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Vertical distribution of heavy metals associated with the coarse and medium sand fraction in the forest soils of European Russia

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To accurately model metal behavior in soils, studies on possible geochemical changes occurring within a specific grain-size fraction during pedogenesis are needed. In the present study we analyze concentrations and vertical distributions of heavy metals associated with the coarse and medium sand fraction (1–0.25mm) for soils in the middle Protva basin, situated in the mixed forest zone of European Russia. Two soil types were analyzed: well-differentiated sod-podzolic soils (podzoluvisols) with AEBtC–profile, the major soil type in the study area occupying the interfluve's sub-horizontal surfaces and gentle slopes; and poorly differentiated soddy soils of subordinate positions: soddy soils, soddy gleyic soils and soddy soils with buried fluvial soil horizons. In total 27 samples, collected from 4 soil profiles, were analyzed for Fe, Ti, Mn, Cu, Ni, Co, Cr, Zn, Pb and Zr contents in the partitioned coarse and medium sand fraction.

The median concentrations calculated are for Fe − 4%, for Mn − 760 ppm; for Ti − 980 ppm; for Zr − 130 ppm; for Zn − 30 ppm; and for Cu, Pb, Co, Cr, Ni − 67, 13, 11, 38, 33 ppm, respectively. The metal concentrations in total sample population vary differently, with the variation coefficients diminishing from Mn (171%) and Fe (112%) to Zr, Ni and Pb (53%). Comparing the chemical composition of coarse and medium sand fractions in the vertical sequence of horizons within a soil profile showed that in the sod-podzolic soil developed on mantle loam metals are enriched in the sand fraction of the upper A and AE horizons. The second but less distinct maximum levels for Cu, Ni, Fe, Cr, Mn and Co were found in the subsoil with gleyic features (Cg horizon). In soddy soils developed on diluvium on the steep section of the slope the studied sand fraction generally showed larger amounts of metals in A and AC horizons. In similar soils with gleyic features the concentrations of Fe, Cr, Co, Ni, Cu are the highest in the uppermost horizon, while the levels of Mn, Pb, Ti, Zr are higher in the ACg horizon. In the genetically heterogeneous soil profile combining horizons typical for contemporary soddy soils and buried fluvial soils the metal concentrations depend on the genesis of the sand fraction, with higher concentrations found in the contemporary soil horizons and lower concentrations in the buried fluvial soils.

Thus, our results imply that during soil formation, under the influence of soil and geochemical processes conditioned by a humid temperate climate, the composition of the sand fraction in relation to metal contents changes. In most cases the enrichment of the sand fraction with a wide spectrum of metals was found in upper soil horizons of the studied soil types where humus accumulation, active biogeochemical processes and sand grain weathering takes place. Periodic saturation of the soils with water might also have contributed to metal accumulation in the sand fraction through the formation of iron and manganese compounds which can serve as sinks for metals.