



The Levels of Polycyclic Aromatic Hydrocarbons (PAHS) and Some Heavy Metals in Ibagwa, River, Akwa Ibom State, Nigeria

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Abstract

This study assesses the levels of Polycyclic Aromatic Hydrocarbons (PAHs) and some Heavy Metals in the water body and Sediment of Ibagwa River. The samples were collected using standard analytical sample methods during the dry season. The samples were analyzed for the determination of Polycyclic Aromatic Hydrocarbons and Heavy Metals using gas chromatography mass spectrophotometry (GC - MS) and Atomic Absorption spectrophotometry respectively. P^H, salinity, electrical conductivity and temperature were also assessed using standard methods. Results obtained were subjected to statistical analysis such as standard deviation and error. The concentration of Polycyclic Aromatic hydrocarbons in water samples was negligible while in sediment, the following were recorded Acenaphthalene (0.22 ppm), Anthracene (0.37 ppm), and Pyrene (0.45 ppm). These values were moderately above the World Health Organization (WHO) maximum permissible limits (0.002 ppm) for water. The concentration range of the Heavy Metals of both water and sediment was 0.07 – 44.30 mg/kg. These values were above the World Health Organization and National Environmental Standards and Regulations Enforcement Agency (WHO/NESREA) standards (0.001-5.0 mg/kg). While some heavy metals were below the Dutch Water Quality Standards (DWQS) for freshwater sediment. Other analyzed parameters results were as follows: pH (6.35 – 7.69), salinity (0.00 – 0.01 %), electrical conductivity (16.64 – 117.4 μ S/cm) and temperature (27.5 – 27.9 °C). This study has provided baseline information on the levels of PAHs and some Heavy Metals in Ibagwa River. Hence there is need for routine monitoring and remediation for a safer and healthier environment.

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1.0 Introduction

Aquatic organisms are regularly exposed to pollutants as part of their natural environment. Currently, both marine and terrestrial environments are characterized by an excess of persistent organic pollutants. Included in these pollutants are heavy metals and hydrocarbons produced by natural geochemical activities. The diet plays a major role in determining human health by providing adequate nutrients and reducing levels of harmful microorganisms and chemical contaminants. PAHs are a significant group of persistent organic pollutants with multiple fused benzene rings that cause environmental pollution. They are commonly found in both oceanic and land-based settings (Bouloubassi *et al.*, 2006; Nsi *et al.*, 2020) and are considered a priority pollutant by the EU and USEPA because of their mutagenic and carcinogenic characteristics (USEPA, 2006). Being chemically stable and lipophilic (Ekanem *et al.*, 2019), these compounds can readily pass through lipid membranes and may accumulate in aquatic organisms. PAHs are categorized into high molecular weight (HMW) and low molecular weight (LMW) types based on their physical and biological characteristics. These HMW compounds, which contain six aromatic rings, have been proven to be less easily broken down by native microorganisms and can accumulate in aquatic organisms.

Overall, elevated levels of heavy metals such as Lead and Cadmium, as well as organic substances like hydrocarbons and pesticides, have been detected in different quantities in numerous rivers and streams within the Niger

Delta area of Nigeria, as documented by Nwabueze (2011) and Ubong (2020). It is crucial to monitor the levels of these pollutants in the environment as they have a strong tendency to accumulate in living organisms and undergo biomagnifications in the food chain (James *et al.*, 1998; Ubong *et al.*, 2023b). Examining Polycyclic Hydrocarbon and heavy metals such as Lead (Pb) and Cadmium (Cd) in samples like sediment and water will reveal the potential effects on human health and the environmental risk faced by humans. Utilizing natural accumulator species to monitor and evaluate contaminant levels in our aquatic environment is crucial for understanding the impact on different components of the ecosystem. Some sediment-dwelling species like fish, plants, and benthopelagic organisms can accumulate high levels of pollutants from diluted solutions without showing harmful effects (Obot *et al.*, 2025). Chemical pollutants are recognized for their negative impacts on aquatic environments, with pollutant concentrations in water reflecting only the sampling time's situation (Karadede *et al.*, 2004; Anyanime, 2016). The build-up of polycyclic aromatic hydrocarbons (PAHs) in the river may have a severe impact on aquatic life. In addition, PAHs that lead to contamination in seafood have a low solubility and strong attraction to particles, resulting in their attachment to settled or suspended particles in the water (Ikpe *et al.*, 2022). The European Union has emphasized the importance of measuring PAHs in a wide range of food products to gather data on their presence and concentration in different matrices, as

recommended by Ann *et al.* (2020). The main sources of heavy metals (HMs) and polycyclic aromatic hydrocarbons (PAHs) in the rivers are precipitation and urban runoff which leached these pollutants from both natural and anthropogenic sources into water environment (Nwaichi *et al.*, 2010). It has been reported that the high rate of untreated effluent discharged into the river is alarming and that the rural dwellers use this as a toilet as well as means of getting rid of their solid waste and the water is the main source of drinking water to some of them as well as sources of their seafood. They eat and export for income. and the degradation of water quality is a significant problem for the inhabitant because of the rapid growth of the city which has not been accompanied by development of wastewater and runoff collection as well as treatment plants whether for domestic or Industrial waste water. Therefore, due to these anthropogenic activities, it becomes pertinent for a routine assessment of the water body and the aquatic lives in the Ibagwa river (Ubong *et al.*, 2023).

