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Assessment of the Polycyclic Aromatic Hydrocarbons (PAHs) Concentration in Different Drying Methods

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ABSTRACT
This study aimed to assess the levels of PAHs that may build up in freshwater fish dried using heat from charcoal, sunlight, ovens, and polythene-assisted drying methods. The exact levels of sixteen PAHs were measured in the fish samples collected from the Otuochas River in Anambra State during October 2024, November 2024, and January 2025, Nigeria. Fish samples were dried, ground, and then subjected to soxhlet extraction with n-hexane, at 60°C for 8 hours. The water content of the extracts was further eliminated using florisil clean-up before GC-MC analysis. The results indicated that sun dried fish had a PAHs level/concentration of 35.7 + 0.2µg/g; oven-dried fish had 47.7 + 0.2µg/g, and charcoal dried fish had 79.53 + 0.2 µg/g, firewood gave in 188.1 + 0.2µg/g. The charcoal combined with polythene led to a PAHs concentration/level of 166.2 + 0.1µg/g, whereas fish dried with firewood and polythene materials had a PAHs level/concentration of 696.3 + 0.2µg/g. Freshwater samples & the undried fish samples (control) showed that the freshwater contained a total PAHs concentration/level of 2.86 + 0.1µg/ml, whereas the fresh fish had 4.97 + 0.2µg/g. The PAHs concentrations in all the dried fish using different drying methods were clearly higher than the control. This is concerning, as even the fish dried in the sun had PAHs levels significantly greater than the control ($p<0.05$). It is clear that the increase in PAHs likely originated from the PAHs in the environment during the sun drying process. For the other drying methods, where PAHs levels were significantly higher than those of sun-dried fish, it can be concluded that the high amount of PAHs in the dried fish samples were due to the "burning" or drying agents used. A significant increase in PAHs was noted when drying was enhanced with polythene, which is known to produce high levels of PAHs when burned. Therefore, consumers should be cautious about the dried fish they buy from local markets.

Keywords:
Polycyclic Aromatic Hydrocarbons,
Fresh Water Fish,
Various Drying Methods

INTRODUCTION

Polycyclic aromatic hydrocarbons are organic compounds made up of two (2) or more fused (joined) benzene rings, or structures formed from hydrogen and carbon atoms arranged in rings of 5 or 6 carbon atoms (Obruche et al., 2018; Umudi et al., 2025).

When an alkyl molecule or other radical molecule is added to the ring, they are referred to as "PAH derivatives," and when a carbon atom in a ring is removed & replaced by oxygen, nitrogen or sulfur, they are called heterocyclic aromatic compounds (HACs). PAHs primarily come from human activities,

