MAG38-17   Room:501   Time:May 2 14:45-15:00

The distributed models to predict interannual changes in inventory and discharge of rCs from river basin

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Radioactive materials emitted from Fukushima Dai-ichi Nuclear Power Plant (FDNPP) in March 11, 2011, are spreading to wide area and deposited on the ground. Abukuma mountains where vast amount of radioactive nuclides are deposited, is mostly covered by forest. Transition of radioactive nuclides arises with hydrologic and material cycles in forested mountain watershed, and the redistribution will proceed for a long time. Monitoring of the distribution and time changes in radioactive materials are necessary. At the same time, the prediction of long term behavior of radioactive materials is necessary to make use of restoration of contaminated area. The purpose of the study is to calculate erosion rate in wide area, and predict long term change in the inventory of radioactive cesium, especially cesium 137, by distributed parameter model.

Spatial resolution of the distributed model is 25m, same as aerial monitoring of dose rate and inventory maps published by MEXT. The area of calculation is the extent of 36 river catchment within the 80 km zone from FDNPP including Abukuma River Basin.

Members of USLE (Universal Soil Loss Equation) to calculate erosion rate are derived from observation in USLE plots established in different land cover in Yamakiya District, Kawamata Town, Fukushima Prefecture, by team Tsukuba University.

Land use type for each grid cels is derived from present vegetation map prepared by Ministry of Environment. Gridded land use map with 25m resolution is created from shape file of the vegetation map. Topographic parameters are extracted from 25m resolution DEM re-constructed from 10m DEM by GSJ (Geospatial Information Authority of Japan). Vegetation cover ratio map is created from MODIS NDVI datasets with 250m resolution processed by Tokyo University of Information Sciences.

Erosion rates on each grid cell are calculated and make distribution map. Erosion rate is high in crop land, and low in forested area. Average erosion rate in crop land is about 1.4 ton/ha/year, and the one in forested area is about 0.1 ton/ha/year.

The model that calculate the transition of cesium-137 is developed and the changes in the inventory from 2011 to 2041 are calculated. The erosion rate is annual value, so time step is set to one year. The eroded sediment is transported to down slope. Sediment Delivery Ratio (SDR), the ratio of transported sediment over total sediment, should be determined, however, the proper SDR is knot known, so SDR=1 is adopted in the calculation and maximum transportation rate is assumed.

The amount of cesium-137 is calculated by introducing Sc. Sc is the ratio of effluent cesium-137 (Bq/kg) over inventory (Bq/m2). Sc is determined by observations at the USLE plots of different land use. Out flowing cesium-137 is calculated by erosion rate multiplying by Sc.

The movement of debris along the slope is generally very slow, however, after the debris reach to the valley bottom, where saturation usually occur at the precipitation events, sediment is removed by flowing water. DEM is used to calculate Topographic Index (TPI) to designate the area of stream flow generation. When sediments reach to the area, cesium-137 flushes to the outlet of the watershed. In this calculation, all the cesium-137 is considered to be removed to the cell, and flushes to the outlet.

The calculation shows the average inventory of cesium-137 is about 10% lower than the one that only radioactive decay is considered. Total amount of discharge of cesium-137 at Iwanuma point, Abukuma River, is the order of 10^13 Bq in both case in the first year after the deposition of radioactive materials. Discharge of cesium-137 sharply decrease in the first years, after the sharp drop, discharge decreased in exponential form.

The result of the study is based on the empirical model, however, it considers the established knowledge in the field of stream flow generation. The results reflect the actual condition of cesium-137 transition.

Keywords: Universal Soil Loss Equation, erosion rate, radioactive cesium, inventory change, distributed model, FUKUSHIMA