Assessment of Radiological Effect during the Growing Season of Rice at Different Times

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1. Introduction

When nuclear power plant accidents are being occurred, one of the most important factors is weather that determines the distribution of radioactive contamination. In case of Korea, there are four distinct seasons and different weather characteristics. For this reason, the ground concentration of radioactive material induced by nuclear accident should be considered in each season. As well as differences in the season, there is a difference in the concentration of each year.

In addition we consider that crops have different absorption rates of radioactive material depending on the time of the growth status. That will have an impact on how much crops contaminated by radioactive material. And we choose the rice that is the country's staple food crops that widely grown. Due to the above mentioned features, the rice plant might be easy to exposure from soil contaminated by radioactive material. That's why we choice the rice plant. And we applied absorbed rate factor to calculate absorbed material density in the rice.

The purpose of this study is to compare the results between the ground concentration of radioactive material and absorbed material density in the rice in each season.
Lastly we calculate the annual effective dose on the assumption that people eat the contaminated rice in each season from 2008 to 2010.

2. Materials and Methods

2.1 MACCS2

MACCS2[1] is used to estimate the radiological doses, health effects, and economic consequences that result from accidental release of radioactive materials to the atmosphere. And MACCS2 is consist of three module (ATMOS, EARLY, CHRONC)
In this study, ATMOS module was used to evaluate the atmospheric transport using the Gaussian plume model. This module can calculate the amount of distributed radioactive material according to the distance.

2.2 MACCS2 Input data

Since the spectrum of accidents probability occurring in a nuclear power plant is very wide, we have to select which accident scenario should be applied as the basis of determining the amount of radioactivity distribution according to the distance Because the amount of released radionuclide from the nuclear power plant is different in each accident. But what we want in this study is the radioactive material distribution season by season. So we select a specific accident that Loss of Offsite Power(LOOP) and station blackout(SBO) caused by unavailable Emergency Diesel Generator (EDG). The accident is assumed that reactor vessel is ruptured in high pressure condition of Reactor Coolant System. And we take a Kori city weather data (2008-2010). From the above condition we could determine the fraction of released radionuclide. Also the inventory of the nuclear power plant reactor is Kori power plant data.

2.3 Absorption rate

Table I: Transfer factor with different application time (m^2/kg)

Application time (DAT)	Cs-137	Co-60	Sr-90
13day	1.50E-04	3.60E-05	3.90E-04
40day	2.00E-04	4.80E-05	4.80E-04
67day	7.00E-04	3.00E-05	5.50E-04
89day	5.30E-04	4.60E-05	7.60E-04
112day	0.000052	2.60E-04	1.10E-04

Table Ⅱ: Date and DAT

Date	DAT	Date	DAT
04/28	0	07/04	67
05/11	13	07/26	89
06/07	40	08/18	112

*DAT : days after rice transplanting

Radioactive material transfer factors[2] were used from soil to seed eating part for calculate the annual effective dose. As shown in table1, cesium, cobalt and strontium have different transfer factor at different times.

$$TF = \frac{\text{The concentration of radionuclides at harbest in the rice } (\frac{Bq}{Kg})}{\text{radionuclides per unit area (decay corrected to the time of harvest}(\frac{Bq}{m^2}))}$$

2.4 Annual rice intake and Effective dose coefficient

According to the National health statistics report (2011)[3], People eat the 186.1g of the rice in a day. If people eat the rice harvested in a area contaminated by radioactive material. The amount of rice will run to 67.9Kg per year.

Table Ⅲ: Dose coefficients for ingestion

Nuclide	Physical Half-life	f_1	e(τ)
		≥ 1y	Adult
Co-60	5.27y	0.100	3.4E-09
Sr-90	29.1y	0.300	2.8E-08
Cs-137	30.0y	1.000	1.3E-08

The dose coefficients[4] were used to evaluate the annual effective dose.

