Study on the Korean Ingestion Dose for a Hypothetical Accident by using COMIDA2

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1. Introduction

Internal exposure due to the ingestion of contaminated food is the critical information to evaluate a chronic effect following an operation of nuclear power plant (NPP) including design basis accident, and severe accident. The COMIDA2 which is a module of MACCS2 (MELCOR Accident Consequence Code System) is very often used to assess the ingestion dose for peoples by ingestion of the contaminated food as a consequences of a severe accident in a NPP.

In this study, the individual effective ingestion dose for adults was calculated by using the COMIDA2 code. The main purpose of this work is to investigate the effect of some domestic data such as food consumption rate of people and feedstuff consumption rate of livestock on the individual ingestion dose.

2. Materials and methods

2.1 Assumptions

Three radionuclides, Sr-90, Cs-137 and I-131, were considered in the calculation because of their importance for ingestion dose in severe accidents.

Nine foodstuffs were considered in the present calculation; grains, leafy vegetables, root vegetables, fruits, legumes, beef, milk, poultry, and pork.

Dose coefficients used in this calculation were taken from the ICRP Publication No.119 [1].

Wet-to-dry ratio of agricultural plant, a conversion factor from kg-fresh to kg-dry, was taken from literature [2].

Processing factor is the fraction of radioactivity that is remained in the food after processing during food preparation. This factor for leafy vegetables was assumed to be 0.5 [3], and that for other plants was assumed to be 1 with the assumption of no food processing effect.

The COMIDA code requires some time parameters regarding agricultural characteristics of the date of tillage, the start and end dates of growing crops, the start date of growing pasture, the start dates of growing hay, the start and end date of grazing livestock, day of grazing milk cow, and the release incident date. These data are summarized in Table 1 [4]. The accident was assumed to occur on August 31 (Julian day 243) to investigate the effect of ingestion dose for the deposition when the crop is almost fully developed.

Table 1. Time parameters used in calculation

Activity	*Start date (julian day)*	*End date (julian day)*
Crop growing season (for rice)	5/1 (121)	9/30 (273)
Livestock grazing season	1/1 (1)	1/1 (1)
Crop tillage	5/1 (121)	
Pasture growing season	5/1 (121)	
Hay growing season	5/1 (121)	
Release Incident	8/31 (243)	

2.2 Investigated Input Data

Individual annual food consumption rate was taken from the database from Korea Health Industry Development Institute (KHIDI). For foodstuffs considered, the average value during 2011 to 2015 was selected for consumption rate for each. To meet the assumption in COMIDA2 that 100 % self-sufficient food is consumed by people in the calculation region, the input data obtained by multiplying the self-sufficiency rate and the consumption rate is shown in Table 2.

Table 2. Individual food consumption rate for adults

Crop category	*Consumption rate (kg/yr)*
Grain	25.4
Leafy Veg.	76.5
Root Veg.	46.4
Legumes	0.6
Fruits	52.7
Subtotal	201.5
Beef	3.4
Milk	18.4
Poultry	13.3
Pork/Egg	9.4
Subtotal	54.4
Total	255.9

To reflect the contamination of animal products consumed by people, the feedstuff fraction of livestock was investigated. The data was obtained from a national statistics [5]. The feedstuff is assumed to be 100 % self-sufficient and calculated by multiplying self-sufficiency rate and feedstuff consumption rate. Since most feedstuff for domestic livestock are produced in the feed factory, the soil ingestion and the grazing are not considered in the present calculation. The feedstuff consumption rate for each livestock in Korea is shown in Table 3.

Table 3. The feedstuff consumption rate for each livestock in Korea (kg/yr)

Livestock	*Pasture*	*Hay*	*Grain*	*Legumes*	*Soil*
Beef cow	0	4.11	1.02	0.11	0
Milk cow	0	7.54	1.86	0.21	0
Poultry	-	-	0.03	0.003	0
Pork	0	0	0.55	0.06	0

3. Results

The effective ingestion doses were calculated for the unit deposition. If parameters were not described here, the COMDIA default values were used in the calculation.

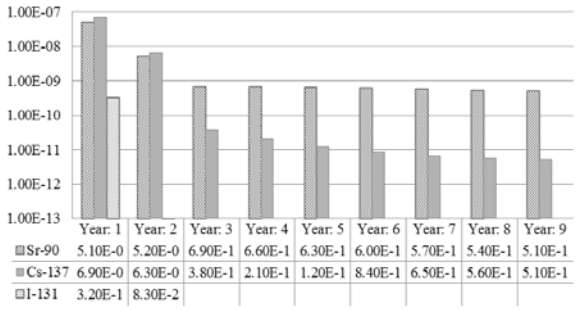

Fig. 1. Effect of Sr-90, Cs-137, I-131 on temporal individual effective ingestion dose [Sv/(Bq/m^2)]

3.1 Effect of radionuclides

For all radionuclides considered in this study, the effective ingestion dose decreased with time (Fig.1).

In the first year, the activity concentration of plants was the highest due to the direct deposition onto leaf for the growing season, and subsequently the effective ingestion dose became large.

