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Assessment of Polycyclic Aromatic Hydrocarbons contents in Water and Sediment Samples in selected Streams in Ikwuano Local Government, Abia State, Nigeria.

Okeoma-Franklin, A. F[1]., Ogbonna P. C.[1] and Okeoma T. F.[2]

[1]Department of Environmental Management and Toxicology, Michael Okpara University of Agriculture Umudike, Nigeria

[2]Department of Mechanical Engineering, Gregory University, Uturu, Abia State

*Corresponding Author Email: Onoziefavour94@gmail.com

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Abstract

Safe drinking water is fundamental to human health. The aim of this study was to assess the Polycyclic Aromatic Hydrocarbon (PAH) contents of water and sediments in selected streams in Ikwuano local government, Abia state. Experimental study design was used for this work. Water and sediment samples were collected from four different locations for PAH analysis. PAH analysis were conducted using various recommended routine laboratory techniques. Result shows that all the PAH concentration in stream water exhibited a significant difference (p<0.05) between the four sampling stations and three sampling points within each location in the study area. For PAHs, the highest mean concentration were Naphthalene 0.11 mg/L, Acenaphthylene 0.32 mg/L, Acenaphthene 0.42 mg/L, Fluoranthene 0.42 mg/L, Fluorine 0.42 mg/L, Phenanthrene 0.30 mg/L, Anthracene 0.21 mg/L, Pyrene 0.19 mg/L, Benzo (a) anthracene 0.22 mg/L, Chrysene 0.22 mg/L, Benzo (k) fluoranthene 0.22 mg/L, Benzo (a) pyrene 0.11 mg/L, Indeno (1_2_3) pyrene 0.40 mg/L, Benzo (a_h) anthracene 0.15 mg/L and Benzo (g_h_i) perylene 0.30 mg/L for water samples, while the highest mean concentration were Naphthalene 0.21 mg/Kg, Acenaphthylene 0.95 mg/Kg, Acenaphthene 0.76 mg/Kg, Fluoranthene 0.22 mg/Kg, Fluorine 0.38 mg/Kg, Phenanthrene 1.28 mg/Kg, Anthracene 0.94 mg/Kg, Pyrene 0.22 mg/Kg, Benzo (a) anthracene 0.37 mg/Kg, Chrysene 0.43 mg/Kg, Benzo (k) fluoranthene 0.32 mg/Kg, Benzo (a) pyrene 0.96 mg/Kg, Indeno (1_2_3) pyrene 0.25 mg/Kg, Benzo (a_h) anthracene 0.20 mg/Kg and Benzo (g_h_i) perylene 0.32 mg/Kg for sediment samples. The Principal Component Analysis (PCA) showed a cumulative variation of 100% respectively in water and sediment samples of the variance in the data set. Cluster Analysis (CA) reveals that the prevailing conditions at MOUAU as at the time of sampling is similar to the prevailing conditions at Umuariaga.

1. Introduction

Water resources in many rural communities remain a vital component for domestic use, agricultural activities, and local economies [1]. However, these resources are increasingly threatened by environmental contaminants, notably Polycyclic Aromatic Hydrocarbons (PAHs), which are persistent organic pollutants with recognized carcinogenic and mutagenic properties. PAHs typically originate from anthropogenic activities such as fossil fuel combustion, industrial discharges, and agricultural runoff, posing a significant risk to aquatic ecosystems and human health [2].

Ikwuano Local Government in Abia State, Nigeria, is predominantly agrarian, with several streams serving as critical water sources for the local populace. Despite their importance, these water bodies are vulnerable to contamination from nearby farming activities, waste disposal, and transportation systems, potentially leading to elevated PAH levels. This study focuses on evaluating the concentration and distribution of PAHs in water and sediment samples from selected streams within Ikwuano LGA, shedding light on potential environmental risks and providing baseline data for environmental management strategies [3].

Polycyclic Aromatic Hydrocarbons (PAHs) are hazardous organic compounds that pose severe risks to both environmental and public health due to their carcinogenic, mutagenic, and toxic properties [4]. The World Health Organization (WHO) reports that millions of people are exposed to unsafe levels of PAHs globally, with water sources being a significant pathway for human exposure. According to WHO, contaminated water contributes to over 485,000 diarrheal deaths annually, many of which are linked to polluted sources, including those affected by toxic compounds like PAHs [5].

In Ikwuano Local Government Area of Abia State, streams are vital for drinking water, agriculture, and daily domestic activities. However, these streams are at increasing risk of contamination due to agricultural runoff, improper waste disposal, and other anthropogenic activities, leading to potential PAH accumulation. Despite the significance of these water bodies to the local population, there is a critical gap in data regarding the levels of PAH contamination in both water and sediment samples within this region.