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especially from the incomplete burning of organic compounds (fuels, kerosene etc). They are found widely in the atmosphere, with natural events like forest fires and volcanic eruptions also contributing to their presence (Umudi et al., 2024). PAHs can exist in both solid and gas forms, depending on their state or volatility. However, low molecular weights PAHs, which have 2 or 3 aromatic rings (with molecular weights from 150 to 180 g/mol), are released in gas form, while high molecular weights PAHs, with molecular weights from 230 to 280 g/mol and 5 & above rings, are found in solid form (ASTM, 2005; Obruche et al., 2025). PAHs mainly result from human beings activities related to incomplete burning (combustion) of organic materials and pyrolysis. The main sources of PAHs influence their characteristics, distribution, and toxicity. However, the Major sources (reservoir) of PAH emissions can be categorized into four groups: stationary source (that is, industrial and domestic), mobile emissions, natural sources and agricultural activities (Itodo et al, 2021; Clark et al., 2025). Certain PAHs are released from point sources, and this emission remains relatively unchanged over extended periods. Stationary sources can be categorized into two primary types: domestic and industrial (El-Seshtawy & Ahmed, 2017). The origins of PAHs encompass emissions from various industrial processes, including primary coke and aluminum manufacturing, petrochemical manufacturing, cement and rubber tire production, asphalt and bitumen operations, commercial heat, power generation & wood preservations, as well as waste burning/incineration (Okoli et al., 2015; Umudi, 2019). Exposure to these PAHs through soil, food, air, and water occurs frequently. The exposure pathways consist of inhalation, ingestion & dermal contact in both non-occupational & occupational environments (Okerentugba & Ezeronye, 2003; Erienu et al., 2022). Some instances of exposure may involve multiple routes simultaneously, influencing the total amount absorbed dose (for example, inhalation & dermal exposure from polluted air). The impact on human body or health primarily depends on the longevity or duration and route of exposure, & the quantity or concentration/level of PAHs encountered, & the inherent (absorbed) toxicity of the PAHs themselves (Obayori & Salam, 2010). Additionally, various other factors or reasons can influence health states or outcomes (Ukpong & Peter, 2012; Obruche et al., 2019). The capacity of PAHs to cause short-term human health effects remains uncertain. Health consequences from chronic or prolonged exposure to PAHs may encompass cataracts, diminished immune function, damage to the kidneys and liver (e.g., jaundice), respiratory issues, asthma-like symptoms, and abnormalities in lung function, while repeated skin contact may lead to redness and inflammation (Udosen et al., 2012; Umudi et al., 2025). Naphthalene, a particular PAH, has the potential to cause the destruction of red blood cells if ingested or inhaled in significant quantities. Certain mixtures rich in PAHs are known to be carcinogenic to humans. Research on animals indicates that specific PAHs can impact the hematopoietic and immune systems, as well as cause reproductive, neurological, and developmental issues (Udo, 2006; Ekpo et al., 2023). Food smoking is one of the oldest methods of preserving food that humans have utilized, particularly in fish processing. It has evolved into a way to provide a variety of high-value goods (products), serving as an extra marketing options for certain fish products (species) when fresh intake or consumption is limited (Uboh et al., 2011; Ekpo et al., 2025). Traditional smoking methods involve filleted fish with heat from charred wood, treating presalted, where smoke from incomplete burning (combustion) of wood directly contacts the product. If not properly monitored or controlled can result in contamination with PAHs (Binkova et al., 2007; Umudi et al., 2022). The smoke is generated by smoldering sawdust or wood in the oven, positioned directly beneath the hanging fillets or fish, which are arranged on mesh. The smoke's composition and the processing conditions influence the shelf life, sensory quality and safety of the products. Notwithstanding, Potential health risks linked to dried fish foods may arise from carcinogenic elements in wood smoke, primarily PAHs, their derivatives like nitro-PAHs or oxygenated PAHs, and to a lesser degree, heterocyclic amines (Ogwuche and Obruche, 2020).

This research aims to assess the levels of sixteen (16) PAHs in freshwater fish, PAHs in river water samples, and PAHs across various smoking methods: sun, firewood + 20g polythene material, charcoal + 20g polythene material, firewood, oven and charcoal

MATERIALS AND METHODS

Study Site

The study area is located in the Eastern part of Nigeria which extended from the main Atlantic Ocean, encompassing a large area of forest that reaches the lower edge of the savannah forest zone. Otuocha, situated in Anambra State, is positioned between longitudes 3°E-9°E and latitudes 5° 40’N-8° 21’N. This land includes various communities like Onitsha, Nsugbe & Ogurugu, all located in Anambra State (Obruche et al., 2019; Umanah et al., 2025).

Figure 1: Map showing Otuocha River in Anambra State

All chemicals used in this study were of reagent grade and required no additional treatment. n-Hexane, Dichloromethane (99.99% purity), Sodium Sulphate (90% purity), Magnesium Silicate (37.7%), Methanol (98% purity), and Acetone (98.90% purity) were provided by Merck. Distilled water was sourced from Delta State College of Education, Mosogar, Nigeria.

