PRELIMINARY DETERMINATION OF POLYCYCLIC AROMATIC HYDROCARBON (PAHs) IN AIR ENVIRONMENT AT MAJOR TRAFFIC JOINTS OF HANOI

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) have long been recognized as hazardous environment chemicals. Some PAHs were known to be carcinogenic to man. In this study, the street dust samples in air were collected at 43 important traffic joins in Hanoi from April to July, 2002 and one blank sample from reserve forest as a reference sample. Ultrasonic method was used for sample extraction then they were identified by GC/MS. All analytical results showed that traffic snarls in Hanoi have been polluted by PAHs. So crossroads of 182.8 ng/m^3 and Vong joint of 176.8 ng/m^3 were identified as the most polluted areas. And the ambient air concentrations of Benzo(a) Pyrene (BaP) being also evaluated as highest at both of them were 11.58 and 13.40 ng/m^3, respectively.

Introduction

Hanoi located in the North of Vietnam has an area of 927.9 km^2 and a population of 3.5 millions. Sixty-two percents of Hanoi have to transport commonly. Nowadays, the transportation of city is not suitable with citizen demands. Hanoi has 1.7 millions motorbikes and more than 99 thousands motor cars (statistic 2001) not included a large number of transport vehicle from surrounding areas also contributing in traffic of town. The major character of streets in Hanoi is small and having many road-joints, the surrounding roads of city are being conducted and widened and a little overpasses. The traffic jams not only happen in the rush-hours at crossroad and T-junctions but also happen at any time when ever the streets got troubles. Therefore, the emission of exhaust gas became the most intensity at these points.

Many air environmental pollutants were found in exhaust gases of motor vehicles using gasoline, diesel fuels. One of the organic compound groups being warned as toxic contaminants is the polycyclic aromatic hydrocarbons (PAHs). And currently motor vehicles are thought to be a major source of atmospheric PAHs [9]. The epidemiology evidence illustrated that high PAHs concentration at urbanization areas relates closely to increasing lung cancer risk [2]. One of the reasons is exposure with carcinogenic and mutagenic compounds such as PAHs and other products in exhaust gases of transport vehicles. Consequently, it is necessary and urgent to determine the trace levels of PAH in air environment at traffic joints in metropolitan cities like Hanoi.

Until now there are still almost no results and data about PAH levels in atmosphere in Vietnam especially at traffic points. This investigation is a primary research of PAH concentrations in air environment at the important traffic points in Hanoi. Sixteen most relevant PAH components, which EPA proclaimed, were measured by collection of dust samples at Hanoi and one dust sample was collected at Cuc Phuong forest (more 100 km far from Hanoi) which can be considered as pristine and reference area.

Experimental

Materials

Reagents and solvents (methanol, dichloromethane, n-hexane and acetone) used for PAHs extraction from dust samples of analytical grades (Mecrk AG).

Individual standards of PAHs are crystals, were bought from EQ, Dr.Ehrenstorfer GmbH Co. (Germany). The standard stock solutions were prepared in acetone at concentrations of 0.5-1 mg/mL. Solution of internal standard IS (Chrysene - d_{12}) and surrogate compound (Benzo[a]pyrene - d_{12}) were prepared both of 0.1 mg/mL.

Whatman filter paper, GF/F grade (d.47mm) was used to filtrate the dust particles having diameter larger than 0.7μm.

