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Study on the Content and Influence of Heavy Metal Elements in Dust of Xiqing District of Tianjin

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Abstract. At present, heavy metal elements in dust have great influence on air quality and human health,therefore, the content and influence of heavy metal elements on campus were studied. Firstly, PM10 and total dust in the autumn campus atmosphere were sampled for 10 consecutive days, and then digested by electric heating plate digestion method. Then, inductively coupled plasma emission spectrometer (ICP-OES) was used to detect and analyze the content and concentration ratio of seven heavy metal elements Cu, Pb, Cd, Zn, Cr, Hg and Ba in PM10 and total dust. Finally, through comparative analysis, it is concluded that heavy metal pollutants in the atmospheric environment are mainly Zn and Ba, and the concentrations of Cd, Zn and Ba are seriously exceeded, so the air quality in Xiqing District of Tianjin is poor, and the particle size distribution of Cd and Hg makes it easy to enter the human body, which is especially unfavorable to human health.

1 Introduction

1.1 Research background

In recent years, heavy metals in dust have gradually become the focus of research. Heavy metals in dust have a great impact on human health,however, the environmental quality standards for atmospheric dustfall have not yet been established in China,although dust and heavy metals have been studied in depth, the research on heavy metals in dust is almost blank, and the relevant evaluation indexes for air conditions are various, and few heavy metals in dust are included in the evaluation indexes. By comparison at home and abroad, it can be found that the average content of heavy metals in atmospheric deposition in China is generally higher than that in foreign countries. This may be related to China's current economic development level, industrial development structure and local value of heavy metals in soil. With the gradual improvement of economic level, society pays more attention to health,it can be predicted that heavy metals in dust will become a hot research target.

1.2 Research status at home and abroad

(1) Experimental basis

Existing laboratory instruments are adopted, including TSP for PM10, FC-3 for total dust and ICP-OES for detection.

(2) Research methods

Content of heavy metal elements in filter membrane samples are inductively coupled plasma mass spectrometry (ICP-MS)[1], emission spectrometry (ICP—AES) [2], ion chromatography[3] and atomic absorption spectrometry (AAS) [4].

Generally speaking, the current research on heavy metals in dust has attracted wide attention from the society and academic circles, and the research results from various perspectives in academic circles are rich and colorful, but the research on heavy metals in campus areas is still blank,therefore, this paper compares the concentrations of heavy metals in inhalable particles (PM10) and total dust to explore their harm to human body.

2 Experiment of heavy metal elements in dust

Dust is divided into respirable dust and total dust,PM10 and total dust were investigated by experimental method.

2.1 Dust heavy metal sampling

According to the literature, it is found that the dust heavy metals in atmospheric deposition mainly include Cu, Pb, Cd, Zn, Cr, Hg and Ba. These dust and heavy metals which have been studied at present have caused great harm to human health. Therefore, this experiment mainly samples and detects the above seven heavy metal elements.

2.1.1 Sampling place and time

(1) Sampling location

The sampling site is chosen at the entrance of East

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Fifth Gate of Tianjin University of Technology, which is typical and representative, with both large flow of people and surrounding traffic nearby.

(2) Sampling time

Sampling conditions such as sampling time and flow rate are shown in Table 1 .

Table 1. Dust sampling status.

Dust type	Sampling time	Sampling flow	Sampling times
Total dust	90min	5L/min	1 time per day
Inhalable particles	300min	100L/min	1 time per day

(3) Sampling meteorological conditions and results

This sampling is carried out under the normal conditions of Tianjin University of Technology and the corresponding environmental standards (standard volume),after 10 days of instrument sampling, the dust sampling results can be obtained, as shown in Table 2 .

Table 2. Meteorological conditions and results of dust sampling.

Sampling time	Temperature/℃	Air pressure /KPa	Air quality PM10	Weather conditions	Sample number	Sampling volume /L
9.12	29.5	101.1	84	Cloudy	z-01 h-01	450 33294
9.13	22	101.0	85	sunny	z-02 h-02	450 33692
9.14	22	101.6	112	Cloudy	z-03 h-03	450 28132
9.15	25.5	101.5	15	Cloudy	z-04 h-04	450 30459
9.16	19	102.3	21	Cloudy	z-05 h-05	450 29141
9.17	25.5	101.6	43	Cloudy	z-06 h-06	450 30000
9.18	21	101.3	52	sunny	z-07 h-07	450 30431
9.19	16	101.2	56	Cloudy	z-08 h-08	450 30145
9.20	24	100.8	57	Cloudy	z-09 h-09	450 31000
9.21	20	100.6	33	sunny	z-10 h-10	450 27304

2.1.2 Sampling equipment and methods

The equipment and methods used in this experiment are shown in Table 3 .

Table 3. Sampling 3 Equipment and Method.

