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Mapping fields of 137Cs contamination in soils in the context of their stability and hierarchical spatial structure

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Technogenic radioisotopes now dispersed in the environment are involved in natural and technogenic processes forming specific geochemical fields and serving as tracers of modern mass migration and geofield transformation. Cs-137 radioisotopes having a comparatively long life time are known for a fast fixation by the top soil layer; radiocesium activity can be measured in the surface layer in field conditions. This makes ^{137}Cs rather convenient for the study and modeling a behavior of toxic elements in soils [1-3, 5] and for the investigation of relative stability and hierarchical fractal structures of the soil contamination of the atmospheric origin [2].

The objective of the experimental study performed on the test site in Bryansk region was to find and prove polycentric regularities in the structure of ^{137}Cs contamination field formed after the Chernobyl accident in natural conditions. Such a character of spatial variability can be seen on the maps showing different soil parameters and chemical element distribution measured in grids [3-5]. The research was undertaken to support our idea of the regular patterns in the contamination field structure that enables to apply a mathematical theory of the field to the geochemical fields modeling on the basis of a limited number of direct measurements sufficient to reproduce the configuration and main parameters of the geochemical field structure on the level of the elementary landscape geochemical system (top-slope-bottom). Cs-137 field measurements were verified by a direct soil sampling. Soil cores dissected into subsamples with increments of 2, 5 and 10 cm, were taken to the depth of 40 cm at points with various surface activity located at different elements of relief.

According to laboratory measurements ^{137}Cs inventory in soils varied from 344 to 3448 kBq/m^2 (983 kBq/m^2 on the average). From 95,1% to 98,0% to of the total inventory was retained in the top 20-cm soil layer. This confirmed that field gamma spectrometry could be used to investigate patterns of ^{137}Cs spatial redistribution in the top soil layers. The portion of ^{137}Cs conserved in top layers corresponded to the meso- and micro relief elements.

The character and stability of ^{137}Cs spatial structure was studied by measuring its activity within nested plots with different steps of 5, 2, 1 and 0,2 m (the latter was a minimum resolution step for the field NaI detector). Performed measurements showed that the contamination field of ^{137}Cs had a regular structure of polycentric character and exhibited a decrease in spatial variability of contamination with the decrease of the measured area. Repeated measurements of soil contamination in successive years of 2005-2008 along and cross the slopes provided with topographic survey proved the stability of contamination field (r=0, 915, n=121, r=0,912, n=30) and its relation to the meso- and microrelief features. Variation ^{137}Cs activity in lateral direction (along the slopes and thalweg of the hollow)showed a regular character also. In our opinion the regularity in ^{137}Cs spatial structure in the soil cover may result from radionuclide redistribution with the surface and subsurface water flow highly sensitive to the changes in elevation of different scale, and to the slope length and inclination. Cs-137 lateral distribution pattern was likely to reflect alternation of lateral and vertical water mass migration along the slopes. The performed study showing regularity in ^{137}Cs redistribution seems to open new possibilities to develop the deterministic strategy in the study of contamination fields and modeling toxic elements spatial distribution in the soil cover on different scales.

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