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Assessment of Polycyclic Aromatic Hydrocarbons in Agricultural Soils of Teskelewu Community and Environs Impacted By Gas Flaring in Delta State, Nigeria

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ABSTRACT: Polycyclic aromatic hydrocarbons (PAHs) are emerging ubiquitous environmental pollutants with reported carcinogenic, mutagenic and teratogenic potentials on living organisms and humans. The objective of this study was to assess the concentrations of PAHs in agricultural soils of Tsekelewu Community and environs (Egbema Kingdom) in Warri North Local Government Area of Delta State, Nigeria impacted by gas flaring using gas chromatograph system Agilent 5890 Series 11 gas chromatograph equipped with Flame ionization detector (GC-FID). The results revealed that station 1 and 2 were fairly contaminated; with mean total PAH concentration of 236.40 µg/kg and 279.75 µg/kg respectively. Stations 3, 4, 6, 7 and 9 having mean total PAH concentration of 692.45µg/kg, 726.22 µg/kg, 739.82 µg/kg, 609.38 µg/kg, and 772.99 µg/kg were moderately contaminated. Heavy contamination was recorded in station 5 and station 8 with mean PAH concentrations of 1231.08µg/kg and 1224.33 µg/kg. The dominant PAHs in soil samples were benzo(a)anthracene, phananthrene and chrysene with benzo(a)anthracene having the highest concentration across all sample stations. The PAH concentration observed in this study is thus a serious cause for concern since soil contamination from gas flaring will likely continue. Measures that will attenuate PAHs concentrations in soil should be adopted as farmers are likely exposed by largely inhalation.

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Polycyclic aromatic hydrocarbons (PAHs) have become ubiquitous environmental pollutants thereby attracting the interest of the researchers all over the world. This increased interest emanates from the reported carcinogenic, mutagenic and teratogenic potentials of PAHs on living organisms and humans (Olsson *et al*., 2010; Zheng *et al*. 2012). PAHs are a group of semi-volatile organic compounds that are composed of two or more aromatic (benzene) rings fused together in a variety of configurations (Doherty *et al*., 2015). Generally, PAHs are characterized by high lipid solubility, facile bioaccumulation, environmental toxicity, and persistent nature, with high melting and boiling points and low vapor pressure (Akyuz and Cabuk, 2010; Abdel-Shafy *et al*., 2016). Formation of PAH is due to incomplete combustion of organic matter through the condensation of ethylenic radicals in the gas phase to form the larger polycyclic compounds (Lane, 1989). PAHs may originate from natural sources (PAH background values) such as forest fires, volcanic activity or as a result of anthropogenic activities like incomplete combustion of fossil fuels and industrial emissions (Al-Saad *et al*., 2019). PAHs found in the urban environment are predominantly anthropogenic in origin. They may be either associated with (a) petroleum products introduced to the environment through spills and industrial discharges (generally termed "petrogenic") or (b) the incomplete combustion of organic materials emitted by various engine types from automobiles to power plants (termed "pyrogenic"). Depending on their molecular structure and number of aromatic rings, PAHs can be grouped into low-molecular weight PAHs (LMWPAHs), with two or three aromatic rings, and high-molecular weight PAHs (HMWPAHs), with four or more aromatic rings (Gereslassie *et al.,* 2018). Low-molecular weight (LMWPAHs) are environmentally abundant, occur in the atmosphere and are highly toxic compounds. However, they are relatively less persistent, have lower carcinogenicity, and are more easily degradable than high-molecular weight (HMWPAHs) (Kumar *et al*., 2012). Low molecular weight alkyl PAHs generally indicate petrogenic origin (alkylated PAHs), whereas high molecular weight generally indicates pyrogenic origin (parent PAHs). The ratio of similar mass PAH isomers can give an indication of their likely source (Doherty *et al.*, 2015). PAH exhibit their mutagenic and carcinogenic activity through biotransformation to chemically reactive intermediates which bind covalently to cellular macromolecules (*inter alia* DNA) (WHO, 2000). PAHs are prone to enrichment in the soil matrix long after being adsorbed by the soil and sediment organic matter and more than 90% of the total mass of PAHs in the environment is stored in soils (Bergamasco *et al*., 2015; Bi *et al*., 2016). Therefore soil is considered as the final reservoir and repository for such hydrophobic organic contaminants (Kwon and Choi 2014, Wang *et al*. 2015). In warmer climates, soil can contribute PAHs to the atmosphere (Dalla-Valle *et al*., 2005). Further, leaching of PAHs from soils can contaminate groundwater (Bortey-Sam *et al.*, 2014). Therefore, monitoring concentrations of PAHs in soils is important for assessing their potential effects on the environment or humans. Gas flaring practices has been preferred as a means of disposing associated or waste gas by various petroleum exploration and production companies operating in the Nigeria's Niger Delta for the past five decades (Ite and Ibok, 2013). This practice has enormous impact on the soil, water and atmospheric conditions of the immediate environment. Assessment of the PAH compound ratios, phenanthrene/anthracene and fluoranthene/pyrene, suggested that predominant PAHs of pyrogenic sources on surface soils is an indication that oil leakage and/or gas flaring contributes to soil contamination (Sojinu *et al.*, 2010). Gas flaring in Tsekelewu Community is thus a threat to the inhabitants of the community due to the release of associated contaminants such as benzene, toluene, ethyl benzene, and xylenes (BTEX), aliphatic and polycyclic aromatic hydrocarbons (PAHs) which ultimately deposit in the soil. Assessment of the level of contamination in these soils is thus a necessity.