Sampling sites

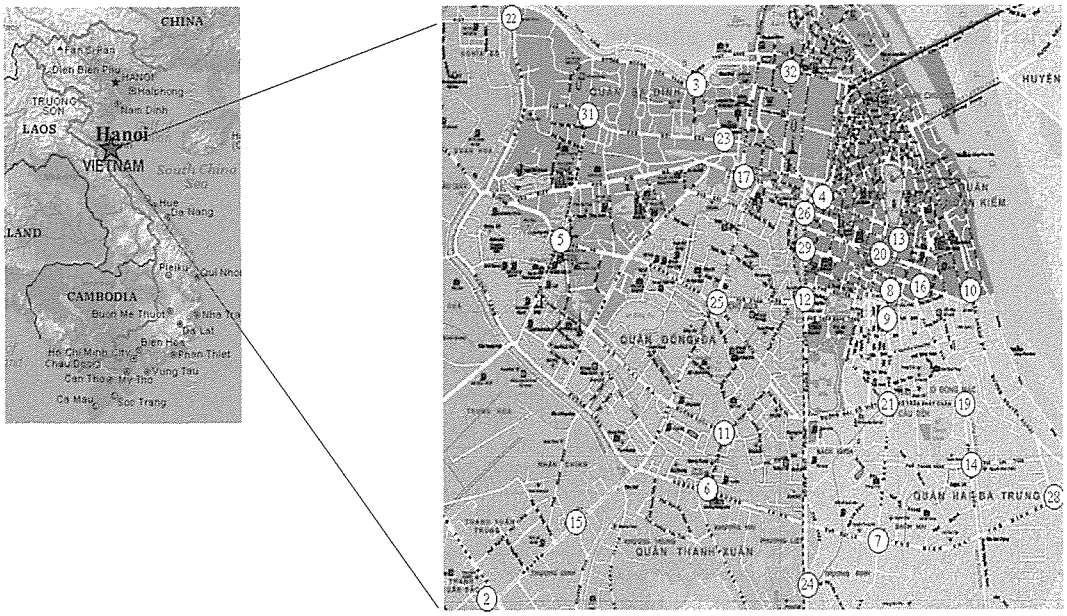
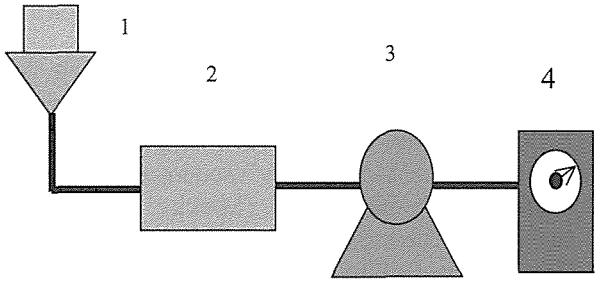


Figure 1: Some sampling sites in Hanoi

The air dust samples were collected at 43 most important traffic joints in the urban area of Hanoi. These are sites where frequency of motor vehicles is relatively high (see Fig.1). One reference sample was collected at Cuc Phuong forest. There are almost no traffic activity and other artificial activities (e.g. biomass burning). The samples were collected in the rainy season from April to July, 2002.

Sample collection



1. Filter
2. Air flow controller
3. Pump
4. Air flow meter

Figure 2. Air sampling equipment

The air dust samples were duplicated. The dust samples were collected by low volume pump ULVAC, DA-SOS (Japan) with 35W capacity using Whatman filters GF/F grade which was activated in prior at 200^0C for 2 hours. The sampling time was always taken for 2 hours from 8 a.m. to 8 p.m. with sampling flow of

24L/min. Two pumps were placed on a shelf located 1.5-2m above the ground bottom. After sampling, the filters were stored in fridge until analysing.

Sample preparations

In order to have a relatively fast extraction of PAHs from collected dust samples using only small amount of consumed chemicals, the ultrasonic method was chosen. The chosen ultrasonic extraction is the one applying ultrasound waves (20 Hz frequency) to change associated affinity of PAH components and dust particles on the filter. Using a suitable solvent, the PAH compounds could be separated from dust surface and going into solvent phase.

The flow chart of sample preparation by ultrasonic can be described, as follows:

