

## HEAVY METALS IN SITE-SPECIFIC URBAN RUNOFF IN BEIJING, CHINA: OCCURENCE AND PARTITIONING

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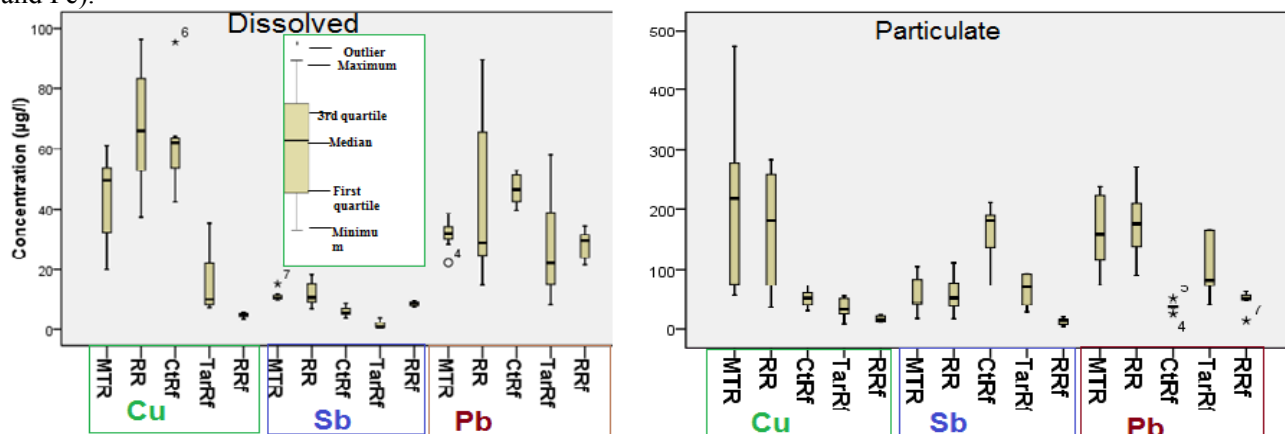
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**Introduction:** The Chinese capital, Beijing, experiences serious airborne pollution and the most important sources are vehicular emissions and coal burning for energy production (Gunawardena, Egodawatta, Ayoko, & Goonetilleke, 2013; Pan & Wang, 2015). In urban regions, atmospheric wet depositions (rainfall) and dry depositions are the major pathways for removing the pollutants from the atmosphere to the urban surface (Pan & Wang, 2015) and in consequence the urban stormwater becomes polluted. Urban stormwater is a major non-point source of pollution comprising significant levels of heavy metals and organic contaminants. This study aimed to investigate the level of heavy metals in site-specific urban runoff and their partitioning between solution and particulate phases in Beijing runoff.

**Methods:** Samples were collected from a moderate traffic road (MTR), residential road (RR), tar paper coated roof (TarRf), concrete roof (CtRf) and residential roof (RRf) of the area around the Chinese Academy of Sciences at the Olympic Science Park in the Chaoyang district, Beijing. A total of 15 rain events were collected during March to November in 2015. Samples were separated as dissolved and particulate metals by following the methods of APHA (1992). pH, electrical conductivity (EC) and total suspended solids (TSS) were measured by standard methods. Samples were analyzed for heavy metal by ICP-MS. IBM SPSS statistics 23 software was used for data treatment.

**Results:** Eighteen metals were analyzed and among them 7 (Cu, Sb, Pb, Zn, Al, Fe and Mn) with the highest concentration levels were selected in this study. The variations of particulate and dissolved concentrations of metals in different urban locations are presented in **Figure 1** (Cu, Sb and Pb) and in **Table 1** (Zn, Mn, Al and Fe).



**Figure 1:** Concentration of particulate and dissolved fractions of Cu, Sb and Pb in different urban locations in Beijing, China (Minimum, first quartile, median, 3rd quartile and outlier of data set in a box-plot is presented in green rectangle)

The results revealed that most of the metals are predominantly particulate bound. Though, the Beijing municipality has been washing the MTR 4-6 times daily, the concentrations of metals are comparatively higher than for other surfaces including RR. Higher amount of median dissolved Pb (15-20 times), median total Cu (5-6 times), median dissolved Mn (5-6) times are found in MTR and RR than other study (Huber, Welker, & Helmreich, 2016) and 5-6 times higher dissolved Fe, 2 times dissolved Pb and 3 times dissolved Mn are found in roof surfaces than a study in Beijing (Li, Shen, Tian, Liu, & Qiu, 2012). The total and the dissolved concentrations of Sb is found to be 15-20 times and 5–10 times higher, respectively, than in other

studies (Huber et al., 2016). Among the samples from roof surfaces, cemented roof contain higher amount of particulate Sb (172 µg/l) than other roof samples. A possible reason is that the cemented roof is situated nearby MTR (traffic road) and height of the roof is also lower than other roofs.

**Table 1** Median concentrations (dissolved and particulate) of metals in different urban locations

Sites	Zn (µg/l)			Mn (µg/l)			Al (µg/l)			Fe (µg/l)		
	D <sub>-</sub>	P <sub>-</sub>	N	D <sub>-</sub>	P <sub>-</sub>	N	D <sub>-</sub>	P <sub>-</sub>	N	D <sub>-</sub>	P <sub>-</sub>	N
MTR	55.5	300	40	62.8	132	40	116	3010	40	140	4221	40
RR	43.7	292	36	94.8	134	36	90.0	4780	36	1277	5847	36
CtRf	296	36.9	7	100	8.19	7	524	903	7	382	296	7
TarRf	405	231	15	94.4	39.7	15	361	1649	15	284	1941	15
RRf	13.6	103	7	9.65	69.7	7	32.2	1782	7	20	3028	7

D<sub>-</sub> dissolved; P<sub>-</sub> particulate; N-number of samples

Median dissolved and particulate concentrations of Cu, Sb, Pb, Zn, Mn, Fe and Al are found in the samples from most of the sites and they are higher than in other studies (Huber et al., 2016). Persons correlation analysis reveals significant correlations ( $p < 0.01$  level) with correlation coefficients in the range 0.68-0.96. Al highly correlates with Fe. Mn correlates with Fe, Al, Zn, Cu, Ni and Pb. Pb correlates with Zn, Cu and Ni. The regression coefficient for Fe and Al is 0.93 and for Mn and Pb is 0.78.

**Conclusion:** Elevated particulate and dissolved concentrations of heavy metals are found in this study compared to other studies. Samples from urban road surfaces contain higher amount of heavy metals than roof surfaces. Fe and Al, Mn and Pb, Mn and Ni and Mn and Zn showed significant correlations between each other.

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