Test item	Method of sampling	Sampling equipment	Analytical method
Total dust	Enrichment method with dust filter membrane	FC-3 dust sampler	Weight method
Inhalable particles (PM10)	Enrichment method with dust filter membrane	Intelligent TSP sampler	Weight method
Temperature	Direct reading	Direct reading	No
Air pressure	Direct reading	Direct reading	No

2.1.3 Detecting equipment and principle

The detection method used in this experiment is inductively coupled plasma emission spectrometry, and the detection instrument is inductively coupled plasma emission spectrometer (ICP-OES), so the content of each heavy metal element can be determined.

2.2 Membrane electric heating plate digestion

Take a proper amount of filter membrane samples, cut them into small pieces with scissors, put them in a beaker, add 20.0 ml nitric acid-hydrochloric acid mixed digestion solution, immerse the filter membrane fragments in it, cover it with a watch glasses, heat and reflux at 100±5°C for 2 hours, and cool it; Rinse the inner wall of beaker with water, add about 10ml of water, and let stand for 0.5h for leaching; Filter the extract into a 100 ml volumetric flask, and adjust the volume to 100 ml scale with water, to be tested [5].

2.3 Wavelength selection

After igniting the plasma, analyze and compare the intensity, spectrum and interference of each spectral line, and select the best analytical spectral line of each metal element according to the standard HJ777-2015; Introducing the mixed metal standard solution into an emission spectrometer in turn for measurement and establishing a calibration curve; Before analyzing the sample, flush the system with the system washing solution until the blank intensity value is reduced to the minimum, and start analyzing the sample after the analysis signal is stable [5].

2.4 Measurement and analysis

2.4.1 The result indicates

Test results of ICP-OES are shown in tables 4 and 5 .

Table 4. ICP-OES test results of total dust.

Sample number	Cu (μg/m^3)	Pb (μg/m^3)	Cd (μg/m^3)	Zn (μg/m^3)	Cr (μg/m^3)	Hg (μg/m^3)	Ba (μg/m^3)
z-01	5.00	1.39	0.10	224.41	0.41	3.53	200.89
z-02	7.63	22.13	0.46	318.45	0.15	1.17	204.96
z-03	6.09	7.94	0.15	181.31	0.39	0.92	143.41
z-04	8.18	0.20	0.09	266.70	1.47	1.44	220.74
z-05	3.60	0.27	0.13	372.85	1.08	1.46	86.21
z-06	3.89	1.37	0.06	216.64	0.95	1.24	173.84
z-07	11.96	11.49	0.05	187.81	1.38	0.68	303.34
z-08	1.62	1.79	0.06	661.94	0.13	4.53	137.42
z-09	17.29	0.81	0.10	204.78	0.13	0.50	75.27
z-10	7.03	4.09	0.07	221.55	0.50	2.27	106.30
Average	7.23	5.15	0.13	285.64	0.66	1.77	165.24
Average proportion	1.55%	1.11%	0.03%	61.32%	0.14%	0.38%	35.47%

Table 5. ICP-oes test results of PM10.

Sample number	Cu (μg/m^3)	Pb (μg/m^3)	Cd (μg/m^3)	Zn (μg/m^3)	Cr (μg/m^3)	Hg (μg/m^3)	Ba (μg/m^3)
h-01	0.35	0.37	0.08	3.28	0.09	0.07	17.65
h-02	0.75	0.05	0.32	64.53	0.02	0.04	28.03
h-03	0.24	0.35	0.08	86.02	0.06	0.03	0.40
h-04	0.43	0.01	0.04	12.12	0.02	0.04	24.21
h-05	0.83	0.05	0.09	10.25	0.38	0.08	9.03
h-06	0.38	0.49	0.05	33.19	0.01	0.00	8.63
h-07	0.93	2.14	0.04	24.83	0.03	0.04	26.64
h-08	0.04	0.13	0.05	4.08	0.03	0.15	3.45
h-09	1.34	0.52	0.06	27.07	0.03	0.03	1.10
h-10	0.04	0.20	0.06	29.60	0.05	0.04	27.56
Average	0.53	0.43	0.09	29.50	0.07	0.05	14.67
Average proportion	1.17%	0.95%	0.20%	65.06%	0.15%	0.11%	32.36%

According to the data in Table 5 and Table 6, by comparing and analyzing the average concentration of total dust and Huchen, it is concluded that the main components of heavy metals in total dust in Xiqing District of Tianjin are Zn and Ba,among which Zn is the main one, and its concentration accounts for 61.32% of the total heavy metal concentration, reaching 285.64μg/m^3 . The main components of heavy metals in huchen are consistent with the total dust, followed by Zn and Ba, in which Zn concentration accounts for 65.06% of the total heavy metal concentration, reaching 29.50μg/m^3 .

2.4.2 Analysis of results

(1) Analysis of the influence of heavy metal elements on air quality

According to "Ambient Air Quality Standard" (GB3095-2012)[6], the following results can be obtained by analyzing the data in Tables 5 and 6:

①The concentration of Cd seriously exceeded the standard, reaching 0.13μg/m^3 in total dust and 0.09μg/m^3 in respirable dust, far exceeding the limit value of 0.005μg/m^3 .

