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Metal distribution and mobility in lateritic soils affected by Cu-Co smelting in the Copperbelt district, Zambia

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The copper smelting activities in the Copperbelt mining district (Zambia) left a huge pollution related to the disposal sites of smelting waste (slags) and to the continuous deposition of the smelter stack particulates in the soil systems. We sampled 196 surface and subsurface soils in the vicinity of the Nkana copper smelter at Kitwe and a 110 cm deep lateritic soil profile in order to assess the regional distribution of metallic contaminants and their vertical mobility. The content of contaminants in soil samples were measured by ICP techniques and the lead isotopic compositions (206Pb/207Pb and 208Pb/206Pb ratios) were determined by ICP-MS. The spatial distribution of the major contaminants (Cu, Co, Pb, Zn) indicated the highest contamination NW of the smelter stack corresponding to the direction of prevailing winds in the area. The highest metal concentrations in soils were: 27410 ppm Cu, 606 ppm Co, 480 ppm Pb, 450 ppm Zn. Lead isotopes helped to discriminate the extent of metallic pollution related to the smelter emissions having similar 206Pb/207Pb ratio of 1.17–1.20 in contrast to the regional background value of 1.32. The investigation of the lateritic soil profile sampled in the near vicinity of the Nkana smelter indicated that contamination is mostly located in the uppermost soil horizons enriched in organic matter (< 10 cm). The sequential extraction procedure indicated that up to 33% of Cu and <10% of Co, Pb and Zn was mobile in the profile, being bound in the exchangeable fraction. However, in the deeper parts of the soil profile, metals were mostly bound in reducible fraction, presumably to hydrous ferric oxides. The combination of sequential extraction and lead isotopic determination indicated that the “mobile” fractions of Pb in the soil profile corresponded to the signatures of smelter particulate emissions (206Pb/207Pb = 1.17-1.20), which means that the anthropogenic emissions are the important source of mobile (and potentially bioavailable) metals.