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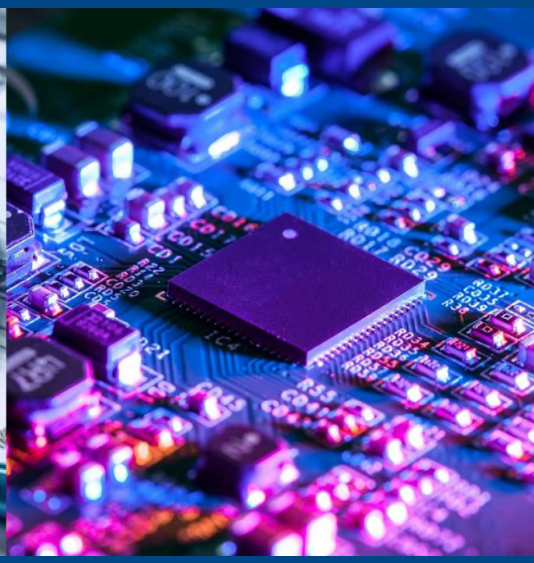

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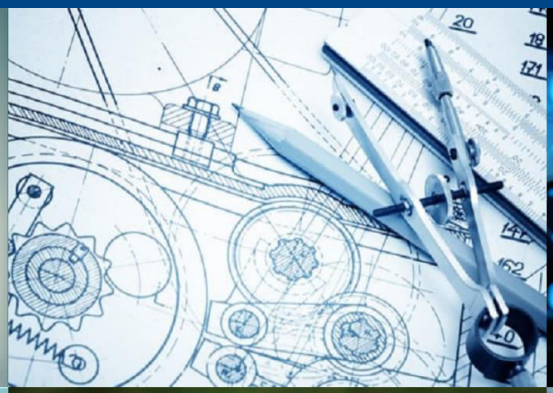

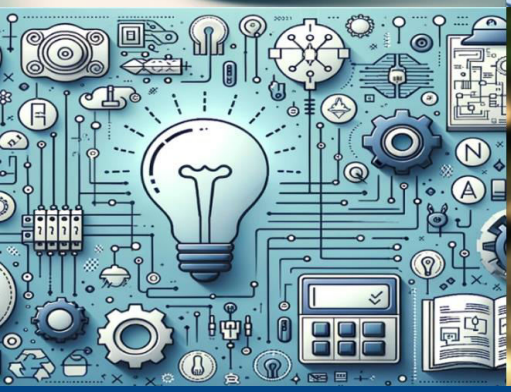

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Analysis of Blackwater (Sewage) Pollution Generated from Vessels; Environmental and Public Health Implications in Onne, Rivers State

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ABSTRACT: The discharge of blackwater (sewage) from maritime vessels poses a considerable challenge to both environmental integrity and public health, especially in busy port regions such as Onne, Rivers State, Nigeria. This research examines the level of blackwater pollution produced by ships docked at Onne Port and evaluates its ecological and health consequences for nearby communities. Water samples were gathered from three sites around the port and analyzed for essential physico-chemical parameters, including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), heavy metals, and microbial indicators like Escherichia coli and total coliforms. The results indicated heightened levels of organic and microbial pollutants, with measurements such as pH (8.87), Conductivity (682.67), Turbidity (31), Total Suspended Solids (1697.67), Chemical Oxygen Demand (981.33), OIL/Grease (12.93), Biochemical Oxygen Demand (30.17), Lead (0.140), Cadmium (0.228), and Iron (2.16) surpassing the regulatory thresholds established by the Department of Petroleum Resources (DPR) and the World Health Organization (WHO). These results imply inadequate disposal practices for sewage generated by vessels, insufficient port reception facilities, and ineffective regulatory enforcement. Furthermore, the study underscores the potential risks of waterborne diseases, ecological degradation, and the bioaccumulation of harmful substances in aquatic life consumed by local communities. In light of these findings, the study advocates for the implementation of international maritime waste management regulations (such as MARPOL Annex IV), enhancement of port sewage reception infrastructure, and regular environmental monitoring. Immediate actions are essential to avert long-term harm to the marine ecosystem and protect public health in the Onne area.