After the second year, plants are dominantly contaminated by the root uptake. The effect of translocation, resuspension, and rainsplash appeared to be insignificant. On the other hand, the effective ingestion dose maintained still higher even in the second year because the contaminated products harvested at the first year was left over for consumption in the subsequent year.

After the third year, the effective ingestion dose seems to be similar with time. However, the decrease of ingestion dose from Cs-137 after the third year, unlike other radionuclides, came from the leaching to the fixed soil which does not affect the ingestion dose anymore. Due to the short half-life of I-131, as the degree of contamination of the third year decreased rapidly, the ingestion dose of the subsequent year was considered as negligible.

3.2 Contribution of food crops from Sr-90

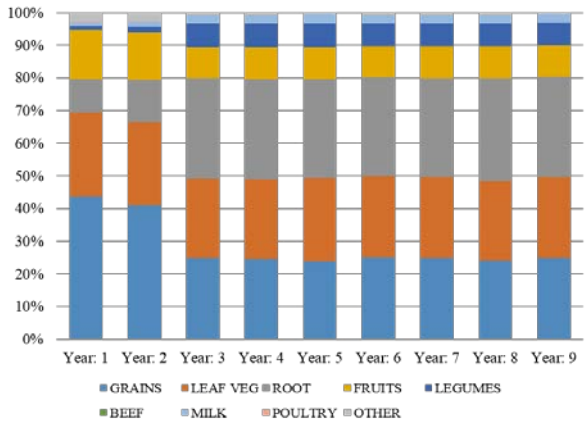

Fig. 2. Contribution of foodstuff on temporal individual effective ingestion dose contributed by Sr-90 [%]

The contribution of foodstuff on the individual effective ingestion dose for Sr-90 is shown in Figure 2. In the first year, grain was the most dominant contributor to the ingestion dose. It was affected by almost fully developed growth on release accident date.

3.3 Contribution of food crops from Cs-137

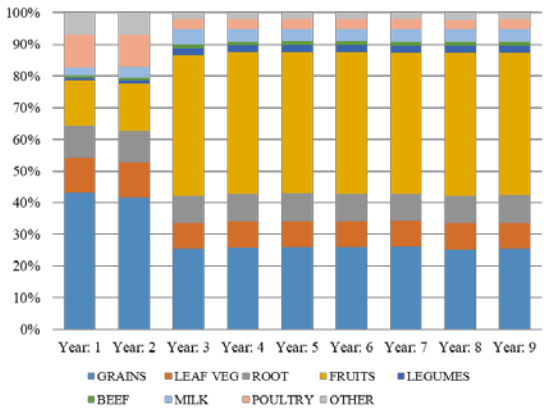

Fig. 3. Contribution of foodstuff on temporal individual effective ingestion dose contributed by Cs-137 [%]

The contribution of foodstuffs on the individual effective ingestion dose for Cs-137 is shown in Figure 3. In the first year, the dominant crop was grain (over 40 %). The reasons were same as described for Sr-90. Unlike Sr-90, the contribution of grain was decreased and the contribution of fruits was largely increased from third year. It came from the high root uptake rate of fruits.

3.4 Contribution of food crops from I-131

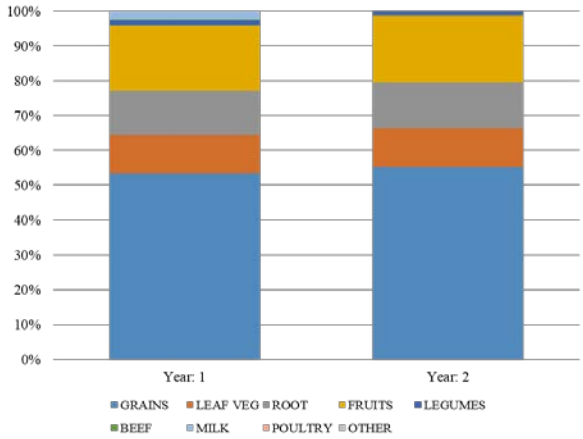

Fig. 4. Contribution of foodstuff on temporal individual effective ingestion dose contributed by I-131 [%]

The contribution by food crops for I-131 is shown in Figure 4. In the first year, the dominant crop was grain (over 50 %). The reasons were the same as described for Sr-90 and Cs-137. Since I-131 has totally short half-life, the degree of contamination is considered to be negligible and that makes the ingestion dose negligible as well.

4. Conclusions

When the radionuclides are released into the environment as the result of a severe accident, the evaluation of internal exposure due to the ingestion of contaminated food is significant. The individual effective ingestion dose for three major radionuclides, Sr-90, Cs-137 and I-131, was predicted by using the COMIDA2 code together with some domestic data, and the effect of radionuclides and foodstuff were investigated.

By the direct deposition, the activity of plants appeared to be the highest in the deposition, and after the second year the activity decreased rapidly. The degree of contamination by foliar absorption has rapidly decreased for all crops and radionuclides after the second year. The root uptake appeared to be dominant pathway to contaminate the plant after the second year.

For more reliable results, much more experimental data is required.

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