Determination of Heavy Metal Concentrations in Idemili River: Implications for Public Health and Environmental Management.

[1]Amaechi, Mercy, [2]Okoye, Oguejiofor Chinedu, [1]Onuoha, Chijioke David, and [1]Ogbo, Ojiakor Godfrey

[1]Department of Environmental Management, Faculty of Environmental Sciences, Nnamdi Azikiwe University, Awka
[2]Department of Urban and Regional Planning, Faculty of Environmental Sciences, Nnamdi Azikiwe University, Awka

Corresponding Author's Email: amaechimercy09@gmail.com ; Phone: +2348145139896

ABSTRACT

Heavy metal contamination of surface water has become a critical environmental and public health concern, particularly in developing countries where industrial and domestic effluent regulations are weak. This study assessed heavy metal concentrations in River Idemili; implications for public health and environmental management, during the year 2025. The river was divided into three segments (upstream, midstream, and downstream). A total of three water samples were collected from the river, one from each segment and analyzed for selected heavy metals in duplicate laboratory runs using Atomic Absorption Spectrophotometry (AAS). data were summarized using descriptive statistics and compared with the World Health Organization (WHO, 2017) drinking water standards to assess the degree of contamination and potential health implications. Concentrations of lead (Pb), cadmium (Cd), iron (Fe), manganese (Mn), aluminium (Al), arsenic (As), and mercury (Hg) exceeded WHO limits across most sampling points, with midstream values showing the highest contamination. Essential macro-elements such as magnesium (Mg), sodium (Na), potassium (K), and calcium (Ca) remained within acceptable limits. Spatial variation indicated a strong anthropogenic influence from industrial, abattoir, and domestic discharges. The study concludes that the river Idemili is under a progressive heavy metal stress, posing potential risks to aquatic life, agriculture, and human health. Hence, we recommend effective pollution management strategies and continuous monitoring of the river.

Keywords:

River Idemili; Heavy metals; AAS, Water pollution; Effluents; Abattoir; Dumpsites; Public health.

1.1 Introduction

Water is an essential component of life, forming an integral part of the food chain and supporting both terrestrial and aquatic ecosystem. The day-to-day activities of man are highly dependent on water, and thus the importance of clean water in the environment for drinking, household use, and agriculture cannot be overemphasized. It constitutes about 50-97% of the biomass of living organisms and about 70% of the human body (Allan, 2006). Despite its importance, water remains one of the most poorly managed natural resources globally (Peace and Richard, 2011). Increasing population, rapid urbanization, and industrialization have intensified water pollution, particularly in developing countries where wastewater treatment and environmental enforcement

remain inadequate (UN-Water, 2021).

Wastewater is generated when water used in domestic, agricultural, or industrial processes undergoes physical, chemical, or biological changes that make it unsuitable for intended uses such as drinking or irrigation (Peace and Richard, 2011). Globally, about 44% of wastewater is released into the environment untreated, contributing to severe surface water pollution (UN-Water, 2021). Industrial effluents, in particular, introduce pollutants such as heavy metals, organic compounds, and nutrients into rivers and streams, leading to eutrophication, oxygen depletion, and the disruption of aquatic ecosystems (Kaur and Brraich, 2021). Surface water pollution from industrial effluents has become a significant environmental and public health challenge in Nigeria, particularly in industrialized regions like Anambra State (Amaechi, Onuoha, and Onwuka, 2025).

Heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), and arsenic (As) are naturally occurring in the earth's crust but become toxic when their concentrations increase through anthropogenic activities such as industrial discharge, abattoir waste, open dumpsites, and agricultural runoff (Amaechi and Onwuka, 2021). These metals can accumulate in aquatic flora and fauna, and through bioaccumulation and biomagnification, they pose risks to higher organisms, including humans. The use of contaminated water for irrigation can also result in the transfer of heavy metals to soil and crops, threatening agricultural productivity and food safety (Sajid, Tabassum, and Masood, 2015).

In sub-Saharan Africa, access to potable water remains a challenge. According to the World Health Organization (WHO, 2023), about 58% of people in the region lack safely managed drinking water services, and nearly half of its rural residents depend on unimproved sources. In Nigeria, rapid industrial expansion without corresponding environmental safeguards has worsened river pollution, especially in industrialized states such as Anambra (Haruna, 2020). Availability and access to portable water has been a major challenge in Anambra State. The industrial sector plays a vital role in the economic growth and development of Anambra State, Nigeria, contributing significantly to job creation and wealth generation. However, unregulated discharge of industrial effluents into rivers has emerged as a critical environmental and public health concern. The proximity of industries to rivers such as River , River Niger and a host of others in the state exacerbates water pollution, threatening the aquatic ecosystem and the health of dependent communities (Okereke, Ogidi, and Obasi, 2016). Despite the importance of these water bodies to local livelihoods, there is a lack of sufficient regulation and enforcement regarding effluent treatment and disposal (Haruna, 2020). The population of Anambra, particularly communities surrounding River , and others relies heavily on these water bodies for

