

Polycyclic Aromatic Hydrocarbons in Ado-Ekiti Roadside Soil, Nigeria: Distribution, Source Identification, Composition Profiles, and Toxic Potential

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Abstract

The study considered the level, origin with toxic potentials of PAHs in soil roadside of Ado-Ekiti, Nigeria. Gas chromatographic technique was employed for the identification of PAHs after extraction and silica gel cleanup. Average concentration of the PAHs ranged from ND – $51.6 \pm 46.7 \mu\text{g}/\text{kg}$, while total polycyclic aromatic hydrocarbons (TPAHs) ranged of $61.8 \pm 32.3 - 204 \pm 28.0 \mu\text{g}/\text{kg}$ with contamination pattern of ADY > AJI > EKSU > NNPC. The percentage distribution of LMW ranged from 17.3 – 54.2%, while the HMW-PAHs showed 46.0 - 82.7%. The PAHs pattern was dominated majorly by 5- and 6- ring with distribution range of 15.1 and 43.2%. The overall diagnostic ratios of the soils suggested pyrogenic, coal/wood/grass/vehicular combustion in most cases. To evaluate the toxicity of the PAHs in the samples, PAHs toxic equivalence factors (TEFs) revealed that carcinogenic PAHs contributed majorly (over 95%) to toxicity of the soil



Article History

Received: 14 June 2021
Accepted: 19 December 2021

Keywords

Carcinogenic;
Petrogenic; Pyrogenic;
Roadsides; Soil Toxicity.

Introduction

Ubiquitous nature of PAHs in terrestrial and marine environment made them an important.¹ PAHs are concern due to persistent nature. The EU and USEPA have prioritized PAHs due to carcinogenic and mutagenic properties.² High and low molecular weight are the two class of PAHs. The 4 to 6 aromatic rings are HMW with less bio-degradable properties, while LMW-PAHs consists 2 to 3 rings with less carcinogen properties than HMW types.³ US Environment Protection Agency have identified

sixteen (16) PAHs as priority pollutants.⁴ PAHs often contain elevated level of HMW and fewer LMW-PAHs.⁵ PAHs could be transported through the atmosphere to remote areas with increase in general background level of soils⁶⁻⁷ and lake sediments⁸⁻¹¹ where they accumulate due to their stability. Soils and river sediments often becomes environmental burden of these compounds.¹²

In Nig, comoseria,¹³ and other countries, Australia,¹⁴ Germany,¹⁵ USA,¹⁶ Korea,¹⁷ Brazil,¹⁸ China,¹⁹⁻²²

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Doi: <http://dx.doi.org/10.12944/CWE.17.1.20>

Norway,²³ Malaysia,²⁴ Czech Republic,²⁵ India,²⁶⁻²⁸ Slovakia,²⁹ studies of PAHs in soil have been reported. Their toxicity and widespread distribution have made PAHs important globally. The number of PAHs in city soil and propinquity of the compounds

in soil could lead to life exposure.³⁰ The study, therefore, assesses the distribution, sources, make-up, and toxic potentials of PAHs in soil roadside soil of Ado-Ekiti in Nigeria.

