Concentration Characteristics of Heavy Metals in Atmospheric Particulate Matter in Urumqi in Recent Years (Postprint)

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Abstract

Atmospheric particulate matter TSP, PM10, and PM2.5 were collected at Xinjiang Agricultural University in Urumqi during the heating periods of 2014, 2015, and 2017 using the gravimetric method. Mass concentrations of five heavy metal elements in the particulate matter were measured using a TAS-990 flame atomic absorption spectrophotometer, a PF3 atomic fluorescence spectrometer, and a graphite furnace atomic absorption spectrophotometer. The enrichment factor method was utilized to analyze the enrichment levels and sources of the heavy metal elements. The results indicate that: the mass concentrations of TSP and PM10 at this sampling site during the heating period have shown a decreasing trend in recent years; the variation trend of PM2.5 mass concentration followed the order 2017 > 2015 > 2014; the mass concentration of arsenic (As) was the highest among all heavy metal elements in atmospheric particulate matter across different particle sizes, and both the heavy metal content (except for chromium, Cr) and the enrichment levels of heavy metal elements in heating-period atmospheric particulate matter have exhibited a significant decreasing trend in recent years; the heavy metal elements As, Cr, Zn, and mercury (Hg) were more readily enriched in fine particulate matter.

Full Text

Preamble

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Abstract: By using the gravimetric method, atmospheric TSP, PM10, and PM2.5 were collected over the campus of Xinjiang Agricultural University in Urumqi, Xinjiang, China during the heating periods of 2014, 2015, and 2017 and analyzed for mass concentrations of five heavy metal elements. A TAS-990 flame atomic absorption spectrophotometer was used to determine the concentration of Zn, a PF3 atomic fluorescence spectrometer was used to determine the concentrations of As and Hg, and a graphite furnace atomic absorption spectrophotometer was used to determine the concentrations of As and Hg. The results are as follows: the concentration of Cr is 1.31–8 ng · m ^{3}; the concentration of Hg is 0.15–3.14 ng · m ^{3}; the concentration of As is 11.79–120.47 ng · m ^{3}; the concentration of Zn is 5.16–31.11 ng · m ^{3}; the concentration of Pb is 1.05–6.83 ng · m ^{3}. The enrichment factor method was used to analyze the enrichment degree and source of heavy metal elements, and the study explored the characteristics of elements and sources of pollution in different particle sizes at Xinjiang Agricultural University of Urumqi. The results showed that during the heating period, the mass concentration of atmospheric particles TSP and PM10 exhibited a downward trend in recent years, while the mass concentration of PM2.5 showed an upward trend. In recent years, the mass concentration of the heavy metal As in airborne particles across different particle sizes was the highest. The concentrations of heavy metals As, Pb, and Zn have shown a significant downward trend in recent years, while the concentration of heavy metal Cr has been increasing gradually. The concentration differences of As, Cr, Zn, and Hg in different particle sizes were presented in descending order as PM2.5, PM10, and TSP, while for Pb the descending order was TSP, PM10, and PM2.5, indicating that heavy metals As, Cr, Zn, and Hg were more easily concentrated in fine particles. The enrichment factor analysis results showed that the enrichment degree of heavy metals As, Cr, Hg, and Zn in atmospheric particulates followed a descending order of PM2.5, PM10, and TSP. The degree of enrichment of As, Pb, and Zn in recent years indicated the highest value in 2014, the lowest value in 2017, and an intermediate value in 2015. For the Cr element, the highest value occurred in 2017, the lowest in 2014, and an intermediate value in 2015. For the Hg element, the highest value occurred in 2015, the lowest in 2017, and an intermediate value in 2014. The heavy metal Hg is moderately enriched, indicating obvious enrichment from anthropogenic pollution sources. The EFi value of the heavy metal As is basically in the range from 1 to 10, which belongs to mild enrichment from natural and artificial sources. The EFi values of heavy metals Zn, Cr, and Pb are between 0 and 10, indicating they are mainly derived from crustal materials. Overall, the degree of enrichment of heavy metal elements other than Cr in atmospheric particulate matter TSP, PM10, and PM2.5 shows a downward trend in recent years, and heavy metal elements in the atmosphere are more likely to be concentrated in fine particles.

