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Review Article

An Examination of the Ocean Pollution Risks in Nigeria: A Review

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ABSTRACT

Despite having a wealth of natural resources and a variety of ecosystems, the ocean suffers numerous pollution-related problems. Pollution, the discharge of unwanted and frequently hazardous waste elements, seriously threatens the integrity of the Earth's support systems and the survival of human cultures. Despite the global community's efforts in large-scale research initiatives like GEOTRACES1, IMBER2, and SOLAS3, which greatly enhanced the amount of data available, knowledge on ocean systems is still limited and unevenly distributed. The purpose of this review is to present knowledge about ocean pollution, specifically in Nigerian waterways.

Keywords: Water; Pollution; Public; Health and issue; Nigeria

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INTRODUCTION

Global review of Ocean pollution

The biosphere, rich in natural resources and ecosystems, is facing pollution issues, particularly in marine ecosystems. The ocean's vastness makes it a convenient waste dump, but over time, marine organisms may accumulate toxins, potentially causing fatal consequences.

Marine pollution, including oil spills, sewage, and industrial effluents, affects coastal waters through physical, chemical, and biological processes. Storm water transports waste into water bodies, affecting coral ecosystems. Sewage contributes nutrient enrichment, leading to phytoplankton blooms and eutrophication. High nutrient levels can cause algal blooms and aquatic plant infestations, affecting the water's ecology (Ajibola *et al*., 2005). The ocean's diverse and active nature provides ecosystem services like food security, climate regulation, habitat, cultural experiences, and nutrient cycling, promoting biodiversity and carbon sequestration across its surface, benthic, and coastal realms (Hattam *et al*., 2015). Climate change and human impacts are threatening ocean ecosystems (Hatje *et al*., 2021), causing habitat loss, pollution, and harmful algal blooms. The provision of goods and services for 7.8 billion people is also contributing to these changes (Desa, 2019). As the human population grows, the need for food, fuel, water, and sanitation increases, necessitating increased fertilizer consumption and nutrient runoff.

The risk of harmful Algal blooms (HABs) is expected to rise in emerging countries like South America and Africa by 2050 (Glibert, 2020). Ocean pollution and ocean degradation are closely related, causing negative health and social effects (Knap *et al*., 2002; Weihe *et al*., 2016). Over 80% of wastewater worldwide is untreated, potentially ending up in the ocean (Ryder, 2017). Human advancements in agriculture, industry, and technology have led to the use of trace metals and organic chemistry, which can contaminate marine ecosystems. These chemicals and their by-products can cause harmful effects on seafood consumption, microbial pollution, and natural toxins (Bell *et al*., 2017; Depledge *et al*., 2010; Miranda *et al*., 2021; Weihe *et al*., 2016).

The United Nations (UN) has announced the Decade of Ocean Science for Sustainable Development from 2021 to 2030 to promote ocean science and sustainable development (Fleming *et al*., 2019; Le Blanc *et al*., 2017). The primary goals are to stop degradation, foster sustainable development, and generate interdisciplinary science for understanding ocean ecosystems. The Decade aims to produce seven interconnected societal outcomes, including a "clean ocean" where pollution sources are minimized or eliminated, ensuring minimal inputs of pollutants and contaminants (Arico *et al*., 2020; Ryabinin *et al*., 2019).

The South Atlantic Ocean, between the Equator and the Southern Ocean at 60_S, is understudied due to disparities in institutional, scientific, and infrastructure capacities. The South Atlantic has reported lower levels of significant ocean-wide pollutants, including Hg and Pb. Insufficient information hinders proper understanding of natural processes, marine life impacts, policy advice, and South Atlantic Ocean governance due to limited, expensive, and challenging access to research vessels and equipment. (Anderson, 2020; Boyle *et al*., 2014; Hatje *et al*., 2018; Lamborg *et al*., 2014).

Scientific publications are significantly lower in the South(Inniss *et al*., 2016), and there is a low level of international collaboration, as evidenced by the low share of international co-authored articles (Isensee & Commission, 2020), despite the fact that the number of Atlantic researchers in the South (731) and the North Atlantic (807) is comparable (Valdés, 2017). Despite vast coasts and diverse ecosystems, there are few marine and ocean research institutes in the region, especially in low-income nations where traditional coastal communities heavily rely on fish-based diets (Foltz *et al*., 2019).

The effectiveness of transnational, interdisciplinary marine research in environmental preservation is hindered by limited capacities, including tools for conservation programs, integrated shipping regulation, environmental monitoring systems, and legally binding tools. (de Oliveira Soares *et al*., 2020; Lourenço *et al*., 2020).

