	Equipment cleaning and general cleaning	High pollution loading wastewater containing oil and grease, flour, sugar, and yeast and detergent.	• Screening of waste water • Install the oil interceptor • Wastewater to be taken throughtreatment plant • Treated wastewater can be recycled for general cleaning.
Manufacture of sugar from sugar cane			
	Crushing of sugar cane (sugar extraction)	wastewater	• Crush the cane unwashed i.e. Do not wash the cane before crushing
	Crushing of sugar cane (sugar extraction)	Bagasse	• May be used as fuel for boilers • May be used as raw material for paper manufacturing • Use as a material for compost
	Clarifying	Non-sugar contaminants (fats, gums, waxes)	Dispose mud cake in sugar cane farms
	Purification	Mollasses	Used as raw material for production of power alcohol.
	Packaging	Solid waste	• Re-use, recycle, of packaging materials
	Energy generation	Dust	• Install air pollution control equipement
	General cleaning	Wastewater	• Minimise use of water through scrapping, soaking of leakages and spillages • Channel waste water to treatment plant
MANUFACTURE OF BEVERAGES			
Manufacture of soft drinks; production of	On-site water treatment for process input	Contaminated backwash	Incorporate air (air sparging) to reduce the amount of water required for backwashing.

Sub-sector	Activity	Waste type	Preventive and control measures
mineral waters and other bottled waters	Equipment cleaning and general cleaning	Wastewater containing residual syrup and detergent.	• Wastewater to be taken through treatment plant • Treated wastewater can be recycled for use in the production process and for general cleaning.
	Preparation of product	Leakages	• Maintenance • Automated loading
	Packaging of products	Waste of packaging materials	• Reuse • Recycle • Dispose to municipal dumpsite
	Cleaning	Wastewater	• Minimise use of water through scrapping • Channel waste water to treatment plant
MANUFACTURE OF WEARING APPAREL			
Manufacture of wearing apparel	Cutting and sewing	Waste pieces of materials and string.	• Reuse or recycle the cuttings • Solid waste can be incinerated • Solid waste can be disposed of at a designated dumping site.
	Dyeing	Spent liquor, leakages	• Discharge into a wastewater treatment plant
	Washing of finished products	Wastewater contaminated with detergents, dyes and caustic chemicals	• Treat wastewater to to remove degradable matter and laundry chemicals. • Treated wastewater can be recycled for use in general cleaning.
	Operating fuel oil or diesel boilers using fuel oil or diesel for steam generation	Gaseous emissions containing oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Incorporate facility to trap particulate matter and sulphur oxides in flue gas, e.g. wet scrubbers and electrostatic precipitators. • Incorporate mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas.

Sub-sector	Activity	Waste type	Preventive and control measures
			• Use low sulphur fuel.
	General cleaning	Wastewater	• Treat wastewater to remove degradable matter and laundry chemicals. • Treated wastewater can be recycled for use in general cleaning
Manufacture of knitted and crocheted apparel	Cutting	Waste cuttings of materials and string.	• Recycle cuttings • Solid waste can be incinerated • Solid waste can be disposed of at a designated dumping site.
	General cleaning	Wastewater	• Treat wastewater to remove degradable matter and laundry chemicals. • Treated wastewater can be recycled for use in general cleaning.
MANUFACTURE OF LEATHER AND RELATED PRODUCTS			
Tanning and dressing of leather; dressing and dyeing of leather	Beamhouse activities: • Trimming	• Hide trimmings	• Trimmings can be used to make animal feed
	• Soaking and Washing – dirt soaking, main soaking and final soaking	• Wastewater contaminated with blood, dung, soil, salt and some soda ash and preservatives	• Wastewater should be segregated and taken through primary and secondary treatment
	• Fleshing	• Fleshings and fat	• Treated wastewater should be directed to evaporation ponds for salt recovery • Treated salty wastewater can be discharged into the sea • Fleshings and fat can be used to make animal feed or tallow • Biodegradable organic solid waste can be used for

Sub-sector	Activity	Waste type	Preventive and control measures
			biogas production. • Wastewater should be screened to remove animal hair or fur.
	• Liming: o Dehairing using sodium sulphide / sodium hydrogen sulphide (Na_2S/NaHS) and lime and soda lime ($Ca(OH)_2$ /NaOH)	• Wastewater contaminated with hair (fur), sulphides and production of hydrogen sulphide gas.	• Wastewater should be segregated and treated in a separate stream where hydrogen sulphide gas (H_2S) formation is inhibited by maintaining alkaline conditions. H_2S is oxidised to thiosulphate and sulphate through aeration in the presence of manganese sulphate catalyst. The sulphate precipitates and the sulphide free wastewater can be safely discharged.
	o Re-liming using lime, soda ash and soda lime ($Ca(OH)_2$, $NaCO_3$ & NaOH).	• Re-liming agents	• Re-liming agents can be recycled and/or re-used
	• De-liming using ammonium chloride (NH_4Cl) or ammonium sulphate ($(NH_4)_2SO_4$)	• De-liming agents	• De-liming agents can be recycled and/or re-used • Use carbon dioxide (CO_2) or weak acids or esters as the de-liming agents.
		• Wastewater containing nitrogenous compounds	• Wastewater can be treated in a conventional treatment facility to the secondary stage and recycled.
	Tanyard activities: • Pickling using water, salt, formic acid / suphuric acid	• Pickle liqour	• Pickle liqour can be recycled and/or re-used

Sub-sector	Activity	Waste type	Preventive and control measures
	• Chrome Tanning using Chromium (III) sulphate [chromic acid ($H_2Cr_2O_3$) and sodium sulphate (Na_2SO_4)]	• Chrome liqour	• Chrome liqour can be recycled and/or re-used
	• Vegetable Tanning using plant extracts, e.g. tannin from oak, mangrove and wattle bark.	• Acidic wastewater (pH 3 – 3.5)	• Treat wastewater before discharge
	• Splitting Shaving and Trimming	• Shavings and trimmings	• Shavings can be used in leather board manufacture • Biodegradable organic solid waste can be used for biogas production.
	Re-tan, colour, fatliquor: • Re-tanning	• Tanning liquor	• Re-tanning liquor can be recycled.
	• Bleaching and dyeing using e.g. anionic dyes, acid dyes, direct, metal complex compounds and basic dyes.	• Colouring liquor	• Colouring liquor can be recycled
	• Fat-liquoring with natural or synthetic oils.	• Fat-liquor	• Fat-liquor can be recycled
	Finishing: • Conditioning, Staking, Dry Milling and Buffing	Dust emissions	Use dust arresters in controlled systems, e.g. dust precipitators and srubbers.
	• Finishing using phenolics, melamine,	Finishing reagents	Finishing reagents can be recycled or re-used.

Sub-sector	Activity	Waste type	Preventive and control measures
	acrylics, polymers, naphthalene, etc.		
Manufacture of footwear, luggage, handbags and related products	Cutting	Splits, trimmings and shavings. Leather dust.	• Cutting ratio to be optimised by the operator such that wastage is minimised. • Solid waste to be disposed of t designated dumpsite.
	Maintenance of equipment	Oils and grease	• Operator to minimise cleaning spirits and oil wastes
	General cleaning	Solid waste	Solid waste to be disposed of at designated dumpsite.
MANUFACTURE OF WOOD AND PRODUCTS OF WOOD AND CORK, EXCEPT FURNITURE; MANUFACTURE OF ARTICLES OF STRAW AND PLAITING MATERIALS			
Sawmilling and planing of wood	Sawmilling and planing	Bark, sawdust, edgings and off-cuts trimmings, split wood, planer shavings and sanderdust	• Coarse material such as edgings and trimmings, split wood and planer shavings can be used as fuel. • Coarse material can be used for pulp production • Sawdust and sanderdust can be used for particleboard production.
Manufacture of veneer sheets and wood-based panels	Plywood production	Bark, core, sawdust, lillypads, veneer clippings and waste, panel trim, sanderdust	• Bark, core, veneer clippings, panel trim can be used for pulp production. • The above can be used as fuel • Sawdust and sanderdust can be used for particleboard production.
	Particleboard production	Bark, screening fines, panel trim, sawdust, sanderdust	Most of the waste can be recycled for particleboard production.
Manufacture of builders' carpentry and joinery	• Production of beams, rafters and roof struts • Production of	Edgings and off-cuts trimmings, split wood, planer shavings, saw dust	• Coarse material such as edgings and trimmings, split wood and planner shavings can be used as fuel.

