2A3) Characteristics of Heavy Metals in Road Dust in Ulsan City, Korea

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1. Introduction

Road dust is a significant pollution source in the urban environments. Concentrations of heavy metals in road dust are elevated. Contamination by heavy metals associated with road dust is the major concern because of their toxicity and adverse effects to human health. The main sources of heavy metal contamination related to road dust in urban areas are vehicle exhaust, industrial emissions as well as human activities.

The urbanization and industrialization of the Metropolitan City of Ulsan, Korea have significantly raised environmental concerns. The levels of heavy metal contaminations from road dust in Ulsan have not been investigated yet. Much attention is given to studies on the characteristics of heavy metals in road dust in Ulsan.

2. Methods

Road dust samples were conducted at five places in the Ulsan city areas as follows: a residential area, a downtown area, a road side at rotary with heavy traffic and highway starting point, and two industrial areas located at petrochemical and non-ferrous metal industrial complex (IC). Road dust sampling was carried out in March, 2006. Road dust was obtained inside the VPF-300 filter attached in the vacuum cleaner operated by an electrical generator. Road dusts were taken along the left and right side of the road.

In the laboratory, the collected road dusts which have a diameter of above 2000㎛ were removed by sieving and then the remained road dusts were separated into four size-fractions by using the stainless steel sieves as follows: 2000㎛, 850㎛, 180㎛ and 75㎛. The heavy metals in road dust were extracted by aqua regia extraction method. The concentrations of heavy metals including Cd, Cu, Pb, Zn, and Ni were analyzed by atomic absorption spectrometry (Varian-AA240).

3. Results and discussion

The concentrations of Cd, Cu, Pb, Zn and Ni extracted from the road dusts with different particle sizes and their standard deviations were shown in Table 1. The average values of five heavy metals (Cd, Cu, Pb, Zn, and Ni) in the road dust samples with different emission characteristics were shown in Fig. 1.

The results show that the analyzed road dusts have elevated concentrations of Cd, Cu, Pb, Zn, and Ni. The pseudo-total concentrations of Zn, Cu and Pb extracted in these road dusts much exceeded the warning level of soil contamination and the required counter measures in Korea. In particular, at the petrochemical IC, the concentrations of Cd, Cu, Pb and Zn in the road dusts with all classified particle sizes exceeded significantly the warning level of soil contamination and the required counter measures in Korea. In the non-ferrous metal IC, the concentrations of Cu, Pb and Zn in the road dusts which have less than 850㎛ in diameter exceeded significantly the Korean standard of warning level of soil contamination. In particular, the Cu level exceeded the Korean standard required counter measures. In the road side and downtown areas, the concentrations of Cu and Zn in the road dusts which have less than 180㎛ in diameter much exceeded the warning level of soil contamination in Korea. The Cu level in the road dusts which have less than 75㎛ in

diameter at the residential area exceeded the Korean standard of warning level of soil contamination.

In a comparison of the pseudo-total concentrations the heavy metals in the road dusts showed that the concentrations of the heavy metal at the industrial areas were the most elevated. The total concentrations of Cd, Pb and Ni in the road dust at the petrochemical IC were much higher than those at the non-ferrous metal IC. These results indicate that industrial activities at the petrochemical IC could significantly contribute to the highly levels of heavy metals in the environment. The concentrations of heavy metals in the road dusts at the road side and the downtown area were quite similar, except Zn. The concentration of Zn in the road dust at the heavy traffic rotary was much higher than those at the downtown area due to the traffic density of the road side. The concentrations of Cu, Pb, Zn and Ni in the road dust at the residential area were less than those of the remained areas. However, the Cu level also exceeded the Korean standard of warning level of soil contamination.

Considering the concentrations of Cd, Cu, Pb, Zn, and Ni in four different size-fractions showed that the concentrations of heavy metals increased with decreasing particle size. The industrial activities, the automobile exhaust emission, abrasions of vehicle tires and breaks wear contributed significantly to the heavy metals accumulation in the road dust, in particular, with smaller size collected from the study areas.