The oil spill in the Atlantic Ocean was exacerbated by institutional and procedural constraints, including the ineffective creation of a federal group and lack of coordination among federal, state, and municipal administrative bodies. Civil society and non-governmental organizations contributed significantly to clean-up efforts. To ensure competent activities and preventive measures, regional organizations must establish an institutional framework (Deyoung *et al*., 2019), regional science, innovation, and technology policy frameworks like BRICs, South-South Framework, Galway and Belém Statements, and transatlantic cooperation mechanisms are effective starting points (Polejack & Barros-Platiau, 2020). The Decade of Ocean Science will be influenced by activities in the South Atlantic area, fostering international cooperation. Brazil, the first IOC member state to establish a national committee, organized five internal workshops to create a National Science and Implementation Plan, considering the unique characteristics of each region (Arico *et al*., 2020; Hatje *et al*., 2021).

The review aims at examining the risks associated with ocean pollution in Nigeria's coastal waters.

Ocean Pollution in Nigeria

Pollution is the release of unwanted, often hazardous waste material into the environment by human activity and is one of the major challenges of the present. Pollution endangers the stability of the earth's support systems and threatens the continuing survival of human societies. Pollution especially that of ocean is a great and growing threat to human health (Elenwo & Akankali, 2015). It is the largest environmental cause of disease in the world today, responsible for an estimated 9 million causes deaths per annum. It causes enormous economic losses, undermines national trajectories of economic development, and impedes attainment of the Sustainable Development (Elenwo & Akankali, 2015).

The ecological problem of pollution is mostly ignored in Nigerian health plans and development objectives. The argument that pollution is unavoidable, however, is no longer credible due to the development of green chemistry and the growing availability of inexpensive, renewable energy sources (Landrigan *et al*., 2020).

The ocean is a vast, highly dynamic, and large reservoir of unique diversity. It sustains life and provides numerous ecosystem services such as food provision, climate regulation, habitats, cultural service and biogeochemical cycling of nutrients, connecting the coastal, surface and benthic realms of the ocean and promoting the sequestration of carbon (Hatje *et al*., 2021).

Ocean pollution in Nigeria varies from different forms including release of raw sewage, oil spills, garbage dump and industrial effluents. These anthropogenic activities eventually caused significant environmental damages due to consequential change in salinity, temperature, oxygen level, siltation and nutrient enrichment of the ocean that particularly affect not only the aquatic lives but also the coral communities (Ajibola *et al*., 2005). Moreover, Ocean pollution is critically important but not fully recognized component of global pollution. It has multiple direct and indirect impacts on human health while the nature and magnitude of these effects are only beginning to be understood (Landrigan *et al*., 2020).

Toxic Pollution in Nigeria Ocean

Toxic pollution in the environment, particularly from toxins, has increased since the Industrial Revolution and is particularly prevalent in Nigeria's Atlantic Ocean coastline. This pollution poses significant threats to marine life and human health through the food chain. Sources include oil spills, oil exploration, agricultural runoff, and domestic waste. Industries near the marine environment, such as refineries, shipyards, and chemical companies, also contribute to pollution. Consumption of contaminated seafood is the main route of human exposure to these pollutants (Ali *et al*., 2019).

The Niger Delta environment has been severely impacted by anthropogenic activities, including industrial processes, domestic and agricultural use of Potential toxic elements (PTEs) (Onyegeme-Okerenta & West, 2023), and oil and gas exploration. Aquatic organisms like periwinkle, shrimps, and oysters accumulate large quantities of PTEs due to their habitat and feeding nature. Dietary intake of contaminated food, particularly shellfish, is a major source of total human exposure to toxic chemicals such as PTEs Onyegeme-Okerenta and West (2023). These PTEs are characterized by high levels of human toxicity, even at very low concentrations, and are classified as either "known" or "probable" human carcinogens. Studies have shown that some PTEs, such as lead, cadmium, copper, iron, and nickel, are above WHO limits (Basheeru *et al*., 2022), posing a great threat to the ecosystem. Chronic intake of shellfish with these PTEs has numerous deleterious effects, including cardiovascular, developmental abnormalities, skeletal, renal, liver, neurological, bone diseases, hematologic and immunologic disorders, brain and lung damage, various types of cancer, mortality, and behavioural changes.

A study in Lagos, Nigeria, found that coastal sediments in Apapa port were heavily polluted with heavy metals like Cr and Zn, compared to the USEPA guideline. This pollution is believed to be due to human-induced processes like dredging, oil spills, and ship garbage. Persistent organic pollutants (POPs), including Polycyclic Aromatic Hydrocarbons (PAHs) (Ashraf, 2017; Ee *et al*., 2005) are another major pollutant in the marine environment. Carcinogenic PAHs are a major source of environmental contamination, particularly in oil-producing states in Nigeria. A study in Lagos lagoon revealed high concentrations of all 16 USEPA priority PAHs across twelve locations, regardless of the source point (Basheeru *et al*., 2022; Carocci *et al*., 2016).

