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## Concentration, distribution and speciation of toxic metals in soils along a transect around a Zn/Pb smelter in the northwest of Iran

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### Abstract

Non-ferrous metals smelting has been recognized as one of the most important point sources of toxic metals in soil. In this preliminary study, the concentration, distribution and speciation of toxic metals (Pb, Zn, Cd, Cr, Ni and Cu) in soils were investigated along a pre-selected transect around a Zn/Pb smelter in NW Iran. Two groups of the metals were identified in terms of range and variation: Pb, Zn and Cd (Group 1) whose mean concentrations (302, 311 and 9.83 mg/kg, respectively) are significantly higher than the concentrations in the control soil and exhibited high coefficients of variation ( $CV > 2$ ). The concentrations of these three metals decreased exponentially or as power-law model with increasing distance downwind from the smelter, implying that their variations are mainly controlled by inputs from the smelter. Declining trend of concentration along the transect for Cd is different from that of the two other metals, i.e. Cd is levelled off at a longer distance ( $\approx 8000$  m) whereas Pb and Zn concentrations are dropped at a shorter distance ( $\approx 3400$  m) from the smelter. The total concentrations of these metals also decreased significantly with depth by decreasing rates of  $> 50\%$ . By contrast, three other metals Cr, Ni and Cu (Group 2) are characterized by low variability ( $CV < 1$ ) with mean values of 46.1 mg/kg (for Cr), 28.2 mg/kg (for Ni) and 24.8 mg/kg (for Cu). The total contents of these metals did not vary with distance from the smelter and tend to increase with depth, suggesting that they are derived mainly from geogenic source. Marked differences were found between the two groups of metals in terms of their geochemical fractionation in the soils: smelter-related metals (Pb, Zn and Cd) were distributed in all soil fractions, with the most relevant abundances in the reducible one ( $> 45\%$  of their total contents). The amounts of these metals in the non-residual fractions decreased with increasing distance from the smelter. On the contrary, Cr, Ni and Cu had a large percentage of the residual fraction ( $> 80\%$  of the total contents) and relatively small proportion of the non-residual fractions ( $\leq 10\%$  of the total fraction). The mobility factors of all toxic metals studied are found to be low to moderate due to alkaline nature of the soils. The average single factor pollution index (SFPI) from the sampling sites decreased in the order of  $Cd > Pb > Zn > Ni > Cr > Cu$ . In view of the comprehensive pollution index (CPI), soils from the study area showed heavy to warning level of pollution along the transect. The results from this study clearly indicated that Zn smelting activity is responsible for soil contamination in the study area and not only led to significant increases in total contents of some metals but also altered their speciation in soils along the transect. This can pose a significant risk to health of local inhabitants particularly for those living closer to the smelter which should be assessed in future investigations.

**Keywords:** Toxic metals, soil, speciation, Zn/Pb smelter, Iran

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