Polycyclic Aromatic Hydrocarbon Levels in Water and Sediments of Sagbama River, Bayelsa State, Nigeria

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Abstract
This study investigated the distribution and concentration of polycyclic aromatic hydrocarbons (PAHs) in water and sediment samples from the Sagbama River. Water and sediment samples were collected in triplicates from Bolou-Orua, Toru-Angiama and Toru-Orua communities respectively. Concentration of PAHs in the samples were determined out using Gas Chromatography-Flame Ionization Detector (GC-FID). PAHs were detected at varying concentrations. For water samples: Toru-Orua (benzo(a)pyrene-52.59 mg/L, phenanthrene-43.44 mg/L, naphthalene-36.78 mg/L, fluoranthene-34.41 mg/L, pyrene-28.02 mg/L, anthracene-27.65 mg/L, fluorene-25.11 mg/L, chrysene-16.52 mg/L); Bolou-Orua (fluoranthene-81.14 mg/L, acenaphthylene, 73.61 mg/L, anthracene-52.27 mg/L, chrysene-64.96 mg/L, naphthalene-48.58 mg/L, fluorene-36.40 mg/L, benz(a)anthracene- 28.64 mg/L,); Toru-Angiama (phenanthrene- 120.62 mg/L, naphthalene-96.74 mg/L, benz(a)anthracene-81.67 mg/L, pyrene-73.73 mg/L and chrysene-59.59 mg/L). For sediment samples: Toru-Orua (naphthalene- 912.88 mg/kg, chrysene- 764.62 mg/kg, phenanthrene- 716.64 mg/kg, pyrene-622.01 mg/kg, acenaphthylene- 528.01 mg/kg, fluoranthene- 411.75 mg/kg, and fluorene 323.95 mg/kg); Bolou-Orua (acenaphthylene- 932.61 mg/kg, pyrene-857.09 mg/kg, chrysene-673.56 mg/kg, fluorene- 548.42 mg/kg and phenanthrene- 314.71 mg/kg); Toru-Angiama (naphthalene- 575.74 mg/kg, chrysene- 422.41 mg/kg, anthracene- 323.13 mg/kg, benz(a) pyrene- 271.86 mg/kg pyrene- 269.60 mg/kg and acenaphthylene- 258.81 mg/kg). The findings of this study highlight significant variations in the levels of PAHs across different sampling sites in the Sagbama River and sediments in Bayelsa State, Nigeria, indicating diverse sources of pollution. Based on these findings, it is recommended that stricter control policies be placed on industrial discharges to limit PAHs contamination as well as continuous monitoring of PAHs levels for early detection of emerging pollution trends and mitigation of potential long-term effects on the inhabitants around the study area.

Keywords: *water, sediment, concentration, pollution, health,*

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a class of organic compounds consisting of multiple aromatic rings, widely recognized for their environmental persistence and significant toxicological properties (Abdel-Shafy, and Mansour, 2016; Manzetti, 2013; Sahoo *et al*., 2020). These compounds are primarily by-products of incomplete combustion processes, including fossil fuel burning, industrial activities, and biomass combustion, as well as certain natural processes like volcanic eruptions and wildfires (Patel *et al*., 2020; Williams *et al*., 2022). Due to their stable molecular structure, PAHs persist in various environmental compartments, particularly in water and sediments, where they can pose long-term ecological and health hazards (Alegbeleye *et al*., 2017). The ubiquity of PAHs and their potential adverse effects on aquatic ecosystems and human health have made them a major environmental concern globally, leading to their classification as priority pollutants by regulatory agencies such as the U.S. Environmental Protection Agency (EPA) (Ramesh, *et al*., 2011; Jesus *et al*., 2022). Aquatic systems are particularly vulnerable to PAH contamination, as these compounds can enter water bodies through industrial effluents, urban runoff, oil spills, and atmospheric deposition (Anyahara, 2021; Mojiri *et al.,* 2019). PAHs are ubiquitous in the environment, and their presence in water and sediments is a growing concern due to their persistence, bioaccumulation potential, and adverse health effects on both aquatic organisms and humans (Alegbeleye *et al*., 2017). Once introduced, PAHs exhibit hydrophobic properties, leading to their accumulation in sediments. In sediment, PAHs can become more concentrated over time, affecting benthic organisms and posing bioaccumulation risks throughout the food web (Skic *et al.,* 2023; Jesus *et al*., 2022). Additionally, various PAHs, especially those with higher molecular weights and more rings, exhibit carcinogenic, mutagenic, and teratogenic properties (Sun *et al.,*2021; Idowu *et al.,* 2019). Studies have shown that chronic exposure to PAHs can impair immune function, disrupt endocrine systems, and increase cancer risk in humans and other organisms (Zhang *et al*., 2016), further highlighting the importance of monitoring these contaminants in aquatic environments.

