Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 19-20, 2022

A study on the safety of radiation exposure dose through local products around Fukushima nuclear accident

Sangbok Lee[a*], Hyunchae Lim[b*], Jeongsoo Park[a], Seokhwan Lee[a], Kwanggyun Choi[a], Kangmun Shin[b], Doeun Kim[b]
[a]*Deptartment of Radioactivity test & analysis center, Sunkwang T&S, Seoul 08298, South Korea*
[b]*Department of Radiological Science, Gachon University, Incheon 21936, South Korea*
[*]*Corresponding author: lsbguy87@sktns.co.kr*

1. Introduction

On April 13. 2021, the Japanese government announced the 'Basic Policy on Disposal of Treated Water' to discharge contaminated water from the Fukushima Nuclear Power Plant into the ocean[1]. On the 10th anniversary of the Fukushima nuclear power plant explosion caused by the Great East Japan Earthquake, the issue of the nuclear power plant accident came to the surface as Japan decided to discharge contaminated water from the nuclear power plant. As of March 2020, 1.97 Sv of radioactivity was emitted per hour from the concrete cover on the top of the reactor containment vessel, which is an exposure dose that can lead to premature death even with exposure for about 10 minutes[2]. In addition, research results have been found that thyroid cancer and other diseases that can increase due to radiation exposure increase by several orders of magnitude in residents of neighboring areas that are not included in the emergency evacuation area[3]. These circumstances show that even 10 years after the Fukushima nuclear accident, the aftereffects persist. I-131, Cs-134, and Cs-137 are the most common gamma artificial radionuclides that occur during nuclear accidents. These are indicators that are mainly used for nuclide analysis upon import because the analysis time is relatively short. I-131 accumulates in the thyroid gland in the human body and can cause cancer, and in the case of Cs-134 and Cs-137, it is stored in the subcutaneous fat or muscle during internal exposure and can cause DNA changes[4]. In other words, it can lead to death depending on the degree of radiation exposure, so safety management is a very important issue. At this point in time when Japan's decision to discharge contaminated water from nuclear power plants shows public anxiety about radioactivity, the High Purity Germanium detector shows excellent resolution and accurate measurement results for measurement of gamma-ray emitting nuclides. Gamma radionuclide analysis was performed on local products.

2. Methods and Results

2.1 Selection of analysis method

Radioactivity analysis for each nuclide was performed using a high-purity germanium detector (Canberra Co. U.S.). This is a P type, and the measurement range is (50~2 000) keV, and the relative efficiency is 30%. Using Marinelli Beaker as the measuring vessel, conditions were created to measure the radiation incident from all directions. For the samples used, those produced in the area around Fukushima were used as raw materials or products that were processed and imported into Korea were selected. A total of four types of soap are included: soap made by combining Fukushima rape blossoms with mushrooms and tofu from nearby regions, S&B Oroshi Wasabi, Tokuno Milk Candy, and Sakeru Gummi Jelly, which has a factory near Fukushima Prefecture. As the target nuclides for gamma radiation measurement, Cs-134, Cs-137, and I-131, which are representative artificial radionuclides, and K-40, which is detected in large amounts among natural radionuclides were selected. The specifications are shown in Fig. 1.

Division	Specifications
Type	STD P-type Coaxial Detector
Efficiency	30%
FWHM	1.8 @ 1332 (keV)
Weight	1,088 kg
Low back ground lead	100 mm
Tin & copper	1 @ 1.6 (mm)
MCA	16,000 channel
S/W	Genie 2000 basic

Fig 1. High Purity Germanium Detector

2.2 Sample acquisition and pre-treatment

Marinelli Beaker is designed so that a high-purity germanium semiconductor detector can receive a sample geometrically and uniformly, but this must satisfy the condition that the sample fills the inside of the Marinelli Beaker. This is because, if this condition is not met, uniform measurement of the sample is difficult. Pure water was used for the measurement sample, which was used to eliminate measurement errors because bottled water or tap water may contain chlorine or minerals used for disinfection. In addition, in order to manufacture with the same medium as the certified standard material, agar powder that can be diluted and distributed uniformly was used to match the medium. In other words, 110 g of the sample and 10 g of agar powder were diluted in pure water to satisfy the Marinelli Beaker usage condition of 1 L in gel form, and measurement preparation was completed as shown in Fig. 2.

