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The Prevalence of Maritime Shipping and Transportation as a Major Source of Marine Pollution and Environmental Stress: an Academic Discourse

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Abstract:

This study examined the prevalence of maritime shipping and transportation as a major source of marine pollution and environmental stress within the context of growing global trade and economic development. Descriptive survey design was adopted for this study. The study was carried out in Imo state, Nigeria. The targeted population for the study consists of Public Health Personnel and Environmental Scientist in Imo State, Nigeria. A stratified sampling technique was used in selecting 75 Public Health Personnel and 75 Environmental Scientists in Imo State. This gave a total of 150 respondents, which formed the sample size for this study. The instrument used for data collection was a structured questionnaire titled "Maritime Shipping and Transportation with Marine Pollution and Environmental Stress Questionnaire" (MSTMPESQ). Face and content validation of the instrument was carried out by an expert in test, measurement, and evaluation in order to ensure that the instrument has the accuracy, appropriateness, and completeness for the study under consideration. The reliability coefficient obtained was 0.95, and this was high enough to justify the use of the instrument. The researcher subjected the data generated for this study to appropriate statistical technique such descriptive statistics to answer research questions. from the result of the data analysis the effect of maritime shipping and transportation on marine pollution. It was observed that the highest percentage (26.67) was recorded against "introduction of invasive species through ballast water," while the least percentage (22.67) was recorded against "Underwater noise pollution from ships". The result also shows that for mitigating strategies to marine pollution and environmental stress. It was observed that the highest percentage (27.33) was recorded against "Enforcement of stringent environmental regulations," while the least percentage (22.67) was recorded against "Public awareness and community engagement are equally important". The study concluded that although maritime shipping is indispensable to international commerce, environmentally responsible practices are necessary to balance economic progress with the protection. One of the recommendations was that shipping companies should adopt cleaner fuel alternatives such as low-sulphur fuel, liquefied natural gas, and other renewable energy options.

Keywords: Maritime Shipping, Transportation, Marine Pollution and Environmental Stress, Academic Discourse.

Introduction

Maritime shipping and transportation, which is still crucial to international trade, transports vast quantities of manufactured goods, food items, raw materials, and energy resources across continents. According to the United Nations Conference on Trade and Development, shipping is one of the most important pillars of the global economy, accounting for over 80% of global merchandise commerce by volume. Despite fostering international communication and economic growth, the industry's expansion has resulted in serious environmental issues. As illustrated by International Maritime Organization reports, intensified vessel traffic has contributed to growing levels of marine pollution and ecosystem disruption [1].

Among the primary environmental issues related to marine business include pollution from oil spills, ship engine emissions, sewage disposal, ballast water discharge, and antifouling chemicals. These pollutants commonly worsen water quality, threaten marine biodiversity, and upset the natural balance of coastal and ocean ecosystems. Ship-generated waste and accidental discharges continue to pose long-term risks to fisheries, coral reefs, and sensitive habitats. In the same vein, greenhouse gas emissions from vessels, particularly carbon dioxide and sulphur oxides, have intensified concerns about climate change and ocean acidification.

Given these facts, the primacy of maritime transportation as a contributor to mari006Ee pollution has become a major topic of concern in international policy and academic circles. Researchers are looking into measures to reduce environmental stress without compromising economic efficiency, such as technological innovation, stricter regulations, and eco-friendly shipping practices. As illustrated by International Energy Agency findings, cleaner fuels, improved vessel design, and better waste management systems are essential for greener maritime operations. Therefore, understanding how maritime operations affect the environment is necessary to develop balanced policies that protect marine ecosystems and advance global trade.

Statement of the Problem

Maritime shipping and transportation have become indispensable components of global trade and economic development, serving as the primary means through which goods, raw materials, petroleum products, and manufactured commodities are moved across nations. The increasing dependence on maritime transport has led to a rapid growth in shipping activities across oceans, seas, and coastal regions. While this development has contributed significantly to international commerce and economic integration, it has also intensified environmental concerns associated with marine pollution and ecosystem degradation.