The Niger Delta region of Nigeria, known for its abundant natural resources, particularly oil, has experienced significant environmental pressures due to industrialization, urbanization, and extensive oil exploration activities (Nduka *et al*., 2012; Mmom and Igwe, 2012). The Sagbama River in Bayelsa State, part of the Niger Delta, is a vital freshwater resource supporting local communities, biodiversity, and economic activities (Raimi *et al*., 2019). However, the combination of industrial discharges, artisanal refining, and municipal waste disposal in the area increases the likelihood of PAH contamination in this river system (Onyena *et al.,* 2024). Understanding the levels of PAHs in the water and sediments of Sagbama River is critical to evaluating the health of the aquatic ecosystem, assessing the risk to local populations, and guiding effective management and policy measures (Richard, and Odubo, 2024).

This study investigated the distribution and concentration of PAHs in water and sediment samples from the Sagbama River.

Materials and methods

Site description: The research was conducted in a stretch of the Sagbama River which is located in Sagabma Local Government Area of Bayelsa State. The Sagbama river (located on latitude 5.152239°N and longitude 6.192479°E) is a tributary of the Forcados river which cuts across Delta and Bayelsa States.

Sample collection: Water and sediment samples were collected in July 2023 from three collection points located at Bolou-Orua, Toru-Angiama and Toru-Orua communities respectively all in Sagbama Local Government Area of Bayelsa State. Water samples were collected in triplicates (per sampling location) using stainless steel buckets into appropriately labelled glass sample bottles (W1, W2, W3) according to standard protocol while sediment samples (S1, S2, and S3) were collected from the river bed using Van Veen Grab. All samples were obtained in triplicates from each sampling location.

Determination of Polycyclic Aromatic Hydrocarbons (PAHs)

Sample Extraction: Ten grams (10 g) of the sample were placed in an amber glass bottle, followed by the addition of 10 g of anhydrous sodium sulphate (Na_2SO_4) to remove moisture. The mixture was stirred thoroughly. A surrogate standard, 1-chlorooctadecane, at a concentration of 300 µg/mL, was then added. Subsequently, 30 mL of dichloromethane (DCM) was introduced as the extraction solvent. The bottle was tightly sealed and placed on a mechanical shaker, where it was agitated for 5 to 6 hours at room temperature. After shaking, the mixture was allowed to settle for 1 hour before being filtered through 110 mm filter paper into a clean beaker. The resulting filtrate was left to evaporate overnight in a fume cupboard until it was concentrated to a final volume of 1 mL.

Sample clean-up: Sample clean-up was carried out using a glass column. The column was prepared by placing a plug of glass wool at the base. A slurry was made by mixing 10 g of silica gel with 50 mL of DCM, and this slurry was carefully loaded into the column. Subsequently, 10 g of anhydrous sodium sulphate (Na_2SO_4) was added on top, followed by the addition of pentane to condition the column. Once the column was prepared, the concentrated sample extract was combined with 20 mL of cyclohexane in a beaker and poured into the column. The sample was initially eluted using 30 mL of pentane, and the eluate was collected in a beaker placed beneath the column. An additional 20 mL of pentane was then used to continue the elution. Afterward, the column was rinsed with 20 mL of DCM. The collected eluate was left to evaporate overnight at room temperature in a fume cupboard.

