GSAR Journal of Agriculture and Veterinary Sciences ISSN: 3048-9075 (Online)

GSAR Journal of Agriculture and Veterinary Sciences
ISSN: 3048-9075 (Online)
Abbreviated key title: Glob.J. Agri.Vet.Sci.
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjavs-home/

EFFECTS OF RIVER DUMPING ON FISH BIODIVERSITY AND WATER QUALITY: A CRITICAL REVIEW

By

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Article History

Received: 15/06/2025
Accepted: 23/06/2025
Published: 25/06/2025

Vol – 2 Issue –6

PP: -145-159

Abstract

A lot of people do not know that, it is their day-to-day waste dumping activities that results to river dumping, such as household, urbanization, agriculture, industrialization and behaviour of waste management in the ecosystem. It is obvious that dumping of waste (liquid and solids) on land will find its way to the ocean through wind action and water runoff via gutters, streams, creeks, lakes, lagoons, rivers, all leading to the ocean as final dumping zone. The river system is being polluted due to inadvertent plastic dumping along the river. Consequently, the water quality is deteriorating day by day, which impacts fish diversity and other aquatic resources. Anthropogenic activities including wastewater disposal have nearly doubled inputs into the global cycle. Manmade activities have the potential to make an impact on the water quality of an aquatic ecosystem, depending on the water body, disturbance of the aquatic ecosystem may lead to changes in its parameters such as biological, chemical, and physical composition of the water. The high amount of refuse deposition on the river floor might be a potential threat that decreases river depth and may cause massive floods during the rainy season. The massive dumping of macro-plastics has also compromised the quality of consumable fish and aquatic organisms as well as the water purity of the river, continuing this practice in the aquatic systems would be a serious threat to its ecosystem components and be responsible for the spreading of vast micro-plastic sources through the coastal ecosystem. Hence, there is an urgent need to raise awareness among the common people regarding the fate and consequences of river dumping pollution. Every individual should be conscious of waste handling and management. Additionally, policymakers should focus on developing appropriate rules and regulations suitable for a country and its citizens. Finally, enforcement of laws in a proper way is required to reduce the severity of pollution in freshwater ecosystems which are the most affected by human waste pollutions.

KEYWORDS: *Threatened Biodiversity, Aquatic Pollution, Bioaccumulation, Waste Management, Ocean Littering*

INTRODUCTION

Water is a universal solvent that gives ample important advantages to human existence, survival, and continuity (Akankali and Onyeche, 2012). Anthropogenic activities are a result of man-made inclinations toward the ecosystem at large leading to increased pollution of water all over the world. These pollutants can be either organic or inorganic (Akram *et al.*, 2018). Anthropogenic activities including wastewater disposal have nearly doubled inputs into the global cycle. Manmade activities have the potential to make an impact on the water quality of an aquatic ecosystem, depending on the water body, disturbance of the aquatic ecosystem may lead to changes in the biological, chemical, and physical composition of the water (Arora *et al.*, 2018).

Waste dumping in Africa is becoming an increasingly insurmountable burden, with many of the natural habitats and bodies of water becoming severely polluted. Lake Victoria, for instance, which is one of the great African lakes and one

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of the largest fresh-water lakes in the world, adjoining Kenya, Uganda and Tanzania, is suffering from the effects of waste (Treaster, 2011). It is polluted with raw sewage, and has muddied from the erosion of soil from nearby hills which are losing trees and shrubs to people in search of firewood. Like Lake Chad in West Africa, and a few other lakes around the world, it has also been shrinking. In addition, parts of Lake Victoria are also clogged with hyacinths and algae that have been thinning out the fish populations (Treaster, 2011). Rapid urbanization and industrialization have attracted large numbers of people to cities, resulting in large of industrial wastewater and domestic sewage pollution increasing the pollutant load on these water bodies (Feisal *et al.*, 2023; Liang *et al*., 2021; Chen *et al.*, 2023), these problems deteriorate their water quality and weaken their ecosystems (McGrane *et al.*, 2016; Miller *et al.*, 2017; Xu *et al*., 2022). Despite efforts by the governments of Kenya, Uganda, and Tanzania to establish regulations on fishing and pollution, and organizing fishermen groups and restricting fishing of the most popular species, conditions in the lake have continued to deteriorate; with new fishing processing plants and industrial factories continuing to grow and dump their waste into the lake, greater interest from the international scientific community is needed to provide evidence to further regulate the industrial development around these great lakes.

AIM OF THE REVIEW

The aim of the review is on the effects of river dumping on water quality and fish biodiversity.

OBJECTIVES OF THIS REVIEW

The specific objectives of this review are to:

i. Review on the effects of river dumping on water quality;
ii. Review on the effects of river dumping on fish biodiversity.

EFFECTS OF RIVER DUMPING ON WATER QUALITY

Water quality is a general term used to describe the characteristics (physical, chemical, and biological) of water resources. It plays an important role in determining aquatic ecosystems and public health (He *et al.*, 2020; Uddin *et al*., 2022). It is a concern across the world due to the widespread release of pollutants into freshwater ecosystems (Zanoni *et al*., 2022). It plays a vital role in maintaining the ecological integrity of the river ecosystem (Viswanathan *et al*., 2015). As an important indicator of river health, water quality deterioration is a challenge to humanity (Zanoni *et al.* 2022) and is a critical challenge faced by many countries in Africa (Nkwanda *et al.*, 2021; Biswas *et al*., 2019; Borett *et al*, .2019) and other regions (Tiyasha., 2020).

Deteriorating water quality is stalling economic growth and exacerbating poverty in many countries. The explanation is that, when biological oxygen demand-the indicator that measures the organic pollution found in water-exceeds a certain threshold, the growth in the Gross Domestic Product (GDP) of the regions within the associated water basins falls by a third. Urbanization, population growth, unsuitability, untenable land use and industrialization are the main sources of the pollutants that lead to water pollution. These sources lead to the increase of gas emissions, wastes and excessive use of water. Thereafter, these actions result in eutrophication, population loss, lethal substances and acidification. In this regard, the effects of river dumping on water quality and biodiversity by heavy metals, chemicals and other pollutants on the health and quality of fish. Urban rivers play an important role in supporting economic and social development (Feisal et al., 2023; Larsen et al., 2016).