Furthermore, many developing countries, including Nigeria, still experience challenges in enforcing effective maritime environmental protection measures due to weak regulatory frameworks, inadequate monitoring systems, poor waste management practices, and increasing pressure from international trade demands. The growing prevalence of maritime activities within Nigerian waters, especially around major ports and coastal regions, has heightened concerns about environmental degradation, aquatic habitat destruction, and public health risks linked to marine pollution.

Although several studies have examined maritime transportation from economic and commercial perspectives, limited empirical attention has been given to its prevalence as a major source of marine pollution and environmental stress, particularly within the Nigerian context. There is therefore a need to critically investigate the extent to which maritime shipping contributes to environmental pollution and identify sustainable measures capable of reducing its harmful impacts on marine ecosystems.

Therefore, the problem of this study is to examine the prevalence of maritime shipping and transportation as a major source of marine pollution and environmental stress, as well as to explore possible environmentally sustainable practices and control measures that can balance economic development with the protection and preservation of marine ecosystems.

Research objective

1. To determine the effect of maritime shipping and transportation on marine pollution
2. To identify the mitigating strategies to marine pollution and environmental stress

Research question

1. What are the effects of maritime shipping and transportation on marine pollution?
2. What are the mitigating strategy to marine pollution and environmental stress?

LITERATURE REVIEW

Concept of Maritime Shipping and Transport

Maritime shipping and transport refer to the movement of goods and people across seas, oceans, and other navigable waterways using ships and other vessels. It is a major part of global trade, as large quantities of cargo such as raw materials, manufactured goods, and energy resources are transported between countries through sea routes. This system includes ports, shipping companies, cargo handling facilities, and logistics networks that work together to ensure efficient delivery from one location to another.

According to Rodrigue and Notteboom [2], maritime shipping and transport refer to the movement of goods and passengers across oceans and seas through organized shipping systems that

form the backbone of international trade. The majority of international trade is transported by sea, which is recognized as the most cost-effective method of transporting large goods across long distances. It includes a range of vessel types, such as container ships, bulk carriers, and oil tankers, along with essential port infrastructure and logistical services that ensure effective cargo processing and distribution. The idea also encompasses international agreements, safety requirements, and regulatory structures that control maritime activities and encourage effectiveness and environmental responsibility.

As illustrated by Stopford [3], maritime transport operates within an integrated global network of sea routes, ports, and intermodal systems that connect maritime activities with inland transportation modes such as rail and road. The success of maritime shipping is influenced by a number of factors, including international economic conditions, fleet management, port efficiency, and technological improvements. Recently, there has been an emphasis on sustainability, digitization, and marine security to address environmental concerns, reduce emissions, and combat issues like supply chain disruptions and piracy. Therefore, maritime shipping and transportation are essential for global connections, economic growth, and international trade.

Concept of Marine Pollution

Marine pollution refers to the introduction of harmful substances or energy into the ocean and coastal environments, resulting in adverse effects on marine ecosystems, human health, and economic activities. These pollutants originate from both land-based and sea-based sources, including industrial discharge, agricultural runoff, plastic waste, oil spills, and shipping activities. The concept of marine pollution has expanded in recent years to include not only visible contaminants such as plastics and oil but also less visible stressors like chemical toxins, microplastics, noise pollution, and thermal pollution [4].

According to recent studies, marine pollution is a complicated, multifaceted problem that is intimately related to both human activity and environmental change on a worldwide scale. The majority of marine pollution comes from land-based sources, with rivers serving as important conduits for the movement of plastics and other garbage into the ocean. Microplastics, in particular, have gained attention due to their persistence, widespread distribution, and potential to enter the food chain, posing risks to marine organisms and human health [5]. Furthermore, eutrophication, which results in dangerous algal blooms and oxygen depletion in marine environments, is caused by nitrogen contamination from fertilizers.

