SEASONAL VARIATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN AKPAJO AND ABA RIVERS, NIGERIA USING CCME WATER QUALITY INDEX (WQI) MODEL

J. O. Obiora¹ and O.A Ikeh² *Corresponding author: joyezeo36@gmail.com ¹Department of Science Laboratory Technology, Federal Polytechnic Oko ²Department of Pure and Industrial Chemistry Nnamdi Azikiwe University Awka

Abstract

Environmental pollution is the major problem of the people living in industrialized areas. Seasonal variations of physico-chemical and Polycyclic aromatic hydrocarbon (PAHs) were studied in selected Rivers in Port Harcourt(Akpajo) and Aba, Nigeria, across the sampling points. Physico-chemical properties and PAHs were determined using standard methods and Atomic Absorption Spectrophotometer (AAS). Results showed that concentration of PAHs varies across two seasons (dry and rainy seasons). The results of the seasonal variations showed Akpajo River gave highest recorded value of Anthracenedi-Benzyl(A-H)(0.21 mg/l) at station 1 with mean concentration (0.15±0.04) in dry season while the highest recorded value in rainy season was Anthracenedi-Benzyl (A-H)(0.25 mg/l) at station 3 with mean concentration (0.2163 ± 0.03) . Also, seasonal variations of Aba River gave the highest recorded value (Benzo [K] Fluoranthene 0.1328 mg/l) at Point (Station) 1 with mean concentration (0.1163±0.01mg/l) in dry season while the lowest recorded value was Anthracenedi-Benzyl (A-H)(0.001mg/l) at station 1 with mean concentration $(0.008\pm0.01 \text{mg/l})$. The highest recorded value in rainy season was (1,2 Benzanthrene 0.98 mg/l) with lowest recorded value (Anthracenedi-Benzyl (A-H) 0.007 mg/l). These concentrations were above the WHO maximum permissible limits for surface water and are indication of potential adverse effects because of their carcinogenic nature as they enter food chain and this is an indication of pollution from anthropogenic sources. Therefore, we recommend, recycling of industrial/electronics wastes, checkmating the disposal of industrial wastes by Law Enforcement Agencies and use of sustainable strategies.

Keywords: PAHs, Water Pollution, Physico-chemicals, Water Quality Index and Carcinogenic

Introduction

Surface water use has been of significant applicability across the globe for many purposes: domestic, industrial, and agricultural, according to (Obodo, 2004; Igwilo, Afonne, Maduabuchi, and Orisakwe , 2006).Polycyclic aromatic hydrocarbons (PAHs) are found naturally in coal, crude oil, and gasoline, and are also discharged into the environment when these materials are burned (Abdel-Shafty and Mansour, 2016). Many PAHs are found in cigarette smoke and people are frequently exposed to PAH combinations. Exposure can occur from breathing air contaminated with motor vehicle exhaust, cigarette smoke, wood smoke, or vapors from asphalt roadways. People who are grilled or charred meats or foods, or items on which PAH particles had dropped from the air, were exposed to PAHs and suffered blood and liver problems as a result (Krzebietke and Mackiewicz 2011). Several PAHs, as well as several PAH

combinations, are thought to be cancercausing compounds (Gupta, Herren, Wenger, Krebs and Hari, 2016).

Description of Akpajo River

The research was conducted on the Akpajo River, which is located in Akpajo town, Eleme Local Government Area, Rivers State.



Fig 1 Map of Akpajo River Showing Sampling points/stations (source) Description of Aba River

Aba River is located in Ogbor community and this constitutes the study area. Aba river lies between latitude $5^{\circ}05$ to $5^{\circ}30$ North and longitude $7^{\circ}15$ to $7^{\circ}40$ ' East, it is a tributary of Imo River and transverse Aba town.



Fig 2: Map of Aba town showing Aba River and road networks (Source:NGSA, 2004)

Materials and Methods Collection of Water Samples for PAHs

Sample Collection and Storage: Samples were collected in plastic glass bottles. All bottles were pre-cleaned and rinsed

thoroughly with turbid free water. The samples were analyzed immediately after collection; the remaining was kept at 4°C in a

refrigerator for 48 hours and was used for heavy metal digestion and determination.