Sample Separation and Detection using Gas Chromatograph - Flame Ionization Detector (GC-FID): The separation and detection of compounds in the samples were performed using an Agilent 6890N Gas Chromatograph equipped with a Flame Ionization Detector (GC-FID). A 3 µL portion of the concentrated sample eluate was injected into a GC vial. Prior to sample injection, the GC micro-syringe was rinsed three times with blank DCM to ensure cleanliness, and then further rinsed with the sample extract. The sample was subsequently injected into the GC column for compound separation. Following separation, the analytes passed through the flame ionization detector (FID), which identified and quantified the compounds present. The concentration of polycyclic aromatic hydrocarbons (PAHs) in each sample was determined from the resulting chromatograms and expressed in g/kg.

Results and Discussion

The PAHs detected in the samples studied include: Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Benz (b) fluoranthene, Benz (k) fluoranthene, Benz(a) pyrene, Indeno (1, 2, 3-cd) pyrene, Dibenz (a, h) anthracene, Benzo (g, h, i) perylene (fig. 1 and fig. 2). Naphthalene is a PAH with a simple structure of two fused benzene rings. It is commonly found in products like mothballs and coal tar and it is also a byproduct of burning fossil fuels (Tarrad *et al*., 2024). Exposure to Naphthalene can lead to respiratory issues and skin irritation. In severe cases, it can cause hemolytic anemia, especially in individuals with certain genetic vulnerabilities. Naphthalene is classified as a potential human carcinogen, raising concerns about its long-term health impacts, particularly through inhalation of contaminated air or water exposure (Sudakin *et al*., 2011). Naphthalene concentration levels in the Sagbama water, measured 36.78 mg/L in Toru-Orua, 48.58 mg/L in Bolou-Orua, and 96.74 mg/L in Toru-Angiama. The observed increase in Naphthalene levels from Toru-Orua to Toru-Angiama suggests a gradient of pollution, with the highest concentration at Toru-Angiama, possibly due to anthropogenic activities like oil spills, industrial discharges, or increased urban runoff downstream which agrees with the studies of (Li *et al*., 2020). Naphthalene is known for its volatility, and while it is the simplest PAH, its higher concentrations could have adverse effects on aquatic life, potentially causing stress responses in fish and other organisms. Long-term exposure to elevated levels of Naphthalene is linked to health issues like hemolytic anemia in humans, raising concerns for communities dependent on this water source, and this agrees with that of Pampanin and Sydnes (2013). While in the sediments, Naphthalene concentrations were detected at 912.88 mg/kg in Toru-Orua and 575.74 mg/kg in Toru-Angiama, while it was not detected in Bolou-Orua. The significantly higher levels in Toru-Orua and Toru-Angiama suggest localized sources of pollution, potentially from oil spills or industrial discharges, which are more pronounced in these areas (Tarrad *et al*., 2024). The absence of Naphthalene in Bolou-Orua may indicate lower pollution inputs or rapid degradation in this segment of the river. Naphthalene's persistence in sediment could impact benthic organisms, as its bioavailability in aquatic environments poses a risk to ecosystem health. This disparity between water and sediment concentrations indicates that Naphthalene has a stronger tendency to adsorb onto particulate matter, thus accumulating in sediments as also reported by Quantin *et al*., (2005).