Sediments are crucial for carrying nutrients, heavy metals, and other contaminants from river systems to the ocean and sea (Ali and Khan, 2019; Ikpe *et al.*, 2019). Heavy metals are frequently found in the environment, being present in both water bodies and organisms, with origins either natural through weathering and erosion or anthropogenic from mining, industry, and agriculture. Urban areas usually have higher levels of heavy metal contaminants compared to nearby rural areas (Ebong *et al.*, 2025). Heavy metals are typically metallic elements with high atomic weight that are toxic at low levels, according to Lentech (2011). In addition, the build-up of heavy metals in fatty tissues can impact both the digestive and central nervous systems. PAHs and Heavy Metals are significant contributors to aquatic pollution due to their durability and tendency to bioaccumulate in aquatic organisms (Quatara and Sangare, 2021). The constant threat to the aquatic ecosystem

from these substances persists due to ongoing discharges or natural processes, making it the main receptacle for such contaminants (Vaikosen *et al.*, 2014). And overtime if contacted by humans, these (PAHs and Heavy metals) might lead to health implications such as Carcinogenicity, respiratory problems, cardiovascular diseases, neurological effect, reproductive and development issues, etc. However, this study will be of great importance to the scientific community, as the evaluation of the hydrocarbons and heavy metals in Ibagwa River, Akwa Ibom state will expose the dangers that aquatic organism and villagers within this community, are exposed to and enable regulatory bodies determine the root cause of these contaminants and trace it to the company or individual activities responsible for the pollution. This creates an opportunity whereby the public could be sensitized on the health impact of drinking water or fetching water from the river. The study is aimed at investigating the levels of PAHs and Heavy metals in samples of sediments and water in Ibagwa River.

2.0 Materials and Methods

2.1 Study Area

The study area is Ibagwa River; it is located at the back of Willington Bassey Army Barracks in Abak Local Government Area of Akwa Ibom State (Figure 1). The Local Government was formally part of Cross River State. It was later sub-divided into other Local Government Areas such as Oruk Anam, Etim Ekpo, Ukanafun and Ika L.G.A, all in the Annang ethnic region of Akwa Ibom state. The major economic activities of the people are palm produce business, exported through the river port at Ekpene Okpo, Ntak Ibeseit, a distance of about 8 km from Abak town. The Local Government headquarter is located about 18 kilometers from Uyo, the State capital. It has a landmass of 304 square kilometers. Abak was the economic hub of the former south eastern Nigeria. The area is blessed with natural resources which include rich

mineral deposits such as sand, gravel, clay, salt and crude oil (corked). It is situated in the

tropical rain forest that supplies abundant palm produce, cassava and various vegetables.

