Slope-scale Cs-137 wash-off processes estimated with erosion plot observations and laser-scanning

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To predict the fate of Cs-137 deposited on terrestrial due to the accidents of nuclear power plants, understanding of Cs-137 redistribution associated with sediment dynamics is important. Previous studies quantified slope-scale Cs-137 wash-off from various land uses using soil erosion plots and the results were useful for parameterizations of large-scale predictions. However, temporal trends of Cs-137 wash-off has hardly been elucidated because of lack of related long-term observations. It adds uncertainty in predictions of the fate of Cs-137. Previous studies relating to Cs-137 redistribution indicated that Cs-137 concentration of sediments and hence its redistributions depend on erosional processes on slopes, such as rill formation and deposition. Elucidating relation between soil erosion and Cs-137 wash-off processes will improve our understanding of fate of Cs-137. This study presents a Cs-137 wash-off observation and a series of morphological survey on a soil erosion plot established in area affected by the accident of Fukushima Dai-ichi Nuclear Power Plant. Based on these results, we discussed the seasonality of slope scale Cs-137 wash-off. A soil erosion plot with length of 22.13 m and width of 5 m was established on a tobacco farmland in Yamakiya district of Kawamata town on July 2011. The initial Cs-137 deposition was 370 kBq m-2 and the slope gradient was 4.4 degree on the plot. Eroded sediments were collected every one month in winter and every two weeks in other season until August of 2014. Collected sediments were dried, weighed and then served for Cs-137 measurements. Precipitation and surface runoff were also monitored. Surface soil was scanned for ten times using a 3D laser profiler during the observation. Obtained scan data were converted into 1 cm mesh DEM and the differences of the elevation were calculated by subtracting elevation values from those obtained in the previous scanned. During the observation, total amount of eroded sediment was 9.8 kg/m^2 and total Cs-137 wash-off was 107 kBq/m^2. Mean concentration of Cs-137 in eroded sediment was 13 kBq/kg with 38 % of variation coefficient. A decreasing trend in temporal variations in Cs-137 concentration was found but not significant. However, Cs-137 concentration gradually decrease from spring to autumn and it recovered as high as increased again as high as those after winter. Morphology of surface soil showed seasonality. Rill was expanded from spring to summer. There was no significant change from summer to autumn. Soil surface was elevated from winter to spring. Averaged difference of elevation was negatively correlated with amount of eroded sediment. No significant correlation was found between the average difference of elevation and Cs-137 concentration of eroded sediment. However, average difference of elevation during warm season (from spring to autumn) was negatively correlated with Cs-137 concentration of both coarse and fine sediment, whereas the positive correlation was found in winter (from autumn to spring). These relationships suggest the difference of erosion and Cs-137 processes between winter and other seasons. In winter, freezing and thawing cycles provided sediments of high Cs-137 concentration and subsequent snowmelt and rainfall could wash off the detachable sediment. In other seasons, rill was a dominant pathway for transporting sediments with relatively low Cs-137 concentration whereas intensive rainfall event expanded the contributing area of sediment with relatively high Cs-137 concentration. The results of this study suggest that Cs-137 wash-off shows seasonality and

consequently long-term observations will be necessary for more accurate predictions of Cs-137 fate.

Keywords: Laser scanning, Soil erosion, Cs-137

