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Concentration of Polycyclic Aromatic Hydrocarbons (PAHs) in the Surface Water of Elechi Creek, Rivers State.

By
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Abstract
Polycyclic aromatic hydrocarbons (PAHs) also known as polynuclear aromatic hydrocarbons are class of organic chemical consisting of two or more fused aromatic rings. The concentration of PAHs in surface water of Elechi Creek River State detected the 16 priority PAHs outlined by WHO (2003) and USEPA (2007) at three stations namely:, NAPAS Company (POD)(S1), Master Energy (S2) and New Calabar River (S3). PAHs were extracted using the Liquid-Liquid Extraction method and their concentration were determined with the use of No:HP 5890 Series 11 Gas Chromatography-Flame Ionization Detector USA. The result showed that the total PAHs(ΣPAHs) concentration ranged from 2918.27µg/l to 9018.98µg/l with the mean value of 1123.36µg/l. The individual PAHs ranged between 37.05µg/l to 2500µg/l, while fluoranthene had the highest concentration, followed by Benzo(b)fluoranthene and Chrysene(3340µg/l,2110µg/l and 2094.24µg/l) respectively while Phenathrane, Naphthalene and Indeno(1,2,3,c,d) pyrene had the least concentration of PAHs (301µg/l, 239.08µg/l, 211.56µg/l) respectively. The concentrations of PAHs detected showed predominance of high molecular weight PAHs (4-6 rings). This study concluded that the surface water of Elechi Creek was contaminated mostly with HPAH and these concentrations exceeded the maximum permissible limit of 10µg/l recommended by World Health Organization (WHO, 2003) and so, the water can adversely affect the biota found in the creek and there is also the possibility of their bioaccumulation and transfer to higher trophic levels through the food chain. There is also a plausible adverse effects upon the usage of this water for domestic and agricultural purposes.

Key words: PAHs, Concentrations, Pollution, Surface Water, Elechi Creek

1.0 Introduction

Due to rapid economic development in Nigeria, environmental pollution has become an issue of concern. Crude oil exploitation based on its importance for energy and national economy has led to the contamination of land, marine and estuarine environments. Pollution arising from oil spill or effluent discharges from oil and gas industry activities into the marine environment have for some time remained a tropical issue. It is increasingly difficult to maintain a balance in the environment especially in areas where developmental activities continue to grow (Dambo and Ekweozor, 2000). There have been imminent problems of pollution in the coastal regions which has resulted to significant damage in the marine ecosystem. Crude oil is a complex mixture of hydrocarbons containing more than 17,000 compounds (Marshall and Rodger, 2004). Among the constituents of crude oil there is a group of substances called polycyclic aromatic hydrocarbon (PAHs) which happened to be one of the persistent organic pollutant (POPs) in the environment. Polycyclic aromatic hydrocarbons (PAHs) also known as polyaromatic hydrocarbons or polynuclear aromatic hydrocarbons are a class of organic chemical consisting of two or more fused aromatic rings and do not contain heteroatom or carry substitution (Fetzer, 2000). There are two forms of PAHs which are responsible for the formation of PAH in the environment; they are pyrolysis and pyrosynthesis PAHs. Pyrolysis involves the combustion of organic materials like crude oil at its high temperatures leading to small unstable fragments while pyrosynthesis involves the subsequence recombination of the organic molecules (Abrajano *et al*., 2004). Polycyclic aromatic hydrocarbons reveal their toxicity following biotransformation to toxic metabolites through metabolic activation that is one or two electron oxidation in the organism (Olsson *et al.,* 2010). Exposure of PAH in humans can cause adverse health effects such as lung cancer, cataracts, kidney failure, liver damage (e.g Jaundice), breathing problems and immune disorders (Diggs *et al.,* 2011).These pollutants (PAHs) occur in the environment mainly through anthropogenic activities and have no significant natural sources (Fetzer,2000). PAHs also occur in oil, coal and tar deposits and are produced as byproduct of fuel burning (Fetzer, 2000). Over 100 compounds existing in the environment have been identified to date. In practice PAHs analysis is restricted to the determination of 6 to 16 PAHs as priority pollutants but benzo(a)pyrene, chrysene, benzo(a)anthracene are considered to be potential fish and human carcinogens (Igwe and Ukaogo,2015).

