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Perceived Effect of Shipborne Sewage Discharge on Water Quality of Apapa Sea Port

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ABSTRACT

The Apapa Sea Port in Lagos, Nigeria, faces significant environmental concerns due to shipborne sewage discharge. Over 3 billion tons of sewage are discharged annually, posing health risks and causing disease outbreaks. Understanding this relationship is crucial for developing policies to protect marine environments and port operations. The study investigates the perceived effects of sewage wastewater pollution on the marine environment, focusing on Apapa Port, Nigeria's largest and busiest port. The study used a sample of 475 individuals, with a stratified frame of 323 respondents, resulting in a sample size of 245 using Yaro Yamane's formula. Descriptive statistical methods were used to summarize and interpret data, with a mean score of 2.5 as the threshold for classification. Inferential statistics, including ANOVA and regression analysis, were used to test the research hypotheses. The results shown that the perceived impact of sewage pollution on water quality, with findings showing a strong awareness and concern among port personnel regarding its deleterious effects, including eutrophication (mean rating: 3.825), harmful algal blooms (mean rating: 3.921), habitat degradation (mean rating: 3.868), and waterborne diseases (mean rating: 4.018). The Hypotheses testing confirmed that sewage discharge significantly impacts the study area (p-value = 0.048) and that the implementation of MARPOL Annex IV has a significant influence on pollution levels (p-value < 0.05). The study concludes with recommendations to improve treatment processes, enforcement mechanisms, infrastructure, and stakeholder collaboration to ensure compliance and protect the marine ecosystem at Lagos Port, among many others.

Keywords: Apapa seaports, sewage, shipborne, pollution, waste management.

INTRODUCTION

The Apapa Sea Port in Lagos, Nigeria, is a vital maritime hub that facilitates the import and export of goods. However, the environmental impact of port activities, particularly shipborne sewage discharge, has become a pressing concern (1). Shipborne sewage, including human waste, wastewater from galleys, and other effluents, can introduce pollutants into marine environments, such as pathogens, nutrients, and organic matter (2), which can adversely affect water quality and marine ecosystems. Environmental pollution refers to the introduction of substances or energy into the marine environment, resulting in harmful effects on living resources, marine life, human health, and marine activities. The shipping industry is increasingly focused on promoting safe shipping and protecting the marine environment due to pollution from vessel-generated garbage (3,4). The International Maritime Organization (IMO) estimates over 3 billion tons of sewage are discharged into the ocean annually,

posing health risks and causing disease outbreaks, degraded water quality, and beach closures (5). Global concern about marine pollution has led to the implementation of international conventions and accords, such as the London Convention, the Kyoto Protocol, the United Nations Convention on the Law of the Sea (UNCLOS), and the MARPOL 73/78 Convention. Sewage pollution affects marginalized communities (6), public health, quality of life, coastal regions, and economies. Understanding the relationship between shipborne sewage discharge and water quality at Apapa Sea Port is crucial for developing effective policies and practices that ensure the protection of marine environments and the sustainability of port operations (7).

This study aims to assess the effect of shipborne sewage discharge on water quality in the vicinity of Apapa Sea Port by examining various water quality indicators, including biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrient levels, and microbial contamination.

LITERATURE REVIEW

The lack of adequate sanitation is a significant global challenge, impacting billions of people and leading to severe environmental and public health issues. Approximately 4.5 billion people live without adequate sanitation, with more than half of the population in Sub-Saharan Africa and many tropical islands lacking any form of sanitation (8). Even in countries with extensive modern sanitation facilities, poor design and inadequate maintenance result in massive pollution, as untreated sewage, stormwater, and industrial waste are discharged into surface and groundwater. In the United States alone, over 4.54 billion cubic meters (1.2 trillion gallons) of untreated sewage flow into rivers annually due to overburdened treatment systems (9,10). Recent global models predict widespread contamination of surface waters due to extensive sewage pollution. Research indicates that almost every country experiences severe surface water contamination in at least one city, with regions like Los Angeles and San Francisco exhibiting contamination levels comparable to areas in China and India, where sanitation (11) is nearly nonexistent. Sewage discharge introduces a range of pollutants, including endocrine disruptors, heavy metals, pharmaceuticals, and pathogens, posing significant environmental and health risks (12). The impact of sewage pollution extends beyond human health, affecting wildlife and natural habitats. Contaminants from sewage accumulate in plants and animals, leading to biodiversity loss and ecosystem degradation. For example, juvenile salmon near wastewater treatment plant outfall sites have been found with over 40 sewage-borne contaminants (13,14).

