Heavy metal ecological risk assessment of Atmospheric Dust of Xi'an City

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Abstract

Atmospheric dust samples of perennial accumulation were collected by labor at 13 national control points of atmospheric dust in Xi'an from January. to November. 2013. Contents of heavy metals were tested. Heavy metal ecological risk assessment and source apportionment of atmospheric dust were studied. The results show that Cu, Zn, Cr and Ni ecological risk index was smaller in atmosphere dust of Xi'an city, the ecological risk level is low; secondly, Pb and As ecological risk level is medium; ecological risk index of Cd which is the most serious ecological harm is much higher than other heavy metals. From the computational results we can also conclude that the enrichment factor, Cd in various functional areas were greater than 20, the highest among all the heavy metals, it has strong enrichment degree. The enrichment factor of Pb and Zn between 4-10, significantly enriched.

Keywords

Atmospheric dust; heavy metal; ecological risk assessment.

1. Introduction

Atmospheric dust refers to the natural landing on the ground of air particles, and particle size more than 10μm. In general, the artificial sources of urban particulate matter are more complex, and it easy to form a multi-pollution source superposition of complex pollution, which mainly from the following aspects: a variety of industrial and civil fossil fuel combustion, industrial and mining production, motor vehicle emissions and all kinds of dust. Atmospheric dust itself contains a large number of toxic and hazardous substances, while the dust absorption of organic pollutants and heavy metal content are higher and more toxic. Atmospheric dust, especially smaller particles and their heavy metal pollutants on the health effects of the human body has become a domestic and international environmental science, which is medical field of hot research topics. Once the heavy metals in the atmosphere into the environment system has become a permanent potential pollutants, and heavy metals in the environment of the conversion is generally only between the different valence state of the conversion, and difficult to be microbial degradation [1]. At the same time, heavy metals can migrate, enrich, and harm human health through the food chain. Foreign developed countries on the atmospheric heavy metal research more fully, as early as the 20th century, 70 years has begun the study of atmospheric heavy metal settlement [2-5]. However, our country has long neglected the heavy metal pollution in the atmosphere. The "ambient air quality standard" only stipulates the content of heavy metals in most of the heavy metals, and it does not strictly limit the concentration of heavy metals in most heavy metals. Compared with the international research progress, atmospheric heavy metal pollution research of China has a certain lag. At present, domestic scholars are still in the exploratory stage of ecological risk assessment of heavy metals in atmospheric dust, which for the method of evaluating heavy metal pollution in sediments.

2. Methods

2.1 Sampling point selection

In this study, 13 national control points in Xi'an were sampled as the sampling points. The points were distributed in five districts of east, west, south, north and north of Xi'an, representing industrial areas, commercial areas, residential areas and tourist areas A typical urban functional area, can fully reflect the overall level of dust in Xi'an and the difference between the functional areas. The specific distribution of the points is shown in Table 1.

Table 1. Atmospheric dust sampling points

Functional area	Point name	Region	District
Industrial area	Baqiao textile city	Outside the third ring road	Baqiao
	Switch factory	Iutside the third ring road	Lianhu
	Eonomic development Zone	Outside the third ring road	Weiyang
	Yanliang environmental protection bureau	Suburbs	Yanliang
Business district	Gaoxin software park	Iutside the third ring road	Yanta
	Xiaozhai	Iutside the third ring road	Yanta
Residential area	Mingde door	Iutside the third ring road	Yanta
	Xingqing district	Iutside the second ring road	Beilin
	Weiyang environmental protection bureau	Iutside the second ring road	Weiyang
	Xi'an University of Posts	Outside the third ring road	Changan
Tourist area	Lintong environmental protection bureau	Suburbs	Lintong
	Guangyun Tan	Outside the third ring road	Baqiao
	Qujiang new district	Outside the third ring road	Yanta

2.2 Sampling method

Sampling platform in January to November 2013 dust samples collected, the sampling points are located far away from all types of pollution sources and a high distance from the ground more than 10m above the roof, surrounded by high buildings without shelter.

2.3 Sample analysis method

The test metal samples Pb, Zn, Cu, V, Ba, Cr, Cd, Ni were analyzed by inductively coupled plasma mass spectrometry ICP-MS with reference to EPA3052.

2.4 Research methods

The ecological risk index and the enrichment factor of dust and heavy metals in different functional areas were calculated by using the method of potential ecological hazard index and enrichment factor method respectively, and the pollution level and ecological hazard degree of heavy metals in annual precipitation of Xi'an were discussed.

Potential ecological risk index

The prerequisites for this method are indicators of metal content, data addition, biotoxicity, index sensitivity, which reflect the effects of each heavy metal pollutant in a given environment and the combined effects of various pollutants [6]. In this paper, the risk factors of heavy metals Cu, Pb, Zn, Cr, Cd, Ni and As, which are the most ecological hazards in atmospheric dust, are evaluated according to the potential ecological risk index method.

