Road Dust Emission Spatial Characteristics of Shijiazhuang in 2014 Spring

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Abstract. City road dust was one of the main sources of PM_{10}. In this paper, roads were classified into four types: expressway, trunk road, secondary trunk road and branch road. Dust samples were collected from 17 representative roads of Shijiazhuang city, and were analyzed by laser particle size analyzer. And high-resolution vector quantization images of roads were extracted by Google Earth with Photoshop, GlobalMapper and ArcGIS. On the basis, road silt loading of Shijiazhuang in 2014 spring were obtained. The results showed that D50 (Median diameter) of the road dust ranged from 27.7-63.6 μm. Average silt loading of different road types were 6.2-13.4 $g \cdot m^{-2}$, and the sequence was branch road > secondary trunk road > expressway > trunk road.

Introduction

In recent years, with the rapid development of economy, regional environmental air pollution has been more and more serious in China. The haze weather has mainly been caused by particulate matter, especially PM_{10} and $PM_{2.5}$ [1]. The particulate matter is not only harmful to environment and climate, but also to human health [2]. The haze weather frequently occurs in Shijiazhuang. The air source apportionment results here show that road dust has contributed 37.5% to PM_{10} in 2013 [3].

The road information extraction is the foundation. With the development of computer technology, PhotoShop, ArcGIS, MapInfo, GlobalMapper, can be used for information extraction [4]. The combination methods of computer software for road information extraction have the advantages of few steps, a high accuracy and wide application.

In this paper, Shijiazhuang was the research area, road information was extracted by Google Earth, PhotoShop, GlobalMapper and ArcGIS. Road silt loading in 2014 spring was established. The results can provide a certain basic reference for preventing and controlling road dust pollution of Shijiazhuang.

Experimental methodology

The dust samples of road were collected from 1st Feb to 1st Apr, 2014. 17 representative roads were chosen as research objects. 54 sampling points were set up on them. The 17 roads were: South Second Ring Road, Huai'an Road, Heping Road, Zhongshan Road, Yuhua Road, Jianhua Street, Zhonghua Street, Tiyu Street, Jianshe Street,Tanan Road, Shiluan Road, Huitong Road, Youyi Street, Donggang Road, Huaizhong Road, Fanxi Road and Sizhong Road.

According to the above method, 54 road dust samples were collected. Then they were taken back to lab and the large impurities in them were picked out. After the natural air-dry, 54 samples were respectively weighted and put in the sealed bags. Next the samples were pretreated as follows: Firstly one sample was screened by the 20 meshes standard sieve, next the undersize fraction was screened by the 200 meshes standard sieve. And the oversize fraction of 20 meshes sieve and the oversize fraction of 200 meshes sieve were respectively weighted by the analytical balance. Then the undersize fraction of 200 meshes sieve was stored in a sealing bag and labeled. 54 samples were sieved in turn. The dust samples from the same road were mixed as one mixed sample. The data of

the sample weight was used to calculate road silt loading. The mixed samples were used for determination of the granularity.

The granularity of samples were measured by the BT-9300S laser particle size analyzer. The determination process was as follows, firstly, the laser particle size analyzer and the external circulation system were turned on and the deionized water was put into the external circulation system. After one minute, the background value of the analyzer was measured. Secondly, a mixed sample was put into the external circulation system and mixed with the deionized water to form a stable system. Then ultrasonic vibration was opened for two minutes. Until the continuous testing results were shown in the analyzer, the stable data result was chosen as the granularity of the sample.

Based on the combination of Google Earth Pro V7.1.1 polygon tool and computer drawing softwares, high-resolution images of the roads were extracted. Next PhotoShop was used to make the road tracked and mapped. Then the format of the image was transformed in GlobalMapper. At the last, the road area was quantized in ArcGIS.

