Analysis of radiocesium discharge distribution using GeoWEPP in Iitate village, Fukushima

*Seigo Fujiwara[1], Mari Saito[2], Kazutoshi Osawa[2], Hiroyuki Matsui[2]

1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2. School of Agriculture, Utsunomiya University

Background

On March 11th, 2011, a massive tsunami inundated the Fukushima Dai-ichi Nuclear Power Plant, which resulted in an enormous amount of radioactive fallout and deposition on the soil in and around Fukushima Prefecture. Radiocesium deposited on the soil is predicted to be discharged into coastal and fluvial areas during rainfall events. Especially, the half-life of radiocesium137 (^{137}Cs) is 30.2 years. Thus, the effects in Fukushima Prefecture is an ongoing, long-term issue to the local population. On April 1st, 2017, the evacuation order in Iitate Village was lifted except the difficult-to-return zone. However, few forest areas were included in the so-called rational and efficient decontamination. Thus, a large amount of radiocesium remains in upland forests on the plateau. Since most ^{137}Cs is in the depth of 0-5 (cm), the remaining radiocesium has been redistributed with water and sediment transport. The aims of this study are (i) to detect the ^{137}Cs discharge dynamics with river monitoring, which was conducted on two rivers, Mano river and Hiso river, in Iitate village, Fukushima Prefecture from 2013 to 2018 using the Geospatial Interface for the Water Erosion Prediction Project (GeoWEPP), and (ii) to identify the sources of the ^{137}Cs discharge in the watersheds.

Method

GeoWEPP fundamental data and observed data were modified to run analyses on GeoWEPP. Moreover, the data of laboratory experiments about soil erosion were collected to calibrate the estimated values by WEPP. After finishing the data processing, the calibration of effective hydraulic conductivity (K_e) and rill erodibility (K_r) was conducted. Observed and simulated streamflow and sediment yield were compared at annual and whole-simulated time step, by means of model evaluation statistics. The applied statistics were the Nash–Sutcliffe efficiency (NSE), the root mean squared error (RMSE), the percent bias (PBIAS), and the deviation of runoff volume (Dv). At last, the calculation of ^{137}Cs discharge was conducted with the influence of radioactive decay and the decontamination efforts in the residential areas and agricultural lands without the ‘difficult-to-return’ area.

Results

The study areas experienced significant variation in annual precipitation. The annual field-observed streamflow ranged from 62 in 2016 to 215 (mm) in 2015 at Mano river, 65 in 2018 to 179 (mm) in 2015 at Hiso river. In both cases, there is a maximum value in 2015 because there was a big typhoon that caused flood around Fukushima and other prefectures in Japan.

Overall, the GeoWEPP model simulation values were in good agreement with the observed values due to the calibration of streamflow and sediment yield. In terms of streamflow after K_e calibration at both rivers, evaluation results at annual and whole-simulated time step showed better or maintained close values. In the case of sediment yield after K_e and K_r calibration at both rivers, the majority of the simulated years showed ‘satisfactory’ and evaluation results for the whole-simulated years were better. Lastly, the sources of the ^{137}Cs discharge in the watersheds were determined and verified with multiple sampling ^{137}Cs discharge data.

Discussion

The ^{137}Cs discharge was adjusted with the land-use data to introduce the influence of the decontamination works. However, the land-use data are 100m×100m cell size. If there were more fine mesh land-use data, the ^{137}Cs discharge maps would be very helpful to understand the sources of the ^{137}Cs discharge.

Keywords: Radiocesium, Soil erosion, Modelling, GeoWEPP