Acenaphthylene has a unique structure with two aromatic rings fused to a five-membered ring. It is often detected in cigarette smoke and vehicle emissions. This PAH is particularly harmful to aquatic life, where prolonged exposure can lead to mutations and damage to aquatic organisms, compromising ecosystem health. Its persistence in the environment makes it a pollutant of concern, especially in water bodies close to urban and industrial areas (Sahoo *et al*., 2020). Acenaphthylene was not detected in Toru-Orua and Toru-Angiama, but it had a concentration of 73.61 mg/L in Bolou-Orua. This localized presence suggests specific point-source pollution, potentially from industrial effluents or nearby combustion processes which also agrees with that of Lucadamo *et al.,* (2024). Acenaphthylene is known to be harmful to aquatic organisms, where prolonged exposure can result in mutagenic effects, thus indicating localized contamination hotspots that require further investigation. While in the sediments, Acenaphthylene was present in all sampled locations, with the highest concentration in Bolou-Orua (932.61 mg/kg), followed by Toru-Orua (528.01 mg/kg), and the lowest in Toru-Angiama (258.81 mg/kg). The elevated levels in Bolou-Orua suggest significant localized contamination, likely from industrial activities or specific point-source emissions. Its widespread presence across all sites indicates that Acenaphthylene contamination is relatively pervasive, potentially affecting aquatic life due to its known mutagenic properties as also reported in the study of El-Bouhy *et al.,* (2024). The simultaneous presence of Acenaphthylene in both water and sediments at Bolou-Orua, especially at elevated levels in sediment, indicates a localized source of pollution, likely industrial effluents. Its persistence in sediments suggests that it may have a slower degradation rate in that environment which also agrees with that of Hughes *et al*., (2024).

Acenaphthene is structurally similar to Acenaphthylene but lacks a double bond, making it slightly less reactive (Altarawneh and Ali, 2024). It is typically found in coal tar and as a combustion byproduct. Acenaphthene is moderately toxic, with a lower carcinogenic risk compared to other PAHs. However, it still poses a threat to aquatic environments, where it can impair the health of fish and other organisms (Jarvis *et al.,* 2014). Interestingly, Acenaphthene was not detected in either water or sediment samples at any of the sites. This complete absence might indicate that acenaphthene is not a significant pollutant in this region, possibly due to the lack of sources or its rapid degradation in both water and sediment matrices.

Fluorene consists of three fused rings, with two being benzene rings. It is commonly associated with petroleum products and emissions from the combustion of fossil fuels (Pal and Sen, 2024). In humans, exposure to Fluorene can cause liver and kidney damage, while in aquatic ecosystems, it is known to be harmful to fish and invertebrates, affecting their reproduction and survival rates (Mesquita *et al*., 2023). Fluorene was detected at moderate levels, with concentrations of 25.10 mg/L in Toru-Orua and 36.40 mg/L in Bolou-Orua, but it was not detected in Toru-Angiama. This pattern suggests potential sources like vehicular emissions or oil spills in the areas where it was detected which agrees with the study of (Fuge, *et al*., 2019). Fluorene exposure can negatively affect liver and kidney functions in aquatic organisms, indicating possible ecological impacts in Toru-Orua and Bolou-Orua, this compares well with the study of (Zuo *et al*., 2019). While in the sediments, detected concentrations of Fluorene