The samples were collected from points/stations of the rivers and whole processes of analyzing material were achieved in steps as follows: sampling, storage, sample preparation, sampling sample measurement, evaluation of sample results, comparison with standard or threshold values and finally assessment of result. The tests were carried out on two Rivers Akpajo and Aba. There are 3 sampling points (stations) each of the Rivers making it total of 6 stations (points). The samples were collected in two season's precisely dry and rainy seasons, making it total of 12 samples.

Experimental

Determination of Physico-chemical Parameters

The physical parameters tested are pH, electrical conductivity, total dissolved solid, temperature while the chemical parameters are calcium, magnesium, total alkalinity, turbidity, chloride and biological oxygen demand.

p H (Hydrogen ion Concentration) Measurement

The pH values were determined using calibrated WTW 232 digital pH meter, at the sight of the rivers. The electrode was rinsed with distilled water calibrated using buffer solutions and immersed in the samples collected at the sight using polyethylene container. The analyses were done in triplicate and the results recorded. The electrode was dipped into the sample solution, swirled and waited up to 1 minute for steady reading. The pH readings were recorded accordingly (Verma, 2010; De, 2010)

Electrical Conductivity Measurement

A simple conductivity meter with dip-type cell was used for this purpose. The instrument and cell was calibrated using 0.005M KCl solution (conductivity=654 μ s/cm)[·] Hand held Conductivity meter TDS METER Hanna instruments range 10- 1999ppm, accuracy ± 2%) was used for this purpose. Triplicate samples were used for each analysis and results recorded.

Determination of Turbidity of Water

This was achieved using Turbidimeter after calibration and Standardization. Standards were measured on the turbid meter from 0.2ppm to 1ppm. This helped to check the accuracy of the instrument calibrated scales. Standard of known concentration was run and absorbance readings recorded (James, 1993). The result was calculated using the equation given below

OS X D = Tr

Determination of Dissolved Oxygen

Winkler method: 100ml sample was measured accurately with the aid of a pippete in a three separate 250 ml bottles and added 2ml of 40% KF (to mask Fe³⁺), 2ml of 36% MnSO₄ and 2ml of alkaline iodide-azide solution in each bottle. The whole content of 100 mL was poured carefully into another conical flask. The liberated I₂ was titrated with 0.025M Na₂S₂O₃ solution using starch indicator until blue colour disappeared.The mean result was calculated and recorded using the formula,

Dissolved oxygen in mg/litre = $(c.c \times N)$ of the titrant $\times 8 \times 1000$

 $V_1 - V$

Where, c.c = volume of the titrant N = Normality of the sodium thiosulphate $V_1 = volume$ of sample bottle after placing the stopper V = volume of MnSO₄ and KI solution added

Determination of Biochemical Oxygen Demand (BOD)

Determination of Chemical Oxygen Demand (COD) (De, 2010).

Compressed air was bubbled in distilled water for 30 minutes. This water is the dilution water.

Iml each of phosphate buffer, MgSO₄, CaCl₂ and FeCl₃ solution was added to 1 litre of dilution water and mixed well. Dilution was carried out in a large bucket and mixed well. Two sets I and II of B.O.D bottles were filled. The dissolved oxygen of the sample bottles was determined immediately. The dissolved oxygen of the sample bottles of set II was determined after keeping the bottles in a B.O.D incubator at 20°C for 5 days. Two BOD bottles were filled with dilution water; one bottle was used to determine dissolved oxygen immediately while the other was

 $Total alkalinity = \underbrace{V_A x N_A x 500}_{Volume of the sample}$ Where V_A =volume of acid solution when methyl orange is used as the indicator

 N_A =normality of the acid.

Determination of Total Suspended Solid (TSS) (Agomuo *et al.*, 2011)

Marked evaporating crucible (eg; A1, B1, C1, etc) were heated in an oven and cooled in a desiccator. The clean crucibles were weighed with an analytical balance. 20ml of each of the sample was measured with a measuring cylinder, poured into each crucible and placed on the water bath to

evaporate to dryness. Upon drying, the crucibles were removed and placed in an oven at 105°C for one hour after which they were cooled in a desiccator for 20 minutes and reweighed using an analytical balance.

