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Post-accidental riverine dispersion of sediments contaminated by radionuclides: confrontation of lessons learnt from Chernobyl and Fukushima case studies in catchments from Russia (1986-2009) and Japan (2011-2012)

Olivier Evrard (1), Vladimir Belyaev (2), Yuichi Onda (3), Caroline Chartin (1), Jeremy Patin (3), Irène Lefèvre (1), Sophie Ayrault (1), Nadezda Ivanova (2), Philippe Bonté (1), and Valentin Golosov (2)

(1) Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Gif-sur-Yvette, France (olivier.evrard@lsce.ipsl.fr), (2) Laboratory of soil erosion and fluvial processes, Faculty of Geography, Lomonossow State University, Moscow, Russia, (3) Department of Environmental Radionuclide Transfer, University of Tsukuba, Tsukuba, Japan

Chernobyl (1986) and Fukushima (2011) nuclear power plant accidents led to the release of important quantities of radionuclides (e.g., Cs-134; Cs-137) into the environment, and to the formation of severe contamination plumes (with initial Cs-137 activities exceeding typically 400 kBq m-2) on soils of the regions exposed to the radioactive fallout. This leads to important consequences for agriculture in strongly contaminated areas where the most affected fields should not be cultivated anymore during long periods of time, depending on the half life of the emitted radionuclides. Furthermore, sediment transfer in rivers can lead to the dispersion of radioactive contamination into larger areas over time.

In this paper, we propose a methodology to trace and model radioactive contamination in river catchments over the short (2 yrs) and the longer term (25 yr) after major nuclear power plant accidents. This methodology is established and confronted to two case studies.

The most recent study was conducted in the coastal catchments of the Rivers Nitta, Mano and Ota (ca. 600 km^2) draining the main part of the radioactive pollution plume that deposited across Fukushima Prefecture. Three field campaigns were conducted to sample riverbed sediment along those rivers after the summer typhoons and the spring snowmelt (i.e. in Nov 2011, April 2012 and Nov 2012). Based on their analysis in gamma spectrometry, we show the rapid dispersion of the inland contamination and its progressive export by coastal rivers to the Pacific Ocean. This is confirmed by measurements of the Ag-110m: Cs-137 ratio. Analysis of sediment sequences that accumulated in reservoirs of the region provides additional information on the magnitude on sediment transfers in those areas.

This rapid dispersion of radioactive contamination in Japan is confronted to lessons learnt from a case study conducted in the Plava River catchment (ca. 2000 km^2) located in the so-called "Plavsk contamination hotspot", in western Russia. We used the Landsoil expert-based erosion model, 137Cs inventory profiles and alluvial sediment core analyses to understand and quantify contaminated sediment transfer across the cultivated catchment since 1986. Our results show that soil redistribution in the fields was dominant, and that sediment eroded from cropland mostly re-deposited in dry valleys during the heaviest storms. Overall, only 15 to 25% of material eroded from the hillslopes was delivered to the river valleys. Accumulation of contaminated sediment in dry valley systems therefore constitutes a major problem 25 years after Chernobyl accident.

In conclusion, we show how the experience acquired after the Chernobyl accident contributed to facilitate the urgent analysis of sediment transfers across Fukushima Prefecture, where the possible measurement of relatively short-lived radionuclides (Ag-110m, Cs-134) provided a way to conduct a rapid quantitative assessment of contaminated sediment sources and exports.