Surface water pollution is one of the major environmental problems faced in the urban areas especially in Nigeria (Ana *et al*., 2005). PAHsin surface water may either evaporate, disperse into the water column, become incorporated into bottom sediments, concentrate in aquatic biota or experience chemical oxidation and biodegradation (Igwe and Ukaogo, 2015). Natural water like oceans, seas and lakes are another important sink for PAHs. There are some permissible standards for concentration of PAHs in natural waters as set by European community, for instance the reference concentrations for most dangerous PAHs are 10mg/liter for benzo(a) pyrene, 100ng/liter for phenanthrene and anthrecene in ground water(Djozan and Assadi, 1999). Studies carried out by Okoro (2008) found that concentrations of PAHs in Ekpan Creek in the Niger Delta were from pyrogenic origin and include phenanthrene,anthracene .The concentrations of these PAHs ranged between 2.8 x 10^1 to 2.4 x 10^2mg/l. Ogunfowokan *et al.* (2003)showed that Oshogbo and Ile –Ife study areas have the mean levels of PAHs in surface runoff which ranged between 0.1 to 15.81mg/l while in more industrialized Lagos area concentrations of PAHs ranged between 0.1to 73.72mg/l. Coastal and Inland water usually act as receptors for pollutant especially polycyclic aromatic hydrocarbons (SEPA, 2010). Watercraft engines are known to release substantial amounts of petroleum products into the ecosystem (Oris *et al.,* 1998). According to WHO (1998) exposure to water containing PAHs, especially naphthalene via the oral route, could predispose the populations to symptoms such as nausea , vomiting and convulsions after one to several days and often followed by diarrhea (Ana *et al.,* 2005). The increase in industrial activities in Niger Delta have subsequently brought an increase in the concentration of polycyclic aromatic hydrocarbon in surface water, especially compounds that are indicators for PAH toxicity such as the benzo(a) pyrene. Concentrations of PAH in the surface water indicates that the aquatic ecosystem is polluted. Exposure and Contamination of aquatic ecosystems by PAHs have been recognized as a major public health risk (Okafor and Opuene 2007).

Elechi Creek is characterized by increasing industrialization and urbanization. There are various industrial, commercial and domestic activities in the surrounding areas of the creek and these have contributed to the release of effluents, solid wastes and emissions into the water, atmosphere and sediments as a result of lack of sufficient waste management facilities. The river water from Elechi Creek is used for domestic purposes hence, pose human health risks that may be attributed to long term exposure and accumulation of PAHs. Several studies have been carried out in Elechi Creek to ascertain the level of heavy metal pollution, PCBs, and Pesticides (Chindah and Briade, 2003; Chindah *et al.,* 2003; Davies *et al*., 2006; Ogamba *etal.*, 2005) but there is virtually no comprehensive study of polycyclic aromatic hydrocarbons in the surface waters of this creek. This has necessitated the current study which assessed the Levels of physico-chemical parameters, polycyclic aromatic hydrocarbons in the surface water and the evaluation of percentage of LPAH and HPAH found in Elechi Creek, in Rivers State, Nigeria.

2.0 Materials and Methods

2.1 Description of the study area

Elechi Creek located in Port Harcourt, River State Nigeria lies between the latitude N 04^0 15^1 to N 04^0 50^1 and longitude E 006^0 50^1. It is a distributary of the Bonny Estuary in the Niger Delta and also branches off from the Bonny Estuary close to main Port Harcourt Wharf. Elechi Creek complex is a mangrove intertidal creek within the upper reaches of the Bonny Estuarine system, adjoining a populated municipal environment near the Eagle lsland by the Rivers State University. The tidal amplitude is between 1.5 to 2m. The creek is characterized by high sea flow and low fresh water input from adjoining swamp forest and municipal sewer within Diobu area of Port Harcourt (Upadhi *et al*., 2012). Discharges along Elechi Creek includes effluent from sawmills, abattoir, tank farms, tyre waste dump and water treatment plant (Davies *et al.,* 2006).

2.2 Sample Points

The stations were selected based on the point of effluent discharge, run off and ecological settings.

Three (3) main sampling stations were selected along the stretch of the creek are shown in Fig. 1.

2.3 Sample Collection and Method

2.3.1Collection of Surface Water Samples

The surface water samples were collected using the method as described by Takalani *et al.* (2014). The samples were collected by lowering the containers by hand about 15 to 20cm below the surface level with minimum disturbance to avoid turbulence and ensuring a smooth flow of the samples into the sampling bottles. The water samples were stored in cold pack immediately after collection and taken to the laboratory for PAH analysis.

