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Heavy Metal Contamination in Road Deposited Sediments in Colombo Urban Area

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1. Introduction

Heavy metal pollution is a persistent problem in many urban cities in the world. As a result, millions of people living in and around urban centres are exposed to an unnatural and unhealthy environment which may cause a serious threat for the human health as well as for the environment. With the exception of natural and bedrock sources, most of heavy metal pollutants are anthropogenic in origin (Kim *et al.*, 1998).

Atmospheric pollution is one of the major sources of heavy metal contamination of water and soil. Heavy metals can accumulate in topsoil from atmospheric deposition by sedimentation. Top soils and road deposited sediments (RDS) are useful probes to understand the atmospheric pollution of an urban area (Li *et al*., 2001). Dusts deposited on the roads are usually called road dusts, road-deposited sediments or street dusts (Wei *et al*., 2008). These can also acts as a significant pollution source, especially when storm water runoff removes a large part of the RDS and its associated metals causing a pollution threat to the surface and sub-surface water resources (Singh, 2009).

Population of Sri Lanka is of 19.7 million of which more than 15% lives in the urban areas. Colombo Metropolitan Region (CMR) covers an area of 37.29 km^2. More than 80% of industries of the country operate in close proximity to Colombo (Asian Development Bank report, 2006). Relative humidity in Colombo varies from 75–95 % and receives an average annual rainfall of approximately 2,400 mm. The mean annual temperature in Colombo is approximately 25 to 28 ^{0}C with a small variation in the mean monthly temperatures. The wind flow in to the city varies depending on monsoonal conditions. Wind mainly flows from the north western direction and moves across the city towards the central parts of the country. Lateritic peaty soil cover is predominated in the area (Cooray, 1984).

Information on heavy metals in road deposited sediments of urban environments of Sri Lanka is not available. Hence, there is a need to identify the point and non-point sources of contaminants and the level of toxic contaminations in the urban environment. Therefore this study focuses to investigate the heavy metal and organic carbon concentrations in RDS of three different land use areas in CMR.

2. Methodology

2.1. Sampling

Forty six (46) road deposited sediment samples were collected within the CMR. Sample sites were selected considering the intensity of commercial and industrial activities as well as the density of residential. Industrialised

Rathmalana area, Colombo city centre as being commercialised area and residential areas in the small cities were also selected for the sampling (Figure. 1). Samples were collected by using a hand shovel in to polythene bags and transported to the laboratory for further analyses.

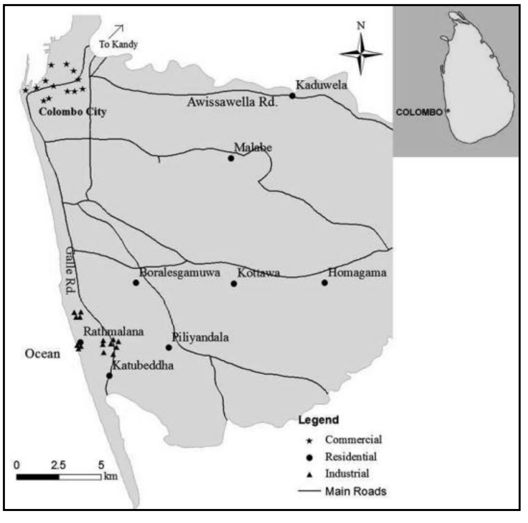

Figure 1 - Study area in and around Colombo Metropolitan Region.

2.2. Laboratory Analysis

Samples were dried, crushed, sieved (sieve size 0.63 mm) and the pan fraction was selected. Organic matter content of all sediment samples was measured by loss on ignition method (Robertson and Taylor, 2007). Acid digestion of 0.1g of these samples were done by microwave digestion method using HNO_3, $HClO_4$ and HF (HNO_3:$HClO_4$: HF = 7:2:1). Concentrations of Cu, Zn, Pb, Fe, Mn, in digested samples were determined by using flame atomic absorption spectrophotometer (Varian AA240FS).

3. Results and Discussion

3.1. Total Organic Matter Content

Obtained results show that the total organic matter content increases in the order of industrial < commercial < residential area (Table 1) within a range of 1.4%-17.8%. All these values are relatively higher than the values observed in the RDS samples from other cities of the world such as Manchester, UK (Robertson and Taylor, 2007) and in Zhenjiang, a city in the eastern China (Zhu *et al*., 2007).