Collection of Fish Samples and Drying

The sample collection techniques were akin to those described by Umudi et al. (2025), with minor adjustments. The fish (Tilapia spp) used in this study were sourced from the Otuocha's Community Rivers in Anambra State during October 2024, November 2024, and January 2025 (Ugochukwu et al., 2025). The fish samples were collected in the dry season months from October to late January. However, the samples, which included Tilapia spp., Arius heudeloti, and others, are most common during this period when the dry season occurs. They were gathered from the Otuocha River, an area with minimal recent exploratory activity. The selection of Otuocha River aimed to eliminate any potential pollution from exploratory activities (petroleum). The fish samples were not categorized into different kinds of species as the focus was on determining the levels of PAHs present in the fish from various drying methods. However, river water was also collected for synthesis/analysis to assess the PAH levels in the river and identify any other sources that might influence the results. The fish were grouped, and the wet fish weight of each group was recorded. The groups included: Group A, homogenized fresh fish. Group B, sundried fish. Group C, oven-dried fish. Group D, charcoal-smoked fish. Group E, firewood-smoked fish. Group F, fish smoked with charcoal-enhanced polythene material (20g). Group G, fish smoked with firewood-enhanced polythene material (20g). The smoking process lasted for 3 days, with each session lasting 2 hours at a high temperature exceeding 250°C. Notwithstanding, these smoking methods involved creating smoke from smoldering charcoal or hardwood positioned directly beneath the hanging fish arranged on mesh. Here, a piece of cardboard is placed over the fish, as is customary, to cover them during the process. This cardboard captures the smoke, allowing it to act directly & straight on the fish samples. However, the group that was dried in the sun was left for 3 days. Dried fish were immediately ground using a washed, clean & dry grinder & gently stored in a refrigerator at 40°C before extraction and synthesis/analysis. The extraction, synthesis or analyses were conducted right away to prevent aging.

Soxhlet Extraction

The extraction method utilized was based on the process described by (USEPA, 1994) and Umudi et al. (2025). The fish samples were homogenized, cut into smaller sizes or fillets, & blended with a grinder. Exactly 20 g of homogenized fish was gently mixed with 60 g of anhydrous sodium sulfate in a mortar to absorb the moisture. However, the homogenate was placed (put) into an extraction cellulose thimble covered with a Whatman filter paper (125 mm diameter) and inserted (put) into a Soxhlet extraction chamber (area) of the Soxhlet extraction units. The extractions were performed with 200 mL of n-hexane using the EPA 3540C method for 8 hours. The crude extracts generated (obtained) was carefully evaporated using a Ribby RE 200B 51 rotary vacuum evaporator at 40°C, until dry. The residue (left over) was re-dissolved in 5 mL of n-hexane & transferred into 10 mL florisil column for clean-up.

Preparation of Florisil for Clean-up

The preparation method utilized was based on the process described by Festus-Amadi et al. (2021) and Abeokuta et al. (2025). This clean up stage/step to eliminate more polar substances was carried out using activated florisil (magnesium silicate) & anhydrous Na_2SO_4. However, this florisil was heated in an oven at about 130°C for 12 hrs (overnight) and then transferred to a 250 mL beaker and placed in a desiccator. Exactly 1.0 g Anhydrous Na_2SO_4 was added to activated florisil (2.0g) in a 10 mL column that was plugged with glass wool. However, the packed column was conditioned with 5 mL of n-hexane. The extract was then moved or transferred to the column using a disposable Pasteur pipette from an evaporating flask. The crude extract was eluted on the column with the stopcock wide open. Each evaporating flask was rinsed 3 times with 1 mL of n-hexane & added to the column using the Pasteur pipette. The eluate was collected in an evaporating flask and rotary evaporated to dryness. The dry eluate was then mixed & dissolved in 1 mL of n-hexane for gas chromatographic analysis.

