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Assessment of Pollution Load And Its Ecological and Societal Impacts Along the Ona River, Ibadan, Nigeria

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Abstract: This study investigates the impact of pollution load on the aquatic ecosystem of the Ona River in southwestern Nigeria, as well as the associated risks to the surrounding riverine communities. The Ona River, a vital freshwater resource traversing densely populated and industrialised zones, receives diverse effluents from industrial, agricultural, and domestic activities. A stratified sampling strategy was employed across nine sites, with water samples analysed for physicochemical and microbiological parameters, including heavy metals. The Pollution Load Index (PLI) was used to quantify the levels of contamination. Results revealed significant concentrations of heavy metals, notably lead (0.008–0.028 mg/L), iron (0.115–0.396 mg/L), arsenic (0.04 ± 0.02 mg/L), and chromium (0.06 ± 0.03 mg/L), several of which exceeded World Health Organisation (WHO) permissible limits. These contaminants pose substantial ecological risks by threatening aquatic biodiversity and disrupting ecosystem services, while also presenting severe public health concerns such as neurotoxicity, carcinogenesis, and organ dysfunction. Statistical analysis indicated uniform distribution of pollutants across sites, suggesting persistent pollution sources. The findings underscore the urgent need for regular monitoring, stringent pollution control, and targeted remediation strategies, including phytoremediation and the use of constructed wetlands. This research contributes to sustainable river management by providing empirical evidence to inform policy interventions that safeguard both ecological integrity and human health.

Keywords: Phytoremediation, Carcinogenesis, Neurotoxicity, Biodiversity, Remediation

I. Introduction

Aquatic ecosystems are vital components of the biosphere, providing a range of ecological services including water purification, habitat for biodiversity, and sustenance for human populations (Wanjari et al., 2024). However, these ecosystems are increasingly threatened by anthropogenic activities that lead to the accumulation of pollutants in water bodies (Ogidi & Akpan, 2022). Among such ecosystems, riverine systems are particularly vulnerable due to their dynamic nature and direct exposure to industrial, agricultural, and domestic discharges (Mukherjee et al., 2023). In developing countries, where regulatory enforcement is often weak, the impact of pollution on rivers and adjacent communities is especially pronounced (Fayiga et al., 2018). The Ona River, located in southwestern Nigeria, exemplifies a river system under significant environmental stress. Flowing through densely populated and industrialised areas, the river receives effluents from a variety of sources, including food processing plants, tanneries, textile industries, and municipal waste streams (Akande, 2025). This has resulted in deteriorating water quality and disruption of aquatic life, with concomitant implications for the health and livelihoods of communities that rely on the river for drinking water, fishing, and other socio-economic activities (Ojo, 2018).

Rivers are fundamental components of the hydrological cycle, serving as essential water resources for domestic, agricultural, and industrial purposes (Yang, 2021). However, their ecological integrity and utility are increasingly threatened by diverse sources of pollution, which compromise water quality and aquatic biodiversity (Giri, 2021). The origins of river pollution are broadly categorised into point and non-point sources. Point sources are discrete and identifiable, often originating from industrial effluents, sewage treatment plants, and wastewater outfalls (Schäffner et al., 2009). These sources typically introduce concentrated loads of contaminants such as heavy metals, persistent organic pollutants, nutrients, and pathogens directly into water bodies (Huang & Xiang, 2015). In contrast, non-point sources are diffuse, spatially dispersed, and difficult to monitor. They include agricultural runoff, urban stormwater, and atmospheric deposition, which contribute to river pollution through episodic events such as rainfall and flooding (Lisetskii et al., 2023). These sources introduce a broad spectrum of pollutants, including pesticides, fertilisers, hydrocarbons, and sediments, into river systems, often with cumulative and long-term ecological consequences. The contaminants alter water's chemical composition and reduce dissolved oxygen levels, threatening aquatic biodiversity and posing health risks to human populations. Such pollutants often enter rivers through direct discharge via pipes or drainage systems, especially in regions with weak environmental regulation (Bulbul & Mishra, 2022)

This study aims to assess the impact of pollution load on the aquatic ecosystem of the Ona River and evaluate the socio-environmental consequences for surrounding riverine communities. Through a multidisciplinary approach that integrates water quality analysis and ecological assessment, the study aims to provide a comprehensive understanding of how pollution affects both the biophysical environment and human well-being. Consequently, the findings aim to inform policy frameworks and intervention strategies that restore the ecological integrity of the Ona River and safeguard the health of dependent populations.

