Heavy metal contents in roadside deposit and their comparison with soil matter collected at street water inlets　(道路わき粉塵の重金属含有量とその雨水枡堆積泥との比較)

Tomohiro Iwasa [a], *Ta Thi Thao* [a, b], *Taro Urase* [a]

a: Department of Civil Engineering, Tokyo Institute of Technology, b: Department of Analytical Chemistry , Hanoi University of Science,

東京工業大学大学院　学生会員　○岩佐　知洋
東京工業大学大学院　正会員　　浦瀬　太郎
ハノイ科学大学分析化学科　　Ta Thi Thao

1. Introduction

Heavy metals at trace levels present in natural water, air, dust, soil and sediment play an important role in human life. Roadside deposit or street dust consisting of vehicle exhaust, sinking particles in air, house dust, soil dust and aerosols makes a significant contribution to the pollution in urban environments. Three main factors known to influence the levels of heavy metals in dust samples are traffic, industry and weathered materials. The heavy metal analyses of types of locality helped to explain the distribution of trace metals within the area. The aim of this work is to estimate the heavy metal contents in roadside deposit in urbanized area and recognize the correlation of metal contents in roadside deposit with soil matter collected at street water inlets.

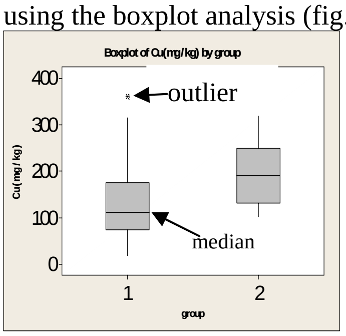
2. Methodology

This study examines the heavy metal contents in roadside deposit collected at 83 sampling sites in Meguro, Ota and Setagaya area in Tokyo. Sampling was taken over four consecutive days during February, 2005 after several days of dry weather. The roadside deposit samples were collected from the gutter or pavements, using polyethylene brush, tray and transferred to clean self-sealing plastic bags. The samples were dried in an oven at 110 ^{o} C for 24 hours and then were sieved in a 2-mm plastic sieve to remove gravel-sized materials, leaves and large stone. A small portion of the sample (0.5 g) was acid-digested at 120^{o}C for 2 hours using 2 ml of conc. nitric acid and 4 ml of conc. hydrochloric acid. The solution was filtered using GF/C mesh glass filter. Multi-element analysis (Ti, Cr, Mn, Fe, Ni, Cu, Zn, Pb) was performed by ICP-AES using an Shimadzu ICP-7000 model. The sample loss-on-ignition (L.I.) at 600 ^{0}C for two hours was used to estimate the organic matter contents in soil samples.

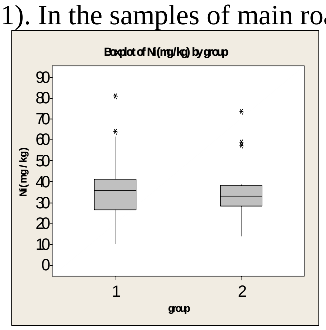
3. Results and discussion

3.1. The heavy metal contents in roadside deposit

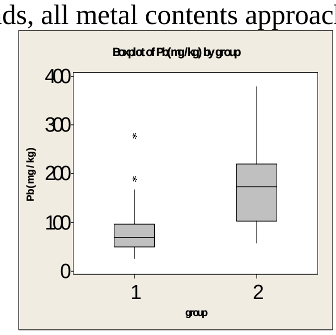
The results were sub-divided into two groups according to the types of sampling sites: main roads (19 samples) and minor streets in residential area (64 samples). The outliers in each data set of heavy metal contents were excluded using the boxplot analysis (fig. 1). In the samples of main roads, all metal contents approached normal distribution with



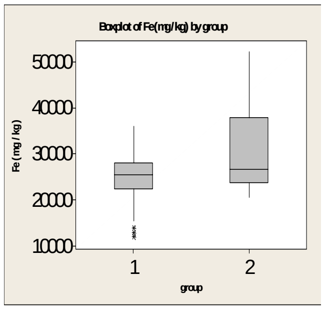
Cu : $Mean_1$ =131; SD_1= 78
$Mean_2$=207, SD_2 = 88



