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Distribution of polycyclic aromatic hydrocarbons (PAHS) in roadside soils from industrial and high traffic area of greater Guwahati City, Assam, India

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ABSTRACT

Road site soil samples were collected during premonsoon and postmonsoon season for two consecutive years of 2010-11 and 2011-12 and PAHs were determined. Various sites were selected for investigation to represent the industrial and high traffic activity areas of greater Guwahati, Assam, India. The road dust samples were collected from 32 sites over greater Guwahati. Eight common environmental PAH [Phenanthrene-(PHE), Benzo(K) Fluoranthene-(BKF), Benz(a) Pyrene-(BAP), Benzo(ghi)Pyrene-(BGHIP), Benzo(a) Anthracene/Chrysene-(BAA/CHR), Fluoranthene-(FLT), Pyrene-(PYR), Anthracene-(ANT)] were found to be distributed and their concentrartion were determined by using HPLC technique. The present data indicates that the total average of PAHs over the investigated sites was ranged from 1.58 ng/g to 13.17 ng/g. On individual scale, the highest concentration were 13.17 ng/g and 9.80 ng/g for BKF and PYR , meanwhile the lowest was BAA/CHR with value 2.29 ng/g in the industrial area. The investigation showed that the carcinogenic content of PAHs ranged from 40.05% to 40.89%. Polycyclic aromatic hydrocarbons (PAHs) are potentially mutagenic and carcinogenic substances occurring at various concentrations in atmosphere, soils, waters and sediments. PAHs, inherited both from natural and anthropogenic processes, are persistent organic pollutants (POP) due to their chemical stability and biodegradation resistance. The increase of road transportation, and of industrial and activities has led to a notable build up of PAH amounts in the environmental media.

Keywords: Polycyclic aromatic hydrocarbons (PAHs), pyrene, high performance liquid chromatography (HPLC), zone.

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous products of the incomplete combustion of organic materials derived primarily from burning of fossil fuels (coal/coke, oil, gas), waste and biomass, transportation (vehicular traffic, railway) exhausts, domestic heating or industrial emissions (including iron and steel industry)[1-7]. They are known for their persistence in the environment, bioaccumulation tendencies and adverse effects on humans and animals (carcinogenicity, mutagenicity, endocrine disrupting activity) [8-14]. PAH loading in the soils is strongly affected by proximity to sources and the likelihood of atmospheric deposition [15] and it results from the balance between inputs (wet and dry atmospheric deposition) and losses due to volatilization, biodegradation and mixing/burial to depth [16-18]. Environmental analyses often involve wide variety of matrices, ranging from air to sewage water to polluted soil samples [19-21]. Motor vehicles are thought to be the major source of atmospheric PAHs. PAHs occur in particles [22] or in the vapour phase and are often emitted into the atmosphere [23],[24].

Some of these compounds e.g. Benzo (a) Pyrene have been classified as carcinogenic and mutagenic materials [25],[26]. Concentrations of PAHs in soil were assumed to be influenced by traffic density, road condition, traffic behavior, meteorological condition, particulate matter in environment and their rates of deposition [27],[28]. PAHs are released during industrial activities such as aluminium, iron and steel production in plants and foundries, waste incineration, mining or oil refining. PAHs have also been detected at low levels in cigarette smoke and motor vehicle emissions. They are persistent organic pollutants and are slow to degrade in the environment [29]. Various studies on workers that breathed in or touched PAHs for a long time have suggested that PAHs may cause lung or skin cancer. The International Agency for Research on Cancer (IARC) stated that some PAHs are carcinogenic to humans. Occupational exposure may also cause breathing problems, chest pain and irritation and coughing. There are few commercial uses for many PAHs, including BaP. Anthracene is used in the production of dyes, synthetic fibres, and acenaphthene is used in the manufacture of dyes, plastics, pigments, pharmaceuticals and pesticides. Other PAHs may be contained in asphalt used for the construction of roads, as well as roofing tar. Several PAHs, including BaP, have been classified by the International Agency for Research on Cancer (IARC) as being carcinogenic in humans. The PAH content of soil often decreased with increasing depth [30].

MATERIALS AND METHODS

2.1 Methods for extraction of PAHs from soil

The extract for estimating the polycyclic aromatic hydrocarbon in soil was prepared by the soxhlet extraction procedure[31]. 60.0 g of soil sample was soxhlet extracted with 180 ml of hexane for 16 hours (at 12 cycles/h). The extract was filtered using sintered glass disc, to eliminate undissolved particulate matter, and transferred into a 50 ml conical flask. The extract was dried by a flow of dry nitrogen and the dried extract was weighed to determine the benzene soluble organics.