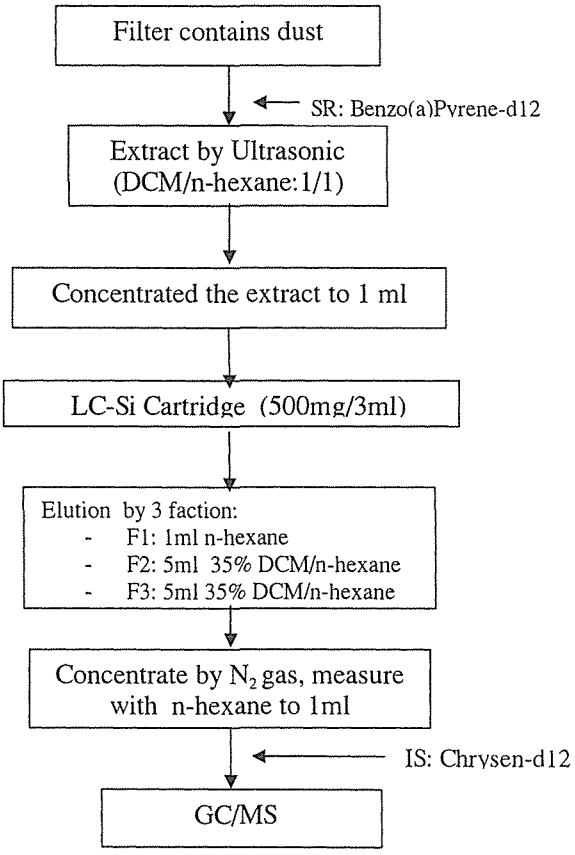


Figure 3. Flow chart of sample preparation for collected dust samples

The filter was cut to small pieces, put into glass 10mL tube with topper. Add SR standard Benzo (a) Pyrene-d12 and extract by ultrasonic with 10mL of mixture of dichloromethane (DCM) and n-hexane (1/1:v/v) for 15 minutes. Repeat the extraction step twice again for each sample. The extracted liquids were combined after three extraction times and concentrated to 1mL by vacuum evaporator. Next, the sample was cleaned-up throw the silica gel cartridge LC-Si 500mg/3mL (Merck). The PAH components were eluted by solvent mixture of n-hexane and DCM. Then, the eluted solution was concentrated by nitrogen gas. Add IS standard solution Chrysen-d12, fill up to 1mL by n-hexane and inject 1µl into GC-MS.

Analysis of PAHs

The PAHs compounds were identified and quantified by a GC 17/MS-QP 5000, Shimadzu (Japan). The used gas chromatography (GC) was equipped with a 30m x 0.3mm id DB5 bonded phase fused silica capillary column (J & W Scientific, USA).

The helium carrier gas flow rate was 1.5mL/min. The injector temperature was 300^0C at a splitless mode. The interface temperature was 300^0C. A quantitative analysis was performed using selective ion monitoring (SIM) method at electron energy of 70eV and detector voltage of 1.5kV. The oven temperature was held at 50^0C and them programmed to 100^0C at 25^0C/min and 300^0C at 8^0C/min and finally held isothermally at 300^0C for 15 minutes. The detection limits of instrument for16 selected PAHs were ranged from 1.7÷ 6.7 ppb (see Table 1).

Table 1: Retention time, m/z ion and detection limit of GC/MS equippment (DL) and recovery of analytical method for 16 PAH compounds

No.	Compound	Ret. time (min)	m/z ion	Detection Limit (ng/mL)	Recovery (%)
1	Chrysene-d12(IS)	22.2	240		
2	Naphthalene	5.5	128	2.6	76
3	Acenaphthylene	9.3	125	3.4	63
4	Acenaphthene	9.8	153	2.1	55
5	Fluosene	11.3	165	2.7	81
6	Phananthsene	14.1	178	2.1	79
7	Anthracene	14.2	178	2.8	69
8	Fluoranthene	17.8	202	1.7	72
9	Pyrene	18.4	202	2.5	81
10	Benzo(a)anthracene	22.2	228	3.8	78
11	Chrysene	22.3	228	3.4	70
12	Banzo(b)fluoranthene	25.4	252	4.3	66
13	Benzo(k)fluoranthene	25.5	252	5.5	74
14	Pyrene-d12	26.2	264	6.2	82
15	Benzo(a)pyrene	26.2	252	6.7	74
16	Indeno(1,2,3-cd)pyrene	26.2	252	6.7	74
17	Dibenzo(a,h)anthracene	29.5	278	6.6	65
18	Benzo(g,h,I)perylene	30.1	276	5.5	72

Calculation

After being identified and quantified by GC/MS equipment, the selected PAHs in collected dust samples were calculated by the formula as below:

$$C_{air} = \frac{C_i}{V_{(air)}} \times \frac{1}{h} \times V_s$$

In there:
- V_{air} : The air sampling volume (m^3)
- C_i : The concentration of i component in the final extractor (ng/mL)
- V_s : The extracted sample volume before injection into GC (mL)
- h : Recovery efficiency (%)
- C_{air} : The concentration of i component in air (ng/m^3)

Results and discussion

The results of PAHs determination for collected dust samples in Hanoi showed that three points of total 43 important traffic joints suffer from quite high PAHs concentrations in air environment, even more than 100ng/m^3. The highest amounts of PAHs were obtained for So crossroad and Vong crossroad with total PAHs concentrations of 182.8ng/m^3 and 176.8ng/m^3, respectively. The obtained data are in coherent with the observed phenomena that these both traffic sites were known as most terrible traffic points of Hanoi. They are connection of the south provinces to capital city and showed quite high transportation frequency of many different kinds of motor vehicles and the traffic jams also happen daily at these sites. The joint of Nguyen Chi Thanh and De La Thanh with total PAHs amounts of 111.8ng/m^3 has just been enlarged and connected to the new constructed street, Lieu Giai so that motor vehicles frequency became very high. Therefore, exhaust gases formed during the fuel combustion processes of motors can be considered as the major source causing the PAHs levels in atmosphere at those traffic joints being much higher than others.