were 323.95 mg/kg in Toru-Orua and 548.42 mg/kg in Bolou-Orua, with no presence in Toru-Angiama. The relatively high levels in Bolou-Orua suggest localized sources, possibly from industrial discharges or petroleum-related activities. Fluorene's potential to impair liver and kidney function in aquatic organisms highlights the ecological risks associated with its presence in these sediments (Fuge, *et al*., 2019). Fluorene's presence in water was detected at Toru-Orua (25.10 mg/L) and Bolou-Orua (36.40 mg/L) but was absent in Toru-Angiama. Sediment concentrations were higher in Bolou-Orua (548.42 mg/kg) compared to Toru-Orua (323.95 mg/kg), with no detection in Toru-Angiama. The higher sediment levels, especially in Bolou-Orua, suggest that Fluorene is more stable in sediments, likely due to its hydrophobic nature as also seen in the study of Droppo *et al.,* (2016). The absence of this compound in Toru-Angiama's samples could imply minimal pollution sources or effective dispersion in this area.
Phenanthrene features three benzene rings arranged in a linear structure. It is prevalent in coal, crude oil, and as a byproduct of combustion processes. Phenanthrene exposure in humans can lead to skin and respiratory tract irritation. In aquatic environments, this PAH is toxic to various species, potentially causing sublethal effects that impair growth and reproduction (Priyadarshanee *et al*., 2022). Phenanthrene showed high concentrations of 43.44 mg/L in Toru-Orua and 120.62 mg/L in Toru-Angiama, while it was not detected in Bolou-Orua. These elevated levels indicate significant pollution, likely from industrial activities, particularly in areas associated with oil exploration or transportation which agrees well with the study of (Sarma *et al*., 2016). Phenanthrene is moderately toxic to aquatic organisms, capable of causing chronic effects such as impaired reproduction in fish. While in the sediments Phenanthrene was notably concentrated in Toru-Orua (716.64 mg/kg), with a lower concentration in Bolou-Orua (314.71 mg/kg), and was absent in Toru-Angiama. The higher levels observed in Toru-Orua point to significant upstream sources, such as industrial runoff or petroleum spillage and it compares well with the study of (Zhang *et al*., 2012). Phenanthrene is moderately toxic, with potential to cause chronic effects on benthic species, impacting their reproduction and growth. The water samples showed elevated levels at Toru-Orua (43.44 mg/L) and Toru-Angiama (120.62 mg/L), but it was undetected in Bolou-Orua. For sediments, the highest concentration was in Toru-Orua (716.64 mg/kg), with moderate levels in Bolou-Orua (314.71 mg/kg) and absence in Toru-Angiama. This substantial difference between water and sediment concentrations in Toru-Orua suggests significant historical sediment accumulation, likely from earlier pollution events. The high levels in Toru-Angiama's water sample may indicate ongoing pollution, possibly from recent sources.
Anthracene is another three-ring PAH but has a different structural arrangement compared to Phenanthrene. It is widely used in the production of dyes, plastics, and pesticides. Although less toxic than many other PAHs, Anthracene still poses risks to aquatic life, especially at high concentrations, where it can affect the health and survival of fish and invertebrates (El-Bouhy *et al*., 2024). Anthracene, concentrations were measured at 27.65 mg/L in Toru-Orua and 52.27 mg/L in Bolou-Orua, with the highest levels in Bolou-Orua, but it was absent in Toru-Angiama. The absence of Anthracene in Toru-Angiama may suggest a dilution effect or the lack of specific pollution sources as also observed in the study of (Jesus *et al*., 2022). Although Anthracene is considered less toxic compared to other PAHs, its presence can still cause stress responses in aquatic life. While in the sediments Anthracene was detected exclusively in Toru-Angiama at a concentration of 323.13 mg/kg, while it was absent in Toru-Orua and Bolou-Orua. This suggests a localized source of pollution, potentially linked to recent industrial activities or specific discharge events in Toru-Angiama. Given its ability to accumulate in sediments, Anthracene may pose risks to sediment-dwelling organisms over time which also agrees with the study of Maletić *et al*., (2019). Anthracene was detected in the water samples from Toru-Orua (27.65 mg/L) and Bolou-Orua (52.27 mg/L), with no detection in Toru-Angiama. However, it was only found in the sediment sample from Toru-Angiama (323.13

mg/kg). This contrasting distribution could be indicative of site-specific pollution sources, with possible sedimentation processes or degradation occurring in the water column of the other sites ((Maletić *et al*., 2019).

Fluoranthene is a four-ring PAH that includes a five-membered ring within its structure. It is typically found in emissions from burning organic matter, particularly from diesel engines. Fluoranthene is known for its carcinogenic properties and environmental persistence, which can lead to bioaccumulation in both terrestrial and aquatic organisms. This accumulation can disrupt food chains and cause long-term ecological damage (Alegbeleye *et al*., 2017). Fluoranthene was found at moderate to high levels of 34.41 mg/L in Toru-Orua and 81.14 mg/L in Bolou-Orua, but was not detected in Toru-Angiama. The elevated levels in Bolou-Orua point to significant pollution, likely from pyrogenic sources, such as combustion processes as also observed in the study of (Kieta *et al*., 2022). Fluoranthene is known for its carcinogenic properties and can cause developmental issues in fish larvae, posing risks to aquatic ecosystems. While in the sediments Fluoranthene was not detected at any of the sampled locations. This absence may indicate minimal sources of this PAH, which is often linked to high-temperature combustion processes, or effective degradation mechanisms within the river sediments. Fluoranthene is a known carcinogen, and its non-detection could signify reduced anthropogenic pressure in terms of pyrogenic emissions.