Result and Discussion

Cs-137, Co-60, Sr-90 were selected as a radioactive material for evaluation that have a high generation

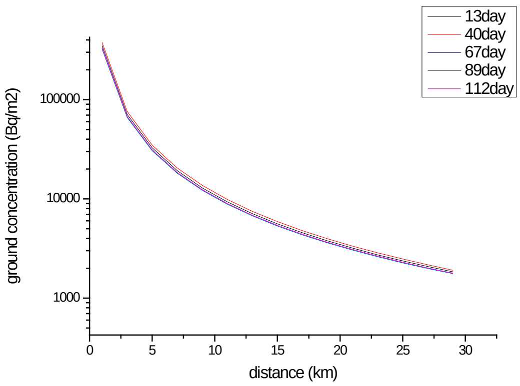

Figure1. Ground Concentration of Cs-137 in 2010

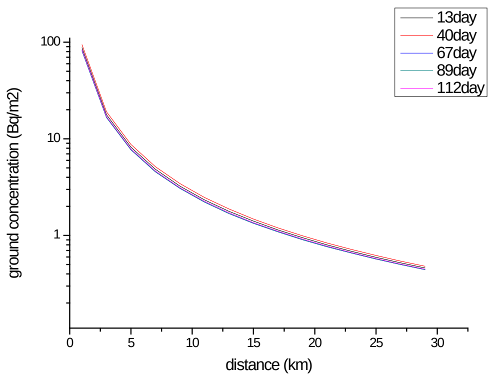

Figure 2. Ground Concentration of Co-60 in 2010

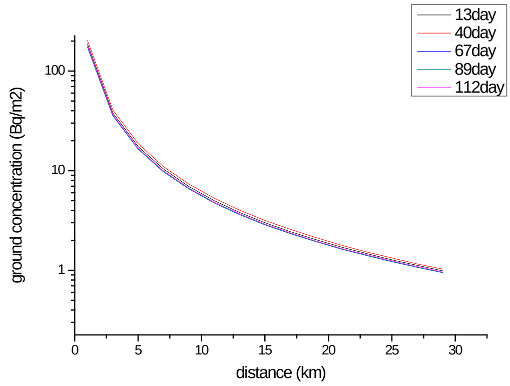

Figure 3. Ground Concentration of Sr-90 in 2010

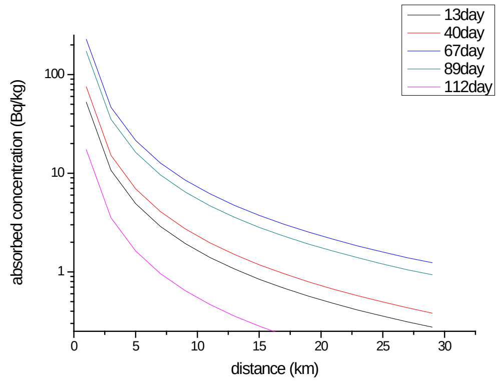

Figure 4. Absorbed radioactive material of Cs-137 in 2010

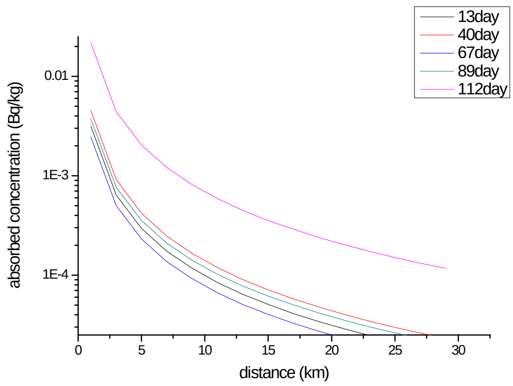

Figure 5.Absorbed radioactivity material of Co-60 in 2010

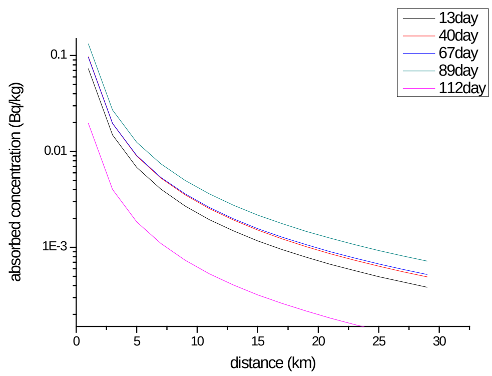

Figure 6. Absorbed radioactive material of Sr-90 in 2010

Against our expectations, The figure 1,2,3 represent that the ground concentration of radio-active material is little different in each season from 2010 weather data

Many substances have been deposited at close distance rather than far distance. And the amount of cesium was highest also generally 40days to the May have high concentration other than days.