Lemessa *et al.* (2023) researched on the assessment of the impact of industrial wastewater on the water quality of rivers around the Bole Lemi Industrial Park (BLIP), Ethiopia. They reported that the analyzed water samples were unsuitable for consumption and fish survival. They stressed that water quality assessment is an important aspect of water resources management that can provide empirical evidence for investigating the level of water quality deterioration and implementing appropriate measures to reduce the effects of pollution. With increasing economic and societal development, the deterioration of river water quality has become increasingly prominent (Kuriqi *et al*., 2019). Maintaining a good level of river water quality is crucial for sustainable development and human health (Uddin *et al.*, 2022; Tripathu *et al.*, 2019). Studies about the changing characteristics of water quality and their causes have become a hot issue in the field of water sciences (Yu *et al.*, 2022).

River water quality is an important environmental concern that must be monitored (Chakravart *et al*., 2021). With a rise in people' s awareness of environmental protection, the monitoring of water quality in rivers has gained extensive attention for its use in sustainable urban development (Powers *et al*., 2016). Physicochemical water quality parameters play significant roles in assessing and monitoring river water (Rahama *et al*., 2016). Strong economic growth and urbanization contribute to the increase in industrial and domestic waste (Fakayode *et al*., 2005). Effluents can easily be discharged directly into rivers without wastewater treatment, resulting in reduced water quality (Ferezer *et al.*, 2012). Although rivers are essential natural resources that support socioeconomic development (human use, livestock drinking, irrigation, industries, transportation, recreation, etc.), they have largely been subjected to various anthropogenic sources of pollution (Barakat *et al.*, 2016). These include industries, among other sources (Mustapha *et al*, 2013; Oketola *et al*., 2013), that cause the deterioration of river water quality. Poorly treated and untreated industrial wastewater discharged into rivers has resulted in the pollution of rivers in Ethiopia (Worku *et al*., 2018). Although industrial parks provide economic benefits, their environmental costs-such as water pollution, loss of biodiversity etc.-result in the degradation of ecosystem functions and services (Legaspi *et al.*, 2015). In this trade off, a well-developed and science-based management of aquatic ecosystems is required. Such management should include knowledge of water quality

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(physical, chemical, and biological) data and other information (Levin *et al.*, 2009).

The World Health Organization (WHO) says that polluted water is water whose composition has been changed to the extent that it is unusable. In other words, it is toxic water that cannot be drunk or used for essential purposes like agriculture, and which also causes diseases like diarrhoea, cholera, dysentery, typhoid and poliomyelitis that kill more than 500,000 people worldwide every year. The main water pollutants include bacteria, viruses, parasites, fertilizers, pesticides, pharmaceutical products, nitrates, phosphates, plastics, faecal waste and even radioactive substances and they are triggered by anthropogenic activities. These substances do not always change the colour of the water, meaning that they are often invisible pollutants. That's why small amounts of water and aquatic organisms are tested to determine water quality (Iberdrola, 2024).

Shan-e-hyder *et al* (2023) researched on appraisal of climate change and sources of heavy metals sediments in water of the Kunhar River watershed, Pakistan. They reported that the Kunhar Rivers water quality is excellent, except for a slightly higher BOD value that can be minimized by preventing the dumping of human-oriented trash around the river or stream. They stressed the concentrations of metals in water have the trend of decreasing in water and specimens, indicating that the accumulation of metals on the sediment can affect the water chemistry of aquatic systems due to any physical or chemical process in the system. They opined that climate change will worsen the accumulation of these variety of metals to a huge risk on aquatic life.

Water pollution is one of the major complications in India in recent times which are affecting the lifestyle of humans, creatures and animals. The major effects of water pollution are experienced by fishes as it leads to their habitat degradation. Different human activities are the main causes of water pollution such as septic tanks, domestic wastes, nuclear waste, runoff from agriculture and other industries, pesticides, organic wastes and others (Malik et al. 2020). The use of different chemicals in industries has highly increased which is one of the core contributors in water contamination in India. Hence, the increasing level of water pollution is decreasing the quality of fish as well as health of humans are also affected by this issue (Malik *et al.*, 2020).

Aragaw and Giovanini (2022) researched on pollution potential of dumping sites on surface water quality in Ethiopia, using leachate and comprehensive pollution indices. They reported that dumping sites posed a considerable risk of pollution to adjacent water resources. They stressed that the overall Leachate Pollutions Index (LPI) ranged from 23.34 to 27.35, which is higher than the discharge standard LPI of 5.69, indicating that dumping sites can threaten the surrounding water resources and human health as well as aquatic lives. The physicochemical analysis of the leachates showed high TDS, with the presence of ammonia, nickel, lead, and cadmium which were above WHO and FEPA standards as employed (Rainbow, 1995 and Amaeze *et al*., 2012). The high level of solutes from a variety of decomposing and degrading materials may be responsible for the high turbidity reported, which eventually would impact the overall turbidity of the Lagoon. Biological contamination of water resources arises from unplanned settlements and associated poor sanitary conditions, as well as the improper disposal of wastes. Many human settlements are established in river catchment areas though many households do not have latrines or pit latrines, resulting in faecal material contaminating the surface and ground water resources. The lack of authority to control sanitary installations and the maintenance of sewer reticulation networks has led to the overflow of septic tanks and sewers (SDNP. 2006). Dumping in the rivers and lakes, particularly faecal contamination, has contributed to the spread of water borne diseases such as cholera, typhoid, and bilharzia. Cholera is one of the leading causes of morbidity and mortality (UNEP. 2016).

A study on the Accra metropolitan area in Ghana revealed that the major pollutants into the Densu, Lafa, and Bale rivers and the Gbegbe Lagoon were organic waste and faecal coliforms from runoffs from the municipal landfills or dump sites, together with indiscriminate defecation and refuse disposal into the water systems. This resulted in high levels of biochemical demand in order to purify the water (Nartey *et al.*, 2012).

Attah *et al.* (2023) researched on the assessment of microplastic pollution in selected water bodies in Rivers State, Nigeria. They opined that the present of plastics in water, sediment and fish tissues is very worrisome, as the water are used for domestic purposes and fish tissues consumed as protein by the inhabitants. They stressed that there should be urgent enlightenment on the possible danger of microplastics pollution which bring about microplastics pollution in the aquatic environment and to dissuade dumping of solid wastes in the rivers.