The residue obtained was redissolved in 1.0 ml of acetonitrile and was preserved analysis. The estimation was carried out with the help of reversed-phase HPLC technique.

2.2 Analytical conditions for reversed-phase HPLC

Measurements were carried out using a HPLC system (Shimadzu LC-10 AD) with UV-visible detector. The analytical column was of 250 mm length and 4.6 mm i.d., packed with totally porous spherical RP-18 material (particle size 5µm). A guard column (10 mm long and 4.6 mm i.d.) preceded the analytical column. Acetonitrile-water mixture (70:30) was used as mobile phase at a flow rate of 1.0 ml per minute.

Samples of 100 ml were injected into the column through the sample loop. A UV detector set at 254 nm for absorption was used for detection of the compounds. The data was processed with a CR 7A chromatopac data processor. Several dilutions corresponding to 0.2 to 20 ng absolute of synthetic standard mixture of individual components of phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, benzo(k)fluoranthene, and benzo(a)pyrene (supplied by Polyscience, USA) dissolved in HPLC grade acetonitrile was used for determining the retention data and for studying the linearity of the detector. The response was linear for a wide range of concentrations mentioned above. Using this method, PAH concentration of less than a nanogram in the sample could be quantified.

RESULTS AND DISCUSSION

The results of average concentration of PAHs determined in 128 soil samples collected from 32 sample locations during pre-monsoon and post-monsoon seasons for the consecutive two years (2010-11 and 2011-12) in the greater Guwahati are discussed here.

The 32 sampling locations were divided into industrial zone termed as Zone I and high traffic activity zone termed as Zone II. In the present study eight PAHs were determined namely Phenanthrene-(PHE), Benzo(K) Fluoranthene-(BKF), Benz(a) Pyrene-(BAP), Benzo(ghi)Pyrene-(BGHIP), Benzo(a) Anthracene/Chrysene-(BAA/CHR), Fluoranthene-(FLT), Pyrene-(PYR), Anthracene-(ANT).Among all these PAHs BAP,BAA/CHR, and BKF are carcinogenic according to CCME(Canadian Council of Ministers of The Environment).

In general, concentration of all PAHs during post-monsoon season was low as compared to pre-monsoon. The post-monsoon season in the city experiences high humidity and due to high humidity less photochemical degradation of these PAHs is responsible for this low concentration.

The ratio of non-carcinogenic to carcinogenic PAHs was found to be 71.84**:**52.84 (table 10) for the Industrial locations and 69.93**:**46.18(table 9) for the high traffic zone locations. The general existence of different PAHs ranged between 1.26 ng/g to 36.05 ng/g (table 9) for high traffic zone and 6.32 ng/g to 26.88 ng/g (table 10) for the industrial zone. The lower concentration existence were found for BAA/CHR (1.26 ng/g)(table 9) and 6.32 ng/g (table 10)in the high traffic and industrial zone. BKF was found to have the highest concentration with the amount of 36.05 ng/g (table 9) and 26.88 ng/g (table 10) for high traffic and industrial zone amongst the studied PAHs. Both in the industrial zone and traffic zone the minimum concentration among all the PAHs was found for BAA/CHR [3.04 ng/g (table 1) and 0.90 ng/g (table 6)] in the pre-monsoon season of the year 2010-11 and 2011-12 and maximum concentration among all the PAHs was found for BKF [13.65ng/g(table 5) and 12.86 ng/g (table 4)] in the pre-monsoon season of the year 2011-12 and post-monsoon season of the year 2010-11.The concentration of PYR of zone I(12.07 ng/g) (table 7) was more than the concentration of zone II (0.41 ng/g)

(table 8) in the post monsoon season in the session 2011-12.The post monsoon concentration of BAP (9.91 ng/g) (table 3) of zone I was larger than the pre monsoon concentration of of zone II(5.79 ng/g) (table 2) in the session 2010-11

The reason of high concentration of PAHs in the industrial zone as compared to high traffic zone may be due to release of PAHs during production of Aluminium , Iron and steel industries, foundries and waste incineration. Presence of many more coke processing units in the two sides of the road may responsible for the high concentration of PAHs in the samples of industrial zone. Other sources for the presence of PAHs in the environment include lubricating oils, atmospheric depositions, plants, domestic heating systems. Petrol and diesel engines and various industrial activities [32-36].

Poly aromatic hydrocarbons are known for their persistence in the environment, bioaccumulation tendencies and carcinogenic and mutagenic effects on humans and animals. The unexpected higher amounts of PAHs in the study area is a matter of great environmental concern with their possible contribution towards the prevalent increasing carcinogenic effects amongst the residents surrounding the studied zones. Thus immediate measures should be taken to remediate the area because these toxic compounds constitute a potential health hazard in the region.

