HYDROCARBON PROFILE OF OIL-SPILL-IMPACTED SOILS FROM OGONI IN RIVERS STATE, NIGERIA

ABSTRACT

This research examined the total extractable hydrocarbon content comprising of polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbons (TPHs), total hydrogen carbon (THC) and total organic nitrogen (TON) of an oil-spill-impacted site in Ogoni land, Okenta Alode, Eleme local government area, Rivers state, Nigeria. Sediment samples of crude oil hydrocarbon contaminated soils were randomly collected from different points at the study sites. Samples were collected between 0 - 15cm (surface m level) and 15 - 30cm (in-depth level) with soil auger and thereafter bulked to obtain composite sample. Bio remediated soil, obtained at about 200 m away from the contaminated site was also collected making a total of twelve (12) samples, with the coordinates of the locations recorded with a GPS device. The samples collected in sterile non-reactive polythene bags and transported using icepacks to the laboratory for analyses and the sediments stored at 6°C and extracted within 14 days of collection. The result of the study revealed among others that the oil-spill-impacted sites contain high concentration of TPH, as the highest concentration obtained from the different sites was 298.57 mg/kg and the lowest was 100.80 mg/kg. Also, the in-depth samples contain higher concentrations than the surface level samples, while similar results were also observed for PAHs and THC. The THC values for surface level samples are in the order of P3/S/O2 (129.000 mg/kg) > P5/S/O1 (229.300 mg/kg) > P1/S/O1 (232.200 mg/kg) > P4/S/O1 (256.111 mg/kg) > P2/S/O1 (303.100 mg/kg). The PAHs concentration in the sediment were within the acceptable limits and showed trend of DBA > Chr > BbFL > Ind > BaA > BkFL > Pyr > Fl > Flu > Ant > AcPY > Phen > AcP > NaP. There was no non-carcinogenic and carcinogenic risk posed to the populace as a result of PAHs contamination. Thus, the result suggest that these sediments may be contaminated with PAHs, TPH and THC and has reduced TON due to hydrocarbon contamination which may reduce plant growth in the study area. It recommends that these contaminations resulting from hydrocarbons be contained to prevent it from resulting to deleterious health effects to the exposed populace.

Keywords: Hydrocarbons, Sediment, Remediated, Contaminated, Polycyclic aromatic hydrocarbons, Total organic nitrogen.

1. INTRODUCTION

Exploration, processing and utilization of petroleum and its fraction is one of the imperative Nigeria's economic ventures. These processes have resulted to heavy metals' ingress and petroleum hydrocarbons' release into the soil, water and air. Since the inception of petroleum drilling in 1958 in Nigeria, several millions of barrels ranging from 9.1 to 13.1 million have been spilled in Nigeria [1,2]. These hydrocarbons spillage often emanate from pipelines' corrosion, tankers, sabotage (bunkering) and using obsolete and non-functional equipment for processing [3]. Petroleum hydrocarbon release has accounted for over 45% of environmental pollution in Niger delta, south–south region, Nigeria. This Niger delta is a resource-based region of petroleum for Nigeria [2, 4]. Petroleum refers to three basic hydrocarbon forms, condensate,

natural gases and crude oil (the flow able and liquid form of petroleum hydrocarbon). Petroleum is chemically composed of over 16,000 organic compounds, with each having its own solubility, density, volatility and toxicity level [5, 6]. Total petroleum hydrocarbon entails a wide family of many hundreds of chemical constituents originating from crude oils. It also connotes a chemical mixture of many carbon compounds. TPHWCG [7] described Total petroleum hydrocarbon, TPH as a measure of mass and concentration of various constituents of petroleum hydrocarbons in water or soil. TPH is composed of aromatic and aliphatic hydrocarbon constituents consisting of structural carbon chains atoms ranging C_5 to C_{35}. The hydrocarbon compounds become more hydrophobic as the complexity of this atomic structure increases, which will cause the Total petroleum hydrocarbon to resist any form of degradation by some micro-organisms thereby persisting in water and soil [8, 9, 10]. The presence of numerous chemical compounds (hydrocarbon) in petroleum makes it difficult to measure each compound separately and differently. Hence there is need to measure the total petroleum hydrocarbon in any given polluted soil or site. Some of these chemicals include gasoline, benzene, fluorine, xylene, hexane, naphthenes, naphthalenes, toluene, petroleum products and ethyl benzene. Total petroleum hydrocarbon encompasses both the total volatile petroleum hydrocarbon (TVPH) and the total extractable petroleum hydrocarbon (TEPH).

Volatile petroleum hydrocarbon is any chemical organic compound occurring in gasoline or petrol carbon range (C_6 - C_{10}), whereas extractable petroleum hydrocarbon is in the range of C_{10} - C_{28}.

Petroleum hydrocarbon spillage retards oil nutrients' availability, soil productivity and plants' growth. These hydrocarbons' spillage is of outmost concern because of the devastating effects and threats to plants growth, soil biodegradability and soil structure [11, 12, 13, 14]. Extractable petroleum hydrocarbons confer dispersion effects on ginger sprouting, with many variable effects on biomass of microbes. They further weaken microbes in soils, hence retarding their activities. Extractable petroleum hydrocarbons, EPHs in soil, hinder plants' root enhancement, plants' water absorption from soil, cause nutrient deficiency and result to poor crop performances [15, 16]. Hydrocarbons in soil, hinder seed germination and pose some detrimental effects to functional abilities of plants' growth and the soil [17]. These extractable petroleum hydrocarbons are large complex molecules, which persist in nature and most often require some tough reagents to counter any effect they render on plants and agriculture soils.

2. MATERIALS AND METHODS

2.1 SAMPLE AREA

The study area is Okenta Alode in Ogoni land, Eleme Local Government Area of Rivers State, Nigeria. This area is vulnerable to crude oil pollution due to the network of pipelines, oil wells and reserves around this region. However, a section of this area has been bio remediated and that is where the control samples were collected.

