



## Assessment of Polycyclic Aromatic Hydrocarbons in the Soils of Selected Villages in Ahoada West, Rivers State, Nigeria

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### Article Info

#### Article history:

Received 6 April 2025

Revised 3 October 2025

Accepted 5 October 2025

Published 1 November 2025

#### Keywords:

Ahoada West,  
Illegal bunkering,  
Polycyclic aromatic  
hydrocarbons,  
Soil pollutants.

### Abstract

**Background:** Environmental contamination brought about by human and natural activities is one of the biggest issues facing some villages in Rivers State today. Contamination could be as a result of Polycyclic Aromatic Hydrocarbons which are persistent in the soil environment and have harmful effects on organisms.

**Aims:** The objective of the study was to assess the polycyclic aromatic hydrocarbons levels in the soils of three communities (Akinima, Oruama and Joinkrama 4(JK4) in Ahoada West Local Government Area, Rivers State.

**Methods:** Materials and Methods: Soil samples from various depths (0-5cm, 0-10cm, and 0-15cm) were examined using Gas Chromatography (GC) to determine polycyclic aromatic hydrocarbons concentration. To determine if there was significant difference between the groups, statistical analysis was done using analysis of variance at 5% probability. Significant means were tested with Tukey Test.

**Result:** The results revealed significant variations in concentrations of polycyclic aromatic hydrocarbons across the communities and depths. Results from Joinkrama 4(JK4) show the highest levels for most of the depths. Benzo(ghi)pyrene was below detectable limit for Akinima in all the depths. The  $\Sigma$ 16PAHs for the communities was in the range (ppm) 2709.25-13742.78, 2136.59-9734.23, 3658.61- 14101.53 for 0-5,0-10 and 0-15 cm, respectively.

**Conclusion:** Notably, PAH concentrations were above WHO guideline in all communities posing potential health risk. The study concludes that the analyzed soil samples accumulate PAHs which may result to significant environmental and health threats.

**To cite this article:** Akuru, U. B., Owota, K. M., Nicholas, S. C. (2025). Assessment of Polycyclic Aromatic Hydrocarbons in the Soils of Selected Villages in Ahoada West, Rivers State, Nigeria. *Open Soil Science and Environment*, 3(1), 20–28.

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## 1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are widespread organic pollutants made up of two or more fused rings that mostly come from the incomplete incineration of organic matter and certain natural sources (Krzebietke *et al.*, 2022). The prime sources of PAHs in various environmental matrices (soil, water, atmosphere, and food) are natural sources and anthropogenic processes, including diverse industrial activities, particularly those involved in incomplete combustion of coal (Okoye *et al.*, 2023). PAHs are persistent in the soil environment and have a harmful effect on organisms functioning as mutagens and carcinogens (Krzebietke *et al.*, 2022). The content of PAHs in soil is greater in the surface layer and decreases deeper into the soil profile (Farahani *et al.*, 2010; Krzebietke *et al.*, 2022). Cousin *et al.* (1999) and Krzebietke *et al.* (2022) reported that accumulation

of PAHs is in the upper soil layer and content decreased deeper into the soil (Also, removing PAHs from clay soil can be more difficult than from sandy soil (Ortega-Calvo *et al.*, 2013; Krzebietke *et al.*, 2022)).