The presence of long-lasting contaminants like PAHs in high concentrations in Guwahati road side soils is a reality and their continuous monitoring is a necessity for health protection because in some areas, in particular the residential ones surrounding the industrial zones in the present context, they could be transferred to grazing animals or domestic birds and further to primary animal food products (milk, meat, eggs) consumed by the inhabitants or commercialized on the food market, becoming potential pathways of human exposure.

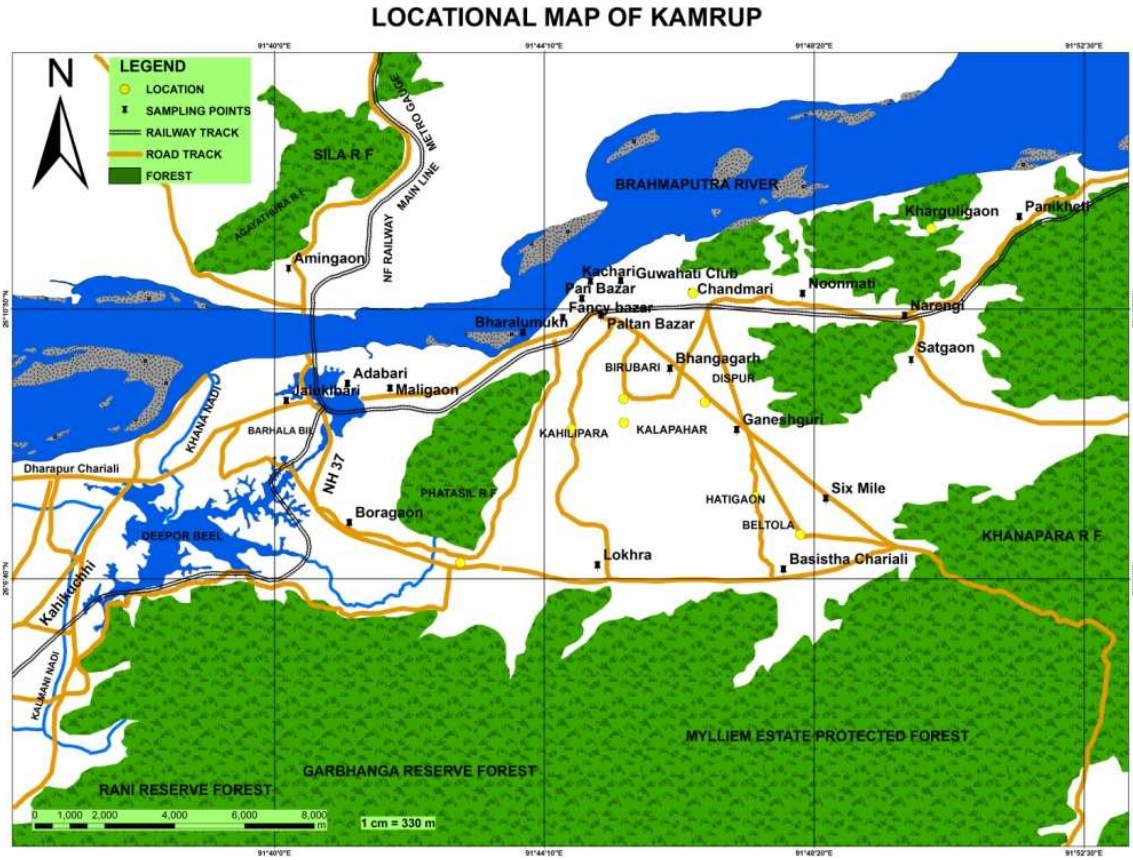

Fig.1. Map showing sample locations within greater Guwahati city

Table 1. Concentration of PAHs for the pre-monsoon season of Zone I(Industrial Area) for the year 2010-11