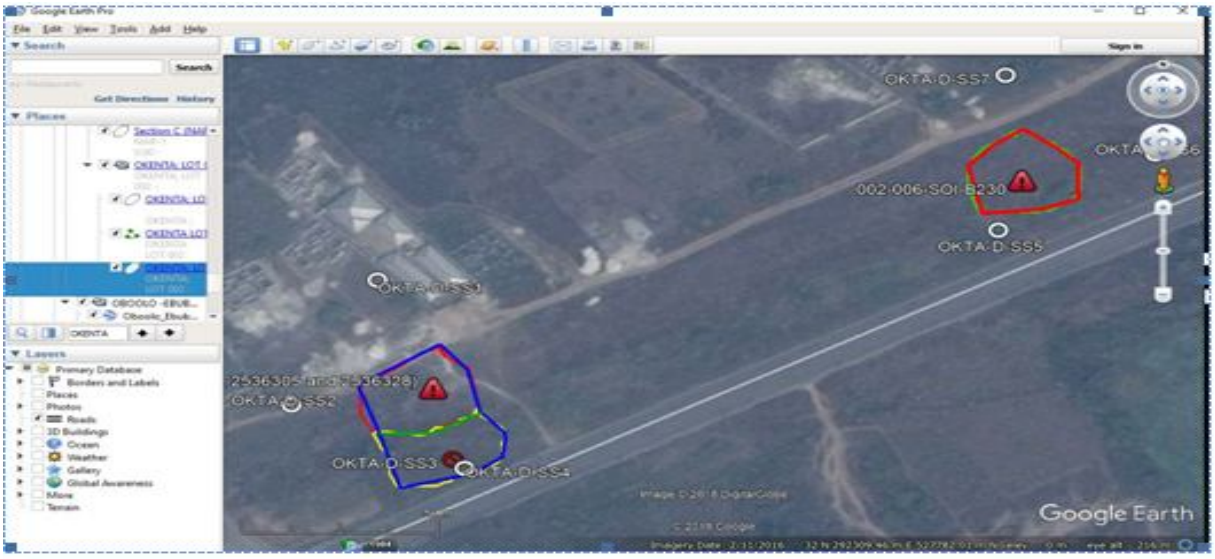

Figure 1: Google map of sites with coordinates in UTM Grid

2.2 SEDIMENT SAMPLE COLLECTION AND PREPARATION

Soil samples of crude oil hydrocarbon contaminated soils were randomly collected from different points at the site of collection in Ogoniland, Okenta Alode, Eleme local government area, Rivers state, Nigeria. Samples were collected between 0 - 15cm (surface m level) and 15 - 30cm (in-depth level) with a soil auger and thereafter bulked to obtain composite sample. Bio remediated soil, obtained at about 200m away from the contaminated site was also collected and a total of twelve (12) samples were obtained. The GPS coordinates of the locations were recorded with a GPS device. The samples were collected in sterile non-reactive polythene bags and transported using ice-packs to the laboratory for analyses. The sediments were stored at 6°C and extracted within 14 days of collection.

2.3 Sample Analysis

Wet samples were chemically dried with anhydrous sodium sulphate to eliminate water molecule and increase the surface area to enhance penetration capacity of dichloromethane thereby extracting the hydrocarbon log in it, using solid-liquid technique. The sample (20g) was accurately weighed into the extraction bottle and suitable quantity of anhydrous sodium sulphate was added into the extraction bottle. The mixture was stirred with a stirring rod until the sediment became dried and loose. Dichloromethane (140ml) was analytically added into the extraction bottle. The mixture was vortex for 2 hours and allowed to settle before commencement of filtration through glass funnel stuff with glass wool and covered with anhydrous sodium sulphate. The filtrate was received into a 250ml beaker and kept within a fume hood for solvent exchange. The sample was packed into 2ml via land ready for gas chromatographic separation of its components.

2.5 STATISTICAL ANALYSIS

The data was analyzed using statistical package for social science version 16.0 (SPSS Inc., Chicago, IL, USA). The mean and the standard deviation error were obtained to compare the variation between groups of same samples.

3. RESULT

3.1: Description of Soil Sediments Sample Label Obtained from Okenta Alode in Eleme, Rivers state, Nigeria

The definition of the sample labels which contains the stations are shown in Table 1

Table 1: Soil Sediments Sample Label

SAMPLES	DESCRIPTION
P1/D/CO1	Control sample 1 collected at in-depth level from a remediated site
P1/S/CO1	Control sample 2 collected at surface level from a remediated site.
P1/D/O1	Sample 3 collected from station one at in-depth level
P1/S/O1	Sample 4 collected from station one at surface level
P2/D/O1	Sample 5 collected from station two at in-depth level
P2/S/O1	Sample 6 collected from station two at surface level
P3/D/O2	Sample 7 collected from station three at in-depth level
P3/S/O2	Sample 8 collected from station three at surface level
P4/D/O1	Sample 9 collected from station four at in-depth level
P4/S/O1	Sample 10 collected from station four at surface level
P5/D/O1	Sample 11 collected from station five at in-depth level
P5/S/O1	Sample 12 collected from station five at surface level

3.2 Concentration of PAHs in Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria.

The concentration of individual PAHs in sediments (in-depth and surface level) obtained from six stations in Okenta Alode in Eleme of Rivers State, Nigeria is represented in Table 2.

The concentration of Napthalene in the analyzed sediments ranged from BDL - 1.50E-04 mg/kg. The highest concentration of naphthalene was recorded in the sediment obtained from P1/D/O1 station.

The concentration of acenaphthylene in the analyzed sediments ranged from 1.31E-08 - 1.06E-02 mg/kg. The highest concentration of acenaphthylene was recorded in the sediment obtained from P1/D/O1 station whereas the lowest was observed in P1/D/CO1 station.

The concentration of Acenaphthene in the analyzed sediment samples ranged from 5.71E-07 - 6.14E-04 mg/kg. The highest concentration of Acenaphthene was recorded in *sediment samples obtained* from P2/S/O1 station. The lowest was recorded in P1/S/CO1 station.

The concentration of Fluorene in the sediment samples ranged from 8.03E-07 - 1.21E-01 mg/kg. The highest concentration of Fluorene was recorded in sediment samples collected from P1/D/O1 station whereas the lowest was seen in P1/S/CO1 station.

The concentration of Phenanthrene in the analyzed sediment samples from the present study ranged from 3.38E-08 – 4.97E-03 mg/kg. The highest concentration of Phenanthrene was recorded in sediment samples collected from P1/D/O1 station whereas the lowest was seen in P1/S/CO1 station.

The concentration of Anthracene from the present study ranged from 6.39E-07 - 2.07E-02. The highest concentration of anthracene was observed in *sediment samples obtained from P1/S/O1 station whereas the lowest was seen in P1/D/CO1 station*.

The concentration of Fluoranthene in the sediment samples ranged from BDL - 2.42E-01 mg/kg. The highest concentration of Fluoranthene was recorded in sediment samples extracted from P1/D/O1 station.

Pyrene concentration in the analyzed sediment samples in the present study ranged between BDL - 1.91E-01 mg/kg with the highest concentration seen in sediment samples collected from P2/S/O1 station.

The concentration of Benz (a) anthracene in the sediment samples obtained from the six stations ranged from 3.07E-08 - 2.29E-01. The highest concentration of Benz (a) anthracene was recorded in *sediment obtained from P2/S/O1 station whereas the lowest was observed in P1/S/CO1 station.*

The concentration of Chrysene in the analyzed sediment samples ranged from 1.57E-08 - 7.24E-01 mg/kg. The highest concentration of Chrysene was recorded in *sediment obtained from P2/S/O1 station whereas the lowest was observed in P1/D/CO1 station*.

The concentration of Benzo (b) fluoranthene in the sediment samples analyzed ranged from 2.19E-08 - 8.14E-01 mg/kg with the highest concentration observed in sediment samples collected from P1/D/O1 station and the lowest was shown in P1/D/CO1 station.

Benzo (k) fluoranthene concentration in the analyzed sediment samples from different stations range from 1.89E-08 - 2.94E-01 mg/kg recording the highest concentration in sediment samples extracted from P2/D/O1 station and the lowest was seen in P1/D/CO1 station.

There is no concentration of Benzo(a)pyrene detected in the sediment samples collected from the various stations (BDL).

There is no concentration of Benzo(g,h,i)perylene detected in the sediment samples collected from the various stations (BDL).