The weights were recorded as A2, B2, C2, etc. The differences in the weights A2-A1, B2-B1, C2-C1, etc were calculated as total solids. (Agomuo *et al.*, 2011)

incubated for 5 days. The results were obtained using the formula below

B.O.D mg/l = $(D_0 - D_5)$ x dilution factor Where D_0 = concentration of the dissolved oxygen in the sample. D_5 = concentration of dissolved oxygen after 5 days.

DeterminationofTotalAlkalinity:According to (Christian, 2004)100ml samplewas introduced into 250ml conical flask and2 drops of phenolphthalen indicator added.

2 drops of methyl orange indicator was added to the solution and the solution becomes yellow indicating the presence of bicarbonate ion.The solution was titrated with 0.1N HCl from the burette and the T value was recorded. The result was calculated as follows

Ts (mg/1) = (weight of Sample in Dish – Weight of empty Dish

Volume of sample

Determination Total Dissolved Solids (TDS) (APHA, 2012)

Determination of TDS was determined using Gravimetric method (APHA, 2012) in which the sample is vigorously shaken and measured volume transferred into a 100ml graduated cylinder by means of a funnel. The sample was filtered through a glass filter and a vacuum applied for about three minutes to ensure that water was removed as much as possible. The total filtered samples were transferred (with washings) to a weighed evaporating dish and evaporated to dryness in an oven at temperature of 180°C for 1 hour. The dried sample was cooled in desiccators and reweighed. Drying and reweighing processes were repeated until a constant weight was obtained. Calculation: TDS = (A-B)10 mg/l

Sample volume in ml , A=weight of crucible +solids (g) ;B= weight of crucible before use(g)

Determination of Dissolved Carbon Dioxide (Verma, 2010)

100mL of the sample was taken in a 250 cm³ conical flask and acidified. 2-3 drops of phenolphthalein indicator were added to the solution. The colour does not turn pink. Free CO_2 is absent. Since the sample remains colourless, it was titrated with 0.05N NaOH solution until a pink colour appears (Verma, 2010).

Calculation, Free CO₂, mg/litre = A X N of NaOH X 1000 X 44

2 x Volume

Where N is the normality of NaOH and A = volume of the titrant used

Determination of Nitrite-Nitrogen: Using diazothization method,

40 ml of sample was placed in Nessler tube; set aside until preparation of standard are completed. 2 ml of buffer-colour reagent was added to each standard; mixed and allowed colour to develop for at least 15 minutes. The absorbance in the spectrophotometer was measured at 540 nm against the blank and concentration of nitrite-nitrogen plotted against absorbance. If less than 40 ml of sample was taken, calculation of the concentration is as follows : NO⁻ 2-N in mg/1

= $(\underline{mg}/1 \text{ from standard curve x } 50)$

ml of sample(mg/1 to three significant figures)

Determination of Nitrate-Nitrogen

Brucine sulphanilic method: The pH of the samples were adjusted to approximately 7 with acetic acid to (6.7) or sodium hydroxide to (6.8) and filtered to remove turbidity. Sample tubes were put in the rack to handle reagent blank, standards and samples. A set of duplicate samples was ran to which all reagents except the brucine-sulfanilic acid have been added. 10.0 mL of standards and samples or an aliquot of the samples dilutedto 10.0 mL was pipetted into the sample tubes. 2 mL of the 30% sodium chloride solution was added the reagent blank, standards and samples when the samples are saline. Contents of tubes were mixed by swirling the rack in cold water bath (0 - 10°C). 10.0 mL of sulfuric acid solution was pipette into each

tube and mixed by swirling. Tubes were allowed to come to thermal equilibrium in the cold bath. Temperatures were made to be equilibrated in all tubes before continuing. 0.5 mL brucine-sulfanilic acid reagent was added to each tube (except the interference control tubes and carefully mixed by swirling. The rack of tubes in the 100°C water bath was placed for exactly 25 minutes and removed from the hot water bath and immersed in the cold water bath and allow to reach thermal equilibrium (20-25°C).