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 4	Khanapara	1.99	12.76	8.09	BDL	1.06	2.39	2.11	BDL
2	SDG 5	Jorabat	11.47	18.1	8.6	8.65	1.3	1.97	3.18	0.52
3	SDG 7	Noonmati	23.41	11.99	8.14	5.85	0.25	2.19	1.21	3.29
4	SDG 17	Lokhara	6.21	21.98	5.3	3.27	0.59	5.19	1.26	0.58
5	SDG 18	Boragaon	4.33	18.68	6.29	BDL	0.19	4.22	1.19	0.59
6	SDG 19	Jalukbari	4.81	7.79	0.18	BDL	0.32	BDL	BDL	0.23
7	SDG 20	8th Mile	0.38	6.15	11.89	1.99	5.22	13.33	35.22	0.88
8	SDG 21	9th Mile	1.35	10.52	9.19	3.87	4.11	15.45	17.45	11.21
9	SDG 22	10th Mile	4.89	8.85	6.29	2.97	1.18	0.99	14.83	9.08
10	SDG 23	11th Mile	13.17	9.92	16.28	4.46	BDL	2.68	11.51	23.89
11	SDG 24	12th Mile	14.89	22.82	15.36	5.41	BDL	3.59	18.22	18.47
12	SDG 25	13th Mile	16.49	9.52	16.88	0.97	0.81	0.39	15.12	18.66
13	SDG 26	14th Mile	13.96	7.68	5.68	BDL	2.27	0.44	13.6	3.95
14	SDG 27	15th Mile	8.63	12.53	4.4	BDL	3.19	2.49	15.51	6.33
15	SDG 28	Bornihat	19.42	33.35	22.47	12.57	24.29	9.29	39.62	1.92
16	SDG 29	Narengi	3.27	8.15	BDL	BDL	BDL	1.62	0.94	BDL
17	SDG 31	Satgaon	0.83	6.36	5.32	BDL	0.57	9.62	1.79	2.57
18	SDG 32	Amingaon	2.56	11.58	8.88	1.57	0.26	1.18	BDL	0.35
		MIN	0.38	6.15	0.18	0.97	0.19	0.39	0.94	0.23
		MAX	23.41	33.35	22.47	12.57	24.29	15.45	39.62	23.89
		AVRG	8.45	13.26	9.37	4.69	3.04	4.53	12.05	6.41
		MEDIAN	5.55	11.05	8.14	3.87	1.06	2.49	12.56	2.93
		SKEW	0.70	1.55	0.86	1.37	3.48	1.41	1.15	1.28
		KURT	-0.62	2.40	0.59	1.89	12.72	0.95	0.89	0.41

Table 2. Concentration of PAHs for the pre-monsoon season of Zone II(High Traffic Area) for the year 2010-11

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 1	Chandmari	19.52	BDL	0.53	0.14	0.16	1.48	BDL	BDL
2	SDG 2	Ganeshguri	16.63	BDL	1.26	2.88	0.31	0.79	BDL	BDL
3	SDG 3	Six Mile	1.51	0.42	BDL	1.21	0.05	0.28	BDL	BDL
4	SDG 6	Bhangagarh	6.49	22.8	1.77	3.39	0.28	0.47	0.69	BDL
5	SDG 8	Paltan Bazar	29.49	1.86	0.51	2.46	0.43	3.63	BDL	1.89
6	SDG 9	Bharalu	7.52	BDL	0.21	BDL	BDL	0.67	BDL	BDL
7	SDG 10	Maligaon	12.64	44.38	9.9	11.86	0.75	27.99	BDL	21.88
8	SDG 11	Adabari	10.04	25.86	8.79	6.62	0.62	12.44	0.19	18.48
9	SDG 12	Panbazar	12.16	9.87	2.57	2.64	BDL	0.38	BDL	BDl
10	SDG 13	Fancy Bazar	1.46	3.11	BDL	BDL	0.71	0.23	BDL	0.32
11	SDG 14	Guwahati Club	2.61	3.58	1.71	7.48	0.33	BDL	0.17	1.23
12	SDG 15	Kachari	3.12	2.24	4.39	2.23	0.25	0.35	0.2	0.85
13	SDG 16	Beltola Chariali	4.47	19.74	BDL	1.94	0.5	1.47	1.33	0.87
14	SDG 19	Jalukbari	4.81	7.79	0.18	BDL	0.32	BDL	BDL	0.23
15	SDG 30	Panikhaiti	0.74	0.16	BDL	BDL	BDL	BDL	BDL	BDL
		MIN	0.74	0.16	0.18	0.14	0.05	0.23	0.17	0.23
		MAX	29.49	44.38	9.9	11.86	0.75	27.99	1.33	21.88
		AVRG	17.76	23.64	5.79	7.79	0.79	8.36	1.03	11.44
		MEDIAN	6.49	5.69	1.71	2.64	0.33	0.73	0.20	1.05
		SKEW	1.33	1.40	1.46	1.48	0.35	2.66	1.42	1.47
		KURT	1.64	1.56	0.90	1.94	-0.66	7.14	1.16	0.26

Table 3. Concentration of PAHs for the post-monsoon season of Zone I(Industrial Area) for the year 2010-11

