Development and Performance of a Multipurpose Environmental Radiation Survey System

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1. Introduction

According to the lesson learned from the nuclear accident of Fukushima Daiichi nuclear power plants (FDNPP), the importance of an environmental radiation survey (ERS) was extensively raised to quickly and accurately measure radioactive deposits in the ground. To make an efficient response and risk management, it is advisable to perform the comprehensive ERS, which means diverse survey platforms, such as a backpack, carborne, and airborne survey, in three accident phase, that is, the early, intermediate, and recovery phase. However, the integration method of a large number of comprehensive survey results is a complicated problem to be considered to maintain the consistency of results.

In general, the reliable results of the mobile survey system are closely based on the well-established survey technology of ground based gamma-ray spectrometry at 1 m above the ground and its experimental verifications. In this study, a multipurpose ERS system equipped with two $LaBr_3$(Ce) detectors was developed to utilize to the ground based gamma-ray spectrometry using a tripod as well as mobile gamma-ray spectrometry using a backpack, carborne, and airborne survey. The purpose of this system is to efficiently integrate a large number of comprehensive survey results with the consistency, so that it can reduce the uncertainty induced from the different survey platforms in the case of integrating diverse survey results.

To simultaneously determine the dose rate and radioactivity in the environment using a developed multipurpose ERS system, the dose rate spectroscopy [1-3] was applied to this system through the Monte Carlo simulations. Two information, that is, dose rate and radioactivity, can be achieved from the ground based gamma-ray spectrometry using a tripod. On the other hand, only dose rate is generally evaluated in the mobile survey, such as backpack, carborne, and airborne gamma-ray spectrometry. Finally, the feasibility of developed multipurpose ERS system was experimentally verified in the well-characterized site using a portable HPGe detector, as assessing the radioactivity concentration in the ground and its dose rate at 1 m above the ground by the nuclide.

2. Methods and Results

2.1 Multipurpose ERS system

For the comprehensive radiation survey in the environment, a multipurpose ERS system was developed to efficiently integrate a large number of survey results using diverse survey platforms, as shown in Fig. 1. The GPS (global positioning system) and altimeter was equipped in the system for mobile survey. Two gamma-ray spectrometers, which consists of a 2"φx2" $LaBr_3$(Ce) detector with MCA (multichannel analyzer), were inserted in the system and the measured energy spectra were then transferred to a tablet PC through the Bluetooth interface. The multipurpose ERS system has total weight of below 6 kg including two spectrometers and low battery power consumption.

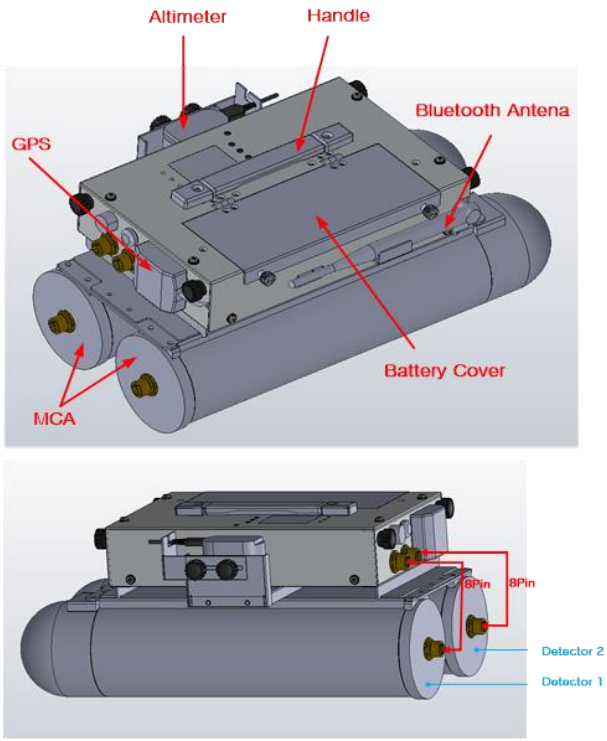

Fig. 1. The schematic diagram of a multipurpose ERS system based on two units of a 2"φx2" $LaBr_3$(Ce) detector