KEYWORDS: Blackwater Pollution, Vessel Sewage Discharge, Environmental Impact, Water Quality Assessment, Public and Environmental Health.

I. INTRODUCTION

Water pollution continues to be one of the most pressing environmental issues confronting coastal and riverine communities globally. In recent years, the rapid pace of industrialization, urban growth, and maritime development has greatly exacerbated the decline in water quality, particularly in port areas (UNEP, 2016). Among the numerous contributors to water pollution, discharges related to maritime activities, including blackwater the sewage and wastewater produced on vessels pose a significant risk to aquatic ecosystems and public health, especially in developing countries where environmental regulations and enforcement are often inadequate (IMO, 2018).

Blackwater is defined as sewage that is generated from toilets, urinals, and medical facilities aboard ships. It generally contains human waste, pathogens, nutrients (such as nitrogen and phosphorus), pharmaceuticals, detergents, and various organic substances (GESAMP, 2009). When improperly treated or released untreated into coastal waters,

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blackwater becomes a serious pollutant that can contaminate surface water, endanger aquatic organisms, and present substantial health hazards to humans who depend on these waters for domestic, recreational, or livelihood purposes (Nguyen et al., 2020). Although international maritime regulations, such as MARPOL Annex IV, prohibit the discharge of untreated sewage within specific distances from land, enforcement is often inconsistent, particularly in busy and inadequately monitored port areas (IMO, 2020).

In Nigeria, the maritime industry has experienced significant growth over the past twenty years, primarily driven by oil and gas exploration and the nation's advantageous coastal position in West Africa. One of the most prominent maritime areas in the country is Onne, situated in Rivers State, within the Niger Delta region. The Onne Port Complex serves as a crucial logistics and operational hub for offshore oil exploration, catering to both domestic and international shipping firms. This port includes container terminals, oil service facilities, and maintenance yards, managing a considerable amount of vessel traffic on a daily basis (NPA, 2021). Nevertheless, this heightened maritime activity has raised considerable environmental issues, especially concerning the management and disposal of ship-generated waste, such as blackwater.

Despite Nigeria's affiliation with the International Maritime Organization (IMO) and the implementation of MARPOL regulations through the Nigerian Maritime Administration and Safety Agency (NIMASA), there is substantial evidence of inadequate waste management practices by vessels operating in Nigerian waters. Numerous studies have highlighted the insufficiency of appropriate reception facilities in Nigerian ports, limited enforcement capabilities, and poor adherence to environmental regulations among operators (Adeleke et al., 2019; Ologunorisa & Adeyemo, 2020). As a result, many vessels are thought to discharge blackwater directly into adjacent water bodies, either due to negligence or the lack of feasible disposal options.

The Onne region is especially susceptible to the detrimental impacts of blackwater pollution, primarily because of its closeness to densely populated human settlements and delicate ecosystems. Numerous local communities rely on fishing, mangrove harvesting, and subsistence practices that are intricately linked to the well-being of the nearby waterways. The release of untreated sewage into the marine environment not only elevates biological oxygen demand (BOD) and chemical oxygen demand (COD) but also encourages the growth of harmful microorganisms such as Escherichia coli, Salmonella, and Vibrio cholerae (WHO, 2019). These pathogens are recognized for causing waterborne illnesses, including diarrhea, cholera, typhoid, and hepatitis, particularly in populations with restricted access to clean water and healthcare services.