drinking water, bathing, farming, fishing, and bathing. With limited access to urban water supply, many residents turn to boreholes, wells, or directly use water from these rivers. The presence of harmful contaminants in these water sources, especially during certain seasons, poses significant health risks, including exposure to toxic chemicals and waterborne diseases (Osakwe and Asukwo, 2017). Previous studies have documented elevated levels of heavy metals in rivers across the state, including the Niger and Nkissi Rivers, primarily due to effluent discharge, abattoir waste, and leachates from dumpsites (Okereke, *et al*, 2016; Oboh and Edema, 2007; Olatunji and Osibanjo, 2012).

River Idemmili, located in Umuota Akuora, Obosi, within Idemili North Local Government Area, is one of the most ecologically and culturally significant rivers in Anambra State. The river flows through densely populated and industrialized areas, receiving runoff from factories, abattoirs, refuse dumps, and surrounding settlements. Beyond its ecological role, the river also holds cultural and traditional significance for local communities, serving as a site for rituals, festivals, and other socio-cultural activities (Ezeh, Nwankwo, and Akachukwu, 2018). Such practices, alongside anthropogenic discharges, contribute additional organic and inorganic materials that may influence the river's water quality. There are large farmlands around this river whose water is used for irrigation. When water from such river is used for cooking, drinking, and irrigation, the pollutants directly or indirectly gets to man through the food chain. Studies have shown cases of metal contamination in Rivers and water sources across the country; for instance, the works of Okolo, Okoye, and Egwuonwu, (2012), buttresses this. The aquatic ecosystems of the river is particularly vulnerable to these disturbances. Furthermore, the trans-boundary nature of water bodies means that pollution in one area can affect downstream communities, further complicating water management (Okereke, *et al*, 2016). Corruption and insufficient enforcement of environmental regulations aggravate the problem, leaving rivers in industrial areas like Onitsha highly polluted. This lack of accountability contributes to the unchecked discharge of toxic substances, putting both human and environmental health at significant risk (Haruna, 2020). Without comprehensive and systematic data, policymakers and environmental agencies cannot develop effective regulations or enforce existing standards.

Given these environmental pressures and the lack of effective pollution control measures, it becomes imperative to investigate the presence and concentration of heavy metals in River Idemili and to assess the potential implications for public health and environmental management in the study area.

1.2 Aim and Objectives

The aim of this study is to determine the concentration levels of selected heavy metals in

river Idemili with a view to establishing its implication for public health and environmental management.

To achieve this aim, the following objectives were pursued:

1. to determine the presence and concentration levels of selected heavy metals (Pb, Cd, Cr, Hg, Ag, Zn, Cu, Mn, Fe, Co, As, Se, Ni, Mg, Na, K, Ca, Al, Mo, V) in the three water samples,
2. to compare the measured concentrations of heavy metals with the World Health Organization (WHO, 2017) drinking water quality standards to assess the degree of contamination, and
3. to provide evidence-based recommendations for effective environmental regulation and public health protection.

1.3 Hypothesis

Hypothesis one: There is no significant difference between the heavy metals in the sample and the WHO standards.

2.0 Literature Review

Environmental quality is one of the most important determinants of human well-being and sustainability (Rusen, 2012). The quality of the environment directly affects the quality of life, reflecting the interactions between human activities and natural systems. Water quality degradation is influenced by various factors, including climate change, vegetation cover, topography, and especially anthropogenic activities within catchment areas. Sustainable Development Goal (SDG) 6 emphasizes clean water and sanitation, specifically Target 6.3, which aims to improve water quality by 2030 through pollution reduction, elimination of dumping, and minimization of hazardous discharges (United Nations, 2025).

Heavy metals are among the most persistent and toxic pollutants in aquatic environments. Unlike organic contaminants, metals such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr), and nickel (Ni) do not biodegrade and can accumulate through trophic levels, posing risks to aquatic organisms and human populations (Balali-Mood, Naseri, Tahergorabi, Khazdair, and Sadeghi, 2021). In many developing countries, ineffective regulation of industrial effluents, abattoir discharges, and solid waste dumping contributes significantly to heavy metal contamination of rivers and streams (Okereke et al., 2016).