2. Methodology

2.1 Study Area

The study was carried out in Ikwuano Local Government Area (LGA) of Abia State. Ikwuano Local Government Area was created out of the defunct Umuahia L.G.A. on the 27th of August 1991 and has its headquarters at Isiala Oboro. Ikwuano L.G.A. is located between latitudes 5° 241 N and 5° 301 N of the equator and longitudes 7° 321 E and 3° 371 E of the Greenwich Meridian. Ikwuano L.G.A has a population of 137,993 people which comprise of 61,945 males and 71,020 females (NPC, 2006). It has a land area of about 310 square kms and a population density of 194 person/km. The major occupation of the people is farming. The major food crops grown are cassava, yam, melon, cocoa, vegetable, three-leaf yam and cowpea. Some important cash crops grown in Ikwuano LGA are oil palm and cocoa, while animals reared are goats, sheep, pigs and poultry. The map of the Study area is shown in Figure 1

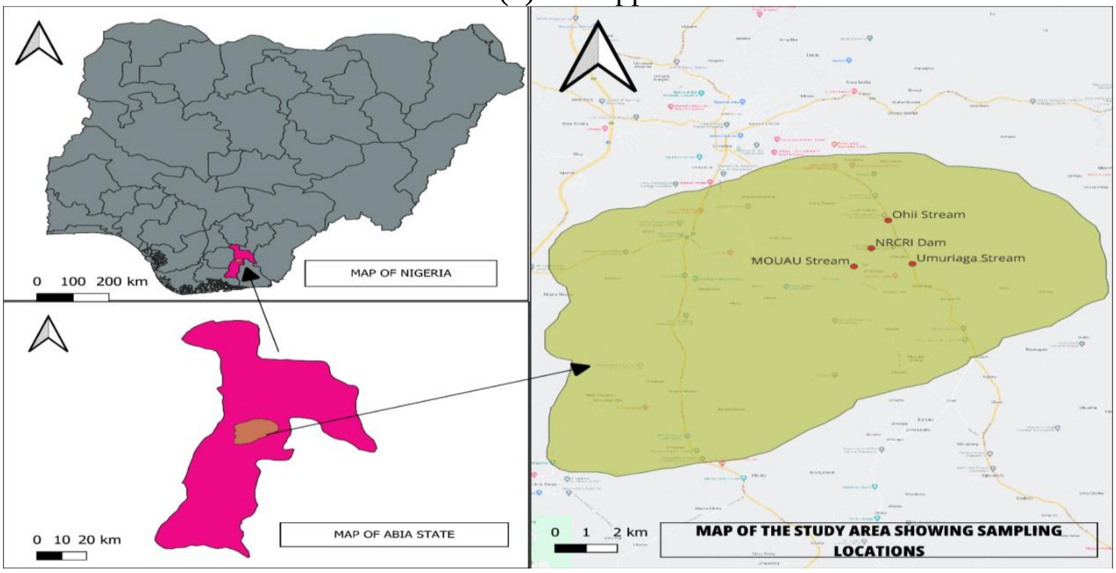

Figure 1: Map of the Study Area

2.2 Water Sample Collection Technique

Thirty six (36) 1-litre plastic bottles was used for sample collection. Water sampling was done twice (8am and 4pm) [6]. From three (3) different points at each sampling stations (upper stream, middle stream, lower stream and the outskirts of stream which is the control sample). Each sampling bottles of one (1) liter by volume was pre-conditioned with 5% nitric acid and later rinsed thoroughly with distilled de-ionized water. The water samples was collected 20cm below the edge of the left side of the bank of the river, the middle of the sampling point and at the edge of the right side of the river to form a good representative sample of the river. The assistance of two other persons was employed to enable collect the samples at the same time [7].

At each sampling station, the sampling bottles was filled to the brim at a depth of 20cm below the surface of the river and was covered tightly. The three (3) representative water samples from each sampling stations and control was acidified with 10% HNO_3 analytical grade, covered air-tight, labelled well, placed in an iced-chest container and transfer to the laboratory for pre-treatment and analysis. Samples from each stations was mixed separately to form one homogenous representative sample for the station (e.g all water samples from three different points of the upper stream was mixed thoroughly). While in the laboratory: the homogenous water samples was stored in the refrigerator and about 4^oC prior to the analysis. Adequate precautions was exercised to avoid contamination of water during sampling, transport and handling. Thirty six (36) water samples each was collected morning and evening from the three (3) sampling stations and control site. A total thirty six (36) water samples was collected in all [8].

2.3 Sediment Sample Collection Technique

The sediments sampling was done twice (8am and 4pm) [9]. From three (3) different points at each sampling stations (upper stream, middle stream, lower stream and the outskirts of stream which is the control sample) using a polar grabber. The collected sediments samples was wrapped using aluminum foil. The three (3) representative water samples from each sampling stations and control was acidified with 10% HNO_3 analytical grade, covered air-tight, labelled well, placed in an iced-chest container and transfer to the laboratory for pre-treatment and analysis [10].

2.4 Determination of Polycyclic Aromatic Hydrocarbon

The sample stored in the laboratory freezer was taken out and allowed to defrost. The water and sediment samples collected at different point was used for the analysis. The procedure described by

calibration curve (external standard) method based on the signals of UV-DAD and fluorimetric detectors was used for the PAHs analysis using gas chromatography. The sample was automatically detected as it emerged from the column (at a constant flow rate) by the FID detector whose response is dependent upon the composition of the vapor.
The extraction methods for the analysis of PAH profile in samples was followed by employing modified method of ASTMD3328 and ASTM 3415. 5.0g of the pulverized sample was weighed 250ml capacity beaker of borosilicate material and 50ml of the ratio 3:1 redistilled hexane: dichloromethane was added. The beaker and its contents placed in the sonicator to extract the hydrocarbon for about 2hours. The organic layer was filled into the 250ml capacity borosilicate beaker. The extract was dried by passing the filtrate through the funnel containing the anhydrous sodium sulphate. The dried extract was concentrated with a stream of hydrogen gas [15].