The idea also encompasses the long-term and cumulative effects of contaminants on marine biodiversity and ecosystem functioning. Marine pollution can harm habitats like mangroves and coral reefs, upset food webs, and make marine systems less resilient to climate change. As a result, addressing marine pollution requires an integrated approach that considers ecological, social, and economic dimensions [6].

Nature of Maritime Transportation

Maritime transportation is a fundamental mode of global movement of goods and passengers, characterized by its large-scale capacity, cost efficiency, and strong dependence on international trade dynamics. It is widely regarded as the backbone of global commerce, accounting for over 80–90% of world trade by volume due to its ability to move bulk cargo over long distances at relatively low cost compared to other transport modes . One of the key features of maritime transport is its economies of scale, where larger vessels reduce unit transportation costs, making it highly suitable for commodities such as oil, minerals, and agricultural products. Additionally, maritime transportation operates through an interconnected system of ports, shipping routes, and logistics networks, making it an integral part of global supply chains and international trade facilitation. However, its nature is also shaped by slower transit times and dependence on port infrastructure, weather conditions, and navigational routes, which distinguish it from faster but more expensive modes like air transport.

Another important nature of maritime transportation is its dynamic and evolving structure influenced by technological, environmental, and geopolitical factors. Modern maritime transport is characterized by containerization, automation, and digitalization, which have significantly improved efficiency, safety, and cargo handling processes. To strike a balance between meeting human needs and protecting natural resources for future generations, it incorporates social, economic, and environmental factors [7]. At the same time, the sector faces challenges such as environmental

sustainability, climate change impacts, and disruptions from global crises like pandemics and geopolitical conflicts. These challenges highlight the concept of resilience, defined as the ability of maritime systems to anticipate, adapt, and recover from disruptions while maintaining operational continuity.

Components of Maritime Transportation

Moving cargo and people across oceans and inland rivers is made easier by the complex system of maritime transportation, which is made up of a number of interconnected parts. These components collectively ensure efficiency, safety, and sustainability in global shipping operations, which account for over 80% of world trade by volume [1].

- **Shipping vessels**

Shipping vessels, which are the main mode of transportation, are one of the essential elements. These include passenger ships, bulk carriers, oil tankers, and container ships, each of which is made to carry particular kinds of cargo and meet particular operational needs. Advances in ship design, including larger vessel sizes and energy-efficient technologies, have improved transport capacity and reduced emissions [8].

- **Seaports and terminals**

Another crucial element is seaports and terminals, which serve as centers for the loading, unloading, and processing of cargo. To handle a variety of cargo types, ports are outfitted with specialist terminals like container terminals, liquid bulk terminals, and dry bulk terminals. Efficient port infrastructure and management systems significantly influence shipping turnaround time and overall logistics performance [9].

- **Cargo handling equipment and facilities**

Cranes, conveyors, automated guided vehicles, and storage systems are examples of cargo handling facilities and equipment that are closely related. By cutting down on loading and unloading times and decreasing human error, these devices improve operational efficiency. Automation in cargo handling has become increasingly important in modern ports to meet rising trade demands [10].

- **Maritime workforce**

Seafarers, port operators, logistics managers, and marine regulators make up the maritime workforce, which is another crucial element. Managing port logistics, operating vessels, and ensuring adherence to environmental and safety regulations all demand skilled workers. Continuous training and certification are necessary to adapt to technological advancements and evolving industry regulations [11].

- **Navigation and communication systems**

Navigation and communication systems, which guarantee the safe and effective movement of vessels, are another essential element. Technologies such as the Global Positioning System (GPS), Automatic Identification System (AIS), radar, and satellite communication provide real-time tracking, route optimization, and collision avoidance. These systems are critical for maintaining maritime safety and operational efficiency [12].