Sub-sector	Activity	Waste type	Preventive and control measures
	glue-laminated or metal connected prefabricated wooden roof trusses • Production of doors, windows, shutters and their frames, • Production of wooden beadings and mouldings, shingles and shakes, • Production of parquet floor blocks, strips etc., assembled into panels.	and sanderdust	• Coarse material can be used for pulp production. • Sawdust and sanderdust can be used for particleboard production. • Waste material can be used as fuel.
Manufacture of wooden containers	• Production of packing cases, boxes, crates, drums and similar packings of wood. • Production of pallets, box pallets and other load boards of wood. • Production of barrels, vats, tubs and other coopers' products of wood. • Production of wooden cable-drums.	Edgings and off-cuts trimmings, split wood, planer shavings, saw dust and sanderdust	• Coarse material such as edgings and trimmings, split wood and planner shavings can be used as fuel. • Coarse material can be used for pulp production. • Sawdust and sanderdust can be used for particleboard production. • Waste material can be used as fuel.
Manufacture of other products of wood; manufacture of articles of cork, straw and plaiting materials	• Manufacture of wooden utility products, such as; o wooden handles and bodies for tools, brooms, brushes wooden clothes hangers o wooden mirror	Edgings and off-cuts trimmings, split wood, planer shavings, saw dust and sanderdust	• Coarse material such as edgings and trimmings, split wood and planner shavings can be used as fuel. • Coarse material can be used for pulp production. • Sawdust and sanderdust can be used for particleboard production.

Sub-sector	Activity	Waste type	Preventive and control measures
	and picture frames household utensils and kitchenware of wood o wooden statuettes and ornaments, wood marquetry, inlaid wood o wooden cases for jewellery, cutlery and similar articles o natural cork processing, manufacture of agglomerated cork o manufacture of plaits and products of plaiting materials: mats, matting, screens, cases etc.		• Waste material can be used as fuel.
MANUFACTURE OF PAPER AND PAPER PRODUCTS			
Manufacture of corrugated paper and paperboard and of containers of paper and Paperboard	Preparation of stock • beating and washing of stock (pulp) • sizing and incorporation of fillers	• wastewater with suspended solids consisting of degradable cellulose fibre, fillers and dyes. • soap (Rosin soap) and chemicals (e.g. aluminium sulphate, zinc oxide, zinc sulfide, hydrated silica, calcium sulfate, hydrated alumina, talc, barium sulfate and asbestos.	• Treat wastewater to remove degradable matter. • Treated wastewater can be recycled for use in the process.
	Formation of paper sheet by machines • filtration, pressing	• Wastewater	• Treat wastewater to remove

Sub-sector	Activity	Waste type	Preventive and control measures
	and consolidating the paper sheet	arising from excess water removed from paper sheet. Wastewater may be contaminated with pigments (e.g. Titanium dioxide), and chemical fillers (e.g. zinc oxide, zinc sulphide, hydrated alumina $Al_2O_3.xH_2O$ etc)	metal contaminants
	Softening of paper with high-pressure steam in corrugator	Wastewater from cooled steam may be contaminated with cellulose	• Teat wastewater to remove degradable matter. Treated wastewater can be recycled for use in the process.
Manufacture of other articles of paper and paperboard (from virgin fibre and secondary fibre)	Processing of virgin fibre is as presented in previous section on preparation of stock	As above	As above
	Processing wastepaper for cellulose fibre: de-inking and dispersing (units) recycled wastepaper	• Sludge containing ink, caustic, soap, heavy metals, which is potentially hazardous. • Wastewater containing ink and heavy metals and other chemical contaminants.	• Sludge disposed off in a landfill • Wastewater to be treated to tertiary stage to remove metal contaminants.
	Filtration, pressing and consolidating the paper sheet (is as presented in previous section on formation of paper sheet by machines)	As above	As above
	Converting to utility products e.g.	Mill broke consisting of paper	Waste paper is normally clean and contaminant free and can

Sub-sector	Activity	Waste type	Preventive and control measures
	duplicating paper, newsprint, exercise books paper, envelope paper, toilet tissue, napkin paper, facial tissue paper, offset paper - used for printing magazines, bag kraft, and test liner and fluting medium - used to make corrugated boxes.	trimmings and other waste paper	be recycled.
PRINTING AND REPRODUCTION OF RECORDED MEDIA			
Printing	Graphic arts applications	Volatile organic compounds.	Explore possibilities of substituting conventional products with low-solvent or solvent-free products
	Offset printing	Paper trimmings	Wastepaper can be used as a source of secondary fibre for paper making.
		Used cartridges	• Recycle • Dispose according to the label instructions
MANUFACTURE OF RUBBER AND PLASTICS PRODUCTS			
Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres	Buffing tyres in preparation for retreading	Rubber material of the original tread and undertread.	• Can be ground for recycling as a source of rubber for the manufacture of other products. • Can be used as a fuel. • Waste material (unusable) can be disposed of at a landfill.
	Inspection for quality control	Rejected tyres	• Can be ground for recycling as a source of rubber for the manufacture of other products. • Waste material (unusable) can be disposed of at a landfill.
	Cooling	Waste hot water	• Install cooling unit
Manufacture of plastic products	Production processes, e.g. moulding, extrusion	plastic waste	• Can be recycled within the production process

Sub-sector	Activity	Waste type	Preventive and control measures
	etc.		• Plastic waste can be ground and used as fillers in other products.
		Wastewater from production processes	• Use a lagoon to allow settlement of suspended particulate matter and recycle
	Energy generation	Gaseous emissions containing carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Use low sulphur fuels • Install facility to trap particulate matter and sulphur oxides in flue gas, e.g. wet scrubbers and electrostatic precipitators. • Incorporate mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas.
MANUFACTURE OF OTHER NON-METALLIC MINERAL PRODUCTS			
Manufacture of glass and glass products	Cleaning the sand	Solid waste and Wastewater	• Treat waste water • Recycle treated waste water • Dispose mud-cake into municipal dumpsite
	Production processes; mixing of raw materials, heating and moulding.	Glass scrap	Can be recycled within the production process.
	Energy generation	Gaseous emissions containing carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Use low sulphur fuels. • Incorporate facility to trap particulate matter and sulphur oxides in flue gas, e.g. wet scrubbers and electrostatic precipitators. • Incorporate mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas. • The use of secondary glass

Sub-sector	Activity	Waste type	Preventive and control measures
			material (cullet) to supplement the raw material in the production process is encouraged to reduce energy consumption.
Manufacture of clay building materials	Production processes; combustion of clay bricks	Gaseous emissions containing carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Use low sulphur fuels. • Install facility to trap particulate matter and sulphur oxides in flue gas, e.g. wet scrubbers and electrostatic precipitators. • Install mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas.
		Rejected bricks	Use in land filling.
		Abandonned quarry	Rehabillitate the borrow pits
Manufacture of cement	Quarrying, crushing and grounding	Suspended particulate matter; dust	Wetting the material can reduce emissions of particulate matter.
	Post extraction management	Wasteland	Rehabilitation of quarry by planting of trees (afforestation) to - control dispersion of dust, - facilitate carbon sequestration to mitigate atmospheric carbon dioxide build-up.
	Clinker production; pyroprocessing	• Emissions of carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x) from combustion • Emissions of CO_2 from calcinations process. • Suspended	• Use low sulphur fuels. • Use of alternative fuel/renewable energy, e.g. used cement packaging, used tyres, waste plastic materials etc. • Install facility to trap particulate matter and sulphur oxides in flue gas, e.g. wet scrubbers and electrostatic precipitators.