Bashir *et al*. (2020) researched on the concerns and threats of contamination on aquatic ecosystems. They opined that the discharge of various pollutants into aquatic environments is the outcome of countless anthropogenic activities, threatening the heath of the living beings and damaging the quality of the environment by rendering water bodies unsuitable (Abowei and Sikoki, 2005; Ekubo and Abowei, 2011). They stressed that the degradation of aquatic ecosystems is largely due to human activities as well as increased urbanization and industrialization are greatly responsible for water pollution. Human Contribution to water pollution is enormous, such as dumping of solid waste, wastes, industrial wastes and domestic waste. Water pollution is a major concern to the world and a major environmental education is very important to reduce the pollution of aquatic ecosystems.

In Malawi, 22% of the country’ s surface area is covered by lakes, rivers, and wetlands, while ground water quality is generally acceptable throughout the country, many surface water sources are polluted or under pressure from deforestation, unsustainable agriculture, settlements, mining, industry, commerce, tourism, and climate change that is

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causing flooding and droughts (Kandodo, 2017). Soil erosion caused by deforestation has increased sediment loads into the rivers, altering the directions or restricting the flow of the rivers, and causing flooding and further water pollution. Agricultural chemicals, such as inorganic chemicals, herbicides, and pesticides have also increased nutrient levels in the rivers and lakes, causing the proliferation of algal blooms (Kandodo, 2017). Effluents and solid waste from small and large companies are often dumped into the water bodies in Malawi due to insufficient waste disposal mechanisms. For example, the chemical values in the Lilongwe and Mudi rivers – the main water sources supporting Malawi' s two largest cities – have been measured with contaminants above safe limits. Large populations in informal urban settlements with low access to sanitation facilities also pose a great health risk to the local residents (Kandodo, 2017). Waste from factories and market sites in Malawi, which mostly remains uncollected by the official garbage collection or recycling system, finds its way into the Lilongwe river whose water is used by vendors for cooking, thus putting the lives of many people at risk. The waste that is dumped into the rivers also has some elements that are harmful to the biodiversity of the ecosystem. Thus, there is need for companies to implement waste treatment systems, rather than dumping directly into the rivers.

Waste dumping in Africa is becoming an increasingly insurmountable burden, with many of the natural habitats and bodies of water becoming severely polluted. Lake Victoria, for instance, which is one of the great African lakes and one of the largest fresh-water lakes in the world, adjoining Kenya, Uganda and Tanzania, is suffering from the effects of waste (Treaster, 2011). It is polluted with raw sewage, and has muddied from the erosion of soil from nearby hills which are losing trees and shrubs to people in search of firewood. Like Lake Chad in West Africa, and a few other lakes around the world, it has also been shrinking. In addition, parts of Lake Victoria are also clogged with hyacinths and algae that have been thinning out the fish populations.

A considerable problem caused by tourism in Africa is that while some hotels have their own water treatment systems, most of the smaller hotels and restaurants use the natural waterways to dispose of their waste. In addition, tourists generate more solid wastes than locals; with hotels, restaurants, shops, diving and adventure trip organizers all using large amounts of products that come in personal single-use plastic packaging (Quaade, 2018). Tourism development in Malawi is now also being affected by sewage and solid waste disposal. The Mangochi District Council of Malawi, for instance, does not have a sewage disposal system outside the town area, so holiday resorts have had to construct their own sewage and solid waste disposal systems. The UN says that more than 80% of the world's sewage finds its way into seas and rivers untreated. Constructing these disposal systems is costly and often unaffordable for the smaller hotels, meaning that this waste often ends up in the surrounding bodies of water, polluting the waterways and posing health hazards to humans and wildlife (Ngochera *et al.*, 2018). Waste in Malawi is also harming the prospects of further tourism, with poor ecological conditions becoming a detractor to any future potential tourists and industrial waste (SDNP. 2006). Tourism, however, remains the single largest driver of waste dumping into Lake Malawi. Many tourist sites around the lake act as locations for people to be able to interact with nature, which has resulted in numerous businesses arising to support the tourism activities, while providing employment to people from various different backgrounds and professions. Tourists visit Lake Malawi from all over the country, and from other countries, to explore the waters, and to taste the multitude of fish species that reside in the waters. In the process, however, there is a considerable amount of waste produced. Many lodges, hotels, and restaurants, for instance, deposit garbage and human waste into the lake; while many residents from the surrounding villages, such as those employed in the thriving tourism industry, dump food residues, defecate, wash, and bath in the lake. Tourists, too, dump large amounts of plastics and food items that they use into and around the lake (Tsuro, 2021).

Europe attracts some of the highest numbers of tourists, however many resorts have poor waste management records: some cases include waste dumping into the Mediterranean Sea where Turkey, Spain, Italy, and France were reported to dump 144, 126, 90, and 66 tons per day, respectively (WWF, 2018).Following legal action from the EU, and directives on bathing water and urban wastewater, 99% of the UK' s 632 designated beaches have, however, been largely restored and are deemed safe for swimming. This was achieved following considerable legal and financial motivations, requiring £30bn of investment by water and waste companies over more than two decades (Mosbergen, 2018). Aside from the major increase in safety to public health and the environment due to these improvements in water quality, they have also generated considerable economic benefits, with the UK sea side tourism industry now being worth £3.6 billion each year, and supporting 210,000 jobs in England and Wales alone (Tsuro.,2021).

Another problem area in Malawi is the Mulanje Mountain, which is affected by the dumping of plastics, such as plastic bags and bottles. These waste items attract pests such as rats and other smaller creatures, which have made the area extremely unhygienic and prone to disease. Additionally, when left in the open, the rain causes the plastics to leach chemicals into the soil, which further infiltrates and contaminates the streams and rivers. Water from Mulanje Mountain, for instance, is utilized by many Malawians; so the pollutants are directly affecting the health of the surrounding populations (Progression, 2019).

Plastics are currently considered one of the extensively distributed pollutants in aquatic environments (Emmerik *et al*., 2022; Blettler *et al*., 2017). Plastic is a general term for polymeric materials that may incorporate additional ingredients to enhance performance, decrease production cost, and/or generate the desired colour (Hahladakis *et al*., 2018; Li *et al*., 2016). Several assimilations of polymer resins make up the polymers needed to create desired plastic items such as

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polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinyl chloride (PVC), low-density polyethylene (LDPE), polypropylene (PP), polystyrene (PS), polycarbonate (PC), acrylic, and nylon, which are the common polymer types in plastic production worldwide (Li *et al*., 2016; Yuan *et al*., 2022; Law *et al*., 2022). Due to the frequent presence of plastic particles in the environment and the subsequent negative environmental impact, the growth in plastic deposition and resulting garbage have become a great concern in the freshwater ecosystem of Bangladesh. A massive expansion of the production of various plastic wastes on a global scale has been reported between 1950 and 2015 (Almeshal *et al.*, 2020; UNEP. 2018). About 6300 million metric tons (MMT) of plastic garbage was produced in 2015, of which 9% was recycled, 12% was burned, and 79% was piled up in the natural environment (Zhao et al., 2022; Winton *et al.*, 2020).