Results

In table 1, the roads were classified into four types of expressway, trunk road, secondary trunk road and branch road by road wide. In table 2, the D50 (Median diameter) of the road dust ranged from 27.7μm to 63.6μm. The percentage of TSP in the road dust accounted for more than 85%. The percentage of PM_{10} in the road dust ranged from 2.1% to 25.6%. And the percentage of PM_{10} of the trunk road dust was the most, which of the average value is 12.3%.

Table1 Road wide of the different road types

Road types	expressway	trunk road	secondary trunk road	branch road
Road wide (m)	>40	30～40	20～24	14～18

Table 2 Determination results of the road dust granularity

Road types	Road No.	TSP (%)	PM_{10} (%)	D_{50}(μm)
expressway	1	89.2	7.4	60.6
	2	100.0	20.2	31.1
trunk road	3	85.5	2.1	64.1
	4	100.0	25.6	27.7
	5	95.5	7.6	48.7
	6	97.1	9.8	45.9
	7	99.7	22.9	34.9
	8	85.8	4.9	63.6
	9	99.7	19.8	34.7
secondary trunk road	10	86.1	7.0	63.0
	11	94.2	8.2	50.9
	12	96.3	8.4	46.5
	13	94.4	7.7	51.4
branch road	14	90.4	2.2	56.7
	15	94.8	3.7	53.1
	16	93.8	7.0	52.0
	17	95.0	6.9	49.0

Table 2 Road information and road silt loading

Road Types	Road No.	Road length （km）	Traffic flow （h⁻¹）	sL (g·m⁻²)	Average sL (g·m⁻²)
expressway	1	10.5	4560	6.2	6.9
	2	11.5	5354	7.5	
trunk road	3	11.3	1370	3.8	6.2
	4	11.7	1180	5.4	
	5	11.6	3657	15.2	
	6	10.4	2759	10.0	
	7	10.6	1867	3.5	
	8	10.4	3499	2.1	
	9	10.3	3047	3.8	
secondary trunk road	10	7.6	821	15.6	11.8
	11	1.9	1248	9.4	
	12	2.9	1820	17.6	
	13	9.2	1838	4.6	
branch road	14	5.7	890	14.6	13.4
	15	7.7	805	12.9	
	16	1.1	1176	1.8	
	17	0.8	980	24.2	

In Table 2, the silt loading of the different roads in Shijiazhuang were 1.8-24.2 $g·m^{-2}$, the maximum value appeared on Sizhong Road, while the minimum appeared on Fanxi Road. The average silt loading of the different road types in Shijiazhuang was 6.2-13.4 $g·m^{-2}$, it was much higher than that of Beijing city (0.17-2.6 $g·m^{-2}$) [5]. Obviously, the roads of Shijiazhuang were dirtier. The reasons were that there were more high pollution industries in Shijiazhuang, for example, cement, steel and plate glass, moreover, there were more construction sites without suppressing dust measures. The average silt loading of the different road types was branch road > secondary trunk road > expressway > trunk road. Because branch road had the characteristics of less cleaning and less traffic flow, while trunk road or expressway was with more traffic flow and more cleaning times. The road silt can easily be brought up with the vehicle to form fugitive dust into the air. So the effect of traffic flow on the road silt loading was the most important.

Conclusion

In this study, the road silt loading of Shijiazhuang in 2014 spring was obtained, and the road information was extracted by the combination methods of Google Earth, PhotoShop, GlobalMapper and ArcGIS. On the basis, the road dust emission spatial characteristics were established.

(1) The D50 (Median diameter) of the road dust ranged from 27.7 μm to 63.6 μm. The percentage of TSP in the road dust accounted for more than 90%. The percentage of PM_{10} ranged from 2.1% to 25.6%. The percentage of $PM_{2.5}$ was very low.

(2) The silt loading of the different roads in Shijiazhuang was 1.8-24.2 $g·m^{-2}$. The average silt loading of the different road types in Shijiazhuang was 6.2-13.4 $g·m^{-2}$. The average silt loading was in sequence of branch road > secondary trunk road > expressway > trunk road.

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