Sub-sector	Activity	Waste type	Preventive and control measures
		particulate matter	• Install mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas.
	Clinker cooling and clinker grinding	Suspended particulate matter - dust	Install dust filtration system to trap particulate matter.
	Cement packaging	Suspended particulate matter	• Install measures to minimise dust emissions during cement packing. • Use of biodegradable packaging material.
	Transportation of raw material from quarries.	Emissions of carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Use low sulphur fuels. • Regular maintenance of vehicles to enhance efficiency, and minimise fuel consumption and emissions of green house gases.
MANUFACTURE OF BASIC METALS			
Manufacture of basic iron and steel	Steel making using a basic oxygen furnace (BOF) from iron, scrap metal and high purity oxygen	Dust and sludge, contaminated with metals	• Install facility to trap particulate matter or dust. • Contaminated sludge can be used for landfill.
		Carbon monoxide (CO), Nitrogen oxides (NOx) and ozone (O_3) (generated during the melting process)	• Use low carbon fuel. • Incorporate mechanism for recycling of flue gas to increase residence time of nitrogen oxides and reduce concentrations of the oxides in flue gas.
		Slag	• Slag is useful in concrete, aggregate road materials, as ballast, etc.
	Steelmaking using an electric arc furnace (EAF) from scrap metal, electric energy and graphite electrodes	Dust and sludge, contaminated with metals	• Install facility to trap particulate matter or dust. • Contaminated sludge can be used for landfill.

Sub-sector	Activity	Waste type	Preventive and control measures
	Forming, Cleaning, and Descaling	• Wastewater and sludge from rolling, cooling, descaling, and rinsing operations, may contain cadmium, chromium and lead. • Wastewater from the rinse baths. Rinse water from coating processes may contain zinc, lead, cadmium, or chromium.	• Tertiary treatment of wastewater will remove metal contaminants. • Contaminated sludge can be used for landfill.
		• Oils and greases from hot and cold rolling	• Can be recovered and reconstituted for reuse
		• Spent pickle liquor. • Pickle liquor and rinse water sludge from cleaning operations	• Pickle liquor can be neutralized with lime before safe disposal. • Sludge can be neutralized with lime and disposed of in a landfill.
MANUFACTURE OF REFINED PETROLEUM PRODUCTS			
Manufacture of refined petroleum products	Loading, discharging, and storage (oil spills at sea and land)	Oil spillages during handling	• Contact the police (security office) to control and caution people and motorists against the risks of fire outbreaks. • Contact the Kenya Maritime Authority (KMA) and other relevant Authority to initiate oil spill response action. • Alert the Kenya Ports Authority pollution control office which is the custodian of the oil spill

Sub-sector	Activity	Waste type	Preventive and control measures
			response equipment in the case of oil spills at sea. • Compliance with rules and regulations governing the design of storage facilities for petroleum products, e.g. bunding to contain spills or leakages.
	Discharging cooling water from the petroleum refinery	Oil contaminated wastewater	• Contaminated cooling water to be taken through a treatment facility where oil is skimmed before discharge • Put in place measures for reusing/recycling cooling water to minimise discharge volume and conserve water.
	Discharging wastewater from production processes	Caustic liquid effluents	Pre-treatment of toxic caustic effluent to remove/reduce concentrations of hydrogen sulfide, mercaptans and organic acids
	Catalsyt	Solid waste	Export the exhausted catalyst to be reactivated where appropriate facilities are available
MANUFACTURE OF CHEMICALS AND CHEMICAL PRODUCTS			
Manufacture of paints, varnishes and similar coatings, printing ink and mastics	Equipment cleaning and washing, between production batches	Water-alkali solutions, and solvents	• Pre-treat wastewater to recover organic solvents and neutralise effluent before discharge. • Treated wastewater to be recycled for production of low quality paints.
	General cleaning	Wastewater contaminated with detergents and antiseptics	• Pre-treat wastewater before discharge.
	Use of organic solvents in paints	Emission of volatile organic compounds	Reduction of proportions of organic solvents in paints

Sub-sector	Activity	Waste type	Preventive and control measures
		(VOCs)	
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Loading, discharging, and storage (oil spills at sea and land)	Oil spillages during handling	• Alert the Kenya Ports Authority pollution control office which is the custodian of the oil spill response equipment in the case of oil spills at sea. • Alert other relevant Authority • Compliance with rules and regulations governing the design of storage facilities for oil products, e.g. all storage tanks are surrounded by bunds.
ELECTRIC POWER GENERATION			
Thermal power generation	Steam generation by diesel or fuel oil fired boilers	Emissions of carbon dioxide (CO_2), oxides of sulphur (SO_x) and oxides of nitrogen (NO_x)	• Use low sulphur fuels. • Use of flue gas desulfurization (FGD), e.g. wet FGD using limestone or dry FGD using lime. • Use a selective catalytic reduction (SCR) system to control NO_x emissions • . • Plant trees/eastablish green lanes around the facilities to absorb carbon
	Steam generation by coal	Suspended particulate matter – fly ash, smoke and soot	-Incorporate dust control systems capable of over 99% removal efficiency, such as Electrostatic Precipitators (ESPs) or Fabric Filters. -Plant trees/eastablish green lanes around the facilities to absorb dust, smoke and soot
		Emissions of CO_2, SO_x and NO_x	• Use high heat content coal • Use low sulphur coal • Incorporate integrated desulfurization in coal-fired fluidized bed combustion boilers by use of lime

Sub-sector	Activity	Waste type	Preventive and control measures
			(CaO) or limestone (CaCO3) • Use of flue gas desulfurization (FGD), e.g. wet FGD using limestone or dry FGD using lime. • Use a selective catalytic reduction (SCR) system to control NO_x emissions • Plant trees/eastablish green lanes around the facilities to absorb carbon
		Fly ash, bottom ash, boiler slag, and FGD sludge contaminated with traces of heavy metals	• Can be used in construction materials and fills, e.g. bricks and concrete. • Use low ash coal.
		Hot cooling-water	• Hold hot water in cooling lagoons to lower temperatures and recycle. • Use closed-cycle re-circulating water cooling systems, e.g. use of natural or forced draft cooling towers or air cooled condensers.
SALT EXTRACTION			
Salt production by evaporation of sea water or other saline waters	Intake and retaining of brine in evaporation ponds	Brine seepage into groundwater	• Use impervious soils to seal pond floors to eliminate brine seepage • Leak-proofing communication channels to eliminate seepage. • Construct ponds away from freshwater reservoirs
	Crystallization	Bitterns	• Can be further processed to extract other chemical products, e.g. magnesium chloride, magnesium sulfate, potassium chloride, and magnesium bromide. • Remaining solution can be