The aim of this study is to assess of concentrations of PAHs in agricultural soils of Tsekelewu Community impacted by gas flaring in Warri North Local Government Area of Delta State.

MATERIALS AND METHODS

Study Area: The study was carried in Oil rich Tsekelewu community and environs in Delta State, Southern Nigeria. The nine communities involved were Tsekelewu - Station 1 (Long. N05.97527°, Lat. E004.97356°); Ikpoku-gbene - Station 2 (Long.N05.94935°, Lat. E005.01663°); Iralatei - Station 3 (Long.N05.94627°, Lat. E005.02834°); Agoduba - Station 4 (N05.94014°, E005.04122°); Ozuoedodo - Station 5 (Long.N05.94054°, Lat. E005.04335°); Weke-gbene - Station 6 (Long N05.93746°, Lat. E005.04745), Opuama - Station 7 (Long.N05.91754, Lat. E005.05929°); Ayara-Gbene - Station 8 (Long N05.92470°, Lat. E005.02323°) and Tangege-gbene - Station 9 (Long. N05.93379°, Lat. E005.03247°). The map of the study area (Figure 1) was created with QGIS software (Version 3.6.1) using satellite imagery.

Sample Collection: An initial survey was carried out on the site prior to sample collection in order to ensure that challenges during sampling would be minimized. Surface soil samples were collected from agricultural soils of Tsekelewu community and environs that are subjected to gas flaring activities. Samples were collected using a hand held trowel that was washed and dried after collection from each station. The samples were placed in polyethylene plastic bags, properly labeled and transported on an ice chest to the laboratory where it was stored in a chiller at 4°C.