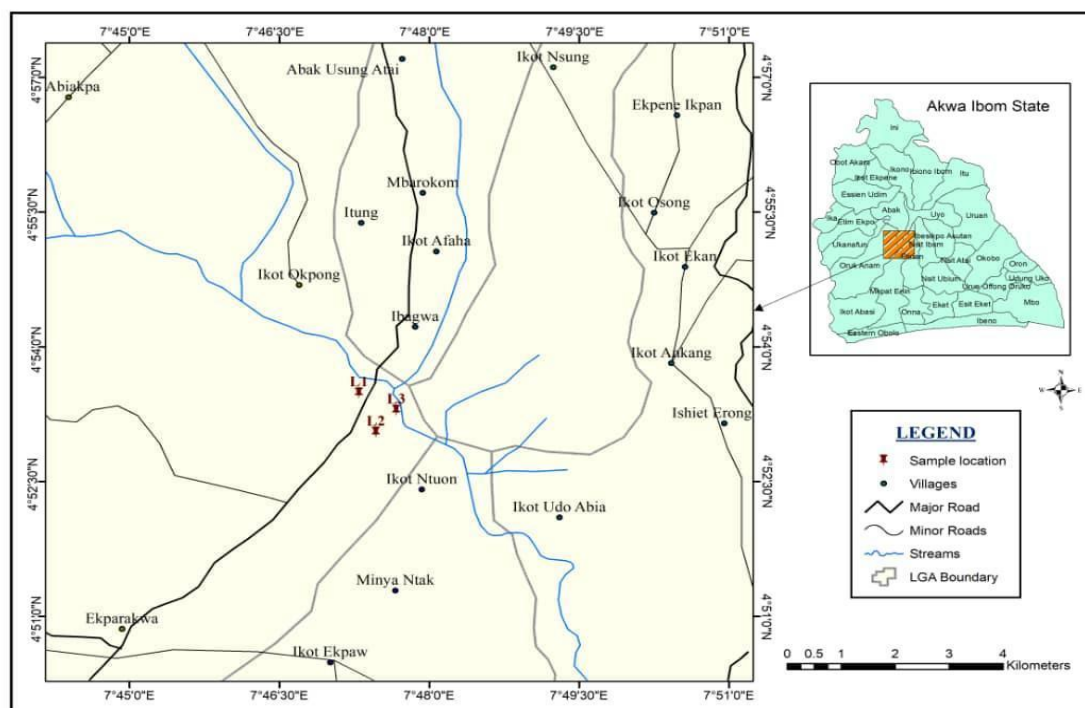


Figure 1: Locations of sampling stations along the Ibagwa River

Table 1: Sampling Locations Geographical Coordinates and site description

Site	Coordinate	Site Description/Activities
1	N04°53' 21. 2' E007°47' 33.0	Lumbering activities and washing of clothes/vehicles/sand mining
2	N04°53'19.3 E007°47'31.4'	Lumbering activities and washing/sand mining
3	04°53'212" E007°47'33.0	Lumbering, farming and washing of clothes, vehicles/household items

2.2 Sample Collection

River water and sediments samples were collected in a pretreated clean 100 ml sample bottle for analysis and the sediment from up and down streams of the river were also collected using standard method according to (Ikpe *et al.*, 2023) in order to assess the level of PAHs and Heavy Metals present in the Ibagwa River. The water and the sediment samples were collected at different points as shown in Figure 1 for three months during the dry season (November to January). The two samples were later preserved in the refrigerator for a day before sample

preparation and analysis using standard methods (Ikpe *et al.*, 2023; Ebong *et al.*, 2024c).

2.3 Standard and Reagents for both PAHs and HMs

All chemicals used were of analytical grade and of highest purity. Reagents used include Hexane, dichloromethane, acid, anhydrous sodium sulphate, Acetone and deionized water (Ebong *et al.*, 2024).

2.4 Sample Preparation for PAHs

2.4.1 Extraction of Samples for PAHs Analysis

The water samples were extracted using standard analytical methods that involved

liquid-liquid extraction of about 50 ml of water samples were introduced into a 250 ml Separatory funnel followed by introduction of 60 ml of extraction solvent (Dichloromethane and Acetone in the ratio of 1:1). The Separatory funnel was later swirled for about 10 minutes for extraction to occur, the process was repeated for about thrice for complete extraction to be achieved. The extracted samples were later concentrated using a regulated water bath (at 50⁰c) before the purification process (Edidiong *et al.*, 2022).

The sediment samples (50 g) were extracted using the extraction solvent (Dichloromethane and acetone in the ratio of (1:1) with about 150 ml using Soxhlet apparatus for about 8 hours using standard method (Ikpe *et al.*, 2023). The extracted samples were later concentrated, purified before introducing into Chromatographic fial ready for GC-MS analysis.

2.4.2 Purification of Extracted Samples (Water and Sediment)

The already extracted samples were purified using Standard Analytical Methods. During this process, the column was packed with 10 g of HPLC Silica gel. Before packing the column, it was first packed with glass wool to support the column (Ikpe *et al.*, 2013). After that, 15 ml of Hexane was used to purify the column before pouring in the sample. After pouring the sample, a 20 ml dichloromethane solvent was used to wash down the extractor through a glass funnel to avoid gross contaminant, on top of the glass funnel glass wool was used to block it before anhydrous sodium Sulphate was introduced onto the cotton wool in order to remove any residual water content in the extract (Ikpe *et al.*, 2023; Archibong *et al.*, 2024). The purified samples were concentrated using a rotary evaporator at 20 °C and later introduced into a Chromatographic fial ready for GC – Ms Analysis.

2.5 Sample Preparation for Heavy Metals Analysis

2.5.1 Digestion

2.5.1.1 Digestion of water samples for Heavy Metals Analyses

50 ml of water sample and 10 ml of conc. Nitric acids were mixed together in a digestion flask and were heated using a heating mantle in the laboratory until one third (1/3) of the sample remained. The samples were then removed and allowed to cool. Later, the samples were filtered and made up to the mark of 100 ml standard volumetric flask, ready for analysis using Atomic Absorption Spectrophotometer (AAS) (Ikpe *et al.*, 2023; Anwuli *et al.*, 2024).

2.5.1.2 Digestion of Sediment for Heavy Metal Analyses

1 g of the sample was used for digestion with a mixture of 5 ml of perchloric acid and 10 ml of Nitric acid in the ratio of 1:2 respectively. After that, the sample was heated using a heating mantle until a clear solution of the sample digest was achieved. The sample digest was removed and allowed to cool later 5 ml of distilled water was added before filtering it into a 100 ml standard volumetric flask making it up to mark with deionized water.

2.6 Determination of Physico-Chemical Parameters

2.6.1 Determination of Temperature

Temperature which is the quantifiable way to describe the warmth or coldness of a substance was determined in both samples using thermometer (Ubong *et al.*, 2023).