The absorbance against the reagent blank was read at 410 nm using photoelectric colorimeter.

Calculation

The absorbance of the sample without the brucine-sulfanilic reagent was subtracted from the absorbance of the sample containing brucine-sulfanilic acid and determine mg NO³⁻ by multiplying by an appropriate dilution factor since 10 mL of sample was taken.

Determination of Phosphate (Verma, 2010)

Stannous Chloride Method

Phosphate determination was done using standard Spectrophotometric method (De, 0.05ml (1 drop) phenolphthalein 2010). indicator was added to a 100ml water sample free from colour and turbidity. Strong acid solution was added dropwise to discharge the colour, if sample turns pink. When more than 0.25 ml (5 drops) was required, a smaller volume of sample was taken and diluted to 100 ml with de-ionised water and then a drop of phenolphthalein indicator added and discharged if sample turned pink colour with acid. 4.0 ml molybdate reagent and 0.5 ml (10 drop) stannous chloride reagent were added with thorough mixing after each addition.

Between 10 and 12 minutes, the absorbance was measured at wavelength of 690 nm on a spectrophotometer; the spectrophotometer was zeroed with blank solution Concentration of the Sample (mg/l) =

Absorbance of Sample x Concentration of Standard

Absorbance of Standard

From the calibration curve, the concentration of the samples was determined using measuring absorbance. The results were expressed in mg/1 to 3 significant figures (Verma, 2010).

Determination of Sulphate (Verma, 2010) Turbimetric Method: 50ml sample was measured and diluted to 100 ml into a 250 ml Erlenmeyer flask. Exactly 5 ml conditioning reagent was added and mixed by stirring. A spoonful of barium chloride crystals was added while still stirring and commenced timing for 60 seconds at a constant speed. After stirring, the absorbance was measured at 420 nm on the spectrophotometer-Ultra spec model II within 5 minutes. The result were read direct from the calibration curve, and expressed in mg/1, to three significant (APHA, 1998) (Verma, 2010)

Determination Total Hardness (Calcum and Magnesium) (Christian, 2004)

EDTA Titrimetric Method: A 50ml of the water sample was pipetted into a 250ml conical flask. 5ml of ammonia buffer was added to the content of the flask and swirled followed by 30mg each of (KCN) Potassium cyanide and hydroxyl-amine hydrochloride were added and the flask and shaken to dissolve the solids.Then 0.02g of Erio. T. black indicator was added and the solution

titrated with 0.025N EDTA to blue end point (Christian, 2004). Calculation: Total Hardness as $CaCO^3$ (mg/1) = <u>Titre value x 0.4008 x10⁶</u>.

Volume of sample used x 1000 **Procedure Calcium Hardness**

A 50ml of the water sample was pipetted into a 250ml conical flask. 4ml of 8M aqueous KOH was added to the content of the flask and swirled. 30mg each of (KCN) Potassium cyanide and hydroxyl-amine hydrochloride were added and the flask shaken to dissolve the solids. Then 0.02g of Pattern and Readers indicator was added and the salmon to purple colour solution titrated with 0.025N EDTA to blue end point (Christian, 2004).

Calcium Hardness CaCO₃ (mg/1)) = <u>value</u> <u>x 0.2432X 10⁶</u>.

Volume of

sample used x 1000

Magnesium was calculated by differential method;

Magnesium Only = Total Hardness Calcium Only

Total Phosphate Determination

100ml water sample was measured and transferred in a beaker and digested with1 ml Conc. H_2SO_4 .and 5 ml Conc. HNO₃ and evaporate to dryness. This digestion and evaporation was repeated. The residue was leached with 5 ml of 5N HNO₃ and transferred to a 50ml volumetric flask. 5ml of 10% Ammonium Molybdate, and then 5 ml of 0.25% Ammonium Vanadate (in 6N

HCL). The solution was diluted to mark with distilled water and allowed to stand for 10 minutes. The absorption of the yellow reaction product, vanadium molybdophosphate was measured at 460nm including the blank treated in the same way.