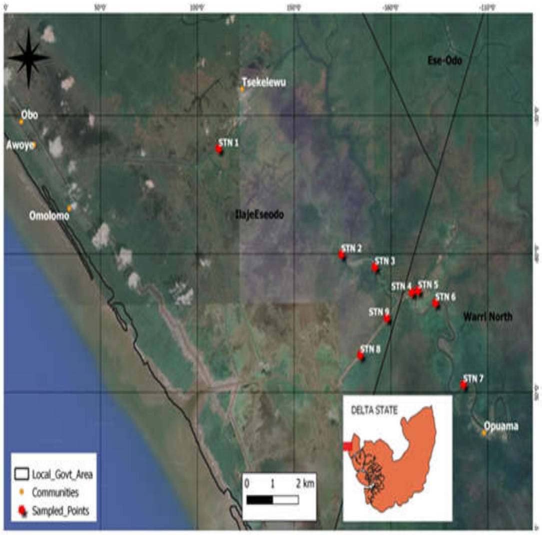

Fig 1: Map showing the stations sampled in the study area

Soil Sample Extraction: The extraction of soil sample was carried out by weighing 5g each soil sample into pre-cleaned 25ml amber glass bottles. 10ml of hexane was added, respectively. The bottles were sealed with a screw cap closure lined with a PTFE-faced silicone rubber septum and shaken vigorously to suspend the contents. The bottles were then sonicated in a high performance ultrasonic bath with microprocessor control for precision time and temperature controlled operation for 30 min. the sample bottles were intermittently inverted and shaken to continually re-suspend the samples after which the sample was filtered. After filtration the solvent was evaporated/blown down under gentle steam of oxygen to 0.5ml.

Clean up: One cm of moderately packed glass wool was placed at the bottom of 10mm ID × 250 Loup chromatographic column. Then 3.5g silica gel was poured into the chromatographic column. To the top was added 0.5 cm of sodium sulphate. The 0.5 ml extracted sample was poured into the column. The extraction bottle was rinsed with 7ml of hexane and added to the column immediately. The effluent/extract was collected with a 10ml bottle and evaporated/blown down under gentle steam of oxygen to 0.2ml. The aromatic concentrates were transferred into labeled 1.5ml glass vials and hexane was added up to 0.5ml. The vials were capped with Teflon rubber crimp and sealed in preparation for the GC analysis.

PAHs analysis: The determination of PAHs was performed on a high resolution gas chromatograph system Agilent 5890 Series 11 gas chromatograph equipped with Flame ionization detector (GC-FID), with on-column capillary injection system and Hewlett-Packard model 7673 autos ampler. For the PAHs determination, 0.5 micro-litre of each sample was injected by the auto-sampler a splitless mode. The separation was performed on fused silica capillary columns DB-5, 30 m x 0.25 mm internal diameter, and 0.25 µm film thickness (5% phenyl silicone, 95% methyl silicone). High purity nitrogen was used as carrier gas at flow rate of 1 mL/min and 30 mL/min respectively. The oven temperature programmed was as follows: initial temperature of 80 °C was held for 2 min, increased to 190 °C at 5 °C/min, and then increased to 280 °C at 10 °C/min. The injector and detector temperatures were set at 250 °C and 300 °C, respectively. Identification of the individual PAHs was based on comparison of retention time between samples and the standard solution. Quantification was performed by five-point calibration method (from 100 to500 ng/mL, $r^2 > 0.992$) in all cases.

RESULTS AND DISCUSSION

The summary of PAH concentration in the study stations are shown in Table 1. Mean ranges of the 16 PAHs in this study werenaphthalene (0.00 – 246.07 µg/kg), Acenaphthene (0.67 – 153.55 µg/kg) Acenaphthylene (0.00 – 80.91 mg/kg), Flourene (0.00 – 101.67 mg/kg), Phenanthrene (0.00 – 714.28 µg/kg), anthracene (0.00 – 31.41 µg/kg), flouranthene(0.00 – 331.60 µg/kg), pyrene (0.00 – 167.54 µg/kg), Chrysene (1.05 – 812.36 µg/kg), Benzo (a) anthracene (0.35 – 1146.65 µg/kg), Benzo (b) flouranthene (0.00 – 15.77 µg/kg), Benzo (k) flouranthene (0.84 – 18.08 µg/kg), Benzo (a) pyrene (0.00 – 35.68 µg/kg), indeno (1, 2, 3 –d) pyrene (0.00 – 64.63 µg/kg) Dibenzo (a, h) anthracene (0.00 to 62.67 µg/kg), and Benzo (g, h) perylene (0.00 – 2165.74 µg/kg). Mean concentration of the 16 PAHs in all the sampled stations varied between 14.78±29.37 µg/kg to 76.94±191.40 µg/kg. The highest (1231.08 µg/kg) sum concentration of PAH were observed in station 5 while the lowest (236.40µg/kg) was observed in station 1. Pearson correlation between the PAH concentration is shown in Table 2. Significant positive correlations were observed between Acy/Ace (0.833), Fln/Ace (0.864), Fln/Acy (0.985), Phe/Ace (0.892), Phe/Acy (0.984), Phe/Fln (0.993), Ant/Ace (0.862), Ant/Acy (0.965), Ant/Flu (0.992), Ant/Phe (0.977), Flu/Ace (0.910), Flu/Acy (0.822), Flu/Fln (0.890), Pyr/Ace (0.827), Pyr/Fln (0.634), Pyr/Phe (0.624), Pyr/Ant (0.692), Pyr/Flu (0.908), BbF/Ace (0.740), Bbf/Flu (0.621), Bbf/Pyr (0.763), BaP/Fln (0.624), BaP/Phe (0.662), BaP/Ant (0.632), BaP/Flu (0.787) and BaP/Pyr (0.850).

