Analysis of step-structure affecting Cs and sediment transport at hillslope scale

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Kawamata Town, Fukushima Prefecture was designated as a special decontamination area due to the Fukushima Daiichi Nuclear Power Plant accident in 2011, and decontamination activities were carried out in 2014. During the decontamination activities, the surface layer of 5 cm of soil with high Cs-137 concentration was stripped by heavy machinery, and coarse granitic sand was applied. In the decontaminated area, many step-structure microterracettette were observed during strong rainfall. Furthermore, the amount of sediment discharge was reduced in the decontaminated area compared to the pre-decontaminated area. Thus, it is necessary to elucidate the microterracettette structures that are considered to affect sediment transport.

This study was conducted in rainfall experiments and USLE plots (22.13 m long ×5 m wide) in Yamakiya area of Kawamata Town, Fukushima Prefecture, which is a decontaminated area, and in Tsukidate City, Fukushima Prefecture, which is an un-decontaminated area. The purpose of this study is to elucidate the Cs-137 and sediment transport process at hillslope scale by using the observation of Cs-137 and sediment discharge, surface change, and RFID (Radio Frequency IDentification) tags. Surface runoff and sediment discharge were observed at the lower end of the plot, and Cs-137 concentration and sediment discharge were measured. Surface changes were calculated from 3D data obtained by Unmanned Aerial Vehicle - Structure from Motion (UAV-SfM). The shear stress of surface flow was estimated from the distance of sediment movement with different particle sizes using RFID tags. In addition, a scraper plate survey was conducted in the microterracettette area in the un-decontaminated plot to analyze the relationship between sediment transport and Cs-137 discharge according to the depth distribution of Cs-137.

In field tests, the accuracy of the surface change map in the field test was 0.1 cm in mean error and 0.3 cm in standard deviation error compared with laser survey. The surface change showed microterracettettes above the rill erosion area during large rainfall events, and large sediment discharge was observed during these events. Microterracettettes were formed in both decontaminated and un-decontaminated plots.

In rainfall experiments, UAV-SfM survey and RFID tags were used to obtain the surface change map and the transport distance of soil particles. Two types of RFID tags were used: one with a small particle size with a median value of 2.8 mm and the other with a large particle size with a median value of 3.9 mm. Comparing the results between the agricultural and sand plots with a slope of 5°, where the slope length and slope were the same and the distance from the top of the slope at the location where the RFID tag was placed was the same, the surface change was more pronounced at the lower end of the sand plot, where rill erosion occurred. It was found that the traveled RFID tags distance was longer in the agricultural plot, suggesting that surface flow was also generated at the top of the slope.
The terracettes were shown to be formed in the middle of the inter-rill area (upper part) and the rill area (lower part). Furthermore, the terracettes were formed in a wider area in the agricultural soil plot than in

the sand plot.

In conclusion, the contribution of sediment discharge in the sand plot is linear, while that in the agricultural plot is a wider area. Furthermore, terracette is more likely to form when the slope is greater than 5° and the rainfall intensity is greater than 130 mm/hr, and terracettes are likely to form in agricultural plots. In addition, the terracette is formed in the middle of the inter-rill area (upper part) and the rill area (lower part). In addition, field tests showed that terracette can form even at low rainfall intensity, but require a certain level of flow rate.

Keywords: soil erosion, surface change, UAV-SfM, Cs-137, decontamination activity