Instrumental Analysis

The gases used were Hydrogen and Helium with a purity of 99.999% served as carrier gases at a constant/steady flow of about 30 and 300 mL/min respectively. The synthesis/determination of PAHs was conducted on the standards and samples using a Buck 901 GC-FID. Exactly 1.0 g of extracted samples was dissolved in 10 mL of n-hexane. A portion was taken into a 2 mL chromatographic vial and made up/another 2 mL of toluene was added, injected, & separated on a Restek chrompack capillary column CP5860 with 5% phenylpolysiloxane phase (oven max. temperature 3500C) and a 95% methyl. The carrier gas was helium at about 28 cm/sec. The temperature (%) profile during the chromatographic analysis was 500 ^{0}C for 3 minutes, then increased at 80C/min to 3200C and held for 15 minutes, with the detector at 3200C. The detectors are typically maintained at the high end of the oven and at the right temperature range to reduce the risk of analyte precipitation (ASTM, 2005; Umudi et al., 2025).

Statistical Analysis

The data collected from the lab experiment were subjected to analysis of variance, ANOVA. Data from the groups were compared across different groups, & differences were deemed significant at $p<0.05$. The analysis was conducted using SPSS software version 18.

RESULTS AND DISCUSSION

Tables 1-5 display the sixteen priority PAHs identified in the fish samples during this research. These compounds were detected and measured. Table 1 illustrates the various/differents groups and their corresponding weights before drying and after drying over the 3 months of the study. The fish were considered dry when a constant weight was maintained for a certain period. However, the drying process lasted for 2 hours each day & continued for 3 days.

Table 1: Effects of different fish processing methods on body weigh changes used

Variables	October				November				January			
	Wet wt.	Dry wt.	% water loss	Mean ±SD	Wet wt.	Dry wt.	% water loss	Mean ±SD	Wet wt.	Dry wt.	% water loss	Mean ±SD
Fresh fish	134				150				150			
Firewood	245	53.10	78.30	78.30+0.01	300	61.00	79.60	79.65+0.1	270	57.5	78.7	78.71+0.01
Charcoal	250.30	55.00	78	78.05+0.1	270.50	58	78.50	78.55+0.1	240.2	50.8	78.9	78.82+0.1
Sunlight	211.90	47.60	77.50	77.55+0.10	230	50	78.30	78.35+0.1	235	50.7	78.4	78.42+0.02
Oven	200.30	45.30	77.40	77.55+0.10	220.40	47.20	78.60	78.65+0.1	240.2	51.2	78.8	78.60+0.01
Firewood + polythene (20g)	233.70	50.60	78.30	78.35+0.10	260	56.20	77.60	77.65+0.1	240	50.8	78.8	78.81+0.01
Charcoal + polythene (20g)	220.40	49.50	77.50	77.63+0.01	240.70	51.00	78.80	78.85+0.1	240.5	51.0	78.8	78.82+0.02
Total				**77.90+0.3**				**78.61+0.6**				**78.69+0.2**

Table1 displays the wet and dry weights of the fish collected over three months. In October 2024, the percentage of water removed showed slight variations with different drying methods. The highest water removal rates were 78.3% for firewood, 78.0% for charcoal, and 78.3% for firewood plus 20 g of polythene. In November, the lowest percentage of water loss was 77.6% in the fish sample dried with firewood and polythene (20 g), while the highest was in the fish dried with firewood. These results are in agreement with the work of (Umudi et al.,

2025) and Akpoveta et al., (2024) in a PAH in fish. By January 2025, the percentage of water loss across the various drying methods remained relatively stable, ranging from 78.4% to 78.9%. The average percentage of water lost over the three months was 77.8% in October, 78.6% in November, & 78.7% in January. From the calculated results, it indicated that $p>0.05$, suggesting no significant difference in water loss among the different drying methods used for the fish. Water samples were collected from a 230-meter stretch of the river (where the fish were caught) at 50-meter intervals and at a depth of 5-10 feet. These water samples were combined into a 400 mL composite mixture prior to analysis.

