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Metals in particle size fractions of two small erosional landforms in a mixed forest zone: a comparative analysis

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Landscape-geochemical approach for studying environmental pollution with heavy metals has been receiving greater significance due to the necessity to predict the behaviour and pathways of the pollutants in the environment. A special attention is paid to the analysis of small erosional landforms, which play a vital role in the transfer of soil material within river basins. The purpose of the present study is to examine metal concentrations in different grain-size fractions and assess the effect of particle sizes on metal distribution in two small erosional landforms – a gully and a balka – located in a mixed forest zone of European Russia. The gully is a smaller and younger system with a concave form of longitudinal profile and a cross-section represented mostly by a "V"-shaped form. It cuts through various lithologies including glaciofluvial sands and silts with only limited involvement of loessial loams and boulder clays. The balka is an older system with a "U"-shaped form of cross-section and smoothed longitudinal profile incised entirely into loamy deposits. Its length is about 400 m, twice the length of the gully. In each system 11 representative samples of surface soil horizon were selected for the physical fractionation into 5 particle size groups which were further analysed for concentrations of heavy metals (Fe, Mn, Ti, Zr, Cu, Ni, Co, Cr, Zn, Pb).
The average levels of heavy metals were found to be dependent on particle sizes and particles' genesis. The sand particles on the gully's sides and bottom are of glaciofluvial origin, and in the balka they are derived from decalcified loess. This explains why the coarse and medium sand, separated from the topsoil of the gully system, on average is richer in Fe than other fractions while in the balka it has the highest levels of Cu, Co and Mn. The coarse silt of both erosional landforms is characterized by minimal concentrations of the majority of he elements except for Zr. The highest average concentration of Ti is found in the medium and fine silt fraction, however in the gully this fraction also reveals the highest concentrations of Cu and Pb. The clay in the two erosional landforms contain generally higher amounts of Zn, Ni, Cr and Mn than other fractions, but in the gully the clay is also enriched in Co, and in the balka in Pb, Fe, Cu. These differences in the elements' concentrations between the same particle size groups separated from humus horizons of the two systems are probably related to specific lithogeochemical parameters of their parent materials. The spatial variability of the metals' contents, the patterns and magnitudes of their distributions along the system "catchment → landform sides → bottom → detrital fan" show the dependence on the particle sizes. The highest magnitude in the lateral distribution of the metals was found in the coarse and medium sand fraction, the lowest – in the clay fraction. The difference in the patterns of metals' lateral distribution between the landforms is most clearly manifested in the coarse silt fraction.