The concentration of Dibenz (a,h) anthracene in the present study ranged from 4.93E-08 - 1.133 mg/kg having the highest concentration in sediment samples collected from P1/S/O1 station and the lowest was seen in P1/S/CO1 station.

The concentration of Indeno(1,2,3-cd)pyrene in the analyzed sediment samples ranged from 1.09E-08 - 2.72E-01 mg/kg. The highest concentration of Indeno(1,2,3-cd)pyrene was recorded in sediment samples extracted from P1/D/O1 station whereas the lowest was observed in P1/S/CO1 station.

Σ_2PAHs concentration in the analyzed sediment samples ranged from 4.47E-07 - 1.08E-02 mg/kg with the highest Σ_2PAHs concentration recorded in *sediment samples collected from P1/D/O1 station and the lowest was seen in sediment samples extracted from P1/S/CO1 station*.

Σ_4PAHs concentration in the analyzed sediment samples ranged from 1.82E-06 - 1.32E-01 mg/kg with the highest Σ_4PAHs concentration recorded in *sediment samples collected from P1/D/O1 station and the lowest was seen in sediment samples extracted from P1/S/CO1 station*.
Σ_8PAHs concentration in the analyzed sediment samples ranged from 2.58E-06 - 4.53E-01 mg/kg with the highest Σ_8PAHs concentration recorded in *sediment samples collected from P1/D/O1 station and the lowest was seen in sediment samples extracted from P1/S/CO1 station.*
The concentration of Σ_{16}PAHs in the analyzed sediment samples ranged from 3.20E-06 - 2.40 mg/kg with the highest Σ_{16}PAHs concentration recorded in *sediment samples collected from P2/S/O1 station whereas the lowest was seen in P1/S/CO1 station.*
Σ 2- ring PAHs concentration in the analyzed sediment samples ranged from BDL - 1.50E-04 mg/kg with the highest Σ 2- ring PAHs concentration recorded in *sediment samples extracted from P1/D/O1 station*.
Σ 3- ring PAHs concentration in the analyzed sediment samples ranged from 2.38E-06 – 1.49E-01 mg/kg with the highest Σ 3- ring PAHs concentration recorded in *sediment samples collected from P1/D/O1 station and the lowest was observed in the sediment samples from P1/D/CO1 station*.
Σ 4- ring PAHs concentration in the analyzed sediment samples ranged from 1.96E-07 – 1.14 mg/kg with the highest Σ 4- ring PAHs concentration recorded in *sediment samples obtained from P2/S/O1 station and the smallest was recorded in P1/S/CO1 station*.
Σ 5- ring PAHs concentration in the analyzed sediment samples ranged from 4.08E-08 – 8.69E-01 mg/kg with the highest Σ 5- ring PAHs concentration recorded in sediment samples obtained from P1/D/O1 station and the lowest was observed in P1/D/CO1 station.
Σ 6- ring PAHs concentration in the analyzed sediment samples ranged from 6.02E-08 – 1.39 mg/kg with the highest Σ 6- ring PAHs concentration recorded in sediment samples obtained from P1/S/O1 and the lowest was seen in P1/S/CO1 station.
ΣLMW PAHs concentration in the analyzed sediment samples ranged from 2.54E-06 - 1.49E-01 mg/kg with the highest ΣLMW PAHs concentration recorded in sediment samples obtained from P1/D/O1 station and the lowest was recorded in P1/S/CO1 station.
ΣHMW PAHs concentration in the analyzed sediment samples ranged from 6.60E-07 – 2.39 mg/kg with the highest ΣLMW PAHs concentration recorded in sediment samples obtained from P2/S/O1 station and the lowest was observed in P1/S/CO1 station

Table 2: Concentration of PAHs in Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria

PAHs	Ring No	P1/D/CO1	P1/S/CO1	P1/D/O1	P1/S/O1	P2/D/O1	P2/S/O1	P3/D/O2	P3/S/O2	P4/D/O1	P4/S/O1	P5/D/O1	P5/S/O1
Napthalene	2	6.41E-07	4.94E-09	1.50E-04	-	-	-	1.45E-04	1.34E-05	7.16E-06	-	-	-
Acenaphthylene	3	1.31E-08	4.42E-07	1.06E-02	7.27E-04	1.23E-04	8.41E-04	4.61E-04	2.82E-05	3.81E-06	2.38E-06	8.51E-04	6.13E-05
Acenaphthene	3	7.17E-07	5.71E-07	3.97E-04	4.20E-04	7.86E-05	6.14E-04	4.97E-05	1.70E-05	3.88E-06	9.83E-06	4.55E-04	1.96E-05
Fluorene	3	9.25E-07	8.03E-07	1.21E-01	2.08E-02	8.97E-03	3.67E-03	2.20E-04	3.45E-04	1.41E-06	3.59E-05	1.38E-02	4.30E-06
Phenanthrene	3	8.60E-08	3.38E-08	4.97E-03	4.21E-04	2.87E-03	1.26E-03	6.43E-04	1.73E-06	1.48E-05	2.01E-06	6.50E-04	7.58E-05
Anthracene	3	6.39E-07	6.81E-07	1.20E-02	2.07E-02	6.68E-05	1.11E03	7.92E-04	2.49E-06	3.85E-04	1.69E-06	1.07E-02	1.58E-05
Fluoranthene	4	3.52E-09	1.96E-08	2.42E-01	-	2.14E-04	2.96E-04	1.90E-02	1.32E-05	6.25E-05	4.62E-05	8.10E-03	3.66E-05
Pyrene	4	7.56E-07	1.99E-08	6.21E-02	-	1.04E-01	1.91E-01	4.21E-02	3.24E-06	1.74E-04	2.59E-06	1.89E-01	3.42E-02
Benz(a)anthracene	4	4.82E-07	3.07E-08	9.54E-02	2.08E-01	7.13E-02	2.29E-01	3.66E-02	7.15E-06	7.72E-04	1.28E-05	1.66E-01	1.22E-02
Chrysene	4	1.57E-08	1.26E-07	8.77E-02	4.01E-01	4.26E-01	7.24E-01	1.74E-02	6.31E-04	2.73E-04	1.50E-04	6.42E-02	6.08E-02
Benzo(b)fluoranthene	5	2.19E-08	3.44E-07	8.14E-01	1.59E-01	2.37E-01	3.05E-01	2.43E-02	1.20E-03	2.79E-04	6.44E-04	8.58E-02	2.62E-02
Benzo(k)fluoranthene	5	1.89E-08	5.93E-08	5.51E-02	1.73E-01	2.94E-01	9.48E-02	7.47E-03	4.17E-04	1.33E-04	1.52E-04	6.41E-02	2.95E-02
Benzo(a)pyrene	5												
Benzo(g,h,i)perylene	6												
Dibenz(a,h)anthracene	6	5.71E-07	4.93E-08	3.07E-01	1.133	8.65E-01	6.36E-01	9.58E-01	5.06E-02	2.09E-02	3.13E-02	6.70E-01	5.08E-04
Indeno(1,2,3-cd)pyrene	6	1.83E-07	1.09E-08	2.72E-01	2.56E-01	1.58E-01	2.14E-01	2,63E-01	1.15E-02	5.35E-03	1.14E-02	9.88E-02	4.67E-05
Σ_2PAHs		6.54E-07	4.47E-07	1.08E-02	7.27E-04	1.23E-04	8.41E-04	6.06E-04	4.16E-05	1.10E-05	2.38E-06	8.51E-04	6.13E-05
Σ_4PAHs		2.30E-06	1.82E-06	1.32E-01	2.19E-02	9.17E-03	5.13E-03	8.76E-04	4.04E-04	1.63E-05	4.81E-05	1.51E-02	8.52E-05
Σ_8PAHs		3.78E-06	2.58E-06	4.53E-01	4.31E-02	1.16E-01	0.20	6.34E-02	4.24E-04	6.53E-04	1.01E-04	2.24E-01	3.44E-02
Σ_{16}PAHs		5.07E-06	3.20E-06	2.08	2.37	2.17	2.40	1.11	6.48E-02	2.84E-02	4.38E-02	1.37	1.64E-01
Σ 2- ring PAHs		6.41E-07	4.94E-09	1.50E-04				1.45E-04	1.34E-05	7.16E-06			
Σ 3- ring PAHs		2.38E-06	2.53E-06	1.49E-01	4.31E-02	1.21E-02	0.01	2.17E-03	3.94E-04	4.09E-04	5.18E-05	2.65E-02	1.77E-04
Σ 4- ring PAHs		1.26E-06	1.96E-07	4.87E-01	6.09E-01	6.02E-01	1.14	1.15E-01	6.55E-04	1.28E-03	2.12E-04	4.27E-01	1.07E-01
Σ 5- ring PAHs		4.08E-08	4.03E-07	8.69E-01	3.32E-01	5.31E-01	4.00E-01	3.18E-02	1.62E-03	4.12E-04	7.96E-04	1.50E-01	5.57E-02
Σ 6- ring PAHs		7.54E-07	6.02E-08	5.79E-01	1.39	1.02	8.50E-01	9.58E-01	6.21E-02	2.63E-02	4.27E-02	7.69E-01	5.55E-04
ΣLMW		3.02E-06	2.54E-06	1.49E-01	4.31E-02	1.21E-02	0.01	2.31E-03	4.08E-04	4.16E-04	5.18E-05	2.65E-02	1.77E-04
ΣHMW		2.05E-06	6.60E-07	1.94	2.33	2.16	2.39	1.10	6.44E-02	2.79E-02	4.37E-02	1.35	1.63E-01