2.4.1 PAH Separation

The concentrated oil was separated into the aliphatic profile and poly aromatic hydrocarbon profile by packing the glass column with activated alumina, neutral and activity/ grade 1. The 10ml of the treated alumina was packed into the column and cleaned properly with redistilled hexane. The extract was poured into the alumina and was allowed to run down with the aid of the redistilled hexane to remove the aliphatic profile into a pre-cleaned 20ml capacity glass container [16].
The aromatic fraction was recovered by allowing the mixture of hexane and dichloromethane in ration 3:1 and finally remove the most polar PAH by removing with the chloromethane into the pre-cleaned borosilicate beaker. The mixture was concentrated to 1.0ml by stream of the nitrogen gas before the gas chromatography analysis [17].

2.5 Method of Data Analysis

The quantitative data was subjected to one way Analysis of Variance (ANOVA) using statistical packages for Social Sciences (SPSS Version 22). Pearson Correlation analysis was carried out to determine the relationship between the concentration of heavy metals in water and sediment as well as PAHs in water and sediment.

3. Results and Discussion

Table 1: Concentration of PAH at Different Stations of Stream Water

Location	Point	Naphthalene	Acenaphthylene	Acenaphthene	Fluorine	Phenanthrene	Anthracene	Flouranthene	Pyrene	Benzo (a) anthracene	Chyrsene
ABSU	Upper stream	$0.11^{b} \pm 0.00$	$0.32^{a} \pm 0.00$	$0.09^{d} \pm 0.00$	$0.03^{d} \pm 0.00$	$0.22^{d} \pm 0.00$	$0.21^{a} \pm 0.00$	$0.26^{b} \pm 0.00$	$0.19^{a} \pm 0.00$	$0.22^{a} \pm 0.00$	$0.22^{a} \pm 0.00$
	Middle stream	$0.11^{a} \pm 0.00$	$0.32^{a} \pm 0.00$	$0.09^{d} \pm 0.00$	$0.03^{d} \pm 0.00$	$0.22^{d} \pm 0.00$	$0.21^{a} \pm 0.00$	$0.26^{a} \pm 0.00$	$0.19^{b} \pm 0.00$	$0.22^{b} \pm 0.00$	$0.22^{a} \pm 0.00$
	Down stream	$0.11^{b} \pm 0.00$	$0.32^{a} \pm 0.00$	$0.09^{d} \pm 0.00$	$0.03^{d} \pm 0.00$	$0.22^{e} \pm 0.00$	$0.21^{b} \pm 0.00$	$0.26^{b} \pm 0.00$	$0.19^{c} \pm 0.00$	$0.22^{b} \pm 0.00$	$0.22^{a} \pm 0.00$
Behind PG School	Upper stream	$0.11^{b} \pm 0.00$	$0.21b^{c} \pm 0.00$	$0.63^{a} \pm 0.00$	$0.42^{a} \pm 0.00$	$0.29^{b} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.10^{e} \pm 0.00$	$0.10^{g} \pm 0.00$	$0.11^{c} \pm 0.00$	$0.22^{a} \pm 0.00$
	Middle stream	$0.11^{b} \pm 0.00$	$0.21^{bc} \pm 0.00$	$0.63^{a} \pm 0.00$	$0.42^{a} \pm 0.00$	$0.29^{bc} \pm 0.00$	$0.11^{f} \pm 0.00$	$0.10^{e} \pm 0.00$	$0.10^{gh} \pm 0.00$	$0.11^{cd} \pm 0.00$	$0.22^{a} \pm 0.00$
	Down stream	$0.11^{a} \pm 0.00$	$0.21^{b} \pm 0.00$	$0.63^{a} \pm 0.00$	$0.42^{a} \pm 0.00$	$0.29^{bc} \pm 0.00$	$0.11^{c} \pm 0.00$	$0.10^{d} \pm 0.00$	0.10h ± 0.00	0.11d ± 0.00	$0.22^{a} \pm 0.00$
NRCRI	Upper stream	$0.10^{c} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.26^{c} \pm 0.19$	$0.22^{d} \pm 0.00$	$0.30^{a} \pm 0.00$	$0.10^{i} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.12^{d} \pm 0.00$	$0.03^{e} \pm 0.00$	$0.20^{b} \pm 0.00$
	Middle stream	$0.10^{c} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.37^{b} \pm 0.00$	$0.22^{d} \pm 0.00$	$0.30^{a} \pm 0.00$	$0.10^{i} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.12^{d} \pm 0.00$	$0.03^{e} \pm 0.00$	$0.20^{c} \pm 0.01$
	Down stream	$0.10^{c} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.37^{b} \pm 0.00$	$0.22^{d} \pm 0.00$	$0.30^{a} \pm 0.00$	$0.10^{i} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.12^{d} \pm 0.00$	$0.03^{e} \pm 0.00$	$0.20^{b} \pm 0.00$
Umuariaga	Upper stream	$0.00^{e} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.30^{b} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.11^{g} \pm 0.00$	$0.10^{f} \pm 0.00$	$0.12^{f} \pm 0.00$	$0.01^{f} \pm 0.00$	$0.03^{d} \pm 0.00$
	Middle stream	$0.00^{f} \pm 0.00$	$0.11^{f} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.30^{b} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.11^{h} \pm 0.00$	$0.10^{h} \pm 0.00$	$0.12^{f} \pm 0.00$	$0.01^{h} \pm 0.00$	$0.03^{d} \pm 0.00$
	Down stream	$0.00^{e} \pm 0.00$	$0.11^{g} \pm 0.00$	$0.22^{c} \pm 0.00$	$0.29^{c} \pm 0.00$	$0.00^{a} \pm 0.00$	$0.11^{h} \pm 0.00$	$0.10^{f} \pm 0.00$	$0.12^{e} \pm 0.00$	$0.01^{g} \pm 0.00$	$0.03^{d} \pm 0.00$