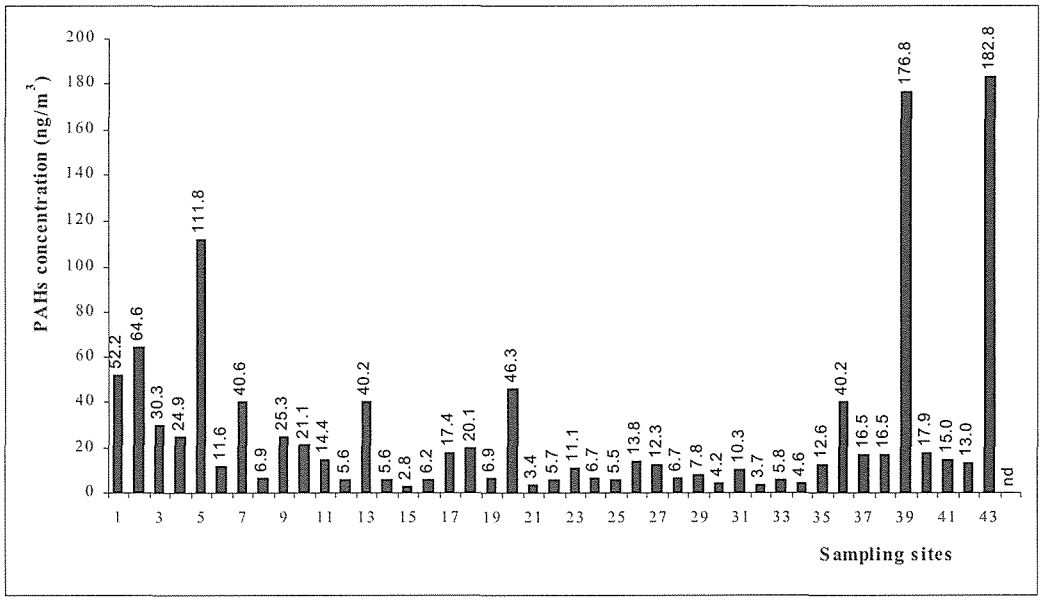


Figure 4: Total concentration of PAHs (ng/m^3) at selected traffic joints in Hanoi city

The obtained air concentrations of PAHs are found in range of 40-70ng/m^3 at the sites where less motor vehicles attending transportation observed. There are totally 29 traffic joints showing PAHs concentrations in air lower than 20ng/m^3, where only small streets are the less transportation activities recognized.

Some other observed sites, where transportation frequency is rather high such as Giay bridge, Phap Van T-junction, Ha Dong bridge, joint of surrounding road of Thang Long road and Co Nhue str., Quoc Viet road and Buoi, but fortunately the PAHs levels there are not so high as expected. It is likely that the wider space at these sites can cause an easier diffusive process of PAHs compared to the smaller streets as mentioned before.

This difference became again more obvious that the PAHs amounts in air environment at all traffic joints of Hanoi are much higher in comparison those of Cuc Phuong forest. Almost no PAH component could be detected in this reference sample at Cuc Phuong.

Table 2: Percentage content of 16 most relevant PAH compounds at Hanoi's traffic joints

No.	Compound	Mean Value (ng/m^3)	Range (ng/m^3)	Percents (%)
1	Napthalene	4.09	<0.1 – 49.10	15.3
2	Acenaphthylene	0.51	<0.2 – 6.04	1.9
3	Acenaphthene	0.47	<0.1 – 4.03	1.8
4	Fluorene	0.88	<0.1 – 7.41	3.3
5	Phenanthrene	0.88	<0.1 – 7.12	3.3
6	Anthracene	1.31	<0.1- 18.65	4.9
7	Fluoranthene	0.81	<0.1-6.83	3.0
8	Pyrene	0.90	0.15-6.24	3.4
9	Benzo(a)anthre	1.18	<0.2-17.42	4.4
10	Chrysene	1.42	<0.2-14.72	5.3
11	Benzo(b)Fluoran	3.41	<0.3-25.34	12.8
12	Benzo(k) Fluoran	2.31	0.3-20.18	8.7
13	Benzo(a) Pyrene	1.47	<0.3-13.40	5.5
14	Indeno(1,2,3-cd)py	2.11	<0.3-14.00	7.9
15	Dibenzo(a,h)anth	2.25	<0.3-40.96	8.4
16	Benzo(g,h,i)pery	2.68	<0.3-19.92	10.0
	Total:	**26.68**	2.80-182.80	

