

Metals in environmental media: A study of trace and platinum group metals in Thohoyandou, South Africa

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Abstract

A detailed study has been conducted to determine the contamination of Thohoyandou roadside soils, vegetation, sewage and river waters by Zn, Cu, Cr, Pb, Cd, Fe, Pt and Pd. The study further investigated the correlation between these trace metals in roadside soils and vegetation in order to infer the potential impacts of roadside trace metals contamination of vegetation. Collected surface soil and vegetation samples were analysed with atomic absorption spectrophotometer for Zn, Cu, Cr, Pb and Cd while water samples were analysed by inductively coupled plasma atomic emission spectrometry (ICP-OES) for Zn, Cu, Fe, Pt and Pd. A linear correlation was observed between soil and vegetation metal concentration, which suggests the same source of metals in the samples except for Cu. The findings also revealed a general reduction in soil and vegetation metal concentrations some distance away from road traffic. For both experimental soil and vegetation samples, the mean concentrations were found to follow the decreasing orders: Pb > Zn > Cr > Cu > Cd and Pb > Zn > Cd > Cr > Cu respectively. For water samples, trace metals were highest in raw sewage and lowest in river waters. The sewage system leaking directly into the rivers was found to be the major source of pollution by trace metals. The mean concentrations of the trace metals in the water bodies were found to follow the following decreasing order: Fe > Zn > Pt > Cu > Pd.

Keywords: trace metal contamination; roadside soil; vegetation; water; Thohoyandou, South Africa

Introduction

Zn, Cu, Pb, Fe, Cd and Cr are trace metals that commonly cause pollution of urban environments. Motor vehicles and sewage systems constitute some of the major sources that release these metals directly into the urban environments (Fatoki, 1996; Fatoki and Ayodele, 1991; Sörme and Lagerkvist, 2002). Metals from vehicle emissions are released into the atmosphere and are subsequently deposited into the surrounding soil, vegetation and water bodies. These metals can also leach from the roadsides during rains to surrounding water bodies. Poorly maintained sewage systems can also be a major source of trace metal contamination, especially if there are pipes leakages.

Several researchers (Fatoki, 1996; Fatoki and Ayodele, 1991; Sithole et al., 1993; Onyari et al., 2002; Okonkwo et al., 2003) have reported elevated concentrations of trace metals even as far as 250 m from the roadside. Vehicle exhausts, lubricating oils, tyres and plating materials have been cited as components that contain one or more of these metals (Lagerwerff and Specht, 1970; Ward et al., 1977). Roofing materials, food wastes, sewage system pipes and taps are among the major sources of trace metals in the sewage (Sörme and Lagerkvist, 2002). Under normal circumstances, the major sources of these metals are heavy industries such as mining and metal industries.

Zn, Cu, Fe and Cr are all essential elements for many plants, animals and man but at trace levels. At high concentrations, they are all potentially toxic (Nyriagu, 1988; Goyer, 1996). Pb and Cd are generally regarded as toxic elements even at trace levels (Goyer, 1996). It has been shown by Morton et al. (2001), Moldovan et al. (2001) and Ravindra et al. (2004) among oth-

ers that Pt and Pd released by automobile catalytic converters accumulate to contaminant concentrations with time in roadside soils, water and vegetation. Morton et al. (2001) reported concentrations of Pt, Pd and Rd in roadside soil samples from Mexico City of 300, 70 and 40 µg/l, respectively. Despite the low quantities of these Pt group elements (PGE) emitted from catalytic converters, the accumulation of these elements in soils, water and plants along heavily travelled roads rises with their use (Morton et al., 2001). Monitoring of these metals in urban environments is therefore critical as it gives vital information as to whether exposure concentrations can cause adverse effects especially to humans.

This study attempted to investigate the contamination of soil, vegetation and water bodies within Thohoyandou peri-urban town by Zn, Cu, Cd, Pb, Cr, Fe, Pt and Pd. The study further correlated the soil and vegetation metal concentrations in the study area. Similar studies (Mathee and Schirnding, 2002) have been concentrated in major cities in South Africa at the expense of small or peri-urban towns like Thohoyandou. The previous study by Okonkwo et al. (2003), investigated only Pb pollution in soil and vegetation along the major Thohoyandou roads. The study left out Zn, Cd, Cu, Cr and Pt group metals which are common trace metals and emerging contaminants, respectively. Okonkwo et al. (2003) study, did not investigate the level and presence of these contaminants in surface water bodies which is equally important since the surrounding community depend on it for household and agricultural activities. Okonkwo and Mothiba (2005) study on pollution levels of trace metals in rivers in Thohoyandou apart from not considering pollution in soil and vegetation also left out Pt group metals. None of the two studies directly investigated pollution link to sewage system. Thohoyandou town has also seen an increase in both population and traffic since the end of the old system of government. This is evidenced by the continued expansion of central business district, residential areas and traffic congestion at peak hours.

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Received 28 February 2005; accepted in revised form 21 June 2005.