Determination of PAHs in Water

Determination was done after necessary extraction of the sample and calibration of the GC-MS machine prior to analysis (**Itodo** *et al.*, **2018**).

Extraction Procedures for PAHs

Water samples were extracted by liquidliquid extraction method and concentrated. A 150-ml water sample was transferred to 250 ml separating funnel and 9 ml of dichloro methane was added. The separatoy funnel was shaken for a period of 2 minutes and the organic layer was separated and collected in a 50 ml flat bottomed flask containing 2g of anhydrous sodium sulphate. The extraction step was repeated several times, and the resulting extracts were combined. The combined extract was concentrated to near dryness using rotary evaporator, transferred into amber vial and kept in the refrigerator prior to analysis (Itodo *et al.*, 2018).

Assessment of the Quality of the Rivers.

Assessment of the quality of the Rivers was done using Canadian Council of Ministry of the Environment Water Quality Index Model (CCME WQIM),(2001).



Normalized sum excursion

X = No. of failed variables; Y= Total No. of variables; Z = Total No. of tests. and E = Total No. of failed tests(parameters exceeding WHO MPL). Failed test value

STEP 3.1 Excursion =
$$\frac{1 \text{ active cost rates}}{Objectives} - 1$$

Statistical Analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software (Version 16.0) and Microsoft Excel Word (2013) was used in calculation of Water quality index model. Canadian Council of Ministers of the Environment CCME WQI Model 2001 was used in summarizing the physico-chemical water analytical data into information that are easily understandable by anyone.

RESULTS

Table 1: Physico-chemical Composition of Water Samples from Akpajo River in Dry Season

Parameters	Point 1	Point 2	Point 3	Mean±SD	WHO STD
EC (µs/m)	167.8	58.9	47.3	91.33±16.97	100(µs/m)
Ph	5.4	5.7	6.1	5.7±0.35	6.5-8.5
Ca (mg/l)	15.06	18.32	67.12	33.5±29.16	75(mg/l)
Mg (mg/l)	47.13	18	49.11	38.08±17.41	50(mg/l)
TDS (mg/l)	201	115.4	131.6	149.33±45.47	100(mg/l)
T.ALK (mg/l)	40.6	37	25.2	34.27 ± 8.06	120mg/l
TURB(NTU)	25.5	5.3	4.3	11.7±11.96	5(NTU)
Cl(mg/l)	222	102	103	142.33 ± 68.99	250(mg/l)
BOD(mg/l)	34.99	35.6	6.49	25.69±16.63	5(mg/l)
Temp (^O C)	30.5	30.1	29.1	29.9±0.72	26.6(°C)

EC= Electrical Conductivity;TDS= Total Dissolved Solid;T.Alk= Total Alkalinity; Chemical Oxygen Demand; BOD= Biochemical Oxygen Demand; Temp= Temperature; Cl =Chloride and TURB. = Turbidity

Parameters	Point 1	Point 2	Point 3	Mean±SD	WHO STD
EC µs/cm	159	47.6	40.9	82.5± 54.2	100(µs/m)
Ph	5.7	6.1	6.3	6.03±0.25	6.5-8.5
Ca (mg/l)	10.1	11.17	10.11	10.46±0.50	75(mg/l)
Mg (mg/l)	54.1	26.16	28.7	36.32±12.60	50(mg/l)
TDS (mg/l)	100.40	106.00	103.00	103.13±2.3	100mg/l
T.ALK (mg/l)	26.10	21.90	17.50	21.83±3.50	120mg/l
TURB (NTU)	16.83	6.84	4.01	9.22±5.40	5(mg/l)
Cl(mg/L)	290.00	173.00	46.50	169.83±99.40	250(NTU)
BOD(mg/L)	29.10	27.30	4.90	20.43±11.00	5(mg/l)
Temp ^o C	29.90	28.20	27.80	28.63±0.91	26.6 °C

Table 2: Physico-chemical Composition of Water sample of Akpajo River in Rainy Season

EC= Electrical Conductivity;Tds= Total Dissolved Solid;T.Alk= Total Alkalinity; DO Dissolved Oxygen;COD= Chemical Oxygen Demand; BOD= Biochemical Oxygen Demand; Temp= Temperature ;Cl =Chloride and TURB. = Turbidity