Industrialization in Nigeria has been linked to elevated heavy metal levels in water bodies due to poor effluent treatment practices. For instance, Nweke, Okechukwu, Omokpariola, Umeh, and Oze, (2023) evaluated effluents from a brewery in Benue State and found concentrations of Cr, Ni, Pb, Mn, As, and Cd above WHO (2017) permissible limits, while Fe, Zn, and Co remained within safe levels. The study concluded that such discharges posed moderate ecological risks, primarily due to Pb, As, and Ni enrichment. Similarly, Bekeowei

and Bariweni (2021) analyzed wastewater from paint industries in Yenagoa, reporting mean concentrations ranging from Pb (0.036–0.098 mg/L), Zn (0.478–3.302 mg/L), Cu (0.0345–1.343 mg/L), As (1.195–5.022 mg/L), and Cd (0.002–0.528 mg/L)—many of which exceeded WHO and Nigerian Industrial Standards (NIS) limits.

In southeastern Nigeria, Obeta, *et al*. (2019) investigated the influence of industrial effluents on surface water quality in Onitsha and found high levels of BOD, COD, Fe, Cu, Pb, and Cr, with E. coli and total coliform counts exceeding WHO standards, indicating both chemical and microbial pollution. These studies collectively show that industrial effluents are a key driver of heavy metal enrichment in surface waters, including those in Anambra State, where River Idemmili is located.

Abattoir activities are another significant source of heavy metal and organic contamination. Obukohwo and Onosemuode (2024) assessed water bodies surrounding three abattoirs in Warri and reported wet- and dry-season concentrations of Cd, Cr, Ni, Zn, Pb, and Cu ranging from 0.8 to 15 mg/L, far exceeding WHO guidelines. They attributed this to the use of automobile tires for singeing animal hides and poor wastewater management.

Similarly, Ajibade and Amusa (2016) studied soils around abattoirs in Oyo, Ogun, and Lagos States, observing elevated Pb (0.32 mg/kg), Cu (0.45 mg/kg), and Cr (0.31 mg/kg) concentrations exceeding FEPA standards. The authors linked these to open burning, flaying, and singeing processes, which release metal-rich particulates into nearby soils and waters.

In Maiduguri, Abdullahi, Abubakar, and Titus (2020) found wastewater from the Kasuwan Shanu abattoir contained Ni > Zn > Mn = Hg > Cd > Fe > Cr, with most metals above WHO limits except Fe, Mn, and Zn. These findings demonstrate that abattoirs contribute substantially to local and downstream contamination through poorly managed effluent discharge.

Leachates from municipal dumpsites also introduce metals and other pollutants into surface and groundwater. Adelekan and Alawode (2011) found significant buildup of Pb, Cd, and Cr in soils and groundwater near refuse dumps in Ibadan, with concentrations exceeding WHO permissible limits, indicating ongoing contamination. Similarly, Chiedozie, Patrice, Hillary, Victor, and Helen. (2023) assessed boreholes around an unlined landfill in Nnewi and discovered contamination by heavy metals such as Cd, Pb, and Ni, attributed to leachate infiltration, with both wet- and dry-season values surpassing WHO standards.

Across southeastern Nigeria, studies consistently report elevated levels of toxic metals in water bodies near industrial and abattoir clusters. Given that River Idemmili flows through Umuota Akuora, Obosi, an area characterized by industrial activity, open dumping, and slaughtering practices, these previous findings provide critical context for understanding potential contamination pathways. The reviewed literature underscores

the likelihood that industrial effluents, abattoir wastes, and refuse leachates are the dominant contributors to metal loading in River Idemmili, necessitating systematic monitoring and management.

3.0 Materials and method

3.1 Study Area

River Idemili is located at Umuota Akuora, Obosi, in Idemili North Local Government Area of Anambra State, Nigeria. Umuota Akuora is one of the five principal villages that make up Obosi town, a historic community in southeastern Nigeria known for its strong cultural institutions and socio-economic vibrancy (Agbodike, 2015). The river flows through residential and agricultural zones, receiving runoff from nearby industries, abattoirs, and refuse dumpsites before merging downstream with the River Niger.

Obosi is bordered by Onitsha to the northwest, Nkpor to the northeast, and Oba to the southeast. Idemili North LGA has a projected population of 583,992 for 2017 while
Obosi town has a projected population of 86,410 (Anambra-Ire-Obosi-Final-ESMP-Report, 2017)The settlement pattern is characterized by clustered households and mixed land use, with farming, trading, and small-scale manufacturing forming the economic base (Eze et al., 2018; Onyema, 2019).

Umuota Akuora experiences a tropical rainforest climate, typical of southeastern Nigeria, with two distinct seasons: the rainy season (April-October) and the dry season (November-March). The mean annual temperature is about 26°C, average annual rainfall ranges between 1,800-2,000 mm, and relative humidity averages 70-80% throughout the year (Weather Atlas, 2024). The community depends heavily on river Idemili for domestic use, irrigation, fishing, and cultural practices.

The river holds cultural and traditional significance, serving as a site for community gatherings and rituals associated with local heritage (Nwadialor, and Ewelukwa, 2024). However, increasing anthropogenic pressures, including effluent discharge, abattoir waste, and solid waste dumping, have contributed to the deterioration of water quality in recent years. The high dependency of the population on the river for domestic and agricultural purposes underscores the environmental and public health importance of this study.

