Field Experiment for Evaluation of Long-term Behavior of Radiocesium Deposited on Land

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1. Introduction

Following the accident at the Fukushima Dai-ichi Nuclear Power Plant in March 2011, radionuclide, including radiocesium, were deposited over eastern parts of Japan. In land, most of the fallout was initially trapped by the tree canopy, some of which was then washed out by rainfall and gradually migrated into ground surfaces by throughfall and stemflow. Once radiocesium reaches the ground surface and infiltrates into the soil, especially finer soil particles such as clay and silt, the rainfall-runoff process plays an important role in its redistribution [1]. In this study, field monitoring was conducted to estimate radiocesium runoff from forest area and to simulate soil and radiocesium erosion and transport.

2. Field Experiment

The key issue in field experiments to understand soil erosion process due to rainfall is which instruments are used to measure soil splash and erosion. In literature review, most of equipment in this research is not commercially available and researchers manufacture themselves what is needed for their scientific purposes [2]. In this study, we have designed a research instrument based on the assumption that radiosecium is very strongly bound to the soil particles for long-term estimation. As shown in the figure, the equipment consists of a part that insulates about 10 cm from the surface of the soil and isolates it from the surrounding soil particles, and a tank part which collects when the inside soil is eroded by the rain. Rainfall is observed by rainfall gauges every 10 minutes. As a result, it is possible to analyze the relationship between rainfall intensity, soil particle size and weight. Two experimental equipment were built, one is on the mountain near the Korea Atomic Energy Research Institute and the other is installed on the mountain near Daejong Stream in Gyeongju. In this study, we analyzed the results of observations at KAERI.

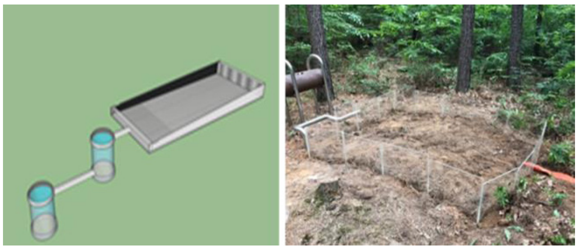

Fig. 1. Observation equipment schematic and photograph of installed equipment in KAERI.

3. Results and Discussion

Six eroded soil samples were collected from June to August 2017. The collected soil samples were analyzed for soil particle size distribution by image analysis technique.

Table 1. Observation data of rain and soil

No	D_{10}	D_{60}	C_u	Rainfall (mm)
28 June	0.0497	0.2192	4.41	14.00

3 July	0.0462	0.2471	5.35	54.20
7 July	0.0444	0.2934	6.61	75.20
17 July	0.0488	0.2574	5.27	27.30
25 July	0.0490	0.2238	4.57	9.90
1 August	0.0483	0.2348	4.86	75.20

D_{10} is termed as the effective particle size it means that 10 percent of the particles are finer. Similarly, D60 means diameter of the soil particles for which 60 percent of the particles are finer and 40 percent of the particles are coarser than D_{60}. The uniformity coefficient C_u is defined as the ratio of D_{60} by D_{10} [3]. As shown in the table 1, the uniformity coefficient is large, relatively large amount of coarser soil are contained in the soil samples.

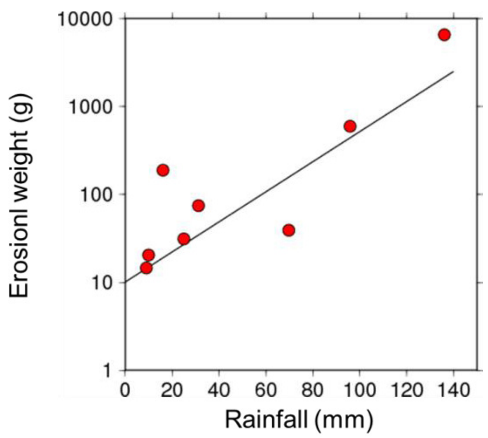

Fig. 2. Relationship between rainfall and uniformity coefficient.

Rainfall erosion is a complex process and, in reality, no absolute measure of rainfall erosivity exists. Various parameters (eg. rainfall kinetic energy) and combinations of parameters (eg. product of storm rainfall energy and the maximum 30-minute intensity) are used as indices of rainfall erosivity and, as a consequence, soil erodibility is nothing more than an empirical coefficient in the relationship between an index of rainfall and soil loss. The general form of equation used by U.S. Department of Agriculture is following

$$e_s = C_f \exp(-c_h h) r^2 \qquad (1)$$

in which C_f is a constant related to soil and surface properties, c_h represents the damping effectiveness of surface water. The parameter r is rainfall intensity; h is water layer thickness on land. The function exp() is 1.0 prior to runoff and its minimum is 0 for very deep flow. In general, the parameter C_f is known to have a value between 20 to 500 [4], in this study, the C_f of evaluation using Eq.1 was 198.3.

Future studies, we will also present a numerical model using this analysis and a river transport model for long-term evaluation.

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REFERENCES

[1] International Atomic Energy Agency, “Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments”, Technical Report Series No. 472 (2010).

[2] M. Fernández-Raga, et al., “Splash erosion: a review with unan-swered questions”, Earth-Science Reviews, 171, 463–477 (2017).

[3] A. Verruijt, “Soil Mechanics”, Delft University of Technology, 315 (2001).

[4] L. D. Meyer, et al., “Mathematical simulation of the process of soil erosion by water”, Trasactions of the American Society of Agricultural Engineers, 12(6), 754-762 (1969).