Table 2: Result of Fish Samples in October 2024 (µg/g)

Component	Sundried	Charcoal dried	Firewood	River Water Sample	Oven dried	Fresh fish	Charcoal +20g Polythene	Firewood+ 20g Polythene
Acenaphthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Acenaphthylene	N.D	N.D	0.5	N.D	N.D	N.D	N.D	N.D
Anthracene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	10.0
1,2 Benzanthracene	N.D	N.D	114.3	N.D	38.0	N.D	N.D	16.2
Benzo (a) pyrene	1.2	N.D	64.4	N.D	N.D	N.D	2.4	N.D
Benzo (b) fluoranthene	N.D	N.D	2.6	N.D	N.D	N.D	N.D	404.3
Benzo (g,h,i) pyrene	N.D	N.D	1.6	N.D	N.D	N.D	N.D	N.D
Benzo (k) flouranthene	27.0	40.4	ND	2.0	6.2	4.5	46.2	134.8
Chrysene	N.D	N.D	0.3	N.D	N.D	0.65	N.D	N.D
Dibenz (a,h) anthracene	N.D	N.D	ND	ND	ND	N.D	9.0	N.D
Fluoranthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	17.7
Indeno (1,2,3-cd) pyrene	N.D	N.D	N.D	N.D	N.D	N.D	68.0	4.4
Naphthalene	7.0	39.0	3.3	1.0	1.0	N.D	39.1	2.3
Phananthrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Pyrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	94.8
Fluorene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	10.8

Table 3: Result of Fish Samples in November 2024 (µg/g)

Component	Sundried	Charcoal dried	Firewood	River Water Sample	Oven Dried	Fresh fish	Charcoal +20g Polythene	Firewood+ 20g Polythene
Acenaphthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Acenaphthylene	N.D	N.D	0.6	N.D	N.D	N.D	N.D	N.D
Anthracene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	9.8
1,2 Benzanthracene	N.D	N.D	114.5	N.D	40.0	N.D	N.D	16.6
Benzo (a) pyrene	1.4	N.D	64.6	N.D	N.D	N.D	2.6	N.D
Benzo (b) fluoranthene	N.D	N.D	2.8	N.D	N.D	N.D	N.D	404.5
Benzo (g,h,i) pyrene	N.D	N.D	1.8	N.D	N.D	N.D	N.D	N.D
Benzo (k) flouranthene	27.2	40.3	N.D	1.96	6.5	4.3	46.1	135.0
Chrysene	N.D	N.D	0.2	N.D	N.D	0.67	N.D	N.D
Dibenz (a,h) anthracene	N.D	N.D	N.D	N.D	N.D	N.D	10.0	N.D
Fluoranthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	17.5
Fluorene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	11.2
Indeno (1,2,3-cd) pyrene	N.D	N.D	N.D	N.D	N.D	N.D	69.0	4.6
Naphthalene	7.1	39.1	3.5	0.93	1.2	N.D	39.1	2.5
Phananthrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Pyrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	95.0

Table 4: Result of Fish Samples in January 2025 (µg/g)

Component	Sundried	Charcoal dried	Firewood	River Water Sample	Oven Dried	Fresh fish	Charcoal +20g Polythene	Firewood+ 20g Polythene
Acenaphthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Acenaphthylene	N.D	N.D	0.7	N.D	N.D	N.D	N.D	N.D
Anthracene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	9.9
1,2 Benzanthracene	N.D	N.D	114.7	N.D	42.0	N.D	N.D	16.4
Benzo (a) pyrene	1.6	N.D	64.8	N.D	N.D	N.D	2.2	N.D
Benzo (b)	N.D	N.D	3.0	N.D	N.D	N.D	N.D	404.7
fluoranthene								
Benzo (g,h,i) pyrene	N.D	N.D	2.0	N.D	N.D	N.D	N.D	N.D
Benzo (k)	27.4	40.5	N.D	1.87	6.83	4.1	46.1	135.2
flouranthene								