2.6.2 Determination of pH

The pH was determined in water and sediment samples using a pH meter. The pH meter was initially calibrated by immersing the pH electrode in the buffer solution of known pH (pH 4, 7 and 9) and the asymmetric potential control of the instrument adjusted until the meter reads the known pH values of the buffer solutions (Imoisi *et al.*, 2020; Ntuen *et al.*, 2023).

For the water sample, 50 ml of water was measured into a beaker and the pH electrode was immersed in the water. The pH valve was taken after the electrode reading had stabilized (Ebong *et al.*, 2024)

2.6.3 Determination of Electrical Conductivity

Conductivity is a measure of the ability of water to pass an electric current because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Conductivity was measured using a conductivity meter as described by Etesin *et al.*, 2018; Ubong *et al.*, 2023.

2.6.4 Determination of Salinity

Salinity, which is the total concentration of all dissolved salt in the water, was determined in both the water and the sediment samples. These electrolytes form ionic particles as they dissolve each with positive and negative charge. In this study, 10 g of the sediment sample was weighed for the test of salinity and 50 ml of distilled water was also measured and poured into a 100 ml beaker container. The sample was allowed to stand for 30 minutes for proper equilibration (Etesin *et al.*, 2018; Ikpe *et al.*, 2020). After 30 minutes, the samples were taken for the test using the conductivity meter according to standard methods described by Ikpe *et al.* (2023) and Ebong *et al.* (2024b).

3.0 Results and Discussion

3.1 Polycyclic Aromatic Hydrocarbon (PAHs)

The concentration of the 16 US EPA priority PAHs (Naphthalene NAF), Acenaphthalene (Ace), Anthracene (Anc), Fluorene (Flu), Fluorathene (Fra), Pyrene (Pyr), Benzo (a), Anthracene (BaA), Chrysene, Benzo (b), Fluoranthene (BbF), Benzo (K), Fluoranthene (BbF), Benzo (K), Fluoranthene (BkF), Benzo (g), Pyrene (BaP), Indeno (1,2,3 - cd), Pyrene (I cdP), Dibenzo (a,h), Anthracene (DbA), and Benzo (g,h,l), Perylene (Bghip), were determined in both the water and sediment

samples of Ibagwa river in Abak Local Government Area of Akwa Ibom State. The result of the water sample analysis is presented in Table 2 and 3 below.

From the result, there were no PAHs among the 16 US EPA components that were determined in the water body during the analysis. This implies that the water from Ibagwa River is not contaminated with PAHs and as such it has no side effect on human health, plant and animals respectively (Ikpe *et al.*, 2017; Nsi *et al.*, 2017).

In the Sediment sample, Table 3 of the analysis shows that PAHs compounds were present but in a few quantities. Among the 16 US EPA as listed in the Table of analysis only the three PAHs were detected in the specimen sample namely: Acenaphthylene with a concentration of 0.22 ppm, Anthracene with a concentration of 0.37 ppm and Pyrene with concentration of 0.45 ppm. The remaining PAHs Naphthalene, Acenaphthalene, Flurene, Phenanthrene, Fluoranthene, Benzo (a), Anthracene, Chrysene, Benzo (b), Fluoranthene, Benzo (k), Fluoranthene, Indeno (1,2,3, -d), Pyrene and Benzo (g,h,l), Perylene were not detected in the sediment sample as shown in Table 3 below.

The result obtained from the sediment sample was from 0.00 – 0.45 ppm. These values were moderately above the World Health Organization (WHO, 2023) maximum permissible limits (0.002 ppm) for water and also below the result from a similar study within the vicinity of Ikot Akpaden by Ubong *et al.*, 2023. The result was below the result obtained by Ekanem *et al.*, 2019 on the assessment of PAHs in soil around automobile workshops in Eket metropolis, Akwa Ibom state, Nigeria.

3.2 Heavy Metals

The Heavy metals that were determined are; Lead (Pb), Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn), Iron (Fe), Nickel (Ni), and Manganese as shown in Table 4 and Figure 2.

Table 2: Results of Water sample Analysis for PAHs from Ibagwa River in Abak L.G.A, Akwa Ibom State, Nigeria

S/N	TARGET COMPOUND	R.T	RESPONSE	CONCENTRATION
1	Naphthalene	0.000	0	BDL
2	Acenaphthylene	0.000	0	BDL
3	Acenaphthene	0.000	0	BDL
4	Fluorene	0.000	0	BDL
5	Anthracene	0.000	0	BDL
6	Phenanthrene	0.000	0	BDL
7	Fluoranthene	0.000	0	BDL
8	Pyrene	0.000	0	BDL
9	Benzo (a) anthracene	0.000	0	BDL
10	Chysene	0.000	0	BDL
11	Benzo (b)Fluoranthene	0.000	0	BDL
12	Benezo (k)Fluoranthene	0.000	0	BDL
13	Benz (a) Pyrene	0.000	0	BDL
14	Dibenz (a,h) anthracene	0.000	0	BDL
15	Indeno (1,2,3-cd) Pyrene	0.000	0	BDL
16	Benzo (g,h,i) Perylene	0.000	0	BDL

