IOSR Journal Of Pharmacy and Biological Sciences (IOSR-JPBS)
e-ISSN:2278-3008, p-ISSN:2319-7676. Volume 20, Issue 4 Ser. 3 (July. – August. 2025), PP 01-04
www.Iosrjournals.Org

Analysis Of Polycyclic Aromatic Hydrocarbons And Heavy Metals In Some Selected Sachet Water Consumed In Bayelsa State, Nigeria

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Abstract
This research was carried out to evaluate heavy metals and polycyclic aromatic hydrocarbon (PAH) concentration in sachet water located in Bayelsa state, Nigeria. From the analyzed samples the concentration of PAHs and Heavy metal were all below the permissible limits as issued by international bodies. For PAHs analysis the levels of Bghip, DahA, ICP, and phe are the lowest of all the samples' concentrations of polycyclic aromatic hydrocarbons, whereas the levels of nap, Ace, Acep, and flru are the highest of all the samples' concentrations. The highest levels of B(a)A and BKF are found in Ingo. For the evaluation of heavy metal, the metal with the highest concentration is iron which as its highest value in Fido water (1.602±0.0034 ppm) and its lowest in NDU waters (1.024±0.0050 ppm). The reading for Zinc indicates that the highest value for zinc was found in Ayala waters (0.124±0.0016 ppm) and the lowest was found in NDU waters (0.104±0.0010 ppm). For copper analysis the highest value was obtained in Ayala water (0.196±0.0016 ppm) and lowest was in Fido water (0.139±0.0023 ppm). Chromium analysis indicates that the highest level of was found in NDU water (0.091±0.0010 ppm) and the lowest in Fido water (0.055±0.0016 ppm). The concentration of the other heavy metals analyzed are extremely low.
Keywords: *Heavy metals, Polycyclic aromatic hydrocarbon, Chromium, Zinc, Fido wate*

Date of Submission: 01-08-2025 Date of Acceptance: 11-08-2025

I. Introduction

Polycyclic aromatic hydrocarbons (PAHs) represent a class of hydrophobic, thermally stable organic pollutants composed of fused aromatic rings. These compounds, characterized by high melting points and low aqueous solubility, originate from both natural (volcanic activity, forest fires) and anthropogenic sources (industrial emissions, residential combustion). Their environmental distribution patterns reflect source-specific compositional profiles. PAH exposure poses significant health risks, including mutagenic potential, while recent findings highlight concerning aquatic ecosystem contamination (Mojiri et al., 2019).

Heavy metals are defined as metallic elements with densities exceeding 5 g/cm^3 that demonstrate environmental and biological toxicity (Järup, 2003). While certain micronutrients (Zn, Cu, Ni, etc.) are essential at trace levels, they become hazardous at elevated concentrations. In contrast, non-essential metals (Cd, Pb, Hg, As) exhibit toxicity even at minimal exposures (Divrikli et al., 2006). Their environmental persistence allows long-term contamination, while biological toxicity mechanisms include: competitive ion displacement, sulfhydryl group binding, membrane disruption and phosphate group interactions (Okoronkwo et al., 2005).

Human health faces significant risks from drinking water contaminated with heavy metals and polycyclic aromatic hydrocarbons (PAHs), as these persistent pollutants can cause both acute and chronic toxicity. Although most heavy metals and PAHS can bioaccumulate in the human body (for example, in lipids and the gastrointestinal system) and may cause cancer and other dangers, very few heavy metals and PAHS can do so. Populations are predominantly exposed to heavy metals and PAHS through water drinking. The proportion of heavy metals and PAHs in the portable drinking water in Bayelsa state, Nigeria, is the main focus of this study's findings.

II. Materials And Methods

Sample Collecion
Sample Area
The study area for sample collection was Yenagoa, the capital city of Bayelsa State, Nigeria.

Sample collection

This study analyzed potable water samples randomly procured from retail outlets across Yenagoa, Bayelsa State, Nigeria.

Reagent

The analytical procedures employed high-purity reagents including: deionized water (H_2O), dichloromethane (CH_2Cl_2), petroleum ether, sodium carbonate (Na_2CO_3) standards, ethyl chloroformate ($C_3H_5ClO_2$) and concentrated nitric acid (HNO_3, 65%). All chemicals met analytical-grade specifications.

PAHs Sample Analysis

The quantitative analysis of polycyclic aromatic hydrocarbons (PAHs) was performed using gas chromatography (GC) with flame ionization detection, following established analytical protocols.

Gas Chromatography Analysis

Gas chromatography (GC) serves as an effective analytical technique for separating and detecting volatile, thermally stable non-polar compounds. The method is equally applicable for examining semi-volatile substances, including polycyclic aromatic hydrocarbons (PAHs), as demonstrated in recent petroleum science research.

