Assessment of Radiation Dose Resulting from Liquid Effluent Based on Representative Person Concept

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1. Introduction

When operating a nuclear power plant, radioactive effluents are generated and cause radiation exposure to public. Therefore, for operating nuclear power plant, the licensee of the nuclear power plants assesses the radiation doses and confirm that the radiation dose of public is not significant. Also Nuclear Safety and Security Commission (NSSC) set a notice to manage radiation dose to the public resulting from the radioactive effluent from nuclear power plant[1].

In current domestic regulation system, the maximum individual concept which is recommended by Nuclear Regulation Commission (NRC) is accepted to assess radiation dose of public. The International Commission on Radiological Protection (ICRP) published the ICRP 101 report and recommended applying the concept of representative person to reasonably assess radiation doses to the public[2]. However, representative person concept was not accepted in the current regulation system. Therefore, the representative person concept will be applied in regulation system.

The objective of the present study is to assess radiation dose resulting from liquid effluent using the representative person concept. Therefore, this study conducted dose assessments for critical groups residing around actual nuclear power plants. Especially, in the case of habit data, a 95 percentile value was applied for the main exposure pathway and an average value was applied for other exposure pathway.

2. Material and Methods

2.1 Representative Person

ICRP defined a representative person as the concept of a person representing people exposed in high level in a group. This corresponds to the average member of the critical group previously recommended by the ICRP. The critical group location should be where the actual person can exist. ICRP recommended that 95 percentile values should be used for the dominant exposure pathways and lower values should be applied for other pathways to perform dose assessment for the representative person. It is also recommended that radiation doses should be assessed by applying three age groups when applying the representative person concept.

2.2 Source Term

The emission of liquid effluent was assumed for this study (Table 1). The emission rate was assessed by PWR-GALE code with value of APR-1400 Design Control Document (DCD). Assumed liquid effluent can be classified into particle-based sources and Iodine.

Table 1: Source term of liquid effluent (TBq/y)

Nuclide	Emission Activity	Nuclide	Emission Activity
Na-24	7.03×10^{-5}	Rh-106	2.29×10^{-3}
P-32	6.66×10^{-6}	Ag-110m	7.77×10^{-5}
Cr-51	2.22×10^{-4}	Ag-110	4.07×10^{-6}
Mn-54	1.81×10^{-4}	Sb-124	1.59×10^{-5}
Fe-55	3.00×10^{-4}	Te-129m	3.26×10^{-6}
Fe-59	8.88×10^{-5}	Te-129	2.29×10^{-6}
Co-58	4.07×10^{-4}	Te-131m	3.66×10^{-6}
Co-60	5.18×10^{-4}	Te-132	7.40×10^{-6}
Ni-63	6.29×10^{-5}	Cs-134	4.07×10^{-4}
Zn-65	1.30×10^{-5}	Cs-136	1.44×10^{-4}
W-187	5.18×10^{-6}	Cs-137	5.92×10^{-4}
Np-239	8.14×10^{-6}	Ba-137m	1.55×10^{-5}
Sr-89	5.92×10^{-6}	Ba-140	1.67×10^{-4}
Sr-90	8.14×10^{-7}	La-140	1.81×10^{-4}
Sr-91	9.62×10^{-7}	Ce-141	1.11×10^{-5}
Y-91	3.33×10^{-6}	Ce-143	7.03×10^{-6}
Y-93	1.07×10^{-6}	Pr-143	2.41×10^{-6}
Zr-95	4.81×10^{-5}	Ce-144	2.44×10^{-4}
Nb-95	7.70×10^{-5}	Pr-144	9.99×10^{-5}
Mo-99	2.81×10^{-5}	I-131	9.99×10^{-5}
Tc-99m	2.07×10^{-6}	I-132	2.66×10^{-5}
Ru-103	1.44×10^{-4}	I-133	1.26×10^{-4}
Rh-103m	1.37×10^{-4}	I-134	9.25×10^{-7}
Ru-106	2.63×10^{-3}	I-135	8.51×10^{-5}

2.3 Exposure Scenarios and Exposure Pathways

In order to establish a representative person concept for assessing public dose around the nuclear power plant, critical group should be defined. In order to define a critical group, an exposure scenario which is suitable to exposure scenario must be established and selected. In this study, five exposure scenarios were set up: (1) agricultural residents, (2) fishery residents, (3) industrial workers, (4) 10-year residents, and (5) 1-year residents, considering the characteristics of residents living around nuclear power plant. The scenarios for residents were segmented by occupation and age group. Additionally, industry workers represented the exposure scenario of residents living in external area but commuting to area around nuclear power plant.

The exposure pathways of the liquid effluent considered in this study were referred to the exposure pathways given in the Regulatory Guide 2.2 of the Korea Institute of Nuclear Safety (KINS)[3]. Four pathways of exposures were considered: (1) external exposure due to boating, (2) external exposure due to shoreline activity, (3) external exposure due to swimming (4) internal exposure due to ingestion of aquatic products.

2.4 Radiation Dose Assessment

Critical group was selected that were most likely to be exposed for each exposure scenario. Radiation dose conversion factors for internal exposure were referred to ICRP 72[4]. Radiation dose conversion factors for external exposure were referred to FGR-15, which is the latest dose conversion factors presented in EPA[5].

The ingestion rate given in the KINS report was used for the radiation dose assessment[6]. The 99 percentile value should be used for all habit data if the maximum exposure individual concept is applied to perform dose assessments. However, in this study, 95 percentile values were used for the dominant exposure pathway. Also average values were used for other exposure pathways in accordance with the definition of representative person presented by the ICRP. The dominant exposure pathways were selected as shellfish group and mollusca group pathways. Also shoreline activity is dominant exposure pathway that using 95% value. In the case of bioaccumulation factor, we used the value that presented in IAEA[7].

3. Result and Discussion

Table 2, 3 show the results of dose assessment by exposure scenarios and exposure pathways considered in this study. The radiation dose of the representative person was 3.48 μSv/y for the 1-year residents. The results are approximately 10% lower than 3.81 μSv/y which is assessed as maximum exposure individual concept.

Table 2: Representative person dose assessment results (μSv/y) (1/2)

Exposure Pathway	Agricultural Residents	Fishery Residents
Boating	9.95×10^{-6}	1.72×10^{-4}
Shoreline activity	3.38×10^{-2}	3.73×10^{-1}
Swimming	1.62×10^{-5}	3.38×10^{-5}
Ingest aquatic product	1.01×10^{0}	1.01×10^{0}
Total	1.05×10^{0}	1.38×10^{0}

Table 3: Representative person dose assessment results (μSv/y) (2/2)

Exposure Pathway	Industrial Workers	10-year Residents	1-year Residents
Boating	9.95×10^{-6}	4.80×10^{-6}	3.40×10^{-6}
Shoreline activity	3.38×10^{-2}	2.52×10^{-2}	1.19×10^{-2}
Swimming	1.62×10^{-5}	2.70×10^{-5}	3.03×10^{-5}
Ingest aquatic product	1.01×10^{0}	2.00×10^{0}	3.46×10^{0}
Total	1.05×10^{0}	2.03×10^{0}	3.48×10^{0}

4. Conclusion

In this study, the concept of representative person was applied to assess the public dose assessment of liquid effluent. The result indicated that the dose for the 1-year residents was derived the highest at 3.48 μSv/y. The result of this study can be used as a prior study for the introduction of representative person concept recommended by ICRP 103 in Korea in the future.

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