Assessment of Lead and Cadmium Levels in Selected Soils of Anuradhapura District of Sri Lanka

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Abstract
Various heavy metals have been reported as dangerous agents to the human health and wildlife when they occur in the environment at high concentrations. Cadmium (Cd) and lead (Pb) compounds are classified as hazardous metals. In this study, concentrations of Cd and Pb were investigated in cultivated and uncultivated lands of both upland and lowland areas at two depths (0-15 cm, 15-30 cm) in soils of Anuradhapura district. The design was Completely Randomized Design (CRD) in three factor factorial with three replicates. Total Cd and Pb and available cadmium and lead in the soils were determined. In addition other soil properties such as total organic carbon (TOC), microbial biomass carbon (MBC), water soluble carbon (WSC), and permanganate oxidizable carbon (POC) were also measured. Cd was not detected (detection limit 0.02 mg/kg) in any of the samples. The total Pb and available Pb ranged between 1.61 to 11.72 mg/ kg and 0.982 to 7.202 mg/kg, respectively. Total Pb and available Pb did not show any significant difference with elevation, land-use and depth. As the maximum permissible level of soil Pb is 150–300 mg/kg, according to European Community standard, values of the tested soils are safe in terms of Pb hazard. Total Pb and available Pb showed a highly negative correlation with distance from main road. Both total and available Pb showed weak negative correlations with TOC and water soluble carbon whereas both total and available Pb showed significant negative correlation at 95% confidence level with MBC.

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Introduction
Heavy metals namely Cadmium and lead are main threats to human health when exposed. Heavy metals have been used by humans for thousands of years. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries. During the last century, lead emissions to ambient air have caused considerable pollution, mainly due to lead emissions from petrol. Children are particularly susceptible to lead exposure due to high gastrointestinal uptake and the permeable blood-brain barrier. Blood levels in children should be reduced below the levels so far considered acceptable. The use of lead-based paints should be abandoned, and lead should not be used in food containers, whereas cadmium reaches agricultural soils mainly through the application of phosphorus fertilizers especially from imported Triple Super Phosphate (TSP) which contain high level of Cd content than the rock phosphate. Moreover farmers apply fertilizer 2-8 times greater level than the recommended level in Sri Lanka (Jayathilake and Bandara, 1989).

The knowledge about the relationship between soil organic carbon fractions and available heavy metals would yield appreciable information in managing agricultural soils. The soil organic matter improves most of the physical, chemical and biological properties that favorably affect crop production. Chronic renal failure is becoming a public health problem worldwide and it is reaching epidemic level in North Central Province (NCP) of Sri Lanka. Pb being a hazardous metal, causes health effects such as decrements in intelligence scores, shortened concentration spans, reading and language problems even in low level exposure for longtime, especially in children.
There are limited studies available in soils of Sri Lanka regarding these metals, Therefore this study has planned in these selected locations with the following objectives.

- Assessment of availability of hazardous metals namely Cadmium (Cd) and Lead (Pb) in Anuradhapura (Reddish brown earth-RBE) soils in cultivated and uncultivated areas as well as up land and low land soils
- Assessment of carbon fractions in those selected areas and to study the effect of such fractions on metal ion availability

Materials and Methods
Study area
The study was carried out in Anuradhapura district of North Central Province of Sri Lanka.

Samples were collected in upland and lowland soils; within each sample was collected from cultivated and uncultivated lands. Three locations were selected randomly and in each location soil samples were taken from low land and uplands of cultivated and uncultivated soils. Hence sample collection was done in twelve locations (Table1).In this study, carbon fractions were investigated in cultivated and uncultivated lands of both upland and lowland areas at two depths (0-15 cm, 15-30 cm). The design was Completely Randomized Design (CRD) in three factor factorial with three replicates.

Table 1: Sampling sites in Anuradhapura District

Location	Elevation	Landuse
Ganewalpura	Upland	Cultivated
		Uncultivated
Hatharayala	Upland	Cultivated
		Uncultivated
Ungangala	Upland	Cultivated
		Uncultivated
Ipologama	Lowland	Cultivated
		Uncultivated
Epawala	Lowland	Cultivated
		Uncultivated
Nuwarawewa	Lowland	Cultivated
		Uncultivated

Sample analysis

Total Cd and total Pb digested according to Sposito *et al.* (1982) method and available Cd and Pb extracted by Lindsay and Norvell, (1978) method and finally measured by using atomic absorption spectrophotometer. Microbial biomass carbon was extracted by using the chloroform fumigation and extraction method with the fresh samples. Soil samples were air dried, passed through 2 mm sieve and tested for total organic carbon using 'wet' oxidation by acidified dichromate of organic carbon (Baker, 1976). The labile fractions of soil organic carbon mainly from the active carbon pools were determined by the $KMnO_4$-oxidizable carbon estimation and the water labile organic carbon was also estimated (Baker, 1976)

Results and Discussion

Cadmium

Total Cd digested according to Sposito *et al.* (1982) method and available Cd extracted by Lindsay and Norvell, (1978) method were not in the detectable limits by the atomic absorption spectrophotometer. As the lowest detectable limit is 0.02 ppm they were below 0.02 mg/kg in the soils tested from Anuradhapura district. The Cd content in the study area is in safe level since the European Community set standards in 1986 for the maximum concentration of Cd allowed in agricultural soils treated with sewage sludge range from 1–3 mg/kg.