Chromatographic condition

GC	Hp 6890 powered with HP Chemstation Rev. A09.1
Column:	HP-1
Column length	30m
Column ID	0.25m
Injection Temperature	250C
Detector Temperature	20C
Detector	FID
Initial Temperature	60c for 5mins
First Rate	15c/mins for 14mins and maintain for 3min
Second Rate	10c/mins for 5mins and maintain for 4mins
Mobile Phase or Carrier	Nitrogen
Nitrogen Column Pressure	30psi
Hydrogen Pressure	28psi
Compressed Air Pressure	32psi

Water Samples Preparation: Each 3L water sample was concentrated to 50mL via evaporation at 80°C using a sand bath. Following addition of 4mL concentrated H_2SO_4, samples underwent 3-minute digestion in a Digesdahl apparatus. Oxidation was completed with 10mL H_2O_2 under heating. After cooling and filtration, extracts were diluted to 50mL final volume with deionized water.

Heavy Metal Analysis

The water samples underwent wet acid digestion prior to quantitative heavy metal analysis by atomic absorption spectrophotometry (AAS).

Digestion of Water Sample

Following the EPA-approved vigorous digestion method (Gregg, 1989), 100 mL aliquots of water samples were processed in Pyrex vessels with 10 mL concentrated HNO_3. Sequential heating and acid addition (5 mL HNO_3 increments) preceded evaporation to near-dryness. Post-cooling, 5 mL 1:1 HCl was added, followed by 5 mL 5M NaOH after warming. Filtered digests were diluted to 100 mL final volume for elemental analysis.

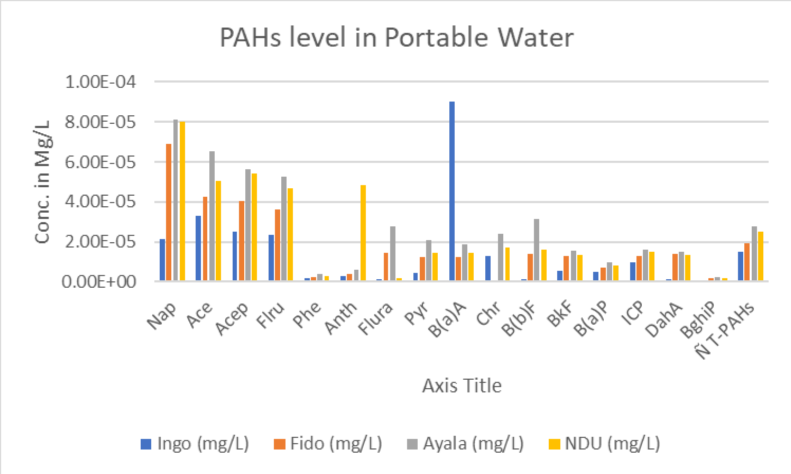
III. Results

Table 1; shows the concentration of PAHs in the Maize samples.

PAHs (mg/L)	Ingo (mg/L)	Fido (mg/L)	Ayala (mg/L)	NDU (mg/L)
Nap	$2.15E^{-5}$	$6.90E^{-5}$	$8.12E^{-5}$	$8.02E^{-5}$
Ace	$3.31E^{-5}$	$4.26E^{-5}$	$6.51E^{-5}$	$5.03E^{-5}$
Acep	$2.53E^{-5}$	$4.04E^{-5}$	$5.64E^{-5}$	$5.41E^{-5}$
Flru	$2.34E^{-5}$	$3.64E^{-5}$	$5.27E^{-5}$	$4.66E^{-5}$
Phe	$1.87E^{-6}$	$2.14E^{-6}$	$3.93E^{-6}$	$2.71E^{-6}$
Anth	$2.75E^{-6}$	$3.89E^{-6}$	$6.21E^{-6}$	$4.85E^{-5}$
Flura	$1.35E^{-6}$	$1.43E^{-5}$	$2.79E^{-5}$	$1.74E^{-6}$
Pyr	$4.55E^{-6}$	$1.26E^{-5}$	$2.07E^{-5}$	$1.47E^{-5}$
B(a)A	$9.01E^{-5}$	$1.23E^{-5}$	$1.85E^{-5}$	$1.46E^{-5}$
Chr	$1.30E^{-5}$	$1 .47E^{-5}$	$2.42E^{-5}$	$1.74E^{-5}$

B(b)F	1.15E-6	1.40E-5	3.15E-5	1.63E-5
BkF	5.50E-6	1.31E-5	1.55E-5	1.33E-5
B(a)P	4.91E-6	7.15E-6	9.70E-6	8.18E-6
ICP	9.89E-6	1.31E-5	1.59E-5	1.50E-5
DahA	1.25E-6	1.38E-5	1.52E-5	1.37E-5
BghiP	8.51E-7	1.84E-6	2.13E-6	1.78E-6
Ñ T-PAHs	1.50E-5	1.95E-5	2.79E-5	2.49E-5
Mean±SD	2.25E-5 ±1.5029E-5	1.83E5± 1.9458E-5	2.35E-5 ±2.7923E-5	2.33E-5 ±2.4944E-5

Fig 1. Bar chart showing the level of PAHs in different Brands of water



Analysis of 16 priority PAHs in water obtained from three portable water suppliers showed that the mean and standard concentration in the samples obtained from Ingo 2.25E^{-5} ±1.5029E-$^{-5,}$ Fido 1.83E^{-5}±1.9458E^{-5}, Ayala 2.35E^{-5} $^{\pm}$2.7923E-05, Niger Delta University (NDU) 2.33E^{-5} ±2.4944E-05. Statistical analysis indicated no significant differences ($p>0.05$) between these mean values.