Table 1: Summary statistics of PAHs in agricultural soils of Tsekelewu Community and environs

	PAH	**Stations**				**Class**
		Station 1	**Station 2**	**Station 3**	**Station 4**	
Naphthalene	NaP	9.66±16.73 (0.00 – 28.97)	82.02±142.07 (0.00 – 246.07)	0.98±1.70 (0.00 – 2.94)	72.78±126.06 (0.00 – 218.34)	2B
Acenaphthene	Ace	9.7413.12 (0.67 – 24.78)	8.46±6.29 (1.37 – 13.37)	12.79±14.60 (2.15 – 29.44)	8.55±6.82 (2.88 – 16.11)	NC
Acenaphthylene	Acy	1.18±2.04 (0.00 – 3.54)	1.45±2.52 (0.00 – 4.36)	2.75±4.76 (0.00 – 8.25)	1.92±3.33 (0.00 – 5.76)	NC
Flourene	Fln	2.69±4.66 (0.00 – 8.08)	2.83±4.89 (0.00 – 8.48)	7.87±13.64 (0.00 – 23.62)	4.98±8.63 (0.00 – 14.95)	NC
Phenanthrene	Phe	27.59±47.79 (0.00 – 82.78)	9.27±16.05 (0.00 – 27.80)	33.28±57.65 (0.00 – 99.85)	28.87±50.00 (0.00 – 86.60)	NC
Anthracene	Ant	0.98±1.70 (0.00 – 2.95)	0.75±1.30 (0.00 – 2.25)	3.74±6.48 (0.00 – 11.23)	1.33±2.31 (0.00 – 3.40)	NC
Flouranthene	Flu	19.47±33.72 (0.00 – 58.41)	11.95±20.70 (0.00 – 35.85)	74.89±129.72 (0.00 – 224.68)	16.67±28.87 (0.00 – 50.00)	NC
Pyrene	Pyr	9.05±15.67 (0.00 – 27.14)	5.22±9.03 (0.00 – 15.65)	39.70±68.77 (0.00 – 119.11)	6.19±10.72 (0.00 – 18.60)	NC
Chrysene	Chr	24.16±33.25 (4.80 – 62.56)	13.78±18.02 (1.05 – 34.40)	38.67±62.90 (1.24 – 111.29)	279.57±461.53 (2.77 – 812.36)	2B
Benzo (a) anthracene	BaA	119.99±200.38 (3.99 – 351.36)	112.95±186.51 (0.35 – 328.24)	470.99±509.90 (1.35 – 719.50)	297.09±509.90 (1.32 – 885.87)	B
Benzo (b)fluoranthene	BbF	0.51±0.88 (0.00 – 1.53)	0.13±0.22 (0.00 – 0.38)	0.34±0.59 (0.00 – 1.02)	0.05±0.08 (0.00 – 0.14)	2B
Benzo (k) fluoranthene	BkF	2.86±2.52 (0.95 – 5.71)	7.28±5.11 (1.60 – 11.50)	4.17±2.40 (1.40 – 5.66)	4.63±3.88 (1.15 – 8.81)	2B
Benzo (a) pyrene	BaP	0.33±0.57 (0.00 – 0.98)	0.33±0.57 (0.00 – 0.99)	0.93±1.60 (0.00 – 2.78)	0.38±0.65 (0.00 – 1.13)	B
Indeno(1,2,3-cd)pyrene	icdP	4.06±5.12 (0.00 – 9.81)	11.45±14.41 (0.00 – 27.63)	0.68±1.17 (0.00 – 2.02)	2.15±0.37 (0.00 – 0.64)	2B
Dibenzo(a,h)anthracene	DaA	1.93±3.35 (0.00 – 5.80)	4.31±5.07 (0.00 – 9.90)	0.39±0.68 (0.00 – 1.18)	0.38±0.66 (0.00 – 1.14)	B
Benzo (g,h,i) perylene	BgP	2.20±3.82 (0.00 – 6.61)	7.57±12.34 (0.00 – 21.82)	0.28±0.49 (0.00 – 0.85)	0.68±1.18 (0.00 – 2.04)	NC
	Σ16	**236.40**	**279.75**	**692.45**	**726.22**	
	$\bar{X}$	**14.78±29.37**	**17.48±32.02**	**43.28±116.02**	**45.39±96.62**	