3.3 Composition Profile (%) of PAHs in Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria.

The Composition Profile (%) of PAHs in sediments (in-depth and surface level) obtained from six stations in Okenta Alode in Eleme of Rivers State, Nigeria is represented in Table 3. The composition profile of Napthalene in the analyzed sediments ranged from BDL - 12.635 %. The highest composition profile of naphthalene was recorded in the sediment samples obtained from P1/D/CO1 station.

The composition profile of acenaphthylene in the analyzed sediments ranged from 0.005 - 13.832 %. The highest composition profile of acenaphthylene was recorded in the sediment obtained from P1/S/CO1 station whereas the lowest was observed in P4/S/O1 station.

The composition profile of Acenaphthene in the analyzed sediment samples ranged from 0.004 - 17.869 %. The highest was recorded in *sediment samples obtained* from P1/S/CO1 station. The lowest was recorded in P2/D/O1 and P3/D/O2 stations.

The composition profile of Fluorene in the sediment samples ranged from 3.30E-04 - 25.130 %. The highest was recorded in sediment samples collected from P1/S/CO1 station whereas the lowest was seen in P2/S/O1 station.

The composition profile of Phenanthrene in the analyzed sediment samples from the present study ranged from 1.13E-04 – 1.695 %. The highest was recorded in sediment samples collected from P1/D/CO1 station whereas the lowest was seen in P2/S/O1 station.

The composition profile of Anthracene from the present study ranged from 9.98E-05 - 21.312 %. The highest was observed in *sediment samples obtained from P1/S/CO1 station whereas the lowest was seen in P2/S/O1 station*.

The composition profile of Fluoranthene in the sediment samples ranged from BDL - 11.610 %. The highest composition profile of Fluoranthene was recorded in sediment samples extracted from P1/D/O1 station.

Pyrene composition profile in the analyzed sediment samples in the present study ranged between BDL - 20.896 % with the highest composition profile seen in sediment samples collected from P5/S/O1 station.

The composition profile of Benz (a) anthracene in the sediment samples obtained from the six stations ranged from 0.011 - 12.095 %. The highest was recorded in *sediment obtained from P5/D/O1 station whereas the lowest was observed in P3/S/O2 station.*

The composition profile of Chrysene in the analyzed sediment samples ranged from 6.51E-02 – 37.148 %. The highest was recorded in *sediment obtained from P5/S/O1 station whereas the lowest was observed in P2/S/O1 station.*

The composition profile of Benzo (b) fluoranthene in the sediment samples analyzed ranged from 2.74E-02 - 39.052 % with the highest concentration observed in sediment samples collected from P1/D/O1 station and the lowest was shown in P2/S/O1 station.

Benzo (k) fluoranthene composition profile in the analyzed sediment samples from different stations range from 8.52E-03 - 18.024 % recording the highest composition profile in sediment samples was extracted from P5/S/O1 station and the lowest was seen in P2/S/O1 station.

There is no concentration of Benzo(a)pyrene detected in the sediment samples collected from the various stations (BDL). Hence, no composition profile calculated for it.

There is no concentration of Benzo(g,h,i)perylene detected in the sediment samples collected from the various stations (BDL). Hence, no composition profile calculated for it.

The composition profile of Dibenz (a,h) anthracene in the present study ranged from 0.310 - 86.526 % having the highest composition profile in sediment samples collected from P3/D/O2 station and the lowest was seen in P5/S/O1 station.

The composition profile of Indeno(1,2,3-cd)pyrene in the analyzed sediment samples ranged from 1.92E-02 - 26.052 %. The highest was recorded in sediment samples extracted from P4/S/O1 station whereas the lowest was observed in P2/S/O1 station.

Σ 2- ring PAHs composition profile in the analyzed sediment samples ranged from BDL – 12.635 % with the highest Σ 2- ring PAHs composition profile recorded in *sediment samples extracted from P1/D/CO1 station.*

Σ 3- ring PAHs composition profile in the analyzed sediment samples ranged from 6.74E-04 – 79.200 % with the highest Σ 3- ring PAHs composition profile recorded in *sediment samples collected from P1/S/CO1 station and the lowest was observed in the sediment samples from P2/S/O1 station.*

Σ 4- ring PAHs composition profile in the analyzed sediment samples ranged from 1.03E-01 – 65.521 % with the highest Σ 4- ring PAHs composition profile recorded in *sediment samples obtained from P5/S/O1 station and the smallest was recorded in P2/S/O1 station.*

Σ 5- ring PAHs composition profile in the analyzed sediment samples ranged from 3.59E-02 41.695 % with the highest Σ 5- ring PAHs composition profile recorded in sediment samples obtained from P1/D/O1 station and the lowest was observed in P2/S/O1 station.

Σ 6- ring PAHs composition profile in the analyzed sediment samples ranged from 7.64E-02 – 1110.280 % with the highest Σ 6- ring PAHs composition profile recorded in sediment samples obtained from P3/D/O2 and the lowest was seen in P2/S/O1 station.