- **Regulatory and institutional frameworks**

The governance structure of maritime transportation is composed of institutional and regulatory frameworks. National marine agencies and international organizations like the International Maritime Organization (IMO) create and implement regulations pertaining to environmental preservation, shipping operations, and safety. Compliance with these regulations ensures sustainable maritime practices and reduces risks associated with marine pollution and accidents [13].

- **logistics and intermodal transport systems**

Lastly, maritime transportation is integrated with other modes like road, rail, and inland waterways through logistics and intermodal transportation networks. Because of this connectedness, items may travel smoothly between supply chains, increasing trade efficiency and cutting down on transit times. The increasing adoption of digital logistics platforms has further enhanced coordination and transparency in maritime transport systems [14].

The Prevalence of Maritime Shipping in Nigeria

As the main means of international trade and a vital force behind economic growth, maritime transportation has a significant impact on Nigeria's economy. Nigeria mostly depends on maritime transportation for the import and export of goods because of its advantageous location along the Gulf

of Guinea and access to the Atlantic Ocean. Recent estimates indicate that over 80% of Nigeria's international trade by volume is carried out through maritime shipping, highlighting its prevalence and importance in national and regional commerce [1].

A large amount of West Africa's cargo traffic is handled by the nation's major seaports, which include Lagos (Apapa and Tin Can Island), Port Harcourt, Onne, and Calabar. Lagos ports are among the busiest in sub-Saharan Africa, handling the majority of containerized traffic. The high volume of maritime activities reflects Nigeria's dependence on imported manufactured goods, machinery, and petroleum products, as well as the export of crude oil, which remains the backbone of its economy [15]. This significant dependency highlights how important maritime shipping is to maintaining trade flows and bolstering industrial activity.

Globalization, population expansion, and rising consumer demand have all had an impact on Nigeria's maritime shipping prevalence in recent years. The expansion of port infrastructure and modernization initiatives, such as the Lekki Deep Sea Port, are aimed at improving capacity and efficiency to accommodate growing trade volumes [16]. Additionally, although there are still difficulties, digitalization in port operations and shipping logistics is progressively improving turnaround times and lowering congestion.

Despite its importance, the maritime industry has a number of problems, such as port congestion, poor infrastructure, Gulf of Guinea piracy, and ineffective regulations. These difficulties may impede the efficient operation of marine commerce and raise shipping expenses. Nevertheless, ongoing reforms and investments in port development and maritime security are expected to strengthen the sector's performance and sustain its dominance in Nigeria's trade system [17].

Effect of Maritime Shipping and Transportation on Marine Pollution and Environmental Stress

Marine pollution is greatly impacted by the introduction of invasive species through ballast water. To maintain stability, ships frequently take in ballast water in one area and release it in another. Bacteria, plankton, and small aquatic creatures are among the marine organisms that are inadvertently transferred across habitats by this method [18]. These non-native species have the potential to become invasive, upsetting ecosystem balance, outcompeting native species, and changing food chains. With long-term effects on fisheries and biodiversity, the spread of invasive species is increasingly regarded as one of the main ecological risks associated with maritime transportation.

Also, oil pollution via unintentional spills, leaks, or unlawful oily waste discharge is one of the most obvious and detrimental consequences of maritime shipping. Toxic materials are introduced into marine environments by oil spills, covering marine species and interfering with their physiological processes. According to Walker [19], fish, seabirds, and marine animals may perish as a result, and coastal ecosystems like coral reefs and mangroves may be harmed. Long-term environmental deterioration results from the accumulation of even minor, regular discharges.

Another significant impact of maritime shipping on marine pollution is air pollutants and ocean acidification. Pollutants include carbon dioxide (CO_2), sulfur oxides (SO_x), nitrogen oxides (NO_x), and particulate matter from fuel burning is released by ships. These emissions contribute to ocean acidification and climate change in addition to deteriorating air quality. The pH of the ocean is lowered as CO2 dissolves in saltwater, which has an adverse effect on marine life like corals and shellfish that depend on calcium carbonate for their skeletons and shells. Therefore, shipping emissions are a major environmental stressor that has an impact on global climate systems as well as marine ecosystems.