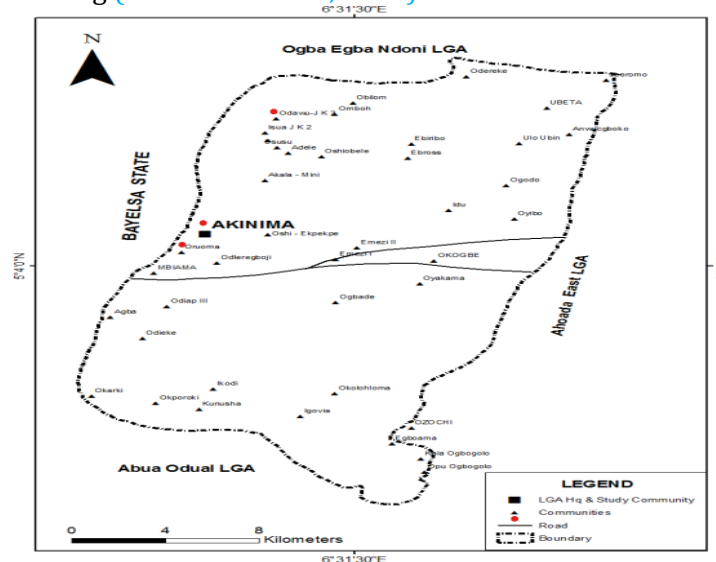
Soil pollution originating from oil and gas activities has a detrimental effect on soil fertility, thereby hampering plant growth. Crude oil pollution occurs when the extraction, storage or transportation of petroleum results in a detrimental change to the chemical, physical or biological quality of the environment that is either man-made or man-aided (Nnaji *et al.*, 2019). Several countries have exploited crude oil for extended periods of time, which has resulted in complex contamination in many cities by petroleum hydrocarbons and PAHs. The Niger Delta region of Nigeria is one of the world's most important regions for the exploration of crude oil. It has experienced several oil spills, aerial deposition of organic by-products from flared gases and extensive environmental degradation by both inorganic and organic pollutants (Okoye *et al.*, 2023). Over time, the region has witnessed decrease in soil fertility, agricultural decline, pollution of air and water, a decline in fisheries, the extinction of species and a depletion of biodiversity (Onwuka *et al.*, 2021). Therefore, it is necessary to ascertain the concentration of PAHs in the soil from selected communities in Ahoada-West LGA, Rivers State, which is also part of the Niger Delta region of Nigeria.

*This study is novel in providing the first depth-resolved (0–5, 0–10, and 0–15 cm) assessment of Σ16 PAHs in soils of Akinima, Oruama, and Joinkrama 4 in Ahoada West, Rivers State, thereby generating baseline data for understudied rural Niger Delta communities with chronic exposure to oil- and gas-related contamination.*

## 2. Methods

### 2.1 The Study area

The samples were collected from Ahoada West Local Government Area, and the research started from September to November 2023 at Austino Laboratory, Alakahia, Port Harcourt, Nigeria. Ahoada West is a Local Government Area (LGA) located in Rivers State, Nigeria, with Akinima serving as its administrative center (Figure 1). Situated in the Northwest of the state, it was formed from the former Ahoada Local Government in 1996. The Orashi River borders the LGA, making it part of the Orashi region. The local population, primarily engaged in farming and trading of food crops. The study focused on three communities, namely: Akinima, Oruama, and Joinkrama IV. According to the National Population Commission, the population of Ahoada West increased from 249,232 in 2006 to approximately 280,730 by December 2010, marking a 3% growth. This rise in population has led to increased demand for food and heightened vulnerabilities, given that the residents rely heavily on farming, fishing, and hunting (Olunwa & Lawal, 2021).



**Figure 1.** Ahoada West Local Government Area

Source: Adapted from Olunwa & Lawal (2021)

## 2.2 Sample Collection

Composite soil samples were collected at depths of 0-5cm, 0-10cm and 0-15cm using a clean soil auger from four locations in selected communities (Akinima, Oruama and Joinkrama 4) in Ahoada West LGA, Rivers State. For each collecting site, four soil samples were taken and combined to form a representative sample of that location. Immediately after collection, the samples were sealed with air tight container and stored in a cool, dark place until analysis.

## 2.3 PAH Determination in the Soil Sample

The sample was added to 1L separating funnel. Then the sample bottle was filled with 50ml of methylene chloride and sealed. This was shaken for 30 seconds to rinse the inner surface. The solvent was then transferred to the separating funnel; it was agitated for two minutes while periodically being vented to reduce excess pressure. The organic layer was allowed to separate from the water phase for a minimum of ten minutes. In a 250ml flask, the methylene chloride extract was collected. The extraction procedure was repeated for the second and third time and combined in an Erlenmeyer flask.