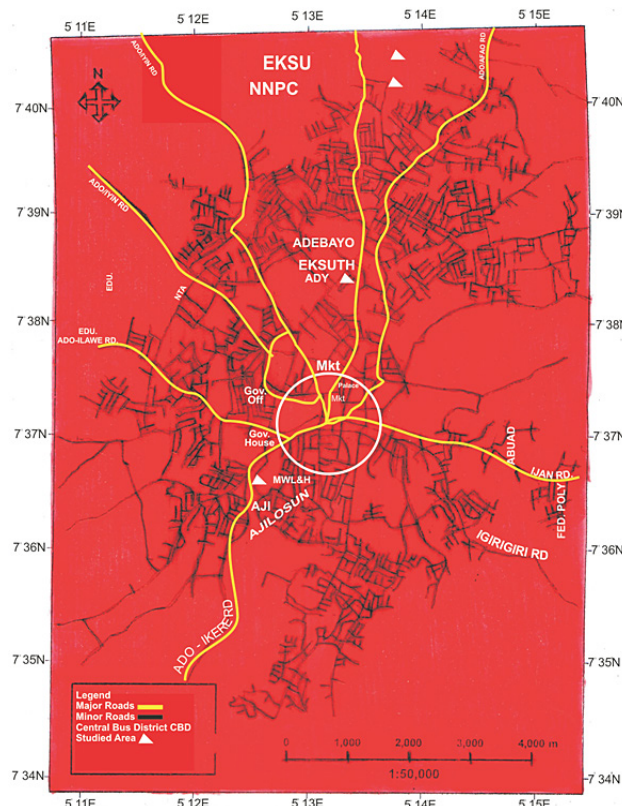


Fig 1: A map showing the position of the sampling locations

Materials and Methods

The Study Area

Soil were sampled from various locations in Ado-Ekiti, capital city of Ekiti State in Nigeria. The State covers an estimated land area of about 6,353 km² (Wikipedia), Ado-Ekiti the capital city covers about 732 km² of this area and lies between latitude 7° 37'16" N and longitude 5° 13'17" E. The city is a major trade center for farm produce. The major means of transportation in Ado-Ekiti is by road. Figure 1, depicts the map of the area indicating the sampling spots

Sample Collection and Preparation

Samples of roadside soils were taken from various locations within Ado-Ekiti in June, 2017. Locations, where soil samples were collected include Adebayo

(ADY), Ajilosun (AJI), Ekiti State University (EKSU) gate and Nigerian National Petroleum Corporation (NNPC) mega station roads. Table 1 showed the coordinates of the sampling sites.

Two composite samples were collected at each site with about 40 m between them. Composite soil samples were representative of four different spots within each area. These samples (four) were polled together to form a composite one. Soil samples were taken at 15cm depth. The soil samples collected from each area were placed appropriately in labeled glass sample bottles. Samples were later air-dried in the laboratory, ground in an agate mortar, and sieved with mesh size 2 mm. The sieved samples were later stored in glass bottles.

Table 1: The coordinates of the sampling area

Sampling area	Geographical locations of the sampling area		Distance between the sampling area (m)
AJI	7° 36' 29" N	5° 13' 17" E	40
	7° 36. 19" N	5° 13' 21" E	
ADY	7° 38' 53" N	5° 13' 30" E	40
	7° 38' 30" N	5° 13' 20" E	
EKSU	7° 42' 52" N	5° 15' 38" E	40
	7° 42' 55" N	5° 15' 40" E	
NNPC	7° 40' 44" N	5° 14' 40" E	40
	7° 40' 49" N	5° 14' 44" E	

AJI = Ajilosun Road; ADY = Adebayo Road; EKSU = Ekiti State University Road; NNPC = Nigerian National Petroleum Corporation Road.

Extraction of PAHs in the sample with Clean-Up Procedure

Sample extraction and cleanup were done according to USEPA (method 3550C).³¹ Twenty gramme each of dried soil sample and anhydrous Na₂SO₄ (1:1 g/g) was ultrasonically extracted using 50 mL mixture of 1:1 v/v of n-hexane: acetone

for 45 min. The supernatants were collected and extraction repeated three times with fresh 50 mL mixture. The supernatants were collected together and concentrated by a rotary evaporator to about 2 mL. The extracts was dissolved in n-hexane (5 mL) and concentrated in rotary evaporator to 2 mL at 40 °C.

Table 2: Operating conditions of GC

GC type	Agilent 7890A
Carrier gas	Helium
Carrier gas flow rate	1.2 ml/min
Inlet mode	Split less
Inlet temperature	250 °C
Column	Fused silica HP5 (30 m x 320 µm x 0.25µm)
Oven temp	60 °C for 1 minute
First ramping	12 °C/min for 15 min, continued for 2 min
Second ramping	8 °C/min for 10 min, continued for 5 min
Detector	Flame ionization detector (FID)
Detector temp.	325 °C
Total run time	32.25 minutes

Clean-up column was developed by slurring about 10g of activated silica gel (about 100-200 mesh, activated at 200 °C for 16 h) with n-hexane into a chromatography column. About 1g of anhydrous Na₂SO₄ was added and pre-eluted with 20 mL of n-hexane. The extract were moved quantitatively to the column and eluted using 25 mL of 2:3 v/v of n-hexane/dichloromethane. The hexane/dichloromethane extract was concentrated using rotary evaporator, adjusted

to 2 mL with n-hexane for gas chromatographic (GC) analysis. Table 2 depicted the operating conditions of gas chromatography.

