Review of Radiological Impact Assessment Model in Disposal of NORM Waste

Do Yeon Lee, Seong Yeon Lee, Hyun Jun Na, Seong Hun Jeon, Kwang Pyo Kim*
Nuclear Engineering Dep.t, Kyung Hee Univ., Gyeonggi-do, Korea
**Corresponding author: kpkim@khu.ac.kr*

1. Introduction

Naturally occurring radioactive material (NORM) industries deal with a variety of raw materials such as phosphate, titanium dioxide, and zircon. In this process, by-products and residues such as sludge and scale are generated. The IAEA has mentioned that the wastes generated from the operation of NORM industries may cause radiological impacts on residents near the industries. Also, the IAEA has mentioned that radiological impacts on workers occur during the waste disposal process.

Recently, concerns about the radiological impacts of NORM waste such as radon beds have increased in Korea. Accordingly, the Ministry of Environment announced legal standards for disposal of natural radioactive product waste. However, in Korea, a standard assessment model for radiological impacts in disposal of NORM waste has not yet been clearly established. Therefore, it is necessary to develop the standard assessment model.

The objective of this study is to investigate the model for the assessment of radiological impacts related to NORM waste. For this, we investigated the literature related to the radiological impact assessment model for NORM waste disposal presented by IAEA, EC, and NRC.

2. Analysis of Exposure scenario

The IAEA presents 10 major exposure scenarios [1]. And each exposure scenario considers external exposure, internal exposure through inhalation, and internal exposure through ingestion. Among the 10 major exposure scenarios, exposure scenarios related to the disposal of NORM waste include a landfill worker scenario and a landfill nearby resident scenario. The landfill worker scenario assumes unintentional intake of radioactive material. In the case of residents nearby landfills, exposure pathways assumed that radioactive material is deposited on nearby crops due to the landfill facility and that residents ingest the deposited crops. However, the pathways are exceptionally not considered for external exposure.

The EC presents 8 worker scenarios and 4 resident scenarios [2]. And each exposure scenario considers external exposure, internal exposure through inhalation, and internal exposure through ingestion. Among the exposure scenarios considered by the EC, exposure scenarios related to the disposal of NORM waste include a landfill disposal worker scenario and a landfill nearby resident scenario. The landfill disposal worker scenario includes NORM residue disposal such as landfill surface profiling, as well as normal work procedures in the landfill operation process. Landfills generally cover the contaminated material with a cover layer to prevent the spread of radioactive material into the surrounding facility. However, in the scenario of residents nearby landfills, landfills not covered with a cover layer are assumed. In addition, it is assumed that landfill waste contains various types of undiluted NORM materials, and a conservative estimate is made for nearby residents.

The NRC presents exposure scenarios by dividing them into landfill, incineration, and recycling [3]. And each exposure scenario considers external exposure, internal exposure through inhalation, and internal exposure through ingestion. Among the exposure scenarios presented by the NRC, exposure scenarios related to the disposal of NORM waste can be landfill and incineration. The scenarios related to landfill are considered similarly to those of the aforementioned institutions. However, in addition to this, the NRC presents scenarios for residents nearby the landfill and residents on the landfill site after the landfill operation is closed. The scenarios assume that after the operation of the landfill is completed, it is used for public facilities such as parks and golf courses, and for housing. In the case of residents on the site after the operation of the landfill, most houses do not have privately owned fields or gardens, so exposure pathways due to food intake are exceptionally excluded. In the case of nearby residents after the operation of the landfill was closed, only drinking water intake was considered as an exception because a lot of time had elapsed. Scenarios related to incineration are largely divided into scenarios for waste collector, incinerator workers, and residents near the incineration plant.

