Assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air of Oil Producing Communities in Yenagoa and its Environs

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Abstract

The distribution and toxicity of sixteen (16) US EPA priority PAHs in ambient air of oil producing communities in Bayelsa State were evaluated using USEPA method 8015B. The communities are: Otuoke (AQOT), Imiringi (AQIM), Tombia (AQTR), Berger junction (AQBJ) and Gbaran Ubie (AQGU). Benzo (b)fluoranthene was the most abundant compound at all sites with a total of 116 ± 16.06 μgKg^{-1} followed by Benzo(a)anthracene (85.0 ± 14.02 μgKg^{-1}), Chrysene (51.0 ± 7.50 μgKg^{-1}), Fluoranthene (49.0 ± 4.7 μgKg^{-1}, Phenanthrene (21.0 ± 7.5, μgKg^{-1}), Anthracene (9 ± 2.81) etc. The concentrations of PAHs at different sites increased in the order: AQBJ>AQOG>AQTR> AQIM> AQOT>AQGU. Multivariate analysis including principal component analysis (PCA) and Correlation Matrix (CR) showed that industrial activities, commercial activities, and biomass combustion were responsible for the concentrations measured and sites with similar activities correlated well. The risks posed by these pollutants to the inhabitants of these communities were calculated and the results expressed in terms of hazard quotient (HQ) (Pyrene 1.0 ; anthracene 0.87; fluoranthrene 0.35; napthanlene 0.1) and 'excess life cancer risk' (ELCR) (dibenzo (a,h) anthracene $1.27x10^{2}$; benzo(a)anthracene $14.6x10^{-1}$; indeno (1,2,3-cd) pyrene $4.2x10^{-1}$; benzo(k)fluoranthene $1.7x10^{-1}$ and chrysene $2.1x10^{-3}$) for non-cancer PAHs and carcinogenic PAHs respectively. This calls for holistic monitoring of the PAHs emission in this region, as exposure to this POPs causes a variety of negative health effects

Keywords: PAHs, Ambient air, Fluoranthene, Multivariate analysis, Health effects, Anthracene.

Introduction

There has been urgent concern by environmentalist on release of persistent organic pollutants (POPs) in Nigeria environment. This concern is mainly because of adverse effects in the environment. The main sources of POPs to Nigerian environment are crude oil, gas production, transportation, burning of electronic wastes, furniture, and mattresses. Among this group of pollutants, polycyclic aromatic hydrocarbons (PAHs) is of great concern [1].

PAHs are a class of organic chemicals consisting of two or more fused aromatic rings and do not contain heteroatom or carry substituents [1]. High molecular mass PAHs are of 4 and more condensed aromatic rings which are considered to be more dangerous than low molecular weight which are 2 and 3 rings PAHs [2]. Although there are thousands of PAH compounds in the environment but in practice PAH analysis is restricted to 16 priority compounds listed by US EPA as potentially toxic [3]. Sources of PAHs in the environment can be natural or anthropogenic [5]. Natural sources of pyrogenic PAHs such as forest fires and volcanic eruptions do not significantly contribute to overall PAHs emission [6]

The main anthropogenic sources are aluminum production, coke production from coal, fossil fuel combustion, traffic, electricity production, domestic heating and wood preservation [7]. An agricultural practice in developing countries which involves massive biomass contributes significantly to atmospheric deposition of PAHs [8]. Similarly, traffic exhaust especially diesel also contributes significant PAHs to the environment [9]. The PAHs are known to have relatively low solubility in water, but are highly lipophilic [10].

Recent concern on presence of polynuclear aromatic hydrocarbons is mainly due to their negative effect on the ecosystem. PAHs are ubiquitous in nature, highly carcinogenic and have toxic impact on living organisms [11]. Exposure to PAHs causes a variety of negative health effects which includes reproduction defects, DNA mutations, leukemia and cancer of the lungs, bladder, bone, brain and scrota [12, 13]. PAHs can bind to cellular proteins and DNA resulting to biochemical disruption and cell

damage leading to mutations, developmental malformation, tumors and cancer [14].Various studies such as [15,16] has shown that PAHs are tetratogenic, genotoxic and ecotoxicological pollutants.