BDL = Below Detection Limit

Table 3: Results of Sediment sample Analysis for PAHs from Ibagwa River in Abak L.G.A, Akwa Ibom State, Nigeria

S/N	TARGET COMPOUNDS	R.T	Q ION	RESPONSE	CONCENTRATION	UNITS	DEV.	MIN.
1	Naphthalene	0.000	-	0	BDL	-	-	-
2	Acenaphthylene	3.091	152	786	0.22	ppm		42
3	Acenaphthene	0.000	-	0	BDL	-	-	-
4	Fluorene	0.000	-	0	BDL	-	-	-
5	Anthracene	5.076	178	801	0.37	ppm		54
6	Phenanthrene	0.000	-		BDL	-	-	-
7	Fluoranthene	0.000	-	0	BDL	-	-	-
8	Pyrene	6.789	202	1295	0.45	ppm		58
9	Benzo (a) anthracene	0.000	-	0	BDL	-	-	-
10	Chysene	0.000	-	0	BDL	-	-	-
11	Benzo (b)Fluoranthene	0.000	-	0	BDL	-	-	-
12	Benezo (k)Fluoranthene	0.000	-	0	BDL	-	-	-
13	Benz (a) Pyrene	0.000	-	0	BDL	-	-	-
14	Dibenz (a,h) anthracene	0.000	-	0	BDL	-	-	-
15	Indeno (1,2,3-cd) Pyrene	0.000	-	0	BDL	-	-	-
16	Benzo (g,h,i) Perylene	0.000	-	0	BDL	-	-	-

*BDL = Below Detection Limit

The result of the study reveals that out of the eight heavy metals that were investigated in both water and sediment samples, four were found in sample A (water) while all the heavy metals were found in sample B.

The four heavy metals that were found in the water sample were Copper, Zinc, Iron and Manganese. However, heavy metals for this study were found to be higher in sediments compared to water. This corroborates with the finding by Adelaja *et al.*, 2011, who reported similar higher values for sediment in Lagos lagoon Ibeshe and Gaditam River, Tamihadu India respectively. Higher concentration of metals in sediment compared to surface water may also be connected with the fact that pollutants discharged into the aquatic environment does not remain in aqueous phase but instead are absorbed onto the sediments (Oguzie and Okhanguzo, 2010; Ikponmwen *et al.*, 2021).

Amongst all the eight heavy metals that were examined in both water and the sediments samples, Iron (Fe) has the highest concentration in both the water and sediment samples as shown in the result Table 4 and 5 below or Figures 2 and 3

Iron is a mineral that the body needs for growth and development. The body uses Iron to make hemoglobin a protein in red blood. Iron occurs naturally in water at a rate of roughly 1-3 parts per billion (ppb) in ocean water, about 1 part per million (ppm) in river water and 100 pm in ground water. Iron comes from various minerals in the soil which is why groundwater contains iron. Iron levels in water vary depending on several factors and can affect aquatic population's behavior and health. When usually high amounts of Iron exist in water this is usually due to pollution related to construction of Iron mining. Iron is very good for the body, it promotes enzyme growth and gives blood its red colour (Ikpe *et al.*, 2018). Iron binds to oxygen and travels with it in the blood transporting the

carbon dioxide out. Green plants use iron for nitrogen binding. At normal level iron is not deadly to any aquatic animal. Higher levels of iron in fish and aquatic plants also have negative effects on the people or creatures consuming them.

The concentration of iron in the study was very high at the concentration of 44.3 mg/l while the sediment was 0.9 mg/kg which is above the recommended range of 0.3 mg/l for drinking water by (WHO, 2023). As such iron is very high in the water samples which can be dangerous if taken in large quantities. The level of manganese was also higher in sediment than in water as shown in the Table 4 and 5 below or figure 2 and 3. Manganese concentration for water was 0.02 mg/l while that of sediment was 0.55 mg/kg though the sediment concentration is slightly above the maximum allowable level of WHO (2023) standard of Mn in water which is 0.05 mg/L. Mn is an essential micronutrient for both plants and animals. Lack of Manganese can result in severe skeletal and reproductive abnormalities in mammals. It is frequently associated with iron deposits Mn in aquatic environments and has been attributed to detrital material, ferromanganese minerals, clay minerals and accessory sulphide minerals (Ukpong *et al.*, 2017).

Copper (Cu) is one of the heavy metals which are essential to human health. It's in the aquatic environment may be due to accumulation of domestic and agricultural waste. Copper combines with certain proteins to produce enzymes that act as catalyst to help in the body functions and it is also necessary for the synthesis of hemoglobin (Ann *et al.*, 2020), Copper (Cu) values for this study were 0.07 mg/kg for sediment and 0.03 mg/l for water which were below the WHO Maximum permissible level of 1.50 mg/L and slightly within the WHO highest desirable level of 0.05 mg/L for water whereas sediment values were

below the Dutch water Quality Standard (DWQS) for freshwater sediment.