Potential ecological risk index for a single metal:

Eir = Tir ×Ci / C0

Ci, C0, Tir are the measured concentrations, reference values and biooxicity coefficients of the ith heavy metals, respectively.

Enrichment factor evaluation method

According to the principle of EF, it is the use of appropriate elements as a standard element, and then use the sample contamination of the elemental mass fraction and the reference element mass fraction ratio and the background value of the ratio of the ratio of the two as the EF value [7-9]. The formula is as follows: EF=(Ci/X)sample/(Ci/X)background

(Ci/X) sample is the ratio of the mass concentration of element i in the dust sample to the mass concentration of element X; (Ci/X) background is the ratio of the mass concentration of i element to the X mass concentration in the background.

According to the size of the enrichment factor can be divided into four categories of pollution levels, see Table 2.

Table 2. Classification of pollution enrichment

Element enrichment factor	Enrichment
＜2	Non-enrichment components, and derived from the crust
2-5	Moderate enrichment
5-20	Significant enrichment
20-40	Slightly strong enrichment
＞40	strong enrichment

3. Analysis and discussion

3.1 Ecological risk assessment of atmospheric dust of heavy metals in Xi'an city

3.1.1 Potential ecological risk index

At present, there are no clear and unified evaluation criteria for heavy metal content in the atmosphere. In this paper, the mean value of the heavy metal elements in the soil layer of Shaanxi Province is selected as the reference value [10]. Tir was used to reflect the toxicity level of heavy metals and the sensitivity of biology to heavy metals. According to the standardized toxicimetric biooxicity coefficient developed by Hakanson, the toxicity coefficients of Cu, Pb, Zn, Cr, Cd, Ni and As were 5, 5,1,2,30,5,10 [11]. The reference value and toxicity coefficient of heavy metal elements are shown in Table 3.

A variety of heavy metals potential ecological hazard index: RI=ΣEir

The ecological hazard index (Eir) of the single element of heavy metals and the ecological risk index (RI) corresponding to the comprehensive ecological risk index (RI) of various elements are shown in Table 4.

Table 3. Element ratio and coefficient of toxicity of heavy metal pollution evaluation

Heavy metal	Cu	Pb	Zn	Cr	Ni	Cd	As
Biological toxicity coefficient	5	5	1	2	5	30	10
Shaanxi background value (mg/kg)	20.1	20.9	66.1	61.1	27.7	0.0886	10.8

Table 4. Heavy metal potential ecological risk degree grading standard

Potential ecological hazard coefficient of individual metals E^i_r	Potential ecological risk of heavy metals in single factor	Potential ecological hazard index of various heavy metals RI	Total ecological risk of heavy metals
<40	Ⅰ Low ecological hazard	<150	Ⅰ Low ecological hazard
40—80	Ⅱ Ecological hazards moderate	150—300	Ⅱ Ecological hazards moderate
80—160	ⅢEcological hazards are high	300—600	ⅢHigh ecological hazards
160—320	ⅣHigh ecological hazards	>600	ⅣEcological hazards are extremely high
>320	Ⅴ Ecological hazards are extremely high		

The average potential ecological risk index (Eir) of 7 kinds of heavy metal elements in various functional areas of Xi'an is shown in Table 5. From Table 4, the Cu, Zn, Cr and Ni ecological risk index is small, the ecological hazard level is low, and the impact on the urban and surrounding suburb ecosystem is very small. Secondly, the RI values of Pb and As are 73.61 and 86.11 respectively, ecological risk The ecological risk index of Cd is 1412.81, which is much higher than that of other heavy metals, and the risk level is at a very high level, which indicates that Cd has the highest contribution rate to ecological risk index, and the ecological risk index of Cd is higher than that of other heavy metals Ecological hazards are the most serious.

Table 5. 7 kinds of average degree of potential ecological risk of heavy metal element classification

Heavy metals	Cu	Pb	Zn	Cr	Ni	Cd	As
RI	31.13	73.61	10.66	6.43	12.94	1418.38	86.11
Grade	Ⅰ	Ⅱ	Ⅰ	Ⅰ	Ⅰ	Ⅴ	Ⅲ
Level	low	medium	low	low	low	very high	higher

Potential ecological risk index of heavy metals (Eir) in various functional areas of Xi'an and said seven elements integrated potential ecological risk index (RI) Table 6. From the results shown in Table 6, except for a few heavy metal, ecological risk of heavy metals in the index (Eir) in the industrial, commercial, residential and tourist area showed a moderate and below the level of ecological risk. Cd in the functional areas showed a high ecological risk level, indicating that the overall Cd pollution in Xi'an as a whole, the degree of ecological hazards, should pay attention to the pollution problem, take appropriate measures to control the heavy dust in the atmospheric dust pollution; Industrial areas and commercial areas of the potential ecological hazard index is high, which is directly related to the characteristics of the two functional areas, the foregoing has made it clear that not repeat them, Pb in residential areas and tourist areas of the ecological risk at a moderate level, taking into account the Pb Biological toxicity will have a direct and indirect impact on the human body and animals and plants, the relevant environmental protection departments should strengthen the two functional areas of Pb pollution control efforts; heavy metal As in the functional areas also showed a high level of risk in the tourist area the risk level has reached a moderate level, which may absorb and farmland ecosystems in the area of plant roots and enriched excess of As of As of secondary dust caused by the soil; districts of Cu, Zn, Cr and Ni ecological risk index was small, low on people's life and production activities affect, not the degree of ecological harm, but Cu and Zn in the potential ecological risk index for residential areas High, dense population of the area it will cause serious health hazards. Integrated potential ecological risk index (RI) of each functional area larger than all of 1000, the potential ecological risk in order: the business district> Industrial area > residential area > tourist area.