②Hg concentration exceeds the standard, reaching 1.77μg/m^3 in total dust and 0.05μg/m^3 in respirable dust, with a limit of 0.05μg/m^3.

③Pb concentration exceeds the standard, reaching 5.15μg/m^3 in total dust and 0.43μg/m^3 in respirable dust, with a limit of 0.5μg/m^3.

④Cr concentration slightly exceeded the standard, reaching 0.66μg/m^3 in total dust and 0.07μg/m^3 in respirable dust, with a limit of 0.05μg/m^3.

⑤Cu concentration exceeded the standard, reaching 7.23μg/m^3 in total dust and 0.53μg/m^3 in respirable dust, with a limit of 0.253μg/m^3.

⑥ The Zn concentration seriously exceeded the standard, reaching 285.64μg/m^3 in total dust and 29.5μg/m^3 in respirable dust, with a limit of 0.232μg/m^3.

⑦Ba concentration seriously exceeded the standard, reaching 165.24μg/m^3 in total dust and 14.67μg/m^3 in respirable dust, with a limit of 2.13μg/m^3.

According to the above data, the air quality in Xiqing District of Tianjin is poor.

(2) Analysis of the influence of heavy metal elements on human health

According to the data in Tables 4 and 5, the concentration distribution of heavy metals can be obtained, and the results are shown in Table 6 .

Table 6. Heavy metal concentration distribution.

Sample Numbering	Cu	Pb	Cd	Zn	Cr	Hg	Ba
01	7.07%	26.61%	87.14%	1.46%	22.18%	2.00%	8.78%
02	9.79%	0.21%	70.29%	20.26%	15.09%	3.33%	13.68%
03	3.92%	4.41%	57.18%	47.44%	15.09%	2.86%	0.28%
04	5.29%	5.65%	43.62%	4.54%	1.61%	2.58%	10.97%
05	23.0%	18.59%	70.29%	2.75%	35.63%	5.60%	10.47%
06	9.68%	35.76%	77.47%	15.32%	1.00%	0.33%	4.97%
07	7.73%	18.59%	77.91%	13.22%	2.29%	5.74%	8.78%
08	2.62%	7.02%	75.14%	0.62%	22.39%	3.33%	2.51%
09	7.73%	64.21%	56.87%	13.22%	24.76%	5.88%	1.47%
10	0.50%	4.87%	86.99%	13.36%	10.83%	1.63%	25.93%
Average	7.73%	18.59%	70.29%	13.22%	15.09%	3.33%	8.78%

From the data analysis in Table 6, the following results can be obtained:

①The particle size distribution of Cd in dust in Xiqing District of Tianjin is mainly below 7.07μm, and the concentration ratio of respirable dust to total dust is 70.29%. Data show that the respiratory tract is the main channel for Cd exceeding the standard in Tianjin. Cd is not easily absorbed by intestinal tract, but absorbed by body through breathing, so the particle size distribution of Cd in the atmosphere is harmful to human body.

②The particle size distribution of Hg is mainly over 7.07μm, and the concentration ratio of respirable dust to total dust is only 3.33%. The data show that the main channel of Hg contact with human body in Tianjin atmosphere is skin contact. Mercury is easily absorbed by skin, respiratory tract and digestive tract, so the particle size distribution of Hg in the atmosphere is harmful to human body.

3 Conclusion

After sampling PM10 and total dust in the campus atmosphere for 10 consecutive days in autumn, the following conclusions are drawn:

①The concentrations of seven heavy metal elements Cu, Pb, Cd, Zn, Cr, Hg and Ba in the atmosphere of Xiqing District of Tianjin were measured by experiments, among which Zn was the highest, followed by Ba, so the heavy metal pollutants in the atmosphere were mainly Zn and Ba.

②The concentrations of Cd, Hg and Pb seriously exceed the standard, while the concentrations of Cu, Pb, Cr and Hg exceed the standard, so the air quality in Xiqing District of Tianjin is poor, and the particle size distribution of Cd and Hg makes it easy to enter the human body, which is especially unfavorable to human health.

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References

1. X.Y Li, H.Z Lian, Y.J Chen, et al. Spectroscopy and Spectral Analysis, ,9 2181-2186 (2008): .
2. J.R Tang, J.P Lu, Z.F Tong, Environmental Science and Technology, 5 126-128 (2010) .
3. X Liu, Environmental Chemistry, 6 741-743 (2005) .
4. Z.L Chen. Spectroscopy and Spectral Analysis, 5 601-

https://doi.org/10.1051/e3sconf/202124801042

605 (1998) .

5. Determination of metal elements in air and exhaust gas particulate matter.HJ777-2015 (2015).
6. Ambient air quality standard .GB3095-2012 (2012).