And we applied a transfer factor to the concentration for calculate the amount of absorbed radioactive material in the rice. As shown in Figure 4,5,6 all radionuclide have different values because of different absorption factors

Table Ⅳ: Annual Effective dose in 2008 (mSv)

	distance	13day	40day	67day	89day	112day
Cs-137	1km	5.25E-02	1.85E-01	7.47E-01	7.12E-01	3.50E-02
	3km	8.86E-03	2.56E-02	1.09E-01	9.67E-02	5.87E-03
	5km	3.64E-03	1.01E-02	4.53E-02	3.45E-02	2.40E-03
Co-60	1km	8.22E-06	2.89E-05	2.09E-05	4.03E-05	1.14E-04
	3km	1.39E-06	4.01E-06	3.04E-06	5.47E-06	1.91E-05
	5km	5.70E-07	1.58E-06	1.27E-06	1.95E-06	7.84E-06
Sr-90	1km	6.31E-04	2.05E-03	2.71E-03	4.72E-03	3.43E-04
	3km	1.06E-04	2.84E-04	3.96E-04	6.41E-04	5.74E-05
	5km	4.38E-05	1.12E-04	1.64E-04	2.28E-04	2.35E-05

Table Ⅴ: Annual Effective dose in 2009 (mSv)

	distance	13day	40day	67day	89day	112day
Cs-137	1km	1.36E-01	8.49E-02	7.83E-01	2.67E-01	3.27E-02
	3km	1.95E-02	1.27E-02	1.11E-01	4.82E-02	5.01E-03
	5km	7.27E-03	5.14E-03	4.20E-02	2.10E-02	2.07E-03
Co-60	1km	2.13E-05	1.33E-05	2.19E-05	1.51E-05	1.07E-04
	3km	3.05E-06	1.99E-06	3.11E-06	2.73E-06	1.63E-05
	5km	1.14E-06	8.03E-07	1.17E-06	1.19E-06	6.74E-06
Sr-90	1km	1.64E-03	9.42E-04	2.84E-03	1.77E-03	3.20E-04
	3km	2.34E-04	1.41E-04	4.05E-04	3.20E-04	4.90E-05
	5km	8.73E-05	5.70E-05	1.53E-04	1.39E-04	2.02E-05

Table Ⅵ: Annual Effective dose in 2010 (mSv)

	distance	13day	40day	67day	89day	112day
Cs-137	1km	1.43E-01	2.69E-01	8.63E-01	7.26E-01	8.24E-02
	3km	2.39E-02	4.60E-02	1.28E-01	1.05E-01	1.16E-02
	5km	9.94E-03	1.87E-02	4.99E-02	3.91E-02	4.44E-03
Co-60	1km	5.31E-03	1.01E-02	2.67E-02	2.04E-02	2.28E-03
	3km	3.18E-03	5.94E-03	1.56E-02	1.22E-02	1.29E-03
	5km	2.26E-03	3.86E-03	1.00E-02	7.93E-03	8.57E-04
Sr-90	1km	1.56E-03	2.72E-03	7.15E-03	5.52E-03	6.24E-04
	3km	1.16E-03	2.09E-03	5.31E-03	4.02E-03	4.71E-04
	5km	9.06E-04	1.55E-03	4.06E-03	3.16E-03	3.41E-04

Lastly, we calculate the annual effective dose using by above equation from 1km to 5km. calculated annual effective dose was very low.

$$\text{Annual Effective dose} = \text{radioactive material in rice}\left(\frac{Bq}{Kg}\right) \times \text{annual intake}(Kg) \times e_{50}\left(\frac{Sv}{Bq}\right)$$

In this study, we can see that there is no distinct difference in deposited radioactive material from month to month. But Calculated Annual Effective dose have a big differences each other.

Conclusion

Calculated Effective dose around the 1,3,5 km less than Effective dose limits that 1mSv. It is not give a major impact to public. The different results could be expected, however, if the accident emitting more radioactivity was assumed. We expect that results obtained can be revised after the repeating simulation of MACCS2 with more weather data.

References

[1] M.L.young, D.chanin,Code manual for MACCS2:Volume 1,User's Guide

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[3] MISISTRY OF HEALTH &WELFARE, Korea Centers for Disease Control and Prevention, national health statistics(2011)

[4] International Commission on Radiological Protection, ICRP publication 72: Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients, Pegamon Press, Oxford, 1995