Keywords: Urumqi city; heavy metals; pollution evaluation; concentration characteristics

1. Methods

1.1 Sampling

Atmospheric TSP, PM10, and PM2.5 samples were collected during the heating periods of 2014, 2015, and 2017 at the campus of Xinjiang Agricultural University in Urumqi. Samples were collected at a flow rate of 100 L/min using [sampling method], with 1–2 samples collected each period according to reference [20].

1.3.2 TSP, PM10, PM2.5 Analysis

Samples were digested using the HNO –HClO method for determination of Zn, Cr, Pb, As, and Hg. A total of 360 samples were analyzed for heavy metal concentrations.

1.3.3 Detection Methods

Pb and Cr were determined by [method], Zn by [method], and As and Hg by [method] using appropriate analytical instruments.

2. Results

2.1 Mass Concentrations of TSP, PM10, and PM2.5

During the heating periods from 2014 to 2017, the mass concentrations of atmospheric particles showed distinct trends. In 2014 and 2015, concentrations were [specific values], while in 2016 and 2017, 1–2 samples showed [specific patterns]. The PM2.5 and PM10 concentrations [relationship to GB3095-2012 standard]. The mass concentrations of TSP and PM10 showed a downward trend in recent years, while PM2.5 concentrations increased: 2017 > 2015 > 2014.

Table 1. Atmospheric particulate matter mass concentration and quality level

Period	PM2.5 (g • m ^{3})	AQI Category
2014-1	151	v
2014-2	109	—
2014-3	127	—
2015-1	154	v
2015-2	167	v
2015-3	96	v
2016-1	112	—
2016-2	134	—
2017-1	[value]	[category]

Fig. 1. Different particle size and particle size distribution

2.2 Heavy Metal Concentrations in TSP, PM10, and PM2.5

The concentration ranges of heavy metals in atmospheric particulates were: Cr 1.31–8 g·m ^{3}, Hg 0.15–3.14 g·m ^{3}, As 11.79–120.47 g·m ^{3}, Zn 5.16–31.11 g·m ^{3}, and Pb 1.05–6.83 g · m ^{3}. The descending order of heavy metal concentrations varied by year: in 2014, As > Zn > Pb > Cr > Hg; in 2015, As > Zn > Cr > Hg > Pb; and in 2017, As > Cr > Zn > Pb > Hg.

The enrichment factor (EFi) analysis revealed that As, Cr, Zn, and Hg concentrations were highest in PM2.5, followed by PM10, then TSP, indicating these metals preferentially accumulate in fine particles. In contrast, Pb showed the opposite pattern with highest concentrations in TSP, then PM10, then PM2.5.

Table 2. Relationship between EFi and enrichment of elements in particle size particles

EFi Range	Enrichment Level	Source
EFi 1	–(cid:236)(cid:134)(cid:135)	v(cid:236)(cid:134)(cid:135)
1 < EFi 10	3(cid:157)	uUFG(cid:157)
10 < EFi 100	Œ(cid:236)(cid:134)(cid:135)	uUFG(cid:157)
100 < EFi 1000	¤(cid:134)(cid:135)	uUFG(cid:157)
EFi > 1000	(cid:255)C(cid:253)ST	uUFG(cid:157)

Table 3. Relationship between EFi and enrichment of elements in particle size particles

Element	Background Value (mg · kg ^{1})
[Element 1]	47.40
[Element 2]	10.78
[Element 3]	26.70
[Element 4]	11.20
[Element 5]	0.160

Fig. 3. TSP, PM10, PM2.5 enrichment factor of heavy metals

The enrichment factor analysis indicates that Hg is moderately enriched (EFi 10-100), suggesting anthropogenic sources. As shows mild enrichment (EFi 1-10), indicating mixed natural and artificial sources. Zn, Cr, and Pb have EFi values between 0 and 10, suggesting they originate primarily from crustal materials.

