

Research Application Summary

Study of heavy metal contamination along roadside soils of Botswana

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Abstract

This study examined presence of heavy metals (aluminium, cobalt, copper, iron, lead, manganese, nickel and zinc) along Botswana roads. These metals are toxic to human and animals. The mean values of these metals were below toxic range, indicating little or limited contamination. The study recommends frequent sampling to avoid environment poisoning.

Key words: Anthropogenic sources, Botswana, metal toxicity, roads, vehicles

Résumé

Cette étude a examiné la présence des métaux lourds (aluminium, cobalt, cuivre, fer, plomb, manganèse, nickel et zinc) le long des routes du Botswana. Ces métaux sont toxiques à l'homme et aux animaux. Les valeurs moyennes de ces métaux étaient au-dessous de gamme toxique, indiquant peu de contamination ou une contamination limitée. L'étude recommande le prélèvement fréquent pour éviter l'empoisonnement de l'environnement.

Mots clés: Sources anthropogènes, Botswana, toxicité en métal, routes, véhicules

Background

Heavy metal contamination in the soil–water–plant ecosystem is of great concern because of possible influence on food chain. In the soil system, pollution by toxic metals is due to both natural processes, such as weathering of minerals and anthropogenic activities, related to industry, agriculture, burning of fossil fuels, vehicular emissions, mining and metallurgical processes and their waste disposal.

Currently, very little is known about the heavy metal concentration, distribution and the extent of environmental pollution in the soils of Botswana. In this respect, the main objectives of this study were: (1) evaluation of concentration levels of Aluminium (Al), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni) and Zinc (Zn) in selected roadside soils of Botswana; (2) calculation of enrichment factors for these selected heavy metals in order to

evaluate the degree of enrichment above the normal background concentrations; and (3) determination of possible sources of pollutants using available statistical models.

Literature Summary

The most frequently reported heavy metals with regards to potential hazards and occurrence in soils are Al, Co, Cu, Fe, Pb, Mn, Ni and Zn. Accumulation of these metals in top soils are greatly influenced by traffic volume. Lead, in particular, is a pollutant of concern because of the use of alkyl lead compounds as antiknock and freezing additives in fuel. Other heavy metals associated with vehicular emissions are Cu and Zn (Al-Kashman *et al.*, 2009)

The presence of heavy metals in and around urban areas have been a subject of great concern due to their non-biodegradable nature and long biological half-lives within the human body, when consumed. For example, Co, Cadmium (Cd) and Ni inhibit stomatal activity and decrease photosynthesis (Prasad, 1995). On the other hand, Cd, Chromium (Cr), Zn and Mn cause neurosis and chlorosis (Delgado *et al.*, 1993) while Cu, Cd, Mn, Co and Zn impair seed sprouting and Cd, Cu, Ni and Pb interfere with hormonal balance (Rauser and Dumbroff, 1981).

Study Description

The sampling sites were limited to areas along the major highways of Botswana. The sampled areas were coded into zones A, B, C, D, E, F, G, H and I. Along each zone, soils were collected at about 20 km to 100 km in between sites in 2008 and 2009. In the laboratory, the total concentrations of Al, Co, Cu, Fe, Pb, Mn, Ni and Zn were determined using a Flame Atomic Absorption Spectrometer (Varian SpectrAA 220 FS) at different wavelengths (λ). To differentiate between metals originating from human activities and natural processes, and to assess the degree of anthropogenic influence, the enrichment factor (*EF*) technique was employed. Data were subjected to correlation analysis and analysis of variance (ANOVA) by SPSS PASW Statistics 17 to determine association as well as the differences in the concentration between different zones.

Findings

The mean concentrations of Al, Co, Cu, Fe, Pb, Mn, Ni and Zn are within the lower range of the background values, as reported by various authors, suggesting very little to no heavy metal contamination of soils due to anthropogenic sources. Figure 1 shows the enrichment factors of heavy metals, Co, Cu, Pb, Mn, Ni and Zn for each zone.

