Uncertainty Analysis on the Health Risk Caused by a Radiological Terror

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1. Introduction

When an intentional release of radioactive materials occurs in an urban area, air quality for radioactive materials in the environment is of great importance to take action for countermeasures and environmental risk assessments. Atmospheric modeling is part of the decision making tasks and that it is particularly important for emergency managers as they often need to take actions quickly on very inadequate information. In this study, we assume an ^{137}Cs explosion of 50 TBq using RDDs in the metropolitan area of Soul, South Korea. California Puff Model (CALPUFF) is used to calculate an atmospheric dispersion and transport for ^{137}Cs, and environmental risk analysis is performed using the Monte Carlo method.

2. Method & Result

2.1 Risk assessment

Toxic materials may enter the body in different ways and these ways are called the route of exposure. Three specific intake routes for radioactive materials are generally considered: inhalation, ingestion, and skin contact[1]. The most common route of exposure is through inhalation, and inhalation is mainly considered in this study. Estimates of exposure concentrations are recommended to be based on actual monitoring data such as air pollutant concentrations for ^{137}Cs, when accidental or intentional releases have occurred. But it is not easy to monitor at the spot in reality therefore, we use the results from computer modeling for the radioactive materials. The potential health risks for the public associated with toxic materials can be assessed by risk coefficients recommended by US EPA[2]. These coefficients provide numerical factors for use in estimating the risk of cancer from the exposure to radaionuclides. The risk coefficients can apply to an average member of the public, in the sense that estimates of a risk are averaged over the age and gender distributions of a hypothetical closed stationary population. There are two health risk coefficients: a mortality risk coefficient and a morbidity risk coefficient. The mortality risk coefficient is an estimate of the risk to an average member of a population of dying from cancer as the result of an intake of a radionuclide. And the morbidity risk coefficient is a comparable estimate of the average total risk of experiencing a radiogenic cancer, whether the cancer is fatal or not. Mortality and morbidity risk coefficients for ^{137}Cs inhalation are used to analyze health risks in this study. Estimating potential human risks and health effects of radionuclides in inhalation involves the use of large amounts of data and the use of dispersion models for estimating air concentrations for target isotopes. Therefore, uncertainty analysis is needed to quantify the risks and to give more specific information on risks for the decision makers. The Monte Carlo simulation is used to analyze the uncertainty of risks caused by inhalation of ^{137}Cs. This Monte Carlo simulation is often used when the risk equation is complex, nonlinear, or involves more than just a couple of uncertain or varying parameters dependent on scenarios.

2.2 Uncertainty analysis

Fig. 1 shows the time-varying concentrations for ^{137}Cs at the position where the maximum concentration occurred. Total activities can be obtained by the integration of the curves. The mortality and morbidity are 6.32E-5 and 9.25E-5, respectively in case of the 7.5m plume-rise scenario.

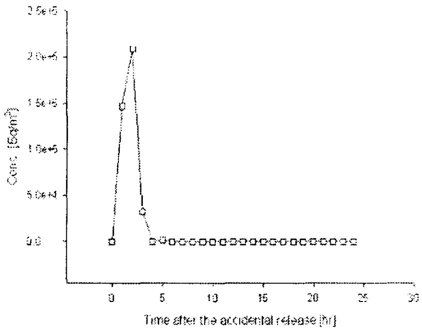

Fig. 1. Time-varying concentrations for ^{137}Cs after the accidental event

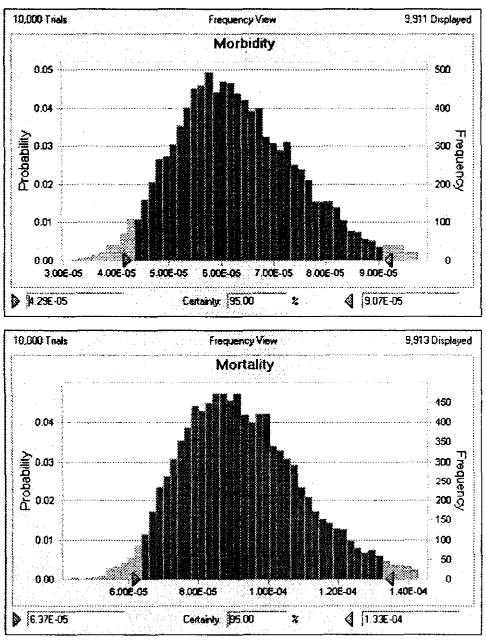

Fig. 2. Frequency distributions for morbidity and mortality caused by ^{137}Cs inhalation

This means that about 6.32 persons among 100,000 persons could die and about 9.25 persons among 100,000 persons could fall ill caused by the ^{137}Cs inhalation. This radiological risk for ^{137}Cs such as morbidity and mortality presents single-point, or deterministic estimate of risk caused by inhalation. But the uncertainty for these estimates can be several orders of magnitude because of the variation of the input variables; air concentration, breathing rate and risk coefficients. To analyze uncertainty for risks of 7.5m plume-rise scenario, input variables for the risk calculation were assumed as probability distributions. The input of air concentration was assumed as a lognormal distribution and the standard deviation for the distribution was set to as 20% value for the air concentration. The other inputs of breathing rate and risk coefficients were assumed as normal and triangular, respectively, while the standard deviations for the distributions were set to as 10% value for each deterministic value. Fig. 2 shows the result of Monte Carlo simulation of morbidity and mortality. 95% confidence interval for morbidity was from 4.31E-5 to 9.08E-5, and mortality was from 6.37E-5 to 1.33E-4 respectively.

3. Conclusions

Atmospheric dispersion modeling and uncertainty analysis were carried out to support the decision making in case of radiological emergency events. The risk caused by inhalation is highly dependent on air concentrations for radionuclides, therefore air monitoring and dispersion modeling have to be performed carefully to reduce the uncertainty of the health risk assessment for the public.

4. Acknowledgement

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5. References

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[2] US EPA. Cancer risk coefficients for environmental exposure to radionuclides, Federal guidance report. No. 13, 1999