Although PAHs are multimedia contaminants which occur in all parts of the environment, however there is paucity in information of atmospheric contamination by PAHs globally [17, 18]. Air remains the most important component of the environment and must be given due attention. Niger delta is one of the major oil exploring regions in the world [19] and major portion of the oil wells are located in Bayelsa State. The exploration and production of oil and gas has led to release of various pollutants in the Niger delta environment. Mosses have been used for the estimation of atmospheric PAHs deposition for over a decade [20], and *Orthodicranum flagellare* was used for this evaluation. The aim of this study therefore, is to estimate the health risk posed by this pollutant to the inhabitants of these communities by determining the concentrations and distribution of PAHs in the ambient air of the studied area.

Study Area

Bayelsa State is in South-South Nigeria. The state is geographically located within the latitude $4^o15'$ North and latitude $5^o23'$ South. It is also within longitude $5^o22'$ West and $6^o45'$East. The state is bounded by Delta State on the north, River State on the East and Atlantic Ocean on the Western and Southern part. The State is one of the states in oil rich Niger delta region of Nigeria with total area of $706km^2$and population of 353,344 [21]. It is located within the lower delta plain believed to have been formed during the Holocene of the quaternary deposits and has a low land characterize by tidal flats and coastal beaches, beach ridge barriers and flood plains. The major soil types in the state are young shallow, poorly drained soils and acid sulphate soils. There are four ecological zones: coastal barrier island forest, mangrove forest, freshwater swamp and brackish water swamp. The vegetation is a typical wet land with two seasons (wet and dry), the temperature ranges between 28.6^oC to 37.5^oC throughout the year.

Description of Sampling Stations

Table 1: Sampling Locations, Coordinates and Local Activities

S/N	Sampling Location	Location Code	Coordinates	Activities
1.	Federal University Otuoke Farm	AQOT	$4^o47'$ 40.81″N $6^o18'$ 52.28″E	Farming, residential, academic activities and research, low traffic
2.	Shell Flow Station Imiringi	AOIM	$4^o51'$ 06.62″N $6^o22'$ 16.50″E	Crude oil production, exploration, gas flaring, low traffic
3.	Shell Flow Station Otuabagi	AOOG	$4^o40'$ 01.92″N $6^o18'$ 29.81″E	Crude oil production, low traffic, residential activities
4.	Tombia Round About	AATR	$4^o57'$ 14.02″N $6^o21'$ 29.57″E	High vehicular movement, major parks, commercial activities, open dump site and abbatours
5.	Berger Junction Gbaran Ubie	AQBJ	$4^o55'$ 42.05″N $6^o20'$ 18.73″E	Pulverization of granite, vehicular movement and commercial activities
6.	LNG Gas Complex	AQGU	$5'01'$ 36.68″N $6^o18'$ 19.71″E	LNG gas production, gas flaring, low vehicular movement, residential activities

Materials and Methods
Samples Collection
Accumulated air bourne compounds in *Orthodicranum flagellare* plant were collected monthly from six sampling locations between October 2015 to August 2016, using spatula, wrapped in an aluminium foil and properly preserved by cooling in a refrigerator at 4^oC. The samples were collected from the following stations with the following keys; Otuoke ,

Sample Preparation and Analysis
Sample preparation and analysis were carried out using standard reference method employed in the analysis of PAHs as outlined by US EPA 8240 and modifed by [22].Efforts were made to reduce errors arising from interference, contamination by diffusion of volatile organics, interference by non-target compounds.

In the laboratory, the samples were homogenized and extracted with freshly prepared extracting solution (1:1 mixture of acetone and methylene chloride). To 10g of each sample 10g of sodium sulphate was added (to remove moisture) and was extracted with 100ml of the extracting solution (ES) in two portions of 50ml each time by sonication for 45 minutes. The extracts were concentrated to about 5ml. Finally, the PAHs fractions were separated from the concentrated extracts in silica gel cartridges using methylene chloride as solvent. The basic GC parameters for the analysis of polycyclic aromatic hydrocarbon were followed and the purified PAHs extracts were analyzed by a calibrated capillary GC-FID using an HP 6890 series GC system equipped with Flame Ionization Detector (FID). The Column used was a HP-5, 30 m x 0.25mm (HP Part No. 19091S-433). Hydrogen (10.2 psi) was used as carrier gas at 1.5 mL/min. The oven was kept at 800^oC (1 min), ramped at the rate of 200^oC/ min to 2800^oC, then the ramp increased at a steady rate of 2.50C/min until finally maximum temperature of 3000^oC was attained. The injector and detector temperatures were 2500^oC and 3200^oC respectively. The total run (throughput) time

was 40min. The amount of each PAH in the analytes was calculated from the peak response, based on the analyte / internal standard response ratio (peak area ratio, PAR) as;

Conc. of analyte (ug/(L) = (Ax)(Is)/(Ais)(RRF)(Ws)) $\times$ 1/SF

Where: Ax = Area of the analyte,

IS = Concentration of internal standard injected (ng)

RRF = Relative response factor from the standard, calibration curve.