Sub-sector	Activity	Waste type	Preventive and control measures
			safely disposed in the sea.
	Milling and processing dry salt	Salt dust	• Adopt a closed milling and processing system to minimise emissions of dust. • Staff working in the plants to wear protective gear eg masks, aprons, etc
Recycling of Used Lead Acid Batteries	Dust	Gaseous	• Sprinkle water on the dusty areas • Provide enclosure and extraction exhaust system at the battery breaking area • Collect dusty from from the cyclone area
	Plastics	Solid waste	• Reuse or recycle into other products
	emissions	Gaseous	• Provide a cyclone • Provide a wet scrubber • Discharge wastewater into a treatment system
Textiles Manufacture			•
Recycling of Used Oil	Spillages during decanting	Waste oil	• Ensure the whole ground is impervious • Provide collection sumps at the used oil discharge and decanting points • Install an oil-interceptor • Desludge the oil-interceptor regularly
Wood preservation	wood chips, cuttings	Solid waste	• Use the material as an energy source • Reuse in furniture manufacture
	Wood treatment	wastewater	• Provide an impervious area for drying the wood after treatment • Provide collection system for the dripping preservative • Provide an oil-interceptor
			•
Bitumen	Mixing the	dust	• Install water sprinklers

Sub-sector	Activity	Waste type	Preventive and control measures
Preparation	aggregates		along the conveyor belts • Install appropriate cyclones • Install scrubbers
Paper Recycling	Dissolution of the papers	wastewater	• Install paper fibre sedimentation uit • Install wastewater treatment plant
Sisal processing	Decoating	Solid waste	• compost
		wastewater	• install wastewater treatment plant
Others	Asbestos Disposal	Solid waste	• Wet surfaces during removal of material • package in 2 layers of gauge 500 polythene sheets • Ensure that the packages are half-full • Paint the undisturbed asbestos material surfaces • Bury the encapsulated material at least 1 metre above the water table at the designated site
	E-waste	Solid waste	• Take the waste electronic products to the designated collection centres or to the nearest refurbisher of the same

3.2 Hotel and Tourism Sector

The sustainability of coastal tourism is directly associated with the maintenance of a healthy coastal and marine environment, which include clean beaches, healthy coral reefs and seagrass lagoons, and untarnished mangrove and terrestrial forests that provide goods and services. Thus, the importance of observing best practice in the management of waste from tourist hotels to avoid pollution and degradation of the environment cannot be gainsaid.

3.2.1 Sources of pollution

The potential sources of pollution from tourism sector activities include the following;

- Hotel operations that produce liquid and solid wastes, green house gases and electronic wastes.
- Development of new hotels and expansion of the existing ones are sources of gaseous and solid wastes.
- Tourists produce considerable quantities of solid waste or litter.
- Activities of beach operators are sources of pollution resulting from oil spills, dumping of derelict boats, antifouling paints and littering.

3.2.2 Activities causing pollution and preventive measures

Table 3.2: Activities causing pollution and preventive measures in the tourism sector

Activity	Waste type	Preventive and control measures
Littering within the facility and beach areas	• Solid waste	• Establish assorted garbage collection and disposal system within the hotel facilities and designated points at the beaches • Develop and circulate code of conduct • Create awareness on the code of conduct campaigns • Creating incentives to encourage PPP in solid waste management • Compliance with withWaste Management Regulations 2006(www.nema.go.ke). • Compliance with BMU by-laws
Boat operations	• Oil spills • Metal based anti-fouling paints • Emissions of green house gases from boat engines	• Encourage regular maintenance of boats • Compliance with KMA regulations prevention of marine pollution. • Comply with conventions on antifouling substances and encourage use of compliant paints.
Kitchen, washroom and	• Wastewater contaminated with soaps	• Promote the use of environmentally friendly detergents

laundry activities	and detergents, bleaching agents and oil • Biodegradable solid waste.	• Discharge wastewater into a wastewater treatment plant • Reuse the treated water • Conduct awareness campaigns on water conservation • Adoption of biodigesters in waste management • Establish collection points for used cooking oil • Separate solids from liquid waste at the source • Adopt the use of water efficient flush toilets. • Installation of appropriate technologies to reduce excessive use of detergents and water • Install oil interceptors
Development of new hotels and expansion of existing ones	• Solid waste, e.g. waste building materials, debris • Dust and noise. • Emmission of CFC's from hotel operations and installations.	• Adherence to mitigation measures during construction to reduce erosion • Salvage of waste building materials for reuse • Use of ecofriendly technologies and materials. • Adoption of Cleaner Production mechanisms. • Adherance to Ozone Depleting Substances regulations (www.nema.go.ke)

3.3 Municipal Waste

Along the coastal area only the city of Mombasa has a functioning wastewater treatment facility handling domestic sewage from part of the west mainland area, with the rest of the city using mainly on-site sewage treatment facilities or discharge directly or indirectly into the marine environment. Waste effluent from manufacturing industries lack a centralised treatment facility and discharge of raw wastewater into the environment is not uncommon. Effective management of solid waste has proved to be a particularly intractable challenge to most urban authorities. It is important to recognise the participation of the urban community and industrial players in ensuring best practice in solid waste management.

3.3.1 Sources of pollution

The main sources of municipal waste include the following;

- Residential areas (solid waste and wastewater)
- Commercial areas (market centres, hawkers, retailers)
- Constructed landscapes and buildings
- Informal (*Jua kali*) sector
- Entertainment centres (restaurants, stadiums, discotheques)

3.3.2 Activities causing pollution and preventive measures

Table 3.3: Activities causing pollution and preventive measures for municipal waste

Activity	Waste type	Preventive and control measures
Illegal dumping and littering from residential, commercial and entertainment places.	• Solid waste	• Create awareness on waste segregation at both municipal and residential areas • Establish assorted garbage collection and disposal system within residential areas • Develop and circulate a code of conduct on waste collection and disposal • Compliance and enforcementof waste management regulations of 2006, Municipal by-laws
Effluent discharge from residential, commercial and entertainment places.	• Wastewater contaminated with detergents,chemicals, greases and oils -	• Segregate waste streams • Install oil and grease interceptors for the residential and commercial outlets.Discharge into appropriate waste water treatment facilities • Compliance with rules and regulations in residential areas regarding sewerage services, water harvesting and surface flows • Comply with regulatory requirements for new housing and infrastructural developments in residential areas • Regular maintenance of effluent disposal systems • Promotion of appropriate technologies on water harvesting, storage and use • Adoption of biodigesters in waste management • Compliance with water quality regulations
Packaging in market centres, retailers and hawkers	- Plastic paper and other packaging material.	• Minimising packaging material usage • Use of biodegradable material for packaging • Price incentives to encourage re-use • Encourage proper packing of goods at farm level to reduce wastes in urban areas • Investment in appropriate technology for recycling of plastic waste • Provide guidelines on tax rebates for investments in non plastic packaging materials.
Spillage of oil, greases and paints by garages and Jua Kali sector	- Waste oil, paints, gaceous emmissions	• Encourage establishment of organisational structures in jua kali garages • Operate in zoned areas to minimize spillage • Code of conduct on use of oils, grease and

		paints • Install oil, grease and paint receptors and solid waste bins - Motor companies to adopt mechanisms for mopping up used motor parts for recycling and re-use
Excessive noise from entertainment establishments and worship places	- Noise	- Compliance with excessive noise and vibrations regulations; EMCA (Noise and excessive vibration pollution control) Regulations, 2009(www.nema.go.ke)
Disposal of carcases and corpses	- Carcases	- Operate sanitary cemeteries in zoned areas - Compliance with rules, regulations and guidelines

3.4 Agricultural Sector

Apart from a few large plantations and irrigation schemes along the major river basins, majority of the farmers engage in subsistence crop or mixed farming, with livestock keeping a cultural occupation of the pastoral communities along Tana River and elsewhere in the region. Generally, subsistence farmers use low quantities of agrochemicals, and include acaricides for control of animal pests.

