Spatial distribution of cadmium concentrations in street dust in an arid environment

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Received: 27 January 2014 / Accepted: 5 March 2014
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Abstract Cadmium (Cd) concentration and its chemical speciation were studied in surface dust samples collected from 26 locations at Amman–Zarqa basin highways. The study area represents a heavily trafficked arid environment associated with highly calcareous soils with an average of 53 % CaCO3; such combination gives the investigation further speculations on abundant Cd bonded forms. Sequential extraction technique (SET) was used to assess the exchangeable, bound to carbonates, bound to iron oxide, bound to organic matter, and residual fractions in surface dust samples. Total and fractional Cd spatial distributions were spatially investigated and utilized to generate Cd contamination factor map. Total Cd concentrations ranged between 4.1 and 17.9 mg/kg where maximum contamination was allocated at the study area center. The exponential behavior of Cd distribution in space gave further distinction of the possible contamination sources. The main Cd speciation was in the following order: bound to iron oxide > residual > exchangeable > bound to carbonate > bound to organic matter. The degree of surface contamination was determined by individual contamination factor that delineated those areas located close to the wastewater treatment plant that had high potential risk to fauna and flora. Relationship between the total and fractional Cd concentrations with soil chemical properties showed that pH, CEC, and amorphous Fe were positively related to total extracted Cd, while carbonate content and OM are negatively correlated with Cd.

Keywords Cd · Speciation · Spatial analysis · Contamination factor map · Cd kriging

Introduction

The potential risk of soil heavy metals on the environment and population has become widespread in a global context, especially in industrial and rapid-urbanization areas. The heavy metals could be emitted by vehicles (Hashisho and El-Fadel 2004), incinerators (Schuhmacher et al. 1997), industrial waste (Mireles et al. 2004), and atmospheric deposition of dust and aerosols, among other activities (Banat et al. 2004). Many heavy metals have been identified as having adverse public health effects due to their toxicity. Several studies revealed that human exposure to high concentrations of heavy metals may cause their accumulation in the fatty tissues of the human body, disrupt the normal functioning of the internal organs (Bocca et al. 2004), affect the central nervous system (Thompson et al. 1988), and may be deposited in the circulatory system (Nriagu 1988; Waisberg et al. 2003). Moreover, many studies showed that children exposure to contaminated soils, dust, and air particulates may ingest a significant amount of toxic elements through the hand–mouth pathway and through other routes of exposure (Mielke et al. 1999; Raghunath et al. 1999). Among these metals, Cadmium (Cd) is well known as a global contaminant and is listed as the most hazardous inorganic contaminants on the EPA Hazardous Substance Priority List (WHO 2006). Cadmium has become a threat to human health when it passes up the food chain (Satarug et al. 2003). Cadmium has toxic effects on microorganisms, plants, animals, and humans. There is sufficient evidence in humans for the carcinogenicity of cadmium and cadmium compounds and for genotoxic effects of its ionic forms in a variety of types of eukaryotic cells. Cadmium enters the body mainly by inhalation and by ingestion (Waisberg et al. 2003).

Street dusts are characterized by short residence times (Allott et al. 1990) and represent only the recent accumulation of pollutants (Harrison et al. 1981). Environmental and health