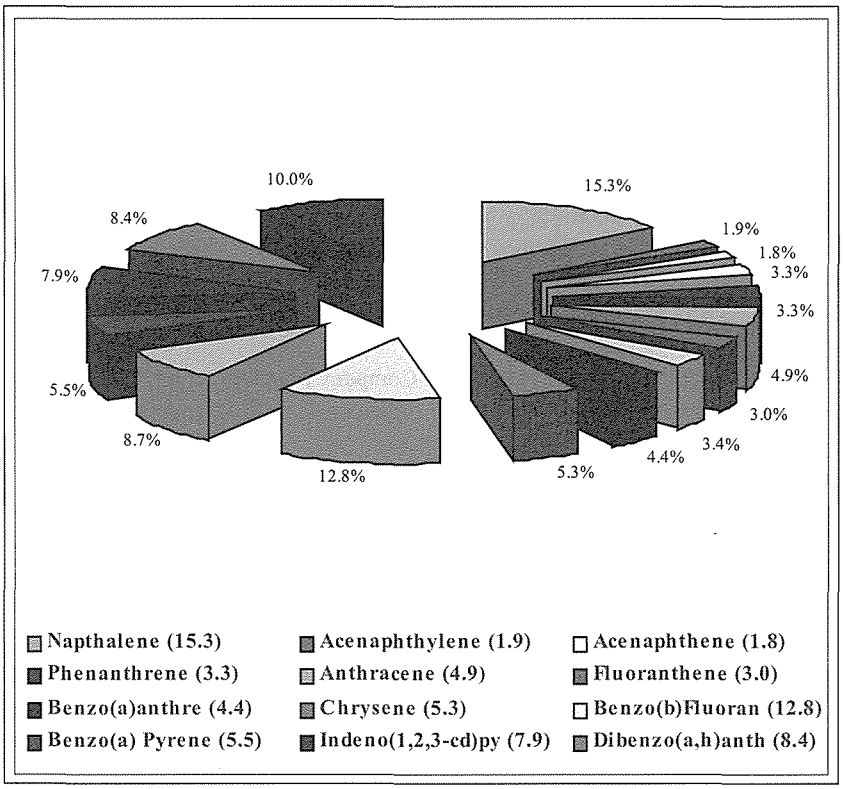


Table 5: Percentages of PAHs components (%) in air dust samples at Hanoi's traffic joints

The average concentration of the major PAHs is 26.68 ng/m^3 in traffic atmosphere in Hanoi (n=43), with a range from 2.80 to 182.80ng/m^3. Among the most relevant 16 PAHs found in air dust samples, the components with 5-6 benzene rings are clearly predominant. The obtained results suggest that the PAH compounds in larger and heaver structures so their deposition and absorptive abilities on dust surface is higher. Except Naphthalene, the percentage of it is highest amount although its molecular is the lightest (there are only two benzene rings in its structure). This shows that one of the major components of PAHs formed in the motor exhaust gases is naphthalene.

Conclusions

The PAHs in deposited dust samplers were extracted, separated by ultrasonic extraction method and measured by chromatography with mass spectroscopy analyzer reached mean recovery of 72% with deviation standard SD of 5-15%. The elevated data of total 16 PAHs in air at 43 traffic points shows that all traffic joints are polluted by PAHs. Specially, the both most polluted sites are So and Vong crossroads. The concentrations of BaP at both So crossroad and Vong crossroad are 11.58 and 13.40ng/m^3, respectively, widely exceeding the air ambient standards limits comparable to other countries in the world only 0.1 – 2ng/m^3 for BaP [12].

This is a preliminary investigation on PAHs in air environment at major traffic joints in Hanoi. The next determination of PAHs amounts shall focus on seasonal fluctuation of PAHs, also in relation of sampling time during day and night in view of getting a picture of atmospheric contaminant situation in Hanoi, especially those which can cause carcinogenic effect such as PAH emitted from motor exhaust gases into the ambient air.