3. Discussion

Recent studies on atmospheric heavy metal pollution in Urumqi have shown [discussion of trends and sources]. The enrichment factor method provides valuable insights into pollution sources, with higher EFi values indicating greater anthropogenic influence. The observed trends suggest [interpretation of results].

References

[13] Chen Xingmao, Feng Lijuan, Li Xianguo, et al. Spatiotemporal distributions of trace metals of atmospheric aerosols in Qingdao area, China [J]. Environmental Chemistry, 2004, (3): 334-340.

[14] Tian H, Zhu Z, Gao CY, et al. Quantitative assessment of atmospheric emissions of toxic heavy metals from anthropogenic sources in China [J]. Atmospheric Chemistry & Physics Discussions, 2015, 15: 10127-10147.

[15] Sun Longren, Zheng Chunxia, Wang Wenquan, et al. Characteristic of heavy metal distribution in PM10 and PM2.5 from atmospheric samples in Urumqi in summer [J]. Tianjin Agricultural Sciences, 2009, 15(2): 37-41.

[17] Ji Yuan, Kang Hong, Li Gang. The heavy metal pollution characteristics and source apportionment of PM2.5 under the heavy pollution of Urumqi winter weather [J]. Arid Environmental Monitoring, 2016, 30(3): 127-131.

[18] Tursun Yalkunjan, Talifu Dilnur, Ablizi Ablikim, et al. Pollution level of heavy metals in PM2.5 and PM10-2.5 during winter in Urumqi [J]. Journal of Xinjiang University (Natural Science Edition), 2010, 27(3): 338-342.

[19] Zhang Hongfang, Wang Weiping, Fan Kai. Research on pollution characteristics of 5 kinds of heavy metals in PM10 and PM2.5 in Baoji City [J]. Journal of Baoji University of Arts and Sciences (Natural Science Edition), 2015, 2(35): 70-76.

[20] Cui Jiusi, Wang Qinyuan, Wang Hanping. Air pollution detection method [M]. Beijing: Chemical Industry Press, 1997: 69-71.

[21] Sarvam Praveena, Miroslav R, et al. The assessment of mangrove sediment quality in Mengkabong Lagoon: An index analysis approach [J]. International Journal of Environmental & Science Education, 2007, 2(3): 60-68.

[23] Wang QQ, Tan JH, Ma YL, et al. Characteristics of heavy metals in PM2.5 during winter in Foshan City [J]. China Environmental Science, 2012, 32(8): 1384-1391.

[24] Yuan XY, Ye ZX, Yang HJ, et al. Characteristics of fine particles in urban road atmospheric environment in Chengdu [J]. Chinese Journal of Environmental Engineering, 2015, 9(9): 4598-4602.

[25] Li YP, Liu HF, Zhou H, et al. Contamination characteristics and health risk assessment of toxic heavy metals in PM2.5 in Chengdu [J]. China Environmental Science, 2015, 35(7): 2225-2232.

[26] Yuan XY, Ye ZX, Yang HJ, et al. Characteristics of PM2.5 pollution during the world car free day in Chengdu [J]. Environmental Science & Technology, 2015, 38(8): 22-26.

[27] China Environment Monitoring Station. Chinese soil element background value [M]. Beijing: China Environmental Science Press, 1990: 329-492.

[28] Yahefu Palida, Huo Jiawumai'er Nuerbiya, Simayi Maimaiti. Evaluation on heavy metal pollution levels in TSP, PM10, PM5, PM2.5 during heating period of Urumqi [J]. Environmental Monitoring in China, 2016, 32(5): 56-59.

[29] Hu Huiling. The investigation of the heavy metal pollution in the Anningqu District [J]. Arid Environmental Monitoring, 2003, 17(2): 117-122.

Note: Figure translations are in progress. See original paper for figures.