Limit of Detection (LOD) and Limit of Quantification (LOQ)

Four concentrations (standard) ranging between 0.2 and 1 mgL⁻¹ were used to prepare calibration graph. Linear calibration curves was gotten in the tested concentration of PAHs standard. The LOD

were based on a signal- to-noise ratio of 3 and the LOQ on the signal-to-noise ratio of 10.

quality assurance standard and made the results acceptable.

Quality Assurance

Correlation coefficients were determined for analysed compounds. Values with < 0.95 correlation coefficients were rejected while, those > 0.95 were accepted. Values of correlation coefficient were between 0.9993 and 0.9999. They thus met the

Statistical Analysis

Statistical analysis used includes mean, corresponding standard deviation and coefficient of variation. Data obtained were subjected to Analysis of variance (ANOVA) using Statistical Software (SPSS Version 17).

Table 3: PAHs (μgkg^{-1}) concentrations of roadside soil from the study area

	AJI	ADY	EKSU	NNPC
Naphthalene	51.6 \pm 46.9 (90.7)	11.4 \pm 2.37(20.8)	10.3 \pm 9.04(90.1)	1.90 \pm 2.67(141)
Acenaphthylene	1.11 \pm 0.33 (20.70)	8.71 \pm 3.00(34.4)	2.12 \pm 0.35(16.5)	0.51 \pm 0.71(139)
Acenaphthalene	4.06 \pm 2.18 (43.7)	5.76 \pm 3.96 (68.8)	4.89 \pm 1.88(38.5)	2.30 \pm 1.20(52.2)
Fluorene	5.05 \pm 2.57 (50.9)	7.02 \pm 1.14(16.2)	5.20 \pm 1.97(37.9)	3.10 \pm 0.66(21.3)
Anthracene	1.57 \pm 0.51 (32.5)	4.78 \pm 1.22 (25.5)	2.03 \pm 1.80(88.7)	2.06 \pm 0.16(7.77)
Phenanthrene	1.61 \pm 0.40 (26.1)	3.20 \pm 0.42 (13.1)	3.23 \pm 1.02(31.6)	0.80 \pm 1.18(148)
Fluoranthene	1.73 \pm 0.60 (34.1)	6.72 \pm 2.39(35.6)	3.28 \pm 3.16(96.3)	0.85 \pm 0.16(18.8)
Pyrene	2.53 \pm 2.55 (101)	8.92 \pm 1.85(20.7)	1.33 \pm 1.88(141)	1.35 \pm 0.58(43.0)
Benzo(a)anthracene*	4.07 \pm 0.52 (12.8)	1.82 \pm 0.30(16.5)	7.80 \pm 3.25(41.7)	2.23 \pm 1.13(50.7)
Chrysene*	1.14 \pm 0.06 (5.30)	5.19 \pm 1.10(21.2)	1.97 \pm 0.38(19.3)	1.56 \pm 0.08(5.13)
Benzo(b)fluoranthene*	5.33 \pm 1.25 (23.5)	19.4 \pm 4.74(24.5)	10.1 \pm 4.64(46.0)	6.21 \pm 4.80(77.3)
Benzo(k)fluoranthene*	3.92 \pm 1.53 (39.0)	3.79 \pm 1.93(50.9)	6.53 \pm 3.79(50.0)	3.30 \pm 0.09(2.73)
Benzo(a)pyrene*	7.42 \pm 1.00 (13.5)	23.6 \pm 6.23(26.4)	13.4 \pm 4.20(31.4)	7.81 \pm 4.58(58.6)
Dibenzo(a,h)anthracene*	1.55 \pm 1.10 (71.0)	5.63 \pm 3.14(55.8)	7.43 \pm 10.5(141)	ND
Benzo(g, h, i)perylene	13.8 \pm 0.02 (0.20)	46.6 \pm 12.7(27.2)	12.2 \pm 8.32(68.3)	14.5 \pm 7.44(51.3)
Indenol(1,2,3, cd)pyrene*	13.6 \pm 2.20 (16.2)	41.5 \pm 7.17(17.3)	12.2 \pm 7.28(34.4)	13.3 \pm 7.40(55.5)
Σ PAHs	120 \pm 61.6 (51.3)	204 \pm 28.0(13.7)	104 \pm 39.2(39.2)	61.8 \pm 32.3(52.3)
Σ 7C-PAHs	37.0 \pm 5.59 (15.1)	101 \pm 20.2(19.9)	68.3 \pm 26.4(38.7)	34.4 \pm 17.9(52.1)
Σ LMW-PAHs	65.0 \pm 52.9 (81.4)	40.9 \pm 0.54(1.32)	27.7 \pm 16.1(58.4)	10.6 \pm 6.51(61.2)
Σ HMW-PAHs	55.1 \pm 8.71 (15.8)	163 \pm 28.6(17.5)	76.2 \pm 23.2(27.2)	51.1 \pm 25.8(50.4)