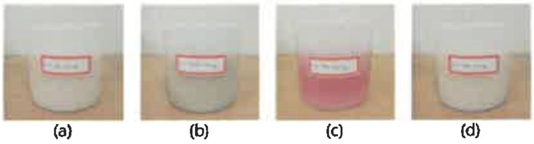

Fig 2. Sample of (a)candy, (b) wasabi, (c) jelly, (d) soap

2.3 Measurement of radioactivity in the sample

For sample measurement, a relative measurement method was used in which a standard radiation source and a sample to be measured were measured under the same conditions and indirectly measured by contrasting radioactive energy peaks. The standard source used in this study was calibrated using the certified standard material produced by the Korea Research Institute of Standards and Science. The measurement time of the sample was measured to be 80,000 seconds. The detection time was determined for more accurate detection of radionuclides and to reduce errors in the sample measurement time. For the measured data, the radioactivity value was calculated using the following Eq 1.

$$A = \frac{N}{m \times \varepsilon \times r \times t_s \times K_1 \times K_2 \times K_3 \times K_4 \times K_5} \quad \text{.. Eq. 1}$$

As a result of measuring the sample, it was found to be less than the minimum detectable concentration except for K-40 as shown in Table 1.

Table 1. Radioactivity measurement result of samples

Food Name	Analysis Date	Weight (kg)	(Bq/kg)	MDA (Bq/kg)		
			K-40	I-131	Cs-134	Cs-137
Candy	2021-05-19	0.11	180.014	0.081	0.075	0.086
Wasabi	2021-05-18	0.11	75.556	0.084	0.074	0.087
Jelly	2021-05-22	0.11	40.800	0.084	0.069	0.080
Soap	2021-05-23	0.11	45.646	0.088	0.071	0.091

2.4 Evaluation of exposure dose

The minimum detectable concentration refers to the minimum detectable radioactivity concentration for each measurement, and is a concept indicating the presence or absence of radioactivity in consideration of the statistical part of the measurement. Based on the measured results, the internal exposure dose was evaluated in accordance with ICRP-119. However, in the case of nuclides detected at less than the minimum detectable concentration, evaluation was performed based on the minimum detectable concentration, and the results are shown in Table 2.

Table 2. Radiation Dose result

Food Name	Radiation Dose (μSv)			
	K-40	I-131	Cs-134	Cs-137
Candy	1.116	0.001	0.001	0.001
Wasabi	0.468	0.001	0.001	0.001
Jelly	0.252	0.001	0.001	0.001
Soap	0.282	0.001	0.001	0.001

3. Conclusions

This study was conducted to inspire the need for continuous monitoring through the analysis of products in the area around the nuclear power plant in the current situation, which is becoming an issue with the announcement of the discharge of contaminated water from the Fukushima nuclear power plant accident. The results of radioactivity analysis on products produced in the accident area seem to indicate safety. However, it is expected that safety can be discussed only when radiation monitoring of products around Fukushima at the national level is continued, and it is expected as a study that will serve as a basis for creating an environment for this.

Acknowledgement

Thank you for the professors of Gachon University to actively cooperating with this study.

Author Contribution

Sangbok Lee[a,c] and Hyunchae Lim[b] are equally contributed to this work. They are co-first authors.

REFERENCES

[1] G. H. Lee, "Government "Bilateral consultation with Japan on Fukushima contaminated water", newsis, 2021.

[2] J. Y. Lee, "Lessons and Challenges of the Fukushima Nuclear Accident", History of Opening Tomorrow, No.78, pp. 56-57, 2020.

[3] J. H. Lim, "Fukushima nuclear accident in March 2011 and 10 years.", SAJ, No.3, pp. 86-87, 2021.

[4] H. J. Kweon et al., "Investigation of radioactive contamination of imported processed foods.", Korean Journal of Environmental Analysis, Vol.23(2), pp. 112-117, 2020.