ΣLMW PAHs composition profile in the analyzed sediment samples ranged from 6.74E-04 - 79.355 % with the highest ΣLMW PAHs composition profile recorded in sediment samples obtained from P1/S/CO1 station and the lowest was recorded in P2/S/O1 station.

ΣHMW PAHs composition profile in the analyzed sediment samples ranged from 2.15E-01 – 123.545 % with the highest Σ 6- ring PAHs composition profile recorded in sediment samples obtained from P3/D/O2 and the lowest was seen in P2/S/O1 station.

Table 3: Composition Profile (%) of PAHs in Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria

PAHs	Ring No	P1/D/CO1	P1/S/CO1	P1/D/O1	P1/S/O1	P2/D/O1	P2/S/O1	P3/D/O2	P3/S/O2	P4/D/O1	P4/S/O1	P5/D/O1	P5/S/O1
Napthalene	2	12.635	0.155	0.007				0.013	0.021	0.025			
Acenaphthylene	3	0.258	13.832	0.509	0.031	0.006	7.56E-05	0.042	0.044	0.013	0.005	0.062	0.037
Acenaphthene	3	14.133	17.869	0.019	0.018	0.004	5.52E-05	0.004	0.026	0.014	0.022	0.033	0.012
Fluorene	3	18.233	25.130	5.805	0.877	0.414	3.30E-04	0.020	0.533	0.005	0.082	1.005	0.003
Phenanthrene	3	1.695	1.058	0.238	0.018	0.132	1.13E-04	0.058	0.003	0.052	0.005	0.047	0.046
Anthracene	3	12.596	21.312	0.576	0.872	0.003	9.98E-05	0.072	0.004	1.358	0.004	0.780	0.010
Fluoranthene	4	0.069	0.613	11.610		0.010	2.66E-05	1.716	0.020	0.220	0.106	0.590	0.022
Pyrene	4	14.902	0.623	2.979		4.798	1.72E-02	3.802	0.005	0.614	0.006	13.771	20.896
Benz(a)anthracene	4	9.501	0.961	4.577	8.765	3.289	2.06E-02	3.306	0.011	2.722	0.029	12.095	7.454
Chrysene	4	0.309	3.943	4.207	16.898	19.653	6.51E-02	1.572	0.974	0.963	0.343	4.678	37.148
Benzo(b)fluoranthene	5	0.432	10.765	39.052	6.700	10.934	2.74E-02	2.195	1.852	0.984	1.472	6.252	16.008
Benzo(k)fluoranthene	5	0.373	1.856	2.643	7.290	13.563	8.52E-03	0.675	0.644	0.469	0.347	4.670	18.024
Benzo(a)pyrene	5												
Benzo(g,h,i)perylene	6												
Dibenz(a,h)anthracene	6	11.255	1.543	14.728	47.744	39.905	5.72E-02	86.526	78.111	73.696	71.527	48.818	0.310
Indeno(1,2,3-cd)pyrene	6	3.607	0.341	13.049	10.788	7.289	1.92E-02	23.754	17.753	18.865	26.052	7.199	0.029
Σ 2- ring PAHs		12.635	0.155	0.007				0.013	0.021	0.021			
Σ 3- ring PAHs		46.916	79.200	7.147	1.815	0.559	6.74E-04	0.196	0.609	0.609	0.118	1.928	0.108
Σ 4- ring PAHs		24.782	6.140	23.373	25.663	27.750	1.03E-01	10.396	1.010	1.010	0.484	31.134	65.521
Σ 5- ring PAHs		0.804	12.621	41.695	13.990	24.497	3.59E-02	2.869	2.496	2.496	1.819	10.922	34.032
Σ 6- ring PAHs		14.863	1.884	27.778	58.532	47.195	7.64E-02	110.280	95.864	95.864	97.579	56.016	0.339
ΣLMW		59.551	79.355	7.154	1.815	0.559	6.74E-04	0.209	0.630	0.630	0.118	1.928	0.108
ΣHMW		40.449	20.645	92.846	98.185	99.441	2.15E-01	123.545	99.370	99.370	99.882	98.072	99.892

3.8: Concentration of Total Petroleum Hydrocarbon (TPH) for Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria.

The mean concentration of total petroleum hydrocarbons (TPH) (mg/kg) from n-C8 to n-C40 in sediment samples obtained from six stations (in-depth and surface level) (P1/D/CO1, P1/S/CO1, P1/D/O1, P1/S/O1, P2/D/O1, P2/S/O1, P3/D/O2, P3/S/O2, P4/D/O1, P4/S/O1, P5/D/O1 and P5/S/O1) obtained from different stations in Alode Okenta in Eleme of Rivers State, Nigeria is shown in Table 4. The results presented showed that the average concentrations of the TPH in the stations descended in the order P2/S/O1 > P1/S/O1 > P2/D/O1 > P1/D/O1 > P5/D/O1 > P3/D/O2 > P3/S/O2 > P4/S/O1 > P1/S/CO1 > P1/D/CO1.

The mean concentration of TPH components obtained from P1/D/CO1 station in the analyzed sediment samples ranged from 8.81E-09 – 1.83E-03 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Pentatriacontane (n-C_{35}), meanwhile, the lowest concentration was observed in Octadecane (n-C_{18}). The average TPH components obtained for P1/D/CO1 station is 1.33E-04 and the total recorded for all the TPH components in P1/D/CO1 is 0.004.

The mean concentration of TPH components obtained from P1/S/CO1 station in the analyzed sediment samples ranged from BDL – 5.01E-03 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Octatriacontane (n-C_{38}). The average TPH components obtained for P1/S/CO1 station is 2.53E-04 and the total recorded for all the TPH components in P1/S/CO1 is 0.008.

The mean concentration of TPH components obtained from P1/D/O1 station in the analyzed sediment samples ranged from BDL – 34.398 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Heneicosane (n-C_{21}). The average TPH components obtained for P1/D/O1 station is 7.061 and the total recorded for all the TPH components in P1/D/O1 is 218.887.

The mean concentration of TPH components obtained from P1/S/O1 station in the analyzed sediment samples ranged from BDL – 49.026 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Heptatriacontane (n-C_{37}). The average TPH components obtained for P1/S/O1 station is 8.304 and the total recorded for all the TPH components in P1/S/O1 is 249.125.

The mean concentration of TPH components obtained from P2/D/O1 station in the analyzed sediment samples ranged from BDL – 41.753 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Nonatriacontane (n-C_{39}). The average TPH components obtained for P2/D/O1 station is 7.341 and the total recorded for all the TPH components in P2/D/O1 is 227.571.

The mean concentration of TPH components obtained from P2/S/O1 station in the analyzed sediment samples ranged from BDL – 72.892 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Heneicosane (n-C_{21}). The average TPH components obtained for P2/S/O1 station is 9.654 and the total recorded for all the TPH components in P2/S/O1 is 289.624.

The mean concentration of TPH components obtained from P3/D/O2 station in the analyzed sediment samples ranged from BDL – 65.468 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Octatriacontane (n-C_{38}). The average TPH components obtained for P3/D/O2 station is 4.643 and the total recorded for all the TPH components in P3/D/O2 is 143.929.