Mean \pm SD (CV%); ND = Not detected; *= Carcinogenic PAHs; Σ 7C-PAHs = Total 7 carcinogenic PAHs; Σ HMW-PAHs = Total high molecular PAHs; Σ LMW-PAHs = Total molecular PAHs.

Results and Discussion

Distribution of PAHs in Soil

The PAHs ($\mu\text{g/kg}$) level in soil from the four selected roadsides in Ado-Ekiti are depicted in Table 3. The average level of PAHs ranged from ND – 51.6 \pm 46.7 $\mu\text{g/kg}$ with the highest recorded for naphthalene in Ajilosun. The PAHs concentration ($\mu\text{g/kg}$) ranged from 1.11 \pm 0.33 (acenaphthylene) - 51.6 \pm 46.7 (naphthalene) in Ajilosun. 1.82 \pm 0.30 (benzo(a)anthracene) - 46.6 \pm 12.7 (benzo(g,h,i)perylene) in Adebayo, 1.33 \pm 1.88 (pyrene) - 13.4 \pm 4.20 (benzo(a) pyrene) in EKSU and ND - 14.5 \pm 7.44 (benzo(g,h,i)perylene) in NNPC. The TPAHs ranged

from 61.8 \pm 32.3 - 204 \pm 28.0 $\mu\text{g/kg}$ with contamination pattern of ADY > AJI > EKSU > NNPC. The presence of carcinogenic PAHs was highly observed in the samples. The seven carcinogenic PAHs were between 34.4 \pm 17.9 $\mu\text{g/kg}$ (NNPC) and 101 \pm 20.2 $\mu\text{g/kg}$ (ADY). The carcinogenic PAHs in the soil was in order: EKSU (60.4%) > NNPC (55.7%) > ADY (49.5%) > AJI (30.8%). A high level of spatial variation was mostly recorded for most PAHs as revealed by the coefficient of variation. Only seven PAHs exhibited low (0.20 - 26.1%) spatial variation in Ajilosun.

Five (Chrysene, fluorene, anthracene, fluoranthene and benzo(k)fluoranthene) in NNPC (2.73- 21.3%), three (acenaphthylene, phenanthrene and chrysene) in EKSU, while most PAHs in Adebayo exhibited moderate spatial variations. The level (0.51 – 51.6 μgkg^{-1}) were comparably lower than those reported for soil in Nigeria (5649 μgkg^{-1})¹³, Delhi, India (41.1 – 9145 μgkg^{-1})²⁸, USA (58680 μgkg^{-1})¹⁶, Hong kong, China (2- 554 μgkg^{-1})¹⁹, Malaysia (1450 μgkg^{-1})²⁴, Shanghai, China (3780 μgkg^{-1})²², Czech Republic (860 -10840 μgkg^{-1})²⁵, Australia (3300 μgkg^{-1})¹⁴, India (4694 \pm 3028 μgkg^{-1} ;²⁶; 6962 \pm 4823 μgkg^{-1})²⁷, Germany (16000 μgkg^{-1})¹⁵, Korea (15800 μgkg^{-1})¹⁷, China (81820 \pm 796200 μgkg^{-1} ;²⁰ ; 3780 μgkg^{-1})²², while the soil in Brazil (96 μgkg^{-1})¹⁸ is comparable to the present study. The concentration trends of the carcinogenic PAHs were in order: I₁₂₃P > BaP > BbF > BaA > BkF > DahA > Chry in Ajilosun; I₁₂₃P > BaP > BbF > DahA > Chry > BkF > BaF in Adebayo; while BaP > I123P > BbF

