Combined chemical and biological assessment of bioavailability of metals from garden soils in mining areas in Southern Morocco

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Abstract:
Garden soils in urban and industrial areas are the place for intensive interactions between man and environment. Their main function is to be a growth medium for edible vegetables. The phytoavailability of metals potentially present in those soils and introduced from contrasted sources is poorly documented. The aim of the present work is the assessment of the concentration, toxicity and phytoavailability of heavy metals in garden soils in the vicinity of three mines in South of Morocco by using concurrently selective chemical extractions, MetPLATETM a toxicity bioassay, and plant growth experiments. Chemical characteristics of garden soils are modified by human activities including gardening practices and industrial inputs of wastes. The pH of garden soils from the three locations varied between 6.7 and 8.0 and levels of chemical fertility were contrasted. The tailing materials systematically present on the sites are sources of contaminated dust and particles. These technogenic materials containing very high concentrations of Mn (4 700 mg kg-1), Cu (627.7 mg kg-1) and Co (82.3 mg kg-1) in mine A, Co (1 779 mg kg-1), Mn (1 396 mg kg-1), Cr (667.6 mg kg-1) and Ni (458.6 mg kg-1) in mine B and Cu (1 687 mg kg-1) and Zn (513.2 mg kg-1) in mine C, are potential contaminants for garden soils and edible vegetables. The metal toxicity of the aqueous extracts of mine tailings and garden soils was assayed, using the biotest MetPLATE. The results showed that the high toxicity of tailings from mine C (86.7% inhibition) and moderate toxicity of tailings from mine B (51.0% inhibition) were mainly due to the relative high concentrations of soluble Cu (370-14 256 Âµg Cu l-1) and Zn (254-2 873 µg Zn l-1). In general, garden soils presented higher total metal concentrations than agricultural soils. Nevertheless, the low metal toxicity observed in most garden soils was confirmed by the low metal concentrations in the soil water extracts, except for two soils from mine A which contained Zn in their water extract exceeding the MetPLATETM EC50s. The non toxicity of those soils could be attributed to the metal speciation in the water extracts. In all garden soils, Lactuca sativa L. (chosen as a model leafy vegetable) and Lolium multiflorum L. (chosen as model fodder grass) contained in their shoots Cd, Co, Cr, Cu and Ni below toxic concentrations while Zn (in all soils) and Mn (in soils GSA3 and GSA4 from mine A) were accumulated at concentrations high enough to be considered phytotoxic. In general, the response of the MetPLATE bioassay was correlated with the biomass production and was inversely proportional to the inhibition percentage. The low biomass produced on garden soils near to mines B and C is explained by the relative low toxicity (6-38% inhibition) compared to mine A. The transfer factor (TF) values for Zn were higher than those found for Mn for both plant species. The relatively lower TF values for Mn confirm that this element (34.1-936.9 Âµg Mn l-1) was present at low bioavailable fraction in soils. The general trend observed was an increase in metal toxicity measured by the bioassay with increase of water extractible metal concentrations of the garden soils leading to the low biomass production. Therefore, the MetPLATE bioassay can be used as a rapid and sensitive predictive tool to assess the heavy metal availability in garden soils highly contaminated by mining activities.

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