Table 1. The concentrations of heavy metals (μg g^{-1}) in the road dusts.

Sampling Site	Particle Size	Cd	Cu	Pb	Zn	Ni
Heavy traffic rotary	850-2000㎛	0.24 ± 0.02	95.80 ± 2.03	31.22 ± 8.04	168.08 ± 6.19	10.90 ± 0.23
	180-850㎛	0.44 ± 0.12	101.50 ± 4.48	50.07 ± 0.95	595.70 ± 2.62	18.64 ± 0.15
	75-180㎛	1.97 ± 0.05	407.72 ± 6.24	199.88 ± 8.80	926.70 ± 13.36	21.53 ± 0.07
	<75㎛	3.11 ± 0.03	520.36 ± 1.50	426.83± 20.90	1,467.90 ± 12.59	31.10 ± 0.17
	Total conc.	5.76	1,125.34	707.99	3,158.38	82.16
Residential area	850-2000㎛	0.19 ± 0.01	20.70 ± 2.05	93.68 ± 4.42	109.33 ± 0.88	5.84 ± 0.09
	180-850㎛	0.55 ± 0.02	120.83 ± 1.03	108.58 ± 4.07	451.80 ± 2.26	12.33 ± 0.16
	75-180㎛	1.76 ± 0.01	150.55 ± 0.42	137.20 ± 1.41	391.80 ± 4.53	18.63 ± 0.10
	<75㎛	1.81 ± 0.02	225.05 ± 2.55	229.68 ± 1.73	744.70 ± 0.07	21.51± 0.22
	Total conc.	4.31	517.13	569.13	1697.63	58.31
Petro-chemical IC	850-2000㎛	6.88 ± 0.06	1,068.50 ± 1.70	1,581.85 ± 3.82	1,713.70 ± 38.96	42.95 ± 0.63
	180-850㎛	18.40 ± 0.80	2,306.63 ± 31.57	4,367.48 ± 29.73	4,987.13 ± 59.26	69.25 ± 0.68
	75-180㎛	89.90 ± 0.24	4,397.90 ± 23.97	7,563.65 ± 52.68	10,037.90 ± 96.03	72.84 ± 2.05
	<75㎛	158.73 ± 3.02	10,649.20 ± 94.63	19,927.47 ± 113.86	36,048.80 ± 339.12	175.40 ± 3.61
	Total conc.	273.89	18,422.23	33,440.44	52,787.53	360.44
Non-ferrous metal IC	850-2000㎛	0.50 ± 0.05	63.83 ± 1.87	70.70 ± 1.18	558.55 ± 11.38	34.71 ± 0.18
	180-850㎛	0.62 ± 0.08	746.20 ± 4.81	271.75 ± 20.86	901.53 ± 4.07	37.85 ± 0.31
	75-180㎛	4.72 ± 0.07	859.98 ± 1.80	764.98 ± 27.75	1,383.85 ± 12.87	64.88 ± 1.22
	<75㎛	9.86 ± 0.02	1,057.25 ± 1.13	1,052.20 ± 14.14	2,494.07 ± 11.45	85.39 ± 0.05
	Total conc.	15.69	2,727.25	2,159.63	5,337.99	222.83
Downtown	850-2000㎛	0.46 ± 0.05	63.83 ± 1.87	78.28 ± 0.12	258.78 ± 1.87	13.20 ± 0.18
	180-850㎛	0.63 ± 0.02	250.10 ± 14.60	158.10 ± 12.87	437.73 ± 7.53	36.86 ± 0.32
	75-180㎛	1.16 ± 0.04	280.88 ± 2.30	192.95 ± 1.13	745.45 ± 8.84	42.50 ± 0.59
	<75㎛	2.15 ± 0.05	343.18 ± 2.37	333.50 ± 5.45	1,195.33 ± 14.53	52.15 ± 0.52
	Total conc.	4.41	937.98	762.83	2,637.28	144.72
Korean standard (1)		12	200	400	800	-
Korean standard (2)		30	500	1,500	2,000	-