Table 6. Heavy metal potential ecological risk of the classification of atmospheric dust of functional areas

Heavy metals	Industrial area		Business district		Residential area		Tourist area	
	$E^i r$	grade	$E^i r$	grade	$E^i r$	grade	$E^i r$	grade
Cu	27.44	I	34.30	I	38.48	I	24.32	I
Pb	88.48	III	76.27	II	69.42	II	60.30	II
Zn	10.81	I	9.68	I	12.74	I	9.44	I
Cr	6.16	I	6.87	I	6.96	I	5.70	I
Ni	13.53	I	14.27	I	13.25	I	10.72	I
Cd	1463.60	V	1494.92	V	1427.20	V	1287.81	V
As	86.31	III	90.21	III	88.27	III	79.64	II
RI	1696.32	V	1726.52	V	1656.31	V	1477.93	V

3.1.2 Enrichment factor method

The requirements for the reference element for the enrichment factor evaluation are of a certain stability, and the method used has high sensitivity to the element, making the measurement result sufficiently accurate. Usually Fe, Si, Ti, Al and Mn can be used as a reference element [12], this article uses more Al as a standardized element. The selection of background values has traditionally been based on the average of the crustal element mass fraction or the global shale element mass fraction as the background value [13], and the choice of background values affects the calculation of the enrichment factor.

The enrichment factor calculation of the heavy metal in the dust in each functional area is shown in Table 7. Heavy metals Cr and Ni in the four functional areas of the EF value is lower than 2, indicating that the pollution caused by human factors smaller, mainly from the crust; Cu element enrichment factor does not follow the functional area of the degree of cleanliness decreased, but the performance The enrichment of commercial areas and residential areas is higher than that of industrial areas, but the overall enrichment is not moderate and medium enrichment. The EF values of As elements are between 4-5 and the functional areas are not obvious. Enrichment factor between 4-10, enrichment significant, indicating that human industrial activities and transportation pollution caused by a greater impact on the city, but the overall Zn than the Pb enrichment is slightly smaller; Cd in the functional area rich Set factors are greater than 20, the highest in all heavy metals, strong enrichment. In summary, in addition to Cr and Ni, the other heavy metals in the functional areas are different degrees of enrichment. Among them, the enrichment of Pb, Zn and Cd in the industrial area is more serious, which shows the contribution of industrial production to the increase of pollutants. Cd and Pb are rich in the commercial area and are polluted. Cu and Zn in the residential area The enrichment factor is the highest in all areas, although the degree of enrichment is not very high, but the side reflects the traffic pollution on the residential area is more serious; tourist area is relatively clean, only Cd there is a certain pollution.

Table 7. Heavy metal enrichment factor of atmospheric dust of functional areas

Functional area	Cu	Pb	Zn	Cr	Ni	Cd	As
Industrial area	3.060	9.866	6.026	1.718	1.509	27.563	4.812
Business district	3.291	7.318	4.642	1.649	1.369	24.223	4.328
Residential area	4.139	7.467	6.850	1.873	1.425	25.925	4.747
Tourist area	2.855	7.078	5.539	1.674	1.258	25.531	4.675

Compared with the two evaluation methods, the potential ecological risk assessment and the enrichment factor evaluation show some similarity in the results, and the two kinds of evaluation results can obtain a more reliable ecological risk level. Compared with the enrichment factor method, the potential ecological risk method is more discriminative and more sensitive to the classification of hazard level. It takes into account the ecological effect of heavy metals, the superposition effect of environmental effect and toxicology, Attribute index grading method to evaluate, than the enrichment factor method of purely on the assessment of the status quo of pollution more convincing.

4. Conclusion

The ecological risk index of Cu, Zn, Cr and Ni in the atmospheric dust of Xi'an is small and the ecological hazard level is low. Secondly, the ecological risk index of Pb and As is moderate; the ecological risk index of Cd is much higher than that of other heavy metals, and its ecological hazard is the most serious. It is also known that the enrichment factor of Cd in each functional region is more than 20, which is the highest in all heavy metals and the enrichment degree is strong. It is also known that the enrichment factor of Cd in each functional region is more than 20, which is the highest in all heavy metals and the enrichment degree is strong. While the enrichment factors of Pb and Zn were between 4 and 10, and the enrichment was significant.

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