Values are mean ± standard deviation of triplicate replications
Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 1 shows concentration of PAH at different sampling stations. Naphthalene was high 0.11 ± 0.00 at Absu and behind PG school and low conc. 0.00e ± at Umuariaga. Exposure to naphthalene, commonly found in mothballs and some industrial processes, can lead to respiratory irritation, hemolytic anemia, central nervous system effects, liver and kidney damage, carcinogenicity, and reproductive and developmental effects in humans [18]. The World Health Organization set 0.2 μg/L as the maximum permissible limit for total PAHs in drinking water while that of benzo(a) pyrene (0.1 μg/L) [22].

Acenephthylene has a high conc. value 0.32 ± 0.00 Absu. Exposure to acenaphthylene, a polycyclic aromatic hydrocarbon found in coal tar and tobacco smoke, can lead to respiratory irritation, carcinogenicity, DNA damage, reproductive and developmental effects, and immunotoxicity in humans, with the range of tolerance varying depending on factors such as duration, frequency, and concentration of exposure [19]. This could be as a result of the streams closeness to petroleum filling station and experimental farm land of National Root Crop Research Institute, Umudike.
Acenaphthene has a high conc. value 0.63 ± 0.00 at behind PG school and low at Absu fluorine has high conc. at the stream behind PG school and low at Umuariaga, Exposure to acenaphthene, a polycyclic aromatic hydrocarbon found in coal tar, cigarette smoke, and vehicle exhaust, can lead to respiratory irritation, carcinogenicity, DNA damage, reproductive and developmental effects, and immunotoxicity in humans [20].

Phenanthrene has high conc. value 0.30 ± 0.00 at NRCRI and low 0.00 ± 0.00 at Umuariaga.
Anthracene was high at (0.21 ± 0.00) at Absu and 0.10 at NRCRI. Exposure to phenanthrene, a polycyclic aromatic hydrocarbon found in water contaminated by industrial runoff and vehicle emissions, can lead to respiratory irritation, carcinogenicity, DNA damage, reproductive and developmental effects, and immunotoxicity in humans [21]. Flouranthene has high conc. (0.10e) at NRCRI and Umuariaga. Fluoranthene is a polycyclic aromatic hydrocarbon (PAH) commonly found in water, air and soil due to combustion processes such as vehicle emissions and industrial activities, can have adverse effects on human health, including respiratory irritation, carcinogenicity, DNA damage, reproductive and developmental effects, and immunotoxicity [22].
Pyrene high conc. value (0.19 ± 0.00) was found in Absu and low 0.10g at behind PG school. Pyrene, a polycyclic aromatic hydrocarbon (PAH) commonly found in water, air, soil, and water as a result of incomplete combustion of organic materials such as fossil fuels and biomass, can have adverse effects on human health, including respiratory irritation, carcinogenicity, DNA damage, reproductive and developmental effects, and immunotoxicity [23]

Benzo (a) anthracee was high 0.22 ± 0.00 at Absu and low 0.01f±0.00 at Umuariaga. is a potent carcinogen associated with respiratory irritation and immunotoxicity. Benzo (k) flouranthene was high 0.22 ± 0.00 at Absu and low 0.001 ± 0.00 at Umuariaga. Benzo[k]fluoranthene is considered a hazardous pollutant due to its toxic properties and potential health effects. It is known to be carcinogenic, meaning it can cause cancer in humans and animals. Additionally, it can cause respiratory irritation, DNA damage, reproductive and developmental effects, and immunotoxicity [24]. Exposure to benzo[k] fluoranthene primarily occurs through inhalation of contaminated air, ingestion of contaminated food and water, and dermal contact with contaminated soil or water. Efforts to reduce emissions from sources such as vehicle exhaust, industrial processes, and tobacco smoke are important for minimizing human exposure to benzo[k]fluoranthene and its associated health risks. Regulatory policies and pollution control measures play a crucial role in mitigating the environmental and health impacts of this compound.

Benzo (a) pyrene has high value 0.22 ± 0.00 at Absu and low value 0.01 ± 0.00 at Umuariaga [25]