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 4	Khanapara	1.97	12.74	8.06	BDL	1.02	2.38	2.1	BDL
2	SDG 5	Jorabat	11.41	18.03	8.58	8.62	1.29	1.95	3.16	0.48
3	SDG 7	Noonmati	23.39	11.97	8.11	5.83	0.24	2.15	1.17	3.27
4	SDG 17	Lokhara	6.18	21.96	5.23	3.18	0.57	5.16	1.25	0.55
5	SDG 18	Boragaon	4.29	18.66	6.28	BDL	0.14	4.19	1.15	0.56
6	SDG 19	Jalukbari	4.78	7.77	BDL	BDL	0.29	BDL	BDL	0.19
7	SDG 20	8th Mile	0.36	6.13	11.85	1.98	5.19	13.29	35.19	0.86
8	SDG 21	9th Mile	1.33	10.48	9.16	3.83	4.09	15.42	17.4	11.19
9	SDG 22	10th Mile	4.87	8.81	6.27	2.95	1.16	0.97	14.81	9.06
10	SDG 23	11th Mile	13.12	9.89	16.27	4.44	BDL	2.66	11.48	23.87
11	SDG 24	12th Mile	14.88	22.75	15.35	5.39	BDL	3.54	18.1	18.44
12	SDG 25	13th Mile	16.48	9.48	16.87	0.94	0.79	0.38	15.09	18.62
13	SDG 26	14th Mile	13.91	7.65	5.66	BDL	2.24	0.39	13.56	3.93
14	SDG 27	15th Mile	8.61	12.49	4.39	BDL	3.18	2.48	15.49	6.31
15	SDG 28	Bornihat	19.39	33.29	22.45	12.54	24.26	9.28	39.59	1.91
16	SDG 29	Narengi	3.26	8.08	BDL	BDL	BDL	1.59	0.91	BDL
17	SDG 31	Satgaon	0.79	6.31	5.19	BDL	0.53	9.56	1.76	2.55
18	SDG 32	Amingaon	2.54	11.54	8.86	1.55	0.21	1.16	BDL	0.33
		MIN	0.36	6.13	4.39	0.94	0.14	0.38	0.91	0.19
		MAX	23.39	33.29	22.45	12.54	24.26	15.42	39.59	23.87
		AVRG	8.42	13.22	9.91	4.66	3.01	4.50	12.01	6.38
		MEDIAN	5.53	11.01	8.35	3.83	1.02	2.48	12.52	2.91
		SKEW	0.70	1.55	1.16	1.37	3.48	1.41	1.15	1.27
		KURT	-0.62	2.40	0.61	1.88	12.71	0.96	0.90	0.42

Table 4. Concentration of PAHs for the post-monsoon season of Zone II(High Traffic Area) for the year 2010-11

Sl.No.	Sample No post	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 1	Chandmari	19.48	BDL	0.5	0.11	0.15	1.45	BDL	BDL
2	SDG 2	Ganeshguri	16.59	BDL	1.21	2.85	0.29	0.77	BDL	BDL
3	SDG 3	Six Mile	1.48	0.41	BDL	1.19	BDL	0.25	BDL	BDL
4	SDG 6	Bhangagarh	6.46	22.79	1.76	3.37	0.25	0.44	0.67	BDL
5	SDG 8	Paltan Bazar	29.45	1.85	0.49	2.44	0.41	3.59	BDL	1.87
6	SDG 9	Bharalu	7.48	BDL	0.19	BDL	BDL	0.62	BDL	BDL
7	SDG 10	Maligaon	12.59	44.37	9.88	11.84	0.74	27.96	BDL	21.86
8	SDG 11	Adabari	9.99	25.84	8.77	6.59	0.59	12.39	0.18	18.45
9	SDG 12	Panbazar	12.11	9.83	2.55	2.59	BDL	0.35	BDL	BDl
10	SDG 13	Fancy Bazar	1.44	3.08	BDL	BDL	0.69	0.19	BDL	0.28
11	SDG 14	Guwahati Club	2.59	3.56	1.68	7.46	0.32	BDL	0.13	1.19
12	SDG 15	Kachari	3.07	2.22	4.38	2.19	0.24	0.31	0.17	0.81
13	SDG 16	Beltola Chariali	4.45	19.72	BDL	1.89	0.48	1.42	1.3	0.84
14	SDG 19	Jalukbari	4.78	7.77	BDL	BDL	0.29	BDL	BDL	0.19
15	SDG 30	Panikhaiti	0.71	BDL	BDL	BDL	BDL	BDL	BDL	BDL
		MIN	0.71	0.41	0.19	0.11	0.15	0.19	0.13	0.19
		MAX	29.45	44.37	9.88	11.84	0.74	27.96	1.3	21.86
		AVRG	8.84	12.86	3.14	3.87	0.40	4.15	0.49	5.69
		MEDIAN	6.46	7.77	1.72	2.59	0.32	0.70	0.18	1.02
		SKEW	1.34	1.31	1.34	1.48	0.64	2.66	1.39	1.47
		KURT	1.65	1.32	0.48	1.94	-0.87	7.15	1.06	0.26

