Soil particle tracing using RFID tags for elucidating the behavior of radiocesium on bare soil surfaces in Fukushima

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Soil particle tracing using RFID tags for elucidating the behavior of radiocesium on bare soil surfaces in Fukushima

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Radioactive materials are generally associated with soil particles in terrestrial environment and therefore the better understanding soil erosion processes is expected to improve the mitigation of radioactive risks. Spatial variability in soil erosion has been one of critical issues for soil erosion management. This study attempts to track soil particle movement on soil surfaces by employing Radio Frequency Identification (RFID) tags for the better understanding radiocesium behavior. A RFID tag contains a specific electronically identifier and it permits tracing its movement by reading the identifier. In this study, we made artificial soil particles by coating the RFID tags with cement material. The particle diameters of the artificial soil particles approximately ranged from 3 to 5 mm. The artificial soil particles were distributed in a reticular pattern on a soil erosion plot (bare soil surface, 22.13 m length $\times$ 5 m width, 4.4° slope) in Kawamata town where radiocesium deposited because of the Fukushima Dai-ichi power plant accident. After their distribution on October 2012, we had read the identifiers of RFID tags and recorded their locations on the plot for 14 times by September 2013. Moving distance (MD) was calculated based on the difference of the location for each sampling date. The topographical changes on the plot were also monitored with a laser scanner to describe interrill erosion and rill erosion area on 11occasions. Median MD is 10.8cm for all the observations. Median MD on interrill and rill erosion areas were 9.8 cm and 20.7 cm, respectively. Seasonal variation in MD was observed; an extremely large MD was found in May 2013, at the first reading after the winter season. This large MD after winter suggests that snowmelt runoff was the dominant process which transported the soil particles. Comparing the MD with the observed amounts of rainfall, sediment and runoff on the plot, significant positive correlation were found if the data of May, 2013. The coefficient of correlation with the amounts of surface runoff, sediment discharge and R-factor were 0.79 ($p < 0.05$, $n = 13$), 0.92 ($p < 0.05$, $n = 13$) and 0.79 ($p < 0.05$, $n = 13$), respectively. These positive correlations supported a possible use of RFID tag for tracking soil particles. There was a negative relationship between Cs-137 in sediment eroded from the plot and median MD ($r = -0.40$, $p > 0.05$, $n = 13$). One possible explanation for this negative relationship is that sediments on the rill area, which contain relatively low concentration of Cs-137, were discharged during intensive rainfall events and they resulted in low concentrations of Cs-137 in sediment eroded from the plot. These results suggest that the spatial distribution on Cs-137 and erosion processes should be considered for predicting radiocesium behavior even at the scale of our erosion plot.