This literature review explores the scope of ship-generated sewage in Apapa Port's lagoon, comparing physio-chemical and microbiological parameters with IMO standards, evaluating impacts on water quality, and identifying challenges in legal requirements implementation to address some of these global issues (15). The conceptual framework for assessing ship-generated sewage in Apapa Port's lagoon outlines the specific components and processes involved in assessing ship-generated sewage (16). It focuses on evaluating water quality, impacts on the ecosystem and public health, regulatory compliance, and challenges in implementation. The framework also includes identifying implementation challenges, such as lack of resources, inadequate enforcement mechanisms, and institutional weaknesses, and promoting capacity-building initiatives to equip regulatory bodies and stakeholders with the necessary skills and resources for effective environmental management (17,18).

The International Maritime Organization (IMO) has established MARPOL 73/78, Annex IV, a regulatory framework aimed at preventing pollution from ship-generated sewage in marine environments. The framework imposes strict guidelines on the discharge of sewage, distinguishing between untreated and treated effluents based on proximity to shorelines and the effectiveness of onboard treatment systems (1). Untreated sewage can only be discharged when a vessel is at least 12 nautical miles from the nearest land and moving at a speed of at least 4 knots. Treated sewage, which has undergone specified treatment processes to meet cleanliness standards, can be discharged at a minimum distance of 3 nautical miles from land. Vessels must be equipped with approved sewage treatment systems to ensure compliance with discharge limits on pollutants like bacteria and suspended solids. Port Reception Facilities (PRFs) play a pivotal role in implementing Annex IV by providing adequate infrastructure for receiving and treating ship sewage. Continuous monitoring and certification are integral to the enforcement of Annex IV, with ships required to maintain detailed records of sewage discharge operations (9,11, 19). The conceptual framework integrates scientific assessment, regulatory compliance, impact evaluation, and stakeholder engagement to propose comprehensive strategies for managing ship-generated sewage in Apapa Port's lagoon. By addressing these components, the framework aims to mitigate environmental and public health risks while enhancing the overall sustainability of maritime activities in the area (20). The Environmental Governance

Theory offers a comprehensive framework for assessing ship-generated sewage in Apapa Port's lagoon. This approach integrates principles from environmental science, public health, regulatory compliance, and stakeholder participation. It emphasizes the importance of multi-level governance, involving various stakeholders in decision-making processes, and adopting adaptive management practices to address environmental issues effectively (21,22). Current research often focuses on specific pollutants or localized impacts, but more holistic impact assessments are necessary to understand the full scope of marine pollution's effects and develop integrated mitigation strategies. This research establishes a baseline for ongoing monitoring of ship-generated sewage impacts in Apapa Port, facilitating future longitudinal studies (23,24). The theory is built on formal institutions such as international conventions, national laws, and local regulations. Robust enforcement mechanisms are necessary to ensure compliance with established standards. Stakeholder participation is crucial for identifying problems, developing solutions, and sharing responsibilities (25,26). Adaptive management involves implementing flexible strategies that can be adjusted in response to changing environmental conditions and new information (27,28). Transparency in decision-making and accountability mechanisms ensure transparency in decision-making processes (29,30). This framework supports effective sewage management that mitigates environmental impacts and ensures the health of the lagoon ecosystem for future generations.