	POINT				
PARAMETERS	1	POINT 2	POINT 3	Mean±SD	WHO STD
E.C $\mu(s/m)$	150.60	147.60	100.90	133.03±27.9	100 µ(s/m)
рН	7.20	7.70	8.15	7.68 ± 0.39	6.5-8.5
Ca(mg/l)	12.07	13.16	15.09	13.44 ± 1.25	75(mg/l)
Mg (mg/l)	14.10	16.71	17.16	15.90 ± 1.35	50(mg/l)
TDS (mg/l)	129.00	110.80	123.50	121.10 ± 9.30	100(mg/l)
T.ALK (mg/l)	53.00	50.90	97.60	67.17 ± 26.40	80-120mg/l
TURB. (NTU)	6.83	6.81	3.70	5.78 ± 1.80	5(mg/l)
CL(mg/l)	90.00	94.00	65.00	$83 \pm \! 12.80$	120(mg/l)
BOD(mg/l)	29.10	9.80	4.60	14.5 ± 12.90	5(mg/l)
Temp °C	28.90	28.00	27.80	28.23 ± 0.48	26.6°C

Table 3: Physico-chemical Composition of Water sample of Aba River in Dry Season

EC= Electrical Conductivity;Tds= Total Dissolved Solid;T.Alk= Total Alkalinity; DO Dissolved Oxygen;COD= Chemical Oxygen Demand; BOD= Biochemical Oxygen Demand; Temp= Temperature ;Cl =Chloride and TURB. = Turbidity

Parameters	Point 1	Point 2	Point 3	Mean±SD	WHO Std
E.C $\mu(s/m)$	147.2	140.80	95.20	127.70 ± 28.40	100 µ(s/m)
рН	7.40	7.90	8.20	7.83±0.33	6.5-8.5
Ca(mg/l)	10.17	12.12	13.10	12.06 ± 1.22	75(mg/l)
Mg (mg/l)	14.95	17.10	18.90	16.98 ± 1.60	50(mg/l)
TDS (mg/l)	97.30	100.70	110.00	102.67 ± 5.36	100(mg/l)
T.ALK (mg/l)	44.60	48.70	50.10	47.80 ± 2.30	80-120mg/l
TURB.(NTU)	7.10	7.05	7.19	7.11±0.06	5(mg/l)
CL(mg/l)	92.00	96.00	98.00	95.33 ± 2.49	120 mg/l
BOD(mg/l)	27.90	4.40	3.60	$11.97{\pm}13.8$	5(mg/l)
Temp ^O C	28.00	27.60	26.50	27.37 ± 0.78	26.6 ^o C

Table 4: Physico-chemical Composition of Water sample of Aba River in Rainy Season

EC= Electrical Conductivity;Tds= Total Dissolved Solid;T.Alk= Total Alkalinity; DO Dissolved Oxygen;COD= Chemical Oxygen Demand; BOD= Biochemical Oxygen Demand; Temp= Temperature ;Cl =Chloride and TURB. = Turbidity

					WHO
PAHs Akpajo River	Point 1	Point 2	Point 3	Mean±SD	STD
Acenaphthylene	0.03	0.01	0.02	0.02 ± 0.01	0.0002
Acenaphthene	0.25	0.15	0.03	$0.14{\pm}0.1$	0.01
Anthracenedibenzyl(a-h)	0.21	0.13	0.12	0.15 ± 0.04	0.0001
Benzo [a] pyrene	0.06	0.04	0.05	0.05 ± 0.01	0.0007
					NO
Benzo [k] fluoranthene	0.14	0.13	0.14	0.13 ± 0.00	STD
Naphthalene	0.01	0.01	0.01	0.01 ± 0.00	0.0001
Phenanthrene	ND	ND	ND		0.0001

Table 5: Polycyclic Aromat	ic Hydrocarbons levels	of Akpajo River for t	the Dry Season(mg/L)
----------------------------	------------------------	-----------------------	----------------------