Research on PAHs in water, sediment, and fish from the Warri River in Nigeria revealed contamination from oil spills from a refinery (Asagbra *et al*., 2015). Out of 16 PAHs, 11 were found in sediments and the rest in fish and water (Moslen *et al*., 2019). The levels of persistent organic pollutants (POPs) were generally higher in sediment (Ogbeibu *et al*., 2014), with dieldrin and endrin accumulating more in fish tissue. Polychlorinated biphenyls (PCBs) in sediments and fish from dredged tributaries and creeks of River Ethiope were moderately to very high, with moderate to very high cancer risk for adults. PAHs, such as Naphthalene and Phenanthrene, are acutely toxic at whole body concentrations above 50,000ppm and deleterious, with Benzo(a)pyrene (BaP) being among the most toxic compounds. They potentially contribute to modern-day diseases, disrupt endocrine and immune systems, and neurobehavioral effects observed (Eyenubo *et al*., 2024). PAHs also have a short-term impact on the ecosystem, depleting oxygen for the survival of living organisms (Yawo *et al*., 2023).

Harmful algal blooms contribute to marine pollution, causing poisoning to humans, waterfowl, livestock, and dogs (Davies & Ogidiaka, 2019). These blooms produce toxins that can cause illness or death. Research shows the presence of CyanoHAB and BacillarioHAB genera in aquatic environments (Davies & Ogidiaka, 2019; Otene & Davies, 2013). Algal blooms are caused by excessive nutrients, mainly phosphorus, from fertilizers and detergents from industrial and residential areas, which enter watersheds through run-off (Davies *et al*., 2019).

Sources of Ocean Pollution in Nigeria

Pollution of the oceans is widespread, worsening, and in most countries poorly controlled. It is a complex mixture of toxic metals, plastics, manufactured chemicals, petroleum, urban and industrial wastes, pesticides, fertilizers, pharmaceutical chemicals, agricultural runoff and sewage. More than 80% arises from land-based sources. It reaches the oceans through rivers, runoff atmospheric deposition and direct discharges (Landrigan *et al*., 2020).

According to Ajibola *et al*. (2005) who worked on pollution studies of some water bodies in Lagos, Nigeria determined Pb, Cd, Cr, Co, Ni and Ag in the water samples collected from the Atlantic ocean, Lagos Nigeria and attributed high metal concentration to local pollution sources.

According to studies conducted by Ogbuka *et al*. (2022) on offshore oil spill response base and management of deep water/offshore oil resources in the Nigerian marine waters: a review, oil spillage is a major environmental thread in Nigeria. Between 1976 and 1996 Nigeria recorded a total of 4835 oil spill incidents, which resulted in a loss of 1,896,960 barrels of oil to the environment. In 1998, 40,000 barrels of oil from Mobil platform off the Akwa Ibom coast were spilt into the environment causing severe damage to the coastal environment. Oil spillage has led to very serious environmental damages thereby resulting in rapid decline in Fish, Planktons, Shrimps, Crabs, Cray Fish and other sea lives along the Coasts and portions of the Atlantic Ocean.

Consequently, in many communities located near oil installations in the Niger-Delta, even when no recent spill occurred, oily sheen can be seen on water, including freshwater, which people depend on for drinking, cooking and washing. Water samples from Luawii, in Ogoni, where there had been no oil production for 26 years since 1993, the water sample had 18 ppm of hydrocarbons, 360 times higher than the world health organization standard permissible limit of pollutants in drinking water. Another sample from Ukpeleide, Ikwerre, contained 34 ppm, 680 WHO standards (Adati *et al*., 2012).

Furthermore, based on the report corroborated by (Ogbuka *et al*., 2022) other incidences of oil spill result from economic sabotage involving oil stealing usually perpetrated by criminal elements operating within the territorial waters of the Nigeria. These illegal maritime activities result in widespread marine oil spills with difficulty associated with incident source identification, since they use unregistered and unknown vessels. On a global scale, it was reported that shipping activities involving oil transportation result in the release of about 600,000–1,750,000 tons of oil into the ocean yearly, while other reports corroborated that the shipping industry is the main oil polluting agent in the marine. Between 2010 and 2014, 5000 tons of the average of 10,000 billion tons of crude oil transported by sea annually spilled as a result of marine accidents.

Wabnitz and Nichols (2010) reported that around 0.2 to 0.3% of plastic products eventually ends up in the ocean, though, most plastics float on the sea surface, there are an increasing report on sunken plastic debris settling to the sea floor at all depth, others reported numerous white plastic shopping bags suspended upside down and freely drifting past a deep-sea submersible at depths of 2,000 m, looking like an assembly of ghosts.