Acknowledgments

We would like to express our sincerest thanks to Japanese Scientific Promotion Society (JSPS) - Core University Program (CUP) for supporting the exchange scientist (Nguyen Thi Hanh). We are also very thankful to the Vietnamese Fundamental Scientific Research Program for their financial support to our research activities.

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Table 3: The concentrations of PAHs in air at some main traffic joints in Hanoi (ng/m^3)

No.	NAME	1	2	3	4	5	6	7	8	9
1	Napthalene	7.75	0.42	1.20	<0.1	3.92	<0.1	12.85	0.58	1.46
2	Acenaphthylene	0.29	0.27	<0.2	<0.2	3.00	<0.2	0.99	<0.2	<0.2
3	Acenaphthene	0.40	0.11	<0.1	<0.1	2.22	<0.1	4.03	<0.1	<0.1
4	Fluorene	1.05	0.22	<0.1	<0.1	5.72	<0.1	2.57	<0.1	<0.1
5	Phenanthrene	1.35	0.58	0.58	0.71	3.58	0.80	2.05	0.34	0.62
6	Anthracene	0.58	0.42	0.12	0.88	2.98	0.95	3.05	0.43	0.10
7	Fluoranthene	0.46	0.98	0.84	0.49	1.98	0.51	3.40	0.20	0.94
8	Pyrene	0.60	1.29	1.20	0.60	3.94	0.67	0.53	0.25	1.24
9	Benzo(a)anthre	1.70	2.97	1.43	0.86	2.02	0.65	1.28	0.23	0.90
10	Chrysene	4.53	7.03	1.56	0.95	4.77	0.82	0.56	0.40	1.41
11	Benzo(b)Fluoran	12.50	17.77	4.89	4.90	3.89	1.78	3.53	0.89	4.23
12	Benzo(k) Fluoran	8.43	13.15	3.63	3.70	4.11	1.34	1.59	0.68	3.14
13	Benzo(a) Pyrene	1.51	2.61	1.81	1.74	1.96	0.85	0.66	0.36	0.88
14	Indeno(1,2,3-cd)py	3.78	6.18	4.83	3.89	14.06	1.19	0.68	0.74	3.87
15	Dibenzo(a,h)anth	2.47	1.71	0.36	0.45	40.96	<0.3	1.18	<0.3	<0.3
16	Benzo(g,h,i)perylen	4.83	8.88	7.83	5.68	12.69	2.08	1.65	1.79	6.48
	Total	**52.24**	**64.59**	**30.28**	**24.85**	**111.81**	**11.64**	**40.59**	**6.89**	**25.27**

No.	NAME	10	11	12	13	14	15	16	17	18
1	Napthalene	1.08	1.37	<0.1	23.34	<0.1	0.61	1.01	0.82	1.84
2	Acenaphthylene	<0.2	0.35	<0.2	1.05	<0.2	<0.2	<0.2	1.04	<0.2
3	Acenaphthene	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	<0.1	<0.1	<0.1
4	Fluorene	0.11	0.28	<0.1	0.60	<0.1	<0.1	<0.1	0.21	0.30
5	Phenanthrene	0.94	0.57	0.79	0.46	0.79	0.40	<0.1	0.50	0.66
6	Anthracene	0.15	0.36	0.95	0.56	0.95	0.12	0.12	1.01	0.82
7	Fluoranthene	0.93	0.40	0.19	0.91	0.19	0.12	0.27	0.30	2.04
8	Pyrene	1.10	0.49	0.18	0.28	0.18	0.20	0.33	0.82	2.35
9	Benzo(a)anthre	1.13	0.52	<0.2	1.45	<0.2	0.22	0.29	0.66	1.62
10	Chrysene	1.58	0.86	0.37	0.90	0.37	0.27	0.44	0.77	1.81
11	Benzo(b)Fluoran	4.07	2.61	0.91	2.32	0.91	0.36	0.98	3.25	1.27
12	Benzo(k) Fluoran	3.02	2.01	0.70	1.74	0.70	0.30	0.75	2.38	2.10
13	Benzo(a) Pyrene	1.23	1.03	0.29	0.98	0.29	0.19	0.43	1.40	1.84
14	Indeno(1,2,3-cd)py	2.22	1.35	0.51	0.40	0.51	0.15	0.49	1.26	0.51
15	Dibenzo(a,h)anth	0.30	<0.3	<0.3	5.01	<0.3	0.14	<0.3	1.12	0.60
16	Benzo(g,h,i)perylen	3.18	2.15	0.82	0.28	0.82	<0.3	1.07	1.88	2.34
	Total	**21.06**	**14.35**	**5.71**	**40.47**	**5.71**	**3.08**	**6.20**	**17.42**	**20.11**