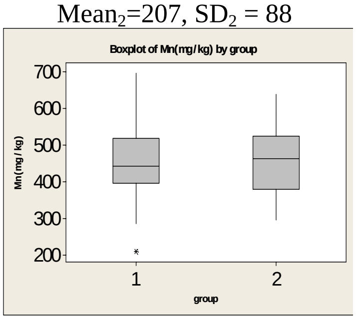
Ni: $Mean_1$ =35.2; SD_1= 13.1
$Mean_2$=36.1; SD_2= 14.2



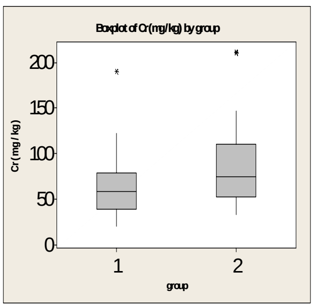
Pb: $Mean_1$ =78.9; SD_1= 44.5
$Mean_2$=172; SD_2=91.1



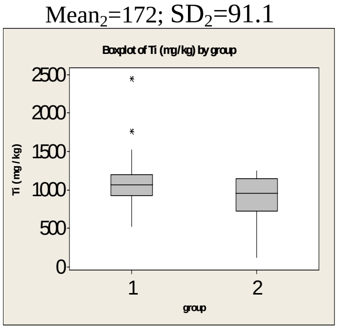
Fe: $Mean_1$ =24998; SD_1= 4747
$Mean_2$=31055; SD_2= 9443



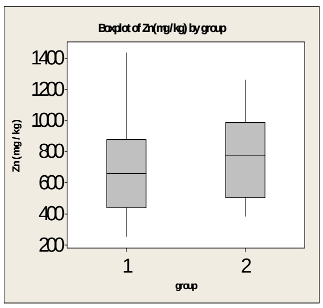
Mn: $Mean_1$ =463; SD_1= 95
$Mean_2$=461: SD_2=97



Cr: $Mean_1$ =62.7; SD_1=30.4
$Mean_2$=92.8; SD_2=50.2



Ti: $Mean_1$ =1064; SD_1= 299
$Mean_2$=943;　SD_2= 212



Zn: $Mean_1$ =685;　SD_1=285
$Mean_2$=769; SD_2= 265

Fig. 1: The boxplot of Cu, Ni, Pb, Fe, Mn, Cr, Ti, Zn contents (mg/kg dry wt.) in roadside deposit.
(group 1: minor streets in residential area; group 2: main roads; SD: standard deviation)

キーワード　道路わき粉塵，重金属，雨水枡，雨天時流出
連絡先　東京工業大学大学院理工学研究科土木工学専攻，03-5734-3548, turase@fluid.cv.titech.ac.jp

small skewness. For the samples taken from minor streets in residential area, five of eight metal contents followed normal distribution except Ti, Cr, Pb contents. The Kolmogorov – Smirnove (KS) statistics with 95% confidence was used to test the goodness-of-fit of the Ti, Cr, Pb contents to log-normal distribution and good results were obtained.

To test the significant differences of metal contents between main or minor streets, the databases were subjected to the two-sample Student-test. The p-values of t-test which were smaller than commonly chosen α-levels (0.05) showed that Cr, Fe, Cu, Pb contents were significantly higher in the main roads than in the minor streets. This also evidenced that the high density traffic may effect to these metal contents. For the other metals Ti, Mn, Ni and Zn, the p-values suggested insufficient evidence of the significant difference of metal contents between the main roads and the minor streets.

Figure 2 shows the result of cluster analysis. Fe, Mn and Ti, which are the main components of soil, formed one cluster, while Pb and Zn formed another cluster, which may indicate the anthropogenic contribution. Cr, Ni, and Cu formed another cluster whose origins are not sure.

The analysis of heavy metal contents in roadside deposit, sidewalk, intersection, roundabout, pavement dust, soil samples was also carried out. The results in table 1 showed that the Fe, Ti and Mn contents in soil samples were much higher than in roadside deposit. It is possible to conclude that the Fe, Ti, Mn contents mainly come from soil. High values of Ni, Cu, Zn contents were also obtained at intersection, roundabout of main roads or the junctions controlled by traffic lights. The metal contents in soil samples collected at two layers suggested that the Zn and Pb contents at the top layer (0-20 cm) were much greater than in the deep layer (20-40 cm). It is possible to reveal the absorption of Zn and Pb in surface of roadside soil.