Underwater noise pollution from ships is another impact of shipping on marine environment. As noted by Sordello. [20], this noise considerably raises background noise levels in marine areas and travels great distances in water. It prevents aquatic creatures like whales and dolphins from communicating, navigating, and feeding. Long-term exposure to noise pollution can endanger marine species' survival by causing stress, habitat displacement, and even hearing loss.

Mitigating Strategies to Marine Pollution and Environmental Stress

Mitigating marine pollution and environmental stress requires integrated strategies that address both the sources of pollution and the resilience of marine ecosystems. Marine environments are increasingly threatened by plastic waste, chemical discharges, oil spills, nutrient runoff, and climate-related stressors such as ocean warming and acidification. Effective mitigation therefore involves regulatory frameworks, technological innovation, ecosystem-based management, and public participation.

- **Enforcement of stringent environmental regulations**

One of the primary strategies is the enforcement of stringent environmental regulations and policies that limit the discharge of pollutants into marine environments. Governments and international bodies have strengthened legal instruments such as the MARPOL Convention to control ship-based pollution, while national policies regulate industrial effluents and coastal waste disposal. Studies show that policy enforcement combined with monitoring systems significantly reduces marine contamination and promotes compliance among industries [21]. In addition, adopting circular economy principles—such as reducing, reusing, and recycling materials—helps to minimize plastic waste entering oceans.

- **Technological innovations**

Another important factor in reducing marine pollution is technological advancements. Pollutant loads are decreased via oil spill response technology, biodegradable materials, and sophisticated wastewater treatment systems. For example, modern filtration and bioremediation techniques use microorganisms to break down harmful substances in water bodies, improving water quality and ecosystem health [22]. Early pollution incident detection is made possible by remote sensing and satellite monitoring, which improves response effectiveness.

- **Ecosystem-based management and restoration**

Another crucial strategy is ecosystem-based management and restoration. By protecting and restoring natural buffers like mangroves, coral reefs, and seagrass meadows, environmental stress can be significantly reduced. These ecosystems act as organic filters, absorbing sediments and contaminants while preserving biodiversity. Restoration projects have been shown to improve coastal resilience and enhance carbon sequestration, thereby addressing both pollution and climate-related impacts [23].

- **Public awareness and community engagement are equally important.**

Public awareness and community involvement are equally important. Involvement of stakeholders and instructional programs encourage proper behavior, such as using fewer single-use plastics and properly disposing of waste. To ensure sustainable practices, governments, corporations, and coastal communities must collaborate. Additionally, promoting sustainable fishing and reducing overexploitation helps maintain ecological equilibrium and decreases the burden on marine ecosystems.

Methodology

Descriptive survey design was adopted for this study. The study was carried out in Imo state, Nigeria. The targeted population for the study consists of Public Health Personnel and Environmental Scientist in Imo State, Nigeria. A stratified sampling technique was used in selecting 75 Public Health Personnel and 75 Environmental Scientists in Imo State. This gave a total of 150 respondents, which formed the sample size for this study. The instrument used for data collection was a structured questionnaire titled “Maritime Shipping and Transportation with Marine Pollution and Environmental Stress Questionnaire” (MSTMPESQ). Face and content validation of the instrument was carried out by an expert in test, measurement, and evaluation in order to ensure that the instrument has the accuracy, appropriateness, and completeness for the study under consideration. The reliability coefficient obtained was 0.95, and this was high enough to justify the use of the instrument. The researcher subjected the data generated for this study to appropriate statistical technique such descriptive statistics to answer research questions. from the result of the data analysis the effect of maritime shipping and transportation on marine pollution

Result and Discussion

Research Question 1: The research question sought to examine the effect of maritime shipping and transportation on marine pollution. To answer the research question, percentage analysis was performed on the data (see Table 1).