Table 1: Comparison of exposure scenarios

	Exposure scenario	
IAEA	· Landfill worker · Landfill nearby resident	
EC	· Landfill disposal worker · Landfill nearby resident	
NRC	Disposal in municipal landfills	· Waste collectors · Landfill worker · Offsite members of the public following landfill closure · Future onsite resident at landfill
	Disposal in municipal incineration	· Waste collector · Incinerator worker · Offsite members of the public

3. Analysis of exposure factors in the assessment model

The radiological impact assessment model presented by the IAEA, EC, and NRC was different for each exposure pathways. the differences appeared for some exposure factors in the same exposure pathways.

In the case of the external exposure model, the IAEA and EC consider exposure time, dilution factor, and decay time, etc. And the NRC considers the number of landfills in operation, the weight of waste, the shielding of heavy equipment, and the fraction of exposure.

In the case of the internal exposure model by inhalation, the IAEA considers the inhalation rate, dust concentration, and specific activity concentration, etc. EC considers the effective dust concentration, coefficient of active concentration of inhalable dust, etc. The NRC considers atmospheric mass loading of waste, inhalation fraction, etc.

In the case of the internal exposure model by ingestion, the IAEA considers the annual intake, specific activity concentration, and transfer coefficient, etc. The EC considers intake rate, exposure time, etc. The NRC considers the intake rate of waste and the amount of waste.

Table 2 shows a Comparison of exposure factors in radiological impact assessment model. In addition, in the case of dose coefficient considered in all pathways, IAEA and EC used ICRP 72 and 68 as dose coefficient. However, NRC used FGR 11 suggested by EPA as a dose coefficient. Therefore, the exposure factors of each exposure model were found to be different from each other.

4. Conclusion

In this study, we investigated the NORM waste-related assessment model proposed by international organizations and foreign organizations. For this, we investigated IAEA, EC, and NRC literature. As a result of the investigation, each institution assumes different exposure scenarios and exposure pathways. Accordingly, it was confirmed that the composition of the exposure factors of each model was different. Therefore, it is expected that it is necessary to select a model suitable for the assessment purpose and target. The results of this study can be used as background data when developing a standard assessment model for radiological impacts in the disposal of natural radionuclide-containing waste.

ACKNOWLEDGMENTS

This work was supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KoFONS) using the financial resource granted by the Nuclear Safety and Security Commission (NSSC) of the Republic of Korea (No. 2105035).

REFERENCES

[1] IAEA Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance, SAFETY REPORTS SERIES No. 44, 2005

[2] EC, Practical Use of the Concepts of Clearance and Exemption – Part II, Application of the Concepts of Exemption and Clearance to Natural Radiation Sources, EC Radiation Protection 122, 2001.

[3] NRC, Systematic Radiological Assessment of Exemptions for Sources and Byproduct Materials, NUREG-1717, 2001.

Table 2: Comparison of exposure factors in radiological impact assessment model

Pathway	IAEA	EC	NRC
External Exposure	· Radiation dose rate · Exposure time · Dilution factor · Decay time · Decay time before exposure · Decay time after exposure	· Average dose rate during the year of exposure · Exposure time · Dilution factor · Decay time	· Number of waste landfills · Weight of waste · Fraction of exposure · Coefficient of shielding of heavy equipment · DCF for external exposure
Internal Exposure (Inhalation)	· Dose coefficient · Dilution factor · Exposure time · Decay constant · Inhalation rate · Concentration of dust · Specific activity concentration	· Dose coefficient · Exposure time · Inhalation rate · Coefficient of active concentration of inhalable dust · Effective dust concentration	· Number of landfill sites · Weight of waste · Atmospheric mass loading of waste · Inhalation fraction · Inhalation rate of workers · Exposure time of workers · DCF for inhalation exposure
Internal Exposure (Ingestion)	· Dose coefficient · Dilution factor · Annual intake · Exposure time · Decay constant · Specific activity concentration · Transition coefficient	· Dose coefficient · Intake rate · Exposure time	· Number of landfill sites · Amount of waste · Waste intake rate · Exposure time of workers · DCF for ingestion exposure