Lusher *et al*. (2014) who worked on microplastic pollution in the Northeast Atlantic Ocean: validated and opportunistic sampling reported that microplastics were found in 94% of samples examined. A total of 2,315 potential plastic particles were identified ranging between 0 and 45 particles per sample. Microplastic density in the Northeast Atlantic was calculated as 2.46 ± 2.43 per m3 (median: 2, 95% CI: 2–2). They concluded that plastic particles are widespread in the sub-surface layer of the Northeast Atlantic Ocean and reported abundance is higher than reported for the western Atlantic (0.001 m_3), although in the same order of magnitude as previous studies from coastal California.

Abowei *et al*. (2011) reported that Ballast water discharged by cruise ships, large tankers, and bulk cargo carriers use a huge amount of ballast water, which is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port. Ballast water discharge typically contains a variety of biological materials, including plants, animals, viruses, and bacteria. These materials often include non-native, nuisance, exotic species that can cause extensive ecological and economic damage to aquatic ecosystems. When a larger vessel, such as a container ship or an oil tanker unloads cargo, seawater is pumped into compartments in the hull. Similarly, when a larger vessel is being loaded it discharges seawater from these compartments. The sea water is meant to help stabilize and balance a ship. Ballast discharges from ships are responsible for tar balls in the open oceans and seas, and can cause problems navigating tanker routes. Nevertheless, the discharge of ballast water only accounts for a small percentage of oil pollution in the marine environment

According to Adeyemo (2003) Intensive agricultural activities are a major threat to Nigerian fishery resources and their biodiversity. Most farmers, in order to increase their yields, use agrochemicals, which then are carried by run-off to the wetlands, thus changing the water chemistry, and triggering vegetation succession and other ecological changes. Aquatic pollution by agrochemicals results mainly from their widespread use in agriculture and in vector control campaigns.

Types of Ocean Oil Pollution

Oil Pollution: According to (Olugbemi, 2020), defines pollution as human-made or man-aided changes to the environment's biological, chemical, or physical quality that are detrimental or exceed permissible limits. Nigeria's primary natural resources include fossil fuels, metallic minerals, radioactive minerals, non-metallic minerals, and arable land, along with various radioactive and non-metallic minerals. Nigeria, Africa's largest oil producer, faces challenges like oil pollution, biodiversity degradation, and extinction due to its vast resources, despite being the 6th largest in OPEC.

Causes of oil pollution: There are two major causes of oil pollution. They are: Oil spillage and gas flaring.

Oil spillage: According to Adoga-Ikong and Adams (2019), an oil spill is defined as the release of hydrocarbon solvents and chemicals during mining operations, oil exploration and production, and other downstream activities. Oil drilling activities cause liquid spills, land contamination, soil damage, and agricultural impediment. The Niger-Delta region's agricultural land, brackish water, and mangrove swamps were severely impacted by the Shell-Bp Bomu II blowout in 1970 and Elf Obagi II disaster in 1972 (Emuedo & Emuedo, 2018). When oil spills into soil, it contaminates the area, rendering it infertile and creating a reservoir that can release hazardous substances. Because of the soil's porosity, spills and leaks can pollute surface and ground water due to gravity and capillary action (Wild, 2003).

In Nigeria, the first oil leak occurred in 1970 (Tolulope, 2004). A 570,000-barrel oil spill into the Forcados estuary occurred in July 1979 as a result of the Forcados tank 6 Terminal incident in Delta state, contaminating the adjacent swamp forest and aquatic ecosystem (Ukoli, 2005). Between January 17 and January 30, 1980, the Funiwa No. 5 well in Funiwa Field blasted an estimated 421,000 barrels of oil into the water. When the oil flow was stopped, 836 acres of mangrove forest within six miles off the shore were destroyed (Gabriel, 2004). Subsequent leaks that occurred after 1979 in Oyakama and Oshika villages resulted in hundreds of barrels of oil leaking into the surrounding environment, destroying vegetation and killing a high number of crabs, fish, and shrimp, respectively (Gabriel, 2004). Due to oil in the lake sediments, eight months after the incident, there was a significant embryonic shrimp death rate and decreased output (Keesing *et al*., 2018).

Oil spills in the Niger Delta are primarily caused by equipment failure, vandalism, oil blowouts, intentional releases, and tanker accidents, with sabotage, erosion, corrosion, and material defects also contributing (Nwilo & Badejo, 2006).

Gas Flaring

Gas flaring is the extraction and burning of surplus natural gas in areas without infrastructure, releasing tons of carbon dioxide into the atmosphere. Nigeria flares 17.2 billion cubic meters annually during crude oil exploration in the Niger Delta (Ishisone, 2004). Gas flaring in Nigeria's environment is detrimental to flora and wildlife, causing digestive tract irritation, liver damage, renal damage, metabolic imbalance, hormonal imbalance, and protein luteinisation. It also leads to thermal, chemical, and odour pollution, acid rain, and global warming (Action & Programme, 2005). The ozone layer is being depleted by carbon monoxide build-up, leading to 75% of Nigerian crude oil gas flares due to global oil exports. This heat pollution harms flora, plants, soil, and agricultural production(Ogunlowo, 2016). Flared gas poses significant health risks, including respiratory illnesses, kidney issues, neurological diseases, and even death, and its adverse effects extend beyond agricultural output (Ndubuisi & Asia, 2007).