Lead

The total Pb ranged between 1.61 to 11.72 mg/kg whereas available Pb varied between 0.982 to 7.202 mg/kg. Total Pb and available Pb did not show any significant difference with elevation, land-use and depth. The European Community set standard values for maximum permissible level of soil Pb is 150–300 mg/kg, therefore the study area is being safe in terms of Pb hazard.

Soil Pb concentration Vs Distance from main road

Total Pb and available Pb show high negative correlation with distance from main road (Figure 1 (a,b)). This may be due to the fact that Pb contaminates the soil via aerosol depositions due to the burning of fossil fuels by vehicles (Mielke *et al.*, 1997). Similar results of decreasing Pb concentration with increasing distance from roadside (Rodriguez-Flores and Rodriguez-Castellon, 1982) has already been reported. Moreover, high Pb concentration in plants were also observed, where the plants grow near to roadsides (Wheeler and Rolfe, 1979a).

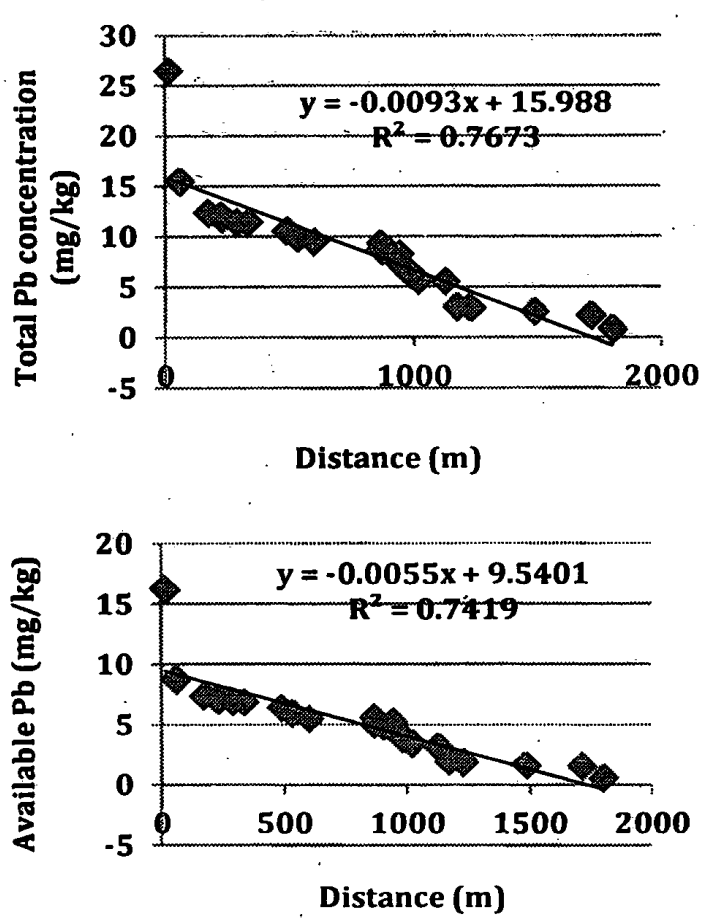

Figure 1: Pb concentration with distance from main road

Link between Carbon fractions and Pb content in soil

Though total and available Pb show negative correlations with TOC, MBC and water soluble carbon, only the correlation between soil Pb content with MBC was significant at the 95% confidence level. Pb content in soil is inversely proportional to the SOM content and the relationship seems to be linear-linear type. Further, availability of Pb in soil for plant could be reduced with increasing SOM and immobilization of soluble Pb in the soil is due to the presence of humic and fulvic acid molecules in SOM (Påhlsson, 1989).

Conclusion

All the soils tested had Cd content below 0.02 mg/kg which is below the hazard level according to the European community standards of maximum permissible level of Cd content in soil (1-3 mg/kg). The total Pb and available Pb ranged between 1.61 to 11.72 mg/ kg and 0.982 to 7.202 mg/kg, respectively. Total Pb and available Pb did not show any significant difference with elevation, land-use and depth. Soil Pb content also found to be at safe level since the maximum permissible level of soil Pb was 150-300 mg/kg set by European community standards. Total Pb and available Pb showed high negative correlation with distance from main road. Though lead contents showed negative trend with carbon fractions namely microbial biomass carbon (MBC), water soluble carbon (WSC) and total organic carbon (TOC), MBC only showed significant correlation.

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