Lately, there has been a growing interest in aquaculture or fish farming with the Government through the Ministry of Fisheries Development prioritizing the development of aquaculture as a contribution towards meeting the goals of Vision 2030. Other players in the sub-sector include NGOs and private developers. Efforts have concentrated on developing skills and construction of ponds for semi-intensive freshwater or seawater aquaculture, but have also included pen culture and seaweed farming. The main environmental issues associated with aquaculture, which increases in prominence with intensive culture systems, are eutrophication due to high concentrations of nutrients, water and wastewater management, and the management and disposal of anoxic / toxic bottom substratum.

3.4.1 Sources of pollution

The main sources of pollution in the agricultural sector include the following;

- Crop farming activities
- Livestock farming
- Aquaculture.

3.4.2 Activities causing pollution and preventive measures

Table 3.4: Activities causing pollution and preventive measures in the agricultural sector

Sub-sector	Activity	Waste type	Preventive and control measures
Crop farming	Preparation of land for planting	Loose top soil prone to wind and water erosion	• Avoid clearing of land in riparian areas 6 m to control soil erosion and siltation of rivers, lakes, the sea and other wetlands or as stipulated in the EMCA (Water Quality) Regulations, 2006 and EMCA (Wetlands) Regulations, 2009. • Avoid clearing of land on hilltops and slopes • Observe best practices in farmland management such as terracing, contour farming and agroforestry (hedge row) • Avoid conversion of environmentally sensitive areas into farmlands
	Application of fertilizer	Excess fertilizer	• Use prescribed amounts to minimise leaching by runoff or seepage into groundwater • Apply fertilizer after rain • Use manure where available
	Application of pesticides; mixing; decanting; spraying; washing of containers; disposal of containers;	Excess and stray applications; spillages; wastewater; solid waste;	• Use prescribed amounts of pesticides • Aerial spraying (large scale) to be carried out during calm weather conditions. • Provide collection sump • Use centralised spraying • Minimise wastewater by use of reverse rinsing (re-use the cleaning water for all the containers) • Dispose wastewater into soak pit with absorbent activated charcoal • Dispose wastewater into a wastewater treatment facility • Ensure containers are disposed at NEMA licensed facilities
	Irrigation:		• Adopt appropriate technologies

Sub-sector	Activity	Waste type	Preventive and control measures
	- over irrigation	Excess water; runoff	e.g drip irrigation that ensures optimum irrigation to minimise wastage of water and pollution of water ways
Livestock farming	Feedlots	Wastewater contaminated with organic matter, nutrients and cleaning detergents	• Wastewater can be treated to secondary stage and recycled
		Solid waste composed of animal dung	• Can be used to make animal manure for crop farming • Can be used for the production of biogas
	Cattle dips	Wastewater with chemicals	• Dispose wastewater into a soak pit in addition to adhering to instructions as provided in user instructions
	Transportation of agricultural produce and products	Emissions of greenhouse gases CO_2, SOx, NOx and dust	• Proper maintenance of vehicles to reduce emissions of greenhouse gasses.
Aquaculture	Semi-intensive and intensive marine aquaculture in ponds in nearshore areas; - Setting/layout - Feeding - Harvesting and cleaning	• Water seepage from ponds resulting in salinization of groundwater. • Wastewater from ponds contaminated with unconsumed fish feeds and excreta. • Sludge from ponds.	• Ensure (through research) that location of culture ponds is at places with impermeable soils that do not allow seepage into groundwater Lining of ponds, for example, is an advisable measure to avoid water seepageSet up a filtration and re-circulating system to facilitate reuse of wastewater • Organic-rich sludge can be composted for use as fertilizer
	Semi-intensive and intensive marine aquaculture in cages and pens in nearshore areas	• Excess nutrients from fertilizer (causing localised eutrophication)	• Set mariculture activities in well-flushed areas to minimise accumulation of nutrients and development of algal blooms, some of which are potentially toxic • Regular monitoring of nutrient levels and algal growth in water for early warning. • Promote integrated farming, e.g.

Sub-sector	Activity	Waste type	Preventive and control measures
			fish and seaweeds, whereby the latter utilise excess nutrients in the water.
		• Antibiotics, vaccines and pesticides used to control diseases and parasites accumulating in the water column and sediment	• Locate mariculture activities in well-flushed areas. • Use chemicals with low persistence in the environment
		• Cultured species escape from cages or wild species getting into the cages/pens competing for food and habitat and introducing non-native DNA and diseases.	• Maintain the integrity of cages and pens to curb escape of species into the wild or entry of wild species into the cages
	Semi-intensive and intensive freshwater aquaculture in ponds; - Setting - Feeding - Harvesting and cleaning.	• Water seepage from ponds resulting in pollution of groundwater. • Antibiotics, vaccines and pesticides used to control diseases and parasites accumulating in the water column and sediment. • Wastewater from ponds contaminated with unconsumed fish feeds, excreta, nutrients and other suspended particulate matter. • Acidic and anoxic conditions	• Ensure that location of culture ponds is at places with impermeable soils that do not allow seepage into groundwater. Lining of ponds, for example, is an advisable measure to avoid water seepage • Use chemicals with low persistence in the environment • Wastewater can be taken through primary and secondary treatment and recycled • Wastewater, rich in nutrients and organic matter can be used directly to irrigate crops. • Periodic emptying of ponds (usually after harvest) and

Sub-sector	Activity	Waste type	Preventive and control measures
		developed at the bottom of ponds due to decomposition of excess organic matter. • Sludge from ponds	neutralising bottom substratum, e.g. using lime. • Sludge can be composted for use as fertilizer

3.5 Transport Sector

The transport sector targeted in this section includes maritime transport (shipping and ports), rail transport, road transport and the aviation sector.

3.5.1 Sources of pollution

Pollution concern from these different forms of transport include impacts of ballast water, invasive species, bilge water, accidental or deliberate discharge of solid and liquid materials and dredge spoils. Other important sources of pollution include combustion of fuel oils which releases SOx, NOx and CO gases, among others. Then there is the problem of having to deal with waste oil and human wastes.

In the **maritime sector**, the pollution sources of concern include ballast water, invasive aquatic species, bilge water, accidental or deliberate discharge of solid and liquid materials and dredge spoils from port expansion activities.

Ballast water is typically contaminated with oil and possibly other wastes within the ballast tanks. Often, some aquatic species form part of ballast water are unintentionally transported to new marine ecosystems. Most exotic invaders do not survive in their new environment, and so do not impose significant ecological or financial costs. However, some flourish and crowd out other species or radically change the balance of existing ecosystems.

Another source of pollution is bilge water; this is seepage which collects in the hold of a ship and must be discharged regularly. On oily tankers the bilge water is typically contaminated with oil, which seeps out of the cargo tanks.

Then there is the accidental or deliberate discharge of solid and liquid materials by ships in water, as another cause of water pollution. The solid and liquid wastes can comprise human and general waste (such as packaging material) and spills (mainly oil). Oily discharges kill marine animals and contaminate coastal facilities, while the disposal of plastics at sea is a significant source of environmental harm, since the materials are both buoyant and persistent.

Spills from water borne vessels (mainly oil and chemicals) are one of the major sources of water pollution from shipping. Cargo spills frequently occur while loading or un-loading in port, due to handling errors or equipment problems, but are relatively small in volume. Much less common, but potentially more dangerous, are cargo spills, which occur when a boat runs aground or breaks up in bad weather.

Oil spills can have wide spread impacts and long-term consequences on the environment (e.g. wildlife, fisheries, human neighbourhoods and human health, coastal and marine habitats, livelihood, provision of social services as well as on recreational resources of communities.

Some standard hull coatings are toxic, slowly leaching into sea water and remaining there for long periods. However, changing hull coatings might lead to increased rates of hull fouling, which can increase fuel requirements and cause other environmental damage. Finally, the routine maintenance dredging of ports and inland waterways stirs up toxic sediment and frequently leads to the disposal of dredged material in open ocean. Dredging also raises toxic materials and poses the problem of where to resettle them.