Lead (Pb) content in the water sample was below detectable limit (BDL) while in the sediment sample was 0.10 mg/kg which was below the Department of Petroleum Resources (DPR) target of 85 mg/kg.

Also, Cadmium was detected in sediment sample in a minute quantity of 0.10 mg/kg which was below the DWQS guidelines for freshwater Sediment, the presence of Cd could be attributed to wear and tear of tyres washed down into the river from the high - way over-time as run-off, whereas it was not detected in the water sample (BDL). Lead and Cadmium has been known as one of the most toxic elements which has no significant biological functions and show their carcinogenic effects on aquatic biota and humans even at low exposure (Ikpe *et al.*, 2020b). Lead (Pb) exposure is known to cause musculoskeletal, renal ocular, neurological immunological reproductive and development effects (Ashamo *et al.*, 2017; Clement *et al.*, 2021).

Cadmium like any other substance could be absorbed via the gills and has been known to cause damage to fish gills while in man, Cadmium (Cd) poisoning could lead to anemia, renal damage, bone disorder and cancer of the lungs (Ashamo *et al.*, 2017). Cadmium was not detected in water samples whereas it was detected in sediment at a low concentration of

0.1 mg/kg shown in the analysis Table (5) or figure 3 when compared to the DWQS guidelines (Ebong *et al.*, 2025).

The level of Zinc (Zn) in sediments was higher than that of water. Zinc is the essential heavy metal to promote metabolism and its shortage can result in some adverse influence i.e. retarded growth dysfunction of the immune system and appetite loss (Ebong *et al.*, 2024). The Zinc concentration for this study was 0.96 mg/kg for sediment and 0.24 mg/l for water which shows that more zinc was detected in the sediment sample than the water. This study reveals that the Zinc concentration in the water samples was above the 5 mg/L of WHO maximum allowable level for water. Also, Zn was higher in the Sediment than the WHO recommended limit of 30 mg/kg. Nickel, a heavy metal that can be naturally found in the environment drinking water and various manufacturing industries. Dermatitis is the most common health condition associated with Nickel exposure, occupational exposure to nickel carbonyl can be fatal. Nickel can enter the environment naturally through weathering of minerals and rocks and through anthropogenic sources. More than 90 % of the Nickel in the aquatic environment is associated with particular water or sediments. The study showed that Nickel was only detected in the sediment but was not detected in water as shown in Table 4 and 5 or figures 2 and 3 of analysis below.

Table 4: Results of Heavy Metals in Water Sample

Metals	Mean (mg/L)	Standard Error (\pm)	Standard Deviation	WHO Standard (mg/L)
Lead	BLD	BLD	BLD	0.30
Cadmium	BLD	BLD	BLD	0.01
Chromium	BLD	BLD	BLD	0.05
Copper	0.03	± 0.000	0.000	0.05
Zinc	0.24	± 0.001	0.001	0.30
Iron	0.90	± 0.002	0.001	0.1 – 1.0
Nickel	BLD	BLD	BLD	0.02
Manganese	0.02	± 0.000	0.000	0.05 – 0.50

*BDL= below detection limit

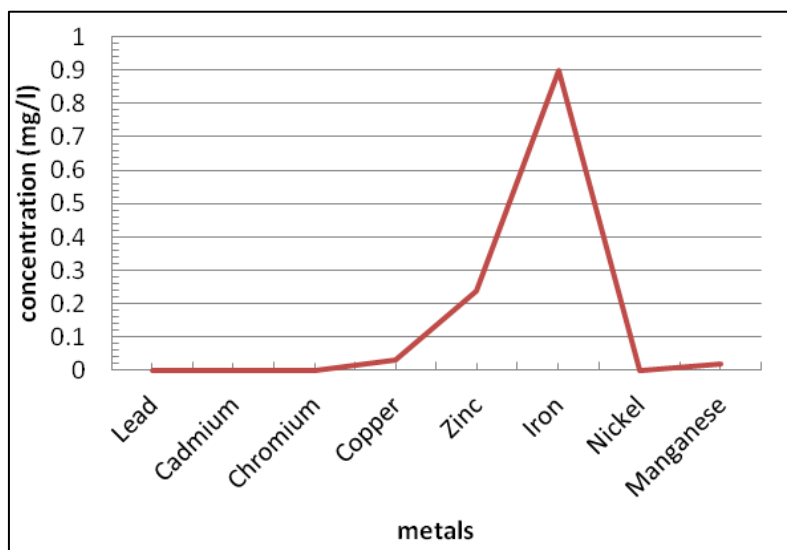


Figure 2: Concentration of heavy metals in water sample

Table 5: Results of Heavy Metals in Sediment Sample

Metals	Mean (mg/kg)	Standard Error (\pm)	Standard Deviation	DWQS and DPR Guidelines for Sediment (mg/kg)
Lead	0.10	± 0.003	± 0.002	85 (DPR)
Cadmium	0.10	± 0.001	± 0.001	0.99 (DWQS)
Chromium	0.10	± 0.003	± 0.002	43.4 (DWQS)
Copper	0.07	± 0.000	± 0.000	31.6 - 35.8 (DWQS)
Zinc	0.96	± 0.001	± 0.000	121 (DWQS)
Iron	44.30	± 0.130	± 0.075	-
Nickel	0.20	± 0.003	± 0.001	-
Manganese	0.55	± 0.001	± 0.001	-