By 2050, approximately 12,000 million metric tons (MMT) of plastic garbage would remain untreated and 12,000 million MT would be burned, if the current production rate and waste management approaches continue (Zhao *et al.* 2022; Kasavan *et al*. 2020; Geyer *et al*., 2017). Plastic pollution has become a crucial environmental hazard and a potential threat to nature globally (Kasavan *et al*., 2020; Emmerik *et al*. 2020; Khan *et al*. 2020; Windsor *et al*., 2019).The final destination of land-based plastic debris is the freshwater and afterward the coastal environment; therefore, a massive amount of plastic litter from urban discharge, agricultural and industrial mismanaged products, domestic garbage, municipal sewage, and pluvial discharge are deposited into the freshwater river system (Blettler *et al.*, 2018; Giarrizzo *et al.*, 2019; Gonzàlez *et al.*, 2017). In turn, freshwater river systems are used to transport a large quantity of plastic garbage toward the oceans (Schmidt *et al.*, 2017; Lebreton *et al.*, 2017). However, previous studies reported that only a small proportion of plastic garbage has been transported by the rivers into the oceans, which means a larger amount is still retained within the river systems (Newbould *et al.*, 2021; Ryan *et al.*, 2021; Meijer *et al.*, 2021).

Henceforth, the freshwater systems are considered significant reservoirs of plastic debris globally (Emmerik *et al*., 2022). Due to the slow degradability and long persistency of plastics debris, most of it has existed for an extended period in the environment and macroplastics (>25 mm) are broken down into mesoplastics (5– 25 mm), microplastics (<5 mm), and nanoplastics (<100 nm) through the action of the sun, water, and other factors in the aquatic environments (Stock et al. 2019; Zhang *et al.* 2021; McGivney et al.2020). Much of the plastic pollution in the ocean comes from fishing boats, tankers and cargo shipping. Finally, the tiny plastic particles are consumed by fish and other aquatic creatures, with potentially harmful effects on the trophic web (Monteiro *et al*., 2018; Okunola *et al*., 2019). The nano, micro, and macro forms of plastics are reported to be linked with microbiological, chemical, and particle toxicities, and other hazardous consequences in aquatic ecosystems (Blettler *et al.*, 2017).

Amaeze *et al.* (2015) researched on coastal dump sites in the Lagos Lagoon and toxicity of their leachate on brackish water shrimp (*Palaemonetes africanus*). They observed that the major waste categories include fabrics (worn clothes), plastics, wood and wood shavings, glass, metallic objects as well as paper and packaging materials. The acute toxicity assessment of leachates from a dumpsite at Abule Eledu indicated moderate toxicity to brackish water shrimps (Palaemonetes africanus) with 96 hr LC50 value of 93.59% (935.9ml/L). The leachate was found to be high on biological and chemical oxygen demand, conductivity, total dissolved solids, nitrate and sulphate. The findings from this study indicate widespread and unregulated practice of coastal solid waste dumping with potential effects on water quality and biota.

The unsustainable practice of coastal dumping of solid waste in the Lagos lagoon is brought to the fore in this study and the findings indicated that it is widespread with minimal regulatory efforts to stop such practices. As per the opinions of Javed and Usmani (2019), the emergence of industrialization and globalization has enhanced waste in business organizations, which has directly affected water quality. Increased pollution has already polluted river water, while groundwater has also started to be affected. Additionally, increased waste has enhanced heavy metals in water bodies which have directly affected the health and survival of fish living in these water bodies. These heavy metals are non-biodegradable and dangerously toxic in nature. Consequently, these aspects have affected fish quality as well as affecting the health of their consumers. It has been observed that the high toxicity of these heavy metals plays a major role in changing the chemical and physiological structure and process of fish' s body systems. Chromium is among the most common and available pollutants along with iron. River contaminants are formed through different activities, including domestic waste, industrial and agricultural waste.

Chemical dumping from Industry, agriculture and livestock farming is one of the main causes of eutrophication of water. The UN says that more than 80% of the world's sewage finds its way into seas and rivers untreated (Iberdrola, 2024). As a nation, the United States of America (USA) generates more waste than any other nation in the world, from manufacturing, retailing, and commercial trade. According to one study, people in the USA deposit about 120 million tons of waste into landfills each year; while most industries and mining corporations dump their waste into the oceans, lakes and rivers (Sampat *et al*., 2021).

According to UNESCO (2003), the types of pollutants plaguing marine ecosystems includes sedimentation, agricultural run offs, thermal and light energy, sewage, solid wastes, chemicals, metals, radioactive substances, oil and biological materials. Thus, this finding in the Lagos lagoons conforms to the UNESCO assertions. The dominant solid wastes recorded in most of the dump sites surveyed were plastics which include nylons (polyethylene bags), containers,

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packaging materials and other plastic products. The dominance of plastics can be attributed to the frequency of use because of their low cost and their non-biodegradable nature. This corroborates the findings of (Ajao, 1996; UNEP, 2006) which noted widespread pollution of the Lagos lagoon. Polyethylene products can lead to suffocation of aquatic animals which mistakenly swims into them and when swallowed may result is blockages of tracts and eventually death. Nubi *et al*., (2008) in their study, reported that most of the wastes found in these dumps are persistent (non-biodegradable) in the environment, and continuously leach heavy metal into the water body. The presence of the solid waste dumps is an indication of unregulated anthropogenic activities in such areas and suggests a general lack of proper waste management service and control. Therefore the use of these open coastal spaces is preferred for its convenience as suggested by (Sankoh *et al.*, 2013). This trend is not unique to this region of Nigeria as it has been a striving trend in the western coast of Africa and other developing countries (Douglas, 1992). Environmental impacts of these coastal dumpsites include nauseating offensive odour, surface metal enrichment, microbial contamination, and human health hazard, the possibility of choking and eventually death of many marine animals. Ingestion of plastics, the releases of dangerous toxins and entanglement are often the major problems plaguing marine animals (UNEP, 2006).

