DISTRIBUTION OF POLYCYCLIC AROMATIC HYDROCARBONS IN URBAN SOILS OF BEIJING, CHINA

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) in 128 surface soil samples (0~20cm) from Beijing urban district were determined using a Varian 3800 gas chromatography- 4000 mass spectrometry (GC/MS) system. Sum of 16 PAHs (∑PAHs) data in 128 samples followed a logarithmic normal distribution. The mean concentration of ∑PAHs was determined to be 1802.6ng/g (geometric mean: 475.8ng/g) with a standard deviation of 1824.2ng/g. Kriging maps (ordinary kriging) showed that Haidian district and inner city showed average heavier PAH contamination in soils. This is possibly because the historical coal usage and heavy traffic emission in these areas. The distribution of roadside samples generally showed decreasing trends with increasing distances from the road. This indicated the direct influence of traffic emission on PAH contamination in urban soils.

1. Introduction

Urban soils are usually much heavier contaminated than rural or background soils[1, 2]. This is because they experience quite frequent management and disturbance from human activities and are generally adjacent to various urban sources[1]. Polycyclic aromatic hydrocarbons (PAHs) are a group of persistent pollutants which are concerned most and many of them are known to be mutagenic and some carcinogenic. They generally tend to accumulate in various environmental mediums and/or ecological systems due to the resistance from various natural degradation processes and affinity of adsorption onto natural organic matters which further protect them from degradation[3, 4]. They are generally formed through incomplete combustion of fuels that contain carbon[5]. Various sources of PAHs has been identified in urban areas including coal combustion related processes and traffic emission which are known to be two most common and important sources in many cities[6, 7, 8]. The intense source emission in cities and retain of PAHs in various ways might result in heavy PAH pollutions in soils of cities and do much harm to human's health. This study investigates the distribution of soil PAHs in the city of Beijing, and, areas near the cities main roads.

2. Sample Collection and Methods

A total of 58 sampling sites distributed mainly in different locations of the city's main urban district were located (Fig. 1). The final total sampling sites included 12 residential areas (RE, 7 aged and 5 newly built), 9 culture and education areas (CU), 9 business areas (BU), 6 classical parks (CL), 12 large public green spaces (LA) and 10 roads (RO). Surface soil of 0~20cm deep was collected and over 5 sub-samples were collected at

each site and mixed to form a composite one. The final samples included a total of 128 ones.

Soils were crushed to 100 meshes and extracted using an ASE by acetone and hexane (1:1, volume) under 100℃ and 1500 psi. Sixteen EPA priority PAHs were quantified using a Varian 3800 GC- 4000 MS system using m-terphenyl as the internal standard. Recoveries for 16 PAHs were 61.75 ± 5.76% (Nap), 63.41 ± 9.05% (Any), 64.48 ± 12.78% (Ane), 79.99 ± 4.54% (Fle), 102.84 ± 5.07% (Phe), 70.73 ± 6.63% (Ant), 86.73 ± 4.66% (Fla), 82.59 ± 7.99% (Pyr), 96.34 ± 5.53% (Baa), 101.11 ± 5.56% (Chy), 86.97 ± 8.24% (Bkf), 85.52 ± 11.90% (Bbf), 86.58 ± 4.08 (Bap), 95.44 ± 10.61% (I1p), 84.57 ± 5.85% (Daa) and 95.62 ± 3.08% (Bgp).