Pyrene is composed of four fused benzene rings and is a common pollutant in vehicle exhaust and industrial processes. Pyrene is known to cause genetic damage and has been linked to respiratory diseases and cancer in humans. Its presence in water bodies can affect the health of aquatic organisms, leading to mutations and reduced populations (Abdel-Shafy *et al*., 2019). Pyrene concentrations were recorded at 28.01 mg/L in Toru-Orua and 73.73 mg/L in Toru-Angiama, but it was absent in Bolou-Orua. The higher concentration in Toru-Angiama may indicate recent pollution from waste disposal or oil leaks which also agrees with the study of (Oliveira *et al*., 2013). Pyrene is associated with DNA damage in aquatic organisms and has potential carcinogenic effects on humans, raising concerns for water safety (Ziyaei, *et al*., 2024). While in sediments Pyrene levels were significantly elevated in Bolou-Orua (857.94 mg/kg), followed by Toru-Orua (622.01 mg/kg), with lower levels in Toru-Angiama (269.60 mg/kg). The high concentration in Bolou-Orua could be attributed to industrial effluents, vehicular emissions, or oil spills and this compares well with the study of (Kumar *et al*., 2021). Pyrene is associated with genetic mutations in aquatic organisms, and its presence at elevated levels poses potential ecological and health risks

Benz(a)anthracene has four benzene rings in a non-linear arrangement and is commonly found in soot, tar, and the byproducts of incomplete combustion. It is recognized as a carcinogen, capable of causing DNA mutations and increasing cancer risk in exposed populations. The compound's persistence in sediments can lead to long-term contamination of aquatic habitats (Saravanakumar *et al*., 2021). Benz(a)anthracene was not detected in Toru-Orua but was detected at 28.64 mg/L in Bolou-Orua and 81.67 mg/L in Toru-Angiama, highlighting localized pollution. Given its carcinogenic nature, the presence of Benz(a)anthracene raises significant concerns for both ecological and human health, particularly in areas where communities rely on river resources as also described in (Ziyaei *et al*., 2024). For the sediments the absence of Benz(a)anthracene in all sites suggests limited industrial or combustion activities known to release this carcinogenic compound in the study area. Alternatively, its absence could be due to degradation in the sediment environment, reducing its detectability.

Chrysene is another four-ring PAH commonly found in coal tar, oils, and combustion byproducts. It is classified as carcinogenic, with strong links to skin and lung cancers. In aquatic environments, Chrysene can accumulate in sediments, posing a risk to bottom-dwelling organisms and potentially entering the food chain. Chrysene levels were recorded at 16.52 mg/L in Toru-Orua, 64.96 mg/L in Bolou-Orua, and 59.59 mg/L in Toru-Angiama. The highest concentration in Bolou-Orua suggests potential sources like industrial or vehicular emissions. Chrysene is a potential human carcinogen, and its presence can lead to bioaccumulation in aquatic species, ultimately impacting the food chain (Aborisade *et al*., 2023). For sediments Chrysene was detected in all three sites, with the highest levels in Toru-Orua (764.62 mg/kg), followed by Bolou-Orua (673.56 mg/kg) and Toru-Angiama (422.41 mg/kg). This widespread occurrence points to ongoing petroleum-based pollution, likely from oil spills, industrial runoff, or vehicular emissions as this also agrees with the study of (Marvin *et al*., 2021). Chrysene's bioaccumulative nature raises concerns about potential impacts on aquatic organisms and human health through the food chain (Udom *et al*., 2023). The presence of Chrysene across both water and sediments indicates continuous pollution, likely from oil-related activities, with sediments acting as a reservoir due to Chrysene's hydrophobic characteristics (Pampanin, *et al*., 2013).

