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Water and radiocesium balance in several paddy fields in Fukushima

YOSHIKAWA, Seiko[1*] ; EGUCHI, Sadao[1] ; ITAHASHI, Sunao[1] ; IGURA, Masato[1] ; KIHOU, Nobuharu[1] ; FUJIMURA, Shigeto[2] ; SAITO, Takashi[3] ; FUJIHARA, Hideshi[1] ; KOHYAMA, Kazunori[1] ; YAMAGUCHI, Noriko[1] ; OHKOSHI, Satoru[3]

[1]National Institute for Agro-environmental Sciences, [2]National Agriculture and Food Research Organization, [3]Fukushima Agricultural Technology Centre

1. Introduction

By the released radionuclides from the Fukushima nuclear disaster in March, 2011, brown rice harvested at a 0.2% of paddy fields exceeded the provisional regulation value in 2011 in Fukushima. Water and radiocesium balance was studied in 3 paddy fields at different geographical sites in Fukushima to estimate radionuclides contamination in brown rice and to develope models for predicting radionuclides dynamics at watershed scale.

2. Monitoring and measurements

Field monitoring has been conducted in the following three paddy fields in Fukushima since spring in 2012. ; (1) a reorganized paddy field facing to forest in one side (clayey soil), (2) mountainous terraced paddy field surrounded by forest in three sides (sandy soil), (3) mountainous terraced paddy field surrounded by forest in three sides (organic soil). Water levels and turbidity of irrigation and drainage water in paddy fields and precipitation have been measured continuously. Water infiltration rates were measured several times during rice cultivation period in (2) and (3) fields. Water samples have been collected once a month for atmospheric precipitation, irrigation, surface drainage, subsurface pipe drainage, and seepage water on a ridge between terraced paddy fields. A membrane filter (0.025μm) was used to suspended solid (SS) and filtrate samples. The radiocesium concentrations were determined by Ge semiconductor detector after drying the SS and filtrate samples, respectively. Rice which was grown experimentally was harvested and measured its radiocesium concentrations by each part. Based on the relationship between turbidity and radiocesium concentrations, and flow rates of irrigation and drainage water, radiocesium concentration in rice plant, in/out flows of radiocesium in paddy fields were estimated for the monitoring period of one year (23rd May, 2012 ˜27th May, 2013). Radiocesium in/out flows induced by heavy rainfalls of 50˜150 mm by in July and October in 2013 were also estimated.

3. Results and Discussions

Monitored precipitation was about 800,900 and 1000mm,the estimated flow-in water (irrigation(+flow-in from spring which could be measured)) was about 300, 1300 and 3300 mm, the estimated flow-out water (surface drainage) was about 600mm, 1000mm and 7700mm for the one year in the (1), (2) and (3) field, respectively. Continuous spring-out of water was observed from side slope of the upper field in (2) and (3) fields. Infiltration and spring-out were almost same level in the surface in (2) field, however, averagely about 4 mm/day of spring-out was measured from the surface of (3) field during rice cultivation period. Furthermore, water flow-in and flow-out on the soil surface under snow and/or ice was observed in winter even in the latter part of January. Therefore, larger amount of water in/out flows were gained in the mountainous paddy fields (2) and (3) in comparison with common paddy fields located in flat areas like (1) field. Radiocesium concentrations of water samples, mainly taken at usual meteorological conditions, were 0.1-0.31 Bq/L for irrigation water, 0.02-1.4 Bq/L for surface drainage, 0.2-0.9 Bq/L for atmospheric precipitation, and 0.01-0.03 Bq/L for pype drainage. Most of the radiocesium was existent in the SS. Radiocesium inflow by irrigation, inflow by atmospheric precipitation, outflow by surface drainage, and carryout by rice harvest were 10^2, 10^2, and 10^3, and 10^2 Bq/m^2 orders in the 3 fields for the one year, respectively. Radiocesium net flow in the 3 fields for the one year was estimated to be outflow of 0.2%, 0.2%, and 0.7% to the amount of radiocesium in soil, respectively. Most of outflows of SS and radiosecium occurred at events such as puddling, transplanting, midsummer drainage, drainage, and heavy rain etc.. The heavy rainfalls in July and October in 2013 induced large amount of SS and radiocesium outflows.

Keywords: radiocesium, water balance, mountainous paddy field, suspended solid