Mousavi *et al.* (2023) researched on the impact of dumping sites on the marine environment: a system dynamics approach. They stated that dumping wastes into aquatic ecosystems put soil and coastline, water quality, mangroves and coral reefs, marine animals, food chains and plantation, and fishery at serious risk and alter the surrounding economic, social and cultural conditions of the environment. They stressed that suspended sediments and sewage disrupt environmental cycles at dumping sites during discharge, it increases turbidity- this impacts the lives of marine species, degrades water quality in general and has negative consequences on human health. They observed that it is necessary to charter practical solutions with a holistic perspective and implement novel designs using system dynamics. Aquaculture is the farming of aquatic organisms. The “ rapidly growing human population is creating an increase in the demand for fish worldwide” (Tidwell and Allan, 2001). The amount of “ fish captured in fisheries is no longer meeting this demand because the annual production of captured fish has not changed significantly since 2011” (FAO. 2016b). “ Aquaculture is becoming a more popular fish production method as it has an annual increase of 6% and is projected to produce over half of the fish consumed by 2025” (FAO. 2016b). “ Aquaculture has tremendous benefits for the humans like seafood production by fisheries and contributes with 15 to 20% of average animal protein consumption to 2.9 billion people worldwide” (Smith *et al*., 2010). The nutritional quality of aquatic products has “ high standard and represents an important source of macro and micronutrients for the people from developing countries” (Roos et al., 2007). Despite the undeniable benefits of aquaculture such as the provision of good quality and accessible food for population and the generation of millions of jobs and billion dollars in budget for the developing countries, the activity is one of the most criticized worldwide, mainly because of the environmental impacts (FAO. 2016c). The most common “ negative environmental impacts that are associated with aquaculture is water eutrophication, water quality, alteration or destruction of natural habitats, introduction and transmission of diseases” (FAO 2006b).

In 1988, a huge toxic waste has been dumped in a farming town in southeast Nigeria's restive oil-producing Delta region, a state government official and a community leader said on Wednesday. The community leader, Collins Edema, president of the National Association of Itsekiri Graduates, said the waste was dangerous to both agricultural produce and aquatic life. It was dumped in Koko, a town in the Warri north local government district of Delta state, said Thankgod Seibi, special assistant to the state's governor on community development (Odogwu and Taiwo, 2017). The waste was brought in from a foreign country into Nigeria and dumped at Koko. The state government has not done anything about it yet, he said. Seibi did not give details of the foreign country. They were called “ the drums of death” . Over 3,500 tons of hazardous waste, packaged in innocent-looking barrels, and shipped to an obscure village in Delta State, causing mayhem, igniting national outrage and eliciting global concern. That was in June, 1988; when Nigeria had no comprehensive environmental laws; when we responded to ecological crisis on an ad hoc basis (Odogwu and Taiwo, 2017). An Italian trickster, Gianfranco Rafaelli, claimed he was shipping residual chemicals and raw materials for a proposed fertilizer manufacturing company to Nigeria. He deceived Nigerian authorities and passed through with his toxic shipment. The killer cargo got to Koko Port – in the present Warri North Local Government Area – from Lagos and finally landed in the backyards of Mr. Sunday Nana, a grandson of the legendary founder of the town, Chief Nana Olomu, (both of whom are now late). As Nana innocently accepted the cargo for safe keep on his land, he unwittingly embraced the Grim Reaper’ s cauldron of afflictions. Influenza, fever, and death followed. The rest is now a well-rehashed history (Odogwu and Taiwo, 2017).

As if the tragic incident was a fortuitous inoculation, Nigeria came to life with the needed structural institutions and processes not only to tackle the emergency, but to prepare for the future. Through diplomatic channels, our government succeeded in getting the Italian government and the Italian company that was the culprit to lift the toxic consignment out of the country. The Nigerian government then followed the repatriation of the poisonous waste by organizing an international workshop on the environment. The result was the formulation of a National Policy on the Environment. Consequent to that, the Federal Environmental Protection Agency (FEPA. 1988) was created and charged with the administration and enforcement of the environmental law. Interestingly, being that it was a military regime, a more aggressive approach was deployed in dealing with such man-made, treacherous ecological breach. The government enacted

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the Harmful Waste (Special Criminal Provisions) Act, 1988, to deal specifically with illegal dumping of harmful waste. From that pedestal, the country evolved its contemporary environmental protection mechanisms and institutions.

Today, agencies like the National Environmental Standards and Regulations Enforcement Agency and the National Oil Spill Detection and Response Agency are offshoots of the FEPA initiative of those days. However, with a current toxic-waste-dumping incident breaking in Koko, 29 years after the Italian affair, the question is whether these agencies are living up to expectation. Just last week, the Itsekiri Environmental and Human Rights Group, in Delta State, petitioned the Minister of Environment over alleged dumping of toxic and carcinogenic waste materials at Koko, by an oil waste management company named Ebenco Global Link Limited. The group in a statement by its coordinator, Mr. Tony Ede, and two others alleged that the toxic materials were dumped in about four acres of excavated pit in Koko community (Odogwu and Taiwo, 2017). According to the statement, " to verify the toxicity of the contents of the sludge and slurry dumped in Koko, we took samples of storm water, soil, sludge and slurry on January 11, 2017, for scientific analysis. The certificate of analysis obtained from our consultant laboratory and the environmental report prepared by Vertical Options Global Services Limited revealed that the environment around the waste dump site is found to be highly toxic and carcinogenic, as well as highly hazardous to health and environmentally unfriendly. Our petition is, therefore, a clarion call for an urgent intervention by the Federal Ministry of Environment to save the people of Koko from the expected devastating effects of the toxic and carcinogenic waste dumped in the town." (Odogwu and Taiwo, 2017). In the Channels Television report on the issue, a site was shown in a video, said to have been shot by a whistle-blower, depicting the actual burying of toxic-looking sludge and slurry in a fenced property. However, it has also been reported that the Federal Government has sent a team of investigators to Koko community to investigate the alleged dumping of toxic waste. Mrs. Amina Mohammed told correspondents last week in Abuja that the team from the ministry was to secure the site and ensure no more waste was dumped; find out who had contributed to the dumping so it could be contained; and then look at how the toxic waste was able to get into the community' s water in the first place (Odogwu and Taiwo, 2017).