Chrysene	N.D	N.D	0.4	N.D	N.D	0.69	N.D	N.D
Dibenz (a,h)	N.D	N.D	N.D	N.D	N.D	N.D	10.0	N.D
anthracene								
Fluoranthene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	17.5
Fluorene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	11.0
Indeno (1,2,3-cd)	N.D	N.D	N.D	N.D	N.D	N.D	69.0	4.6
pyrene								
Naphthalene	7.3	39.3	3.7	0.84	1.4	N.D	39.0	2.7
Phananthrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Pyrene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	94.9

Table 5: Mean Values of the Results for three Months

Component	Sundried Sample	Charcoal Dried	Firewood Dried	Water (River) Sample	Oven Dried	Fresh Fish	Charcoal Dried + 20g polythene	Firewood dried + 20g polythene
Acenaphthene	N.D	N.D	ND	N.D	N.D	N.D	N.D	N.D
Acenaphthylene	N.D	N.D	0.6+0.1	N.D	N.D	N.D	N.D	N.D
Anthracene	N.D	N.D	ND	N.D	N.D	N.D	N.D	9.9+0.1
1,2 Benzanthracene	N.D	N.D	114.5+0.2	N.D	40.0+0.2	N.D	N.D	16.4+0.2
Benzo (a)	1.4+0.2	N.D	64.6+0.2	N.D	N.D	N.D	2.4+0.1	N.D
Benzo (b) Fluoranthene	N.D	N.D	2.8+0.2	N.D	N.D	N.D	N.D	404.5+0.2
Benzo (g,h,i) Perylene	N.D	N.D	1.8+0.2	N.D	N.D	N.D	N.D	N.D
Benzo (k) Fluoranthene	27.2+0.2	40.4+0.0001	ND	1.94+0.1	6.5+0.3	4.3+0.2	46.1+0.1	135.0+0.2
Chrysene	N.D	N.D	0.3+0.1	N.D	N.D	0.67+0.1	N.D	N.D
Dibenz (a,h) Anthracene	N.D	N.D	ND	N.D	N.D	N.D	9.6+0.1	N.D
Fluoranthene	N.D	N.D	ND	N.D	N.D	N.D	N.D	17.5+0.2
Fluorene	N.D	N.D	ND	N.D	N.D	N.D	N.D	11.0+0.2
Indeno (1,2,3,-cd) Pyrene	N.D	N.D	ND	N.D	N.D	N.D	69.0+0.1	4.5+0.2
Naphthalene	7.1+0.2	39.13+0.2	3.5+0.4	0.92+0.1	1.2+0.2	N.D	39.1+0.1	2.5+0.1
Phananthrene	N.D	N.D	ND	N.D	N.D	N.D	N.D	N.D
Pyrene	N.D	N.D	ND	N.D	N.D	N.D	N.D	94.9+0.1
Total PAHs	35.7+0.2	79.53+0.2	188.1+0.2	2.86+0.1	47.7+0.2	4.97+0.2	166.2+0.1	696.3+0.2