Table 1. Percentage analysis of effect of maritime shipping and transportation on marine pollution.

Effect of maritime shipping and transportation	Frequency	%
Introduction of invasive species through ballast water.	40	26.67**
Unintentional spills, leaks, or unlawful oily waste discharge	39	26.00
Air pollutants and ocean acidification	37	24.67
Underwater noise pollution from ships	34	22.67*
TOTAL	**150**	**100**

***The highest percentage frequency**
The least percentage frequency
SOURCE: Field survey

The table 1 presents the percentage analysis of effect of maritime shipping and transportation on marine pollution. From the result of the data analysis, it was observed that the highest percentage (26.67) was recorded against "introduction of invasive species through ballast water," while the least percentage (22.67) was recorded against "Underwater noise pollution from ships". The finding is in agreement with Walker, Adebambo, & Feijoo, (2018) who mentioned that fish, seabirds, and marine animals may perish as a result, and coastal ecosystems like coral reefs and mangroves may be harmed. Long-term environmental deterioration results from the accumulation of even minor, regular discharges. Also, Psaraftis, & Kontovas, (2021) stated that Marine pollution is greatly impacted by the introduction of invasive species through ballast water. To maintain stability, ships frequently take in ballast water in one area and release it in another. Bacteria, plankton, and small aquatic creatures are among the marine organisms that are inadvertently transferred across habitats by this method

Research Question 2: The research question sought to identify the mitigating strategies to marine pollution and environmental stress. To answer the research question, percentage analysis was performed on the data (see Table 2).

Table 2. Percentage analysis of the mitigating strategies to marine pollution and environmental stress.

Mitigating strategies to marine pollution	Frequency	%
Enforcement of stringent environmental regulations	41	26.33**
Technological innovations	39	26.00
Ecosystem-based management and restoration	36	24.00
Public awareness and community engagement are equally important	34	22.67*
TOTAL	**150**	**100**

***The highest percentage frequency**
The least percentage frequency
SOURCE: Field survey

The table 2 presents the percentage analysis of mitigating strategies to marine pollution and environmental stress. From the result of the data analysis, it was observed that the highest percentage (27.33) was recorded against "Enforcement of stringent environmental regulations," while the least percentage (22.67) was recorded against "Public awareness and community engagement are equally important". The finding is in agreement with findings of Liu, Hull, Batistella, DeFries, Dietz, Fu, & Li, (2021) who mentioned that policy enforcement combined with monitoring systems significantly reduces marine contamination and promotes compliance among industries. Also, Duarte, Losada, Hendriks, Mazarrasa, & Marbà, (2020), asserted that ecosystems act as organic filters, absorbing sediments and contaminants while preserving biodiversity. Restoration projects have been shown to improve coastal resilience and enhance carbon sequestration, thereby addressing both pollution and climate-related impacts.

Conclusion

In conclusion, although maritime shipping and transportation play a vital role in supporting international trade and economic development, their environmental consequences cannot be overlooked. The increasing prevalence of ship-related pollution has placed considerable pressure on marine ecosystems through contaminated waters, harmful emissions, and habitat disturbance.

Sustainable solutions such as green fuel adoption, stricter compliance measures, and improved waste management are necessary to reduce these impacts. Hence, promoting environmentally responsible shipping practices is crucial for ensuring both economic continuity and long-term ocean sustainability.

Recommendations

1. Governments and maritime regulatory bodies should enforce stricter environmental laws to control pollution from shipping activities and ensure full compliance by vessel operators.
3. Shipping companies should adopt cleaner fuel alternatives such as low-sulphur fuel, liquefied natural gas, and other renewable energy options to reduce harmful emissions.
4. Modern waste management systems should be installed on ships to ensure the proper treatment and disposal of sewage, plastics, and hazardous materials.

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