METHODOLOGY

This study investigates the perceived impact of pollution of the marine environment by sewage originating from ships in Apapa Port Lagos State, Nigeria. Using cross-sectional Research Design. The survey method collected data from relevant maritime and regulatory agencies using questionnaires. Primary data was collected through questionnaires, while secondary data was obtained from various sources. Semi-structured interviews/questionnaires were used to understand participants' opinions and experiences. The study focuses on Apapa Port, Nigeria's largest and busiest port, which faces logistical challenges such as traffic congestion, inadequate road infrastructure, and limited storage space. Improvements in road infrastructure, storage capacity, and traffic management strategies are needed to enhance the port's functionality and mitigate environmental impacts.

Table 1: Details of the respondents

Determined Sample Size of workers involved in ship sewage Pollution at Apapa Port, Lagos State, Using Yaro Yameni method		
Stratified Groups/Workers	**Sample Frame**	**Sample Size**
Maritime Industry Worker	**182**	125
Government Official	102	81
Environmentalist / Conservationist	23	22
Researchers / Academics	18	17
	325	**245**
Source: Researchers Survey, (2024).		

The questionnaires were administered to respondents using a stratified random sampling technique within each selected agency, as grouped in Table 1 above. This was accomplished by utilizing online platforms and WhatsApp groups of personnel or staff knowledgeable about MARPOL and IMO implementation and regulations. This group of personnels were sampled using stratified random sampling techniques. The questionnaire collected data on the impact of sewage pollution on marine ecosystems, participants' perceptions on the impact of sewage pollution the Marine Environment. The data was analyzed using descriptive statistics.

DATA ANALYSIS AND PRESENTATION

A study on the impact of ship sewage pollution on water quality in Apapa Sea Port was conducted using an online Google survey. The results showed a consensus on the negative effects of sewage discharge on marine life and water quality, aligning with Hypothesis 2 (H02 and Ha2). The study highlights the significant environmental consequences of untreated or inadequately treated sewage from ships, affecting marine life and water quality.

