Transfer Factors of ^{85}Sr and ^{137}Cs for Rice in Three Paddy Soils from the Wolsung Area

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1. Introduction

Several nuclear power plants are operating in Wolsung area, a south-east coastland of Korea. In addition, a medium-level radioactive waste repository is under construction there. If radionuclides are released from these facilities, food crops could be radioactively contaminated, leading to human exposure to internal radiations via food consumption. There are a number of rice fields around the Wolsung nuclear sites. However, almost nothing has yet been reported on the transfer of radionuclides to rice plants from Wolsung soils. In this study, ^{85}Sr and ^{137}Cs transfer factors (TFs) were measured for the rice in three paddy soils collected around the Wolsung nuclear sites.

2. Materials and Methods

2.1 Soils studied

Three paddy soils were collected from three rice fields around the Wolsung nuclear sites. The collected soils were carried to a KAERI greenhouse for the experiments. Physicochemical properties of the soils are summarized in Table I.

2.2 Soil contamination

Soils were contained in lysimeters, which were 30 cm long, 30 cm wide and 40 cm high. Each lysimeter contained 30.4 kg air-dried soil. Of this amount of soil, 20.4 kg of soil was thoroughly mixed with a solution of ^{85}Sr and ^{137}Cs using a mixing machine 27 d before transplanting. These mixed soils were put into the lysimeters as top soils.

2.3 Plant culture

Rice seedlings were transplanted to flooded lysimeters at a density of 4 hills per lysimeter on May 22. Ear emergence started on August 9. Irrigation of the lysimeters was continued till the end of September. Disease and insect controls were made as required.

Table I: Physicochemical properties of the soils

Soil	pH	OM. (%)	Sand (%)	Silt (%)	Clay (%)	EC (cmolkg^{-1})	
						K	Ca
A	5.5	4.4	46.2	43.6	10.2	0.4	6.1
B	5.4	3.3	10.6	69.5	19.9	0.8	14.9
C	5.6	2.4	21.5	50.3	28.2	0.6	6.2

OM: Organic matter, EC: Exchangeable cation.

2.4 Sampling and Measurement

Rice plants were harvested on October 15, 146 d after transplanting. Harvested plants were air-dried for about 3 weeks and separated into three parts - straws, chaffs and brown rice. Rice straws were cut into small pieces. Plant samples for different parts were put into plastic containers for gamma spectrometry using an HPGe detector. Counting error was less than 10% in 2 σ .

2.5 Calculation of TF value

Transfer factors were calculated as follows;

$$TF = \frac{\text{Plant concentration (Bqkg}^{-1}\text{-dry)}}{\text{Soil concentration (Bqkg}^{-1}\text{-dry)}} \quad (1)$$

Decay-corrected activities for harvest day were used for the equation. The TF values were reported in means of triplicate observations

3. Results and Discussions

2.1 Values of transfer factor

The TF values of ^{85}Sr and ^{137}Cs for aerial parts of the rice plants grown in the three soils were presented in Table II. The ^{85}Sr values decreased in the order of straws > chaffs > brown rice, whereas the ^{137}Cs values decreased in the order of chaffs > straws > brown rice. For straws, the ^{85}Sr values were higher than the ^{137}Cs values in all of the three soils. However, this is not true for chaffs and brown rice. In addition, the difference between straws and brown rice was much higher for ^{85}Sr than for ^{137}Cs – by a factor of up to 40 for ^{85}Sr and

Table II: Transfer factors of ^{85}Sr and ^{137}Cs for different parts of the rice plants in three paddy soils

Plant part	Soil	Transfer factor (dimensionless)	
		^{85}Sr	^{137}Cs
Straws	A	1.1×10^{0}	2.5×10^{-1}
	B	4.2×10^{-1}	3.2×10^{-2}
	C	6.2×10^{-1}	1.6×10^{-2}
Chaffs	A	2.8×10^{-1}	4.5×10^{-1}
	B	9.7×10^{-2}	5.6×10^{-2}
	C	1.2×10^{-1}	2.1×10^{-2}
Brown rice	A	2.5×10^{-2}	1.5×10^{-1}
	B	1.6×10^{-2}	2.2×10^{-2}
	C	1.6×10^{-2}	8.1×10^{-3}

2 for ^{137}Cs. These findings may indicate a much higher mobility of radiostrontium within the rice plant than of radiocesium [1-3]. The highest values of both radionuclides having occurred in soil A may partly be attributable to the lowest soil contents of exchangeable K and Ca, analogous ions of ^{137}Cs and ^{85}Sr, respectively [4,5,6]. For ^{137}Cs, the highest organic matter content might have played a more important role in increasing its TF value in soil A [7,8].

2.2 Activity loss by plant uptake

Table III shows the percent losses of ^{85}Sr and ^{137}Cs activities from soil due to plant uptake. The activities contained in the roots and the plant bases were not considered because these parts would go back to the soil. The loss was almost negligible as it was at most 0.5%. Anyway, the percent loss was several times higher for ^{85}Sr than for ^{137}Cs and highest in soil A for both radionuclides. Of the three plant parts considered, the straws contributed about 90% and 50% of the loss for ^{85}Sr and ^{137}Cs, respectively (Fig. 1). This means that returning the straws to rice fields, a recommended agricultural practice, may reduce the loss by a factor of 10 and 2 for radiostrontium and radiocesium, respectively.

Table III: Percent losses of ^{85}Sr and ^{137}Cs activities from three paddy soils due to plant uptake

Soil	Percent loss (% of the total soil activity)	
	^{85}Sr	^{137}Cs
A	5.1×10^{-1}	2.3×10^{-1}
B	3.0×10^{-1}	4.6×10^{-2}
C	3.7×10^{-1}	1.4×10^{-2}

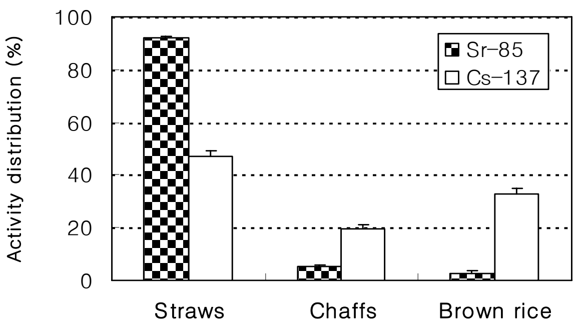

Fig. 1. Distributions of ^{85}Sr and ^{137}Cs activities among three different aerial parts of the mature rice plants.

4. Conclusions

Transfer of ^{85}Sr and ^{137}Cs to rice plants from three paddy soils collected around Wolsung nuclear sites was investigated through lysimeter experiments. The values of soil-to-plant transfer factor were considerably different between the radionuclides, among the soils and among plant parts. The loss of soil activity by the plant uptake was almost negligible. The present results could be used as site-specific data for a radiological impact assessment in the case of a paddy field contamination around Wolsung nuclear sites. However, the number of soils studied was too small for the results to sufficiently cover the soil conditions of Wolsung area. Further investigations may help enhance the representativeness of the transfer data and reduce the uncertainty in such an assessment.

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