Moreover, the nutrient influx from blackwater discharges can lead to eutrophication—a phenomenon where an overabundance of nutrients fosters algal blooms that diminish oxygen levels in water, resulting in hypoxic conditions. This deoxygenation can trigger fish mortality and a decline in biodiversity within marine ecosystems (Carpenter et al., 1998). In tropical regions such as Onne, where water temperatures are elevated, the consequences of eutrophication and organic pollution can be especially pronounced due to the lower solubility of oxygen and heightened microbial activity. Research conducted on sewage contamination in the Niger Delta has revealed increased concentrations of pathogens, nutrients, heavy metals, and organic contaminants in surface waters, indicating that untreated domestic and industrial wastewater significantly contributes to this issue (Ogoni et al., 2021; Woke et al., 2022).

Nevertheless, there exists a considerable deficiency in studies that specifically quantify and evaluate the impact of vessel-generated blackwater on this pollution load. Current environmental evaluations frequently neglect maritime sources, concentrating instead on terrestrial discharges from industries and municipalities. This lack of data and comprehension hinders the formulation of all-encompassing management strategies that tackle every major pollution source in Onne.

Furthermore, the public health ramifications of blackwater pollution are frequently undervalued. Inhabitants of the Onne region often depend on surface water for domestic purposes, fishing, and recreational activities, with limited infrastructure for water treatment or sanitation. Children and individuals with compromised immune systems are especially vulnerable to infections caused by waterborne pathogens. Beyond acute illnesses, prolonged exposure to contaminated water can lead to enduring health issues, including developmental disorders and antimicrobial resistance stemming from the presence of pharmaceuticals in blackwater (Kümmerer, 2009).

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The necessity for a scientific and policy-relevant examination of blackwater pollution in Onne is thus pressing. This study seeks to address the knowledge deficit by analyzing the composition, volume, and discharge practices of sewage produced by vessels, thereby providing empirical data to guide regulatory decisions. Additionally, assessing the environmental and health risks linked to these discharges will illuminate the repercussions of regulatory shortcomings and emphasize the significance of enforcement, awareness, and infrastructure enhancement.

Moreover, this research is in alignment with the United Nations Sustainable Development Goals (SDGs), specifically Goal 6 (Clean Water and Sanitation), Goal 14 (Life Below Water), and Goal 3 (Good Health and Well-Being), as it tackles the intersections of environmental integrity, human health, and responsible industrial practices. Ensuring the appropriate treatment and disposal of blackwater generated by vessels is not only a legal and ethical responsibility but also a vital measure towards sustainable development in maritime areas such as Onne (Ogboeli, et. al., 2023).

In summary, the release of blackwater from ships constitutes a notable yet insufficiently explored contributor to marine pollution in Onne, Rivers State. The repercussions for water quality, biodiversity, and public health are significant, especially in a region that is already challenged by oil pollution, inadequate sanitation systems, and socio-economic fragility. Through a thorough examination of blackwater pollution in this locality, this research aims to establish a basis for evidence-driven policy, better waste management strategies, and strengthened safeguarding of both human and environmental health.

II. MATERIALS AND METHODS

The Onne seaport is situated in the town of Onne, which is part of Port Harcourt. It is positioned at a geographical longitude of 4°431011N and a latitude of 7°91011E. As an urban area within Port Harcourt, it encompasses an estimated land area of approximately 186 square kilometers, contributing to the overall metropolitan expanse of 462 km2. According to the 2006 census, the population was recorded at 1,230,114, within a total metropolitan population of the same year (NPC, 2006). Applying a growth rate of 2.54%, the population is projected to be around 1,580,806 by 2016. The Onne Port Complex was established as a 'Free Port Zone' (FPZ) to act as a central hub for the oil and gas sector in West Africa. This complex, which originated in 1982 as the Federal Lighter Terminal (FLT), has developed significantly over the years, primarily due to Public/Private Partnerships. The Onne Port Complex is located along the Bonny Estuary on Ogu Creek, approximately 25 kilometers south of Port Harcourt, in Rivers State, Nigeria. The geographical scope of the Port extends from NAFCON (now known as NOTORE) Jetty to Bonny Island. It traverses three Local Government Areas in Rivers State, namely Eleme, Ogu-Bolo, and Bonny. The land area, which covers around 2,500 hectares, is located within the Eleme Local Government Area, while the access channel to the Port runs along the Bonny River and Ogu Creek, within the jurisdictions of Bonny and Ogu-Bolo Local Government Areas.