*BDL= below detection limit; DWQS = Dutch Water Quality Standard; DPR = Department of Petroleum Resources

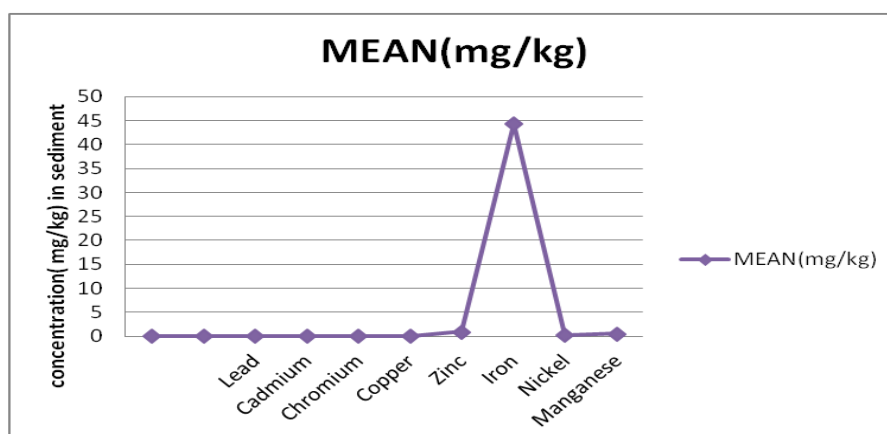


Figure 3: Concentration of Heavy metals in Sediment sample

3.3 Physicochemical properties

Table 6 and figure 4 - 7 shows the results of the Physico-chemical properties from selected parameters.

3.3.1 Temperature

The temperature was determined to be 27.5 °C in water and 27.9 °C in the sediments exceeding the WHO limit of 29.4°C for water, this correlates with a similar study by Ubong *et al.*, 2023.

3.3.2 P^H

The P^H of the Ibagwa River (water and sediment, Table 6) felled within the range of 6.35 – 7.69 which is within the WHO Standards and is in line with a similar study by Okuo *et al.*, 2016 which involves assessment of Delta south aquifer in Delta state, Nigeria.

Moreso, the P^H indicates the negative logarithm of the hydrogen ion concentration, potential hydrogen or power of hydrogen in mol/L (Ikpe *et al.*, 2023; Akpakpan *et al.*, 2024). The more acidic the water, the lower the P^H and the more basic the water, the higher the P^H. According to World Health Organization (WHO) Standards between 6.5 and 8.5 remains the normal range for normal P^H in ground water. The exposure to extreme P^H values results in irritation to eyes, skin and mucous membrane. Eye irritation and exacerbation of skin disorders have been associated pH values above eleven (11) (Isichei *et al.*, 2015; Anyanime *et al.*, 2017)

3.3.3 Electrical conductivity

The electrical conductivity was detected in the water sample to be 117.4 µs/cm at the

temperature of about 7.9 °C while that of sediment sample was detected to be 16.64 µs/cm at the temperature of 27.5 °C. According to WHO standard, the electrical conductivity for water and sediment samples were low and within the recommended standard of 500 µs/cm for water. This low value is an indication of fresh water (Okuo *et al.*, 2016), also Isichei *et al.*, 2015 and Ikpe *et al.*, 2022 asserted that the value of electrical conductivity gives a sense of the dissolved inorganic constituent of the leachate.

3.3.4 Salinity

Salinity was determined to be 0.00 % for water and 0.01 % for sediment respectively. This indicates low salinity status of the river and sediment when compared with the WHO Standard of 250 mg/l. High salinity decreases plant growth and water quality resulting in lower crop yields. This shows that the water from Ibagwa River has no dissolved salt concentration (Ikpe, *et al.*, 2023). This result is in line with a similar study by Usoro *et al.* (2017).

Table: 6 Analyses for the Physico-Chemical Parameters in Both Sample A and B

Parameters	Water Sample(A)	Sediment Sample (B)
Temperature (°C)	27.5	27.9
p ^H	7.69	6.35
Electrical Conductivity (µs/cm)	117.4	16.64
Salinity %	0.00	0.01