3.2 Research Design

The experimental research design was used to determine the presence and concentrations of heavy metals in the water samples. Water samples collected from the rivers were analysed in the laboratory within 12 hours of collection to establish baseline data for their heavy metal contents. The approach combined systematic field sampling with laboratory-based chemical analyses. The laboratory analyses focused on carefully selected heavy metals to yield

relevant and actionable results. The laboratory analysis was done in duplicates.

3.3 Sample Collection

The stratified and purposive sampling technique was employed in this study. Stratified sampling technique is a probability sampling method which allows the researcher to divide the study area into stratums from which samples are be chosen to represent the entire population. Purposive sampling technique is a non-probability sampling method where the researcher will select aspect of the population on purpose. These sampling methods were used to divide the river into three (3) segments (upstream (A), midstream (B), and downstream (C) and randomly select points where samples were collected. River was stratified to enhance spatial determination of pollution gradients. Stratified random sampling was applied within each segment to reduce spatial bias, while purposive sampling was used to target zones of known industrial discharge (Amaechi, *et al,* 2025). A total of six (6) water samples were collected, three primary samples representing each river segment (Upstream A, Midstream B, and Downstream C), and three replicate samples collected for quality assurance, making two runs in total.

Sampling points were geo-referenced using a Global Positioning System (GPS) device, with coordinates recorded in decimal degrees as follows:

Upstream (A): 6.098483° N, 6.841677° E

Midstream (B): 6.098483° N, 6.842486° E

Downstream (C): 6.098733° N, 6.843377° E

Samples were collected using well-labeled pre-cleaned acid-washed 1-liter polyethylene bottles at specific intervals. Sampling was done in March, 2025; sampling points were strategically chosen, between 9:00am and 11:00am. Samples were taken approximately 30 cm below the surface, to avoid surface contaminants and were stored in ice-packed coolers immediately after collection. In-situ measurements of Ph, temperature, and electrical conductivity were conducted using portable meters (Hanna Instruments) immediately after sampling.

3.4 Laboratory Analysis

Within 12 hours of collection, samples were transported to a certified laboratory for analysis. The water samples were subjected to acid digestion using nitric acid (HNO_3) for preservation and preparation. The concentrations of 20 heavy metals including Lead (Pb), Cadmium (Cd), Chromium (Cr), Mercury (Hg), Silver (Ag), Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe), Cobalt (Co), Arsenic (As), Selenium (Se), Nickel (Ni), Magnesium (Mg), Sodium (Na), Potassium (K), Calcium (Ca), Aluminium (Al), Molybdenum (Mo), and Vanadium (V) were determined using Atomic Absorption Spectrophotometry (AAS) and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), following APHA (2017) standard procedures. Quality control was ensured through calibration with certified reference materials and reagent blanks.

3.5 Data Management and Statistical Analysis

Data generated from researchers field work were assessed using Microsoft Excel and SPSS (Version 25). Descriptive statistics (mean, standard deviation, and range) were used to summarize the concentration of each parameter across the three segments. The one sample t-test was used to assess significant differences between the heavy metal concentration of River and the WHO standards. The data that was collected from field observations and laboratory analysis were presented using tables.

3.6 Ethical Considerations

The study adhered to ethical standards for environmental research. Sampling was conducted without disrupting local ecosystems, and permissions were obtained from relevant community leaders and environmental authorities. The research also aligns with the precautionary principle and contributes to public health advocacy

4.0 Results

This section deals with the presentation and analysis of the primary data generated from laboratory analysis.

1.to determine the presence and concentration levels of selected heavy metals in River

Table 4.1: Heavy metals present in the water sample

Parameters (mg/L)	**A Run 1**	**A Run 2**	**B Run 1**	**B Run 2**	**C Run 1**	**C Run 2**
Lead	0.027	0.018	0.227	0.287	0.108	0.117
Cadmium	0.014	0.014	0.018	0.55	0.023	0.004
Silver	0.035	0.025	0.021	0.021	0.023	0.018
Zinc	0.058	0.041	0.167	0.187	0.078	0.036
Copper	0.063	0.053	0.048	0.045	0.038	0.046
Manganase	0.675	0.053	0.045	0.36	0.044	0.153
Iron	0.698	0.241	0.667	0.346	0.361	0.000
Cobalt	0.023	0.013	0.034	0.021	0.012	0.022
Chromium	0.011	0.002	0.017	0.034	0.021	0.023
Mercury	0.024	0.019	0.016	0.019	0.008	0.020
Magnesium	0.778	0.382	0.408	0.286	0.338	0.408
Sodium	1.027	1.991	1.872	1.882	2.089	1.672
Potassium	2.089	2.001	1.667	1.089	1.556	1.438
Calcium	0.499	0.178	0.566	0.506	0.455	0.389
Aluminium	0.308	0.332	0.189	0.267	0.336	0.312
Arsenic	0.208	0.188	0.167	0.261	0.225	0.208
Selenium	0.017	0.014	0.028	0.038	0.018	0.190
Molybdenum	0.015	0.081	0.027	0.021	0.018	0.009
Nickel	0.014	0.015	0.011	0.021	0.027	0.019
Vanadium	0.002	0.007	0.001	0.002	0.003	0.012