No= no standard because it falls below those of no standard = health concern(US EPA,2003) EC= Electrical Conductivity;Tds= Total Dissolved Solid;T.Alk= Total Alkalinity; DO

Dissolved Oxygen;COD= Chemical Oxygen Demand; BOD= Biochemical Oxygen Demand; Temp= Temperature ;Cl =Chloride and TURB. = Turbidity

PAHs	Point 1	Point 2	Point 3	Mean±SD	WHO STD
Acenaphthene	0.2	0.02	0.2	0.14±0.08	0.01
Anthracenedibenzyl(a-h)	0.19	0.2	0.25	0.22 ± 0.03	0.0001
Benzo [a] pyrene	0.04	0.03	0.05	0.04 ± 0.01	0.0007
					NO
Benzo [k] fluoranthene	0.12	0.21	0.15	$0.16{\pm}~0.04$	STD
Benzanthrene	ND	ND	ND		0.0001
Naphthalene	0.00	0.01	0.01	0.01 ± 0.00	0.0001
Phenanthrene	ND	ND	ND		0.0001

Table 6: Polycyclic Aromatic Hydrocarbons levels of Akpajo River for the rainy Season(mg/L)

No= no standard because it falls below those of no standard = health concern(US EPA,2003)

Table	7:	Result	of	Polycyclic	Aromatic	Hydrocarbons	Analysis	of	Aba	River	in	Dry
Season	n(m	g/L)										

					WHO
PAHs	Point 1	Point 2	Point 3	Mean±SD	STD
Acenaphthylene	0.02	0.02	0.02	0.02 ± 0.00	0.0002
Acenaphthene	0.03	0.01	0.02	0.02 ± 0.01	0.01
Anthracenedibenzyl(a-h)	0	0.01	0.01	0.01 ± 0.01	0.0001
Benzo [a] pyrene	ND	ND	ND		0.0007
					NO
Benzo [k] fluoranthene	0.1	0.11	0.13	$0.11{\pm}0.01$	STD
Benzanthrene	0.05	0.03	0.04	0.04 ± 0.01	0.0001
Naphthalene	ND	ND	ND		0.0001
Phenanthrene	0.01	0.03	0.02	0.02 ± 0.01	0.0001

No= no standard because it falls below those of no standard = health concern (US EPA,2003)

 Table 8: Polycyclic Aromatic Hydrocarbons levels of Aba River for the rainy Season (mg/L)

PAHs	Point 1	Point2	Point3	Mean±SD	WHO STD
Acenaphthylene	0.09	0.08	0.1	0.09 ± 0.01	0.0002
Acenaphthene Anthracenedibenzyl(a-	0.06	0.04	0.03	0.05 ± 0.01	0.01
h)	0.01	0.01	0.01	0.01 ± 0.00	0.0001
Benzo [a] pyrene	ND	ND	ND		0.0007 NO
Benzo [k] fluoranthene	0.37	0.21	0.16	$0.25{\pm}0.09$	STD
Benzanthrene	0.98	0.82	0.68	0.83±0.12	0.0001
Naphthalene	ND	ND	ND		0.0001

Table 3: Water Quality Index levels across sample

Stations Using CCME WQI Model

Stations	Akpajo River	Aba River
Station 1	39.46	61.16
Station 2	61.49	66.92
Station 3	85.38	79.78