The mean concentration of TPH components obtained from P3/S/O2 station in the analyzed sediment samples ranged from BDL – 2.387 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Octatriacontane (n-C_{38}). The average TPH components obtained for P3/S/O2 station is 0.206 and the total recorded for all the TPH components in P3/S/O2 is 6.811.

The mean concentration of TPH components obtained from P4/D/O1 station in the analyzed sediment samples ranged from BDL – 5.42E-01 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Hexatriacontane (n-C_{36}). The average TPH components obtained for P4/D/O1 station is 0.093 and the total recorded for all the TPH components in P4/D/O1 is 2.975.

The mean concentration of TPH components obtained from P4/S/O1 station in the analyzed sediment samples ranged from BDL – 1.136 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Hexatriacontane (n-C_{36}). The average TPH components obtained for P4/S/O1 station is 0.153 and the total recorded for all the TPH components in P4/S/O1 is 4.600.

The mean concentration of TPH components obtained from P5/D/O1 station in the analyzed sediment samples ranged from BDL – 30.789 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Nonatriacontane (n-C_{39}). The average TPH components obtained for P5/D/O1 station is 4.805 and the total recorded for all the TPH components in P5/D/O1 is 144.152.

The mean concentration of TPH components obtained from P5/S/O1 station in the analyzed sediment samples ranged from BDL – 2.960 mg/kg. The highest concentration of TPH component in the analyzed sediment samples was recorded in Heneicosane (n-C_{21}). The average TPH components obtained for P5/S/O1 station is 0.560 and the total recorded for all the TPH components in P5/S/O1 is 16.815.

Table 4: Concentration of TPH for Sediments Obtained from Okenta Alode in Eleme, Rivers state, Nigeria

TPH	P1/D/CO1	P1/S/CO1	P1/D/O1	P1/S/O1	P2/D/O1	P2/S/O1	P3/D/O2	P3/S/O2	P4/D/O1	P4/S/O1	P5/D/O1	P5/S/O1
Decane (n-C_{10})	4.44E-07	-	-	-	-	-	-	6.83E-04	-	-	-	-
Undecane (n-C_{11})	9.77E-07	9.60E-08	3.49E-03	-	-	-	2.91E-03	2.07E-04	8.72E-05	-	-	-
Dodecane (n-C_{12})	1.84E-08	2.02E-08	-	1.30 E-02	4.90E-03	2.08E-02	-	1.78E-05	1.64E-05	4.06E-05	-	7.88E-04
Tridecane (n-C_{13})	2.04E-07	4.44E-07	3.48E-02	3.04E-02	3.80E-03	1.08E-02	3.74E-03	2.73E-03	8.37E-05	-	1.21E-03	5.09E-04
Tetradecane (n-C_{14})	1.56E-08	1.03E-07	2.26E-02	7.40E-03	1.76E-03	-	9.21E-04	5.59E-05	4.37E-05	1.65E-04	5.82E-03	2.24E-04
Pentadecane (n-C_{15})	4.08E-08	4.01E-08	4.53E-01	1.42E-02	3.05E-02	1.56E-02	1.53E-02	5.62E-05	2.60E-04	4.37E-04	1.37E-03	1.80E-03
Hexadecane (n-C_{16})	1.83E-08	1.84E-08	5.22E-02	1.21E-02	4.55E-02	1.99E-02	3.03E-03	1.91E-04	1.44E-04	5.47E-04	2.99E-03	1.44E-03
Heptadecane (n-C_{17})	8.13E-07	2.12E-08	1.81E-01	4.00E-03	5.97E-03	1.32E-02	9.22E-04	4.37E-05	1.48E-05	2.91E-04	9.29E-04	7.59E-04
Pristane	1.39E-08	1.55E-08	8.81E-02	6.08E-02	4.33E-01	1.738	7.25E-03	6.07E-06	9.94E-04	1.32E-04	7.74E-02	1.43E-02
Octadecane (n-C_{18})	8.81E-09	2.00E-07	3.15E-01	3.86E-03	4.44E-02	2.61E-02	7.85E-03	8.00E-05	3.57E-05	2.30E-04	1.80E-03	6.80E-05
Phytane	3.7E-08	9.04E-08	5.320	1.23E-02	2.91E-02	1.51E-01	1.40E-02	3.85E-04	6.04E-05	3.42E-04	1.44E-02	-
Nonadecane (n-C_{19})	3.97E-08	2.28E-07	11.077	1.85E-01	6.77E-01	2.91E-01	5.82E-03	1.83E-04	1.36E-03	4.79E-04	1.03E-01	3.08E-02
Eicosane (n-C_{20})	2.41E-07	4.47E-06	15.808	-	12.091	8.200	2.67E-02	2.41E-05	1.08E-04	9.01E-04	2.93E-01	8.69E-01
Heneicosane (n-C_{21})	1.43E-07	1.01E-05	34.398	1.569	3.114	72.892	1.36E-01	1.82E-04	1.12E-02	9.69E-05	7.32E-01	2.960
Docosane (n-C_{22})	3.95E-06	2.41E-06	22.022	5.052	27.106	46.885	9.12E-01	1.56E-03	3.69E-03	3.26E-04	11.064	2.706
Tricosane (n-C_{23})	1.73E-04	9.35E-05	8.756	18.066	14.427	7.912	6.65E-01	2.61E-02	1.17E-02	3.86E-03	2.798	1.319
Tetracosane (n-C_{24})	7.75E-07	6.20E-05	3.370	2.945	9.093	11.418	3.53E-01	6.91E-03	1.74E-02	8.85E-03	1.464	3.87E-05
Pentacosane (n-C_{25})	3.85E-08	8.51E-07	4.766	3.107	11.676	3.596	1.40E-01	5.78E-03	1.95E-03	5.19E-03	3.576	3.72E-01
Hexacosane (n-C_{26})	1.08E-05	1.08E-06	8.820	11.547	10.866	10.034	1.86E-01	6.47E-03	2.58E-03	1.40E-02	5.011	9.64E-01
Heptacosane (n-C_{27})	2.41E-05	3.76E-05	3.422	3.034	2.956	2.198	4.82E-01	1.69E-02	1.99E-03	1.37E-02	8.40E-01	4.21E-01
Octacosane (n-C_{28})	2.75E-04	4.72E-04	1.561	5.628	6.849	7.483	6.35E-01	5.98E-02	1.06E-02	3.65E-02	2.137	5.05E-01
Nonacosane (n-C_{29})	12.17E-05	3.75E-05	10.805	8.838	2.748	8.155	2.71E-01	5.83E-02	7.32E-03	1.05E-02	2.056	2.68E-01
Triacontane (n-C_{30})	5.14E-05	1.07E-05	5.035	6.443	6.031	4.867	5.28E-01	1.17E-01	2.34E-02	1.83E-02	3.053	3.27E-02
Hentriacontane (n-C_{31})	6.13E-05	2.78E-06	2.796	3.449	3.150	3.190	3.80E-01	1.87E-01	2.73E-02	8.54E-03	2.941	4.96E-03
Dotriacontane (n-C_{32})	6.57E-06	2.23E-7	6.649	3.794	4.612	5.916	5.547	2.01E-02	6.84E-02	2.17E-01	1.105	6.08E-04
Tritriacontane (n-C_{33})	5.18E-07	8.68E-04	8.774	8.649	2.960	6.164	6.17E-01	2.01E-02	8.43E-03	1.34E-02	3.318	3.78E-03
Tetratriacontane (n-C_{34})	7.67E-05	8.57E-05	6.362	9.912	8.434	7.348	13.722	6.69E-01	2.24E-01	5.06E-01	5.730	2.32E-01
Pentatriacontane (n-C_{35})	18.34E-04	2.15E-04	8.089	31.187	22.193	25.234	8.869	6.01E-02	3.65E-01	7.44E-01	11.305	8.42E-01
Hexatriacontane (n-C_{36})	13.03E-05	4.47E-04	6.850	12.207	3.952	5.095	2.291	7.42E-02	5.42E-01	1.136	2.682	1.776
Heptatriacontane (n-C_{37})	4.18E-05	5.80E-05	14.543	49.026	3.488	24.387	5.131	1.091	2.08E-01	2.96E-01	15.385	7.03E-01
Octatriacontane (n-C_{38})	3.79E-04	5.01E-03	2.609	39.554	18.612	7.472	65.468	2.387	5.76E-01	3.61E-01	18.095	1.01E-01
Nonatriacontane (n-C_{39})	4.90E-04	5.41E-04	20.164	9.418	41.753	16.469	33.987	1.721	5.69E-01	1.005	30.789	1.917
n-C_{40}	7.14E-04	1.47E-04	5.741	15.357	10.184	2.423	3.521	2.78E-01	2.92E-01	1.98E-01	19.569	7.67E-01
Average	1.33E-04	2.53E-04	7.061	8.304	7.341	9.654	4.643	0.206	0.093	0.153	4.805	0.560
Total	0.004	0.008	218.887	249.125	227.571	289.624	143.929	6.811	2.975	4.600	144.152	16.815