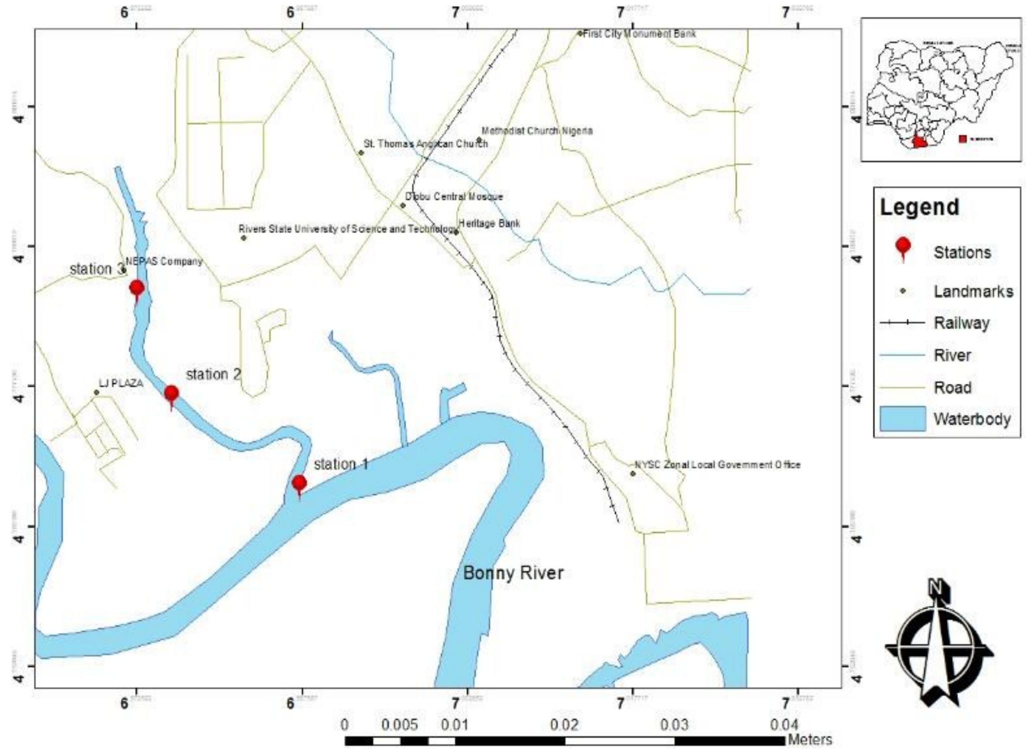

Fig 1- Map of the study area showing the three stations of the Creek.

2.4 Water Analysis

2.4.1Sample Preparation/Extraction

250ml of the water sample was measured into a separator funnel; 1ml of Dichloromethane was used to rinse the container (sample) to ensure total recovering of the sample. Afterwards 25ml of Dichloromethane was also measured to mix with the water sample as the procedure requires but for proper extraction of total PAH, Batch method was used. The PAH was extracted from each sample using two batches. The water sample was divided into two, having 125ml of the water sample; 12.5ml of Dichloromethane was added to the 125ml water sample and was vigorously shacked to mix the solvent well to have the organic solvent extract all the available organic material. This was repeated for the other batch to have 250ml of the water sample to 25ml of Dichloromethane.

2.4.2 Sample Extraction

The organic extract was collected into a receiving container by passing the organic extract through a funnel containing cotton wool, silica gel and anhydrous sodium sulphate. The silica gel aids the cleanup of the extract by disallowing the passage of debris from the extract while the anhydrous sodium sulphate acts as a dehydrating agent to rid the extract of every form of moisture /water from the sample since they are two immiscible liquids. Then cotton wool will finally dry any form of moisture/water, if any. The organic extract collected from the column was allowed to concentrate by allowing the mobile phase and volatile phase to evaporate (Inorganic solvent) while the immobile phase retains (organic substance).

2.4.3 Gas Chromatograghic (Flame Ionization Detector) Analysis

The collected concentrated organic extract was injected into the Gas chromatograph. 1µL of the concentrated sample extract was injected by the means of hypodermic syringe through a rubber septum into the column (capillary column of about 30 meters in length inside the oven in the GC). The various fractions of the aliphatic compounds (C_8-C_{40}) were automatically detected as it emerged from the column by the FID detector (flame lionization detector) whose means is depended upon the composition of the vapour, which means that each of the polycyclic aromatic hydrocarbons was detected at a particular heat and minutes. The results were expressed in PPM or Md/L which are equivalent units. This method was also described by USEPA, (2003b); Megdalena *et al*., (2006) and Zakaria and mahat, (2006).

3.0 Results

3.1 Concentration of PAHs in Surface water

The results of PAH analysis as shown in Table 1 indicate that From the LPAH, Acenaphthene concentration ranged between 32.2µg/l to 1400 µg/l. Station 3 had the highest mean value of 627.15µg/l and station 1 had the least mean value (92.67µg/l). Naphthalene concentration ranged between 0.00 to 256µg/l. Station 3 had the highest means value 165. 1 µg/l and the least mean was value recorded at station 1 (31.82µg/l). 2-methyl-Naphthalene concentration ranged between 0.00 to 1069µg/l. The highest and least mean value was recorded in stations 3 and 1(477.23 and 96.34 µg/l respectively).Acenaphthylene concentration ranged between 36.85-2710µg/l the least mean value was recorded at station 1 (81.61µg/l) and station 2 (951.62µg/l) had the highest mean value.

Fluorene concentration ranged from 26.6 – 1272µg/l in all stations. Station 3 had the highest value (491.63µg/l) and least mean was observed at station 1 (46.35µg/l). Phenanthrene concentration ranged between 6.22-272µg/l with the highest mea at station 3 (198.69µg/l) and the least mean at station 2 (49.32µg/l).Anthracene concentration ranged from 3.5 to 691.6µg/l with the highest mean observed at station 3 (315.36µg/l) and the least mean value at station 2 (32.1µg/l).