Table 5. Concentration of PAHs for the pre-monsoon season of Zone I(Industrial Area) for the year 2011-12

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 4	Khanapara	2.06	12.79	8.16	BDL	1.11	2.45	2.15	BDL
2	SDG 5	Jorabat	11.51	18.14	8.65	8.72	1.37	2.02	3.19	0.57
3	SDG 7	Noonmati	23.46	12.06	8.19	5.92	0.3	2.26	1.24	3.46
4	SDG 17	Lokhara	6.28	22.33	5.38	3.32	0.65	5.24	1.31	0.61
5	SDG 18	Boragaon	4.39	18.74	6.34	0.07	0.26	4.28	1.25	0.66
6	SDG 20	8th Mile	0.42	6.19	11.97	2.06	5.32	13.37	35.28	0.93
7	SDG 21	9th Mile	1.42	10.56	9.29	3.95	4.15	15.51	17.49	11.26
8	SDG 22	10th Mile	4.98	8.88	6.41	3.11	1.27	1.06	14.89	9.15
9	SDG 23	11th Mile	13.23	9.99	16.38	4.49	BDL	2.77	11.57	23.94
10	SDG 24	12th Mile	14.96	22.88	15.46	5.52	BDL	3.66	18.28	18.51
11	SDG 25	13th Mile	16.55	9.58	16.89	1.02	0.88	0.44	15.16	18.69
12	SDG 26	14th Mile	14.03	7.72	5.76	0.14	2.31	0.49	13.63	3.99
13	SDG 27	15th Mile	8.69	12.59	4.49	BDL	3.27	2.56	15.54	6.37
14	SDG 28	Bornihat	19.49	33.38	22.52	12.59	24.39	9.37	39.66	1.96
15	SDG 29	Narengi	3.31	8.19	BDL	BDL	BDL	1.69	0.98	BDL
16	SDG 31	Satgaon	0.95	6.43	5.46	BDL	0.66	9.71	1.88	2.62
17	SDG 32	Amingaon	2.62	11.63	8.93	1.63	0.32	1.21	BDL	0.38
		MIN	0.42	6.19	4.49	0.07	0.26	0.44	0.98	0.38
		MAX	23.46	33.38	22.52	12.59	24.39	15.51	39.66	23.94
		AVRG	8.73	13.65	10.02	4.04	3.30	4.59	12.09	6.87
		MEDIAN	6.28	11.63	8.42	3.32	1.19	2.56	12.60	3.46
		SKEW	0.61	1.47	1.17	1.23	3.37	1.40	1.15	1.19
		KURT	-1.58	1.33	-0.17	0.82	11.11	0.15	0.10	-0.61

Table 6. Concentration of PAHs for the pre-monsoon season of Zone II(High Traffic Area) for the year 2011-12

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 1	Chandmari	19.56	BDL	0.57	0.19	0.19	1.53	BDL	BDL
2	SDG 2	Ganeshguri	16.67	BDL	1.29	2.97	0.35	0.88	BDL	BDL
3	SDG 3	Six Mile	1.56	0.5	BDL	1.27	0.061	0.39	0.15	BDL
4	SDG 6	Bhangagarh	6.53	22.86	1.82	3.45	0.36	0.52	0.74	BDL
5	SDG 8	Paltan Bazar	29.52	1.91	0.55	2.52	0.48	3.66	BDL	1.95
6	SDG 9	Bharalu	7.56	BDL	0.28	BDL	BDL	0.71	BDL	BDL
7	SDG 10	Maligaon	12.69	44.45	10.05	11.92	0.82	28.1	0.05	21.93
8	SDG 11	Adabari	10.11	25.92	8.87	6.69	0.68	12.49	0.22	18.51
9	SDG 12	Panbazar	12.19	9.91	2.66	2.69	BDL	0.41	BDL	BDl
10	SDG 13	Fancy Bazar	1.52	3.16	BDL	BDL	0.78	0.26	BDL	0.37
11	SDG 14	Guwahati Club	2.69	3.64	1.76	8.14	0.37	BDL	0.24	1.28
12	SDG 15	Kachari	3.19	2.29	4.43	3.82	0.33	0.41	0.23	0.94
13	SDG 16	Beltola Chariali	4.52	19.83	BDL	3.01	0.58	1.51	1.39	0.92
14	SDG 19	Jalukbari	4.93	7.84	0.21	BDL	0.39	BDL	BDL	0.27
15	SDG 30	Panikhaiti	0.79	0.21	BDL	BDL	BDL	BDL	BDL	BDL
		MIN	0.79	0.21	0.21	0.19	0.06	0.26	0.05	0.27
		MAX	29.52	44.45	10.05	11.92	0.82	28.1	1.39	21.93
		AVRG	17.87	23.75	5.91	8.49	0.90	8.48	0.86	11.54
		MEDIAN	6.53	5.74	1.76	3.01	0.38	0.80	0.23	1.11
		SKEW	1.33	1.40	1.46	1.32	0.20	2.66	1.75	1.47
		KURT	1.65	1.56	0.93	1.56	-0.51	7.16	2.64	0.27

