Contamination of soils in Guiyang City, China by Polycyclic Aromatic Hydrocarbons

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Polycyclic aromatic hydrocarbons (PAHs) are a class of well-know toxic and carcinogenic compounds that are widely present in industrial waste, gas, automobile exhaust, coal tars, cigarette smoke and meat products, which constitute the most common ways of exposure of humans to the PAHs. PAHs are listed by the US Environmental Protection Agency (USEPA) as priority pollutants.

Guiyang City, located southwest of China (east longitude 106°07' to 107°17', and north latitude 26°11' to 27°22'), owns an urban area of 98 square kilometers, a population of 1 million people, and a vehicle quantity of 170,000. Its altitude is 1050 m. In Guiyang city, coal is widely used for industrial and domestic purposes and the sum of the vehicle is growing, so the PAHs contamination should not be neglected. The PAHs in soil can be accumulated in vegetables and therefore exert a negative impact on human health. However, no data about PAHs in soil of Guiyang city have been reported before.

This study reports the PAHs contamination in soil of Guiyang city. Soil samples were collected at eight urban sites and five suburban sites in Guiyang city in 2005. For all samples, the 0-10 cm depth original surface soil was collected and mixed. Samples were air dried and pulverized to less than 60 mesh .A rapid and accurate method for extraction of PAHs from soil samples is described in this study. This method is only based on sonication extraction with dichloromethane (DCM) and clean-up by silica gel. The determination of PAHs is carried out by HPLC using a program. A chromatographic system (HP1100) equipped with a fluorimetric detector (FLD) and a UV detector. The sample loop is 20 μL. A Waters PAH column (4.6× 250mm, 5μm particulate size, made in Germany) was used for separation of PAHs, and the mobile phase is composed of acetonitrile and water. All reagents are of HPLC grade, and Millipore Milli-Q system deionized water (18.2 MΩ•cm) was used in all the processes.

The concentrations of 16 priority PAHs in soil are listed in Table 1 and the composition pattern of PAHs by ring size in figure 1. The total PAH concentration in soil varies from 61 to 1560 μg/kg. Urban samples and suburban samples show obviously different PAHs levels. Concentration of 16 PAHs is 247-1560μg/kg for urban soils and 61-339 μg/kg for suburban soils. The PAHs concentration of soils in Guiyang city are not only above the endogenous level (1.0-10 μg/kg), but also obviously higher than the target value set by Dutch government for unpolluted soil (20-50 μg/kg) Consequently, similarly with other cities worldwide, Guiyang city is found suffering a soil PAHs contamination and the causes accounting for this contamination should be addressed. According to the total PAHs level, all the samples can be divided into three grades of contamination: Heavy contamination -- PAHs concentration higher than 1000μg/kg, including sample 8; Medium contamination -- PAHs concentration between 500 and 1000 μg/kg, including samples 1, 2, 3, 4, 7 and 12; Slight contamination – PAHs concentration below 500 μg/kg, including samples 5, 6, 9, 10, 11 and 13. Sample 8 shows the highest PAHs content (1560 μg/kg), indicating a heavy contamination. This site is in the city center and is adjacent (about 50m) to a former coal-burning chimney, which had been releasing coal-burning air particulates for more than 30 years before it was closed in 2002. It can be implied that coal burning is the dominant PAHs source accounting for the high PAHs content of this site. Medium contamination soils include 5 urban samples (1, 2, 3, 4 and 7) and one suburban sample (12). Sample1, 2, 3, 4 and 7 are in the urban area, and may be subject to the influence of diverse sources, such as traffic exhaust and coal-combustion. Although in suburban area, sample 12 shows a PAHs concentration of as high as 511 μg/kg, owing to that site 12 is close to a coal pyrolysis plant locating about 300 m away. Accordingly, sample 12 can similarly with sample 8, be regarded reflecting a result of predominant coal combustion. Slight contamination soils include four suburban samples (9, 10, 11 and 13) and two urban samples (5 and 6). Samples 9, 10 and 11 are not adjacent to any PAHs sources,

implying that these sites may only be affected by gaseous diffusion from PAHs sources far away and consequently show a low level of PAHs. Some distance from site 13, there are some iron works and brick works, where coal is burned for calcination. Site 13 may be affected by coal burning in these works, but its PAHs concentration is still low because these works are about 2 km far away and have a limited impact. The two urban samples (5 and 6) show low PAHs concentrations of 247 μg/kg and 351 μg/kg, possibly due to their distance from PAHs sources and slight influence of contamination. The classification of this study is consistent with that proposed by Maliszewska- Kordybach, which suggested that a soil PAHs concentration of 200 - 600 μg/kg is regarded as a weak contamination, a soil PAHs concentration of 600 - 1000 μg/kg is regarded as a medium contamination, and a soil PAHs concentration of above 1000 μg/kg is regarded as a heavy contamination.

