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Natural and anthropogenic enrichments of heavy metals in modern soils: the case study in the Jizera floodplain, Czech Republic

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The timing and realistic quantification of the anthropogenic pollution of soils and sediments are among relevant topics of numerous current environmental geochemistry studies. Geochemical mapping and depth profiling of pollutants in soils and sediments is used for reconstruction of historical pollution and evaluation of previous (cumulative) impacts. In fact, the depth profiles of heavy metals in modern soils are a result of two main processes: deposition of atmospheric fallout (everywhere) or sediment (in floodplains) with anthropogenic components on one hand, and element migration due to biogeochemical processes (Fe oxide transformations, element recycling by plants and joint processes) on the other hand. These processes are not always taken into account, particularly when only one piece of the jigsaw puzzle is in focus, such as development of pollution proxy (e.g., stable lead isotope ratios, MS) or geochemical mapping.

Mature soils, of which surface strata are enriched in heavy metals, are too complex systems to allow simple distinguishing natural and anthropogenic portions of that enrichment; possible natural enrichment factor (EF) ~1.5 has been assumed in the case of Pb and Zn by Reimann et al. Floodplains can offer a “natural isolation of pieces of jigsaw puzzle”, if deposition and erosion in the floodplain have alternated in the past (such behaviour is relatively common). This alteration can produce terraces or related sediment units of different age, but composed of sediment with the same geochemistry, i.e. material with the same provenance and after the same hydraulic sorting before the deposition.

We studied fluvisols in the Jizera floodplain (~50 north-east from Prague, Czech Republic), where a terrace is present along the currently inundated floodplain. We found that atmospheric fallout and/or past pedogenic processes in the terrace above that active floodplain do not cause enrichment of Cr, Cu, Ni, and Zn; perhaps there is an exception for Pb. In a more mature soil outside the historical floodplain heavy-metal depth profiles indicate possible transfer of Ni and Zn from the depth of 0.2-0.3 m toward the topmost strata. Contrarily, in the modern overbank fines (in the Jizera floodplain inundated up to the present time) EFs of all these elements is 1.5-3 in several dm thick surface layer), attributable entirely to the anthropogenic pollution. Generally the concentrations of divalent heavy metals (Cu, Ni, Pb, Zn) in litter in terraces and soils outside the floodplain are 2-3 times larger than the local geochemical average for floodplain sediments and soils. As there are no known atmospheric sources of Cu and Ni in the Jizera watershed, the "surface enhancement" by divalent heavy metals should rather be assigned to natural processes than diffuse sources of a hypothetical anthropogenic pollution. The behaviour of Pb is not much different, although there is a highway E65 in a distance of 1-2 km from the studied profiles. The evaluation of diffuse pollution in soil profiles in a plane European country should hence respect the consequences of natural pedogenic processes.