PAHS concentrations are in µg/Kg. Values are expressed as mean ± standard deviation.

Table 1: Continue

	PAH	**Stations**					**Class**
		Station 5	**Station 6**	**Station 7**	**Station 8**	**Station 9**	
Naphthalene	NaP	75.93±131.51 (0.00 – 227.78)	74.63±129.26 (0.00 – 223.88)	45.01±77.95 (0.00 – 135.02)	18.95±32.82 (0.00 – 56.84)	13.53±23.43 (0.00 – 40.59)	2B
Acenaphthene	Ace	14.20±13.62 (6.17 – 29.82)	12.69±14.86 (2.63 – 29.75)	9.20±4.97 (4.18 – 14.12)	55.03±85.30 (4.30 – 153.52)	53.18±86.93 (1.69 - 153.55)	NC
Acenaphthylene	Acy	0.22±0.37 (0.00 – 0.65)	1.99±3.43 (0.00 – 5.96)	0.48±0.83 (0.00 – 1.45)	26.97±46.71 (0.00 – 80.91)	6.51±11.27 (0.00 – 19.53)	NC
Flourene	Fln	2.81±4.87 (0.00 – 8.43)	5.17±8.96 (0.00 – 15.51)	1.61±2.78 (0.00 – 4.82)	33.89±58.70 (0.00 – 101.67)	10.59±18.34 (0.00 – 31.76)	NC
Phenanthrene	Phe	24.11±41.76 (0.00 – 72.33)	39.84±69.01 (0.00 – 119.53)	13.07±22.63 (0.00 – 39.20)	238.09±412.39 (0.00 – 714.28)	85.52±148.13 (0.00 – 256.57)	NC
Anthracene	Ant	0.86±1.49 (0.00 – 2.59)	1.53±2.65 (0.00 – 4.60)	0.09±0.16 (0.00 – 0.27)	10.47±18.14 (0.00 – 31.41)	3.57±6.17 (0.00 – 10.70)	NC
Flouranthene	Flu	7.34±12.72 (0.00 – 22.03)	28.84±49.95 (0.00 – 86.52)	0.97±1.67 (0.00 – 2.90)	110.53±191.45 (0.00 – 331.60)	89.32±154.71 (0.00 – 267.97)	NC
Pyrene	Pyr	4.50±7.80 (0.00 – 13.51)	10.79±18.68 (0.00 – 32.36)	6.13±10.61 (0.00 – 18.39)	26.65±46.17 (0.00 79.96)	55.84±96.73 (0.00 – 167.54)	NC
Chrysene	Chr	12.77±13.35 (3.95 – 28.13)	295.66±392.44 (57.47 – 748.61)	33.78±40.48 (6.63 – 80.31)	39.42±60.26 (1.63 – 108.91)	35.55±56.31 (1.57 – 100.55)	2B
Benzo (a) anthracene	BaA	338.79±338.05 (0.82 – 676.93)	257.82±443.94 (0.61 – 770.43)	471.17±412.12 (0.66 – 768.15)	591.47±572.76 (2.62 – 1146.65)	389.05±426.74 (11.21 – 851.90)	B
Benzo (b)fluoranthene	BbF	1.44±2.49 (0.00 – 4.31)	2.70±4.67 (0.00 – 8.09)	0.12±0.21 (0.00 – 0.37)	0.87±1.51 (0.00 – 2.61)	5.25±9.10 (0.00 – 15.77)	2B
Benzo (k) fluoranthene	BkF	4.09±2.01 (2.64 – 6.38)	5.30±0.90 (4.27 – 5.91)	4.58±2.25 (2.02 – 6.20)	4.53±3.19 (0.84 – 6.38)	8.25±8.51 (3.16 – 18.08)	2B
Benzo (a) pyrene	BaP	1.33±2.31 (0.00 – 4.00)	0.13±0.22 (0.00 – 0.38)	0.32±0.56 (0.00 – 0.97)	5.54±9.61 (0.00 – 16.64)	11.89±20.60 (0.00 – 35.68)	B
Indeno(1,2,3-cd)pyrene	icdP	19.79±33.07 (0.00 – 57.96)	0.92±1.59 (0.00 – 2.76)	13.95±20.67 (0.00 – 37.70)	23.32±35.88 (0.00 – 64.63)	1.71±2.96 (0.00 – 5.13)	2B
Dibenzo(a,h)anthracene	DaA	0.25±0.43 (0.00 – 0.74)	1.48±2.56 (0.00 – 4.45)	0.41±0.72 (0.00 – 1.24)	23.02±34.49 (0.00 – 62.67)	1.44±2.50 (0.00 – 4.33)	B
Benzo (g,h,i) perylene	BgP	722.65±1249.76 (0.00 – 2165.74)	0.33±0.57 (0.00 – 0.98)	8.49±11.29 (0.00 – 21.28)	15.58±18.78 (0.00 – 36.44)	1.79±2.28 (0.00 – 4.36)	NC
	Σ16	**1231.08**	**739.82**	**609.38**	**1224.33**	**772.99**	
	$\bar{X}$	**76.94±191.40**	**46.24±92.313**	**38.09±116.20**	**76.52±149.23**	**48.31±95.61**	

