Dose Assessment of the Public in Ulsan Under Normal Operation of Nuclear Power Plants Using FLEXPART

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1. Introduction

The radionuclides are released to the environment during normal operation though the air and the water. So, the evaluation of environmental impact due to dispersion of radionuclides is needed by the Nuclear Safety Act of Korea. Gaussian atmospheric dispersion models have been used to evaluate the dispersion. However, Gaussian atmospheric models are hard to simulate the complex meteorological conditions as the distance of dispersion is increasing. The long-range atmospheric transport model needed be used to simulate the transport of radionuclides more elaborately.

The Ulsan city is the place of the highest nuclear power plant density in Korea. This city is located between the Kori and Wolsong nuclear sites. As this location, the radiological impact due to atmospheric dispersion of radionuclides from normal operation of Kori and Wolsong nuclear power plants (NPP) could be overlapped. In this research, the radiological impact of Ulsan from the both nuclear sites were simulated using the FLEXPART long-range atmospheric transport model.

2. Methods and Materials

2.1 Simulation of atmospheric dispersion

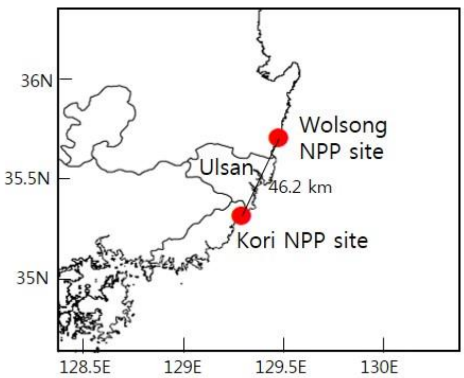

Fig. 1. The location of Ulsan city, Wolsong and Kori NPP.

Fig. 1 shows the location of Ulsan city, Wolsong and Kori NPP sites. The direction of Ulsan is N, NNE and NNW from Kori NPP site. The radionuclides were dispersed in the NPP sites. The simulation was performed using FLEXPART Lagrangian particle dispersion model [1]. The source terms of atmospheric dispersion from the report of Korea Hydro & Nuclear Power (KHNP) are shown in Table 1 [2]. The 0.5°×0.5° Global Forecast System (GFS) data from National Centers for Environmental Prediction (NCEP) in 2015 was used as meteorological data.

Table 1. The amounts of emitted radionuclides to the air [2]

	Kori	Wolsong
^{3}H	1.76E+01	1.41E+02
^{14}C	7.79E-01	9.50E-01
^{41}Ar	3.23E-02	5.19E+00
^{58}Co	8.63E-09	-
^{82}Br	9.66E-07	-
^{85}Kr	1.50E+00	5.45E-02
^{95}Nb	-	4.95E-08
^{131m}Xe	1.36E-02	4.94E-04
^{133}Xe	3.31E+00	1.63E+01
^{135}Xe	2.24E-05	3.26E-01
^{131}I	7.27E-08	2.44E-05
^{132}I	1.37E-05	-
^{133}I	2.36E-07	-

2.2 Dose calculation

The cloud shine and inhalation pathways are considered for dose calculation. The effective dose from cloud shine pathway through external exposure of radiation in the air was calculated as the equation (1):

$$E^{clo} = \sum C \cdot DC_{clo} \cdot (1 - F_{ind} + F_{ind} \cdot F_{loc}) \quad (1)$$

where E^{clo} is the effective dose, C is the air concentration of radionuclide, DC^{clo} is the effective dose coefficient of cloud shine [3], F_{ind} is the indoor time fraction of 0.66, and F_{loc} is the dose reduction factor of 0.4 for indoors.

The effective dose of inhalation of radionuclides in the air was calculated as:

$$E^{inh} = \sum C \cdot V \cdot DC_{inh} \qquad (2)$$

where E^{inh} is effective dose through inhalation, C is the air concentration of radionuclide, V is the breathing rate, DC_{inh} is the dose conversion coefficients [4].

3. Results & discussion

The total effective dose from cloud shine and inhalation pathways were shown in Table 2. The direction of N, NNE and NNW from the Kori nuclear site are the location of Ulsan. The effective dose of individual was the highest in 5 km and N direction from Kori as 3.8E-5 mSv.

Table 2. Effective doses as the direction and distance from the dispersion of Kori nuclear site (mSv)

Distance(km)	Direction		
	N	NNE	NNW
5	3.8E-05	3.5E-05	2.9E-05
10	1.8E-05	2.4E-05	1.7E-05
15	1.1E-05	1.3E-05	1.0E-05
20	6.0E-06	5.0E-06	5.0E-06
30	3.0E-06	4.0E-06	4.0E-06
40	3.0E-06	4.0E-06	3.0E-06

Table 3. Effective doses as the direction and distance from the dispersion of Kori and Wolsong nuclear sites

Distance(km)	Direction		
	N	NNE	NNW
5	4.7E-05	4.5E-05	3.8E-05
10	4.5E-05	5.5E-05	3.7E-05
15	3.0E-05	3.6E-05	2.8E-05
20	4.8E-05	8.1E-05	4.3E-05
30	6.9E-05	1.2E-04	4.6E-05
40	6.2E-06	2.7E-04	3.3E-05

Table 3 shows the effective doses as the direction and distance from the Kori nuclear site through the dispersion of Kori and Wolsong NPP. The effective doses were increased as the dispersion of Wolsong was considered. The location of NNE direction with 40 km was the highest because that location was 5 km far from the Wolsong NPP.

Although both dispersions from normal operation of Kori and Wolsong were considered, the effective doses were not exceed the 1 mSv which is the public dose limit.

4. Conclusion

The radiological impact in Ulsan due to the normal operation of both Kori and Wolsong was considered in this research because of the close distance from the nuclear sites using the atmospheric simulation. The highest effective dose was 2.7E-4 mSv which satisfied the legal limit.

The exposure from ground shine and ingestion pathways were not considered in this study. To calculate the effective doses of public more accurately, all the exposure pathways needed to be considered in the future research.

ACKNOWLEDGMENTS

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning(KETEP) and the Ministry of Trade, Industry & Energy(MOTIE) of the Republic of Korea (No. 20151520302120).

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