Toxic Wastewater

Industrial activities like manufacturing and petrochemical processing release toxic wastewater into water bodies, contaminating marine environments and disrupting aquatic ecosystems, affecting marine organisms and human health (Gollakota *et al*., 2020). The release of toxic wastewater into water bodies contaminates aquatic ecosystems, leading to devastating effects on marine organisms and human health (Bashir *et al*., 2020).

Chemical pollutants in wastewater disrupt the delicate balance of aquatic ecosystems, causing bioaccumulation and biomagnification of toxins in marine life (Zhang *et al*., 2021). This can have severe consequences for human health, as these toxins enter the food chain and are consumed by human (WHO, 2006).

Wastewater effluents from industries, particularly in developing countries like Nigeria, are often untreated or inadequately treated, causing environmental health and safety issues. These effluents can lead to eutrophication and the growth of water-borne pathogens, posing risks to recreational water users. To comply with wastewater legislations and guidelines, adequate treatment before discharge is necessary. Proper planning, treatment, regular monitoring, and legislation are necessary to reduce discharge into receiving water bodies. Discharges of untreated or partially treated wastes containing algal nutrients, heavy metals, and toxicants can accelerate the deterioration of receiving waterbodies (Olaniyi *et al*., 2012).

Industrial development and urbanization lead to increased water consumption and pollution due to improper waste disposal. In developing countries like Nigeria, legislation often fails to meet effluent quality standards (Okereke, 2007). Industrial effluents, produced during industrial activities, are a major source of environmental pollution, posing health hazards. This burden on wastewater management and point source pollution increases treatment costs and introduces chemical pollutants and microbial contaminants to water sources (Bastian, 1993; Eikelboom & Draaijer, 1999; EPA, 1996; Mahvi *et al*., 2004).

Industrial activities and urbanization in developing countries like Nigeria have led to environmental deterioration and increased waste disposal issues. Untreated waste from factories in cities is discharged into inland water bodies, causing stench and discoloration (Akaninwor *et al*., 2007). Increased crude oil exploration in the Niger Delta has contaminated creeks, swamps, and rivers, posing public health and socioeconomic hazards (Kobayashi & Rittmann, 1982). Water quality is adversely affected by pollutants, making it harmful to human health. Public health protection requires adequate quality water (Edition, 2011)., free from pathogenic microorganisms and toxic substances (WHO, 2022).

Adequate legislation is crucial for controlling drinking water quality, as urban industrialization and development increase environmental demands and the need for global monitoring of river characteristics (Akaninwor *et al*., 2007).

Treating wastewater effluents is crucial for preventing water pollution and public health by preventing disease spread. This involves removing oxygen-demanding substances, separating solids, and recycling excess microorganisms back into the system (Abraham-Peskir *et al*., 1997). The Federal Environmental Protection Agency enforces environmental regulations on industrial discharges and pollutants, relying on conventional physicochemical procedures. Industrialization and supply chain complexity increase wastewater production, containing toxic components (Butarewicz *et al*., 2019) and adverse environmental impacts due to non-degradable chemical treatments (Rueda-Márquez *et al*., 2020). Wastewater analysis involves physicochemical, biological, and organic analyses, but routine analyses often overlook toxic effects (Butarewicz *et al*., 2019). Recent attention is on toxicity evaluation for industrial raw and treated effluents due to stringent discharge standards (Chavan *et al*., 2016).

Boating Pollution

The coastal environment is crucial in marine ecology due to ongoing human activities, acting as ecological buffers between terrestrial and deep-water environments. Human activities like land use and coastal development contribute to pollution, soil erosion, habitat degradation, and biodiversity loss in coastal areas, resulting in the decline of macrophytes, macroinvertebrates, and fish communities (Iburg *et al*., 2021).

Large disturbances like eutrophication and fishing in coastal zones are developing, while recreational boat traffic accumulation is emerging, but these concerns are less studied (Iburg *et al*., 2021). Rivers, often used for human habitation and recreation (Showell *et al*., 2016) can be polluted by various activities like housing, agriculture, and forestry (Fields, 2003).

Human activities such as land use and coastal development cause the flow of pollutants and nutrients into coastal waters and thus lead to hypoxia and soil erosion in coastal areas that are heavily influenced by many anthropogenic pressures in terms of habitat degradation and loss of biodiversity of organisms. A growing body of literature shows the decline of macrophytes, macroinvertebrates, and fish communities in degraded areas (such as low humidity and reduced ecosystem services). Aquatic organisms are the largest source of chemical diversity, and environmental degradation in resort areas can cause economic losses and public health issues (Alexander *et al*., 1992).