There is a troubling aspect to this whole saga. If the Federal Ministry of Environment has just become aware of this toxic material dumping for the first time, then what happens to its supposed presence in the states and local governments? One is troubled that if perhaps Koko community did not raise the alarm, they would have continued receiving the cargoes of death! Citizens usually assumed that the government knows better; and is staffed by experts who have eagle eyes to identify vital breaches in governance (Odogwu and Taiwo, 2017). Even more troubling is the official reaction of the indicted indigenous company. Responding to the incriminating analysis by the Itsekiri and Human Rights Group, a top official of Ebenco Global Link Limited, Mr. Francis Akintunde, had said, " A discharged monitoring/effluent report is usually carried out and the analysis is usually sent to the Department of Petroleum Resources, and Federal Ministry of Environment on a quarterly basis. " The management of the company is at a loss about this issue, the claim by the proponent of this unfortunate saga that the result of the sludge analysis indicates toxicity is at variance with the statutory regulations of the government regulatory agencies. The so-called analysis purportedly carries out was not in the presence of the relevant regulatory agencies, representatives of Ebenco Global Link Limited, Koko community and other stakeholders." (Odogwu and Taiwo, 2017).

He pointed out that the chairman of the council, community leaders and stakeholders had visited the company to see things for themselves and were satisfied with its operations. The issue I have with Akintunde' s defense is that in referring to the company' s Environmental Impact Assessment, he tacitly said: " The EIA of our new site is ongoing" . I ask, how can the environmental impact assessment " be ongoing" for a company that is already doing business that is heavily impacting on the environment? It is like counting the bullets of soldiers when the battle is already on. Secondly, nobody can obfuscate the real issues with name dropping. He mentioned the people who had witnessed the company' s activities and " are satisfied that it is environmentally friendly" . In Nigeria, we already know that a lot of people, be they traditional rulers and government officials, can still be persuaded to look the other way or give a wrong testimony. Many people have a price. I think Nigerians should be aware that environment-related businesses all over the world know what the environment really means. The truth is that the stake is high; but we are yet to know the stakes. That is why some of us can afford to sell our ecosystem for peanuts.

History is repeating itself as locally, Koko was once a dump town, from an international perspective. Today, it is still singing the dump town' s dirge, now from a local perspective. Instructively, the company from where the toxic waste is allegedly transported to Koko is " Escravos" – Portuguese word meaning slaves. The indigenous company that collects and buries toxic material in Koko is blinded to its eco responsibilities by the monies it rakes in. That was exactly what drove the Calbert Brothers who shipped the drums of death to Koko three decades ago. Then, as safety laws in Europe and the US pushed toxic disposal costs up to $2,500 a ton, it found easy money in shipping to Africa at as low as $3 a ton (Odogwu and Taiwo, 2017). The Olusosun Nigerian dumpsite is a 100-acre (Jenkins, 2011) dump in Lagos, Lagos State, Nigeria. (Olusosun, 2012). It is the largest in Africa, and one of the largest in the world. The site receives up to 10,000 tons of rubbish each day. Waste from around 500 container ships is also delivered to the site, adding a substantial portion of electronic waste. Some of this material is treated with chemicals to extract reusable products resulting in toxic fumes being released. (Andrew, 2012). Around 500 homes exist at the site in shanty towns, occupied by residents

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who work at the dump scavenging for scrap to sell. The Big Picture (TBP. 2008). Olusosun landfill was once located on the outskirts of the populated area, however Lagos has, in recent years, undergone such massive expansion, that the site is now surrounded by commercial and residential areas (Olusosun, 2012).

Plate I: Dumped Debris into the River (Source: iStock Photo, 2024).

EFFECTS OF RIVER DUMPING ON FISH BIODIVERSITY.

Pollution is one of the biggest threats to biodiversity and the environment in the world. Solid wastes are often everyday by-products of households, commercial, and institutional entities, and include waste such as garbage, sludge from wastewater and water supply treatment plants, as well as other discarded materials from industrial operations. Moreover, heavy metals disrupt aquatic ecosystems such as aquatic fauna and aquatic flora. Heavy metals are the major sources of water pollution and it has been observed that heavy metals causes high damage in fish health that ultimately affects human health. These pollutants have also affected the diversity of fish and have created a major imbalance in aquaculture. Therefore, heavy metal toxicity has impacted the health and quality of fish and consuming them can affect the nervous system and damage sensitive organisms. The prevalence of pollutants and heavy metals has caused a major impact on the health and diversity of fish. Water is among the most important aspects associated with regular activities and the survival of living creatures. Hence, business organizations can focus on improving their waste releasing practices and incorporate sustainability approaches to improve the nature of waste and reduce harmful waste. Adopting these practice help to improve the quality of water by reducing pollution and also improve fish quality and health. Destruction of biodiversity. Water pollution depletes aquatic ecosystems and triggers unbridled proliferation of phytoplankton in lakes — eutrophication (Javed and Usmani, 2019).

Igbani *et al*. (2024) researched on the effects of river dumping on water quality and fish biodiversity: a global concern. They stated that river dumping depletes aquatic biodiversity and water quality due to human activities. They stressed that policymakers should enforce laws that prohibits indiscriminate waste dumping leading to aquatic pollution and endangering aquatic life. They equally observed that river dumping can introduce heavy metals via bioaccumulation to fish species tissues and affect human health through bioaccumulation into biomagnification leading morbidity and mortality.

Sonone *et al*. (2020) have opinionated about the effects of heavy metals and other pollutants on aquaculture which showcases that power plants, biochemical wastes, agricultural activities, electronic wastes, volcanic eruptions and others are the core sources of the heavy metals that affects the aquatic environment and the health of the fishes. Metal bioavailability and metal accumulation leads to habitat loss of the fishes and that creates a poor aquatic environment which eventually negatively affects the health of the fishes (Madhav *et al*., 2020).

Tsuro (2021) researched on the impacts of waste dumping in Lake Malawi. He observed that waste dumping reduces the number of tourist visitors to the Lake. He stressed that waste dumping affects the Inhabitants well-being, aquatic species abundance and diversity, and the Lake water quality. He stressed that for the lake not to lose it economic potentials: food supply, source of income, entertainment, foreign earnings, job opportunity, enhancing sport, home for game and wildlife species and other Cultural activities, such as swimming, therefore, proper waste management systems should be ensured for a healthy aquatic ecosystem.