Table 1: Comparison of metal contents (mg/kg) in roadside deposit and soil collected at the same location.

Sample	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Pb
Roadside deposit	1022	88.7	420.1	22960	28.5	128.2	512.2	160.6
Soil (0-20 cm)	2150	71.2	819.6	42108	37.4	184.3	800.6	126.3
Soil (20-40 cm)	3853	59.6	1328	52448	43.9	129.6	230.4	64.7

3.2. Comparison heavy metal contents in roadside deposit and soil matter in street water inlets

The average metal contents in two types of locality in roadside deposit indicated that most of them were nearly similar to metal contents in soil matter. However, the Zn content was much lower in roadside deposit compared to soil matter. Tire dust which is a significant source of Zn, may have some reasons for the concentration difference.

The heavy metal contents in roadside deposit samples were compared with those in soil matter collected at streets water inlets (carried out by Iwasa et al. at the same locations). The Pearson's correlation coefficients for Cr, Fe, Cu, Pb are 0.532, 0.323, 0.307 and 0.310 respectively. The p-valuesof correlation coefficients of these metal contents in roadside deposit and soil matter were below 0.05, (at 0.05 confidence levels). Those are four elements having the significant difference contents within main roads and minor streets. Some distributions of metal contents in roadside deposit and in soil matter collected at street water inlets were performed in fig. 3.

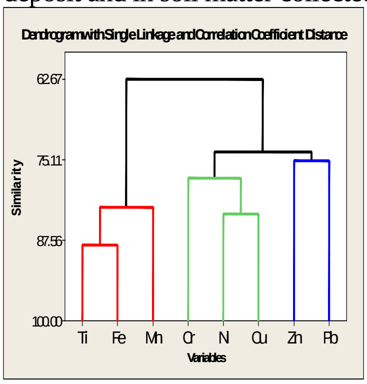
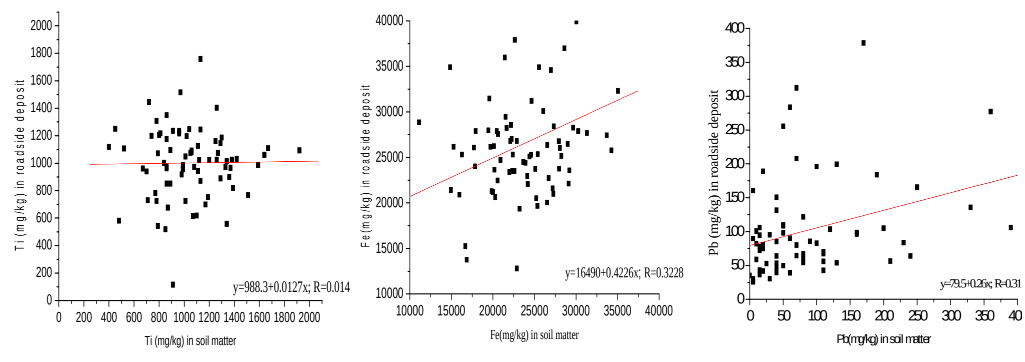


Fig.2: *Cluster analysis of 8 elements*



a- no correlation for Ti content b, c- correlation for the cases of Fe and Pb contents

Fig.3: Correlation between the metal contents in roadside deposit and soil matter collected at street water inlets

4. Conclusions

Heavy metal contents (Ti, Cr, Mn, Ni, Fe, Cu, Zn, Pb) in roadside deposit of Meguro, Ota, Setagaya in Tokyo were studied. The results showed that Cr, Fe, Cu, Pb contents in main roads were significantly higher than in minor streets in residential area. There were also slight relations of Cr, Fe, Cu, Pb contents in roadside deposit and soil matter collected at street water inlets at 0.05 confidence levels. The result of cluster analysis showed that Fe, Mn and Ti, which are the main components of soil, formed one cluster, while Pb and Zn formed another cluster, which may indicate the anthropogenic contribution. Cr, Ni, and Cu formed another cluster. The roadside deposit and top soil samples contain more Pb and Zn than deeper layer soil samples, while deeper layer soil samples contain more Fe, Mn and Ti than roadside deposit and top soil samples taken at the same locations.

参考文献：岩佐知洋，浦瀬太郎(2004):土木学会年次学術講演会，59，VII-008.