Source: Researchers field work, 2025

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Key: A run 1 and run 2 (upstream), B run 1 and run 2 (midstream), and C run 1 and run 2 (downstream)

Table 4.1 provides an analysis of heavy metal concentrations in water samples collected from the river. They include A run 1 and run 2 (upstream), B run 1 and run 2 (midstream), and C run 1 and run 2 (downstream). Each parameter was measured in two separate runs, and the results indicate the presence of multiple heavy metals at varying concentrations, with industrial effluents, abattoir waste, and refuse dumps as the primary source of contamination. The metals detected include Lead (Pb), Cadmium (Cd), Silver (Ag), Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe), Cobalt (Co), Chromium (Cr), Mercury (Hg), Magnesium (Mg), Sodium (Na), Potassium (K), Calcium (Ca), Aluminium (Al), Arsenic (As), Selenium (Se), Molybdenum (Mo), Nickel (Ni), and Vanadium (V). All the metals under study were detected in water samples collected from the three segments of River (upstream, midstream, and downstream), confirming the presence of multiple trace metals in the river.

The concentrations of heavy metals across the upstream (A), midstream (B), and downstream (C) sections of River revealed clear spatial variation. Among the detected metals, Lead (Pb) was consistently found across all locations, with the highest values recorded in B run 1 and 2 (0.227 mg/L and 0.287 mg/L), indicating a strong influence of industrial pollution, suggest strong input from abattoir discharges, refuse dumps, and ritual animal residues. Cadmium (Cd) was also present in all locations, with notably high levels in B run 1 and run 2 (0.018 mg/L and 0.55 mg/L). Silver (Ag), which showed significant variation across locations was detected at much lower concentrations A run 1 and run 2 (0.035 mg/L and 0.025 mg/L), B run 1 and 2 (0.021 mg/L and 0.021 mg/L), and C run 1 and 2 (0.023 mg/L and 0.018 mg/L). Chromium (Cr), a hazardous heavy metal, exhibited alarming concentrations in several locations. The highest value was recorded at B run 2 (0.034 mg/L), reinforcing concerns about industrial, abattoir, and waste dump contamination. Similarly, Mercury (Hg) levels were higher A run 1 (0.024 mg/L), and C run 2 (0.020 mg/L).

Zinc (Zn) increased from 0.041–0.058 mg/L upstream to 0.167–0.187 mg/L midstream, reflecting runoff from metallic and organic waste. Iron (Fe) and manganese (Mn) occurred at relatively high concentrations throughout (Fe: 0.000–0.698 mg/L; Mn: 0.044–0.675 mg/L), discharges. Copper (Cu) and nickel (Ni) showed moderate levels, while chromium (Cr) exhibited a downstream increase (0.002–0.034 mg/L), possibly linked to effluent from metal-based industries. Arsenic (As) and selenium (Se) were present across all locations (As: 0.167–0.261 mg/L; Se: 0.014–0.190 mg/L), with downstream enrichment suggesting cumulative contamination. Aluminium (Al), calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) occurred in all samples, reflecting mineral

dissolution and anthropogenic influence.

Upstream (Location A)

The upstream segment appeared to be less disturbed as it recorded comparatively lower concentrations for most metals. Lead (0.018–0.027 mg/L), Cadmium (0.014 mg/L), and Chromium (0.002–0.011 mg/L) were present at low levels, suggesting minimal direct industrial input. Essential elements such as Calcium, Sodium, and Potassium appeared in moderate concentrations, reflecting natural mineral dissolution from rocks and soil erosion. The presence of minor levels of Iron (0.241–0.698 mg/L), Manganese (0.053–0.675 mg/L), and Zinc (0.041–0.058 mg/L) may be tied to natural sources and runoff from surrounding farmland.

Midstream (Location B)

The midstream section which is closer to abattoir, refuse dumps, a number of industries, and areas where sacrifices are made, showed a noticeable increase in the concentrations of several metals. Lead increased (0.227–0.287 mg/L), Cadmium spiked in Run 2 (0.55 mg/L), and Zinc increased (0.167–0.187 mg/L) relative to upstream levels. On the other hand, Iron (0.346–0.667 mg/L) and Manganese (0.045–0.36 mg/L) also fluctuated, likely reflecting organic-rich effluent inputs from the abattoir and decomposition of animal remains (Chiedozie, *et al*, 2023). The increase metals such as Copper (0.045–0.048 mg/L) and Nickel (0.011–0.021 mg/L) suggests additional inputs from domestic refuse and industrial activities. Elevated Selenium (0.028–0.038 mg/L) at this segment may indicate contamination from biological waste and detergents waste from its manufacturing industry and those used in the slaughter areas.