Ws = Weight of samples extracted in grams (g), and

SF = Split factor

Statistical Analysis
The deposition of polycyclic aromatic hydrocarbons in ambient air of oil producing communities in Bayelsa State were expressed as mean $\pm$ standard deviation (SD). Multivariate statistical analysis (Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) of PAHs concentrations are used to determine relationship between depositions at different locations.

Results and Discussion
The distribution and toxicity of sixteen (16) US EPA priority PAHs in ambient air of communities in Yenagoa and its environs revealed that Benzo(b)fluoranthene was the most abundant compound at all sites with a total of 116 $\pm$ 16.06 μgKg^{-1} followed by Benzo(a)anthracene (85.0$\pm$14.02 μgKg^{-1}), Chrysene (51.0$\pm$7.50 μgKg^{-1}), Fluoranthene (49.0$\pm$4.7 μgKg^{-1}, Phenanthrene (21.0$\pm$7.5, μgKg^{-1}), Anthracene (9$\pm$2.81) etc. (Table 1 below). Generally, there was clear spatial distribution of the PAHs with sites in urban area, flow stations recording high concentrations than sites located at the rural areas. The high concentration of these compounds in these locations would be attributed to traffic, level of industrial and commercial activities. Two sites, AQIM and AQOG, though located at rural areas, have flow station with horizontally gas flaring

taking place. These sites recorded close and moderate high total PAHs concentration of 74.00 and 62.00µgkg^{-1} respectively. Similarity in geographical location and activities may have influenced the PAHs load in both sites. Crude oil explorations contribute significantly to PAHs load [23]. Some of the pollutants like benzo (a) pyrene, dibenzo (a, h) anthracene and benzo (g, h, i) perylene are found to be low or negligible in most of the locations. Compounds like, fuoranthrene and pyrene were found to be relatively high at AQOT taken as control. Concentration level of fluoranthrene and pyrene is influenced by vegetation [24] and they are often associated with natural matrix and considered typical pyrogenic [25, 26]

The concentrations of PAHs determined at different sites increased markedly in this order: AQBJ>AQOG>AQTR>AQIM>AQOT>AQGU. However, a site, Gbaran Ubie where gas production and flaring is taking place had the least concentration of total PAHs. Flaring at Gbaran Ubie is carried out through a very high stack with adequate oxygen and proper smoke dispersion. According to [27, 28] and [29], the presence of PAHs in the ambient air is influenced by atmospheric conditions. Depending on the wind direction, wind turbulence, topography and other meteorological factors, ambient concentration of pollutant may be higher at sites further than vicinity of emission source – the prevailing wind direction is an important factor in determining the areas most affected by air pollution [30]

Multivariate Analysis

The three main factors were identified to influence the distribution of PAHs: industrial activities, such as gas flaring, power generation etc, traffic/commercial activities and biomass burning (Table 2). The PAHs load recorded in most of the sites is influenced primarily by industrial activities. The control site is a 'prestine' environment and is influenced by biomass combustion from farming activities - biomass combustion is a major source of energy in the area. Correlation matrix showed that sites like AQIM, AQOG and AQGU with similar activities were well correlated. Also, two sites with high traffic AQTR and AQBJ correlated well. Similarly, the cluster analysis identified two main clusters- AQTR and others. Besides AQBJ, activities at AQTR differ significantly from other sites. AQTR has high traffic, motor parks, commercial activities, mechanic village, abbattoir, open dump site combustion e.t.c. The dendogramm further classified the control AQOT and AQIM, AQGU, AQBJ and AQOG. Besides, AQBJ, other sites (AQIM, AQGU and AQOG) are rural areas with crude oil and gas production. Therefore, activities at the various sites influenced grouping of the sites into clusters.