> BaA > DahA > BkF > Chry in EKSU and I₁₂₃P > BaP > BbF > BkF > BaA > Chry in NNPC roadside. The percentage distribution of LMW in the study areas ranged from 17.3 – 54.2% with a concentration pattern of Ajilosun > EKSU > Adebayo > NNPC, while the HMW-PAHs ranged from 46.0 – 82.7% with concentration a pattern of NNPC > Adebayo > EKSU > Ajilosun. The percentage distribution of LMW-PAHs showed Ajilosun (54%), EKSU (24.3%), Adebayo (20.0%) and NNPC (17.3%), while the HMW-PAHs reflected NNPC (82.7%), Adebayo (80.0%), EKSU (75.3%) and Ajilosun (46.0%). Based on European classification system of soil contamination,³² \sum 16PAHs < 200 $\mu\text{g}/\text{kg}$ showed no contamination, 200 - 600 $\mu\text{g}/\text{kg}$ corresponds to weak, 600 - 1000 $\mu\text{g}/\text{kg}$ revealed moderate, while > 1000 $\mu\text{g}/\text{kg}$ shows heavy contamination. All the sampling sites except Adebayo indicate no contamination, where its PAHs concentrations revealed > 200 $\mu\text{g}/\text{kg}$ and weak contamination.

Table 4: PAHs guidelines in soil (μgkg^{-1}) in comparison with the present study

	Soil guidelines		Present study
	NOAA (1999)	CCME (2002)	
Naphthalene	5000	600 – 22000	1.90 – 51.6
Acenaphthylene	-	-	0.51 – 8.71
Acenaphthalene	-	-	2.30 - 5.76
Fluorene	-	-	3.10 – 7.02
Anthracene	-	-	1.57 – 4.78
Phenanthrene	5000	5 × 10 ³ - 50 × 10 ³	0.80 – 3.23
Fluoranthene	-	-	0.85 – 6.72
Pyrene	1000	10 × 10 ³ - 100 × 10 ³	1.33 – 8.92
Benzo(a)anthracene	1000	-	1.82 – 7.80
Chrysene	-	1000 - 10 × 10 ³	1.14 - 5.19
Benzo(b)fluoranthene	1000	1000 - 10 × 10 ³	5.33 – 19.4
Benzo(k)fluoranthene	1000	1000 - 10 × 10 ³	3.30 – 6.53
Benzo(a)pyrene	1000	700	7.42 – 23.6
Dibenzo(a,h)anthracene	1000	-	ND – 7.43
Benzo(g,h,i)perylene	-	1000 - 10 × 10 ³	12.2 – 46.6
Indeno (1,2,3-cd)pyrene	1000	1000 - 10 × 10 ³	12.2 – 41.5

One-way analysis of variance (ANOVA) revealed that the p-value = 0.005 (< 0.05 level of significant), this showed enough evidence that the parameters differs. Further analysis also revealed significant variations (p < 0.05) in the levels of naphthalene, fluoranthene, pyrene, benzo(a)anthracene, indeno(1,2,3,cd)

pyrene, benzo(b)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene and acenaphthylene, while the other PAHs showed no significant variations among the sampling locations. The significant variations could be attributed to some factors such as physiochemical properties (soil pH, clay content and

OM) of the soil which could influence the dynamics and fate of both organic and inorganic pollutants in soil. Different accumulation and distribution pattern of some of these PAHs in soil could also contribute to the significant level.

Table 4 showed the recommended guidelines of PAHs in soils. Polycyclic aromatic hydrocarbons level in the study areas was significantly lower than the National Oceanic Atmospheric Administration, NOAA³³ and Canadian Council of Ministers

of Environment CCME³⁴ guidelines for the residential, community, and industrial soils.