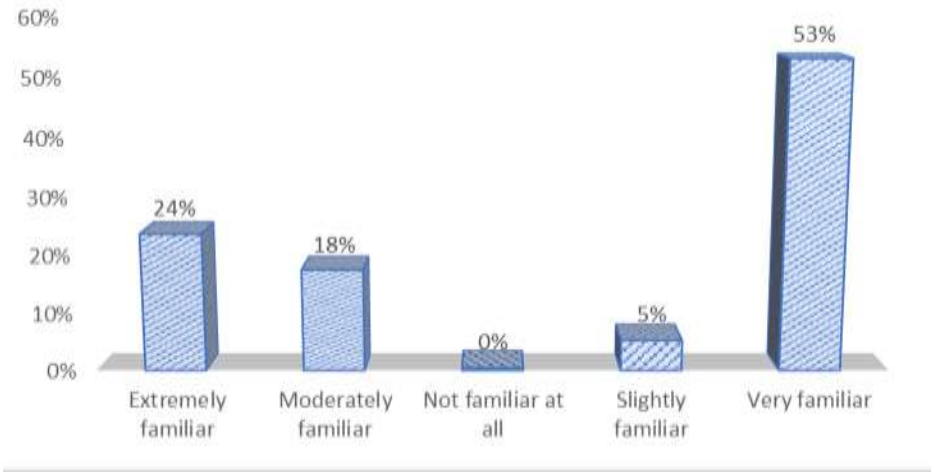

Figure 1: familiarity level of respondents to sewage pollution from ships

The study reveals that a significant number of respondents are familiar with the concept of sewage pollution from ships and its potential impact on the marine environment. Nearly a quarter of respondents have a deep understanding of the issue, making them crucial for leadership roles in environmental management. Over half of the respondents are very familiar with the issue, indicating a strong overall awareness and understanding among the personnel at Apapa port. This broad base of knowledge ensures widespread compliance with regulations and effective environmental management. Moderately familiar (18%) is a significant portion of respondents with a basic understanding but may lack in-depth knowledge or experience. This group is a prime target for further education and training, with practical training sessions, workshops, and exposure to real-world scenarios improving their competence. Slightly familiar (5%) is a small percentage of respondents with minimal knowledge about sewage pollution from ships, representing a potential risk for non-compliance and ineffective environmental management. Simplified training programs, easy-to-access resources, and continuous learning opportunities can help increase their understanding and ensure effective contributions. Not familiar at all (0%) indicates a baseline awareness among all personnel at Apapa port, indicating the success of existing educational efforts. This uniform baseline awareness is crucial for ensuring that all personnel, regardless of their role, have at least a basic understanding of the importance of managing sewage pollution from ships.

Impact of sewage Pollution from ships

Analysis on Table 2 below shows the comprehensive analysis of the Impact of Sewage Pollution from Ships. However, Sewage pollution from ships is a significant environmental concern that affects various aspects of marine ecosystems. This analysis explores the perceived impact of sewage pollution from ships based on a study where respondents rated different environmental impacts. These impacts with mean ratings and remarks and discussed. The result indicated a Mean value of 3.825 with the remark of High Impact. Eutrophication is the process by which water bodies become enriched with nutrients, primarily nitrogen and phosphorus, leading to excessive growth of algae. This phenomenon is significantly influenced by sewage pollution from ships. The mean rating of 3.825 indicates a strong perception that ship sewage contributes to eutrophication. Excessive algae growth can deplete oxygen in the water, leading to dead zones where marine life cannot survive. This disruption in the aquatic environment can affect fisheries, water quality, and overall biodiversity. This result is in agreement of the previous work by (31,32,33) The high impact rating underscores the need for stringent regulations on sewage discharge from ships to mitigate nutrient loading in marine environments.

Table 2. Environmental impacts of sewage pollution from ships

S/N	Items	Mean	Remark (Impact)
1	Please rate the Impact of Eutrophication as an environmental impacts of sewage pollution from ships	**3.825**	High Impact
2	Please rate the Impact of Harmful algal blooms as an environmental impacts of sewage pollution from ships	**3.921**	High Impact
3	Please rate the Impact of sewage pollution from ships to the Disruption of marine ecosystems	**3.912**	High Impact
4	Please rate the Impact of sewage pollution from ships on marine biodiversity of Apapa Port Environment	**3.868**	High Impact
5	Please rate the Impact of sewage pollution from ships on Increase in waterborne diseases	**4.018**	High Impact
6	Please rate the Impact of sewage pollution from ships contribution to marine debris and pollution	**3.781**	High Impact
7	Please rate the Impact of sewage pollution from ships to Disruption of marine habitats	**3.807**	High Impact

Source: Research data Analysis 2024

Harmful Algal Blooms (HABs) with a mean value of 3.921 are a severe consequence of eutrophication as shown in Table 2, where certain types of algae grow excessively and produce toxins that can harm marine life, humans, and ecosystems. Sewage pollution from ships exacerbates the occurrence of HABs, leading to large-scale fish kills, contaminating shellfish, and impacting human health through toxins that cause respiratory and neurological issues. These blooms can result in economic losses for coastal communities that rely on tourism and fishing. Disruption of marine ecosystems is another critical impact of sewage pollution from ships. Marine ecosystems with a mean value of 3.912 are complex networks of organisms interacting with each other and their environment, and sewage discharge introduces pollutants, including pathogens, heavy metals, and organic matter, which can alter these interactions as affirmed by (34,35). The presence of pollutants can lead to the decline of sensitive species, changes in species composition, and overall ecosystem degradation. Addressing sewage pollution is essential to maintain the health and stability of marine ecosystems.