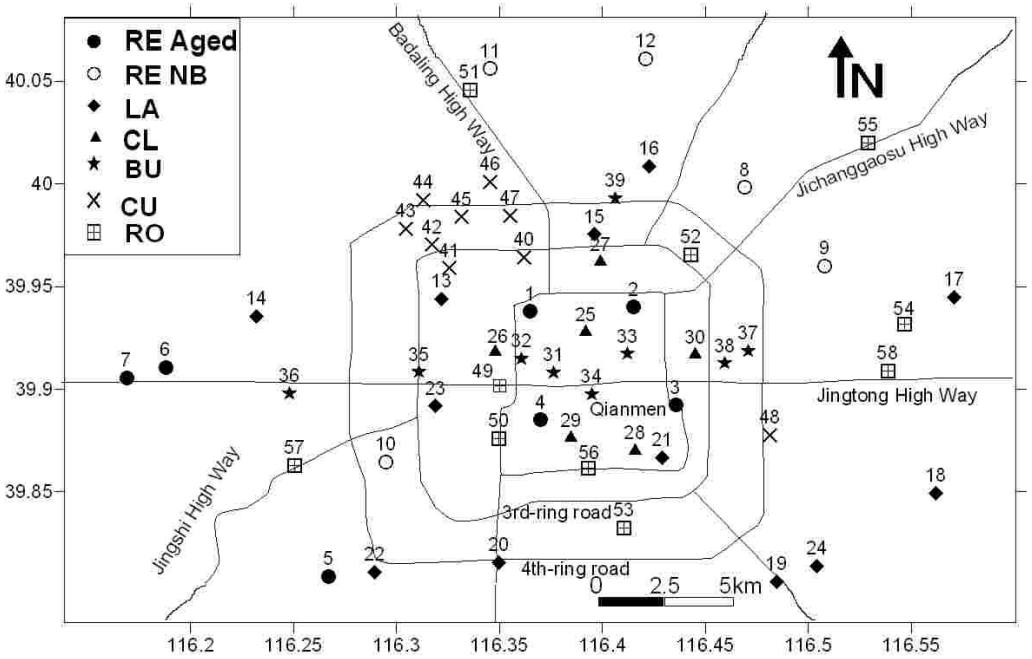


Figure 1 Description of sampling sites.

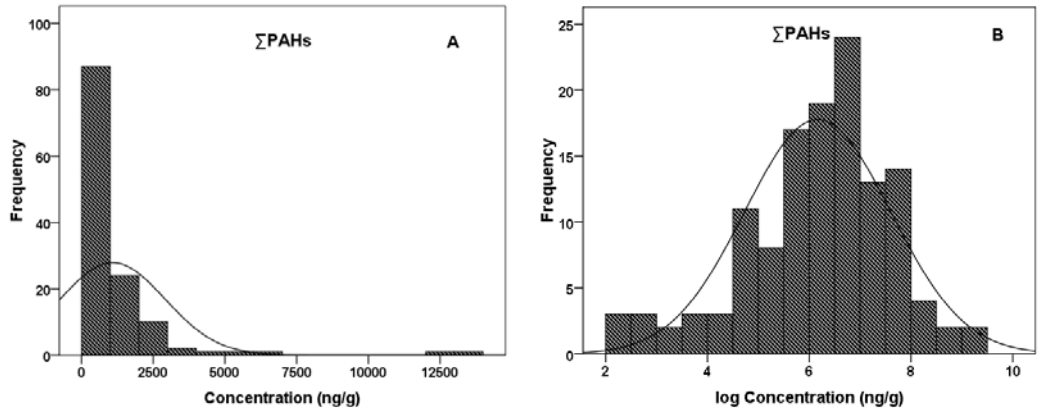


Figure 2 Frequency analysis of ∑PAHs (a) and log ∑PAHs (b) data of the total 128 samples.

3. Results and Discussion

3.1. Distribution in the City

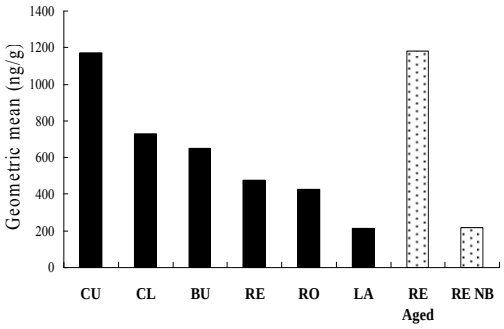


Figure 3 ∑PAHs in soils of different land uses.

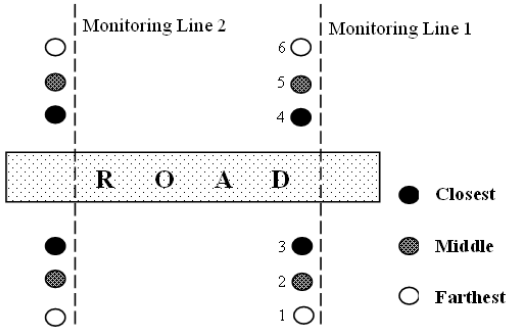


Figure 5 Description of road sampling sites.