Location	Point	**Chyrsene**	**Benzo (k) fluoranthene**	**Benzo (a) pyrene**	**Indeno (1_2_3) pyrene**	**Benzo (a_h) anthracene**	**Benzo (g_h_i) perylene**
ABSU	Upper stream	$0.42^{d} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.28^{c} \pm 0.00$	$0.21^{c} \pm 0.00$	$0.12^{f} \pm 0.00$	$0.11^{e} \pm 0.00$
	Middle stream	$0.42^{c} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.28^{c} \pm 0.00$	$0.21^{c} \pm 0.00$	$0.12^{f} \pm 0.00$	$0.110^{f} \pm 0.00$
	Down stream	$0.42^{c} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.28^{c} \pm 0.00$	$0.21^{c} \pm 0.00$	$0.12^{e} \pm 0.00$	$0.11^{e} \pm 0.00$
Behind PG School	Upper stream	$0.20^{f} \pm 0.00$	$0.10^{f} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.11^{de} \pm 0.00$	$0.14^{c} \pm 0.00$	$0.19^{d} \pm 0.00$
	Middle stream	$0.20^{e} \pm 0.00$	$0.10^{f} \pm 0.00$	$0.11^{d} \pm 0.00$	$0.11^{f} \pm 0.00$	$0.14^{d} \pm 0.00$	$0.19^{c} \pm 0.00$
	Down stream	$0.20^{f} \pm 0.00$	$0.10^{e} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.14^{d} \pm 0.00$	$0.19^{d} \pm 0.00$
NRCRI	Upper stream	$0.43^{a} \pm 0.00$	$0.32^{b} \pm 0.00$	$0.96^{b} \pm 0.00$	$0.25^{b} \pm 0.00$	$0.20^{b} \pm 0.00$	$0.32^{a} \pm 0.00$
	Middle stream	$0.43^{b} \pm 0.00$	$0.32^{a} \pm 0.00$	$0.96^{a} \pm 0.00$	$0.25^{a} \pm 0.00$	$0.20^{a} \pm 0.00$	$0.32^{a} \pm 0.00$
	Down stream	$0.43^{a} \pm 0.00$	$0.32^{c} \pm 0.00$	$0.96^{a} \pm 0.00$	$0.25^{a} \pm 0.00$	$0.20^{b} \pm 0.00$	$0.32^{b} \pm 0.00$
Umuariaga	Upper stream	$0.03^{gh} \pm 0.00$	$0.00^{i} \pm 0.00$	$0.11^{f} \pm 0.00$	$0.11^{de} \pm 0.00$	$0.10^{g} \pm 0.00$	$0.03^{gh} \pm 0.00$
	Middle stream	$0.03^{g} \pm 0.00$	$0.00^{g} \pm 0.00$	$0.11^{g} \pm 0.00$	$0.11^{f} \pm 0.00$	$0.10^{h} \pm 0.00$	$0.03^{h} \pm 0.00$
	Down stream	$0.03^{h} \pm 0.00$	$0.00^{g} \pm 0.00$	$0.11^{h} \pm 0.00$	$0.11^{e} \pm 0.00$	$0.10^{h} \pm 0.00$	$0.03^{g} \pm 0.00$

Chrysene was high 0.43 ± 0.00 at NRCRI and low 0.03 ± 0.00 at Umuariag. Chrysene exposure through drinking water can pose health risks to humans. Chronic exposure to elevated levels of chrysene has been associated with adverse effects on the respiratory system, skin, and eyes. Similar to other PAHs, chrysene is considered a probable human carcinogen by organizations such as the International Agency for Research on Cancer (IARC). Long-term exposure to chrysene may increase the risk of developing certain types of cancer, particularly lung cancer, skin cancer, and bladder cancer [26]. The World Health Organization set 0.2 µg/L as the maximum permissible limit for total PAHs in drinking water while that of benzo(a) pyrene (0.1 µg/L) [22].

Benzo (k) flaoranthen was high 0.32 ± 0.00 at NRCRI and low 0.00 and Umuariaga. Benzo [k] fluoranthene is a polycyclic aromatic hydrocarbon (PAH) that can potentially contaminate river water sources. Exposure to benzo [k] fluoranthene in drinking water from rivers can have several effects on human health and the environment. Benzo [k] fluoranthene exposure through drinking water may pose significant health risks to humans. Chronic exposure to elevated levels of benzo [k] fluoranthene has been associated with adverse effects on the respiratory system, skin, and eyes. It is classified as a probable human carcinogen by organizations such as the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA). Long-term exposure to benzo [k] fluoranthene may increase the risk of developing certain types of cancer, particularly lung cancer, skin cancer, and bladder cancer [27].

Benzo (a) pyrene was high 0.96 ± 0.00 and low 0.11 ± 0.00 at Umuariaga and behind school. Health Risks: Benzo[a]pyrene exposure through drinking water and environmental sources poses significant health risks to humans [28]. Chronic exposure to elevated levels of benzo[a]pyrene has been associated with adverse effects on the respiratory system, skin, and eyes. It is classified as a known human carcinogen by organizations such as the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA). Long-term exposure to benzo [a] pyrene may increase the risk of developing various types of cancer, particularly lung cancer, skin cancer, and bladder cancer. Benzo [a] pyrene contamination in water sources can have severe environmental implications [29]. PAHs like benzo [a] pyrene are persistent organic pollutants that can accumulate in aquatic ecosystems, potentially harming aquatic organisms and disrupting ecological balance. This contamination can have far-reaching consequences for biodiversity and ecosystem health, impacting fish, invertebrates, and other aquatic life.

Indeno (1-2-3) pyrene was high 0.25 ± 0.00 at NRCRI and low 0.11 ± 0.00 at Umuariaga and behind PG school. Indeno (1,2,3) pyrene, a polycyclic aromatic hydrocarbon (PAH), can have several effects if present in drinking water and the environment [30]

Indeno (1,2,3) pyrene exposure through drinking water and environmental sources poses significant health risks to humans. Chronic exposure to elevated levels of indeno (1, 2, 3) pyrene has been associated with adverse effects on the respiratory system, skin, and eyes. It is classified as a probable human carcinogen by organizations such as the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA). Long-term exposure to indeno (1,2,3) pyrene may increase the risk of developing various types of cancer, particularly lung cancer, skin cancer, and bladder cancer [31].