3.12: Concentrations of THC and TON in the Sediment samples obtained from Okenta Alode in Eleme, Rivers state, Nigeria

The concentration of total hydrogen contents (THC) and total organic nitrogen (TON) (mg/kg) in sediments (in-depth and surface level) obtained from six stations in Okenta Alode in Eleme of Rivers State, Nigeria is shown in Table 5. The results presented showed that *the average THC and TON concentration in the sampled stations were in the decreasing order of* P4/D/O1 > P1/D/O1 > P2/D/O1 > P2/S/O1 > P4/S/O1 > P1/S/O1 > P5/S/O1 > P5/D/O1 > P3/D/O2 > P1/D/CO1 > P1/S/CO1 > P3/S/O2 and P1//S/CO1 > P1/D/CO1 > P1/S/O1 > P5/D/O1 > P4/S/O1 > P1/D/O1> P3/D/O2 > P3/S/O2 > P2/S/O1 > P4/D/O1 > P5/S/O1 > P2/D/O1 for THC and TON respectively.

The concentration of THC in the analyzed in-depth and surface sediment samples obtained from the stations ranged from 129.000 - 397.012 mg/kg. The highest concentration of THC in the analyzed sediment samples was recorded in sediment sample obtained from P4/D/O1 station, meanwhile, the lowest concentration of THC was recorded in sediment sample obtained from P3/S/O2 station.

The concentration of TON in the analyzed in-depth and surface sediment samples obtained from the stations ranged from 0.024 - 1.057 mg/kg. The highest concentration of TON in the analyzed sediment samples was recorded in sediment sample obtained from P1/S/CO1 station, meanwhile, the lowest concentration of TON was recorded in sediment sample obtained from P2/D/O1 station

Table 5: Concentrations of THC and TON in the Sediment samples obtained from Okenta Alode in Eleme, Rivers state, Nigeria

SAMPLES	THC (mg/kg)	TON (%)
P1/D/CO1	141.900	1.054
P1/S/CO1	134.400	1.057
P1/D/O1	391.500	0.040
P1/S/O1	232.200	0.088
P2/D/O1	384.100	0.024
P2/S/O1	303.100	0.030
P3/D/O2	191.901	0.040
P3/S/O2	129.000	0.040
P4/D/O1	397.012	0.030
P4/S/O1	256.111	0.054
P5/D/O1	192.200	0.071
P5/S/O1	229.300	0.030

4. DISCUSSIONS.

4.1 Concentration of Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment from Okenta Alode Stations in Eleme, Rivers State

The concentration of PAHs in the sediments extracted from six selected stations (crude oil polluted and remediated areas for control) in Rivers State. A total of 14 sediment samples were analyzed for 16 USEPA priority PAHs. The mean concentrations of total 16 PAHs (**Σ** 16PAHs) and 8 carcinogenic PAHs (**Σ** 8- carPAHs) are summarized in Table 2. The mean concentrations of individual PAHs, in decreasing order, were as follows: DBA > Chr > BbFL > Ind > BaA > BkFL > Pyr > Fl > Flu > Ant > AcPY > Phen > AcP > NaP.

The ∑16PAHs concentrations ranged from 3.20E-06 - 2.40 mg/kg with a mean value of 1.01. The highest ∑16PAHs concentration was recorded in the sediment extracted from P2/S/O1 station and the lowest was observed in the sediment from P1/S/CO1 (surface sediment control). The concentrations of ∑16PAHs showed little or no variability with the highest value slightly higher than the lowest value, indicating that the levels of PAHs did not vary greatly between sediments across stations that were sampled.

∑8-carPAHs ranged from 2.58E-06 – 0.20 mg/kg with the highest seen in sediment extracted from P2/S/O1 station and the lowest was observed in the sediment from P1/S/CO1 (surface sediment control). This almost accounted for over 55 % of the total PAHs concentrations, and the mean concentration of ∑8-carPAHs was 0.09 mg/kg.

The average concentrations of 16 PAHs in the analyzed sediment 1.01 mg/kg. The highest PAH concentrations for sediment was recorded in the sediment extracted from P2/S/O1 station which is an area with more activities of crude oil theft, pipeline vandalization and spillage of crude oil into the environment and water bodies. The observed PAH contamination levels in the analyzed sediments from the present study were lower than those reported from other studies in the YRDR (397 ng/g) 9310.6 ng/g) in the concentrations of PAHs in the sediments from the present study were much lower than the values reported in Sydney in Australia (335 - 8645 ng/g) and closer to the sediment concentrations reported in Viseu in Portugal (169 ng/g) Furthermore, the concentration of PAHs in the analyzed sediment disputed concentrations of PAHs obtained in the study of Wang *et al.*, 2016 who reported higher concentration of PAHs (471.30 ng/g) in the study on Contamination and health risk assessment of PAHs in sediments and crops in industrial areas of the Yangtze River Delta region, China. This high concentration of PAHs observed in these reported studies study may be attributed to the practice of generating singed meat through burning of tires. The PAHs from this burning episodes' deposit on surfaces as well as sediments, which is also absorbed into the in-depth sediments in the event of rainfalls. There is also the gradual absorption of the wastewater used in the sediments on cleaning surfaces which eventually accumulates thereby resulting in the elevation of PAHs in the sediment. Sediment properties (organic pools), environmental conditions (e.g. temperature and rainfall) and history of industrial activity may explain the differences in PAH contamination levels among contaminated sites worldwide. The concentrations of PAHs in the sediment from this present study disagreed with the 932 ng/g reported by Wang *et al* in the Contamination and human health risks of polycyclic aromatic hydrocarbons in surface sediments from Tianjin coastal new region, China which reported higher PAHs concentration when compared to the concentration of PAHs in the present study.