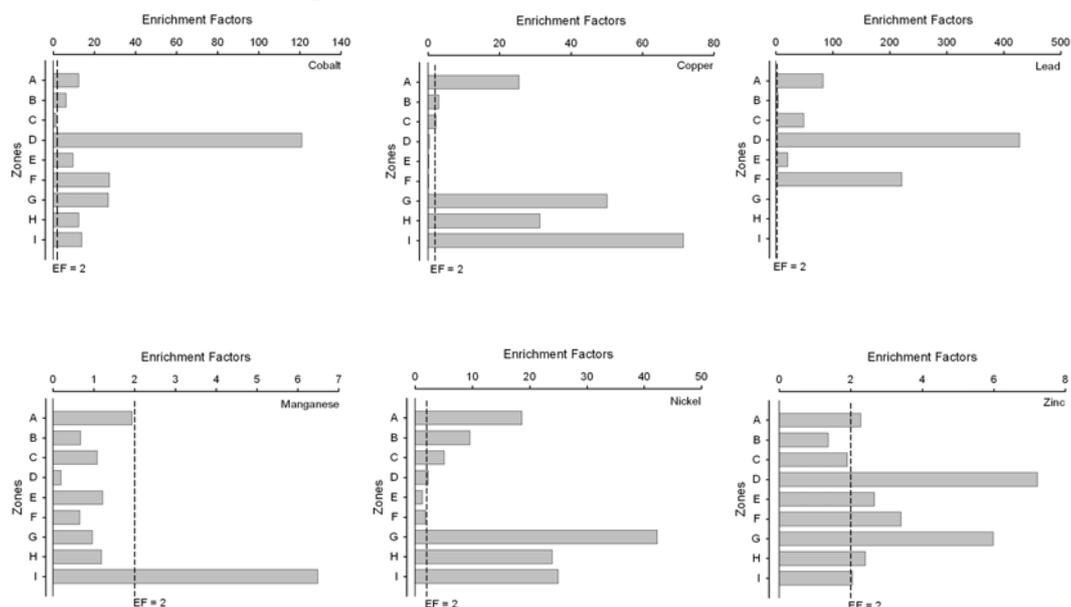


Figure 1. Enrichment factors of Co, Cu, Pb, Mn, Ni and Zn in examined soils from each of the zones, normalized against Fe in world soils. The dotted (----) lines represents enrichment factor, EF = 2.

Factor analysis was used to explore associations that would provide information on the distribution and source of metal pollution in soils. The first principal component (PC-1) accounting for 25.89% of variance showed high positive loadings of Al, Mn, and Fe. This association strongly suggested that these variables had a similar source, and were controlled by natural geogenic and/or pedogenic processes. The second component (PC-2) contributed by Zn, Cu and Pb at 23.53% of total variance. The Pb loading suggested contributions from vehicular emissions; Zn and Cu loading reflected possibilities of anthropogenic or natural parent material sources. The last component (PC-3) comprised of 18.03% of the total variance. This component comprises of Ni and Co, which was ascribed to tyre wear, metal corrossions and brake linings.

Research Application

The results generally show varying degree of heavy metal enrichment along major highway soils of Botswana, mostly affected by pollutants from vehicular emission. Principal Component Analysis showed that elements in both PC-2 and PC-3 components were to some degree, present in soil as a result of human activity, whereas, the PC-1 (Fe, Al and Mn) elements were due to natural processes. This study is preliminary in nature and probably the first ever conducted in the study area in Botswana. It is hoped that the results of this preliminary study will provide impetus for designing contamination control

and further monitoring of the heavy metal accumulation in soils of Botswana.

Recommendation

It is recommended that the study be repeated in several zones that have shown some degree of pollution from enrichment factor calculations.

Acknowledgement

The authors gratefully acknowledge the financial support of the Research and Publications Committee (RPC) of the Botswana College of Agriculture. The Department of Chemistry, University of Botswana is thanked for assistance in metal analysis

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