Abdullah *et al*. (2022) researched on microplastics pollution in the Surma River in Bangladesh: A threat to fish diversity and freshwater ecosystem. They reported that the presence of microplastics affects water quality, freshwater ecosystem and fish diversity due to inadvertent plastic dumping. They also opined that the massive dumping of microplastics has also compromised the quality of consumable fish and aquatic organisms as well as the water purity of the freshwater ecosystem. They stress that, there's an urgent need to raise awareness among the common people regarding the fate and consequences of plastic pollution.

Manalo and Hemavathy (2023) researched on the effects of water pollution on the quality of fish. They opined that water pollution disrupts the growth of the fishes and decreases the quality of them. They noted that the percentage of fish population decreases as well as the percentage of fish decline also increases due to water contamination. They observed that these contaminants are formed through different activities, including domestic waste, industrial and agricultural waste and stated that heavy metals are the major sources of water pollution and it has been observed that heavy metals cause high damage in fish health that ultimately affects human health. Hence, these pollutants have also affected the diversity of fish and have created a major imbalance in aquaculture. They recommended that companies and business organizations should focus on improving their waste releasing practices and incorporate sustainability approaches to improve the nature of waste and reduce harmful waste by adopting best waste management practices which will help to improve the quality of water by reducing pollution and also improve fish quality and health.

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Coral reefs are considered to be important components of marine ecosystems. This is because " coral polyps are important nurseries for shrimp, fish and other animals" (Perkol-Finkel and Benayahu, 2007). The aquatic organisms that live within and around the coral reefs are at risk of exposure to the toxic substances within oil. They are rapidly degrading because of a variety of environmental and anthropogenic pressures. Thus, they are suffering significant changes in " species diversity," " species abundance," " species evenness," and " habitat structure" worldwide (Hughes *et al.*, 2007). " Oil dispersants are potentially harmful to marine life including coral reefs" (Shafir *et al.*, 2007). A study using coral nubbins in coral reef eco-toxicology testing (Shafir *et al.*, 2003) found that dispersed oil and oil dispersants are harmful to soft and hard coral species at early life stages.

Suzianti *et al*. (2023) researched on the anthropogenic disturbance of aquatic biodiversity and water quality of an urban river in Penang, Malaysia. They reported that anthropogenic activities trigger eutrophication, water quality condition as well as the distribution of aquatic species and a major factor to the loss of aquatic biodiversity over time, this made possible due to habitat degradation by pollution. They stressed that habitat degradation and pollution should be minimized to retain and conserve aquatic species as an important water quality indicator. Marine mammals include " bottlenose dolphins, fins, humpbacks, rights, sea whales, sperm whales, manatees, cetaceans, seals, sea otters and pinnipeds." The physical contact of oil with furred mammals affects these animals because they rely on their outer coats for buoyancy and warmth. Consequently, " these animals often succumb to hypothermia, drowning and smothering when oil flattens and adheres to the outer layer" (Lin and Tjeerdema, 2008). Physical contact is one of the major routes of exposure, and it usually affects seabirds. For example, thousands of African penguins (*Spheniscus demerus)* were oiled following the 2000 treasure oil spill in South Africa.

Chemical contamination is one of the biggest challenges to Lake Malawi, where chemical inputs such as fertilisers and pesticides have caused the death of large amounts of fish in the lake, and this is also posing a threat to human life (SDNP, 2006). Chemical contamination of the stream water feeding into the lake is becoming a common problem due to the improper disposal of industrial waste (Botolo, 2010). For instance, the Ntchila, which was the major commercially-fished species in Lake Malawi in the 1950s, is now threatened with extinction because of the increased levels of water pollution due to agricultural and industrial waste (SDNP, 2006).

Mousavi *et al.* (2023) researched on the impact of dumping sites on the marine environment: a system dynamics approach. They stated that dumping wastes into aquatic ecosystems put soil and coastline, water quality, mangroves and coral reefs, marine animals, food chains and plantation, and fishery at serious risk and alter the surrounding economic, social and cultural conditions of the environment. They stressed that suspended sediments and sewage disrupt environmental cycles at dumping sites during discharge, it increases turbidity- this impacts the lives of marine species, degrades water quality in general and has negative consequences on human health. They observed that fit is necessary to charter practical solutions with a holistic perspective and implement novel designs using system dynamics. Aquaculture is the farming of aquatic organisms.

The " rapidly growing human population is creating an increase in the demand for fish worldwide" (Tidwell and Allan 2001). The amount of fish captured in fisheries is no longer meeting this demand because the annual production of captured fish has not changed significantly since 2011" (FAO 2016b). " Aquaculture is becoming a more popular fish production method as it has an annual increase of 6% and is projected to produce over half of the fish consumed by 2025" (FAO 2016b). " Aquaculture has tremendous benefits for the humans like seafood production by fisheries and contributes with 15 to 20% of average animal protein consumption to 2.9 billion people worldwide" (Smith *et al.*, 2010). The nutritional quality of aquatic products has " high standard and represents an important source of macro and micronutrients for the people from developing countries" (Roos et al. 2007). Despite the undeniable benefits of aquaculture such as the provision of good quality and accessible food for population and the generation of millions of jobs and billion dollars in budget for the developing countries, the activity is one of the most criticized worldwide, mainly because of the environmental impacts (FAO 2016c). The most common " negative environmental impacts that are associated with aquaculture is water eutrophication, water quality, alteration or destruction of natural habitats, introduction and transmission of diseases" (FAO. 2006b).

Fish are considered a mostly affected biotic component in response to diverse forms of environmental stress in the aquatic ecosystem (Hossain *et al*., 2022; Islam *et al.*, 2022). Plastic litter may cause a notable reduction in total fish production or abundance in an aquatic habitat due to its adverse effect on the existing ecosystem (Kasavan *et al.*, 2020; Wagner *et al.*, 2014). Therefore, all the aforementioned issues ultimately can cause a serious threat to freshwater biodiversity and ecosystem services (Azevedo-Santos *et al.*, 2021; Chowdhury *et al*., 2019; Khan *et al*., 2022). Global inadequate management of plastic wastes, and its dispersion, bioaccumulation, and biological toxicity of micro- and nanoplastics impose a negative influence not only on ecology and animals but also on humans (Kasavan *et al.*, 2020; Okunola *et al.*, 2019; Consoli *et al.*, 2018)

Among the several human pressures on aquatic ecosystems, the accumulation of plastic debris is one of the most apparent but least studied. Plastics generate significant benefits to the human society" (Andrady and Neal, 2009), but due to its " durability, unsustainable use and inappropriate waste management plastics accumulate extensively in the natural habitats" (Barnes *et al.*, 2009). Because of " high mobility, plastic debris has practically permeated the global marine environment" (Cole *et al.*, 2011; Ivar do sul and Costa, 2014), including the " polar region" (Barnes *et al*., 2009),

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" mid-ocean islands" (Ivar do sul *et al.*, 2013), and " the deep sea" (Van Cauwenberghe *et al.*, 2013). The sources of marine plastics are not very well characterized. A rough estimation predicts that " 70 to 80% of marine litter, most of it is plastics, originate from inland sources and are emitted by rivers to the oceans" (GESAMP. 2010).

