Comparison of Environmental Radioactivity Analysis Results Using a Gamma Spectrometer

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1. Introduction

The operation of nuclear power plants inevitably results in the generation of radioactive materials. To assess the impact of these materials on the surrounding environment, environmental radioactivity analysis is essential. Wolseong Nuclear Facility Environment and Safety Monitoring Committee(WSNESC) conducts various analyses of radionuclides to protect the health and environment of residents living near nuclear power plants.

Among the artificial radionuclides generated by nuclear power plants, gamma-emitting radionuclides such as I-131, Co-60, Cs-134, and Cs-137 can be detected even at routine levels. To identify these radionuclides, high-purity germanium (HPGe) detectors are utilized, as they offer exceptional energy resolution, allowing precise measurement of gamma-ray energy and accurate classification of radionuclides.

This study aims to evaluate the suitability of gamma-ray spectrometry equipment from Baltic Scientific Instruments (BSI, Latvia), Canberra (Mirion Technologies, Inc., USA), and Ortec (AMETEK, USA) for environmental radioactivity sample analysis. Furthermore, by analyzing the collected data, this research seeks to contribute to the establishment of an efficient monitoring system, thereby enhancing the safety of local residents.

2. Methods and Results

2.1 Comparison of Gamma Spectrometry Equipment

The representative gamma spectrometry equipment manufacturers include Canberra, Ortec, and BSI. The gamma spectrometry equipment from Canberra provides high-quality precision and demonstrates excellent performance, particularly in energy resolution. Additionally, its software interface is intuitive and supports automated analysis. Similarly, Ortec offers high-quality precision and outstanding analytical performance for high-resolution energy measurements. On the other hand, BSI is relatively more cost-effective than those of other manufacturers while still meeting the fundamental requirements for gamma radionuclide analysis. The specifications of each piece of equipment are presented in Table 1.

Table I: Equipment Specifications

Equipment	GC3018 (Canberra)	Gem series HPGe (Ortec)	GCD-30200 (BSI)
Manufacturer	MIRION	AMETEK	BSI
Program	Gennie 2000	GammaVision	Spectra GP
Efficiency	>30 %	>66 %	>30 %
FWHM (Co-60)	1.77keV	1.79keV	2.08keV

2.2 Measurment of Gamma Radionuclides

The gamma-emitting radionuclides Am-241, Co-60, Cs-134 and Cs-137 were measured using three different gamma spectrometry instruments available at the WSNESC. For accurate comparative analysis, the same environmental radioactivity proficiency test samples provided by the Korea Institute of Nuclear Safety (KINS) were used under identical conditions for all instruments.

The sample used was spiked watermanufactured by KINS, with a total volume of 1 liter. The measurement time was set to 80,000 seconds for all three gamma spectrometry instruments. Additionally, the calculation of radioactivity concentration and uncertainty was performed using the same methodology, specifically applying the Currie MDA formula to ensure consistency across analyses.

2.3 Measurment of Gamma Radionuclides

The results of the gamma spectrometer data analysis by manufacturer, compared with the 2024 radioactivity proficiency test samples from the Korea Institute of Nuclear Safety (KINS), are presented in Table 2. and 3.

Table II: Comparison of Measurment Data

Nuclide	KINS	Canberra	Oretec	BSI
Am-241	55.9±1.4	52.1±1	51.1±5	54.0±11
Co-60	35.6±1.5	35.7±1	34.7±2	35.5±5

Cs-134	35.2±1.2	30.9±3	36.0±2	30.9±4
Cs-137	60.9±0.9	59.8±8	60.6±4	60.0±7

2.3 Comparison of Results

When compared with the KINS reference values, all three instruments produced results with no statistically significant differences, confirming their suitability for the analysis.

In terms of uncertainty, the Canberra exhibited increasing uncertainty values as the energy range increased. The Ortec showed higher uncertainty values in the lower energy range compared to Canberra. The BSI yielded the highest uncertainty values among the three.

The uncertainty of the Canberra is corrected separately for low and high energy ranges. This may explain why it produced lower uncertainty values in the low-energy range compared to the other instruments. In contrast, the Ortec applies a single calibration for both low and high energy ranges, which likely led to higher uncertainty values in the low-energy region.

Additionally, the shielding materials of the instruments differ: the other two instruments use lead shielding coated with copper, while BSI relies solely on lead shielding. As a result, background radiation from the lead shielding itself may have influenced the uncertainty values observed in the BSI.

3. Conclusions

The analysis results obtained using the three gamma spectrometry instruments were all found to be statistically significant when compared to the reference values provided by KINS.

In the future, the Monitoring Organization needs to conduct comparative analyses using these three instruments across various environmental media.

This study is expected to serve as a fundamental resource for investigating the environmental radioactivity impact of the operation of the WSNESC by accumulating data from gamma spectrometry instruments based on their respective manufacturers.

REFERENCES

[1] Yeon-Kyu, Sohn, Environmental Radioactivity Survey in Andong Area, p 15, 2000.

[2] Eun Sung Jang and Seong Min Baek, A Study on Full-energy Peak Efficiency Curve of HPGe Detector in Radioactivity Measurement of Environmental Samples. 13.4 (2010): 245-249.

[3] Oropesa,P., Hernandez, A. and Gutierrez, R.(2000) Technical factors of quality management in gamma-ray spectrometry of environmental sample. J. Radioanal. Nucl. Chem. 243(3), 809-816