Fig 1 : Water Quality Index of the Rivers studied using the CCME WQI

Discussion

Results of seasonal variations of Polycyclic Aromatic Hydrocarbons of Akpajo River season and gave highest recorded value Anthracenedi-Benzyl(A-H)(0.21 mg/l) at station 1 with mean concentration (0.15 ± 0.04) in dry season while the highest recorded value in rainy season was Anthracenedi-Benzyl (A-H)(0.25 mg/l) at station with 3 mean concentration(0.2163±0.03). Also results of seasonal variations of Polycyclic Aromatic Hydrocarbons of Aba River gave the highest recorded value (Benzo [K] Fluoranthene 0.1328 mg/l) at Point (Station) 1 with mean concentration (0.1163±0.01mg/l) in dry season while the lowest recorded value was Anthracenedi-Benzyl (A-H)(0.001mg/l) at concentration station with mean 1 The highest recorded $(0.008 \pm 0.01 \text{ mg/l}).$ value in rainy season was (1,2 Benzanthrene 0.98 mg/l) with lowest recorded value (Anthracenedi-Benzyl (A-H) 0.007 mg/l) however, these results exceeded the World Health Organization Permissible Limit for PAHs and hence pose serious threat to consumers and environment at large. This is in line with Review work by Abdulazeez and Peter (2017) on review of PAHs in the environment. Aquatic pollution emanates from anthropogenic means like emission from a host of mechanism, including storm, water runoff, direct deposition, and surface run off from road ways and discharges from boats contribute heavily to aquatic pollution pyrene, a four ring PAH was absent. This was also in agreement with report of Itodo et al.,(2018) the eight samples detected where void of pyrene. Generally, the availability and concentrations of the studied pollutants vary across the seasons and study area.

Conclusion

study Finally, this established the environmental risk and contamination of water of Akpajo and Aba river in dry and rainy seasons by polycyclic aromatic hydrocarbon. PAHs levels are in the increasing order of : Phenanthrene< Acenaphthylene <Acenaphthene <Anthracene Di Benzyl[A-H]<Benzo K Benzo [A]Pyrene Fluoranthene < < Anthracene < 1, 2 Benzanthrene in that order. The increase during rainy season could be due to flooding and less evaporation during rainy season. The concentrations of the pollutants in the Rivers exceeded the World Health Organization Standard Threshold Effect Level (WHO TEL) in water which reveals potential adverse effects to humans as it enters food chain.

Recommendations

Since the pollution levels of these contaminants in the water samples analysed exhibited different polluting potentials and varies seasonally and their major sources are anthropogenic means therefore, I recommend recycling of metals, Electronics wastes, and obsolete electronics to prevent the release of these wastes that find their ways to the nearby rivers during flooding, use of efficient technologies to minimize quantities of raw materials and materials processing and production are conducted at such standard that toxic, non biodegradable wastes like heavy metals are minimized, use of activated charcoal filtes in removal of some toxic chlorinated organic. And finally, use of monitoring strategies by Law enforcement agencies to checkmate and discourage the activities of chemical industries in the concerned areas.

References

- Abdel-Shafty, H.I. and Mansour, M.S.M. (2016). A Review on Polycyclic Aromatic Hydrocarbons: Environmental Impact, Effect on Human Health and Remediation. Egyptain Journal of Petroleum Vol 25 :issue 1 P. 107
- Abdulazeez, T .L. and Peter, F. (2017). Polcyclic Aromatic Hydrocarbons. A Review.Cogent Environmental Science Vol 3 issue Pp,200-201
- Gupta, S. K, Herren, T., Wenger, K., Krebs, R. and Hari, T. (2016). In Situ Gentle Remediation Measures for Heavy Metal-Polluted Soils In Phytoremediation of Contaminated Soil and Water, Pp. 303–322, Lewis Publishers, Boca Raton, Fla, USA, View at Google Scholar
- Igwilo, I.O, Afonne, O.J, Maduabuchi, U.J. and Orisakwe, O.E. (2006). Toxicological Study of the Anambra

River in Otuocha, Anambra State, Nigeria. Archives of Environmental and Occupational Heath, 61(5): Pp. 205-208.

- Itodo, A.U, Sha, A.E.O. and Arowojolu M.I.(2018). Polycyclic Aromatic Hydrocarbons in water sample from a Nigeria Bitumemetry Quantification. Bangladessh Journal of industrial and Scientific 53 (4); 319-326,
- Krzebietke, S.J and Mackiewicz- Walec, E. (2021). Content of Polycyclic Aromatic Hydrocarbons in Soil in a Multi- Annual Fertilization Regime. *Environmental Monitoring and Assessment textbook*, 2nd Ed. Pearson Publishers Pp 69-70
- Obodo, G.A. (2004). The Bioaccumulation of Heavy Metals in Fish from Anambra River. J. Chem. Soc. Nigeria, 29(1): Pp. 60-62.