For the other high molecular weight PAHs, including Benz(b)fluoranthene, Benz(k)fluoranthene, Benz(a)pyrene, Indeno(1,2,3-cd) pyrene, Dibenz(a,h)anthracene, and Benzo(g,h,i) perylene, there was generally an absence across both water and sediments. The exceptions were localized detections, such as Benz(k)fluoranthene in Toru-Orua's sediment (411.75 mg/kg) and Benz(a)pyrene in Toru-Angiama's sediment (271.86 mg/kg). These sporadic detections point to site-specific sources, likely from combustion processes, indicating point-source pollution which is also in agreement with the study of (Boente *et al*., 2020).

The overall patterns observed suggest that PAHs generally accumulate more in sediments than in water due to their hydrophobic nature as also described in the study of Maletić *et al*., (2019), which can lead to long-term ecological impacts, particularly affecting benthic organisms (Jesus *et al*., 2022). The site-specific variations highlight localized pollution sources, such as industrial discharges and oil spills. The detection of carcinogenic PAHs, especially Benz(a)pyrene and Chrysene, in some sites raises significant public health concerns, particularly for communities depending on the river for water and fishing.

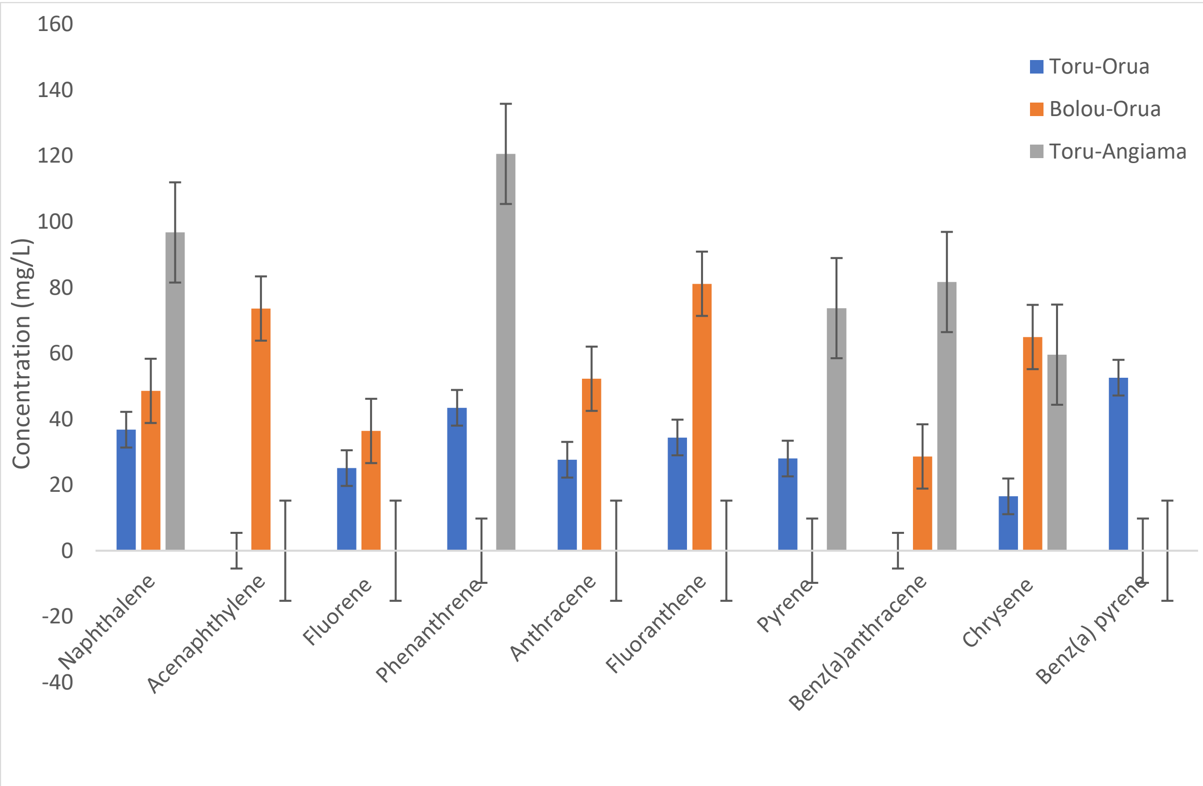