Table 7. Concentration of PAHs for the post-monsoon season of Zone I(Industrial Area) for the year 2011-12

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 4	Khanapara	2.03	12.78	8.14	BDL	1.09	2.42	2.14	BDL
2	SDG 5	Jorabat	11.48	18.12	8.64	8.68	1.33	1.99	3.18	0.55
3	SDG 7	Noonmati	23.44	12.03	8.17	5.88	0.29	2.25	1.22	3.43
4	SDG 17	Lokhara	6.25	22.31	5.37	3.29	0.62	5.21	1.29	0.59
5	SDG 18	Boragaon	4.35	18.71	6.31	0.04	0.23	4.26	1.21	0.62
6	SDG 20	8th Mile	0.39	6.17	11.93	2.02	5.29	13.35	35.25	0.91
7	SDG 21	9th Mile	1.38	10.54	9.25	3.91	4.14	15.49	17.48	11.24
8	SDG 22	10th Mile	4.93	8.87	6.31	3.03	1.24	1.04	14.86	9.14
9	SDG 23	11th Mile	13.21	9.96	16.35	4.47	BDL	2.72	11.54	23.92
10	SDG 24	12th Mile	14.91	22.85	15.39	5.48	BDL	3.62	18.25	18.49
11	SDG 25	13th Mile	16.5	9.55	16.89	0.98	0.84	0.42	15.15	18.68
12	SDG 26	14th Mile	13.99	7.69	5.72	BDL	2.28	0.48	13.61	3.97
13	SDG 27	15th Mile	8.65	12.56	4.44	BDL	3.25	2.51	15.53	6.35
14	SDG 28	Bornihat	19.46	33.36	22.49	12.58	24.35	-12	39.64	1.94
15	SDG 29	Narengi	3.29	8.16	BDL	BDL	BDL	1.66	0.96	BDL
16	SDG 31	Satgaon	0.86	6.39	5.35	BDL	0.61	9.64	1.81	2.59
17	SDG 32	Amingaon	2.59	11.59	8.89	1.59	0.29	1.19	BDL	0.37
		MIN	0.39	6.17	4.44	0.04	0.23	-12	0.96	0.37
		MAX	23.44	33.36	22.49	12.58	24.35	15.49	39.64	23.92
		AVRG	8.69	13.63	9.98	4.33	3.28	3.31	12.07	6.85
		MEDIAN	6.25	11.59	8.41	3.60	1.17	2.42	12.58	3.43
		SKEW	0.61	1.47	1.16	1.24	3.36	-0.20	1.15	1.19
		KURT	-0.78	2.12	0.62	1.68	11.89	2.92	0.89	0.17

Table 8. Concentration of PAHs for the post-monsoon season of Zone II(High Traffic Area) for the year 2011-12