Indeno (1,2,3) pyrene contamination in water sources can have severe environmental implications. PAHs like indeno (1,2,3) pyrene are persistent organic pollutants that can accumulate in aquatic ecosystems, potentially harming aquatic organisms and disrupting ecological balance. This contamination can have far-reaching consequences for biodiversity and ecosystem health, impacting fish, invertebrates, and other aquatic life [32].

Benzo (a-h) anthracene was high 0.20 ± 0.00 at NRCRI and low 0.10 ± 0.00 at Umuariaga. Benzo [a,h] anthracene can also accumulate in soil, particularly in areas with industrial activities or improper waste disposal. Soil contamination with benzo[a,h]anthracene can hinder plant growth and microbial activity, affecting soil fertility and ecosystem function [33]. Benzo[a,h]anthracene exposure through drinking water poses health risks to humans. Chronic exposure to elevated levels of benzo [a,h] anthracene has been associated with adverse effects on the respiratory system, skin, and eyes. It is classified as a probable human carcinogen by organizations such as the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA). Long-term exposure to benzo [a,h] anthracene may increase the risk of developing various types of cancer, particularly lung cancer, skin cancer, and bladder cancer [34].

Benzo (g-h-i) penylene was high 0.32 ± 0.00 at Umuariaga and 0.003 ± 0.00 at Umuariaga. Benzo [g,h,i] perylene contamination in water bodies can have severe environmental implications. PAHs like benzo [g,h,i] perylene are persistent organic pollutants that can accumulate in aquatic ecosystems, potentially harming aquatic organisms such as fish, invertebrates, and algae. This contamination can disrupt ecological balance, impacting biodiversity and ecosystem health. Benzo [g,h,i] perylene exposure through drinking water poses health risks to humans. Chronic exposure to elevated levels of benzo [g,h,i] perylene has been associated with adverse effects on the respiratory system, skin, and eyes. It is classified as a probable human carcinogen by organizations such as the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA). Long-term exposure to benzo [g,h,i] perylene may increase the risk of developing various types of cancer, particularly lung cancer, skin cancer, and bladder cancer [35].

The World Health Organization (WHO) and national regulatory agencies like the National Agency for Food and Drug Administration and Control (NAFDAC) in Nigeria provide guidelines for permissible levels of contaminants, including Polycyclic Aromatic Hydrocarbons (PAHs), in water. WHO sets a stringent guideline for Benzo[a]pyrene, a known carcinogenic PAH, with a permissible level of 0.7 µg/L in drinking water. This reflects the global concern over the toxic and carcinogenic nature of PAHs. However, WHO does not offer specific guidelines for PAH levels in sediment samples, focusing primarily on drinking water quality.

NAFDAC, aligning with WHO and other international standards, typically follows these guidelines for water safety, ensuring that PAH levels in drinking water are within safe limits to protect public health. In environmental contexts, where PAHs in sediments are concerned, guidelines from agencies like the United States Environmental Protection Agency (USEPA) or the European Union (EU) are often referenced. The USEPA provides Threshold Effect Levels (TELs) and Probable Effect Levels (PELs) for PAHs in sediment, which indicate concentrations below or above which adverse effects on sediment-dwelling organisms are unlikely or likely, respectively. For instance, Benzo[a]pyrene has a TEL of 0.0319 mg/kg and a PEL of 0.782 mg/kg in sediment, guiding risk assessment and environmental management.

4. Conclusion and Recommendation

The study conducted in Ikwuano Local Government Area, Abia State, aimed to assess the levels of heavy metals and polycyclic aromatic hydrocarbons (PAHs) in both water and sediment samples from streams in the area. PAHs are environmental pollutants with potential health risks. The study collected samples from various streams within the region and analyzed them for the presence and concentration of PAHs using appropriate analytical techniques. These pollutants often originate from industrial activities, urban runoff, and agricultural practices, posing threats to both aquatic ecosystems and human health.

The study provided valuable insights into the environmental quality and potential risks to both ecosystems and human health in the region. Through comprehensive analysis, the study revealed the presence of polycyclic aromatic hydrocarbons (PAHs) in water samples and sediments collected from the streams. Spatial variations in contamination levels were observed, likely influenced by proximity to industrial zones, urban areas, or agricultural activities. The identification of potential sources of contamination, such as industrial discharges, agricultural runoff, and vehicle emissions, highlighted the need for targeted pollution control measures. Moreover, the study underscored the ecological impacts of heavy metal and PAH contamination on stream ecosystems, as well as the associated human health risks through water consumption or contact.

These findings emphasize the importance of implementing effective management and remediation strategies to mitigate contamination and protect both environmental and human health. Such measures may include improving waste management practices, upgrading wastewater treatment facilities, and promoting public awareness and education on water quality issues.

In conclusion, the study contributed valuable information for policymakers, environmental regulators, and local communities to guide decision-making processes aimed at safeguarding the health and integrity of streams within the Ikwuano Local Government Area, ensuring the sustainable use of water resources for future generations

Based on the study assessing polycyclic aromatic hydrocarbon (PAH) contents of water and sediments in selected streams within Ikwuano Local Government Area, Abia State, here are some recommendations:

i. Government should implement a regular monitoring program to continuously assess the levels of PAHs in water and sediment samples from streams within the area. This will help in understanding any fluctuations in contamination levels over time and facilitate prompt action if necessary.
ii. Government should conduct further investigations to identify the specific sources of heavy metals and PAHs in the streams. This could involve conducting detailed chemical analyses, as well as stakeholder consultations to identify potential sources such as industrial activities, agricultural runoff, or urban pollution.

iii. Government should develop and implement pollution prevention measures to reduce the input of heavy metals and PAHs into the streams. This may include implementing best management practices in industries, promoting sustainable agricultural practices to minimize runoff, and improving wastewater treatment facilities.