Apapa Port, a significant maritime hub, experiences substantial impacts on marine biodiversity due to sewage pollution from ships. Sewage pollution introduces harmful substances that can lead to habitat degradation, species loss, and community structure changes. The high impact rating suggests that sewage discharge is a major threat to the biodiversity of 3.868 of Apapa Port, necessitating targeted conservation and pollution control measures to protect the unique marine life in this area. The highest mean value of 4.018 signifies a strong perception that sewage pollution from ships greatly increases the risk of waterborne diseases. Sewage contains pathogens such as bacteria, viruses, and parasites that can cause diseases in humans and marine organisms. The high impact rating emphasizes the urgent need for improved sanitation and treatment of sewage on ships to prevent the spread of waterborne diseases with a mean value of 4.018.

Sewage pollution contributes to the accumulation of debris and pollutants in the marine environment, including plastics, microplastics, and other waste materials. These pollutants can harm marine organisms through ingestion, entanglement, and habitat degradation. Addressing this issue requires comprehensive waste management strategies and stricter enforcement of international regulations such as the MARPOL Annex IV, which governs the discharge of sewage from ships. Conservation efforts should focus on restoring and preserving marine habitats to ensure the sustainability of marine ecosystems.

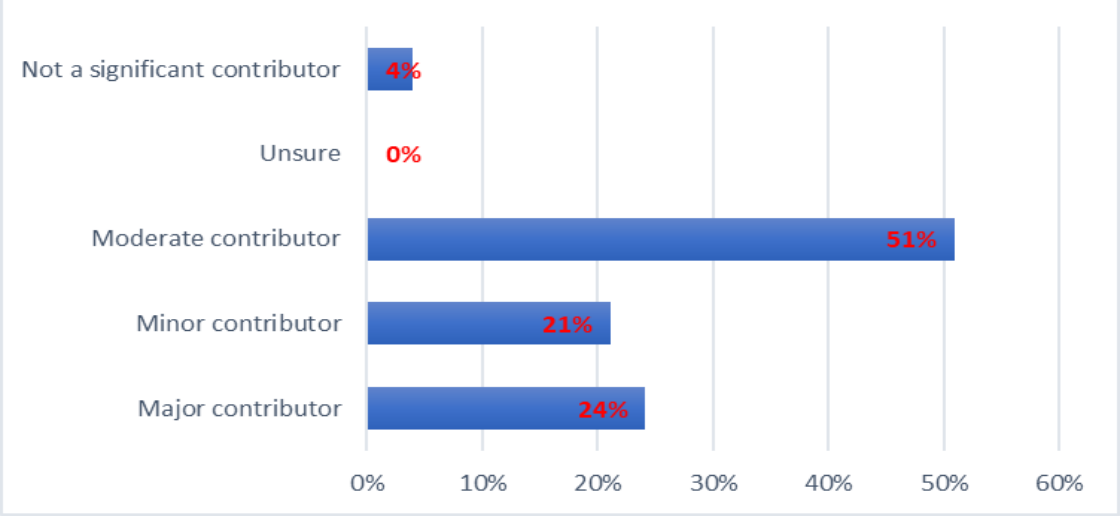

Fig 2. Perception of sewage pollution from ships in global marine pollution

The study reveals that sewage pollution from ships is a significant contributor to global marine pollution, with 24% of respondents viewing it as a significant factor. This indicates a strong awareness of the environmental impact of ship discharge on marine ecosystems, highlighting the need for stringent regulations and effective management practices. The majority (51%) consider sewage pollution from ships to be a moderate contributor, acknowledging that other sources of marine pollution are equally or more impactful. This suggests that while efforts to manage sewage pollution from ships are important, they should be part of a broader strategy that addresses various sources of marine pollution. A minor contributor (21%) sees sewage pollution from ships as a minor contributor, indicating that other pollution sources, such as industrial discharge, agricultural runoff, or plastic waste, are more critical. This perception might lead to prioritizing other pollution control measures over sewage management from ships. A small percentage (4%) do not view sewage pollution from ships as a significant contributor, suggesting a minimal level of concern or awareness about its impact. Enhancing their knowledge can help achieve more comprehensive compliance and pollution management strategies.