The combined extract was poured through a drying column containing packed cotton wool, anhydrous sodium sulphate and silica. The extract was collected into the vial and concentrated by boiling it down with nitrogen gas to 1.0ml. The remaining extract was mixed with 1.0ml of the solvent and 1.0micro liter (1.0 $\mu$ l) was injected into the flame ionization detector gas chromatograph for PAH analysis.

## 2.4 Statistical Analysis

All data collected were statistically analyzed and results were represented as mean  $\pm$  standard deviation. One-way Analysis of Variance (ANOVA), followed by a post- hoc Tukey Test was used to ascertain if there was a significant difference between the experimental groups. A statistically significant level was defined  $p \leq 0.05$ . SPSS version 21 was used for this analysis.

## 3. Results

Table 1-6 shows that the concentrations of PAHs in the soil samples vary depending on the depth and location of the sample. The PAHs concentration in Akinima (Table 1) had significant variations with 0-5 cm having the highest values and 0-10cm with the least values which were significant. Benzo(ghi)pyrene was below detectable limit (BDL) for all the location, benzo(a)anthracene concentration (ppm) was highest for 0-5cm (1395.63 $\pm$ 0.56) and 0-10cm (384.07 $\pm$ 0.12) respectively whereas 0-15cm had anthracene (502.56 $\pm$ 0.02) with the highest value. For Oruama community (Table 2), the PAHs concentration for the various depths (cm) was in the order 0-5 < 0-10 < 0-15cm. Benzo(a) anthracene had the highest PAH concentration (1102.91 $\pm$ 0.67 > 847.02 $\pm$ 1.23 > 398.13 $\pm$ 0.23 mg/kg for 0-15 > 0-10 > 0-5cm respectively) followed by benzo(k) fluoranthene (1046.89 $\pm$ 0.45 > 871.53 $\pm$ 1.23 > 384.76 $\pm$ 0.06 mg/kg for 0-15>0-10>0-5cm respectively) while acenaphthene, phenanthrene, and pyrene were below detectable limit for 0-5cm depth. For JK 4 (Table 3), the depth with the highest PAHs concentration was 0-15cm, followed by 0-5cm and then 0-10cm.

**Table 1.** Polycyclic Aromatic Hydrocarbon concentration (ppm) in soil obtained from Akinima.

PAHs	0-5 cm	0-10 cm	0-15 cm
Naphthalene	538.65 $\pm$ 0.05 <sup>a</sup>	114.39 $\pm$ 3.11 <sup>b</sup>	278.30 $\pm$ 0.23 <sup>c</sup>
Acenaphthylene	805.02 $\pm$ 0.23 <sup>a</sup>	318.64 $\pm$ 2.12 <sup>b</sup>	413.39 $\pm$ 1.23 <sup>c</sup>
Acenaphthene	627.56 $\pm$ 0.23 <sup>a</sup>	BDL	BDL
Flourene	413.10 $\pm$ 1.12 <sup>a</sup>	177.42 $\pm$ 0.99 <sup>b</sup>	374.73 $\pm$ 0.09 <sup>c</sup>
Phenanthrene	996.17 $\pm$ 1.34 <sup>a</sup>	BDL	118.68 $\pm$ 0.03 <sup>c</sup>
Anthracene	BDL	278.04 $\pm$ 1.27 <sup>b</sup>	502.56 $\pm$ 0.02 <sup>c</sup>
Fluoranthene	BDL	123.56 $\pm$ 0.23 <sup>b</sup>	311.18 $\pm$ 0.07 <sup>c</sup>