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II. Research Design

This study employs a quantitative and observational research methodology to experimentally assess the impact of pollution load on the Ona River's aquatic ecosystem and its surrounding communities. The Ona River, located in southwestern Nigeria, traverses both industrial and residential zones, thereby serving as a receptor for a diverse range of effluents, particularly those from hospitals and industries (Ganiyu et al., 2021). To capture these dynamics, a systematic stratified sampling strategy was employed, with nine (9) sampling sites carefully established along the river course. Of these, three (3) sites were specifically positioned at locations directly receiving industrial effluents, given the heightened risk of pathogens and other contaminants entering the aquatic environment. At each sampling site, a cluster of three (3) discrete water samples were collected at uniform intervals of three (3) meters to account for micro-spatial variation and enhance statistical robustness. Samples were obtained following standard protocols to ensure representativeness and minimise contamination, stored in sterilised high-density polyethene bottles, safely transported to the laboratory, and promptly analysed. The analyses encompassed key physicochemical and microbiological indicators, including pH, dissolved oxygen, heavy metals, and total coliforms

III. Result and Discussion

In Table 1, the physicochemical analysis revealed that most parameters exhibited no significant spatial variation across the three sampling locations ($p > 0.05$), except for pH, which showed a significant difference ($p = 0.009$). The pH values (6.7–7.07) indicated slightly acidic to neutral conditions, likely influenced by local geochemical or anthropogenic factors. The temperature remained constant at 32°C, indicating uniform thermal conditions. Variations in turbidity, electrical conductivity, TDS, and TSS were minimal, reflecting similar ionic and particulate composition across sites. DO, BOD, and COD values (1.80–2.83 mg/L, 10.33–16.00 mg/L, and 863.33–1263.33 mg/L, respectively) indicated moderate organic pollution but without significant differences. Likewise, hardness, odour, and colour values were within acceptable limits, implying that the overall water quality was relatively homogeneous across locations, with only pH showing significant localised variation due to minor physicochemical influences.
Table 1: Physicochemical properties of the water sample.

Parameter	Location 1	Location 2	Location 3	Total	p-value
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	
pH	6.7±0.15	6.9±0.05	7.07±0.05	6.9±0.18	0.009*
Temperature (°c)	32.0±0.00	32.0±0.00	32.0±0.00	32.0±0.00	--
Turbidity (NTU)	15.33±3.06	12.67±4.51	16.33±6.03	14.78±4.38	0.635
EC (us/cm)	350.33±8.39	343.67±7.77	404.67±69.21	366.22±45.50	0.210
TDS (mg/l)	135.33±14.50	121.00±22.61	144.33±13.32	133.56±18.13	0.320
TSS (mg/l)	3.47±2.35	6.43±4.24	2.83±1.75	4.24±3.07	0.351
DO (mg/l)	1.80±0.36	2.83±0.42	2.77±0.68	2.47±0.67	0.081
BOD (mg/l)	10.33±2.52	16.00±4.00	15.00±5.00	13.78±4.32	0.254
COD (mg/l)	1263.33±658.96	863.33±397.16	905.00±437.35	1010.56±481.74	0.601
Hardness (mg/l)	9.52±0.81	11.51±1.23	10.26±1.76	10.43±1.44	0.256
Odour (TON)	1.67±0.58	1.33±0.58	2.33±0.58	1.78±0.67	0.178
Colour (TCU)	4.00±1.00	4.00±1.00	4.67±0.58	4.22±0.83	0.593