Government should raise awareness among local communities about the risks associated with heavy metal and PAH contamination in water bodies. Provide education on proper waste disposal practices, the importance of clean water, and potential health impacts. Empowering communities to take action can lead to better environmental stewardship.

References

[1] Mehmet, K., Moniruzzaman, M., Elahi, S.F., Jahangir, M.A.A., (2018). Study on temporal variation of physicochemical parameters of Buriganga River water through GIS (Geographical Information System) technology. Bangladesh J. Sci. Ind. Res. 44(3), 327e334. https://doi.org/10.3329/bjsir.v44i3.4406.

[2] Abdel-Rahman, G.N. (2022). Heavy metals, definition, sources of food contamination, incidence, impacts and remediation: A literature review with recent updates. *Egyptian Journal of Chemistry*, 65(1): 419-437.

[3] Adeniji, A.O., Okoh, O.O. and Okoh, A.I. (2019). Distribution pattern and health risk assessment of polycyclic aromatic hydrocarbons in the water and sediment of Algoa Bay, South Africa. *Environmental Geochemistry and Health*, 41:1303.

[4] Ogbonna, P.C., Demian, P.O., Ubuoh, E.A., Iwok, E.S. and Ukpai, N.P. (2020). Potentially toxic element pollution levels in Clarias batracus (Cat fish) and sediments of Onu Asu River in Arochukwu, Abia State, Nigeria. *Nigerian Research Journal of Engineering and Environmental Sciences*, 5(1): 01-14.

[5] Umeh, C.T., Nduka, J.K. and Akpomie, K.G. (2021). Kinetics and isotherm modeling of Pb(II) and Cd(II) sequestration from polluted water onto tropical ultisol obtained from Enugu Nigeria. *Applied Water Science*, 2021.

[6] Umeh, C.T., Nduka, J.K., Omokpariola, D.O., Morah, J.E., Mmaduakor, E.C., Okoye, N.H., Ekene-Echerebo, I.L. and Kalu, I.F. (2023). Ecological pollution and health risk monitoring assessment of polycyclic aromatic hydrocarbons and heavy metals in surface water, southeastern Nigeria. *Environmental Analysis Health and Toxicology*, 38(2): 1-27.

[7] United Nations (UN), (2016). General Assembly Declares Access to Clean Water and Sanitation Is a Human Right. UN News Centre.

[8] World Health Organization, WHO (2021). Health risks of persistent organic pollutants from long-range transboundary air Pollution. World Health Organization Regional Office for Europe, Copenhagen; pp. 252-259. Accessed in 2003. https://apps.who.int/iris/handle/10665/107471.

[9] Ambade, B., Sethi, S.S., Kurwadkar, S., Kumar, A. and Sankar, T.K. (2021). Toxicity and health risk assessment of polycyclic aromatic hydrocarbons in surface water, sediments and groundwater vulnerability in Damodar River Basin. *Groundwater for Sustainable Development*, 13:10055.

[10] Islam, M.S., Afroz, R., Bodruddoza, M., (2019). Investigation of surface water quality of the Buriganga River Bangladesh: Laboratory and spatial analysis approaches. Dhaka Univ. J. Biol. Sci. 28(2), 147e158. https://doi.org/ 10.3329/dujbs.v28i2.46501.

[11] Islam, M.S., Uddin, M.K., Tareq, M.S., Shammi, M., Kamal, A.K.I., Sugano, T., Kurasaki, M., Saito, T., Tanaka, S., Kuramitz, H., (2018). Alteration of water pollution level with the seasonal changes in mean daily discharge in three main rivers around Dhaka City, Bangladesh. Environments 2(4), 280e294. https://doi.org/10.3390/environments2030280.

[12] Islam, S., Ahmed, K., Raknuzzaman, M., Al-Mamun, H. and Islam, M.K. (2015). Heavy metal pollution in surface water and sediment: A preliminary assessment of an urban river in a developing country. *Ecological Indicators*, 48:282–291.

[13] APHA (2005). Standard methods for examination of water and waste water. 21thed. *American Public Health Association*, Washington, DC,USA.

[14] Khair, (2019). Response of sediments and phosphorus to catchment characteristics and human activities under different rainfall patterns with Bayesian Networks. J. Hydrol. 584. https://doi.org/10.1016/j.jhydrol.2020.124695.

[15] Liu, J.L., Zhang, J., Liu, F. and Zhang, L.L. (2014). Polycyclic aromatic hydrocarbons in surface sediment of typical estuaries and the spatial distribution in Haihe river basin. *Ecotoxicology*, 23(4): 486–494.

[16] Mena, O (2017). Study on temporal variation of physicochemical parameters of Buriganga River water through GIS (Geographical Information System) technology. Bangladesh J. Sci. Ind. Res. 44(3), 327e334. https://doi.org/10.3329/bjsir.v44i3.4406.