From the HPAH, Fluorathene concentration ranged between 5.38 to 730.5µg/l with the highest mean value at station 3 (562.05µg/l) and the lowest mean value at station 2 (248.19µg/l)pyrene concentration ranged from 1.9µg/l. Benzo (a) anthracene concentration ranged from 0.00 to 166µg.l with the highest mean value at station 3 (834.56µg/l) and the least mean value at station 2 (294.84µg/l). Chrysene concentration ranged from 0.00 to 165.6µg/l with the highest mean value at station 3 (195.5µg/l) and the least means value at station 2 (29.74µg/l). Benzo (b)anthracene ranged from 45.3 to 1438µg/l with the highest mean value at station 3 (969-33µg/l and the lowest mean value at station 2 (195.6µg/l). Benzo (a) Pyrene ranged between 15.14 to 517.9µg/l with the highest mean value at station 3 (272.23µg/l) and the least mean value at station 2 (147.57µg.l). Indeno (1,2,3,cd) Pyrene ranged between 6.96 to 153.35µg/l with the least at station 1 (53.16µg/l). Dibenzo (a,h) anthrancene concentration ranged from 7.01 to 1480µg/l with the lowest mean value at station 2 (395.93µg/l) and the highest means value at station 3 (527.3µg/l)

The total concentrations of individual PAHs as shown in Table 2and presented in Fig 2indicate that:

Station1:Benzo(b)Fluorathene>Dibenzo(a,h) anthracene>Benzo(a)anthracene>Flouranthene>Pyrene>Benzo(k)Fluorathene>Benzo(b) Fluorathene>Benzo(a)Pyrene>2methylNapthlene>Acenaphthlene>Acenaphthene>Chrysene>Phenanthene>Indeno(1,2,3,cd)Pyrene> Anthracene>Naphthalene.

Station2: Fluorathene >Acenaphthene>Benzo(b) Fluorathene >Dibenzo(a,h)anthracene>Benzo(a) anthracene>Fluorene>Pyrene>Anthracene> Benzo(k) Flouranthene >Acenaphthlene>Benzo(a) Pyrene> 2-methyl Napthlene>Indeno (1,2,3,cd) Pyrene>Phenanthene> Naphthalene > Chrysene.

Station3:Chrysene>Benzo(b)Fluorathene>Acenaphthalene>Benzo(a)anthracene>Fluorathene >Benzo(a)anthracene>Dibenzo(a,h)anthracene>Acenaphthene>Flourene>2methylNaphthlene>Pyrene>Anthracene>Benzo(k)Fluorathene>Benzo(a)Pyrene>Phenanthrene>Naphthalene >Indeno(1,2,3, cd) Pyrene.

Table 1 - Range, Mean and Standard Deviation(S.D) of PAHs Concentration in Surface water

Compounds (Hydrocarbons)	Symbols	STATION 01		STATION 02		STATION 03	
		Range	Mean ±S.D	Range	Mean ±S.D	Range	Mean ± S.D
Acenaphthene	ACE	32.2-143.7	92.67±56.35	81.49-249	156.16±85.22	174.5-1400	627.15±672.57
Naphthalene	NAP	6.56-72.2	31.82±35.34	0.00-58.1	37.05±29.77	20.3-256	165.1±126.76
2-Methyl-naphthalene	2-MN	11.23-163.8	96.34±77.80	0.00-156.8	123.9±46.53	19.9-1069	477.23±537.31
Acenaphthylene	ACY	46.15-131.6	81.61±44.54	36.85-2710	957.62±1518.26	138.8-1201	499.87±607.29
Fluorene	FLU	26.6-75.68	46.35±25.90	29.37-745	282.27±401.31	91.9-1272	491.63±675.88
Phenanthrene	PHE	6.73-78.3	53.71±40.7	6.22-74.94	47.32±36.29	95.08-272	198.69±92.27
Anthracene	ANT	33.96-68.3	47.47±18.30	3.5-54.5	32.1±26.07	48.78-691.9	315.36±335.37
∑LPAH		163.43-733.58	449.97±298.93	157.43-4049.34	1636.42±2143.45	589.26-6161.9	2769.03±3047.45
Fluoranthene	FLT	38.8-601.6	281.67±289.21	5.38-575.8	248.19±294.51	340.2-730.5	562.05±200.55
Pyrene	PYR	29.54-678.7	251.45±370.1	1.9-649.67	229.46±364.33	138.1-824.14	377.48±387.13
Benzo(a)anthracene	BaA	153.6-554.4	317.28±210.25	0.00-442.67	294.84±209.07	186.55-1667	834.56±757.26
Chrysene	CHR	16.6-55.09	64.5±53.23	0.00-43.98	29.74±20.14	20.11-165.67	195.5±192.04
Benzo(b)fluoranthene	BbF	194.5-1184	631.16±504.88	45.3-1331	510.54±712.67	885-1438	969.33±432.71
Benzo(k)fluoranthene	BkF	35.1-566.87	254.14±277.99	16.2-542.6	195.6±300.57	105.42-688.4	306.19±331.15
Benzo(a)pyrene	BaP	24.24-426.5	176.87±218	15.14-408.23	147.57±225.75	72.89-517.9	272.23±226.1
Indeno(1,2,3 – c,d)pyrene	IND	8.96-126.3	53.16±63.8	6.96-120.8	66.42±57.09	26.94-153.35	91.97±63.28
Dibenzo(a,h)anthracene	DBA	8.78-1299	440.27±743.69	7.01-1168	395.93±668.64	26.3-1480	527.3±825.43
∑HPAH		510.12-5492.46	2470.5±2731.15	97.89-5282.75	2118.29±2852.77	1801.51-7664.96	4136.61±3415.65