Plastics have been reported as a problem in the marine environment since the 1970s, but only recently the issue of plastic pollution in marine and freshwater environments been identified as a global problem" (Carpenter and Smith 1972). It has been reported that " single-use plastics (plastic bags and micro beads) are a major source of this pollution" (Desforges *et al.*, 2014; Perkins, 2015). Potential sources of " MPs include wastewater treatment plants, runoff from urban, agricultural, touristic, and industrial areas, as well as shipping activities, beach litter, fishery and harbors" (Zubris and Richards, 2005; Norén., 2007; GESAMP., 2010; Claessens *et al.*, 2011; Dubaish and Liebezeit, 2013).

Another " potential source is sewage sludge that typically contains more MPs than effluents" (Leslie *et al.*, 2012). A broad spectrum of aquatic organisms are prone to MP ingestion ranging from plankton and fish to birds and even mammals, and accumulate throughout the aquatic food web" (Wright *et al.*, 2013). Due to their large " surface-to-volume ratio and chemical composition, MPs accumulate environmental chemicals from the surrounding environment including metals" (Ashton *et al.*, 2010) and " persistent, bioaccumulative, and toxic compounds" (Koelmans *et al.*, 2013) transferring these contaminants from water to biota. " Plastic particles are also dominated by certain human pathogens like specific members of the genus Vibrio" . Therefore, MPs can act as a vector for waterborne " human pathogens" influencing the water quality. In addition, " plastics contain and release a multitude of chemical additives" (Rochman, 2013; Dekiff *et al.*, 2014) and absorb organic contaminants from the surrounding media (Bakir *et al.*, 2012). Compounds such as MPs can transfered to organisms upon ingestion (Zarfl and Matthies, 2010), this may increase " the chemical exposure of the ingesting organism and thus, toxicity" (Oehlmann *et al.*, 2009; Teuten *et al.*, 2009).

Water contamination" can be reduced from a " personal level" to " national and international level." Every individual has a duty to prevent pollution of water resources. " Water is a basic need for our survival," and hence it should be our first priority to keep all " water resources" free from contamination. There are various " sources of water contamination." Thus, the control of water contamination needs a range of preventive measures. " Measures of prevention and control are essential in improving the quality of water" and reducing the " costly treatment measures that are taken to treat water." Preventive measures and possible solutions to " control water contamination" are given as follows (Xiong *et al.*, 2015; Lan *et al.*, 2015; Xanthos and Walker, 2017; Barmentlo *et al.*, 2018):

- ❖ Do not throw rubbish away in places like the beach, riverside and water bodies rather put it in trash can.
- ❖ Use water wisely. Do not keep the tap running when not in use.
- ❖ Do not throw chemicals, oils, plastics, paints and medicines down the sink drain, or the toilet.
- ❖ Buy more environmentally safe cleaning liquids for use at home and other public places.
- ❖ Not to overuse pesticides and fertilizers in farms. This will reduce runoffs of the chemical into nearby water sources.
- ❖ Natural fertilizers such as peat, compost, manure should be preferred while gardening and farming.
- ❖ Implementing water quality laws they can help in protecting aquatic ecosystems by imposing acceptable concentrations of pollutants and prevents the release of pollutants into water resources.
- ❖ Proper use and disposal of chemicals prevent the contamination of aquatic environments.
- ❖ Use detergents with low or no phosphate because high phosphate content causes eutrophication of lakes.
- ❖ Control storm water runoff. As the storm water runoff flows over impervious surfaces, it collects debris, sediments, chemicals and other pollutants which can have negative effects on the quality of water if the runoff is left untreated.

Plate II: Contaminated water flushed into the river ecosystem (Source: iStock Photo, 2024).

CONCLUSION

Aquatic dumping or ocean littering starts from anthropogenic behaviour with their generated wastes and poor waste management attitude; due to urbanization, a lot of community dustbins were replaced by living structures-due to population blast and the alternative dumping sites are the aquatic ecosystems/waterways dump sites, such as rivers, streams, lakes and lagoons. Most people dump their wastes into gutters for the rains to flush into rivers and the seas by extension. The degradation of aquatic ecosystems are largely due to human activities, increased urbanization, industrialization and agriculture are greatly responsible for water pollution. This article has provided useful data on the effects of river dumping on water quality and aquatic biodiversity in the aquatic ecosystems. Human contributions to water pollution is enormous, such as dumping of solid wastes, industrial wastes, and domestic wastes. Water pollution is a major concern to the world; river dumping has compromised the quality of consumable fish and aquatic organisms as well as the water

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purity of the aquatic environment; continuing this practice of river dumping would be a serious threat to the aquatic ecosystem' s components and it will be responsible for water quality depletion, deterioration and destruction of aquatic biodiversity.

River dumping triggers flash flooding and increased flooding, rendering high plains to become wetlands; runoff move debris to block natural and artificial drainage systems. A change of debris dumping will save a fortune out of damages

RECOMMENDATIONS

Every individual should be conscious of waste handling and management. Environmental education is very important to reduce the pollution of aquatic ecosystems caused by marine littering by environmental experts, the government and Non-governmental organizations (NGOs). Regulatory bodies should spring into action to control the dumping of refuse along the river course, so as to prevent the extinction of aquatic life in the aquatic ecosystems. Individuals should separate their wastes into soft/solid/plastic or biodegradables (decomposing wastes) and non-biodegradables (i.e. not decomposing wastes) in their homes and the industries/companies (should treat their sewage before discharging into the aquatic ecosystems). Open defecation should be discouraged by humans to maintain adequate water quality and healthy potable water for livestock and man.

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