The absence of unsure responses indicates that all respondents at Apapa port have a formed opinion about the role of sewage pollution from ships in global marine pollution, suggesting a high level of awareness and understanding of the issue among the personnel.

Hypothesis Testing

H_{0_1}: Sewage discharge from ships does not significantly impact the marine environment of Apapa Sea Port."

Table 3. Sewage discharges from ships impact the marine environment of Apapa Sea Port.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.24869489
R Square	0.06184915
Adjusted R Square	0.0319989
Standard Error	0.80046973
Observations	228

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	9.293377339	1.327625334	2.07198068	0.047669403
Residual	220	140.9653946	0.640751794		
Total	227	150.2587719			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.645526	0.306582831	11.89083546	1.6591E-25	3.041310844	4.24974116	3.04131084	4.24974116
Eutrophication	0.04904487	0.080906793	0.606189752	0.54501371	-0.11040669	0.20849643	-0.11040669	0.20849643
Disruption of marine ecosystems	0.00214957	0.111404141	0.019295255	0.98462306	-0.21740633	0.22170548	-0.21740633	0.22170548
Harmful algal blooms	0.25626507	0.105095475	2.438402492	0.01554531	0.049142318	0.46338782	0.04914232	0.46338782
Marine biodiversity	-0.2102237	0.097542184	-2.15520765	0.03223137	-0.40246034	-0.017987	-0.40246034	-0.01798698
Contribution to marine debris and pollution	0.06058263	0.078876288	0.768071554	0.44326831	-0.0948672	0.21603246	-0.0948672	0.21603246
Disruption of marine habitats	0.05643305	0.093058542	0.606425251	0.54485764	-0.12696725	0.23983335	-0.12696725	0.23983335
Increase in waterborne diseases	-0.1329195	0.073258543	-1.81438952	0.07097989	-0.27729788	0.01145881	-0.27729788	0.01145881

Significance F.	0.004
Significant Level	0.05
Decision = 0.004 < 0.05 (**HO:** Rejected)	

Source: Researchers Data Analysis Output, 2024.

Table 3 shows the hypothesis (H02): "Sewage discharge from ships does not significantly impact the marine environment of Apapa Sea Port," However, this result was discussed based on the regression analysis output. The regression analysis reveals a Multiple R-value of 0.249, indicating a weak positive correlation between sewage discharge and the marine environment at Apapa Sea Port. The R Square value of 0.062 suggests that only 6.2% of the variability in the marine environment can be explained by sewage discharge from ships, while the Adjusted R Square of 0.032 shows a slight adjustment for the number of predictors, indicating 3.2% of the variance is explained by the model. The Standard Error of 0.800 indicates the typical deviation of the observed values from the predicted values. The ANOVA table provides further insights, where the regression F-statistic is 2.072, and the Significance F is 0.048. Since the Significance F is less than 0.05, the model is statistically significant at the 5% level, suggesting that the overall regression model is a good fit for the data. The intercept coefficient is 3.646 with a p-value of less than 0.001, indicating it is statistically significant. Eutrophication has a coefficient is 0.049 with a p-value of 0.545, showing it is not statistically significant. Disruption of marine ecosystems indicates a coefficient of 0.002 and a p-value of 0.985, indicating no statistical significance. This coefficient is 0.256 for harmful algal blooms with a p-value of 0.016, indicating a statistically significant positive correlation with the impact on the marine environment. Marine biodiversity has a coefficient is -0.210 with a p-value of 0.032, showing a statistically significant negative correlation. Contribution to marine debris and pollution has with coefficient is 0.061 with a p-