Garbage Dumping

Inadequate waste management infrastructure globally poses a threat, especially in coastal areas. It accumulates plastics, metals, and non-biodegradable materials in the ocean, posing risks to marine life. The issue is complex and influenced by fishing industry, fishermen, and tourists (Ronchi *et al*., 2019).

Coastal pollution is a major threat to marine ecosystems, causing harm from plastic debris and heavy metals. Microplastics can harm marine organisms, disrupt growth and reproduction, and absorb harmful substances. Heavy metals in seawater are toxicity-resistant and accumulate in the food chain. Pollution also disrupts marine metabolism, leading to stress, organ damage, and death. Insufficient waste management infrastructure and regulations contribute to the spread of diseases in coastal areas (Kaza *et al*., 2018).

Automobiles contaminating the Oceans

Nonpoint source pollution, involving small and large sources like cars, trucks, boats, and farms, contributes significantly to ocean pollution. Millions of motor vehicle engines release small amounts of oil daily, contaminating roads and parking lots (Basheeru *et al*., 2022; Cirino, 2021). The ocean's capacity to absorb and diffuse pollution is challenged by the current crisis, as the ocean has reached its limits since the industrial revolution, posing a threat to our environment (Simcock & Halpern, 2016).

The ocean is causing pollution in the form of contaminated fish, marine life, plastic, and dead zones. Since 1950, de-oxygenated oceans have quadrupled due to climate change and warming waters. Coastal ecosystems have drastically changed due to human activities, with immense ecological impacts (Breitburg *et al*., 2018). Global ocean contamination is caused by toxic chemicals from agricultural, industrial, landfill, mining, and road runoff (Nitonye & Uyi, 2018).

Effect of Ocean Pollution: Effect of Ocean Pollution in Nigeria

The harmful effects of oil spill on the environment are many. Oil kills plants and animals in the estuarine zone. Oil settles on beaches and kills organisms that dwelled there, it also settles on ocean floor and kills benthic (bottom-dwelling) organisms such as crabs. Oil poisons algae, disrupts major food chains and decreases the yield of edible crustaceans. It also coats birds, impairing their flight or reducing the insulates property of their feathers, thus making the birds more vulnerable to cold. Oil endangers fish hatcheries in coastal waters and as well contaminates the flesh of commercially valuable fish (Ronchi *et al*., 2019).

According to study conducted by Aghalino and Eyinla (2009) on oil exploitation and marine pollution: evidence from the Niger Delta, Nigeria reported that the toxicity of the oil spill demonstrated by the result obtained from a test which showed that 96.5% of the mangrove seedlings among other plants on the shoreline died within fourteen days of exposure to the oil film. Mba *et al*. (2019) worked on Causes and terrain of oil spillage in Niger Delta region of Nigeria reported that the physicochemical properties and heavy metals level of crude oil polluted soil discovered to affect the soil properties irrespective of seasonal variations. Different laboratory test on toxicity were performed and evaluated both the spatial and temporal impact of oil spill on the shore. They concluded that the biomarkers were sensitive to exposures with respect to these kinds of pollutions. Adelodun (2021) who worked on Plastic Recovery and Utilization from Ocean Pollution to Green Economy concluded that due to the abuse of plastics and their improper waste management, vast quantities are indiscriminately discarded on bare lands, oceans, sewers, and drainages which resulted in blockages and subsequent flooding in the cities. This condition often endangers human lives and properties. Whereas, oceanic plastic pollution disrupts ocean navigation, affecting marine productivity and causing the sudden death of some vulnerable marine mammals, thereby degrading the ecosystem. World Economic Forum 2019 concluded that if plastic pollution is not curbed, it will overpopulate and outweigh the Pisces on or before 2050.

According to Wabnitz and Nichols (2010) who worked on Editorial: plastic pollution: an ocean emergency reported that the bodies of almost all marine species, ranging in size from plankton to marine mammals, and including some of the wildest and most vulnerable species on the planet animals that make nearly their entire living far from humans now contain plastic. Sixty percent of 6,136 surface plankton net tows conducted in the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008 contained buoyant plastic pieces, typically millimetres in size. Plastics turn up in bird nests, are worn by hermit crabs instead of shells, and are present in sea turtle, whale and albatross stomachs. Over mammals, have been reported to ingest or become entangled in plastic debris, resulting in impaired movement and feeding, reduced reproductive output, lacerations, ulcers, and death.

Adeyemo (2003) corroborated that acute toxicity of pesticides to aquatic organisms has been seen by a large kill of fish associated with the accidental release of organochlorine pesticides (OCPs), such as DDT, toxaphene, dieldrin, aldrin, and heptachlor into the aquatic environment. Recently, several workers have reported the toxicity of these substances to Nigerian fish, and the substances have been suspected to be carcinogenic in fish and other aquatic organisms

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Impacts of Garbage Dumping on Aquatic Life

Plastics, single-use plastics, fishing gear, and microplastics pose significant threats to marine organisms, including sea turtles, seals, and seabirds. They can cause fatal injuries and ingestion. Non-biodegradable materials, like metals, also contribute to marine pollution, leaching harmful chemicals, disrupting ecosystems, and indirectly contaminating the food chain (Jambeck *et al*., 2015).