From the **rail and road sectors,** the impacts concerning pollution of the environment and its water resources emanate from waste oil/used oil, general waste and human waste. Other issues of concern originating from the transport sector include, emission of gases, originating from combustion of fuel oil, which affect air quality and climate; discharge of trace quantities of additional pollutants such as benzene (a known carcinogen), toluene, poly-nuclear aromatic hydrocarbons, formaldehyde, cyanide, hydrogen sulphide and dioxin, etc. The emissions from combustion of fuel oil most pertinent to air quality in the environment include particulate matter, sulphur oxides (SOx), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC).

Particulate matter is implicated in respiratory and heart diseases. Sulphur dioxides can cause respiratory disease, damage the fabric of buildings and contribute to acid rain. Nitrogen oxides are harmful to organisms, contribute to acid rain and are an ingredient in the formulation of ozone. Volatile organic compounds, in turn are an ingredient of ozone production. Ozone is associated with photochemical smog.

The other waste of concern emanates from the use of mineral oils as lubricants. These lubricants have to be changed regularly. Consequently large amounts of waste mineral oil arise. Used oils can pollute the environment in a number of ways. Typical contaminants in mineral oils include metals, especially when the used oil contains lubricants, dissolved organic pollutants including, in some cases, persistent organic pollutants such as PCBs. Direct exposure to used mineral oils might be a health hazard: skin rashes, headaches and tremors.

In the **Aviation Sector**, the environmental issues of concern include developing adequate facilities for safe disposal of waste. Targeted here are both liquid and solid wastes; human wastes, waste oil and fuel oil. Combustion of fuel oil has been linked to generation of green house gases. Therefore the use of efficient engines in the aviation sector is very important and must be promoted.

3.5.2 Activities causing pollution and preventive measures

Table 3.5: Pollution prevention and control measures in the transport sector

Sub-Sector	Activity	Waste Type	Preventive and Control Measures
Maritime Transport	Ballast Water uptake and Discharge	Invasive Species	Precautionary Approach: • Avoid unnecessary discharge of ballast water • Minimize uptake of ballast water: in darkness, where organisms rise up in the water column, in very shallow waters; where propeller may stir up sediments, or in areas recently dredged Ballast Water Management Options: • Conduct ballast water exchange in accordance to Regulation B-4 of the Ballast Water convention • Develop Ballast Water Management Systems • Discharge to ballast water reception facilities
	Ballast Water uptake and discharge	Sediment	• All ships shall remove and dispose of sediment from spaces designated to carry water in accordance with the ballast water management plan; • Take all practical steps to avoid sediment uptake during ballast water uptake; • Monitor the volume of sediment in the ballast tank regularly; • Remove sediment from ballast tanks in accordance with the Ballast Water Management Plan • Remove sediment from ballast tanks under controlled conditions at the port, at a repair facility or in dry dock;

			• Undertake disposal of sediment in the sea in areas 200nm away from land and with water depths of 200m
	Ballast Water / Sediment Management	Ballast Water and Sediment	Procedures for Vessels • Facilitate the administration of ballast and sediment management and treatment procedures on board each ship; • Record details of ballast water operations; • Ships to make available relevant documentation in fulfillment of the Convention for receiving port State; • Procedures for port State; • Provide ships with details of the State requirement concerning ballast water management, including: *a) Location and terms of use of areas designated for ballast water exchange;* *b) Warnings concerning ballast uptake and any other port contingency arrangements;* *c) Availability, location and capacities of reception facilities provided* i) Assist ships in applying precautionary practices
			Offer education and training to officers and crew on: • Familiarity with duties in the implementation of Ballast Water Management on the ships they serve; • Requirements of the Ballast Water Convention, the ballast water and sediment management procedures and recording; • Ballast water management practices and systems and procedures used on board a vessel;
	Use, storage, leakage; and spillage of oil	Used/Waste Oil	Storage Labeling, Record-Keeping, and Storage Requirements • Provide receptacles for collecting used oil; • Used oil should be stored in holding tanks constructed above ground and the tanks must be kept in good condition and not leaking; • Leaking containers must be repaired or replaced; • Containers and fill pipes must be clearly marked ‘Used Oil’; • If used oil is spilled or released into the environment, it must be immediately collected and properly managed;

			• Records documenting the selected management practices should be maintained to verify compliance; • Institute Prevention Control and Countermeasure for storage tanks that hold large amounts of used oil (SPCC) requirements. Recycling Options; • Keep record of all waste oil generated; • Deliver to a used oil marketer; • Deliver directly to a licensed burner; • Burn in a used oil furnace on site; • Transport used oil to a state-recognized used oil collector.
	Combustion of fuel oil	Combustion gases - SOx, NOx, CO,VOC	• Use low-sulphur fuel; • Demand use of efficient engines for complete combustion to minimize generation of soot and VOC; • Fit catalytic convertors in the exhausts of ship transport
	Generation of wastes	Solid waste, human wastes	• Provide waste bins and other receptacles; • Design a waste management plan; • Put in place institutional and financial arrangements for managing the wastes; • Implement the waste management plan
	Oil Spill	Oil in water	• Raise alarm for Implementation of the Oil Spill Contingency Plan Measures
	Seepage collection in the hold of a ship tank	Bilge water: (– water contaminated with oil)	• Make bilge water pumping a requirement for all vessels; • Install bilge water filters; • Use portable oil/water separators to treat oil bilge water and contaminated fuel; • Install oil/water separators in bilges.
Road and Rail Transport	Use of oils as lubricants in engines and as brake fluids	Used oil; used oil filters, trace metals, dissolved organic pollutants (PCBs)	• Do not spill used oil on the ground; • Store used oil in clean plastic containers with a tight lid; • Clearly label waste oil containers • Do not mix used oil with anything else; • Take used motor oil to a service station or other location that collects used oil for recycling
	Generation	Grey and black	• Provide on-board toilets for travellers

	of human wastes	wastes	• Provide waste bins and other receptacles for solid waste. • Dispose waste in designated sites.
	Combustion of fuel	Particulate matter, sulphur oxides (SOx), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC)	• Use low-sulphur fuel; • Demand use of efficient engines for complete combustion to minimize generation of soot and VOC; • Fit catalytic convertors in the exhausts of road and rail transport
Air Transport	Operations	Liquid and solid waste	Provide receptacles
		Human wastes	Provide flush toilet with containers
		Waste oil	• Do not spill used oil on the ground; • Store used oil in clean plastic containers with a tight lid; • Do not mix used oil with anything else; • Take used motor oil to a service station or other location that collects used oil for recycling
	Combustion of fuel	Particulate matter, sulphur oxides (SOx), carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC).	• Use efficient engines; • Use low-sulphur aviation fuel

3.6 Institutional Waste

Institutional waste is waste generated in institutions. Such institutions may include schools, hospitals, research institutions, hospitals and hotels among others. A great amount of institutional waste is comprised of general wastes, generated by administrative sections, kitchen, staff houses,

class rooms, work-shops etc. Institutional waste can be hazardous or non-hazardous. For non-hazardous waste, the guidelines for pollution prevention and control are similar to those of domestic wastes. However, where hazardous materials are used, the wastes will contain hazardous materials either in solid, liquid or gaseous form.

Major sources of hazardous wastes include hospitals, where biomedical wastes are generated and laboratories where hazardous chemicals and radioactive material wastes are generated. Biomedical wastes are generated from both non-clinical and clinical sources. Some wastes from medical centres, veterinary hospitals and microbiological research laboratories pose specific and severe health hazards. For this reason, it is important to handle and manage the biomedical wastes separately from municipal solid waste and that management systems should be more strictly controlled. The management of biomedical waste requires its removal and disposal from the health care establishments as hygienically and economically as possible, by methods that at all stages minimize the risk to public health and to the environment.

