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Heavy Metal Contamination of Roadside Gully-Pot Sediments, Seoul, Korea

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Introduction

In urban environments, the surface land impermeability fundamentally related to urban growth emphasizes the environmental problems such as the storm water peak flow (so-called the urban flooding) and the pollution. The conventional urban drainage system provides a number of temporary reservoirs intercepting and retaining surface-derived pollutants following their introduction to and deposition upon the impermeable surface. Gully-pots are common features in urban drainage systems in Korea, which were installed for draining rainwater to prevent regurgitation in rainy season and retaining larger particles, hence minimizing pipe blockage problems. When the road runoff conveying sediment enters a gully-pot, the sediment mixes with the gully liquor causing direct pollution of receiving waters. The characteristics of local sediment contamination are usually related to the types of land use activities that take place or have taken place within the area.

This study was undertaken to evaluate the spatial and temporal variations of the contamination of gully-pot sediments in Seoul with respect to heavy metals such as As, Cd, Co, Cr, Ni, Pb, Cu and Zn. The heavy metal data were examined according to the land use type. In this paper, sampling sites in Seoul were divided into six groups (commercial area, industrial area, residental area, motor way, rural area, and local pollution).

Methods

A total of 201 urban gully-pot sediments were collected from 13 localities in Seoul. Sampling from each locality was performed three times (December 1999, March and June 2000) in order to examine the seasonal variation of the status of heavy metal contamination. A series of laboratory studies have been carried out concerning the physicochemical characteristics of the sediment and the distribution of As, Cd, Co, Cr, Ni, Pb, Cu, Zn, Mn and Fe.

Spatial Distribution of Total Metal Concentrations

Ranges and mean values of total metal contents (μg/g) in 201 gully-pot sediments are as follows (Fig. 1): As, 0.70-29.43 (mean = 6.35); Cd, 1.05-18.23 (mean = 2.52); Co, 4.1-429.2 (mean = 14.1); Ni, 81.9-125.8 (mean = 81.9); Cu, 61-7750 (mean = 436); Pb, 56-2269 (mean = 268); Zn, 421-9761 (mean = 2482); Mn, 253-1403 (mean = 452); Fe, 16410-101978 (mean = 36370). The metal concentrations are generally higher than those of uncontaminated or less-contaminated stream sediments, due to the long-term accumulation of pollutants in gully-pot sediments.

The total concentrations of heavy metals are generally higher in the samples from the commercial (e.g., Jung-gu and Dongdaemun-gu area) and industrial (e.g., Guro-gu area) areas than those from other districts, except for Zn (Fig. 1). The Zn concentrations are extremely variable, depending on the land use activities: the Zn content is especially high in the Jung-gu and Yeouido areas. This is probably due to high traffic density. The concentrations of Cu, Cr, Ni and Co are highest in the Guro-gu area, as a result of concentrated industrial activities (mainly, electronic and alloy industries) in the area. These metals are also highly enriched in the sediments from the Jung-gu and Dongdaemun-gu areas where commercial activities are active. On the other hand, Mn and Fe concentrations show little or no difference over the all studied areas in Seoul.

In general, local polluted sites also show the high concentrations of metals (Fig. 1). Excluding this local pollution, the characteristics of sediments contamination seem to be clearly related to the types of land use activities. The As and Cd show the similar distribution pattern with respect to all land use types. The hot spots of Co, Cr, Ni and Cu are undoubtedly found in the industrial area where steel and electrical industries are developed. On the other hand, Zn shows different patterns for the land use types. The motor way and commercial areas show the very high mean concentrations of Zn (commercial area, 2550 μg/g; motor way, 3685 μg/g), indicating that local traffic plays an important role in building-up of Zn content in sediment. For Cu, the motor way and commercial areas are also enriched with Cu. The main source of Cu pollution is the abrasion of brakes and tire ware of vehicles. The Pb contents are relatively constant over the Seoul, except for rural area.

Speciation of Heavy Metals: Results of Sequential Extraction

Sequential extraction experiment was also performed to determine the geochemical speciation of heavy metals (Fig. 2).