The percentage distributions of PAHs compositions are depicted in Table 5. Adebayo, EKSU and NNPC exhibited a greater percentage of high molecular PAHs with a highest amount of 5- and 6- ringed PAHs. Ajilosun showed highest level of 2- and 6- ringed PAHs. Generally, the automobile smoke or exhaust is seen as the major fount or origin of high molecular PAHs.³⁵⁻³⁶

Table 5: Percentage distribution of PAHs composition in the sampling area

No of ring	AJI	ADY	EKSU	NNPC
2	51.6 (43.0)	11.4(5.59)	10.3 (9.90)	1.93(3.12)
3	13.4 (11.2)	14.5 (29.5)	17.5 (16.8)	8.77(14.2)
4	9.47(7.89)	22.7 (11.1)	14.4(13.8)	5.99 (9.69)
5	18.2 (15.1)	52.4(25.7)	37.5(26.1)	17.3 (28.0)
6	27.4 (22.8)	88.1(43.2)	24.4(23.5)	27.8 (45.0)

Levels (%)

Table 6: Diagnostic ratio for PAHs source identification

PAHs ratio	Values	Indication sources	Present study				Reference
			AJI	ADY	EKSU	NNPC	
BaP/ BghiP	< 0.6	Non traffic source	0.54	0.51	1.10	0.54	41
	> 0.6	Traffic source					
IcdP/ (IcdP + BghiP)	< 0.2	Petrogenic	0.49	0.47	0.50	0.48	38
	0.2 - 0.5	Fossil fuel (automobile)					
Flt/ (Flt/Pyr)	> 0.5	Combustion (grass, coal and wood)					
	< 0.4	Petrogenic	0.41	0.43	0.71	0.40	38
	≥ 0.4 - 0.5	Pyrogenic					39
Ant/(Ant/Phe)	> 0.5	Biomass, coal combustion					24
	< 0.1	Petrogenic	0.49	0.60	0.39	0.72	38-39
BaA/(BaA + Chr)	> 0.1	Pyrogenic (Combustion)					
	< 0.2	Petrogenic					
	0.2 - 0.35	Petroleum combustion	0.78	0.26	0.81	0.59	38 - 39
	> 0.35	Grass, coal and wood combustion					

The three and four-ringed PAHs ranged from 11.2% to 16.8% and 7.89% to 13.8% in Ajilosun and EKSU. The ring wise order of their concentration (%) was 6 (43.2% and 45.0%) > 5 (25.7% and 28.0%) > 3 (14.5% and 14.2%) > 4 (11.1% and 9.69%) > 2 (5.50% and 3.12%) in Adebayo and NNPC, while 5 (36.1%) > 6 (23.5%) > 3 (16.8%) > 4 (13.7%) > 2 (9.90%) in Adebayo and 2 (43.0%) > 6 (22.8%) > 5 (15.1%) > 3 (11.2%) > 4 (7.89%) in Ajilosun. This revealed that 5- and 6-ring were mostly predominant from the study areas. Sun *et al.*³⁷ revealed that PAHs of high molecular weight gives rise by high-temperature combustion, while low molecular weight gives rise low combustion temperature.

Source Identification of PAHs

PAHs ratios have been used to demonstrate source identification.³⁸⁻⁴⁰ A high percentage of HMW-PAHs to LMW-PAHs was observed in most cases. Higher proportion of HMW-PAHs was observed in the sampling areas except Ajilosun that showed 54.3%

of LMW-PAHs. The results was characterized by the predominance of high molecular weights. The ratios of low molecular weight to high molecular weight were < 1.0 in NNPC, EKSU, and Adebayo, while Ajilosun reflected 1.18. Isomer ratios of IcdP/(IcdP+BghP), Ant/(Ant+Phe), BaA/(BaA+Chry), Flt/(Flt/Pyr), and BaP/(BaP/BaP+Chr) was used for the source identification. Ratios for PAHs source identification were depicted in Table 6. The PAHs ratio for Ant/(Ant + Phe) and Flt/(Flt/Pyr) showed greater than 0.1 in all the sampling sites and ≥ 0.4 – 0.5 (except EKSU), this indicates pyrogenic (combustion) source of the PAHs in the sampling areas, Flt/(Flt/Pyr) in EKSU indicate combustion of biomass, wood, coal, and grass.