PAHS concentrations are in µg/Kg. Values are expressed as mean ± standard deviation.

Over a thousand PAH compounds have been defined but the United States Environmental Protection Agency (USEPA) classified 16 PAHs as priority pollutants and eight as carcinogens. (Liu *et al*., 2016). The Eight PAHs (Car-PAHs) typically considered as possible carcinogens are: benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene (B(a)P), dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene and benzo (g,h,i)perylene. In particular, benzo(a)pyrene has been identified as being highly carcinogenic (Srogi, 2007). According to the European classification system of soil contamination (Maliszewska-Kordybach, 1996) Σ16 PAHs < 0.20 mg/kg show no contamination, 0.20–0.60 mg/kg corresponds to weak contamination, 0.60–1.0 mg/kg represents moderate contamination, and >1.0 mg/kg indicates heavy contamination.

Table 2: Inter-Item Correlation Matrix

	NaP	**Ace**	**Acy**	**Fln**	**Phe**	**Ant**	**Flu**	**Pyr**	**Chr**	**BaA**	**BbF**	**BkF**	**BaP**	**icdP**	**DaA**	**BgP**
NaP	1.000															
Ace	.161	1.000														
Acy	.111	**.833****	1.000													
Fln	.208	**.864****	**.985****	1.000												
Phe	.199	**.892****	**.984****	**.993****	1.000											
Ant	.166	**.862****	**.965****	**.992****	**.977****	1.000										
Flu	.152	**.910****	**.822****	**.890****	**.875****	**.927****	1.000									
Pyr	.132	**.827****	.533	**.634***	**.624***	**.692***	**.908****	1.000								
Chr	-.122	-.006	.016	.005	.005	.012	.015	.008	1.000							
BaA	-.491	-.356	-.286	-.368	-.360	-.372	-.421	-.419	-.321	1.000						
BbF	.312	**.740***	.303	.386	.437	.396	**.621***	**.763**	-.014	-.346	1.000					
BkF	-.334	.263	-.120	-.139	-.088	-.130	.065*	.268	-.023	.149	.499	1.000				
BaP	.079	.925**	.585	**.624***	**.662***	**.632***	**.787***	**.850**	.013	-.293	.842	.500	1.000			
icdP	-.071	.418	.598	.547	.548	.524	.366	.134	-.112	-.014	-.001	-.099	.221	1.000		
DaA	.012	.047	.045	.036	.037	.032	.024	.004	-.092	.324	.010	.046	.021	.018	1.000	
BgP	-.107	-.071	-.059	-.077	-.076	-.078	-.090	-.092	-.084	.187	-.077	-.097	-.064	.571	-.046	1.00