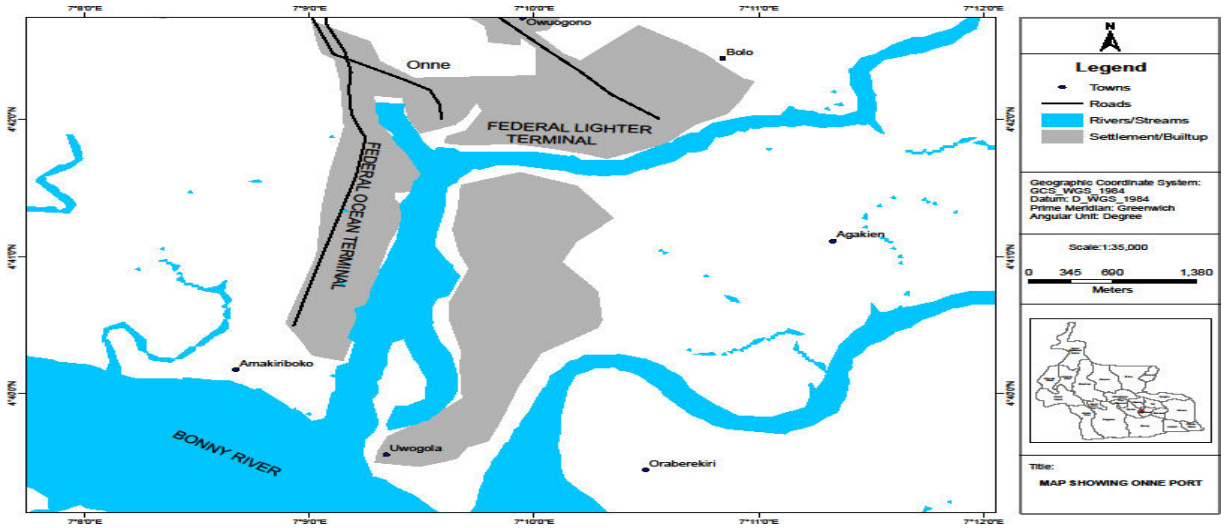

Fig. 1: A map showing the Onne Port Complex in Rivers State, Nigeria.

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A black wastewater sample was obtained from three ocean-going vessels, each with a Gross Registered Tonnage (GRT) exceeding 400 tons, which were anchored in the berthing areas of the Nigeria Port Authority in Onne, Port Harcourt. Samples of black wastewater were gathered from vessels docked at three distinct locations and will be collected from the point source. These samples were taken using sterile 75 cm screw-top plastic bottles and were preserved at a temperature of 4°C. To prevent sample degradation, several pollution indicator parameters were assessed within six hours of the collection of the samples.

III. LABORATORY ANALYSIS

The analyses encompassed the physical, chemical, and microbiological characteristics of the water samples. The parameters evaluated included: pH, temperature, conductivity, total dissolved solids, total suspended solids, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total oil and grease, copper, iron, lead, zinc, cadmium, total coliform count, total heterotrophic bacteria, and total heterotrophic fungi. Data collection employed a sampling technique in which water samples from marine cargo vessels at berths were subjected to physicochemical and microbiological analysis following the American Public Health Association (APHA) method to ascertain the concentration levels of the identified parameters. Standardized procedures were implemented to prepare the samples for analysis. The significant values of parameters obtained from laboratory analysis were compared to the standards specified by the Department of Petroleum Resources (DPR) for effluent discharges from vessels, in order to mitigate: risks to human health, damage to living organisms (both fauna and flora) and aquatic life, as well as degradation of the quality of adjacent land, surface, and groundwater.