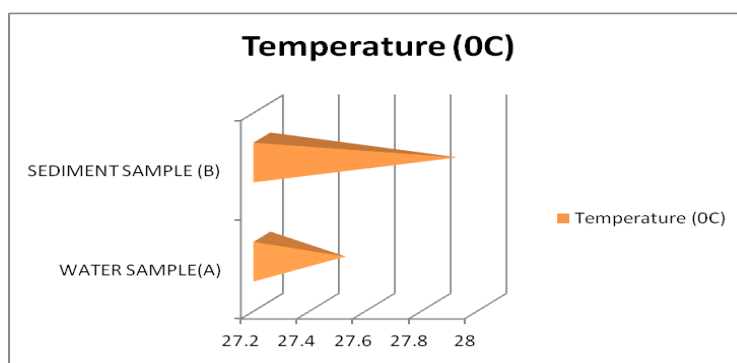


Figure 4: Temperature levels in Sediment and Water sample

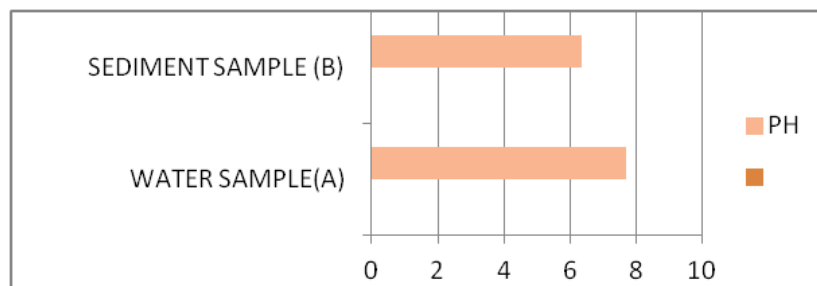


Figure 5: pH levels in Sediment and Water samples

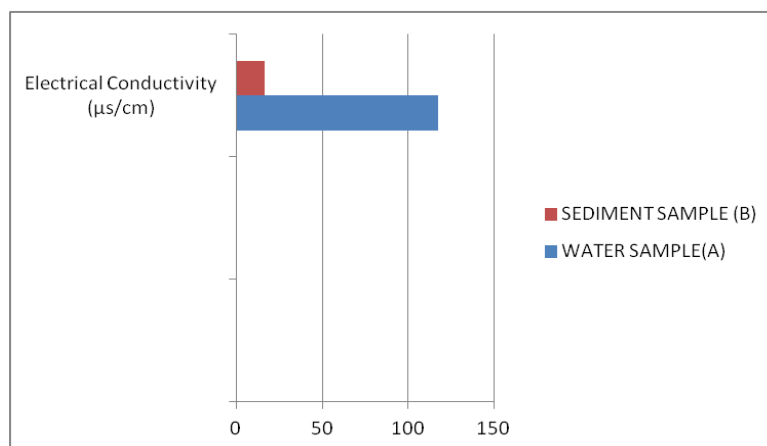


Figure 6: Electrical Conductivity levels in Sediment and Water sample

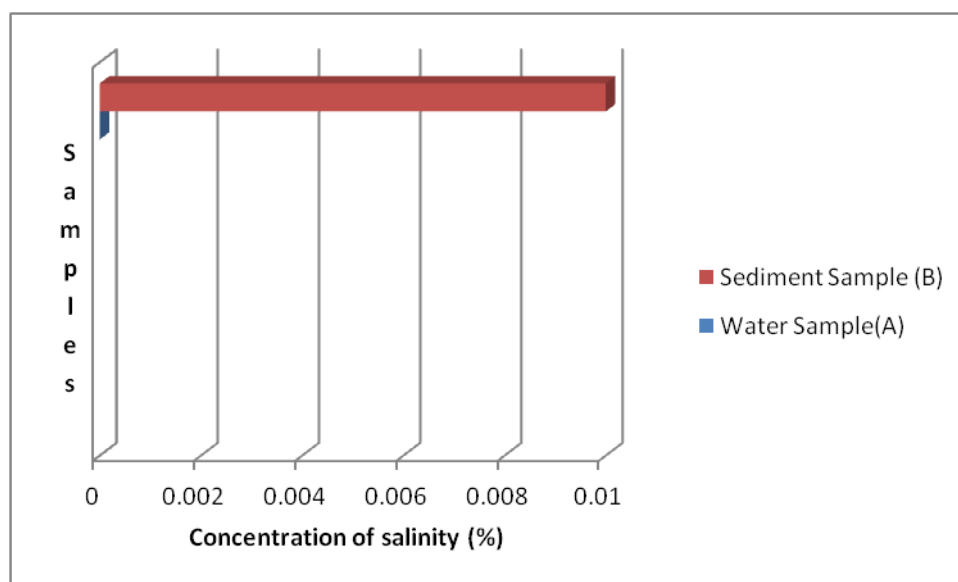


Figure 7: Salinity levels in Sediment and Water samples

4.0 Conclusion

The result from this study provided valuable information on the concentration of both PAHs and the Heavy metals using samples of water and sediment. PAHs concentration in water was not detected but few PAHs were detected in the

sediment sample while four Heavy metals out of eight were detected in the water samples and all were detected in the sediment in very minute quantities. The concentrations were not high in both PAHs and the Heavy metals except the presence of Iron metal in a high concentration.

All others were within the permissible limit of the (WHO) recommended range and DWQS guidelines. The result of this finding presents a valuable baseline data on both the PAHs and the Heavy Metals in the water and sediment samples of Ibagwa River.

Conflict of interest

There is no conflict of interest

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