Pyrene	962.22±0.09 <sup>a</sup>	65.14±0.22 <sup>b</sup>	202.78±0.23 <sup>c</sup>
Benzo(a) anthracene	1395.63±0.56 <sup>a</sup>	384.07±0.12 <sup>b</sup>	426.03±0.08 <sup>c</sup>
Chrysene	902.04±0.23 <sup>a</sup>	102.38±1.23 <sup>b</sup>	221.89±0.08 <sup>c</sup>
Benzo(b )fluoranthene	594.42±0.56 <sup>a</sup>	BDL	BDL
Benzo(k) fluoranthene	810.8±0.34 <sup>a</sup>	318.59±0.98 <sup>b</sup>	335.73±0.23 <sup>c</sup>
Benzo(a)pyrene	BDL	175.38±1.34 <sup>b</sup>	279.78±0.67 <sup>c</sup>
Indeno1,2,3 cd pyrene	396.92±1.23 <sup>a</sup>	78.40±0.12 <sup>b</sup>	194.18±0.04 <sup>c</sup>
Dibenz(a,h) Anthracene	671.46±1.45 <sup>a</sup>	BDL	BDL
Benzo(g,h,i) pyrene	BDL	BDL	BDL
Σ <sub>16</sub> PAHs	9114.46±0.84 <sup>a</sup>	2136.59±0.50 <sup>b</sup>	3658.61±0.57 <sup>c</sup>

Values are expressed as Mean ± Standard Deviation (SD). Values in a row with different alphabetical superscript do differ significantly (p< 0.05). (a) means 0-5 cm is significantly different from other groups. (b) means 0-10 cm is significantly different from other groups and (c) means 0-15 cm is significantly different from other groups

**Table 2.** PAH concentration(ppm) in soil obtained from Oruama.

PAHs	0-5 cm	0-10 cm	0-15 cm
Naphthalene	113.50±0.02 <sup>a</sup>	615.74±0.05 <sup>b</sup>	748.28±0.23 <sup>c</sup>
Acenaphthylene	318.48±0.10 <sup>a</sup>	784.19±0.09 <sup>b</sup>	921.16±0.02 <sup>c</sup>
Acenaphthene	BDL	353.38±0.11 <sup>b</sup>	421.02±0.34 <sup>c</sup>
Flourene	248.13±0.09 <sup>a</sup>	719.96±0.10 <sup>b</sup>	982.67±0.47 <sup>c</sup>
Phenanthrene	BDL	505.67±0.54 <sup>b</sup>	774.89±0.61 <sup>c</sup>
Anthracene	336.15±0.06 <sup>a</sup>	773.19±0.25 <sup>b</sup>	998.20±0.09 <sup>c</sup>
Fluoranthene	128.78±0.12 <sup>a</sup>	611.78±0.23 <sup>b</sup>	819.52±0.45 <sup>c</sup>
Pyrene	BDL	562.93±0.01 <sup>b</sup>	710.65±0.62 <sup>c</sup>
Benzo(a) anthracene	398.13±0.23 <sup>a</sup>	847.02±1.23 <sup>b</sup>	1102.91±0.67 <sup>c</sup>
Chrysene	118.74±0.07 <sup>a</sup>	526.93±0.23 <sup>b</sup>	742.47±0.09 <sup>c</sup>
Benzo(b )fluoranthene	225.29±0.03 <sup>a</sup>	664.97±1.23 <sup>b</sup>	884.43±0.23 <sup>c</sup>
Benzo(k) fluoranthene	384.76±0.06 <sup>a</sup>	871.53±1.23 <sup>b</sup>	1046.89±0.45 <sup>c</sup>
Benzo(a)pyrene	262.21±0.04 <sup>a</sup>	592.99±0.23 <sup>b</sup>	711.67±0.23 <sup>c</sup>
Indeno1,2,3 cd pyrene	174.94±0.11 <sup>a</sup>	723.17±0.10 <sup>b</sup>	802.00±0.09 <sup>c</sup>
Dibenz(a,h) Anthracene	BDL	180.02±0.09 <sup>b</sup>	397.48±0.23 <sup>c</sup>
Benzo(g,h,i) pyrene	BDL	401.48±0.12 <sup>b</sup>	401.18±0.00 <sup>b</sup>
Σ <sub>16</sub> PAHs	2709.25 ±0.7 <sup>a</sup>	9734.23±1.59 <sup>b</sup>	12466.29±0.59 <sup>c</sup>