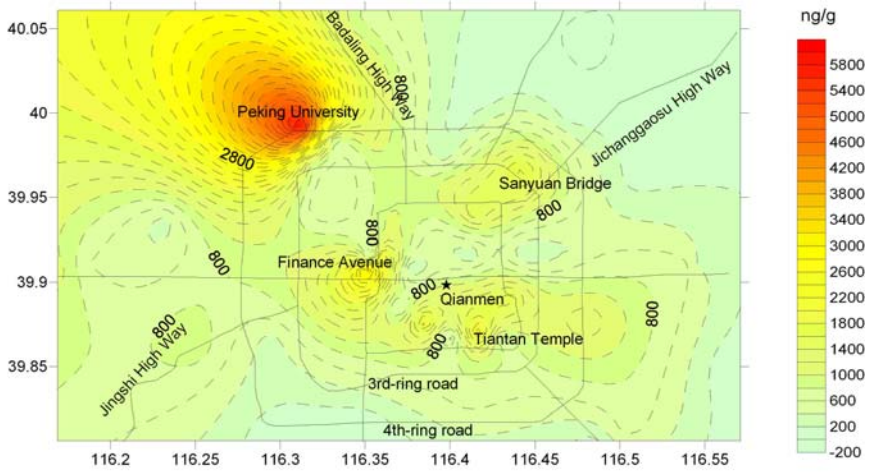


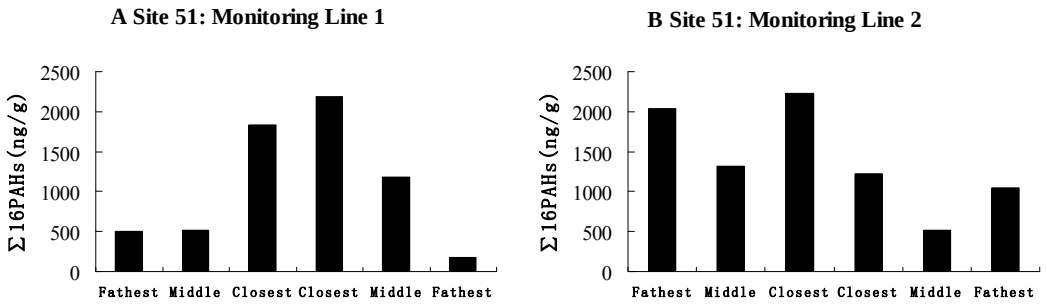
Figure 4 Kriging map (ordinary kriging) of ∑PAHs in urban Beijing.

The determined sum of 16 PAHs (∑PAHs) in Beijing's urban soil ranged from 8.5~13126.6ng/g, with a mean concentration of 1082.6ng/g and a geometric mean concentration of 475.8ng/g. Frequency analysis of ∑PAHs in 128 samples (Fig. 2A) indicated extreme values existed and ∑PAHs generally followed a log-normal distribution in Beijing's urban soil (Fig. 2B). Thus, geometric means of ∑PAHs were applied in comparison of different land uses as shown in Fig. 3. CU exhibited the highest level of ∑PAHs, followed by CL and BU, then RE and RO, and LA exhibited the lowest level of ∑PAHs. A further discrimination of RE into aged RE (RE Aged) and newly built RE (RE NB) found than RE Aged also exhibited much higher ∑PAHs, while RE NB exhibited much lower. It is notable in Fig. 1 that most sites of RE Aged were located in the central part of the city, while most sites of RE NB and LA were located mainly outskirt of the city. Thus, the distinct discrimination of RE Aged and RE NB might relate to their different locations in the city. Most sites of CL and BU which exhibited relatively higher

concentration of ∑PAHs were also located in the city's main central part, while most sites of LA were located mainly outskirt of the city. In order to further investigate the spatial distribution, kriging map (ordinary kriging) of was ∑PAHs constructed as shown in Fig. 4. An elevated zone around Haidian district could easily be observed. Most sites from this district were campuses and the heavier pollution of PAHs might be accounted for historical usage of campus coal-fired boiler for heating and other residential uses. Other relatively higher zones could be found in the city's main central district. These zones mainly centered Finance Avenue, Temple of Heaven, Qianmen and Sanyuan Bridge. The relatively heavier pollution of PAHs in the central city is accountable, because this district has a relatively longer history and the traffic load is much heavier than the outskirt districts. Historical coal combustion and longer period of traffic emission all contribute to the accumulation of PAHs in soils of the central city.