Table 2- Concentration of individual PAHs, LPAH and HPAH in the three stations of Elechi Creek.

	SURFACE WATER				
Compounds	Station 01	Station 02	Station 03	Total	PERCENTAGE
Naphthalene	31.987	37.05	170	239.037	1.03%
2-Methyl Napthlene	96.433	123.9	477	697.333	3.88%
Acenaphthlene	93	160	940	1193	6.64%
Acenaphthene	81.6133	960	500	1541.6133	8.58%
Fluorene	46.4	280	490	816.4	4.54%
Phenanthrene	53.7	47.3	200	301	1.68%
Anthracene	47.4733	32.1333	320	399.6066	2.22%
∑LPAH	450.6066	1640.383	3097	5187.99	28.57%
Fluoranthene	280	2500	560	3340	18.58%
Pyrene	250	250	360	860	4.79%
Benzo(a)anthracene	320	290	830	1440	8.01%
Chrysene	64.5	29.74	2000	2094.24	11.65%
Benzo(b)Fluoranthene	630	510	970	2110	11.74%
Benzo(k)Fluoranthene	250	200	310	760	**4.23**%
Benzo(a)pyrene	180	150	270	600	3.34%
Indeno(1,2,3,cd)Pyrene	53.16	66.42	91.9767	211.5567	1.18%
Dibenzo(a,h)anthracene	440	400	530	1370	7.62%
∑HPAH	2467.66	4396.16	5921.977	12785.8	71.14%
∑PAH	2918.267	6036.543	9018.977	17973.79	100%

