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Assessing the impacts of land cover and land-use change on soil erosion, hydrological process, and radioactive Cesium discharge in headwater catchments in the Fukushima prefecture

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A substantial quantity of radionuclides was deposited on the surrounding environment of the Fukushima prefecture, after the Fukushima Dai-ichi Nuclear Power Plant (FDNPP) accident. Radionuclides are discharged through river systems resulting in downstream contamination of irrigation water, paddy fields, ponds, and sea. In order to reduce the effects of such contamination, the Japanese government has engaged in decontamination works. In farmland and grassland, decontamination was performed by removing the contaminated topsoil and vegetation and recovering the area with uncontaminated soil. Along with the significant reduction of radiation levels, decontamination works have contributed to a critical change in the land-use and soil properties of decontaminated areas. Several decontaminated grassland and farmland are used now as temporal storage sites for the contaminated soils. Such land-use change can influence multiple parameters that control the hydrological, soil erosion, and sediment transport processes like soil infiltration capacity, soil erodibility, surface roughness, and the local capacity to store water and sediment. In this study, we monitored the sediment, water and radioactive Cesium (137Cs) discharges, at plot and basin scale, in order to assess the impacts of land cover and land-use change on soil erosion, hydrological processes and 137Cs discharge. Two USLE-type plots with a length of 22.13 m and a width of 5 m, were installed in 2011 and 2013. Those plots present the use of a grassland area before and after the decontamination works. Four forested headwater catchments with different grassland fractions (0 %, 1.5 %, 19 %, and 23%) were selected to investigate the impacts of land cover on 137Cs discharge. In one of those catchments (the Iboishi-yama catchment), decontamination works were conducted in the grassland area in December 2013. This catchment was served as a case of study to investigate the impacts of land-use change at the basin scale. The results of the present study provide clear evidence of the sensitivity of the hydrological process, soil erosion and 137Cs discharge to the land cover and the land-use change. First, the declining trend of the dissolved (in stream water) and particulate (attached to suspended sediment or coarse organic matter) 137Cs, in the four headwater catchments, was demonstrated with a two-component exponential and a one-component exponential model, respectively. The 137Cs was mainly discharged by suspended sediments (96 $\sim$ 99 %) and the decline rate of the dissolved 137Cs was related to the grassland area extent in the different catchments. Second, we found that the decontamination works resulted in a radical decrease in the 137Cs discharge, a change in the critical radio-cesium source areas, and an increase in sediment yield and surface runoff in the Iboishi-yama catchment and the decontaminated plot. The event-based analysis of sediment flux from the Iboishi-yama catchment showed an increase in sediment yield by 5 to 8.5 times after the decontamination works. Third, the plot experiments showed a significate increase in sediment discharge ($\sim$ 40 times) after the decontamination works. Finally, the relationship between sediment and 137Cs discharge fluxes suggested the potential use of 137Cs as a good tracer of sediment source.