Table 2: shows the concentration of heavy metals in the water samples.

metal	Zn	Hg	Pb	Cr	Cd	Fe	Mg	Cu
NDU	0.104±0.0010	0.003±0.0018	0.009±0.0050	0.091±0.0010	0.004±0.0010	1.024±0.0050	0.024±0.0050	0.146±0.0045
Ingo	0.112±0.0011	0.001±0.0026	0.007±0.0070	0.076±0.0011	0.012±0.0011	1.117±0.0070	0.05±0.0060	0.184±0.0034
Ayala	0.124±0.0016	0.006±0.0024	0.004±0.0042	0.08±0.0016	0.024±0.0016	1.228±0.0042	0.038±0.0040	0.196±0.0016
Fido	0.1180.0016	0.002±0.0027	0.002±0.0034	0.055±0.0016	0.018±0.0016	1.602±0.0034	0.042±0.0032	0.139±0.0023

Fig 2: Bar chart showing the level of Heavy metal in different Brands of water

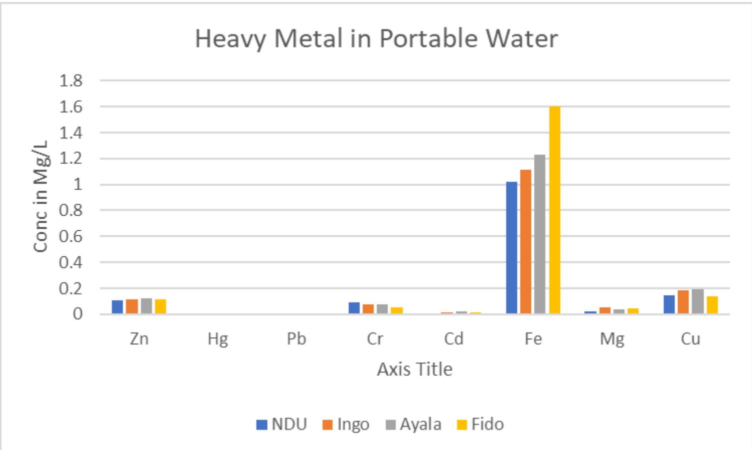


Table 2 shows the concentration of the various priority heavy metals analyzed in four different water samples

IV. Discussion

Table 1 shows the PAH concentrations across analyzed products, revealing significantly low levels overall. The lowest concentrations were observed for BghiP, DahA, IcdP, and Phe, while Nap, Ace, AceP, and Flu showed relatively higher levels. Ingo samples contained the highest B(a)A and BkF concentrations. All measurements complied with WHO (1999) and EU (1998) drinking water regulations. Compared to Turkish studies (Demir et al., 2013), our Ndu, Fido, and Ayala samples showed lower PAH levels than Tarim and Ingo. Notably, BaP concentrations - a key carcinogenic indicator - were substantially lower in Ndu, Fido and Ayala versus Tarim and Ingo. These values were markedly lower than Polish findings (126-9,815 ng/L total PAHs) reported by Kabziński et al. (2002).

Table 2 shows heavy metal levels in 4 water samples. The heavy metal with the highest concentration is iron which as its highest value in Fido water (1.602±0.0034 ppm) and its lowest in NDU waters (1.024±0.0050 ppm). The reading for Zinc indicates that the highest value for zinc was found in Ayala waters (0.124±0.0016 ppm) and the lowest was found in NDU waters (0.104±0.0010 ppm). For copper analysis the highest value was obtained in Ayala water (0.196±0.0016 ppm) and lowest was in Fido water (0.139±0.0023 ppm). Chromium analysis indicates that the highest level of was found in NDU water (0.091±0.0010 ppm) and the lowest in Fido water (0.055±0.0016 ppm). The level of the other heavy metals analyzed are extremely low.

The low PAH and heavy metal concentrations in Ingo, NDU, Ayala, and Fido waters may result from protective pipe coatings preventing leaching during water production and distribution.

V. Conclusion

Results confirm that concentrations of Cd, Mn, Zn, Ni, Cr, Cu, and PAHs in all tested sachet waters comply with WHO drinking water standards, posing no health risks to consumers.

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