Author's data, 2025

* Significant at $p<0.05$ level

EC – Electrical Conductivity

TDS - Total Dissolved Solids

TSS – Total Suspended Solids

DO – Dissolved Oxygen

BOD – Biochemical Oxygen Demand

COD – Chemical Oxygen Demand

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Consequently, the table 3 mean values of heavy metals in the water samples in comparism with permissible limits provided in table 2. The mean Lead, Iron, Copper, Chromium and Arsenic level was 0.02±.006 (mg/l), 0.27±0.09 (mg/l), 0.12±0.04 (mg/l), 0.06±0.03(mg/l), 0.04±0.02 (mg/l), respectively. These parameters were not significantly different across samples and locations (p>0.05)

Table 2 Permissible Limits According to Global Standards

Parameter	WHO Limit (mg/L)	NIS Limit (mg/L)	FAO Limit (mg/L)
Lead (Pb)	0.01	0.01	5.0
Iron (Fe)	0.3	0.3	5.0
Copper (Cu)	2.0	1.0	0.2
Manganese (Mn)	0.4	0.2	0.2
Zinc (Zn)	3.0	3.0	2.0
Nickel (Ni)	0.07	0.02	0.2

Source: World Health Organisation (WHO, 2022). *Guidelines for Drinking-Water Quality*

Nigerian Industrial Standard for Drinking Water Quality (NIS 554:2015)

Shortle et al. (2021): FAO (1985). *Water Quality for Agriculture*

Table 3 Heavy Metals Mean Value

Parameter	Location 1	Location 2	Location 3	Total	p-value
	Mean±S.D	Mean±S.D	Mean±S.D	Mean±S.D	
Lead (mg/l)	0.02±0.007	0.01±0.003	0.01±0.006	0.02±-.006	0.245
Iron (Fe)	0.29±0.09	0.22±0.09	0.31±0.09	0.27±0.09	0.521
Copper (Cu)	0.10±0.01	0.15±0.07	0.12±0.01	0.12±0.04	0.420
Chromium (Cr)	0.06±0.04	0.04±0.02	0.08±0.03	0.06±0.03	0.369
Arsenic (AS)	0.05±0.04	0.02±0.01	0.04±0.02	0.04±0.02	0.403

Author's data, 2025

The analysis of heavy metals in Ona River water showed detectable levels of Pb, Fe, Cu, Cr, and As, all of which are of environmental and public health relevance. Statistical tests ($p > 0.05$) revealed no significant spatial variation, suggesting uniform distribution across sites. Lead (0.02 ± 0.006 mg/L) exceeded the WHO limit (0.01 mg/L), while iron (0.27 ± 0.09 mg/L) remained within but close to the upper threshold, with potential effects on water quality. Copper (0.12 ± 0.04 mg/L) was well below the permissible limits, posing no immediate risk; however, it warranted ongoing monitoring. Chromium (0.06 ± 0.03 mg/L) surpassed the WHO's guideline (0.05 mg/L) in some samples, requiring speciation analysis. Arsenic (0.04 ± 0.02 mg/L) significantly exceeded the WHO standard (0.01 mg/L), emerging as the most critical concern, underscoring the need for routine monitoring and remediation. This is in line with Bhat et al. (2024), who describe asenic contamination in water and soil as a global concern, posing a danger to the environment and public health. The presence of heavy metals in aquatic systems at concentrations exceeding established permissible limits constitutes a critical threat to both public health and environmental integrity. These metals, which include elements such as lead (Pb), Iron (Fe), and Copper (Cu). Chromium (Cr) and Arsenic (As) are non-biodegradable and tend to bio-accumulate within biological organisms, biomagnifying across trophic levels. Prolonged exposure to elevated levels of these contaminants can lead to a range of acute and chronic health conditions in humans, including neurological disorders, renal dysfunction, carcinogenesis, and developmental abnormalities (Ahmad et al., 2021; Koki et al., 2015). Lead levels (0.008–0.028 mg/L) exceeded the 0.01 mg/L limit in several samples, raising serious health concerns due to their neurotoxicity, particularly in children. This is further affirmed by Obasi and Akudinobi (2020), affirming the presence of lead, cadmium, arsenic and mercury as carcinogenic chemicals, which can cause Parkinson's disease, Arsenicosis, acrodynia, sclerosis, Alzheimer's disease, hair loss, mental imbalance and abortion in women. Iron concentrations (0.115–0.396 mg/L) also exceeded the 0.3 mg/L threshold in some cases, potentially affecting water taste, causing staining, and promoting the formation of biofilms.