Source Apportionment of PAHs

The source types can be petrogenic or pyrogenic depending on the thermodynamics of formation of the petrogenic and pyrogenic PAHs isomers [31]. The less stable isomers are mainly generated during combustion at elevated temperature while the more stable isomers are dominant in the absence of combustion due to long duration processes such as diagenesis or catagenesis [32,333]. Anthracene/phenanthrene tanthracene (An/An+Phe) ratios less than 0.1 indicate likely petrogenic origin for PAHs, while ratios greater than 0.1 suggest pyrogenic sources. Also, ratios of benzo(a) anthracene / benzo (a) anthracene + chrysene (BaA/BaA +Chr) less than 0.02 suggest petrogenic sources and values greater than 0.35 indicates dominance of pyrogenic sources [34]. The values that is less than 0.1 were calculated at locations AQIM, AQBJ and AQGU; suggesting the dominancy of petrogenic sources while ratios greater than 0.1 were obtained at AQOT (Control) and AQTR (high commercialized area) indicates dominance of pyrogenic origin. Location AQIM and AQGU are associated with crude oil and gas production activities respectively.

To assess the sources of PAHs more accurately, the ratio of Flu/(FlutPy) is used. Flu and (Py) isomer pair degrades photolytically at comparable rates [35]. [36] suggested that a Flu/(FlutPy) ratio < 0.4 indicates petroleum dominance; ratio between 0.4-0.5, dominance of liquid fossil fuel from vehicles and crude oil combustion and ratio > 0.5 shows dominance from grass, wood or coal combustion. The ratio in this study is 0.5 and thus tend to suggest that sources of PAHs in the ambient air of the studied area originates from mainly vehicular emission and crude oil combustion including gas flaring.

Table 2: Concentrations (µg/kg) of Polynuclear Aromatic Hydrocarbon

S/N	PAH Components	AQOT	AQIM	AQOG	AQBJ	AQGU	AQTR	Total±STD
1.	Naphthalene (Naph)	Bdl	Bdl	Bdl	5.00	Bdl	2.00 ±0.03	7±2.04
2.	Acenaphthylene (Any)	Bdl	Bdl	4.00 ±0.01	Bdl	Bdl	2.00 ±0.02	6±1.67
3.	Acenaphthene (Ane)	Bdl	Bdl	Bdl	Bdl	Bdl	2.00 ±0.01	2±0.82
4.	Florene (Flo)	2.00 ±0.004	Bdl	2.00	Bdl	Bdl	1.00 ±0.00	5±0.98
5.	Phenanthrene (Phe)	1.00 ±0.01	Bdl	18.00 ±7.9	Bdl	Bdl	2.00 ±0.03	21±7.15
6.	Anthracene (Anth)	2.00 ±0.02	Bdl	7.00 ±1.8	Bdl	Bdl	Bdl	9±2.81
	ΣLPAH	**5.00**	**0.00**	**3.00**	**5.00**	**0.00**	**9.00**	
7.	Fluoranthene (Fluo)	7.00 ±0.06	6.00	15.00 ±4.60	13.00 ±3.70	5.00	3.00 ±0.01	49±4.75
8.	Pyrene (Pyr)	12.00 ±3.02	Bdl	7.00 ±2.30	12.00 ±2.4	Bdl	15.00 ±3.48	28±4.55
9.	Benzo(a)anthracene (BaA)	3.00 ±0.72	13.00	8.00 ±2.80	24.00 ±6.20	Bdl	37.00 ±3.44	85±14.02
10.	Chrysene (Chry)	2.00 ±0.1	21.00	7.00 ±2.4	4.00 ±0.06	3.00	14.00 ±2.30	51±7.50
11.	Benzo(b)fluoranthene (BbF)	5.00 ±1.3	39.00 ±4.6	25.00 ±8.20	36.00 ±6.24	7.00	4.00 ±0.02	116±16.06
12.	Benzo(a)pyrene (BkF)	Bdl	Bdl	Bdl	Bdl	Bdl	Bdl	0±0.00
13.	Benzo(k)fluoranthrene (BaP) -cd	3.00 ±0.6	3.00 ±0.04	Bdl	Bdl	Bdl	2.00 ±0.01	8±1.51
14.	Indeno(1,2,3)perylene (IcdP)	4.00 ±0.3	2.00 ±0.01	Bdl	Bdl	Bdl	1.00 ±0.02	7±1.60
15.	Dibenzo(a,h)anthracene (DahA)	1.00 ±0.1	Bdl	Bdl	Bdl	Bdl	1.00 ±0.04	2±0.32
16.	Benzo(g,h,i)perylene (BghiP)	Bdl	Bdl	Bdl	Bdl	Bdl	Bdl	0±0.00
	ΣHPAHs	37.00	74.00	62.00	89.00	15.00	77.00	
	Total ΣHPAHs	42.00	74.00	93.00	94.00	15.00	82.00	

*Bdl – Below detectable limit

Health Risk Assessment

The toxic and mutagenic equivalent of PAHs in the investigation sites is shown in Table 3. Benzo (a) pyrene is the most carcinogenic PAH, and some of the stations were below detection limits. There has been a strong concern about the impact of crude oil exploration and production on the pollution load in the environment of Niger delta, which has caused and is still causing unrest among the citizenry and various interest groups in the area. The 16 priority PAHs are of specific concern as all are toxic and some are known carcinogens [19].