N.D = Not detected

Table 5 presents the average values of PAH concentration/levels over period of 3 months. However, the river water samples showed Benzo (k) fluoranthene (1.94 + 0.1 µg/g) & Naphthalene (0.92 + 0.1 µg/g). The total amount of PAH is 2.86 + 0.1 µg/g. However, other PAHs were not found. The fresh fish samples contained Chrysene (0.67 + 0.1 µg/g) & Benzo (k) fluoranthene (4.3 + 0.2 µg/g) during the months of October, November, & January. However, the total PAH content in fresh fish samples was 4.97 µg/g. Other PAHs were likely below detectable levels. This gives excellent agreement with the previously reported by Mughele et al., (2024) and Umudi et al. (2022), who reported similar results. The sundried fish samples showed Benzo (k) fluoranthene (27.2 + 0.2 µg/g), Naphthalene (7.1 + 0.2 µg/g) & Benzo (a) pyrene (1.4 + 0.2 µg/g). The total PAH content is 35.7 + 0.2 µg/g. However, other PAHs were not detected. The oven-dried fish samples revealed Benzo (k) fluoranthene (6.5 + 0.3 µg/g), 1,2 Benzanthracene (40.0 + 0.2 µg/g), & Naphthalene (1.2 + 0.2 µg/g). The total PAH content is 47.7 + 0.2 µg/g. Other PAHs were not found. The charcoal-dried fish samples contained Benzo (k) fluoranthene (40.4 + 0.1 µg/g), & Naphthalene (39.13 + 0.2 µg/g), while total PAH content is 79.53 + 0.2 µg/g. Majority of them were not detected. The firewood-dried fish samples showed 1,2 Benzanthracene (114.5 + 2 µg/g), Naphthalene (3.5 + 0.2 µg/g), acenaphthylene (0.6 + 0.1 µg/g), Chrysene (0.30 + 0.1 µg/g), Benzo (g,h,i) perylene (1.8 + 0.2 µg/g), Benzo (a) pyrene (64.6 + 0.2 µg/g), & Benzo (b) fluoranthene (2.8 + 0.2 µg/g), while the total PAH content is 188.1 + 0.2 µg/g. Most of the PAHs were not detected. The dried fish samples using charcoal and 20 g of polythene showed, benzo (a) pyrene (2.4 + 0.1µg/g), dibenz (a,h) anthracene (9.6 + 0.1µg/g),indeno (1,2,3-cd) pyrene (69.0 + 0.1µg/g), benzo (k) fluoranthene (46.1 + 0.1µg/g) & naphthalene (39.1 + 0.1µg/g). while the total PAH content was 166.2 + 0.1 µg/g. No other PAHs were found. The dried fish samples using firewood and 20 g of polythene contained anthracene (9.9 + 0.1 µg/g), fluoranthene (17.5 + 0.2 µg/g), naphthalene (2.5 + 0.1 µg/g), fluorene (11.0 + 0.2 µg/g), , pyrene (94.9 + 0.1 µg/g), 1,2 benzanthracene (164 + 0.2 µg/g, and indeno (1,2,3-cd) pyrene (4.5 + 0.2 µg/g), benzo (k) fluoranthene (135.0 + 0.2 µg/g) & benzo (b) fluoranthene (404.5 + 0.2 µg/g), while the total PAH content was 696.3 + 0.1 µg/g. Others PAHs were found. These results agreed with the work of Umudi and Awatefe, (2018) and Obruche et al.,(2025) he carried out in fish in same State. Based on the findings from the various drying methods in this study, the Oven method is the safest for drying fish. However, it may not be affordable for the average African household due to costs and maintenance. Therefore, the charcoal method is recommended as it is the next safest option and is also inexpensive. The use of polythene or plastic materials to enhance charcoal or firewood smoke should be strongly discouraged, as the results indicate that these PAHs can accumulate to harmful levels (exceeding the maximum allowable limits of 10 and 1µg/kg for total PAHs and BaP) in the human body.

CONCLUSION

Polycyclic aromatic hydrocarbons (PAHs) found in the Otuocha river, although at low levels, suggest a consistent source of pollution entering the water. If this is not addressed quickly, it could escalate to harmful levels, particularly in fish, which may impact people who eat these fish from the river. Regarding drying methods, the PAH levels were notably higher in dried fish compared to sun-dried fish. This indicates that the high PAH content in dried fish likely comes from the drying or burning agents used. Notably, there was a significant rise in PAH levels when drying was done with polythene, a material known to release high amounts of PAHs when burned. These levels could potentially lead to various types of cancer, as well as issues such as eye irritation and sensitivity to light, respiratory problems like bronchitis, gastrointestinal issues such as leukoplakia, blood disorders like leukemia, and hematuria in the urinary system. Therefore, consumers should be cautious about the dried fish they buy from local markets.

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