Downstream (Location C)

At the downstream segment of the river, some metals decreased slightly while others remained moderate or rose marginally, reflecting the combined influence of upstream transport and dilution effects. Lead (0.108–0.117 mg/L) remained higher than at the upstream segment but lower than midstream values, indicating cumulative deposition and partial self-purification along the flow. Iron (0.000–0.361 mg/L) and Manganese (0.044–0.153 mg/L) persisted in measurable amounts, likely due to suspended solids and sediments remobilized downstream. The relatively high Sodium (1.672–2.089 mg/L) and Potassium (1.438–1.556 mg/L) levels suggest ionic enrichment from urban runoff and industrial effluents. Slightly increased Chromium (0.021–0.023 mg/L) and Nickel (0.019–0.027 mg/L) indicate continuing metal input, possibly from industrial discharge points near the lower reaches. The presence of Arsenic (0.208–0.225 mg/L) and Selenium (0.018–0.190 mg/L) in all locations points to both anthropogenic and natural contributions.

Across the two laboratory runs, variations in concentrations were consistent, supporting the

reliability of the analytical results. In general, the midstream section exhibited the highest metal load for most parameters, followed by the downstream, while the upstream maintained the lowest values. This trend aligns with the distribution of contamination sources. The detection of multiple metals, even at low concentrations, demonstrates that River receives diverse inputs from both geogenic and anthropogenic sources, notably abattoir waste, decomposed organic matter from sacrificial practices, and industrial and municipal effluents.

Objective 2: to compare the heavy metal concentration of the river with WHO standards

Table 4.2: concentrations of heavy metals from the river segments and the WHO standards.

Parameters (mg/L)	Point A Run 1	Point A Run 2	Point B Run 1	Point B Run 2	Point C Run 1	Point C Run 2	WHO STANDARDS (2017) (mg/L)
Lead	**0.027**	**0.018**	**0.227**	**0.287**	**0.108**	**0.117**	0.01
Cadmium	**0.014**	**0.014**	**0.018**	**0.55**	**0.023**	**0.004**	0.003
Silver	**0.035**	**0.025**	**0.021**	**0.021**	**0.023**	**0.018**	0.01
Zinc	0.058	0.041	0.167	0.187	0.078	0.036	3
Copper	0.063	0.053	0.048	0.045	0.038	0.046	1.5
Manganese	**0.675**	0.053	0.045	0.36	0.044	0.153	0.4
Iron	**0.698**	**0.241**	**0.667**	**0.346**	**0.361**	0.000	0.1
Cobalt	0.023	**0.013**	0.034	0.021	0.012	0.022	0.1
Chromium	0.011	0.002	0.017	0.034	0.021	0.023	0.05
Mercury	**0.024**	**0.019**	**0.016**	**0.019**	**0.008**	**0.020**	0.006
Magnesium	0.778	0.382	0.408	0.286	0.338	0.408	30
Sodium	1.027	1.991	1.872	1.882	2.089	1.672	40
Potassium	2.089	2.001	1.667	1.089	1.556	1.438	12
Calcium	0.499	0.178	0.566	0.506	0.455	0.389	7.5
Aluminium	**0.308**	**0.332**	0.189	**0.267**	**0.336**	**0.312**	0.2
Arsenic	**0.208**	**0.188**	**0.167**	**0.261**	**0.225**	**0.208**	0.01
Selenium	**0.017**	**0.014**	**0.028**	**0.038**	**0.018**	**0.190**	0.01
Molybdenum	0.015	0.081	0.027	0.021	0.018	0.009	0.07
Nickel	0.014	0.015	0.011	0.021	0.027	0.019	0.07
Vanadium	0.002	0.007	0.001	0.002	0.003	**0.012**	0.0051

Source: Researchers field work, 2025.