Risk Associated with Non-Carcinogenic PAHs and Cancer PAHs in ambient air

The risks posed by these pollutants to the inhabitants of these communities were calculated and the results expressed in terms of hazard quotient (HQ); (Pyrene 1.0; anthracene 0.87; fluoranthrene 0.35; napthanlene 0.1) and 'excess life cancer risk' (ELCR) (dibenzo (a,h) anthracene $1.27x10^2$; benzo(a)anthracene $14.6x10^{-1}$; indeno (1,2,3-cd) pyrene $4.2x10^{-1}$; benzo(k)fluoranthene $1.7x10^{-1}$ and chrysene $2.1x10^{-3}$) for non-cancer PAHs and carcinogenic PAHs respectively (Table 4,5) . Certain PAHs such as Naphthalene, Acenapthylene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene and Benzo(g,h,i)pyrene is known to possess non-cancer hazards whereas Chrysene, Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenzo(a,h)anthracene and Indeno-(1,2,3-cd)pyrene are known to be carcinogenic [21]

Chronic Average Daily Intake (CDI) of these PAHs,

$$CDI = \frac{TEQ^{mgm^{-3}} \text{ or } MEQ^{mgm^{-3}} \times IR^{(m^3 \, day^{-1})}}{BW_{(kg)}}$$

where IR is assumed to $20m^3$ per a day and body weight (BW) to be 70kg for male adult. For non-cancer PAHs, risk associated with inhalation of PAHs is indicated by hazard quotient (HQ)[49]

HQ = CDI/RfD

(RFD) = Reference Dose

This HQ is an estimate of the systemic toxicity posed by a single chemical. For systemic toxicity posed by chemicals within a single exposure, the hazard index (HI).

$HI = \Sigma HQ_1 + HQ_2 + HQ_3 +… HQ_n)$

For carcinogenic PAHs, the total carcinogenic risk is estimated in terms of "excess life time cancer risk" (ELCR) where ELCR = CDI x CSF[50]. The TEQBaP value calculated ranged between 0.71 to 6.04 and the MEQBaP ranged between 1.8 to 6.32; showing a marked spatial variation.

The risk based on toxic quotient of the pollutants (PAHs) relative to benzo(a)pyrene (TEQBaP) at AQBJ gave the highest value and AQGU the least. The increasing order of the risk are: AQBJ > AQIM > AQTR > AQOT > AQGU. Similarly, the increasing order of the risk of mutagenicity at sample locations posed by pollutants are: AQIM > AQBJ > AQOG > AQTR > AQOT > AQGU.