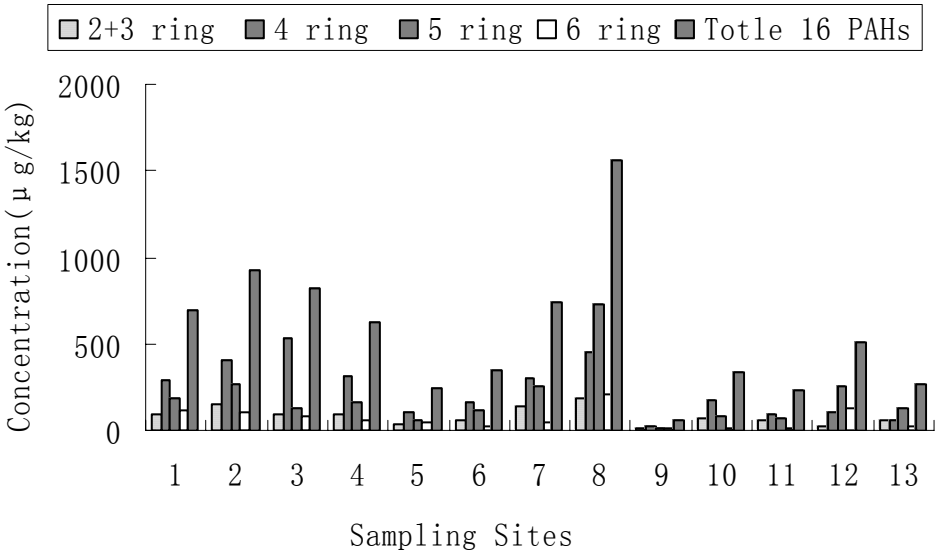

Figure1. The composition pattern of PAHs by ring size.

Table 1 Concentrations of individual PAH compound (μg/kg) in soils of Guiyang City.

Site	Nap	Acy	Ace	FLe	Phe	Ant	Fla	Pyr	BaA	Chr	BbFL	BkFL	BaP	DBA	BPE	Ipy	16PAH
1	13.7	11.2	6.9	2.8	58.5	2.8	158	16.0	16.3	95.0	126	42.2	5.8	77.4	16.5	41.9	692
2	12.6	21.9	103	3.4	5.8	4.1	177	22.5	68.6	138	10.6	57.7	76.5	69.0	116	38.4	926
3	4.5	24.6	7.6	1.6	56.3	ND	481	15.3	8.3	28.0	99.0	8.9	1.7	68.8	13.0	7.7	826
4	4.6	17.4	5.1	1.6	60.2	6.0	195	ND	36.2	81.6	92.6	4.4	8.1	40.1	51.6	21.7	626
5	ND	5.2	3.2	2.4	26.9	1.7	41.1	8.3	10.2	42.9	0.5	16.2	18.8	29.2	18.9	21.6	247
6	ND	5.3	6.0	ND	44.5	0.9	91.7	11.0	13.0	42.3	55.5	16.4	ND	21.0	42.9	0.1	351
7	ND	ND	11.8	ND	118	4.7	102	59.9	34.5	100	134	29.7	40.6	49.5	54.5	0.1	739
8	ND	ND	ND	ND	162	22.3	77.3	30.8	182	157	214	124	205	81.7	181	123	1560
9	ND	1.4	ND	1.2	7.9	ND	8.5	8.5	3.1	5.5	9.9	2.6	3.1	7.9	0.9	ND	61.0
10	3.5	12.0	0.9	13.0	33.6	1.1	86.4	45.6	16.5	30.3	37.1	12.8	13.9	12.2	20.2	ND	339
11	9.8	5.2	3.2	13.3	31.3	0.7	55.8	6.5	3.0	28.2	35.8	0.9	13.5	12.1	14.3	ND	234
12	6.1	4.7	5.6	6.1	2.1	ND	16.4	7.8	30.5	51.4	61.3	23.5	3.6	122	170	ND	511
13	ND	3.6	ND	8.5	43.9	0.6	43.9	6.3	8.7	4.2	52.6	1.7	17.7	3.0	49.5	20.2	264
Mean	4.2	8.7	11.8	4.2	50.1	3.5	118	18.4	33.1	61.9	71.5	26.2	31.4	45.7	57.6	21.2	567
Max.	13.7	24.6	103	13.3	162	22.3	481	59.9	182	157	214	124	205	122	181	123	1560
Min.	ND	1.4	ND	1.2	2.1	ND	8.5	ND	3.0	4.2	0.5	0.9	ND	3.0	0.9	ND	61.0

ND: Not detecte

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