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Long-term trends of plot-scale Cs-137 wash-off from various land uses in Fukushima

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Understanding plot-scale Cs-137 wash-off is indispensable for predicting Cs-137 fate. However, there are only a few numbers of long-term observations and hence lack of information on temporal trends of Cs-137 wash-off leaves uncertainties on future predictions. This study shows approximately three years' observation results of plot-scale Cs-137 wash-off from various land uses after the accident of Fukushima Dai-ichi Nuclear Power Plant. Erosion plots were established in 2011 and 2013 on two uncultivated farmlands (FL-A1, FL-B1), two cultivated farmlands (FL-A2, FL-B2), three grasslands (GL-A, GL-B, GL-C) and one Japanese cedar forest (JCdF) in Kawamata town. Each erosion plot consisted of eroding surface with length of 22.13 m and width of 5 m, surface water monitoring apparatus at the outlet of eroding surface and sediment traps. Sediment traps were connected with pipes in series and it enabled us to collect deposited sediments and suspended sediments separately. Eroded sediments as well as the data of rainfall and vegetation cover were collected almost every two weeks. Collected deposited and suspended sediment were dried, weighed and measured with HPGe type gamma detectors for Cs-137 concentrations. Standardized Cs-137 concentration, Sc (m2/kg), was calculated by dividing Cs-137 concentration by initial Cs-137 deposition. Annual soil loss ranged from 0.04 to 75 t/ha/year and the largest was from FL-A2 followed by FL-B2, FL-A1, FL-B1, GL-A, GL-B, JCdF and then GL-C. Soil erosion rate were positively correlated with mean values of vegetation cover on undisturbed soils, whereas high erosion rate were found on cultivated farmlands compared with even with similar vegetation cover to uncultivated farmlands. Concentrations of Cs-137 in eroded sediments ranged from the order of 103 to 105 Bq/kg and basically depended on the initial Cs-137 deposition. Sediment amount weighted mean values Sc ranged from 0.0062 to 0.084 m2/kg and the largest was from JCdF followed by FL-B1, FL-A1, GL-A, FL-A2, FL-B2, GL-B, and then GL-C. Annual Cs-137 wash-off rate ranged from 0.003 to 9.3 %/year and the largest was from FL-A1 followed by FL-A2, FL-B1, FL-B2, GL-A, JCdF, GL-B and then GL-C. Decreasing trends of Cs-137 concentration were found on FL-A1 and FL-B1, whereas no trend was found on other plots due to constant values on FL-A2 and FL-B2 and due to variable values on GL-C, GL-B, GL-C and JCdF. These results suggest that active soil erosion results in decreasing trends of Cs-137 concentration of sediments on uncultivated slopes and that cultivation enhanced soil erosion and resulted in constant and relatively low Sc in cultivated farmlands assumedly due to mixing of surface soil by tillage. In grasslands and forest, concentrations of Cs-137 were variable and appeared to be positively correlated with ratios of amounts of suspended sediments to total amount of sediments. Although our results quantitatively demonstrated the differences in trends of Cs-137 wash-off, considering erosion processes on each land uses are still important to improve our understandings and future predictions.