Hazardous wastes are those produced in industries, institutes, laboratories and include the special wastes from hospitals. These are dangerous to the living organisms immediately or in the long run to the environment in which they are disposed. The hazard may be due to their physical, chemical, biological or radioactive characteristics. In some cases, various chemicals and their mixtures act as hazardous wastes. Certain hazardous wastes may cause explosions and fires. Hazardous wastes therefore require special handling. Therefore specific guidelines are needed to prevent and control pollution from such source.

3.6.1 Activities causing pollution and preventive measures

Table 3.6: Pollution preventive and control measures for institutional waste

Sub-Sector	Activity	Waste Type	Preventive and Control Measures
Medical Centres – Biomedical Waste	Generation of general wastes	i) Rubbish (non putrescible waste) ii) Garbage (putrescible	• Provide colour coded plastic holding bags • Segregate and recycle usable waste, e.g. paper, bottles, plastics; • incinerate combustible wastes e.g. wood for energy generation; • Compost to produce manure or recycle as

		waste)	animal food • On-site pit disposal, burning and sanitary land-filling
	Excreta, laboratory culture, tissues, contaminated equipment	Infectious waste	• Infectious wastes must be collected in tear-resistant and leakproof containers and transported to a central storage facility/delivery point in carefully sealed condition and without any transfer into other containers or sorting (containers marked with the "biohazard" symbol); • collect and transport in a way that precludes direct contact, and they may not be transferred into other containers at the central storage facility or during delivery; • They must be stored in such a way that gas formation in the collection containers is avoided; • Depending on climatic conditions efforts must be made to ensure that storage periods are as short as possible (e.g. storage at temperatures below +15°C for not more than one week or at a temperature of 3°C to 8°C for a longer storage period). • Infectious waste must either be incinerated (in approved incineration plant) or be disinfected prior to final disposal using a recognized method, preferably treated with saturated live steam; • Disinfected wastes may be disposed of in the same way as domestic waste. The disinfection plants must be operated under the operating parameters prescribed for waste disinfection, and this mode of operation must be documented; • The use of a mobile disinfection plant to treat infectious waste is permissible only if the waste disposer furnishes proof that the plant has been checked by a competent authority or an approved institution for its functional and operational reliability on a regular basis;

			• The efficiency of the vapour disinfection plant must be verified by a recognized institution when the plant is first put into operation and at regular intervals thereafter (e.g. twice a year);
	Human tissues or fluid	Pathological Waste	• Use double bags or containers of a specified colour coding, made of strong and leak-proof material for the collection of these wastes within the health-care establishments; Container should be labelled; • Incinerate in a household waste incineration plant or dispose together with household waste on a controlled landfill site.
	Needles, knives, broken glass, etc	Sharps	• Collect and manage separately from other wastes; • Provide re-usable sturdy and waterproof glass/metal box containers of specific colour with lid; • The collection containers must be puncture-resistant and leak-tight • Container should be labelled; • Store the wastes at a location accessible only to trained personnel. • Shred and bury deep; or • Incinerate on-site at above 1000^0C
	Expired medicines	Pharmaceutical Wastes	• Waste prevention: To reduce the generation of pharmaceutical waste, stocks of pharmaceuticals should be inspected periodically and checked for their durability (expiration date). • Explore possibilities for returning old pharmaceuticals to the producer or handing them over to a special collection system (e.g. pharmacies) for possible subsequent use; • Pharmaceutical wastes which are considered to be hazardous wastes have to be collected separately in appropriate containers. • Intermediate storage takes place at a location which is accessible only to trained personnel; • Provide plastic holdings;

			• Put plastic bags in waterproof containers of specific colour for this type of waste; • Containers should be labelled; • Shred and bury deep • Burn and dispose at sanitary land-fills
	Drugs used in cancer therapy, other genotoxic drugs	Genotoxic Waste	• Contain in covered and impermeable containers, under strictly controlled conditions. • Use coded solid containers for collection; • For reasons of occupational safety, these pharmaceutical wastes must be collected separately from pharmaceutical waste and disposed of in a hazardous waste incineration plant.
	Laboratory reagents, film developer, disinfectants, outdated chemicals	Chemical Waste	• Provide sturdy plastic holding bags • Put in a holding container of a specific colour for this type of waste with a lid; • Containers should be labelled;
	Batteries, broken thermometers, and blood pressure gauges	Contaminated Waste	• Segregate batteries by type; • Place non-conducting materials over electrodes to prevent shorting; • Arrange for pick up and recycling • Do not empty the liquid contents of lead-acid batteries; • Store lead-acid batteries upright in appropriate secondary containment in plastic bags, placed in plastic bucket containers, • Containers should be water proof, have lids of appropriate colour and labelled • Avoid using mercury containing thermometers and blood pressure gauges
	Gas cylinders and aerosol cans	Pressurized Containers and leakage	• Store them upright and in isolated and labelled areas • Undertaking regular maintainance • Crush and recycle aerosol cans • Explore possibilities for returning unsued presured containers to the suppliers
	Unused liquids from radiotherapy,	Radioactive Wastes	• Health-care establishments should segregate radioactive waste and store it within the required period to reduce the

	laboratory, contaminated glass-wares, packages and absorbent paper		activity level; • Once the activity concentration is below the clearance levels, the material may be disposed of through the appropriate methods; • Since the half-life of most radioactive materials used in hospitals is in the range of hours or days, storage for a period of one or two months can be followed by disposal to the ordinary waste system with appropriate monitoring • Decayed non-infectious radioactive waste is placed inside black plastic bags if they are intended for land-filling; • Decayed but infectious radioactive wastes are placed in yellow plastic bags in preparation for disinfection. They should not be used as landfill prior to disinfection • Use coded solid containers for collection; • For reasons of occupational safety, these type of wastes must be collected separately and disposed of in a hazardous waste incineration plant.

3.7 Mining and Exploration Waste

Mining wastes result from the extraction, beneficiation, and further processing of metal and industrial mineral ores. Waste categories from mining and mineral exploration include:

- Waste rock—material moved to gain access to the ore or mineral, including overburden (material overlying the area to be mined) but excluding topsoil and other soil materials that are reused in reclamation);
- Tailings—residuals (usually generated in a slurry form) from beneficiation processes; mine water—groundwater or precipitation that infiltrates mines during extraction; and
- Processing waste-residuals from processing after beneficiation, such as smelting and electrolytic refining operations.

Ore production and waste generation vary yearly in response to market and other conditions. The general nature of mining waste generation is that they do not indicate long-term trends or current generation rates. However, the amount of mine water may be quite high at mining sites, and effective management of acid mine drainage is a challenge at many active and inactive sites.

Similarly, processing ore to obtain marketable products leaves behind waste residues, mostly in slurry form, that must be managed. Depending on their nature, mineral processing waste can be either hazardous or non-hazardous. In most cases, it is also difficult to distinguish between solids/ slurries versus wastewater.

Wastewater in mining sites is usually managed in surface impoundments or ponds. Depending on the nature of the material, some of it may then be reused on-site, charged to surface waters, or injected underground. There is limited data on pollution controls and monitoring at mineral processing facilities.