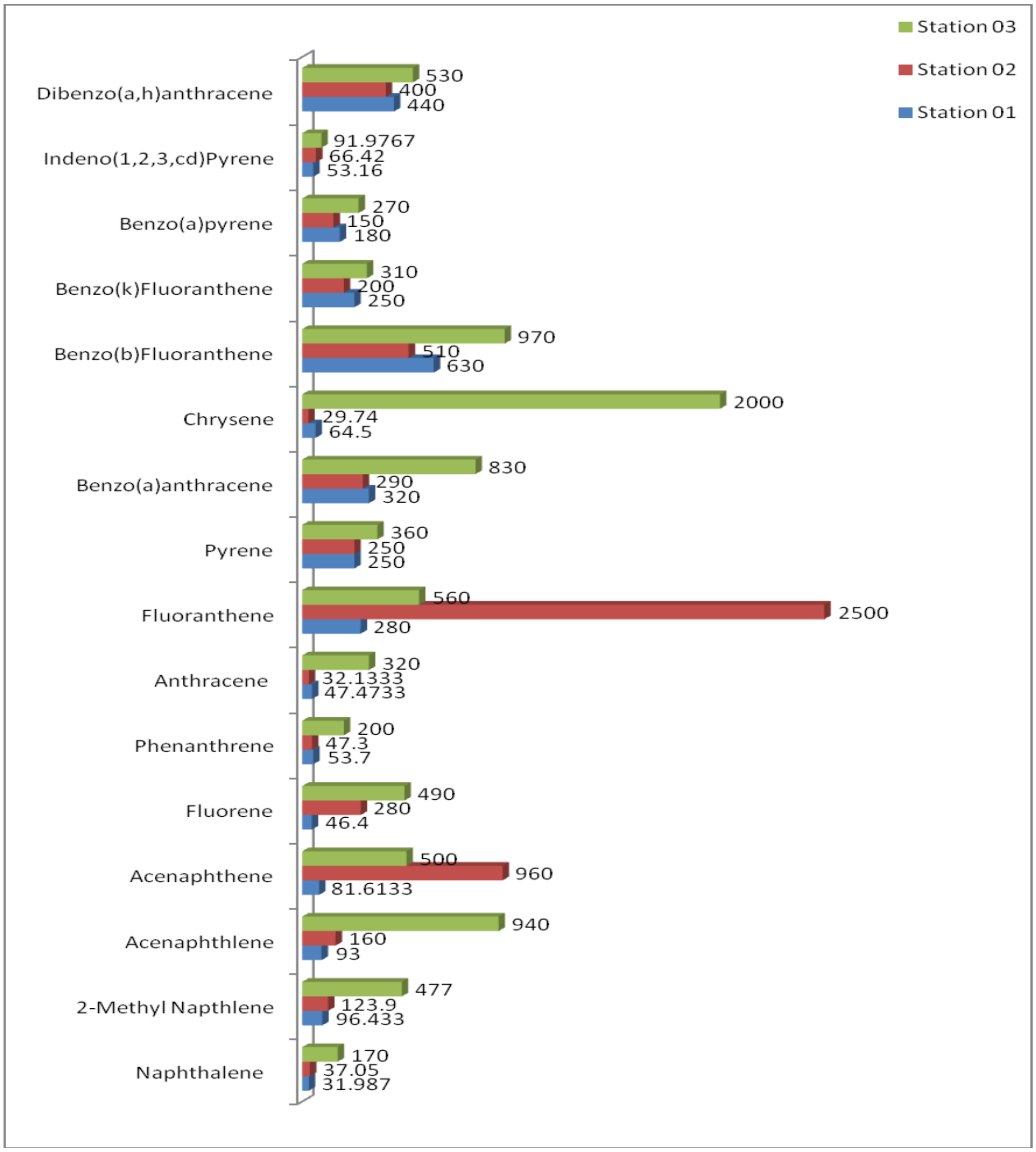

Fig 2: Distribution Of individual PAHs Compound at the three stations of Elechi Creek.

Percentage of PAHs abundance in surface water as shown in Fig 3 was highest in fluoranthene (18.58%) followed by Benzo(b) fluoranthene (11.74%) and Chrysene (11.74%). All belong to 4-5 rings PAHs and the least percentage are Indeno (1,2,3,cdPyrene, Naphthalene, Phenanthrene and Anthracene (1.18%,1.30%,1.68% and 2.22%) respectively, they all belong group 2-3 rings apart from indeno (1,2,3,cd) Pyrene (6 rings)

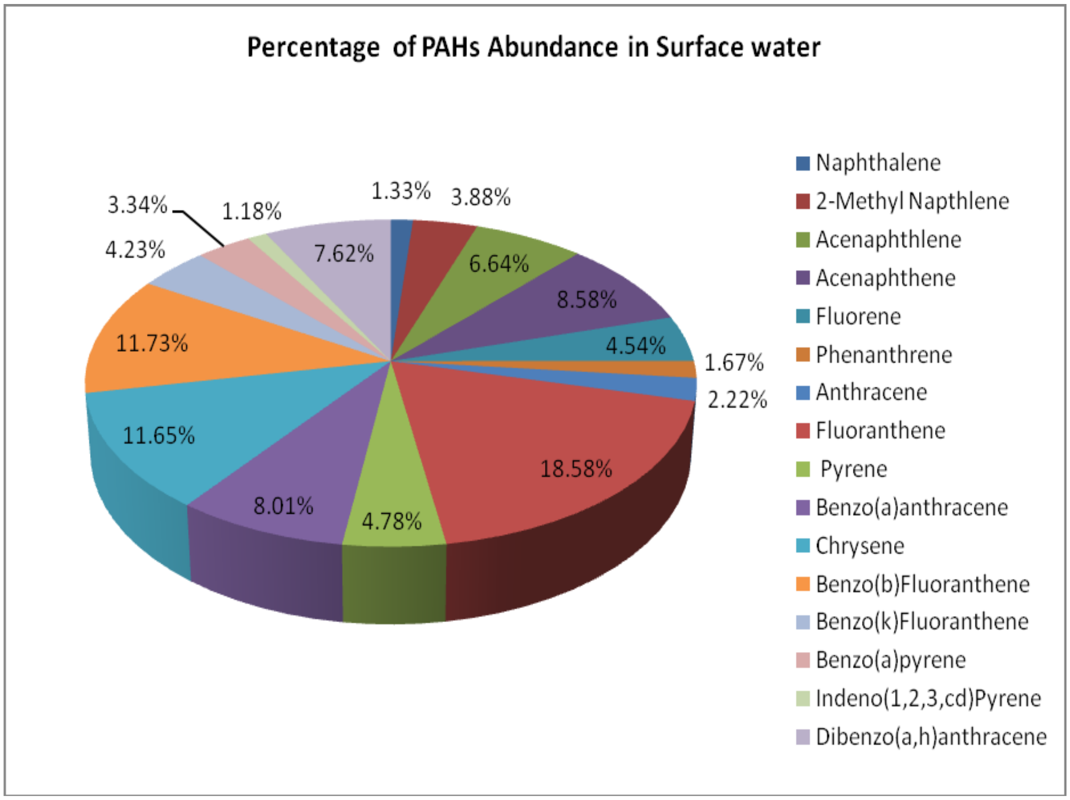

Fig. 3: Percentage of Total PAH abundance in the surface water of Elechi Creek

The pie chart in Fig. 4 shows the percentage of the high molecular weight HPAH (71.14%) was higher than low molecular weight LPAH (28.57%) in Elechi Creek.