[17] Mmaduakor, E.C., Umeh, C.T., Morah, J.E., Omokpariola, D.O., Ekwuofu, A.A. and Onwuegbuokwu, S.S. (2022). Pollution status, health risk assessment of potentially toxic elements and their uptake by gongronema latifolium in peri-urban of Ora-Eri, south-eastern Nigeria. *Heliyon*, 8(8):e10362.

[18] Nduka, J.K and Umeh, C.T. (2021). Bioremediation of heavy metals contaminated aqueous solutions using Zoogloea layer, Moss and Mushroom cells. *Journal of Bioremediation and Biodegradation*, 12(S7):10000

[19] Paris, A., Ledauphin, J., Poinot, P. and Gaillard, J.L. (2018). Polycyclic aromatic hydrocarbons in fruits and vegetables: Origin, analysis, and occurrence, Environmental Pollution 234: 96-106.

[20] Rahmanian, N., Bt Ali, S. H, Homayoonfard, M., Ali, N.J., Rehan, M., Sadef, Y. and Nizami, A. S. (2015). Analysis of Physiochemical Parameters to Evaluate the Drinking Water Quality in the State of Perak, Malaysia. *Journal of Chemistry*, 2015: 1-10.

[21] Sarkar, M., Islam, J.B., Akhter, S., (2016). Pollution and ecological risk assessment for the environmentally impacted Turag River. Bangladesh. J. Mater. Environ. Sci. 7(7), 2295e2304.

[22] World Health Organization (2003). Polynuclear aromatic hydrocarbons in drinking-water. Background document for development of WHO guidelines for drinking-water quality. Geneva: World Health Organization.

[23] Uddin, M.J., Jeong, Y.K., (2021). Urban river pollution in Bangladesh during last 40 years: Potential public health and ecological risk, present policy, and future prospects toward smart water management. Heliyon 7(2), e06107. https://doi.org/10.1016/j.heliyon.2021.e06107.

[24] Umeh, C.T, Asegbeloyin, J.N., Akpomie, K.G., Oyeka, E.E. and Ochonogor, A.E. (2020). Adsorption properties of tropical soils from Awka North Anambra Nigeria for lead and cadmium ions from aqueous media. *Chemistry Africa*, 3: 199–210.

[25] Jin, G.Q., Xu, J., Mo, Y.M., Tang, H.W., Wei, T., Wang, Y.G., Li, L., (2020). Response of sediments and phosphorus to catchment characteristics and human activities under different rainfall patterns with Bayesian Networks. J. Hydrol. 584. https://doi.org/10.1016/j.jhydrol.2020.124695.

[26] Barakat, A., Baghdadi, M.E., Rais, J., Aghezzaf, B., Slassi, M., (2016). Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariate statistical techniques. Int. Soil Water Conserv. Res. 4(4), 284e292. https://doi.org/10.1016/j.iswcr.2016.11.002.

[27] Fang, T., Lu, W., Li, J., Zhao, X. and Yang, K. (2017). Levels and risk assessment of metals in sediment and fish from Chaohu Lake, Anhui Province, China. *Environmental Science and Pollution Research*, 24(18): 15390–15400.

[28] Formicki, G. (2018). Assessment of water quality status of Turag River due to industrial effluent. Int. J. Eng. Inform. Syst. 1(6), 105e118.

[29] Hasan, M.K., Shahriar, A., Jim, K.U., (2019). Water pollution in Bangladesh and its impact on public health. Heliyon 5(8), e02145. https://doi.org/10.1016/ j.heliyon.2019.e02145.

[30] Huang, H.W., Lee, C.H. and Yu, H.S. (2019). Arsenic-induced carcinogenesis and immune dysregulation. *International Journal of Environmental Research and Public Health*, 16: 2746- .

[31] Nduka, J.K., Umeh, T.C., Kelle, H., Ozoagu, P.C. and Okafor, P.C. (2022). Health risk assessment of radiation dose of background radionuclides in quarry soil and uptake by plants in Ezillo-Ishiagu in Ebonyi South-Eastern Nigeria. *Case Studies in Chemical and Environmental Engineering*, 6(1):10026

[32] Nkansah, K. and Amoako, O. (2018) Water pollution in Bangladesh and its impact on public health. Heliyon 5(8), e02145. https://doi.org/10.1016/ j.heliyon.2019.e02145.

[33] Okechukwu, V.U., Omokpariola, D.O., Onwukeme, V.I., Nweke, E.N. and Omokpariola, P.L. (2021). Pollution investigation and risk assessment of polycyclic aromatic hydrocarbons in soil and water from selected dumpsite locations in rivers and Bayelsa State, Nigeria. *Environmental Analysis Health and Toxicology*, 36(4): 1-20.

[34] Okechukwu, V.U., Omokpariola, D.O., Onwukeme, V.I., Nweke, E.N. and Omokpariola, P.L. (2021). Pollution investigation and risk assessment of polycyclic aromatic hydrocarbons in soil and water from selected dumpsite locations in rivers and Bayelsa State, Nigeria. *Environmental Analysis Health and Toxicology*, 36(4): 1-20.

[35] Whitehead, P.G., Bussi, G., Hossain, M.A., Dolk, M., Das, P., Comber, S., Peters, R., Charles, K.J., Hope, R., Hossain, S., (2018). Restoring water quality in the polluted Turag-Tongi-Balu river system, Dhaka: Modelling nutrient and total coliform intervention strategies. Sci. Total Environ. 631e632, 223e232. https://doi.org/10.1016/j.scitotenv.2018.03.038.