3.7.1 Activities causing pollution and preventive measures

Table 3.7: Pollution prevention and pollution control guidelines in the mining sector

Sub-Sector	**Activity**	**Waste Type**	**Preventive and Control Measures**
Mining Subsector	Extraction	Waste rock, overburden	i) Use blasting techniques that make fewer small pieces; ii) Expand underground mining to minimize exposed surface areas; iii) Waste rock can be used in construction industry, road building, etc
		Dust	i) Reduce dust by wetting before blasting. ii) Use blasting techniques that make fewer small pieces; iii) Have chimneys with dust arrestors iv) Restrict blasting activities to morning hours when it's less windy. v) Wear protective gear eg mask, apron, etc
		Noise pollution	i) Wear protective gear eg muffler vi) Use equipment that produce less

			noise and vibrations
	Energy use	Sulphur and carbon emissions	i) Regular maintenance of mining equipments and use of low sulphur fuels. ii) Installation of catalytic converter to reduce carbon emissions. iii) Use of energy efficient equipments
	Beneficiation	Tailing residues	i) Build while retaining embarkments; ii) In-pit filling or co-disposal to backfill voids, reducing elevated waste heaps
	Groundwater, precipitation, infiltration, Processing of metal and industrial mineral ore (smelting and electrolytic refining operations)	Mine water and Waste residuals	i) Use of closed-loop recycling of solutions; ii) chemical or biological treatment of acids or cyanides; iii) the use of drip leaching instead of spray leaching; and iv) use of less toxic leaching and flotation reagents
	Post extraction management	Wasteland	i) Rehabilitation of waste land ii) Compliance with rules and regulations

3.8 Trans-boundary Waste

Due to the universality of environmental problems created by trans-boundary wastes, more than 100 countries of the world have signed the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Signature on the Basel Convention signifies that international agreement has been reached on some underlying principles governing either public health or safe management of hazardous waste. Countries that have signed this convention accepted the principle that the only legitimate trans-boundary shipments of hazardous waste are exports from countries without facilities or expertise to safely dispose of certain wastes to countries which have both facilities and expertise. Such exported waste should be labeled according to the UN recommended standards.

The underlying principles of the Basel Convention are: the “polluter pays” principle, the “precautionary” principle, “duty of care” principle and the “proximity” principle.

3.8.1 Activities causing pollution and preventive measures

Table 3.8: Pollution prevention and control guidelines for the exportation of hazardous chemicals and toxic waste

Sub-Sector	Activity	Waste Type	Preventive and Control Measures
Exportation of hazardous Chemicals/ toxic waste	Trans-boundary Export	Hazardous Chemicals, toxic waste	i) Apply the "polluter pays" principle: channel liability to the body that caused the pollution effect; ii) Apply the "precautionary" principle: design health and safety protective measures; iii) Exercise "duty of care" principle: take responsibility, apply utmost care; iv) Apply the "proximity" principle: Treat and dispose hazardous waste at the closest possible location from its generation source in order to minimize the risks associated with its transport; v) Prohibit tipping/dumping of such waste except in authorized areas; vi) Co-operate with other countries regarding management of hazardous waste; vii) Vet waste disposal firms for their capacity to manage hazardous waste; viii)Register and monitor (by NEMA) all waste disposal firms; ix) Lead institutions should verify waste imported/exported. x) Enforce EMCA (Waste Management) Regulations 2006

3.9 Wastewater treatment facilities

Except for Mombasa's west mainland, where an aerial/biological oxidation sewage treatment facilities has been installed for domestic wastewater treatment, and a few beach hotels; there are no sewage treatment facilities along the Kenya coast. Additionally, the treatment facilities have often faced operational problems due to poor management. This situation has resulted in the

discharge of wastewater directly into the ocean. To ensure efficient working of the existing wastewater treatment facilities, implementation of operational guidelines is mandatory, with those tabulated below, suggested to serve as the blue print for pollution prevention and control.

3.9.1 Activities causing pollution and preventive measures

Table 3.9: Pollution prevention and control guidelines for waste water treatment plants

Sub-Sector	Activity	Waste Type	Preventive and Control Measures
Waste water Treatment Plants	Wastewater treatment	Wastewater; sludge	• Establish operational wastewater treatment plants in all urban areas to enhance adherance to EMCA Water Quality Standards. Artificial wetlands offer alternative solution for instutions such as schools, prisons, etc • Ensure there is buffer zone between wastewater treatment plants and residential areas • Operate and maintain treatment plant equipment, including pumps, valves, filters, blowers, meters, and treatment, injection and pressure systems; • Perform daily water quality monitoring. Inspect the facilities regularly to monitor operations and identify potential operational and maintenance problems; • Develop and implement operational procedures, and safety measures; • Maintain manual and automated performance records, reports, and logs for regulatory compliance; • Respond to emergency situations, such as power outages, system alarms, and adverse water and wastewater treatment conditions; • Perform all wastewater treatment activities in accordance with policies, procedures, and safety policies • Dispose screenings into landfill sites or incenerate • Use sludeg from treatment plant as fertilizer

3.10 Septic Tank Sludge Disposal for Urban Centres without Wastewater Treatment Plants

Sewage sludge is an organic material produced in the treatment of domestic wastewaters. The amount produced has continued to rise steadily over the last decade. Treatment of sewage sludge or septic tank sludge followed by use as a soil conditioner can:

i) Capture methane to produce energy;
ii) Stabilize soil;
iii) Reduce the need for chemical fertilizer.

Use as a soil conditioner requires controls to avoid detrimental effects from:

i) Chemical contaminants;
ii) Pathogens.

Sewage sludge comes from mixed sources, often including industrial discharges and may contain chemical contaminants which have the potential to damage soil. There is an extensive research base showing the level of risk to the environment or human health when used as a soil conditioner. Because we understand the risks, we are able to effectively control them or identify where additional controls are needed.

It is known that treated sewage sludge can contain pathogens. Where this material is used on agricultural land, there is potential for transport into the food chain.

In Kenya, septic tank sludge is in most cases handled by non-water industry operators, some of whom still spread it untreated on land with few regulatory or voluntary controls. It is important that this limited practice does not undermine supply-chain confidence in the highly controlled use of treated bio-solids from the water industry as a soil conditioner.

3.10.1 Activities causing pollution and preventive measures

Table 3.10: Pollution prevention and control guidelines for septic tank sludge disposal for urban centres without wastewater treatment plants

Sub-Sector	Activity	Waste Type	Preventive and Control Measures
Septic Tank Sludge Management	Location and Disposal on land	Septic Tank Sludge	• Septic tanks and soak pits should be located at least 50 meters from water sources

	Drying on beds Heat drying Incineration Lagooning		• Cluster the treatment of septic tank sludge; • Empty effluent storage tanks regularly to avoid spillage, • Regular inspection of water levels to avoid overflows • Develop a common sludge collection point Ensure disposal of sludeg in designated disposal sites • Identify potential holding ground for sludge; • Coordinate sludge treatment practices; • Introduce a communications plan

CHAPTER 4: MONITORING AND EVALUATION

4.1 Introduction

The success of application of the pollution prevention and control guidelines will depend significantly on a number of factors including the level of awareness created amongst stakeholders; willingness of the users to apply them in their routine activities and how effectively they are monitored and evaluated. Besides creating awareness, it is also important that an effective monitoring and evaluation system is put in place to oversee the application of the guidelines.

4.2 Monitoring and Evaluation Objectives

i) To monitor and evaluate application of the guidelines in order to enhance the level of compliance to existing regulations on pollution management.
ii) To collect information necessary for review of the existing regulations and further improvement of the guidelines.

4.3 Monitoring and Evaluation Strategies

a. Establish a monitoring and evaluation system. The system should be clear on the monitoring schedules, the actors to carryout monitoring and the variables to be monitored.
b. Carry out evaluation. NEMA will partner with the relevant lead institutions to undertake evaluation on the use of the guidelines. The evaluation can be on the entire guidelines or sector based.
c. Institute appropriate and timely interventions to either review the existing regulations to respond emerging circumstances or make further improvement of guidelines based on the information gathered.

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