Npl – Naphthalene, Ace – Acenaphthene, Acy – Acenaphthylene, Fl – Flourene, Phe – Phenanthrene, Ant – Acenaphthene, Flu – Flouranthene, Pyr – Pyrene, Chr – Chrysene, BaA – Benzo (a) anthracene, BaF – Benzo (a) Flouranthene, BkF – Benzo (k) Flouranthene, BaP – Benzo (a) pyrene, iEP – indeno (1, 2, 3 – d) pyrene, DaA – Dibenzo (a, h) anthracene, BgP – Benzo (g, h) perylene.

Following this classification, in this study, stations 1 and 2 with total PAH concentration of 236.40 µg/kg and 279.75 µg/kg were weakly contaminated. Stations 3, 4, 6, 7 and 9 were moderately contaminated having total PAH concentration of 692.45µg/kg, 726.22 µg/kg, 739.82 µg/kg, 609.38 µg/kg, and 772.99 µg/kg. Station 5 with total PAH (1231.08µg/kg) and station 8 (1224.33 µg/kg) were heavily contaminated with PAH. Total mean PAH concentration in stations 5 and 8 also exceeded the Department of Petroleum resources (1999) permissible limits of 1000 µgkg^{-1}. The dominant PAHs in soil samples were benzo(a)anthracene, phananthrene and chrysene with the carcinogenic, persistence, bioaccumulative potentials with the toxic 4-ring benzo(a)anthracene having the highest concentration across all sample stations. The ranges for mean concentrations of benzo(a)anthracene, phananthrene and chrysene were (112.95-591.47µg/kg), (9.27-288.09µg/kg) and (12.77-295.66µg/kg) respectively with station 8 having the highest benzo(a)anthracene contamination. The mean PAH concentration in this study are similar with values reported by Nwaichi *et al*., (2016) who reported total PAH range concentration of 531.661 – 4613.020 µg/kg in their study of some oil polluted sites in Delta state. These findings indicate that the soil in the Tsekelewu community stored copious amount of PAH and thus potential danger is inevitable. It has been reported that PAHs in soils might be further deposited on or accumulated into vegetables or other biota via food chains (Li *et al*., 2008). Previous studies have shown that 3-ring PAHs are readily absorbed by maize roots but 2- and 4–6 ring PAHs are less likely to be absorbed into the plants (Banger *et al*., 2010. It is worthy of note that the ground water sources of this community is also at risk due to infiltration of PAH. The low solubility of PAH in water makes them easily sorbed in the organic matter of the soil instead of being solubilized in the infiltrating water thereby transporting them downwards to the ground water (Nwaichi *et al*., 2016).

Given that there is no threshold concentration below which carcinogenic effects of PAH does not occur, the PAH concentration observed in this study is thus a serious cause for concern. Regulatory measures need to be put in place to stop the trend of PAH contamination in the area inorder to avoid contamination of water sources and health risks to inhabitants of the community.

Conclusion: In this study dominant PAHs determined in soil samples collected from Agricultural soils of Tsekelewu Community and environs were benzo(a)anthracene, phananthrene and chrysene with benzo(a)anthracene having the highest concentration across all sampled stations. The PAH concentration observed in this study is thus a cause for concern since soil contamination from gas flaring will likely continue. Measures that will attenuate PAHs concentrations in soil should be adopted as farmers are likely exposed by largely inhalation.

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