Fig. 1: Concentration of PAHs in water samples

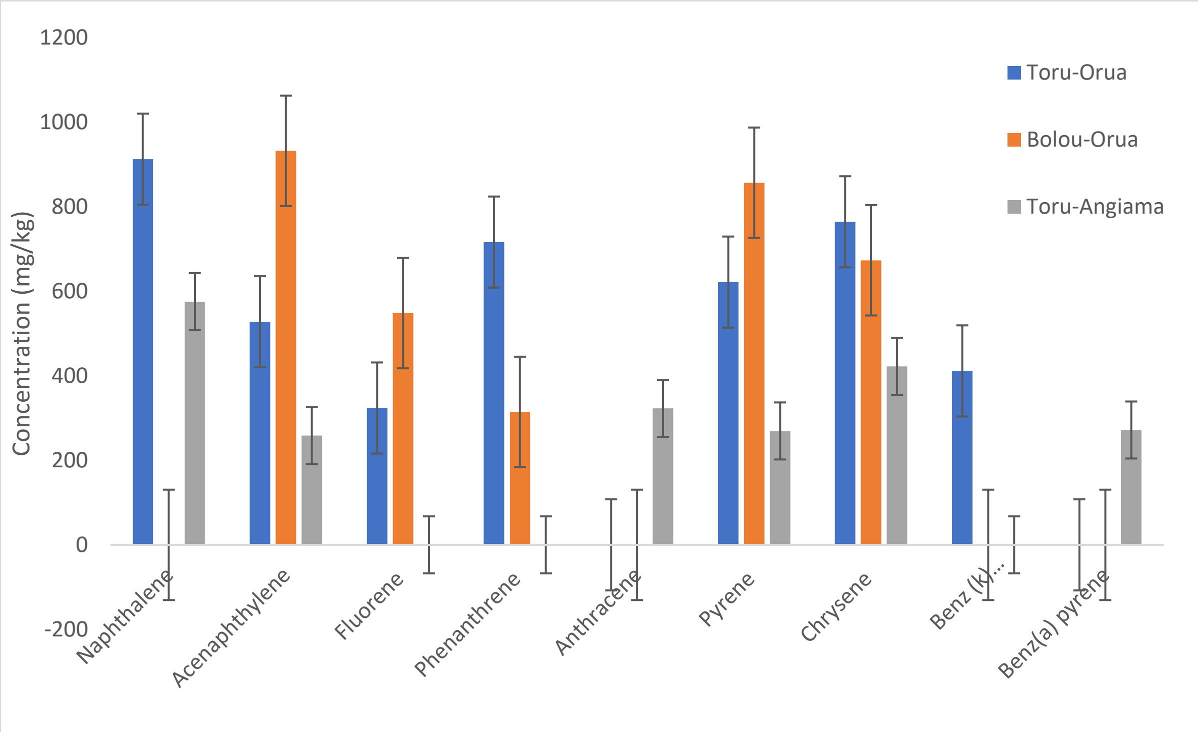

Fig. 2: Concentration of PAHs in sediment samples

Conclusion

By providing baseline data on PAH concentrations in the Sagbama river and sediments, the findings of this study are expected to inform policy decisions and support efforts to mitigate PAH pollution in Bayelsa State and other similarly impacted regions. It is also intended to serve as a valuable resource for environmental scientists, policymakers, and stakeholders involved in the management and conservation of the Niger Delta's aquatic environments. Ultimately, this work underscores the need for proactive environmental monitoring and management practices to safeguard freshwater resources, protect public health, and promote sustainable development in oil-rich regions like the Niger Delta. Based on these findings, it is recommended that stricter controls and continuous monitoring of industrial discharges and PAH levels is crucial for early detection and mitigation of emerging pollution trends. Additionally, conducting detailed ecological and human health risk assessments would be beneficial in mitigating potential long-term effects of these pollutants on the Sagbama River ecosystem and surrounding communities.

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