Risk assessment of radiocesium transfer from soil to plant in decontaminated agricultural land in Tomioka, Fukushima

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After the Fukushima Daiichi nuclear power plant (FDNPP) accident in 2011, decontamination of agricultural land had been taken in highly contaminated areas in Fukushima prefecture except difficult-to-return zone. As a result, the total ^{137}Cs content in the soil surface was basically reduced to less than 5,000 Bq kg^{-1}. However, few studies have elucidated the transfer risk of ^{137}Cs from soil to plant on decontaminated field. Therefore, the objective of this study was to determine total and exchangeable ^{137}Cs content as well as plant-available K content of soil in a wide area of the decontaminated agricultural land because they are reported as important indices to predict the ^{137}Cs transfer risk.
In November 2016, 173 soil samples were collected from the plowed layer (0-15 cm depth) of decontaminated agricultural land in Tomioka town, Fukushima prefecture, Japan (N37˚20’, E141˚00’) located about 10 km south of the FDNPP. The total ^{137}Cs content in soils was determined by γ-ray spectrometry. Potassium in soils was extracted with 1 M CH_3COONH_4 and boiling 1 M HNO_3 to determine exchangeable K and boiling HNO_3 extractable K, respectively. Nonexchangeable K content was obtained by subtracting exchangeable K content from boiling HNO_3 extractable K content. For 32 samples which exceeded 2,000 Bq kg^{-1} in total ^{137}Cs content, exchangeable ^{137}Cs content in soils was also determined by γ-ray spectrometry.
Total ^{137}Cs content in soils was on average 1.2±1.0×10^3 Bq kg^{-1} in the decontaminated fields which was much lower than total ^{137}Cs content before decontamination (6,700 Bq kg^{-1}). The exchangeable K content was on average20.7±8.96 mg K_2O 100g^{-1}. Those of about 80% of soils were less than the recommended value by Fukushima prefecture (25 mg K_2O 100g^{-1}) to reduce ^{137}Cs transfer from soil to plant. Total ^{137}Cs content in soils showed a positive correlation with exchangeable K content ($p < 0.01$). This correlation indicated that decontamination to reduce total ^{137}Cs content also led to the reduction of exchangeable K content. The exchangeable ^{137}Cs content was on average 230±140 Bq kg^{-1} (value range: from 40 to 520 Bq kg^{-1}) and showed a negative correlation with nonexchangeable K content ($p < 0.05$). This negative correlation indicated that ^{137}Cs was strongly adsorbed on the soil in association with nonexchangeable K, since nonexchangeable K was basically related to the specific adsorption site for Cs. In conclusion, in decontaminated agricultural land, 1) the exchangeable K content in soil should be increased for reducing transfer risk of ^{137}Cs and 2) the nonexchangeable K content can be used as a good index to select fields with lower transfer risk of ^{137}Cs.

Keywords: Fukushima, radiocesium, soil, decontamination