IV. RESULTS AND DISCUSSION

The mean pH value of 8.87, along with a low standard deviation of 0.0436, indicates consistently alkaline conditions throughout the sampling sites. These elevated pH levels may result from industrial discharges, alkaline runoff, or microbial processes, which could affect water quality and aquatic organisms (Asonye et al., 2007). Ongoing deviations from established regulatory standards highlight the importance of regular monitoring and the adoption of pollution control measures to protect both environmental integrity and public health. The observed average temperature of 28.22°C exhibited considerable variation among the sampling sites, yet it remained within the acceptable limits set by the Department of Petroleum Resources (DPR). This variability may be affected by environmental factors such as solar radiation, water depth, and localized industrial activities (Akpan & Offem, 1993). While current temperature levels are within permissible limits, values nearing the upper threshold could lead to a reduction in dissolved oxygen levels, adversely affecting aquatic ecosystems. Therefore, consistent monitoring is crucial to address potential thermal pollution.

The average conductivity measured was 682.67 µS/cm, accompanied by a significant standard deviation of 209.08, which greatly surpasses the DPR's recommended threshold of 100 µS/cm for surface water (DPR, 2002). This finding suggests considerable spatial variability, likely influenced by varying concentrations of dissolved ions, industrial effluents, and runoff from adjacent land uses (Obire et al., 2003). Increased conductivity poses a threat to aquatic ecosystems and jeopardizes the well-being of freshwater species, underscoring the urgent need for regulatory interventions and the identification of pollution sources. A mean turbidity measurement of 31 NTU, with a standard deviation of 1.0, reflects minimal spatial variability yet indicates a consistently high concentration of particulates across the sampling sites. The elevated turbidity levels may stem from industrial effluents, domestic wastewater, and sediment runoff, which can negatively impact aquatic organisms and the usability of water (Asonye et al., 2007). The persistent exceedance of regulatory limits underscores the necessity for proactive water quality management and pollution control measures. The average total dissolved solids (TDS) concentration was recorded at 1068 mg/L, with a standard deviation of 378.96, indicating significant variability among the sampling sites. Elevated TDS levels are frequently associated with natural mineral dissolution, urban runoff, and industrial discharges, which may affect the palatability and suitability of water for aquatic organisms (Tebbutt, 1998). Although current measurements remain within acceptable limits, increasing trends could signal deteriorating pollution conditions, necessitating ongoing monitoring.

A mean total suspended solids (TSS) concentration of 1697.67 mg/L, accompanied by a standard deviation of 438.99, indicates significant spatial variability and values that exceed the DPR threshold of 50 mg/L. These heightened levels are likely a result of soil erosion, industrial discharges, and wastewater contributions, which can lead to reduced light penetration, habitat degradation, and ecological stress (Asonye et al., 2007). The results highlight a serious decline in water quality and call for immediate action to avert further environmental harm. The mean chemical oxygen demand

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(COD) of 981.33 mg/L, along with a high standard deviation of 920.02, suggests substantial variability and points to the presence of localized pollution hotspots. Such elevated COD levels indicate significant organic and inorganic pollutant loads from sources including industrial waste, sewage discharge, and surface runoff (Ekhaise & Omoigberale, 2011). Elevated COD levels can diminish dissolved oxygen concentrations, posing a threat to aquatic organisms. Therefore, prompt enforcement of waste management practices and pollution control measures is essential to restore ecological equilibrium. The average oil and grease concentration of 12.93 mg/L, with a low standard deviation of 2.86, reflects consistent contamination across various sites. While these levels remain within regulatory limits, the ongoing presence of oil can create surface films that hinder oxygen exchange and adversely affect aquatic life (Olalekan et al., 2018). It is recommended that continuous monitoring be implemented to mitigate potential long-term ecological consequences.