**Table 3.** PAHs concentration(ppm) in soil obtained from Joinkrama 4.

PAHs	0-5 cm	0-10 cm	0-15 cm
Naphthalene	1084.62±1.34 <sup>a</sup>	519.39±1.67 <sup>b</sup>	1073.59±2.01 <sup>c</sup>
Acenaphthylene	1211.49±1.23 <sup>a</sup>	573.18±2.01 <sup>b</sup>	1264.73±2.13 <sup>c</sup>
Acenaphthene	896.17±0.09 <sup>a</sup>	308.96±0.09 <sup>b</sup>	921.87±1.34 <sup>c</sup>
Flourene	871.53±0.45 <sup>a</sup>	413.84±0.89 <sup>b</sup>	873.03±1.23 <sup>c</sup>
Phenanthrene	796.05±0.78 <sup>a</sup>	278.50±0.34 <sup>b</sup>	740.78±0.12 <sup>c</sup>
Anthracene	1113.16±2.34 <sup>a</sup>	621.61±0.54 <sup>b</sup>	1178.84±0.1 <sup>c</sup>
Fluoranthene	1074.78±3.45 <sup>a</sup>	494.17±1.23 <sup>b</sup>	1086.68±0.23 <sup>c</sup>
Pyrene	648.16±0.12 <sup>a</sup>	317.40±4.03 <sup>b</sup>	662.78±0.09 <sup>c</sup>
Benzo(a) anthracene	1279.52±2.34 <sup>a</sup>	783.17±1.23 <sup>b</sup>	1277.63±0.23 <sup>c</sup>
Chrysene	982.72±0.90 <sup>a</sup>	374.27±0.98 <sup>b</sup>	948.14±0.23 <sup>c</sup>
Benzo(b )fluoranthene	446.22±0.09 <sup>a</sup>	213.49±0.3 <sup>b</sup>	470.64±0.4 <sup>c</sup>
Benzo(k) fluoranthene	1003.05±0.76 <sup>a</sup>	483.52±0.45 <sup>b</sup>	1063.32±0.04 <sup>c</sup>
Benzo(a)pyrene	641.16±0.47 <sup>a</sup>	379.18±1.34 <sup>b</sup>	671.89±0.07 <sup>c</sup>
Indeno1,2,3 cd pyrene	828.95±0.78 <sup>a</sup>	381.89±0.34 <sup>b</sup>	892.16±0.34 <sup>c</sup>
Dibenz(a,h) anthracene	489.15±0.34 <sup>a</sup>	182.44±0.32 <sup>b</sup>	574.89±0.06 <sup>c</sup>
Benzo(g,h,i) pyrene	374.29±0.56 <sup>a</sup>	BDL	401.78±0.34 <sup>c</sup>
Σ <sub>16</sub> PAHs	13742.78±1.78 <sup>a</sup>	6325.13±1.50 <sup>b</sup>	14101.53±1.30 <sup>a</sup>