The impact of garbage dumping on marine life is profound and multifaceted:

- Marine animals often ingest plastics, causing harm and nutrient deficiency.
- Larger debris entangles animals, impairing their survival.
- Habitat destruction occurs when waste accumulates in coastal habitats, disrupting biodiversity and affecting marine organisms' growth and survival.

Plastics and Non-Biodegradable Materials

Plastics, a common waste, pose a significant threat to marine environments due to their ingestion by marine organisms. Microplastics, which persist in the ocean, can cause internal injuries, digestive blockages, and starvation. Larger plastic items can entangle animals, while non-biodegradable materials contribute to pollution.

Effect of Oil Pollution on Biodiversity

Nigeria can boast of a vast biological diversity, with approximately 7,895 plant species, 215 genera, 338 families, and 22,000 invertebrates and vertebrates' species discovered. The Niger Delta region in Nigeria, a top conservation priority, is largely unprotected despite its unique and diverse flora and fauna, according to the International Union for the Conservation of Nature (Glowka *et al*., 1994).

Crude oil has greatly benefited Nigeria, but oil pollution has adverse effects on the country's biodiversity. It leads to habitat destruction and loss of biodiversity, such as mangrove forests in Niger-delta areas, nipa palms replacing wildlife, and farmlands becoming infertile, impacting the right to adequate and healthy food (Ansah *et al*., 2022). The process of photosynthesis is also impaired as a result of the introduction of phytotoxins into the environment (Ebeku, 2006).

Other effects according to Adati *et al*. (2012) are: Nutritional deficiency and food shortages, destruction of traditional means of livelihood, migration and the rise of environmental refugees and militancy.

Effect of Toxic Wastewater

Degradation of wastewater can lead to decreased dissolved oxygen, physical changes, toxic substances release, bioaccumulation, and increased nutrient loads. While it benefits farming communities, it can also negatively impact ecosystems and communities (Holeton *et al*., 2011). The widespread use of toxic wastewater and inadequate treatment funding increase the incidence of diseases and environmental degradation, while intensive irrigation delays their harmful effects and negatively impacts groundwater quality (Mahmood & Maqbool, 2006). Excessive nutrient eutrophication and other constituents of wastewater effluents contribute to dissolved oxygen depletion, with bacterial breakdown and chemical oxidation consuming significant amounts of oxygen in receiving water bodies (Borchardt & Statzner, 1990). These effects may be immediate and short-term or may extend over months or years as a result of the buildup of oxygen consuming material in the bottom sediments (Environmental-Canada & U.S-EPA, 1999).

Untreated wastewater effluent can cause bioaccumulation and biomagnification of contaminants, causing stable substances in plant and animal tissues to accumulate in high concentrations, potentially affecting health and causing long-term chemical stability (Environmental-Canada & U.S-EPA, 1999; Holeton *et al*., 2011).

Biomagnification increases contaminants' concentrations in predator-prey food chains (Chambers & Mill, 1996), causing low concentrations of substances like organochlorine pesticides and heavy metals in wastewater. Despite other sources like industrial discharges and atmospheric contaminants, municipal wastewater remains a significant source of persistent bioaccumulates (Holeton *et al*., 2011).

Effects of Boating Pollution

According to Fields (2003)), Harrison Bresee, marine engineering advisor, identifies four main environmental impacts from recreational boating: occupational hazards, oil products, ship maintenance pollution, and sewage, with increasing sea noise pollution over the past 50 years (Hildebrand, 2009). Human activities can cause changes in marine environments and its organisms (Myrberg Jr, 1990; Popper *et al*., 2005). In recent years, many studies have examined the effects of anthropogenic acoustic disturbances on aquatic organisms (Santulli *et al*., 1999; Sarà *et al*., 2007; Scholik & Yan, 2001). These sounds, associated with transportation, seismic surveys, sonar, and many other anthropogenic sources, cause many types of effects on fish and marine mammals (Buscaino *et al*., 2010; Filiciotto *et al*., 2013; Popper *et al*., 2005; Smith *et al*., 2004; Wysocki *et al*., 2006). Many studies have shown both a decrease in species richness and the changing composition of aquatic macrophytes in shallow inlets due to recreational boating activities associated with infrastructure expansion (Iburg *et al*., 2021). For example, changes in the diversity and composition of macrophytes, and abiotic factors such as waves produced by ships and dumping dredge spoil, have been shown to alter the assemblages of fish and macroinvertebrates (Iburg *et al*., 2021).