Table 4.2 presents the concentrations of heavy metals from the segments of the river and the provisions of the WHO standards. Comparison of the measured heavy metal concentrations with World Health Organization (WHO, 2017) drinking water standards showed that several metals exceeded permissible limits. Lead (0.018–0.287 mg/L) exceeded the 0.01 mg/L limit at all points, indicating significant pollution from industrial and abattoir sources. Cadmium (up to 0.55 mg/L) surpassed the 0.003 mg/L limit, suggesting uncontrolled effluent discharge. Iron (0.000–0.698 mg/L) and manganese (0.044–0.675 mg/L) were also

above WHO limits (0.1 and 0.4 mg/L, respectively), while aluminium (0.189–0.336 mg/L) exceeded its upper permissible range (0.2 mg/L). Arsenic (0.167–0.261 mg/L) and mercury (0.008–0.024 mg/L) concentrations were significantly higher than the 0.01 mg/L and 0.006 mg/L standards, respectively. In contrast, Mg, Na, K, and Ca remained well within safe limits, suggesting a largely natural origin. Nickel (0.011–0.027 mg/L) and molybdenum (0.009–0.081 mg/L) were mostly within the WHO guideline values (0.07 mg/L). However, vanadium slightly exceeded its limit (0.0051 mg/L) at the downstream point (0.012 mg/L). Overall, midstream values showed the greatest deviations, followed by downstream, while upstream values were comparatively lower. These patterns confirm the strong anthropogenic impact of industrial, abattoir, and domestic activities along the river course, raising concerns for both ecological stability and human health.

4.1: Test of Hypothesis

Hypothesis one: There's no significant difference between the heavy metals in the sample and the WHO standards.

Statistical Tool Used: One sample t–test.

Reason for the choice of Tool: One set of observations was compared to a standard.

Degrees of freedom: 17

Decision Rule: Accept the null hypothesis if the p–value is greater than or equal to 0.05, otherwise reject it.

Table 4.4: Comparison of heavy metals of river Idemili with the WHO standards

S/N	Parameter (mg/L)	Mean	WHO	MD	P–value	Remark
1	Lead	0.13	0.01	0.12	0.040	Significantly above WHO
2	Cadmium	0.10	0.003	0.10	0.310	Not significant, above WHO
3	Silver	0.02	0.01	0.01	0.002	Significantly above WHO
4	Zinc	0.09	3.0	-2.91	0.000	Significantly below WHO
5	Copper	0.05	1.5	-1.45	0.000	Significantly below WHO
6	Manganese	0.22	0.40	-0.18	0.145	Not significant, below WHO
7	Iron	0.39	0.10	0.29	0.045	Significantly above WHO
8	Cobalt	0.02	0.10	-0.08	0.000	Significantly below WHO
9	Chromium	0.02	0.05	-0.03	0.001	Significantly below WHO
10	Mercury	0.02	0.006	0.01	0.003	Significantly above WHO
11	Magnesium	0.43	30	-29.57	0.000	Significantly below WHO
12	Sodium	1.76	40	-38.24	0.000	Significantly below WHO
13	Potassium	1.64	12	-10.36	0.000	Significantly below WHO

14	Calcium	0.43	7.5	-7.07	0.000	Significantly below WHO
15	Aluminum	0.29	0.10	0.19	0.000	Significantly above WHO
16	Arsenic	0.21	0.01	0.20	0.000	Significantly above WHO
17	Selenium	0.05	0.01	0.04	0.205	Not significant, above WHO
18	Molybdenum	0.03	0.07	-0.04	0.012	Significantly below WHO
19	Nickel	0.02	0.07	-0.05	0.000	Significantly below WHO
20	Vanadium	0.00	0.0051	-0.00	0.742	Not significant, below WHO

Source: Researcher's statistical computation, 2025.

Table 4.4 contains the comparison of heavy metal of Idemili River in dry season with the WHO standard. It can be seen from the table that; Lead, Silver, Mercury, Iron, Aluminum and Arsenic in dry season are significantly above WHO standard, while Zinc, Copper, Cobalt, Chromium, Magnesium, Sodium, Potassium, Calcium, Molybdenum and Nickel in dry season are significantly below WHO standard. Meanwhile, Cadmium and Selenium in dry season are above WHO standard but not significantly and finally, Manganese and Vanadium are below WHO standard, also not significantly.

5.0 Discussion of Findings

The findings of this study reveals that river Idemili is experiencing heavy metal stress, primarily due to unchecked human activities. The spatial variation across the river segments indicates that midstream section exhibited the highest contamination, which coincides with zones of intense industrial, abattoir, and domestic discharge. The observed exceedances of Pb, Cd, Fe, Mn, Al, As, and Hg beyond WHO (2017) standards indicates a growing water quality deterioration (Amaechi, *et al*, 2025). These metals are often associated with anthropogenic sources such as industrial effluents, abattoir waste, decomposing refuse, and indiscriminate waste disposal along the river bank. High Fe and Mn levels may partly derive from geogenic processes, yet their magnitude implies reinforcement by anthropogenic sources (Okonkwo and Mbaneme, 2019). Although Fe and Mn may also originate from natural geologic formations, the magnitude of their occurrence in this study suggests reinforcement by human-induced inputs (Tchounwou, Yedjou, Patlolla, and Sutton, 2012). Similarly, elevated As and Hg concentrations indicate potential toxicity and carcinogenic hazards to local populations depending on the river for domestic use agricultural and recreative use. From an environmental management perspective, the results underscore a failure in waste regulation and effluent control in the study area. The presence of multiple contamination sources within the catchment reflects poor sanitation infrastructure and weak enforcement policies. Without adequate intervention, these conditions

may lead to ecological imbalance, biodiversity loss, and long-term health burdens.