**Table 4.** PAHs concentration(ppm) in soil obtained from depth 0-5 cm.

PAHs	Akinima	Oruama	Joinkrama 4
Naphthalene	538.65±0.05 <sup>a</sup>	113.50±0.02 <sup>b</sup>	1084.62±1.34 <sup>c</sup>
Acenaphthylene	805.02±0.23 <sup>a</sup>	318.48±0.10 <sup>b</sup>	1211.49±1.23 <sup>c</sup>
Acenaphthene	627.56±0.23 <sup>a</sup>	BDL	896.17±0.09 <sup>c</sup>
Flourene	413.10±1.12 <sup>a</sup>	248.13±0.09 <sup>b</sup>	871.53±0.45 <sup>c</sup>
Phenanthrene	996.17±1.34 <sup>a</sup>	BDL	796.05±0.78 <sup>c</sup>
Anthracene	BDL	336.15±0.06 <sup>b</sup>	1113.16±2.34 <sup>c</sup>
Fluoranthene	BDL	128.78±0.12 <sup>b</sup>	1074.78±3.45 <sup>c</sup>
Pyrene	962.22±0.09 <sup>a</sup>	BDL	648.16±0.12 <sup>c</sup>
Benzo(a) anthracene	1395.63±0.56 <sup>a</sup>	398.13±0.23 <sup>b</sup>	1279.52±2.34 <sup>c</sup>
Chrysene	902.04±0.23 <sup>a</sup>	118.74±0.07 <sup>b</sup>	982.72±0.90 <sup>c</sup>
Benzo(b) fluoranthene	594.42±0.56 <sup>a</sup>	225.29±0.03 <sup>b</sup>	446.22±0.09 <sup>c</sup>

Benzo(k) fluoranthene	810.8±0.34 <sup>a</sup>	384.76±0.06 <sup>b</sup>	1003.05±0.76 <sup>c</sup>
Benzo(a)pyrene	BDL	262.21±0.04 <sup>b</sup>	641.16±0.47 <sup>c</sup>
Indeno1,2,3 cd pyrene	396.92±1.23 <sup>a</sup>	174.94±0.11 <sup>b</sup>	828.95±0.78 <sup>c</sup>
Dibenz(a,h) Anthracene	671.46±1.45 <sup>a</sup>	BDL	489.15±0.34 <sup>c</sup>
Benzo(g,h,i) pyrene	BDL	BDL	374.29±0.56 <sup>c</sup>
Σ <sub>16</sub> PAHs	9114.46±0.84 <sup>a</sup>	2709.25 ±0.70 <sup>b</sup>	13742.78±1.78 <sup>c</sup>

**Table 5.** PAHs concentration (ppm) in soil obtained from depth 0-10 cm.

PAHs	Akinima	Oruama	Joinkrama 4
Naphthalene	114.39±3.11 <sup>a</sup>	615.74±0.05 <sup>b</sup>	519.39±1.67 <sup>c</sup>
Acenaphthylene	318.64±2.12 <sup>a</sup>	784.19±0.09 <sup>b</sup>	573.18±2.01 <sup>c</sup>
Acenaphthene	BDL	353.38±0.11 <sup>b</sup>	308.96±0.09 <sup>c</sup>
Flourene	177.42±0.99 <sup>a</sup>	719.96±0.10 <sup>b</sup>	413.84±0.89 <sup>c</sup>
Phenanthrene	BDL	505.67±0.54 <sup>b</sup>	278.50±0.34 <sup>c</sup>
Anthracene	278.04±1.27 <sup>a</sup>	773.19±0.25 <sup>b</sup>	621.61±0.54 <sup>c</sup>
Fluoranthene	123.56±0.23 <sup>a</sup>	611.78±0.23 <sup>b</sup>	494.17±1.23 <sup>c</sup>
Pyrene	65.14±0.22 <sup>a</sup>	562.93±0.0 <sup>b</sup>	317.40±4.03 <sup>c</sup>
Benzo(a) anthracene	384.07±0.12 <sup>a</sup>	847.02±1.23 <sup>b</sup>	783.17±1.23 <sup>c</sup>
Chrysene	102.38±1.23 <sup>a</sup>	526.93±0.23 <sup>b</sup>	374.27±0.98 <sup>c</sup>
Benzo(b )fluoranthene	BDL	664.97±1.23 <sup>b</sup>	213.49±0.34 <sup>c</sup>
Benzo(k) fluoranthene	318.59±0.98 <sup>a</sup>	871.53±1.23 <sup>b</sup>	483.52±0.45 <sup>c</sup>
Benzo(a)pyrene	175.38±1.34 <sup>a</sup>	592.99±0.23 <sup>b</sup>	379.18±1.34 <sup>c</sup>
Indeno1,2,3 cd pyrene	78.40±0.12 <sup>a</sup>	723.17±0.10 <sup>b</sup>	381.89±0.34 <sup>c</sup>
Dibenz(a,h) Anthracene	BDL	180.02±0.09 <sup>b</sup>	182.44±0.32 <sup>c</sup>
Benzo(g,h,i) pyrene	BDL	401.48±0.12 <sup>b</sup>	BDL
Σ <sub>16</sub> PAHs	2136.59±0.50 <sup>a</sup>	9734.23±1.59 <sup>b</sup>	6325.13±1.50 <sup>c</sup>