A mean dissolved oxygen (DO) concentration of 3.32 mg/L, exhibiting minimal fluctuation (SD = 0.085), indicates consistently low oxygen availability across various sites. Such environmental conditions are suggestive of organic pollution, which adversely affects aquatic respiration and biodiversity (Asonye et al., 2007). The alarmingly low DO levels necessitate immediate remediation efforts to enhance water quality and safeguard aquatic ecosystems. The biochemical oxygen demand (BOD) levels displayed variability among the sites, with an average of 30.17 mg/L and a standard deviation of 16.33. While Location 1 remains compliant with the DPR limit of 30 mg/L, Locations 2 and 3 surpass this threshold (DPR, 2002). The elevated BOD levels indicate a significant presence of biodegradable organic matter, potentially originating from sewage, industrial discharges, or agricultural runoff (Ekhaise & Omoigberale, 2011). Excessive BOD can result in critical oxygen depletion, thereby posing substantial threats to aquatic life.

Heavy Metals:

- Lead (Pb): The average concentration of 0.140 mg/L, accompanied by a standard deviation of 0.016, reflects persistently elevated levels across various sites. Lead contamination, frequently arising from industrial discharges, corroded pipelines, and urban runoff, presents significant health hazards, including neurological and developmental impacts (Nduka & Orisakwe, 2010). Therefore, immediate pollution control measures and ongoing monitoring are essential.
- Cadmium (Cd): A mean concentration of 0.228 mg/L and a standard deviation of 0.021 indicate consistently high cadmium levels. This hazardous metal, often associated with industrial waste, mining activities, and improper disposal practices, is linked to kidney damage and bone disorders (Ogoyi et al., 2011). Thus, rigorous enforcement of environmental regulations and remediation initiatives are critically needed.
- Iron (Fe): The mean concentration of iron at 2.16 mg/L, with a standard deviation of 0.361, suggests persistently high levels. Iron contamination may result from natural leaching, corroded infrastructure, or untreated industrial effluents (Adefemi & Awokunmi, 2010). Excessive iron concentrations can deteriorate water quality and adversely affect aquatic ecosystems. Therefore, mitigation strategies should prioritize controlling source inputs and enhancing water treatment methodologies.

Other heavy metals, including copper, chromium, and zinc, were detected at levels below the DPR regulatory thresholds, indicating minimal concern under the present circumstances.

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Table 1 Descriptive Statistics and Comparison of the Physio-chemical, Microbiological, and Heavy Metal Parameters Obtained from the Black Wastewater and Department of Petroleum Resources (DPR) Nigeria, Specified Limits.

Parameters	Unit	Location 1	Location 2	Location 3	Mean	SD	DPR *Std.	Significant (Mean*> DPR Limit)
pH	-	8.82	8.90	8.89	8.87	0.0436	6.5–8.5	YES
Temperature	°C	26.5	28.4	29.75	28.22	1.6327	30	NO
Conductivity	µS/cm	653	490	905	682.67	209.08	100	YES
Turbidity	mg/L	32	30	31	31	1	10	YES
TDS	mg/L	918	787	1499	1068	378.96	<2000	NO
TSS	mg/L	1900	1194	1999	1697.67	438.99	50	YES
COD	mg/L	182	775	1987	981.33	920.02	40	YES
OIL/Grease	µg/L	15.9	12.7	10.2	12.93	2.86	48	YES
DO	mg/L	3.4	3.33	3.23	3.32	0.085	5	NO
BOD	mg/L	13	32	45.5	30.17	16.33	30	YES
Lead	µg/L	0.127	0.134	0.158	0.140	0.016	0.05	YES
Cadmium	µg/L	0.25	0.209	0.226	0.228	0.021	0.003	YES
Iron	µg/L	2.02	2.57	1.89	2.16	0.361	0.3	YES
Copper	µg/L	0.00	0.397	1.29	0.562	0.661	1.5	NO
Chromium	µg/L	0.007	0.00	0.00	0.0023	0.0040	0.005	NO
Zinc	µg/L	0.04	0.00	0.00	0.013	0.023	1	NO
Total Plate Count	cfu/ml	642	769	894	768.33	126.00		
Presence of Coliform (MCA)	-	Positive	Positive	Positive				
Faecal Coliform Confirmation (EMB)	-	Positive	Positive	Positive				

Source: Researchers Data Analysis 2025. * Extracts from DPR.