The highest amount of Ni (ca. 20 wt. % of the total Ni in each sample) was found in the exchangeable fraction. The major part of Zn is bound to the carbonate and Fe-Mn oxide fraction, representing about 91% of the total Zn concentration. Cu was the

only metal significantly associated with the organic fraction. The main carrier of Pb are the fractions Fe-Mn oxide, carbonate, and residual fractions. The Fe-Mn oxide fraction was also the most important fraction for Cd (ca. 52%), followed by the carbonate fraction (average 38%).

However, the exchangeable fraction contains only minor amount of Cd (average 2%). Exchangeable fraction is also the major part of As. Most of the As and Cr is associated with residual fraction, containing the average 88% and 74%, respectively. The As was not detected in the carbonate, Fe-Mn oxide, and organic fractions.

The results of sequential extraction show that the sequence of mobility and potential bioavailability of the metals examined are Zn > Cd > Ni > Mn > Cu > Pb > As > Co > Fe > Cr.

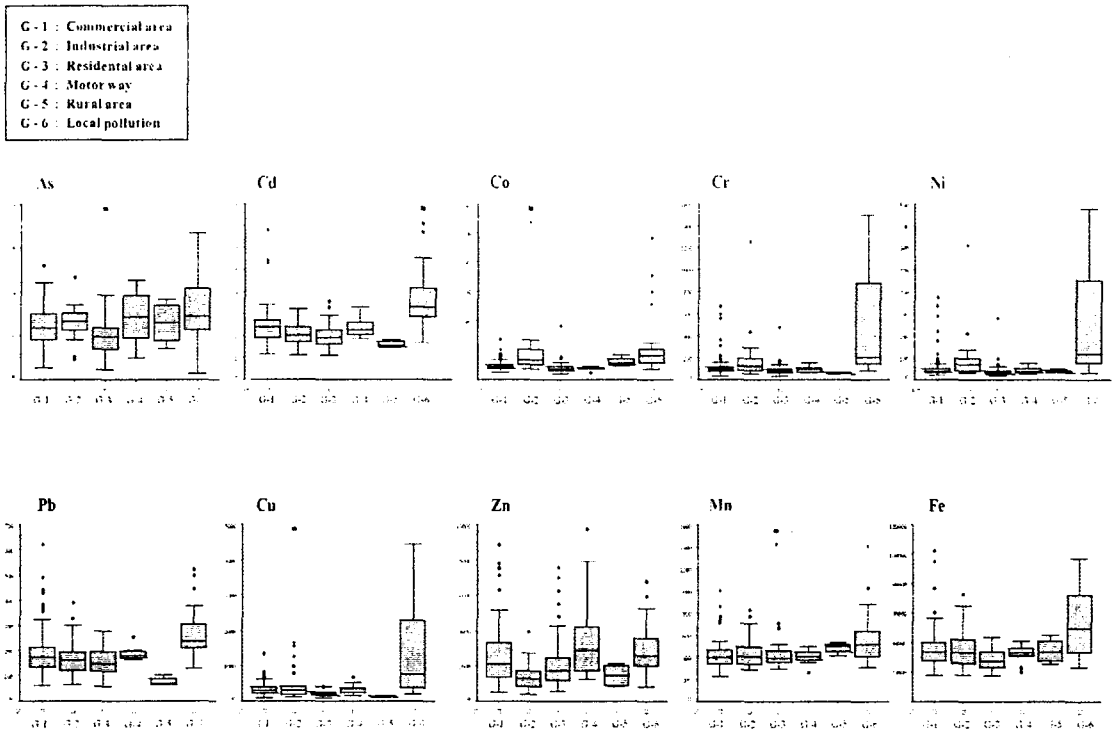

Fig. 1. Boxplots of the total concentration of heavy metals in gully-pot sediments, Seoul area, showing the spatial variation according to the land-use characteristics.

