

Occurrences and toxicological risk assessment of eight heavy metals in agricultural soils from Kenya, Eastern Africa

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Abstract The concentration distribution and toxicological assessment of eight heavy metals including lead (Pb), cadmium (Cd), copper (Cu), chromium (Cr), nickel (Ni), mercury (Hg), arsenic (As), and zinc (Zn) in agricultural soils from Kenya, Eastern Africa, were investigated in this study. The results showed mean concentrations of eight heavy metals of Zn, Pb, Cr, Cu, As, Ni, Hg, and Cd in agricultural soils as 247.39, 26.87, 59.69, 88.59, 8.93, 12.56, 8.06, and 0.42 mg kg⁻¹, respectively. These mean values of eight heavy metals were close to the toxicity threshold limit of USEPA standard values of agricultural soils, indicating potential toxicological risk to the food chain. Pollution index values revealed that eight heavy metals severely decreased in the order Hg > Cd > As > Cu > Pb > Zn > Ni > Cr and the mean value of the overall pollution index of Hg and Cd was 20.31, indicating severe agriculture ecological risk. Potential pollution sources of eight heavy metals in agricultural soils were mainly from anthropogenic activities and natural dissolution. The intensification of human agricultural activities, the growing industrialization, and the rapid urbanization largely influenced the

concentration levels of heavy metals in Kenya, Eastern Africa. Moreover, the lack of agricultural normalization management and poor enforcement of environmental laws and regulations further intensified the widespread pollution of agricultural soils in Kenya.

Keywords Concentrations · Toxicological risk assessment · Agriculture ecological risk · Heavy metals · Kenya · Eastern Africa

Introduction

Heavy metals are environmentally toxic substances, and there is a great concern for monitoring their use and occurrence in the environment. Several main heavy metals including Cr, Cu, Ni, Zn, Pb, Hg, As, and Cd are commonly analyzed in agricultural soils to evaluate their agricultural ecological risk. Human activities, dissolution of parent rock material, and climate change (Jia et al. 2010, Zhang et al. 2008) largely influence the concentration and levels of heavy metals in agricultural soils. Burning of fossil fuel in engines, oil spillage, use of agricultural fertilizers, and agricultural irrigation schemes are the main pollution sources of heavy metals in agricultural soils (Gonzalez et al. 2008, Wei & Yang 2010). These heavy metals could easily accumulate in surface soils and migrate to crops by plant root respiration. Humans maybe exposed directly or indirectly and directly to these pollutants from contaminated soils through consumption of these food plants (Bordajandi et al. 2004), resulting in digestive problems, nervous malfunction, and even cancer (Rukhsanda et al. 2015).

Previous studies conducted in Africa showed that the elevated levels of heavy metals mainly result from mining activities, industrial emissions, agricultural and runoff from fertilizer application in farms, and increase in population (Muendo

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