V. CONCLUSION AND RECOMMENDATIONS

This research emphasizes the urgent concern of blackwater (sewage) pollution produced by maritime vessels operating in Onne Port, Rivers State, along with its resulting environmental and public health consequences. The investigation uncovered substantial levels of contamination in the adjacent waters, characterized by heightened concentrations of biological and chemical pollutants, including pH (8.87), Conductivity (682.67), Turbidity (31), Total Suspended Solids (1697.67), Chemical Oxygen Demand (981.33), OIL/Grease (12.93), Biochemical Oxygen Demand (30.17), Lead (0.140), Cadmium (0.228), Iron (2.16), and pathogenic microorganisms that exceeded the DRP limit. These contaminants compromise water quality, diminish dissolved oxygen levels, and threaten aquatic life and the equilibrium of ecosystems.

Moreover, the existence of untreated or inadequately treated sewage in marine settings promotes the spread of waterborne diseases and the bioaccumulation of hazardous substances in aquatic organisms that are consumed by local communities. The insufficiency or non-adherence of ship-based sewage management systems and port reception facilities to international maritime regulations, such as MARPOL Annex IV, has intensified the issue. This highlights the shortcomings of enforcement mechanisms and indicates systemic regulatory failures in monitoring waste disposal.
The consequences for public health are significant, especially for communities reliant on fishing and those utilizing adjacent surface waters for domestic needs. Prolonged exposure to fecal pollutants and heavy metals heightens the likelihood of gastrointestinal infections, skin ailments, and enduring health repercussions such as organ damage and developmental issues. The environmental repercussions also encompass biodiversity decline, habitat destruction, and the eutrophication of coastal waters.

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Considering the strategic economic significance of Onne Port, the implementation of sustainable waste management practices is not merely an ecological requirement but also an economic necessity. In the absence of immediate action, the ongoing release of blackwater into Onne's marine ecosystem jeopardizes both human health and the long-term sustainability of maritime activities in the area.

To address these environmental challenges, it is crucial to enforce stringent regulatory adherence concerning blackwater treatment and discharge from vessels. Investments in advanced onboard sewage treatment technologies, consistent environmental monitoring, and enhancements to port facilities are vital. Initiatives aimed at raising public awareness and engaging stakeholders, including partnerships among regulatory bodies, shipping enterprises, and local communities, will be essential in promoting sustainable water resource management and safeguarding Onne's delicate aquatic ecosystem.

