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Effects of fluvial processes in different order river valleys on redistribution and storage of particle-bound radioactive caesium-137 in area of significant Chernobyl fallout and impact on linked rivers with lower contamination levels

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Detailed investigations of the post-fallout fate of radionuclide contamination represent an important task in terms of environmental quality assessment. In addition, particle-bound radionuclides such as the most widespread anthropogenic isotope caesium-137 can be used as tracers for quantitative assessment of different sediment redistribution processes. In landscapes of humid plains with agriculture-dominated land use the post-fallout redistribution of caesium-137 is primarily associated with fluvial activity of various scales in cascade systems starting from soil erosion on cultivated hillslopes through gully and small dry valley network into different order perennial streams and rivers. Our investigations in the so-called Plavsk hotspot (area of very high Chernobyl caesium-137 contamination within the Plava River basin, Tula Region, Central European Russia) has been continuing for more than 15 years by now, while the time passed since the Chernobyl disaster and associated radioactive fallout (1986) is almost 29 years. Detailed information on the fluvial sediment and associated caesium-137 redistribution has been obtained for case study sites of different size from individual cultivated slopes and small catchments of different size (2-180 km2) to the entire Plava River basin scale (1856 km2). It has been shown that most of the contaminated sediment over the time passed since the fallout has remained stored within the small dry valleys of the 1-4 Hortonian order and local reservoirs (>70%), while only about 5% reached the 5-6 order valleys (main tributaries of the Plava River) and storage of the Plava floodplain itself represents as low as 0.3% of the basin-scale total sediment production from eroded cultivated hillslopes. Nevertheless, it has been shown that contaminated sediment yield from the Plava River basin exerts significant influence on less polluted downstream-linked river system. Recent progress of the investigations involved sampling of 7 detailed depth-incremental floodplain sediment sections along the Upa River valley, which is the receiving river for the Plava and is characterized by generally much lower caesium-137 contamination within other parts of its basin. One of the sampled sections was located several kilometers upstream from the Plava River mouth and the other 6 – at different distances downstream starting from about 2 km to about 40 km. In this case we can assume the Plava River mouth to be the point-source of sediment-associated radioactive contamination additional to the initial fallout. It has been found that while at the nearest point downstream the floodplain sediment contamination by caesium-137 is about 2 order of magnitude higher, than upstream, it decreases quickly along the Upa River valley two about 3 times higher than upstream at the most remote downstream point. Importantly, the decrease is not represented by gradual and uniform curve. In contrast, it is interrupted by local increase caused by smaller tributary from relatively high contamination area. It is believed that the obtained information on decadal-scale sediment and associated post-fallout caesium-137 redistribution through the fluvial network, patterns of sinks and rate of contamination propagation into the less polluted downstream-linked river basin can be used for testing and improving the predictive models being developed for applications in other contaminated areas such as river basins around the Fukushima Daiichi nuclear power plant, providing that differences in landscape settings, hydrological regime and land use patterns are taken into account.