3.2. Distribution in Roadside Samples

In order to monitor traffic effect on soil PAHs, road sites were specially designed as show in Fig. 5. Two monitoring lines were located on both sides of the road with each away from the other above 1km. Six sampling sites (Fig. 5) with different distances from the road were located on each monitoring line. The closest road sites were within 1 meter from the road. The middle and farthest sites were 8~30m and 25~50m from the road, respectively, due to different circumstances around one specific road, but the distances on one same monitoring line generally increased. ∑PAHs of monitoring lines on selected roads (Site 51, 55 and 57) are shown in Fig. 6. In general, ∑PAHs on each monitoring line generally showed decreasing trends with increasing distances from the road, except some farthest samples which might not polluted by sources of only traffic. Geometric mean concentrations of ∑PAHs of all road samples were calculated. The values were 586.9ng/g, 279.1ng/g and 257.3ng/g for the closest, middle and farthest road samples, respectively, also showing a decreasing trend with increasing distances from the road. Road samples with closest distances to the road showed nearly 2 times of ∑PAHs than the middle and farthest samples. These showed the direct effect of traffic emission on soil PAH contaminations.



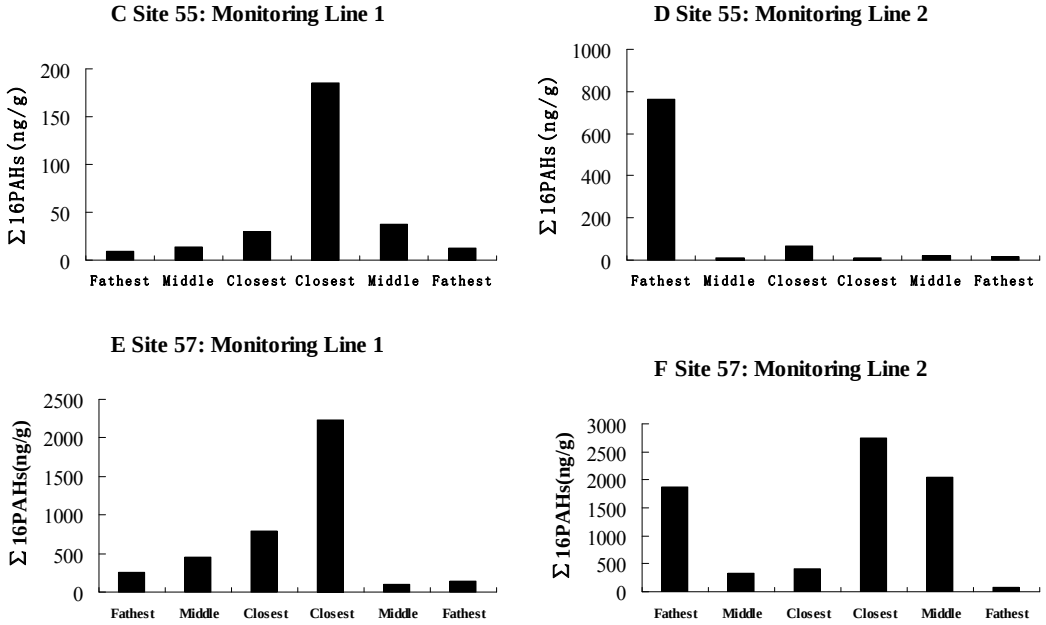


Figure 6 ∑PAHs in soils on monitoring lines of selected roads.

Acknowledgements

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References

1. Tiller K.G.. Aust. J. Soil Res. 1992; 30: 937.

2. Wilcke W. J. Plant Nutri. Soil Sci. 2000; 163: 229.

3. Cornelissen G., Orjan G., Thomas B.D., Jonker M.T.O., Koelmans A.A. and Van Noort P.C.M. Environ. Sci. Technol. 2005; 39: 6881.

4. Morillo E., Romero A.S., Maqueda C., Madrid L., Ajmone-Marsan F., Grcman H., Davidson C.M., Hursthouse A.S. and Villaverde J. J. Environ. Monit. 2007; 9: 1001.

5. Khalili N.R., Scheff P.A. and Holsen T.M. Atmos. Environ. 1995; 29: 533.

6. Harrison R.M., Smith D.J.T., Luhana L.. Environ. Sci. Technol. 1996; 30: 825.

7. Larsen R.K., Baker J.E. Environ. Sci. Technol. 2003; 37: 1873.

8. Simicik M.F., Eisenreich S.J., Loiy P.J. Atmos. Environ. 1999; 33: 5071.