Development and Qualification of Radiation Monitoring System for Water

Jang-Guen Park[1], Jinho Moon[1], Sung-Hee Jung[1,*], Daemin Oh[2], Sungwon Kang[2], Youngsug Kim[2]

[1]*Korea Atomic Energy Research Institute, 111, Daedeok-daero 989, Yuseong-gu, Daejeon, Korea (Republic of), 34057*
[2]*Korea Institute of Civil Engineering and Building Technology, 283, Goyang-daero, Ilsanseo-gu, Goyang-si, Gyeonggi-do, Korea (Republic of), 10223*

[*]*Corresponding author: shjung3@kaeri.re.kr*

1. Introduction

Water is one of the most important natural resources and has to be prevented from any contaminations. In particular, small amounts of artificial radioactive materials with long half-life such as ^{137}Cs which can be generated by an accident of nuclear facilities could cause radioactive contamination in water, extensively. The interest in the radioactive contamination issues have been increasing all over the world since the Fukushima nuclear facility disaster in Japan, and various radiation monitoring system has been developed to monitor radioactive concentration in air. However, it is still a challenge to monitor radiation in water due to its detection distance, supply of electric power, water-proof design, and so on [1-4]. Recently, researchers at the Korea Atomic Energy Research Institute (KAERI) have developed an underwater radiation monitoring system to detect ^{137}Cs (662 keV) and ^{131}I (364 keV), which are produced by nuclear fission. The monitoring system is designed to float on the water by buoy and use solar panel for self-powered operation.

In this study, various experiments and simulations were carried out to evaluate the minimum detectable activity (MDA) and the activity conversion factor to operate the system for ^{137}Cs and ^{131}I. The MDA is the smallest amount of radioactivity that can be reliably detected, and the conversion factor is for converting units from counts into Bq/L.

2. Methods and Results

2.1 Experimental set-up and conversion factor

Fig. 1 shows the structure of water-proof detector system and experimental set-up with 3″ × 3″ NaI(Tl) detector which is also used in the underwater radiation monitoring system. The tank was filled with approximately 5.3 tons of water and the detector system was placed in the middle of the water tank. After injecting ^{68}Ga (511 keV) source, the water was mixed with the source homogeneously by a water pump, then the radiation emitted from the source was recorded. The average activity of the source during the experiments was measured as 2.4 kBq/L. Simulations were also

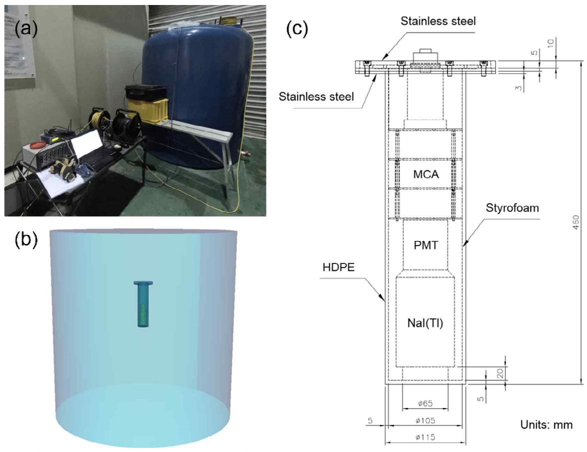

Fig. 1. (a) experimental set-up, (b) simulation geometry, and (c) structure of water-proof detector system.

carried out using Monte Carlo N-Particle (MCNP) 6 program under the same condition as the experiment [5], and the energy spectrum obtained by simulation and experiment was compared (Fig. 2). As shown in Fig. 2, both spectrums correspond to each other equivalently within the photo-peak area of ^{68}Ga. The difference within the low-energy area was occurred due to ^{99m}Tc (140 keV) source which was used before this experiment. Based on this results, simulation data for

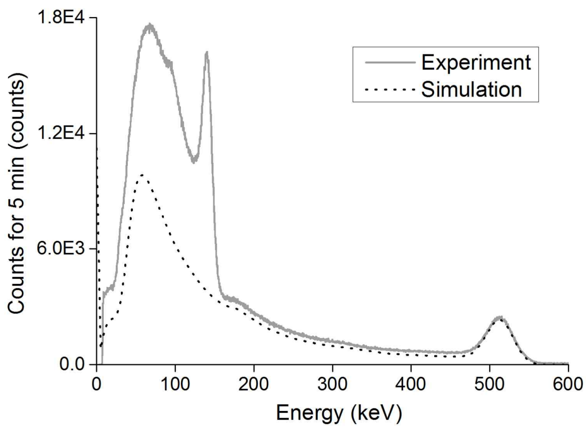

Fig. 2. Energy spectrum comparison between experiment and simulation.

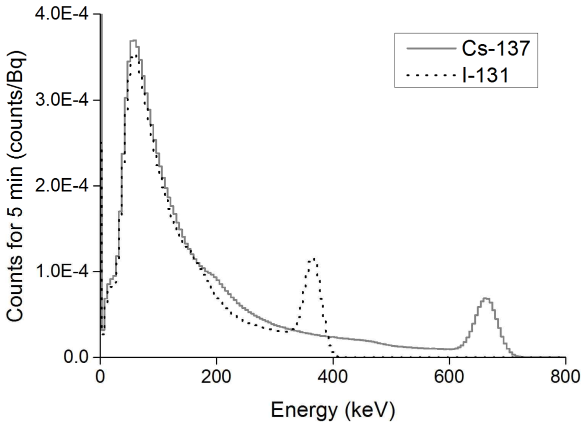

Fig. 3. Calculated energy spectrum obtained by simulations.

^{137} Cs and ^{131}I were obtained and the conversion factor were calculated to be 1.86E-02 (Bq/L)/count for ^{137}Cs and 1.38E-02 (Bq/L)/count for ^{131}I by counting the data within photo-peak area, respectively.

2.2 Minimum detectable activity (MDA)

The MDA in counts unit can be calculated by counts within photo-peak area from the background energy spectrum. The background energy spectrum was measured using the detector system in water tank without any source (Fig. 4). The MDA in Bq/L unit were obtained by multiplying the conversion factors and it turned out to be 0.83 Bq/L for ^{137}Cs and 0.95 Bq/L for ^{131}I.

3. Conclusions

In this study, some experiments and simulations were carried out to obtain the conversion factor and MDA of ^{137}Cs and ^{131}I sources for radiation monitoring system for water. Although the 137Cs and 131I sources were not used during experiments due to radiation regulations, the values were obtained based on the simulation data. The values will be utilized for operating the radiation monitoring system for water.

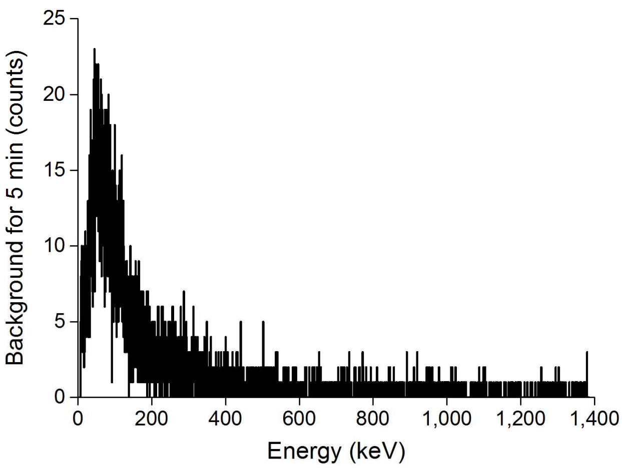

Fig. 4. Background energy spectrum in water.

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