In Table 4, the bacteriological assessment revealed spatial variation in microbial distribution across the three sampling locations. Escherichia coli was detected in all samples, indicating widespread faecal contamination and non-compliance with the World Health Organisation (WHO, 2022) guideline, which stipulates that drinking water must be free from E. coli and coliforms per 100 mL. Klebsiella and Bacillus spp. were found exclusively in Location 1, suggesting site-specific contamination likely from soil runoff or

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organic waste. Pneumoniae occurred only in Locations 2 and 3, while Pseudomonas was isolated from Location 2 alone, reflecting possible anthropogenic influence or localised pollution. Staphylococci appeared solely in Location 3, implying contamination from human or animal contact. The varied microbial composition across sites underscores differences in contamination sources and environmental conditions, with the universal occurrence of E. coli highlighting the need for regular monitoring and effective water treatment interventions to safeguard public health. Exposure to contaminated water directly or indirectly can lead to varying diseases such as gastrointestinal illness, severe complications, and urinary tract infections, among others. This finding aligns with the observation of Lanrewaju et al. (2022), who reported that exposure to contaminated water poses significant public health risks, including the transmission of viral infections. According to Fida, et al, (2023), bacterial contamination such as coliforms and toxic elements like Arsenic (As), Iron(Fe), Nickel (Ni), Chloride (Cl^-), fluoride (F-), Mercury (Hg), and pesticides`were found to be the major causes of waterborne diseases.

Table 4: Coliform Bacteria Presence

Parameter	Location 1	Location 2	Location 3
Klebsiella	✓	x	x
E. coli	✓	✓	✓
Pneumoniae	X	✓	✓
Bacillus spp.	✓	x	x
Pseudomonas	X	✓	x
Staphylococci	X	x	✓

Author's data, 2025

IV. Conclusion and Recommendation

This study provides a comprehensive assessment of the pollution load in Ona River, revealing evidence of moderate pollution that poses potential environmental and public health risks. The physicochemical parameters were largely within permissible limits, except for pH, which showed significant variation across locations, and certain heavy metals—particularly lead (Pb), chromium (Cr), and arsenic (As)—that exceeded WHO (2022) thresholds. The elevated concentrations of these non-biodegradable metals suggest cumulative contamination from industrial effluents and anthropogenic discharges, with implications for bioaccumulation and long-term ecological toxicity. Microbiological analysis further indicated the universal presence of Escherichia coli across all sampling points, alongside opportunistic pathogens such as Klebsiella, Pneumoniae, and Staphylococci, confirming faecal pollution and possible disease transmission routes. The findings align with previous studies, emphasising that contaminated surface waters constitute major reservoirs for waterborne infections and toxic metal exposure in developing regions. It is therefore recommended that periodic monitoring, strict effluent regulation, and implementation of integrated watershed management be prioritized to control pollutant discharge. Additionally, public health awareness campaigns, provision of safe drinking water, and adoption of low-cost treatment technologies such as constructed wetlands and adsorption filtration are essential to mitigate contamination risks. Strengthening collaboration among environmental agencies, local industries, and research institutions will be critical for sustainable management and restoration of the Ona River ecosystem.

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