The BaA/(BaA+Chry) of Adebayo and EKSU indicated grass, coal and wood combustion in most cases. IcdP/(IcdP+BghiP) were between 0.47 to 0.50, suggesting pyrogenic.³⁸ The overall diagnostic ratios suggested that the PAHs were predominately pyrogenic.

Table 7: TEQ_{BaP} (µg/kg) of the soil from the study area

	TEFs	AJI	ADY	EKSU	NNPC
Acenaphthalene	0.001	0.0004	0.006	0.005	0.002
Naphthalene	0.001	0.052	0.011	0.010	0.002
Acenaphthylene	0.001	0.001	0.009	0.002	0.0005
Phenanthrene	0.001	0.002	0.003	0.003	0.0008
Pyrene	0.001	0.003	0.009	0.001	0.001
Fluorene	0.001	0.005	0.007	0.005	0.003
Chrysene*	0.01	0.011	0.052	0.020	0.016
Benzo(b)fluoranthene*	0.1	0.533	1.94	1.01	0.621
Fluoranthene	0.001	0.002	0.007	0.003	0.0008
Dibenzo(a,h)anthracene*	1	1.55	5.63	7.43	-
Benzo(a)anthracene*	0.1	0.407	0.182	0.780	0.223
Anthracene	0.01	0.016	0.048	0.020	0.021
Indeno (1,2,3-cd)pyrene*	0.1	1.36	4.15	1.22	1.33
Benzo(g,h,i)perylene	0.01	0.014	0.047	0.012	0.013
Benzo(a)pyrene*	1	7.42	23.6	13.4	7.81
Benzo(k)fluoranthene*	0.1	0.392	0.379	0.653	0.330
∑16-PAHs	2.43	11.8	36.1	24.6	10.4
∑7C-PAHs	1.41	11.6	35.9	24.5	10.3

Assessment of Soil Toxicity

To assess the soil toxicity, benzo(a)pyrene toxicity equivalents were used. Investigators have established value for individuals PAHs

Toxic Equivalence Factor.⁴²⁻⁴³ It's also alluded to as benzo(a)pyrene toxicity.⁴² Toxic equivalents (TEQs) were used to quantify PAHs toxic potencies of the soil. Total toxic equivalents of PAHs

with respect to BaP (TEQ_{BaP}) was used to establish the carcinogenic potency.

The total benzo(a)pyrene equivalent:

$$TEQ_{BaP} = \sum (TEFi \times Ci)$$

Where Ci = measured individual PAHs for (ith) compound, while TEFi = corresponding toxic equivalent factor.

The average sum of TEQ_{BaP} (µg/kg) were 11.8 (Ajilosun), 36.1 (Adebayo), 24.6 (EKSU) and 10.4 (NNPC). The PAHs toxicity level of NNPC is double and thrice of EKSU and Adebayo. The mean TEQ_{BaP} value were lower than 650 µg BaP_{eq}/kg, India⁴⁴; 542.8 µg BaP_{eq}/kg, India²⁷; 124 µg BaP_{eq}/kg, Spain⁴⁵ and 428 µg BaP_{eq}/kg, China.²² The sum of carcinogenic toxic potency of the soils was in the order: Adebayo (35.9) > EKSU (24.5) > Ajilosun (11.6) > NNPC (10.3). The result further revealed that the carcinogenic potency of the roadside soil was the highest in Adebayo and as such contribute majorly to toxicity of the soil.

Conclusion

The study revealed low PAHs contamination and high percentage distribution of HMW-PAHs with

a percentage composition of 46.0 – 82.7%. The PAHs composition was also characterized by a high 5- and 6- rings PAHs. The overall diagnostic ratio of PAHs suggested mixed pyrogenic sources. Carcinogenic PAHs level within the city soils could be toxic to human exposure. The research, therefore, suggests that PAHs pollution should be discouraged, most importantly traffic exhaust especially diesel exhaust.

Acknowledgement

The authors acknowledge the technical assistance rendered by the Nigerian Institute of Oceanography and Marine Research (NIOMR) Central Laboratory, Victoria Island, Lagos.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest

The author has no conflict of interest including any financial, personal, or other relationships with other people or organizations that can influence the work.

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