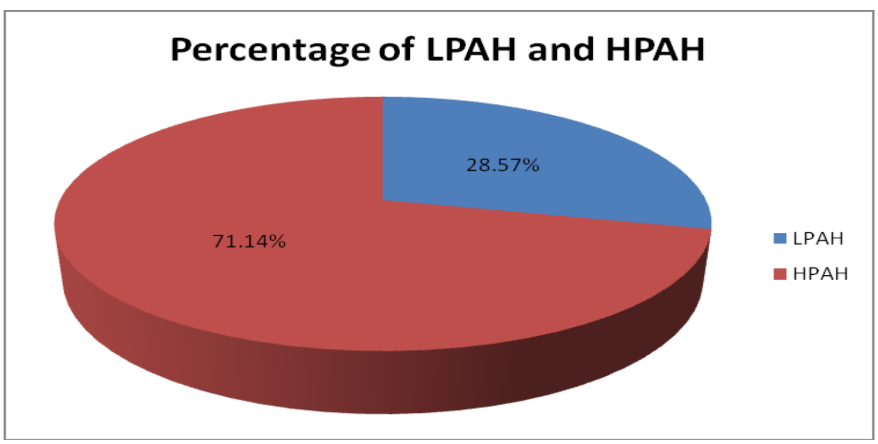

Fig 4: Percentage of Lower molecular weight PAH (LPAH) and High molecular weight PAH (HPAH) in Elechi Creek

DISCUSSION

The concentration of polycyclic aromatic hydrocarbons in the tidal water of Elechi Creek ranged between 37.05µg/l and 2500µg/l in all stations and the total PAHs ranged between 2918.27µg/l and 9018.98µg with the total mean of 1123.36µg/l (Table 3). The highest concentration of ΣPAHs was recorded at station 03 (9018.98µg/l) which is situated close to a tank farm and a waste treatment plant, an area marked with increase in anthropogenic activities, hence the amount of PAHs detected was obviously related to the urban runoffs, sewage discharge, active transportation activities, and burning of tyres as was observed during the period of sampling. Comparatively lower concentration (6036.53 µg/l) of ΣPAH was recorded at station 2 where there is also influence of industrial and anthropogenic activities but not as in station 3, while station 1 where there is little or no anthropogenic / industrial activities showed less concentration(2918.27 µg/l).

Previous reports in Nigeria showed high concentrations of PAHs mostly within the Niger Delta region, Opueme (2004) in a study of the levels of PAHs in the Taylor Creek (Bayelsa State) reported the range of PAHs between 0.008 to 0.249µg/l, which was above the permissible limit of USEPA., (2003) for drinking water (0.20 and 400ppb). Otherstudies in Eleme and Ahoada East (Rivers State) reported higher concentration of PAH when compared to this study. Levels reported within sampled stations in Eleme (8.89×10^4µg/l)and Ahoada East ($8.39 \times 10^3$to 4.15×10^4µg/l) (GREE *et al*., 2004) were higher than those of the present study. These concentrations were higher than the guideline value of 50µg/l (WHO, 1998). Olof and Jonas (2013) reported high concentration of ΣPAHs (7420µg/l) in oil contamination sites in Ogoniland Niger Delta. Ibiebele(1986) also reported concentrations of 53,000-62,700µg/l in refinery waste water in Niger Delta).Lower levels of 1.95 to 10.9µg/l were reported by Anyakora and Coker (2006).The high concentration of PAHs recorded in this study to a large extent agrees with the other areas of the Niger Delta which indicate gross pollution of the aquatic ecosystem(Opunene *et al*., 2009).

Malik *et al. (*2011) in their investigation of the spatial and temporal distribution of PAHs in Gunti River (India) revealed that the total concentration of PAHs in water range from 0.06 to 84.21µg/l.The range of 0.0029 to 1079µg/l ΣPAH reported in the surface water of Todos and Santos in Brazil (Joil *et al*., 2012). These levels were in all lower than the levels recorded in areas of reduced anthropogenic activities in this study. However, the high levels recorded within eight sites along Mederes River, the highly industrialized region of Turkey (1800µg/l and 24, 900µg/l) (Ardag *et al*., 2011) is consistent with the high levels recorded in the highly industrialized area of the current study. It is worthy of note that these high levels are lower when compared with the ΣPAHs found in USA and China with a high concentration of 29323µg/l in surface water (Anyakora and Herbert., 2006, Zhang *et al.,* 2011 and Essumang *et al.,* 2009).