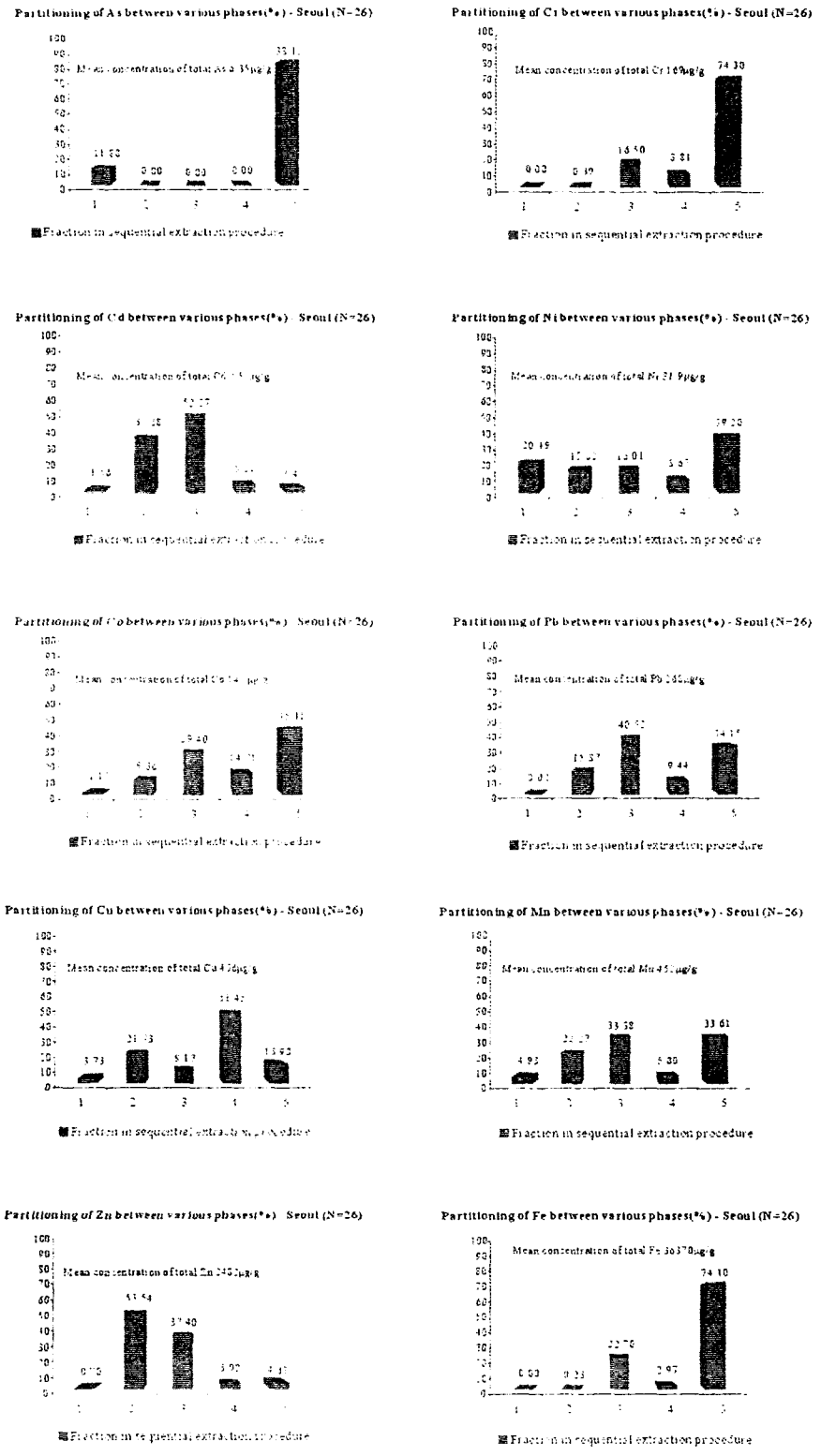

Fig. 2. Fractionation patterns of heavy metals in gully-pot sediments, based on sequential extraction experiments (number of samples = 26).