REFERENCES

1. Adefemi, S.O., & Awokunmi, E.E. (2010). Determination of physicochemical parameters and heavy metals in water samples from major dams in Ekiti State, Nigeria. African Journal of Environmental Science and Technology, 4(6), 145–148.
2. Adeleke, B. O., Olaniran, A. O., & Pillay, L. (2019). Assessment of waste reception facilities in Nigerian seaports: Gaps and implications for marine pollution control. Environmental Science and Pollution Research, 26(9), 8742–8753. https://doi.org/10.1007/s11356-019-04311-5
3. Adeleke, B. O., Olaniran, A. O., & Pillay, L. (2019). Assessment of waste reception facilities in Nigerian seaports: Gaps and implications for marine pollution control. Environmental Science and Pollution Research, 26(9), 8742–8753. https://doi.org/10.1007/s11356-019-04311-5
4. Akpan, E.R. & Offem, J.O. (1993). Seasonal variation in water temperature and its influence on fish abundance in Cross River, Nigeria, Environmental Ecology.
5. Asonye, C.C., et al. (2007). Environmental Pollution and Health Risks of Residents Living Close to Waste Sites in Nigeria, Journal of Applied Sciences.
6. Asonye, C.C., Okolie, N.P., Okenwa, E.E., & Iwuanyanwu, U.G. (2007). Some physicochemical characteristics of surface water in Oguta Lake, Nigeria. Journal of Applied Sciences and Environmental Management, 11(1), 55–61.
7. Carpenter, S. R., Caraco, N. F., Correll, D. L., Howarth, R. W., Sharpley, A. N., & Smith, V. H. (1998). Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications, 8(3), 559–568. https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2
8. DPR (2002). Environmental Guidelines and Standards for the Petroleum Industry in Nigeria.
9. Ekhaise, F.O., & Omoigberale, M.O. (2011). Water quality assessment of river Ethiope in Ubeji, Delta State, Nigeria. Archives of Applied Science Research, 3(6), 243–251.
10. GESAMP. (2009). The Ballast Water Problem: A Global Environmental Challenge. Reports and Studies No. 89. Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.
11. IMO (2018, 2020). International Convention for the Prevention of Pollution from Ships (MARPOL)
12. Kümmerer, K. (2009). Pharmaceuticals in the environment: Sources, fate, effects and risks (3rd ed.). Springer.
13. Nduka, J.K., & Orisakwe, O.E. (2010). Assessment of environmental distribution of lead in some municipalities of south-eastern Nigeria. International Journal of Environmental Research and Public Health, 7(6), 2501–2513
14. Nguyen, H. T., Yamasaki, S., & Matsuoka, Y. (2020). Microbial and chemical contaminants from ship-generated sewage: Environmental implications. Marine Pollution Bulletin, 157, 111345. https://doi.org/10.1016/j.marpolbul.2020.111345
15. Nigerian Ports Authority (NPA). (2021). Annual report and statistics. https://nigerianports.gov.ng/
16. Nigerian Ports Authority. (2020). Annual Reports and Statistics. Lagos: NPA Publications.
17. Obire, O., Aguda, A., & Okigbo, R. N. (2003). Microbiological and physicochemical characteristics of some surface waters in Port Harcourt, Nigeria. Journal of Applied Sciences and Environmental Management.
18. Ogboeli, G. P.; Iyama, W. A. & Onuegbu (2023). Incidences and Trend of Marine Accident Fatalities in Various Rivers Routes Connecting the Major Sea Ports in Nigeria. International journal of research and innovation in apllied science (IJRIAS) 8(4), 109-122
19. Ogoni, S. A., Nwankwoala, H. O., & Akakuru, O. C. (2021). Assessment of water quality in the Niger Delta: Case study of Rivers State. Journal of Environmental Protection, 12(4), 278–295. https://doi.org/10.4236/jep.2021.124016

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

20. Ogoyi, D.O., Mwita, C.J., Nguu, E.K., & Shiundu, P.M. (2011). Determination of heavy metal content in water, sediment and microalgae from Lake Victoria, East Africa. The Open Environmental Engineering Journal, 4, 156–161.
21. Olalekan, R.M., Omidiji, A.O., & Afolabi, O.S. (2018). Oil Spillage and its Impact on the Environment of the Niger Delta. Civil and Environmental Research, 10(4), 1–8.
22. Ologunorisa, E. T., & Adeyemo, A. O. (2020). Environmental management and enforcement challenges in Nigerian seaports. Journal of Environmental Law and Policy, 4(2), 112–127.
23. Tebbutt, T.H.Y. (1998). Principles of Water Quality Control. 5th ed., Butterworth-Heinemann.
24. United Nations Environment Programme (UNEP). (2016). A snapshot of the world's water quality: Towards a global assessment. UNEP.
25. Woke, G. N., Ede, P. N., & Okoye, C. N. (2022). Water pollution in the Niger Delta: Trends, challenges, and mitigation strategies. Environmental Monitoring and Assessment, 194(3), 191–203. https://doi.org/10.1007/s10661-022-09768-2
26. World Health Organization (WHO). (2019). Guidelines on sanitation and health. https://www.who.int/publications/i/item/9789241514705

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