The distribution of PAH compounds among the three stations in this study showed the presence of the 16 priority PAH outlined by USEPA (2007). These are grouped according to their number of rings, 2-3 rings are less toxic and less carcinogenic than 4-6 rings which are more toxic. Fluoranthene (4 rings) recorded the highest concentration (2500µg/l) of individual PAH at Station 2 (Fig. 2). Fluoranthene also had the highest concentration of ΣPAHs ranging from 5.38 to 575.8µg/l with the total mean concentration of 3340µg/l that is 18% of PAH concentration in surface water. Fluorathene also showed a slight significant difference between the stations (P=0.019), followed by chrysene which was observed as the second to the highest individual PAH at Station 3 (Fig. 2). Chrysene ranged from 20.11 to 165.67µg/l , which also ranked the third to the highest individual PAHs concentration (2094.24µg/l) in Elechi Creek with the percentage of 11.65% while Benzo (b) fluoranthene was the second highest individual PAHs concentration (11.74%). High levels of Benzo (b) fluoranthene was also observed at station 3 (970µg).Fluoranthene, Crysene, Benzo (b) fluoranthene, Acenaphthacene and Dibenzo (a,h) anthrancene were found to be abundant in the creek (Fig. 3). Apart from Acenaphthcene,these compounds belong to group 4-6 rings of PAHs. The abundance of 4-6 ring PAHs had also been frequently detected in other studies, especially fluoranthene. According to Farshid, (2015), fluoranthene (4 ring PAH) was the most important pollutant with mean concentration of 27.33µg/l, 53.15µg/l, 16.59µg/l and 65.24µg/l respectively in four stations of Soltan Abad River, in Iran. Jack *et* al., (2015), reported the abundance of PAHs in Eleme and Okirika (Dibenzo (a,h) anthrancene (0.167µg/l), fluoranthene (0.164µg/l) and chyrene (0.158µg/l). However, the concentrations of less than 100µg/l recorded for fluoranthene, pyrene, chrysene and benzo(a) pyrene by Krober and Hackl., (1989) were lower than the concentration of fluoranthene observed in this study.

Studies have shown fluoranthene to be the most commonly detected PAH in cities and populated rural areas of the world and their presence is associated primarily with petrogenic sources, coal-tar, lining of cast Iron or ductile Iron distribution pipes that one employed to channel waste waters, industrial-effluent, combustion process both vehicular and industrial combustions even biomass burning (Kiss *et al*., 2011 and Farshid., 2015).

The concentration of other PAH components such as benzo(b) fluoranthene, benzo(k) fluoranthene and benzo(a) pyrene recorded in Elechi Creek were higher than the range of 1-50µg/l recorded for some rivers in Germany (Krober and Hackl., 1989, GREE *et al.,* 2004). Benzo(b) fluoranthene is most likely to result from the incomplete combustion of variety of fuels including wood and fossil fuel (Obayori and Salam,2010). Oda *et al*., (2001), noted that the cause of high Benzo (b) pyrene can be attributed to automobile exhorts because it emits high proportions of Benzo(a) pyrene. Indeno (1,2,3,c,d) pyrene (6 ring PAH) was recorded as the lowest concentration of individual PAH at (1.18%) with sum total of 211.56µg/l. Indeno (1,2,3,c,d) pyrene(six ring PAH) were hardly detected in other studies(Anyakora and Coker., 2006, Ezemonye, 2006 and Adedayo *et al*, 2012). Whereas Naphthalene was detected at a very low concentration of 1.33% with the sum total of 239.04µg being lower than the concentration of Naphthalene (9100µg/l) reported by Doong and Lin., (2004) in Taiwan. According to WHO, (1998), exposure to water containing PAHs, mostly naphthalene via the oral route, could predispose the populations to symptoms such as nausea, vomiting and convulsions after one to several days and often followed by diarrhea.

The concentration of LPAH ranged from 1.33 to 8.58%, and HPAH ranged between 1.18% to 18.58% with the ΣLPAH of 28.57% and ΣHPAH of 71.14% showing that the concentration of PAH were higher in molecular weight (HPAH). These results were consistent with those of Eno *et al*., (2015), who reported the concentration of HPAH to be higher than LPAH (ranging 0.07% to 3.67% LPAH and 77.1% to 99.5% HPAH). According to Obayori and Salam, (2010) the lower molecular weight PAHs such as naphthalene and anthrancene are more soluble and degradable than higher molecular weight compound such as fluoranthene, chrysene, Benzo(a) anthrancene etc. High concentration of PAHs in surface water can cause impacts to sensitive organisms and sometimes the tolerant organisms are likely to disappear (NRC., 2003). Having a high concentration of PAHs mostly in HPAH being higher than the WHO., 2003 and USEPA., 2007 (10µg). These could pose threat to some aquatic organisms in Elechi Creek especially the filter feeders and this will have some serious health implications on the consumers.

5.0 Conclusion

This study emphasized that due to continuous exposure of the study area to industrial effluent discharges and other anthropogenic activities into the creek indicates a potential risk to human health. It can also pose threat to some aquatic organisms in the environment especially the filter feeders. The study emphasizes the need for the relevant government agencies to regularly monitor the environment and put a stop to the burning of stolen crude oils and materials such as tyres and plastics which generate PAH contaminant close to the creek. The regulation and discharge of untreated effluents and pollutants into the environment should be checked.

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