These results are consistent with reports from other Nigerian rivers similarly affected by industrial and domestic pollution. Elevated levels of Pb, Cd, and Fe have been documented in the River Niger (Adelekan and Abegunde, 2011), Ogun River (Oketola, Osibanjo, and Ejelonu, 2013), and Kaduna River (Owamah, 2013), all linked to industrial and abattoir effluents. Comparable findings were reported by Edori and Kpee (2016) in River Warri, and Ezeonu, Ezeonu, and Udebuani (2019) in Onitsha urban streams, where As and Hg enrichment were associated with abattoir and municipal waste inputs. Internationally, elevated Pb and Cd concentrations in the Ganga River, India (Singh, Malik, Sinha, and Murthy,, 2018) and Yangtze River, China (Zhang, Liu, and Yang, 2020) reveal that heavy metal contamination of surface water is a global environmental issue, especially in developing economies with weak enforcement capacity.

Overall, findings from this study clearly agrees with the study of Dibua, et al. (2025) which reports that water samples from Idemili River are unsafe for human consumption, and aquatic ecosystems, due to leachates infiltration and other accumulation of other pollutants. The result again establishes that River is heavily impacted by anthropogenic activities, particularly around the midstream zone. The concentrations of Pb, Cd, Fe, Mn, Al, As, and Hg consistently exceeded WHO thresholds, indicating serious ecological and health implications a nd the urgent need for intervention(Kaur and Brraich, 2021),). Finally, the findings reveal that the river is under progressive heavy metal stress, posing risks to aquatic life, agriculture, and human health. Effective pollution abatement strategies, periodic environmental monitoring, and community-based awareness programs are crucial for restoring the ecological and public health integrity of river Idemili.

6.0 Summary, Conclusion, and Recommendation

6.1 Summary

This study assessed the concentration of heavy metals in River Idemili. The river was divided into three segments viz: upstream, midstream, and downstream segments. Water samples were analysed for heavy metal contents in two separate laboratory runs

metals. Findings revealed persistent contamination by heavy metals such as Lead, Cadmium, Chromium, Mercury, and Silver across all segments. Comparison of the measured heavy metal concentrations with World Health Organization (WHO, 2017) drinking water standards showed that several metals exceeded permissible limits; thus rendering the water unsafe for consumption.

6.2 Conclusion

The findings from this study cleary indicates that River Idemili is polluted with several heavy metals exceeding the WHO (2017)

permissible limits for drinking water and poses threat to consumers. The presence of high metal burden at the midstream section, provides that it is more polluted than the other segments resulting from its proximity to effluent and other waste discharge points. Lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg), and iron (Fe) were the most critical contaminants, posing potential health and ecological risks through bioaccumulation and biomagnification within the food chain. Although some of these metals such as magnesium (Mg), calcium (Ca), sodium (Na), and potassium (K) were within limits, they have the ability to bio-accumulate overtime and pose long-term threat to human life and the ecosystem at large. The persistence of toxic metals such as Pb, Cd, and Hg implies chronic exposure risks for residents who depend on the river for domestic, agricultural, and recreational purposes. The study therefore concludes that River Idemili is under progressive heavy metal stress, requiring immediate and coordinated remediation, monitoring, and public health response.

6.3 Recommendations

Consequent upon the findings of this study, the following recommendations are made:

1. Targeted interventions should be organized by the Anambra State Ministry of Health and Local Government Health Departments to address the persistent heavy metal contamination in River Idemili.
2. Urgent cleanup should be directed toward the midstream section, where Pb, Cd, and As concentrations were highest. Short-term interventions should include waste removal, effluent channel diversion, and installation of sediment traps.
2.Regulatory agencies such as NESREA and the Anambra State Ministry of Environment should implement and enforce stringent wastewater discharge limits, ensuring that industries treat their effluents before releasing them into the environment.
3. ASWAMA (Anambra State Waste Management Agency) and Ocha Brigade should coordinate the siting, licensing, and supervision of abattoirs and open waste dumps to minimize direct discharges into water bodies.
4.Periodic compliance audits and penalties for non-compliance should be introduced to deter industries and residents from violating environmental standards.
5. Modern abattoir facilities should include blood collection, organic waste recycling, and proper disposal systems to prevent direct discharge into the river.
6.Local authorities and NGOs should conduct health screening and awareness programs for residents relying on the river for drinking, irrigation, or bathing.
7. Riparian reforestation, waste removal, and constructed wetlands should be implemented to improve water quality and ecological resilience.

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