No.	NAME	19	20	21	22	23	24	25	26	27
1	Napthalene	0.49	2.39	0.51	0.65	0.46	0.72	1.10	2.80	0.98
2	Acenaphthylene	<0.2	3.61	<0.2	<0.2	<0.2	<0.2	<0.2	0.25	0.21
3	Acenaphthene	<0.1	2.96	<0.1	<0.1	<0.1	<0.1	<0.1	0.10	0.29
4	Fluorene	<0.1	4.73	<0.1	<0.1	0.16	0.10	0.11	0.23	0.31
5	Phenanthrene	0.34	1.58	0.16	0.57	0.50	0.25	0.42	1.40	0.27
6	Anthracene	0.49	1.97	0.20	0.67	0.18	0.29	0.52	1.36	0.37
7	Fluoranthene	0.21	1.02	0.14	0.33	0.67	0.21	0.25	0.47	0.50
8	Pyrene	0.24	2.23	0.15	0.40	0.84	0.26	0.30	0.32	0.52
9	Benzo(a)anthre	0.31	2.22	0.21	0.29	0.62	0.29	0.28	0.58	0.41
10	Chrysene	0.48	1.63	0.35	0.44	0.88	0.47	0.42	0.47	1.15
11	Benzo(b)Fluoran	1.18	2.25	0.55	0.69	1.79	1.08	0.57	2.24	0.73
12	Benzo(k) Fluoran	0.90	1.69	0.45	0.55	1.36	0.85	0.31	1.11	0.75
13	Benzo(a) Pyrene	0.45	5.51	<0.3	0.31	0.78	0.42	0.32	0.81	1.13
14	Indeno(1,2,3-cd)py	0.68	4.91	0.30	0.30	1.04	0.70	0.14	1.14	1.06
15	Dibenzo(a,h)anth	<0.3	2.31	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	3.42
16	Benzo(g,h,i)perylen	1.13	5.26	0.39	0.48	1.78	1.09	0.79	0.65	0.19
	Total	**6.88**	**46.27**	**3.40**	**5.68**	**11.05**	**6.73**	**5.54**	**13.92**	**12.30**

No.	NAME	28	29	30	31	32	33	34	35	36
1	Napthalene	0.73	1.20	0.60	1.46	0.51	0.95	0.64	0.67	6.34
2	Acenaphthylene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.44	0.58
3	Acenaphthene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.20	1.75
4	Fluorene	<0.1	0.12	0.11	0.11	<0.1	0.12	<0.1	0.48	2.74
5	Phenanthrene	0.83	0.28	0.23	0.82	0.16	0.42	0.33	0.49	1.51
6	Anthracene	0.16	0.33	0.28	0.97	0.20	0.36	0.41	0.68	1.97
7	Fluoranthene	0.30	0.23	0.16	0.35	0.14	0.22	0.16	0.64	1.44
8	Pyrene	0.31	0.26	0.19	0.38	0.15	0.25	0.21	0.33	0.41
9	Benzo(a)anthre	0.31	0.29	0.23	0.51	0.21	0.32	0.23	0.77	0.67
10	Chrysene	0.49	0.48	0.40	0.70	0.35	0.49	0.38	0.82	1.12
11	Benzo(b)Fluoran	1.03	1.21	0.53	1.41	0.55	0.77	0.67	1.00	3.95
12	Benzo(k) Fluoran	0.82	0.94	0.43	1.08	0.45	0.61	0.53	0.79	3.52
13	Benzo(a) Pyrene	0.37	0.39	0.31	0.62	0.27	0.41	0.29	1.10	1.36
14	Indeno(1,2,3-cd)py	0.57	0.82	<0.3	0.75	0.30	0.30	<0.3	0.99	6.84
15	Dibenzo(a,h)anth	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	1.84	5.19
16	Benzo(g,h,i)perylen	0.82	1.29	0.46	1.08	0.39	0.59	0.46	1.34	0.84
	Total	**6.74**	**7.84**	**3.91**	**10.25**	**3.67**	**5.82**	**4.31**	**12.58**	**40.23**