value of 0.443, indicating no statistical significance. Disruption of marine habitats has a coefficient is 0.056 with a p-value of 0.545, showing no statistical significance. The increase in waterborne diseases has a coefficient is -0.133 with a p-value of 0.071, indicating marginal significance at the 10% level. Thus, given that the Significance F value of 0.004 is less than the 0.05 threshold, the null hypothesis ($H0_2$): Sewage discharge from ships does not significantly impact the marine environment of Apapa Sea Port" is rejected, and the alternate hypothesis (Ha_2): Sewage discharge from ships significantly impacts the marine environment of Apapa Sea Port" accepted. This indicates that sewage discharge from ships significantly impacts the marine environment of Apapa Sea Port. In addition, Although the regression model explains only a small portion of the variance in the marine environment (R Square = 0.062), the overall model is statistically significant (Significance F = 0.048). The study rejects the null hypothesis that sewage discharge from ships doesn't significantly impact the marine environment of Apapa Sea Port, indicating that it does. The overall model, which explains only a small portion of the variance, is statistically significant. The result was in line with previous work by (36,37,38,39). The data shows that sewage discharge significantly impacts harmful algal blooms and marine biodiversity, with positive and negative correlations. This indicates that sewage discharge from ships has a significant impact on the marine environment, requiring measures to mitigate its impact for environmental sustainability.

CONCLUSION

Findings on the familiarity levels with sewage pollution from ships at Apapa port indicate that the majority, 53%, are very familiar, and 24% are extremely familiar, indicating strong overall awareness. Meanwhile, 18% are moderately familiar, and 5% are slightly familiar. No respondents are completely unfamiliar. This suggests effective education but highlights the need for targeted training to elevate those with less knowledge. Leveraging highly familiar personnel for mentorship can enhance overall competency and ensure robust environmental management. Findings on the analysis of sewage pollution from ships reveal a consensus on its significant environmental impacts across various factors. Sewage discharge leads to eutrophication, marked by nutrient enrichment that fuels excessive algae growth, depleting oxygen and harming marine life (Mean Rating: 3.825). It also promotes Harmful Algal Blooms (HABs) (Mean Rating: 3.921), disrupting marine ecosystems (Mean Rating: 3.912), and causing habitat degradation and species loss (Mean Rating: 3.868). Additionally, sewage pollution is strongly linked to an increase in waterborne diseases (Mean Rating: 4.018), posing substantial health risks and contributing to marine debris (Mean Rating: 3.781). These impacts underscore the urgent need for effective pollution control measures, stringent regulations, and improved waste management practices on ships. However, addressing sewage pollution is crucial for protecting marine biodiversity, sustaining healthy ecosystems, and safeguarding coastal communities. Collaborative efforts at national and international levels are essential to mitigate these detrimental effects and promote sustainable maritime practices, especially within the Nigerian Apapa port.

Findings on the perceptions at Apapa port regarding sewage pollution from ships in global marine pollution. Nearly 24% view it as a major contributor, indicating strong awareness and concern for stringent regulations and compliance with MARPOL Annex IV. The majority, 51%, see it as a moderate contributor, suggesting a balanced perspective on marine pollution sources. About 21% consider it a minor issue, prioritizing other pollution sources, while 4% see it as insignificant, indicating a need for more awareness. Overall, 75% recognize sewage pollution's significant role, highlighting the need for enhanced education, comprehensive strategies, regulatory compliance, and stakeholder engagement.

RECOMMENDATION

Apapa Seaport's water quality is being assessed due to shipborne sewage discharge. Recommendations include stringent sewage management practices, upgrading port infrastructure, enhancing waste management systems, strengthening regulatory frameworks, promoting best practices for ship operators, monitoring and research, collaborating with maritime organizations, involving local communities, and promoting sustainable practices. Mandatory onboard treatment, regular inspections, enhanced waste management systems, and community involvement are also suggested.

Contribution to knowledge

The study on shipborne sewage discharge in Apapa Seaport, Nigeria, evaluates current management practices and regulatory frameworks, identifying areas for improvement and providing insights on discharge levels and water quality. It emphasizes community and industry involvement in environmental management.

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