Complex assessment of particle-bound radionuclide redistribution in the Plava River basin (Central European Russia)

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Fluvial systems are both the main routes for pollutant transportation and one of the landscape components most vulnerable to negative effects of pollution. In this research we have attempted to evaluate post-fallout redistribution of the Chernobyl-derived radioactive ^{137}Cs in the Plava River basin (Central European Russia) by means of quantification of main components of the basin-scale fluvial sediment budget. Due to its high affinity to clay minerals in finer fractions of soils and sediment, this isotope has, for a few decades, been used as a tracer of soil and sediment redistribution. It can also be used as an experimental analogue for other particle-bound pollutants, such as heavy metals, due to the similar environmental behaviour (Walling, 1999).

The Plava River basin (1856 km^2) experienced generally severe but highly variable pollution by ^{137}Cs shortly after the Chernobyl nuclear power plant explosion in 1986. Maximum initial ^{137}Cs pollution in the central part of the basin around Plavsk City exceeds 185 KBq m^{-2} (the so-called Plavsk hotspot), while in the upper and lower parts of the basin it falls to around 40 KBq m^{-2}. Therefore, the Plava River tributaries in different parts of the basin drain territories with substantially different levels of the isotope inventory. This makes it possible to apply the sediment fingerprinting approach to quantify the contribution of major sediment sources and, simultaneously, to assess post-fallout transformation of the initial spatial pattern of ^{137}Cs pollution within the basin associated with fluvial processes. Determination of the ^{137}Cs concentrations in soils at undisturbed and eroded locations, in sediments redeposited on slopes and in valley bottoms, and in suspended sediments currently transported in rivers, is based on gamma-spectrometric analyses of representative soil or sediment samples after appropriate pre-treatment (Murray *et al*., 1987).

Soil erosion on cultivated slopes was studied in detail within the most polluted left tributary basin of the Plava River – the Lokna River. It was based on a combination of morphometric mapping, soil erosion modelling and field studies at representative key sites. Additional locations within less severely polluted parts of the Plava River were also selected. Flood-plain sedimentation and associated ^{137}Cs accumulation has been studied at five sites along the Plava River valley in 2009 and (during earlier studies) at three sites along the Lokna River. Determination of the Chernobyl fallout ^{137}Cs peak in depth-incremental flood-plain sediment sections allows distinction of sediment layers deposited in 1954–1986 and after 1986. In addition, suspended and freshly deposited sediment samples were collected at a number of locations during the spring snowmelt flood in 2010 in order to characterize ^{137}Cs in the present-day suspended sediment transport. These samples currently undergo the laboratory treatment and radionuclide analyses, therefore the results are not yet available.

The presently available results show that soil erosion on arable hillslopes is the main source of sediment and associated radioactive pollution input into rivers of the studied basin. The ^{137}Cs-based estimates of modern soil redistribution rates on cultivated slopes were compared with results of soil erosion modelling. Sediment delivery ratios were determined for slopes of different morphometric characteristics and for different order valleys. It has been shown that most of the polluted sediments (up to 80–90%) remain redeposited on uncultivated slopes and in the bottoms of the small dry valleys. These form zones with locally increased ^{137}Cs inventories which can

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potentially become secondary sources of pollution in the future. Only limited amounts of polluted sediment (<10% at the basin scale) reach the main river. Measurements of depth-incremental samples yield the thickness of the post-1986 polluted sediment deposition layer along the Plava River flood plain; it varies from 12 to 36 cm.

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