**Table 6.** PAHs concentration(ppm) in soil obtained from depth 0-15 cm

PAHs	Akinima	Oruama	Joinkrama 4
Naphthalene	278.30±0.23 <sup>a</sup>	748.28±0.23 <sup>b</sup>	1073.59±2.01 <sup>c</sup>
Acenaphthylene	413.39±1.23 <sup>a</sup>	921.16±0.02 <sup>b</sup>	1264.73±2.13 <sup>c</sup>
Acenaphthene	BDL	421.02±0.34 <sup>b</sup>	921.87±1.34 <sup>c</sup>
Flourene	374.73±0.09 <sup>a</sup>	982.67±0.47 <sup>b</sup>	873.03±1.23 <sup>c</sup>

Phenanthrene	118.68±0.03 <sup>a</sup>	774.89±0.61 <sup>b</sup>	740.78±0.12 <sup>c</sup>
Anthracene	502.56±0.02 <sup>a</sup>	998.20±0.09 <sup>b</sup>	1178.84±0.10 <sup>c</sup>
Fluoranthene	311.18±0.07 <sup>a</sup>	819.52±0.45 <sup>b</sup>	1086.68±0.23 <sup>c</sup>
Pyrene	202.78±0.23 <sup>a</sup>	710.65±0.62 <sup>b</sup>	662.78±0.09 <sup>c</sup>
Benzo(a) anthracene	426.03±0.08 <sup>a</sup>	1102.91±0.67 <sup>b</sup>	1277.63±0.23 <sup>c</sup>
Chrysene	221.89±0.08 <sup>a</sup>	742.47±0.09 <sup>b</sup>	948.14±0.23 <sup>c</sup>
Benzo(b) fluoranthene	BDL	884.43±0.23 <sup>b</sup>	470.64±0.4 <sup>c</sup>
Benzo(k) fluoranthene	335.73±0.23 <sup>a</sup>	1046.89±0.45 <sup>b</sup>	1063.32±0.04 <sup>c</sup>
Benzo(a)pyrene	279.78±0.67 <sup>a</sup>	711.67±0.23 <sup>b</sup>	671.89±0.07 <sup>c</sup>
Indeno1,2,3 cd pyrene	194.18±0.04 <sup>a</sup>	802.00±0.09 <sup>b</sup>	892.16±0.34 <sup>c</sup>
Dibenz(a,h) Anthracene	BDL	397.48±0.23 <sup>b</sup>	574.89±0.06 <sup>c</sup>
Benzo(g,h,i) pyrene	BDL	401.18±0.00 <sup>b</sup>	401.78±0.34 <sup>c</sup>
Σ <sub>16</sub> PAHs	3658.61 ±0.57 <sup>a</sup>	12466.29±0.59 <sup>b</sup>	14101.53±1.30 <sup>c</sup>

The concentration of PAHs at different locations for 0-5cm depth (Table 4) had the order Oruama<Akinima< Jk4. Whereas for 0-10cm depth (Table 5), it was as follows: Oruama > Jk4> Akinima. Finally, the concentration of PAHs in 0-15cm (Table 6) was highest in Jk4 followed by Oruama and the Akinima.