No.	NAME	37	38	39	40	41	42	43	CP
1	Napthalene	1.48	0.17	49.10	2.42	2.07	0.14	39.60	<0.1
2	Acenaphthylene	0.19	0.16	6.04	0.32	0.42	0.40	2.94	<0.2
3	Acenaphthene	1.54	0.56	2.45	1.38	0.05	0.51	<0.1	<0.1
4	Fluorene	1.74	0.21	7.41	2.76	0.07	0.28	3.18	<0.1
5	Phenanthrene	0.89	0.28	2.09	0.13	0.16	0.36	7.12	<0.1
6	Anthracene	0.85	0.50	18.65	0.90	0.16	0.25	8.39	<0.1
7	Fluoranthene	1.09	0.72	1.26	0.58	0.63	0.85	6.83	<0.1
8	Pyrene	1.32	0.36	4.85	0.24	0.88	0.26	6.24	<0.1
9	Benzo(a)anthre	0.48	0.40	2.62	0.38	0.72	1.93	17.42	<0.2
10	Chrysene	0.46	1.65	2.05	0.28	0.96	0.95	14.72	<0.2
11	Benzo(b)Fluoran	1.92	<0.3	21.56	1.90	2.23	0.60	25.34	<0.3
12	Benzo(k) Fluoran	1.14	0.51	3.79	1.43	1.67	0.47	20.18	<0.3
13	Benzo(a) Pyrene	0.31	2.02	13.40	1.03	0.93	0.51	11.58	<0.3
14	Indeno(1,2,3-cd)py	0.46	1.34	5.67	1.89	2.03	2.99	10.02	<0.3
15	Dibenzo(a,h)anth	1.64	6.25	15.95	1.30	<0.3	1.41	1.80	<0.3
16	Benzo(g,h,i)pery	1.22	<0.3	19.92	1.21	4.58	1.09	7.41	<0.3
	Total	**16.74**	**15.12**	**176.80**	**18.14**	**17.56**	**13.00**	**182.80**	**n.d**

Table 4: The air sampling sites at traffic joints in Hanoi city

Sample sign	Sampling site	Sample sign	Sampling site
1	Chui Bridge - Gia Lam	23	Giai Phong Str. - Nguyen An Ninh Str.
2	Ha Dong bus station	24	O Cho Dua Crossroads
3	Hoang Hoa Tham Str.-Ngoc Ha Str.	25	Hai Ba Trung Str.-Le Duan Str.-Nguyen Khuyen Str.
4	Dien Bien Phu Str.-Nguyen Thai Hoc Str.	26	Truong Dinh Str.-Giai Phong Str.
5	Nguyen Chi Thanh Str.-De La Thanh Str.	27	Minh Khai Str.-Nguyen Khoai Str.
6	Petroleum station Truong Chinh-Ton That Tung Str.	28	Tran Hung Dao Str.-Le Duan Str.
7	Le Van Huu Str. - Ham Long Str.	29	Ha Dong Bridge
8	Hue Str. - Tran Xuan Soan Str.	30	Lieu Giai Str.- Doi Can Str.
9	Tran Khanh Du Str. -Van Kiep Str.	31	Hoang Dieu Str.-Phan Dinh Phung Str.
10	Pham Ngoc Thach Str. - Chua Boc Str-Thai Ha Str.	32	Xanh Market, Thuong Dinh
11	Kham Thien Str. - Le Duan Str. -Nguyen Thuong Hien Str.	33	Trung Hoa Bridge
12	Hang Bai Str. - Hai Ba Trung Str.	34	Giang Vo-Cat Linh Str.
13	Lac Trung - Kim Nguu Str.	35	Lo Duc Str.-Le Van Huu Str.
14	Nguyen Trai Str. - Kim Giang Str.	36	Hoang Quoc Viet Str.- Nam Thang Long Str.
15	Phan Chu Trinh Str. -Tran Hung Dao Str.	37	Giay Bridge
16	Hung Vuong Str. -Nguyen Thai Hoc Str.	38	Phap Van T-junction
17	Nam Thang Long Str.-Co Nhue Str.	39	Vong Crossroads
18	Tran Khat Tran Str. - Lo Duc Str. -Kim Nguu Str.	40	Xuan Thuy Str.-Thang Long Str.
19	Ly Thuong Kiet Str.-Ba Trieu Str.	41	Thai Ha Str.-Tay Son Str.
20	Dai Co Viet Str.-Tran Khat Tran Str. – Hue Str.	42	Long Bien Market
21	Hoang Quoc Viet Str. - Buoi Str.	43	Nga Tu So Crossroads
22	Doi Can Str. - Ngoc Ha Str.	44	Cuc Phuong Forest (Ninh Binh)