(1) Warning level of soil contamination
(2) Required counter measures

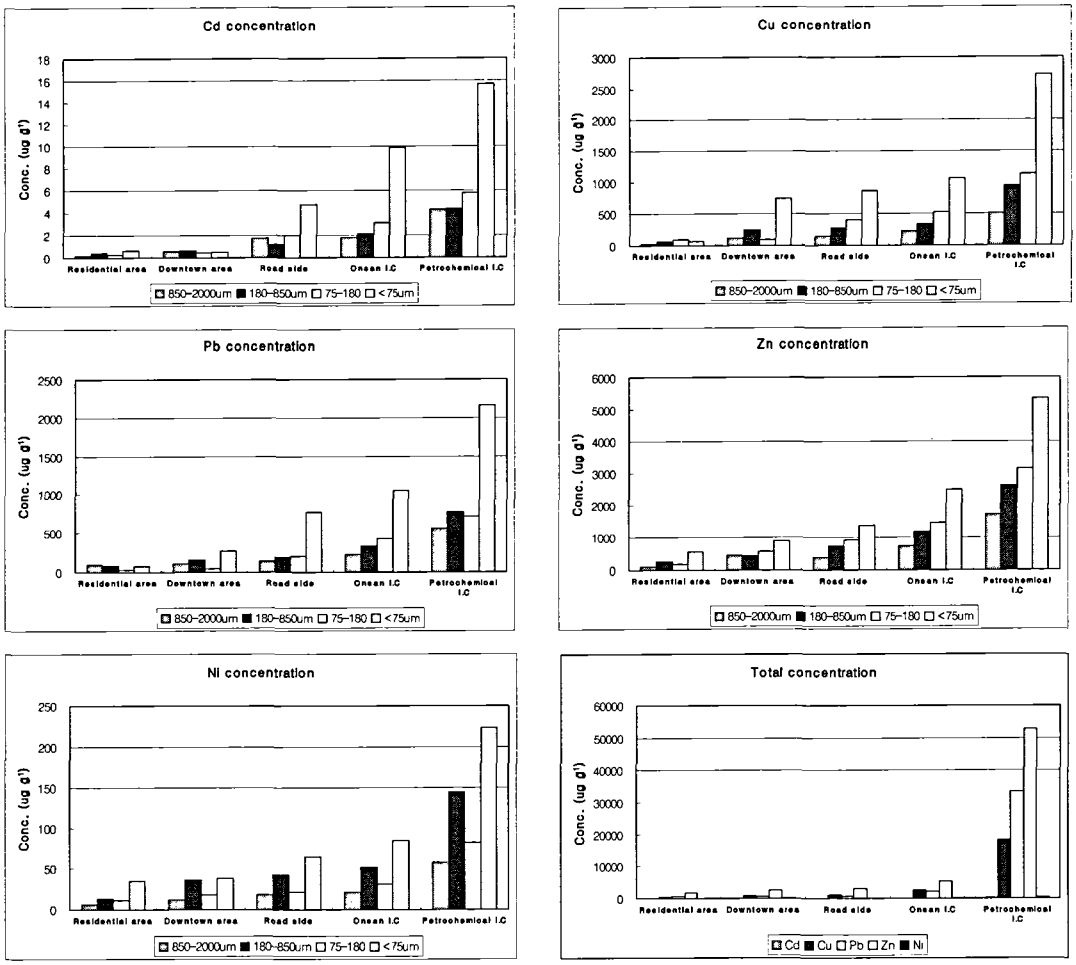

Fig. 1. A comparision of the heavy metals extracted from the road dusts in Ulsan.

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