Geophysical Research Abstracts
Vol. 16, EGU2014-13032, 2014
EGU General Assembly 2014

Effect of Soil Solid-Phase Material Migration on Soil Properties within a Small Watershed Detected Using the Magnetic Tracer Method

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We have performed detailed studies of the lateral migration of the solid soil material and the soil cover within a small catchment area (Russia, Tula region, Lokna river basin).

The main goal of this work is to characterize the migration and accumulation features of the soil solid-phase material within a small watershed and to analyze the effect of the lateral mass transfer on the crucial soil fertility-related properties in the catchment basin under study.

The total area of the catchment and the ravine network elements is 96 ha. The catchment basin is drop-shaped; it slightly curves and is latitudinally oriented. The catchment basin's slopes are of southern, eastern, northern, and intermediate exposures with average inclination of 1,5-5 degrees.

The magnetic tracer method was used to assess the volumes and rates of the lateral migration of the solid-phase soil material on the selected territory. This method is based on the investigation of the spherical magnetic particles (SMPs), which fall onto the soil cover from the atmosphere, where they arrive at the burning of coals and some other fuels, mostly in steam locomotives. The period of the most intensive emission of SMPs into the soil in the territory of Russia corresponds to the last 100–150 years [1].

The reserve of SMPs in the 0- to 25-cm layer is estimated to be 3.8 g/m^{2}on the least eroded sub-horizontal surface. The zones with the concentration of SMPs lower than their average content on the least eroded surface were characterized as dispersion zones. The zones of the basin with significant exceeding the value of 3.8 g/m^2 were marked as accumulation zones of the soil solid-phase material.

Dispersion zones are found in the middle part of the ridge in the north-eastern area, in the middle part of a longslope in the south-western area of the catchment basin, and other [2].

Accumulation zones are observed in a cup-shaped depression on the plowed slope adjacent to the ravine's head, on steep unplowed slopes of the ravine adjacent to its bottom, on the ravine's bottom, and other [2].

The genesis of these zones is result of the summary effect of the exposure, the inclination, and the slope's length, the spatial interference of the zones, the variability of the carrying capacity of the water flow, etc.

The total area of the revealed dispersion zones makes up 35% of the catchment basin; the accumulation zones occupy 26% of the catchment area. The transit-buffer area occupies 39% of the catchment basin. The area proportions of the different functional zones characterize the specific migration structure of the small watershed.

[1] Olson K., Gennadiyev A., Zhidkin A., Markelov M., Golosov V., and Lang J. Use of magnetic tracer and radio-cesium methods to determine past cropland soil erosion amounts and rates. Catena 104 (2013), 103–110.

[2] Gennadiev A., Koshovskii T., Zhidkin A., and Kovach R. Lateral migration of soil solid-phase material within a landscape-geochemical arena detected using the magnetic tracer method. Eurasian Soil Science 46, 10 (2013), 983–993.