Furthermore, the levels of PAHs from the current study corroborated with the study of He et al who reported similar concentration of PAHs in the study Distribution, sources and ecological risk assessment of PAHs in surface sediments from Guan River Estuary, China. In addition, the present study supported the study of Filho et al [29] in Saco do Laranjal in Brazil who reported similar PAHs concentration. However, the PAHs concentrations in the sediments in this present study were higher than the study of Cheng et al who reported lower PAHs concentration when compared to the present study. The high concentration of PAHs in these reported studies may be attributed to the high waste generation, vehicular movements, the use of tyres to burn meat; feces from animals all tend to elevate the level of PAHs in the environment therefore amounting to high PAHs concentrations.

4.2 Composition Profiles of Polycyclic Aromatic Hydrocarbon (PAHs) in Sediment from Okenta Alode Stations in Eleme, Rivers State

The composition profiles of PAHs aids in the estimation of the contribution of individual PAHs and the different ring numbers to the total PAHs concentration in the sediments. The percentage composition profile of the individual PAHs and ring numbers present in sediments from six selected stations in Okenta Alode in Eleme of Rivers State is represented in Table 3. Dibenz(a,h)anthracene contributed the highest percentage composition profile of PAHs with 86.526 % recorded in sediment collected from P3/D/O2 station. Dibenz(a,h)anthracene contributed second highest percentage composition profile of in the contribution of individual PAHs with 78.111 % in sediment obtained from P3/S/O2 station. Cumulatively, Dibenz(a,h)anthracene contributed the highest percentage composition profile of PAHs recording 474.223 %, followed by Indeno(1,2,3-cd)pyrene 128.744 % respectively. The individual 6-ring PAHs contributed the highest percentage composition profile of PAH with 110.280 % recorded in sediment obtained from P3/D/O2 station followed by 6-ring PAHs with 97.579 % observed in P4/S/O1 station. In addition, cumulatively, 6-ring PAHs registered the highest contribution to the total PAHs with 606.269 % followed by 4-ring PAHs 217.366 %. For the molecular weight PAHs, the Individual High molecular weight (HMW) PAHs contributed the highest 123.545 % recorded in the sediment obtained from P3/D/O2 station, however, the cumulative percentage composition profile of the molecular weight PAHs was highest in HMW PAHs (971.914).

4.7 Level of Total Petroleum Hydrocarbons (TPHs) in Sediment from Okenta Alode Stations in Eleme, Rivers State

Rivers State of Nigeria over the years has been embroiled in numerous cases of crude oil drillings via companies and artisanal refineries, spills and illicit pipeline bunkering, crude oil, its fractional derivatives and gas pipeline vandalization, massive gas fares, hydrocarbon installation fire outbreaks, refinery operations, these activities are known to release toxic gaseous hydrocarbons into the atmosphere [18], related emissions from associated-petroleum industries include automobiles, coastal marine transportation, homes, and manufacturing industries utilizing diesel generators, burn-pits also account for total petroleum hydrocarbon (TPH) concentration in the atmosphere [19, 20]. All the releases in the atmosphere undergo chemical interactions, several induced or natural chemical processes such as volatilization, photo-oxidation, and biodegradation, which combine with air moisture before atmospheric rainfall deposition impacting soil, sediment and surface water quality [19]. The in-depth and surface level sediments of the present study area is known to be laden with conjugated and straight-chain hydrocarbon [19], most of which come from atmospheric deposition via air and rainfall.

4.9 Concentrations of THC and TON in the Sediment samples obtained from Okenta Alode in Eleme, Rivers state, Nigeria

4.9.1 Total Hydrogen Content (THC)

Total hydrocarbon content is used to describe the quantity of the measured hydrocarbon impurities present. Usually expressed as methane equivalents. The degree of contamination due to the presence of total hydrocarbon contents in the soil sediments from Gokana local government, Ogoni are shown in Table 4. The results show that the total hydrocarbon contents were 391.500,384.100,191.901,397.012 and 192.200 mg/kg for P1/D/O1, P2/D/O1, P3/D/O2, P4/D/O1 and P5/D/O1 respectively. The above results were precisely for samples obtained at an in-depth level of 15–30cm. The samples obtained at this depth tend to possess higher concentrations when compared to those obtained at the surface level (0-15cm). However, station 5 did not follow the trends, as it was observed that surface level sample (P5/S/O1) gave higher concentration (229.300mg/kg) of total hydrocarbon contents when compared to the in-depth level (P5/D/O1) which gave a concentration of 197.200mg/kg of THC. The surface level samples are in the order of P3/S/O2 (129.000mg/kg) > P5/S/O1 (229.300mg/kg) > P1/S/O1 (232.200mg/kg) > P4/S/O1 (256.111mg/kg) > P2/S/O1 (303.100mg/kg). The values obtained from the control samples are 134.400 and 141.900mg/kg for P1/S/CO1 and P1/D/CO1 respectively. Also, it was observed that P3/S/O2 (129.000mg/kg) gave THC value that is lower than the control samples. The results obtained from this study were lower compared to the study done by Nwankwo et al [21] in evaluating soil contamination due to the spillage of crude in Akinima, Rivers state.

4.9.2 Total Hydrogen Content (THC)

The total organic nitrogen is the sum of nitrate (NO_3), nitrite (NO_2), organic nitrogen and ammonia (all expressed as N). The values obtained by the control samples are quite like the surface level (P1/D/CO1**)** sample and the in-depth (P1/S/CO1) sample. P1/S/O1 gave the highest TON concentration of 0.088mg/kg, followed by P5/D/CO1 which gave a value of 0.071mg/kg. Also, P5/S/O1, P4/D/O1 and P2/S/O1 all gave same TON value of 0.030mg/kg. Furthermore, station 3(P3/D/O1 and P3/S/O1) gave same TON value irrespective of the sampling depth. TON results from this study did not follow any trend just like TPH, PAHs and THC which concentrations increase as their sampling depth increases. However, P2/D/O1 gave the lowest TON concentrations from the study. In conclusion, it can be said that the low TON values obtain from the results can be attributed to high concentration of TPH and THC values experience in the various soil sediments.

5. CONCLUSIONS

The sediments showed low variations in the PAHs, TPH, THC and TON components and the sources of the PAHs are mainly from petroleum sources as revealed by the PAHs sources determination. There was no non-carcinogenic and carcinogenic risk posed to the populace as a result of PAHs contamination. However, there could be carcinogenic risk resulting from TPH contamination since they exceeded their permissible limits in most of the analyzed stations. The result of this study suggest that these sediments may be contaminated with PAHs, TPH and THC

and has reduced TON due to hydrocarbon contamination which may reduce plant growth in the study area. These contaminations resulting from hydrocarbons may result to deleterious health effects to the exposed populace.

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