Recreational boating negatively impacts aquatic plants, biodiversity, and stability of physiochemical variables, posing environmental challenges and causing numerous consequences for marine animals (Iburg *et al*., 2021).

Fields (2003) Ocean pollution includes nutrients, toxic substances, and compounds that bind to sediments, leading to algal blooms and reduced oxygen levels, and toxic substances potentially killing marine life. Adelagan (2004) and Asuquo (1999), highlight the ongoing water pollution in Nigeria, particularly in the Calabar River, causing adverse health and economic effects, emphasizing the need for coastal water quality protection.

Cruise ships significantly impact coastal areas(Warnken & Byrnes, 2004), but legal measures are limited. Regulatory requirements vary based on vessel size and usage. Commercial licensing enforces compliance for certain equipment, but it's difficult to determine mandatory and voluntarily adopted equipment (Byrnes *et al*., 2016). Numerous studies, both national and international, have examined boating operations, particularly their interactions with beneficial megafauna like whales, dolphins, seals, and turtles (Constantine *et al*., 2004; Stamation *et al*., 2010; Steckenreuter *et al*., 2012; Williams *et al*., 2002).

The boating sector's environmental impact and management practices have been under researched, with less focus on quantifying these impacts associated with vessel operation (Byrnes & Warnken, 2006; Byrnes & Dunn, 2020; Leon & Warnken, 2008). Pollution discharges and emissions, including garbage, sewage, and oil, as well as physical disturbances of habitats and fauna, contribute to environmental degradation (Steckenreuter *et al*., 2012; Wiley *et al*., 2011), by fouling organisms (i.e. antifoulants) (Carson *et al*., 2009; Singh & Turner, 2009; Turner, 2010) and oil spills (Andersen *et al*., 2008; Born *et al*., 2003; Dalton & Jin, 2010; Melville *et al*., 2009).

As sailing popularity increases, protecting the environment and human health in marine environments will be a challenge. Education and regulatory programs can help, but new boaters often underestimate the damage their new toys cause (Fields, 2003).

Effect of Anoxic on Aquatic Ecosystems

Anoxic water environments, is characterized by dissolved oxygen, pose a significant threat to aquatic ecosystems due to natural processes like eutrophication and anthropogenic activities like pollution (Muruganandam *et al*., 2023).

Anoxic conditions in aquatic environments are caused by excessive organic matter accumulation, microbial activity, and eutrophication, primarily due to agricultural nutrient runoff (Breitburg *et al*., 2018). Excessive nutrients like nitrogen and phosphorus cause algae blooms (Zhang *et al*., 2024), leading to hypoxic conditions (O'Boyle, 2020). Climate change, including rising temperatures, exacerbates this by increasing water stratification, reducing oxygen-rich surface waters and forming anoxic zones in deeper water bodies (Weinke & Biddanda, 2019).

The effects of Anoxic on Aquatic Ecosystems are itemized as:

1. **Biodiversity Loss**: Anoxic conditions negatively impact aquatic organisms, particularly aerobic ones, leading to biodiversity loss and fish population collapse. Oxygen-dependent species migrate to oxygen-rich areas or perish in anoxic zones, such as the Gulf of Mexico (Rabalais & Turner, 2019).
2. **Alteration of Food Webs**: Anaerobic conditions in aquatic food webs disrupt the food chain, replacing primary producers and herbivores with organisms adapted to low oxygen, leading to a less diverse and resilient food web (Orsi, 2018).
3. **Release of Harmful Substances**: Anoxic conditions can cause harmful substances like phosphorus and toxic metals to release from sediments, causing eutrophication and posing risks to aquatic life and human health (Diaz & Rosenberg, 2008).
4. **Impacts on Water Quality**: Poor water quality in anoxic waters, including foul odors, murky water, and harmful algal blooms, makes it unsuitable for recreational activities, fishing, and drinking, impacting communities economically (Diaz & Rosenberg, 2008).

Climate Change and Ocean Pollutants

The impact of ever-increasing climate change has added another layer of urgency to the growing problem of ocean pollutants (Basheeru *et al*., 2022). Climate change is causing polar regions to become secondary sources of persistent bio-accumulative and toxic substances (PBTs), causing a shift in the distribution of these substances. The semi-volatile nature of PBTs means that some of the global PBT burden is transported to polar regions. This shift is affecting the release of toxic chemicals from materials, stockpiles, and contaminated sites, as well as the distribution of chemical contaminants in air and water.

CONCLUSIONS

In conclusion, pollution seriously jeopardizes Nigeria's ecosystem health, biodiversity, and population well-being, particularly in coastal regions. Government, corporations, communities, and individuals must work together to address these problems. This entails investing in clean technologies and pollution control strategies, encouraging sustainable practices, and implementing strict environmental legislation. Nigeria can lessen the negative effects of pollution and save its natural legacy for future generations by working together.

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