6

Table 3: Locations Toxic and Mutagenic Equivalent Quotient of PAHs

PAHs	TEF Values	MEF Values	TEQ BaP and MEQ BaP Values					
			AQOT	AQIM	AQOG	AQBJ	AQGU	AQTR
Naphthalene	0.001[a]		Bdl	Bdl	Bdl	0.005[a*]	Bdl	0.002[a*]
Acenaphthylene	0.001[a]		Bdl	Bdl	Bdl	0.004[a*]	Bdl	0.002[a*]
Acenaphthene	0.001[a]		Bdl	Bdl	Bdl	Bdl	Bdl	0.002[a*]
Fluorene	0.001[a]		0.002[a*]	Bdl	0.002[a*]	Bdl	Bdl	0.001[a*]
Phenanthrene	0.001[a]		0.001[a*]	Bdl	0.018[a*]	Bdl	Bdl	0.002[a*]
Anthracene	0.001[a]		0.02[a*]	Bdl	0.07[a*]	Bdl Bdl	Bdl	Bdl
Fluorenthene	0.001[a]		0.007[a*]	0.006[a*]	0.015[a*]	0.013	0.005[a*]	0.003[a*]
Pyrene	0.001[a]		0.012[a*]	Bdl	0.07[a*]	0.012[a*]	Bdl	0.015[a*]
Benzo(a)anthracene	0.1[a]	0.082[b]	0.3[a*] 0.25[b*]	1.3[a*] 1.07[b*]	0.8[a*] 0.66[b*]	2.4[a*] 2.0[b*]	Bdl Bdl	3.7[a*] 3.03[b*]
Chrysene	0.001[a]	0.017[b]	0.002[a*] 0.034[b*]	0.021[a*] 0.36[b*]	0.007[a*] 0.12[b*]	0.004[a*] 0.07[b*]	0.003[a*] 0.051[b*]	0.014[a*] 0.24[b*]
Benzo(b)fluoranthene	0.1[a]	0.25[b]	0.5[a*] 1.25[b*]	3.9[a*] 11.31[b*]	2.5[a*] 6.25[b*]	3.6[a*] 9[b*]	0.7[a*] 1.75[b*]	0.4[a*] 1[b*]
Benzo(a)pyrene	1[a]	0.11[b]	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl
Benzo(k)fluoranthene	0.01[a]	1[b]	0.03[a*] 3.0[b*]	0.03[a*] 3.0[b*]	Bdl Bdl	Bdl Bdl	Bdl Bdl	0.02[a*] 2[b*]
Indeno(1,2,3.Cd)pyrene	0.1[a]	0.29[b]	0.4[a*] 1.16[b*]	0.2[a*] 0.58[b*]	Bdl Bdl	Bdl Bdl	Bdl Bdl	0.1[a*] 0.29[b*]
DiBenzo(a,h)anthracene	1[a]	0.31[b]	1[a*] 0.31[b*]	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl	1[a*] 0.31[b*]
Benzo(g,h,i)perylene	0.01[a]	-	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl	Bdl Bdl
ΣTEQ_{BaP} ΣMEQ_{BaP}			2.3 6.0	5.51 16.32	3.43 7.03	6.04 11.07	0.71 1.80	5.30 6.97

Bdl = Below detection limit a = [3], b = [31]
a* = TEQBaP, b* = MEQBaP

Table 4: Risk Associated with Non-Cancer PAHs

PAHs	RfD(mgkg^{-1})	CDImgd^{-1}	HQ
Naphthalene	2 x 10^{-02}	2 x 10^{-3}	0.1
Acenapthylene	2 x 10^{-02}	1.71 x 10^{-3}	0.085
Acenapthene	6 x 10^{-02}	5.7 x 10^{-4}	0.010
Fluorine	4 x 10^{-02}	14 x 10^{-3}	0.04
Phenanthrene		-	-
Anthracene	3 x 10^{-02}	2.6 x 10^{-2}	0.87
Fluoranthene	4 x 10^{-02}	1.4 x 10^{-2}	0.35
Pyrene	3 x 10^{-02}	3 x 10^{-2}	1.0
Benzo(g,h)perylene	4 x 10^{-02}	-	-

Table 5: Risk Associated with Carcinogenic PAHs ([48])

PAHs	SF	CDImg/d^{-1}	ELCR
Chrysene	7.30 x 10^{-3}	2.8 x 10^{-1}	2.1 x 10^{-3}
Benzo(a)anthracene	7.30 x 10^{-1}	0.2 x 10^{12}	14.6 x 10^{-1}
Benzo(b)fluoranthene	7.30 x 10^{-1}	0.87 x 10^{15}	0.64 x 10^{-1}
Benzo(k)fluoranthene	7.3 x 10^{-1}	0.23 x 10^{14}	1.7 x 10^{-1}
Benzo(a)pyrene	7.30	-	-
Dibenzo(a,h)anthracene	7.30	1.74 x 10^{11}	1.27 x 10^{2}
Indeno(1,2,3-cd)pyrene	7.3 x 10^{-1}	5.8 x 10^{-13}	4.2 x 10^{-1}

Conclusion
The study showed a marked spatial distribution of PAHs. Some PAHs such as benzo (a) fluoranthene (BbF), benzo (a)anthracene (BaA), chrysene (Chr) and flouranthene (Fluo) were measured in higher concentrations than others. These levels measured appear to be influenced by certain anthropogenic sources: industrial combustion processes, traffic/commercial activities and biomass burning.
The health risks posed by these pollutants were determined in terms of hazard quotient (HQ) and excess life time cancer risk (ELCR). Only four of the sixteen USEPA priority PAHs were below the limit recommended by various regulatory bodies.This call for holistic monitoring of the PAHs emission into the air in the fragile Niger delta environment, as exposure to this POPs causes varieties of negative health effects such as reproduction defects, DNA mutations, leukemia, cancer of the lungs, bladder, bone, brain and scrota.

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