Sl.No.	Sample No	Sample Location	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
1	SDG 1	Chandmari	19.54	BDL	0.55	0.18	0.17	1.51	BDL	BDL
2	SDG 2	Ganeshguri	16.65	BDL	1.27	2.91	0.34	0.84	BDL	BDL
3	SDG 3	Six Mile	1.53	0.44	BDL	1.25	0.056	0.36	0.12	BDL
4	SDG 6	Bhangagarh	6.51	22.83	1.79	3.41	0.32	0.49	0.72	BDL
5	SDG 8	Paltan Bazar	29.51	1.88	0.53	2.48	0.47	3.64	BDL	1.93
6	SDG 9	Bharalu	7.54	BDL	0.26	BDL	BDL	0.69	BDL	BDL
7	SDG 10	Maligaon	12.66	44.41	10.03	11.88	0.79	28.05	0.03	21.92
8	SDG 11	Adabari	10.06	25.88	8.83	6.66	0.66	12.48	0.2	18.49
9	SDG 12	Panbazar	12.18	9.89	2.61	2.66	BDL	0.39	BDL	BDL
10	SDG 13	Fancy Bazar	1.49	3.14	BDL	BDL	0.73	0.25	BDL	0.36
11	SDG 14	Guwahati Club	2.66	3.62	1.75	7.51	0.35	BDL	0.19	1.25
12	SDG 15	Kachari	3.15	2.27	4.41	2.27	0.28	0.38	0.22	0.89
13	SDG 16	Beltola Chariali	4.49	19.79	BDL	1.98	0.55	1.49	1.37	0.89
14	SDG 19	Jalukbari	4.85	7.81	0.19	BDL	0.37	BDL	BDL	0.25
15	SDG 30	Panikhaiti	0.78	0.19	BDL	BDL	BDL	BDL	BDL	BDL
		MIN	0.78	0.19	0.19	0.18	0.056	0.25	0.03	0.25
		MAX	59.02	88.82	20.06	23.76	1.58	56.1	2.74	43.84
		AVRG	8.91	11.85	2.93	3.93	0.42	4.21	0.41	5.75
		MEDIAN	6.51	5.715	1.75	2.66	0.36	0.765	0.2	1.07
		SKEW	1.33	1.40	1.47	1.48	0.21	2.66	1.75	1.47
		KURT	1.65	1.56	0.94	1.93	-0.66	7.14	2.61	0.27

Table.9.The mean concentrations of PAHs in road site soil [ng/g] of high traffic area

	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
Pre monsoon 2010-11	17.76	23.64	5.79	7.79	0.79	8.36	1.03	11.44
Post monsoon 2010-11	8.84	12.86	3.14	3.87	0.40	4.15	0.49	5.69
Pre monsoon 2011-12	17.87	23.75	5.91	8.49	0.90	8.48	0.86	11.54
Post monsoon 2011-12	8.91	11.85	2.93	3.93	0.42	4.21	0.41	5.75
AVERAGE	26.69	36.05	8.88	12.03	1.26	12.60	1.40	17.21

Table.10. The mean concentrations of PAHs in road site soil [ng/g] of industrial area

	PHE (ng/g)	BKF (ng/g)	BAP (ng/g)	BGHIP (ng/g)	BAA/CHR (ng/g)	FLT (ng/g)	PYR (ng/g)	ANT (ng/g)
Pre monsoon 2010-11	8.45	13.26	9.37	4.69	3.04	4.53	12.05	6.41
Post monsoon 2010-11	8.42	13.22	9.91	4.66	3.01	4.50	12.01	6.38
Pre monsoon 2011-12	8.73	13.65	10.02	4.04	3.30	4.59	12.09	6.87
Post monsoon 2011-12	8.69	13.63	9.98	4.33	3.28	3.31	12.07	6.85
AVERAGE	17.14	26.88	19.64	8.86	6.32	8.47	24.11	13.26

CONCLUSION

The present research assessed the levels of PAHs in the high traffic activity and industrialized area of greater Guwahati. The most contaminated soils obtained for the industrial area and traffic area is Byrnihat and Maligaon . The reason of high PAHs in the industrial area in comparison to traffic area may be due to the presence of various industry like coke industry, brick industry, cement industry, alloy industry, cold drink plants and power plants in the Byrnihat region. Soils near industrial sources such as coal coking also often contain high concentrations of PAHs [37],[38].

Byrnihat is the highly saturated with PAHs concentration amongst all the sampling sites for industrial and high traffic activity area. This location recorded the highest number of individual PAHs components (8) with the highest total PAHs level 20.37 ng/gm. Although the value is lower than the EPA guideline limits could portend serious health hazard to the community. The heavily industrialized area recorded the highest level of Pyrene (the main PAH toxic factor). The increase of road transportation and of industrial activities has led to notable build up of PAH amounts in the environmental media [39]. Anthropogenic activities are responsible for the increased amount of PAHs in the study area. PAHs have drawn considerable attention of the widespread scientific community due to their carcinogenic and mutagenic nature [40]. It is important to understand types and distribution behavior of PAHs

in soil and how their concentration in soil varies significantly with season and correlate it with the corresponding levels in air [41]. Positive value of kurtosis was calculated for all parameters show sharp distribution around the study area. Negative value of kurtosis for the parameters show a flat distribution around the study area. Positive value of skewness gives a distribution with a significant long right tail and negative value of skewness gives a distribution with a significant long left tail.

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