Table 1 - Total organic matter content in RDS

Area	OM %
Residential	12.4
Commercial	9.4
Industrial	6.4

3.2. Total Heavy Metal Concentration

The elemental concentrations show variations among the three sampling groups. Most abundant element is Fe which is in the range of 25,322 – 97,582ppm (Table. 2) in all areas. The average values of samples collected from commercial areas have higher concentrations of Zn, Cu and Pb (349, 180, 444ppm respectively). Manganese (Mn) concentration in commercial and industrial areas are nearly equal (537 and 544ppm respectively) while residential area has a relatively low value (207ppm).

Compared to other cities, Colombo city is less contaminated in terms of Zn and Pb concentrations while Cu concentrations are nearly equal (Figure. 2). Although Zn and Pb concentrations are lower than other cities, still those results are remarkably high when we consider the intensity of urbanisation, traffic density, population density and industrial density of the other cities of the world.

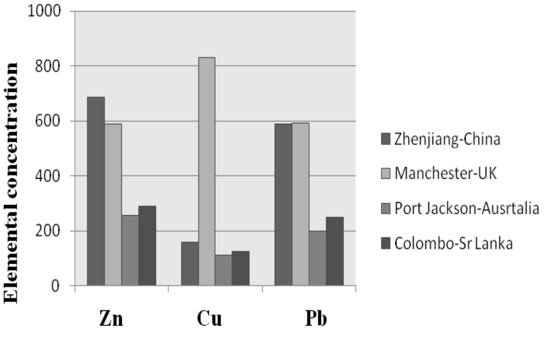

Figure 2 - Comparison of elemental concentration in RDS samples collected from three different parts of the world with this study.

Table 2 - Elemental concentrations (in ppm) of RDS in different land used areas.

Element	Residential		Commercial		Industrial	
	Mean	Range	Mean	Range	Mean	Range
Zn	253	455-53	349	625-135	285	929-73
Cu	57	98-30	180	1181-29	108	260-50
Pb	N/A	N/A	444	5591-b.d.	23	73-b.d.
Mn	207	298-109	537	675-458	544	1019-300
Fe	41,645	50,760-26,360	39,697	52,679-29,986	45,373	97,582-25,322

Zinc (Zn), Cu, Mn and Fe contents in the RDS samples are significantly higher compared to those in the lateritic peaty soil cover in the area (Dissanayake, 1986). This indicates that contamination of the city by means of heavy metals and organic matter is considerably high although it has been heavily urbanised very recently.

3.3. Elemental Correlation

Significant correlation of Cu/Pb, Cu/Zn and Zn/Pb indicate that these metal pollutants have been released from common sources. No such significant correlations were observed between Mn and Fe (Table. 3). Further Zn, Cu and Pb show high positive correlation with the contents of organic matter in the samples.

Table 3 - Correlation coefficient of measured elements and organic matter (OM) of RDS

	Zn	Cu	Pb	Fe	Mn	OM
Zn	1.0					
Cu	0.7	1.0				
Pb	0.7	0.9	1.0			
Cr	0.2	0.4	0.3			
Fe	0.2	0.4	0.2	1.0		
Mn	0.2	0.3	0.0	0.6	1.0	
OM	0.7	0.9	1.0	0.2	0.0	1.0

High percentage of organic matter in sediments contributes significantly to the bioavailability of heavy metals in sediments (Ongeri et al., 2010). Organic matter provides binding sites for metal ions influencing their bioavailability, toxicity and general transport behaviour. Due to the higher percentages of organic matter in Colombo RDS samples, there is a high possibility to increases the content of bio-available toxic metals.

4. Conclusions

Present results suggest that the organic matter content in RDS of Colombo metropolitan region is high. Heavy metal concentrations show variations among different land used areas while metal pollution in the area increases in the order of residential < industrial < commercial area. When compared with the other parts of the world, CMR is less polluted with respect to Zn and Pb. However Cu pollution is high. Zinc (Zn), Cu and Pb may have released from common sources.

5. Acknowledgments

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