#### 4. Discussion

This study looked at the polycyclic aromatic hydrocarbons present in selected Ahoada West villages in Rivers State. Akinima had significantly higher values in this order: 0-5 > 0-15 > 0-10 cm. Benzo(g,h,i) pyrene was not detected at all depths while benzo(b)fluoranthene and dibenz(a,h) anthracene were not detected at 0-10 and 0-15cm. In Oruama village, 0-5cm had the least summed PAHs, followed by 0-10, and 0-15cm, which was significant at  $p < 0.05$ . Acenaphthene, pyrene, phenanthrene, dibenz(a,h)anthracene, and benzo(g,h,i) pyrene were not detected. For Joinkrama 4, 0-15cm and 0-5cm had significantly higher values when compared with 0-10cm. Benzo(g,h,i) pyrene was not detected for 0-10cm. When comparing the locations, the summed PAHs for 0-5cm were as follows Oruama < Akinima < Joinkrama 4. For 0-10cm depth, Σ<sub>16</sub>PAHs was in the order: Akinima < Joinkrama 4 < Oruama and finally for depth 0-15cm, Akinima < Oruama < Joinkrama 4.

Polycyclic aromatic hydrocarbons (PAHs) pollution is a severe environmental issue, due to the health implication of their presence, as neither plants nor animals require them for any function. PAHs can be manmade or naturally occurring (found in air, water and soil). As population and technology grow and develop, there is an indirect increase in environmental contamination, resulting in a continuing and accelerated degradation in the quality of the environment and its ability to sustain life (Ekanem *et al.*, 2019).

In general, the concentrations of PAHs are higher in the shallower soil samples (0-5cm) than in the deeper soil samples (0-10 and 0-15cm). This is likely due several factors including the soil texture. The study observed the environment in which this sample was taken was a waterlogged area which might have the ability to retain good amount of PAHs on the soil surface before sedimentation due to the soil texture. The results from this study showed that the concentration of phenanthracene (except 0-10cm in Akinima and 0-5cm in Oruama communities), chrysene and benzo[a]anthracene concentration in all locations and depths was higher than those of Obini *et al* (2013) when they did a study of PAHs on soils with motor engine in Abakili auto-mechanic village.

The summation of PAHs from this study was higher than that of Umar *et al.* (2023) who had a range of 0.42-77.54mg/kg when they did research on integrated investigation of hydrocarbon

pollution in Ahoada area, Niger Delta Region, Nigeria. In similar vein, the values of  $\Sigma$ 16EPA PAHs obtained by Sojину *et al.* (2010), Onos *et al.* (2015), Akpambang and Izomoh (2016), Ekanem *et al.* (2019), Aoeed *et al.* (2021) and Faboya *et al.* (2023), was lower than that gotten from this study. The values gotten by Faboya *et al.* (2016), was also high as obtained in this study, when they looked at the aliphatic biomarkers distribution in crude oil impacted soils of the Niger Delta region of Nigeria. This study had similar  $\Sigma$ PAHs for Akinima (0-10cm) and Oruama (0-5cm) as obtained by Udoetok *et al.*, (2011). From the study, Akinima seems to have the least PAHs concentration, although higher than the FAO/WHO (2005) standard of  $\Sigma$ PAHs 20mg/kg. The study highlights the critical importance of conducting regular assessments of soil to determine its suitability and potential for various land use practices. This PAHs evaluation is essential for ensuring sustainable agricultural development, land management, and environmental conservation. By analyzing soil characteristics such as chemical properties and contamination level, researchers can better understand how different soil amelioration and remediation methods can impact soil health and productivity (Omatule *et al.*, 2023; Ukabiala *et al.*, 2025).

## 5. Conclusions

The result of the study revealed that Polycyclic Aromatic Hydrocarbons (PAHs) concentration in the Ahoada West communities especially in Akinima, Oroma and JK4 were significantly high. However, the concentrations of PAHs were consistently high in all three communities, indicating a severe environmental risk. When compared to the World Health Organization (WHO) guidelines for PAHs in soil, the concentrations found in all three communities were dangerously high. The presence of high concentrations of PAHs in the soil poses a significant risk to the health of residents of the Ahoada West communities. The result emphasizes how crucial it is to control soil pollution in order to protect public health and agricultural output.

## 6. References

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