The multipurpose ERS system can be used in several survey platforms by using brackets for the multipurpose use, as shown in Fig. 2. First, the ground based gamma-ray spectrometry using a tripod can be conducted at 1 m above the ground. Then, the multipurpose ERS system can be directly loaded to the mobile units, such as backpack, monitoring car, and drone to survey the wide contaminated site. This procedure can make a good performance of mobile surveys, because the ground based gamma-ray spectrometry at 1 m above the ground can be particularly useful as reference values in the mobile system.

Fig. 2. Application of a multipurpose ERS system to the mobile and ground based gamma-ray spectrometry

2.2 Dose Rate Spectroscopy

The spectrometric determination of dose rate is very useful method by using the dose rate spectroscopy (DRS). This method can produce the results of ambient dose rate as well as dose rate by the nuclide. In addition, because the dose rate by the nuclide is directly related to its radioactivity, the method can also give the information of the radioactivity concentration in the ground by applying the dose conversion factor, which can be calculated from the Monte Carlo simulations. In this study, a G-factor of developed multipurpose ERS system was calculated in the unit of nGy/h/cps for incident gamma-rays with the energy from 50 to 3000 keV.

2.3 Experimental Verifications

The performance of a multipurpose ERS system was evaluated by applying it to ground based gamma-ray spectrometry at 1 m above the ground and mobile gamma-ray spectrometry using backpack, carborne, and airborne survey. Fig. 3 shows an example of measured energy spectra using a multipurpose ERS system at 1 m above the ground. By using the DRS method, the ambient dose rate and dose rate by the gamma nuclide were calculated at the detector position.

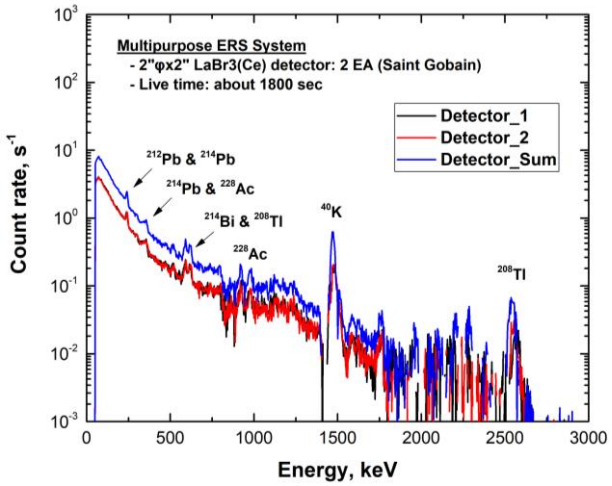

Fig. 3. Measured energy spectra using a multipurpose ERS system at 1 m above the ground

The radioactivity concentration in the ground of detected gamma nuclides was then obtained by applying a G-factor to the dose rate by the nuclide. The experimental verification was then conducted by comparing the results between the multipurpose ERS system and a portable HPGe detector. The difference between two detecting system, which was installed at 1 m above the ground using a tripod, was below 20 % for natural radionuclides.

3. Conclusions

A multipurpose ERS system based on two units of a 2"φx2" $LaBr_3$(Ce) detector was developed to utilize to the ground based gamma-ray spectrometry using a tripod as well as mobile gamma-ray spectrometry using a backpack, carborne, and airborne survey. This system can make a simultaneous determination of dose rate and radioactivity by applying the dose rate spectroscopy. The experimental verification of the measured radioactivity using this system was conducted by applying to the well-characterized site using a portable HPGe detector.

REFERENCES

[1] Ji YY, Chung KH, Lee W, Park DW, Kang MJ, 2014. Feasibility on the spectrometric determination of the individual dose rate for detected gamma nuclides using the dose rate spectroscopy. Radiat. Phys. Chem. 97, 172-177.
[2] Ji YY, Chung KH, Kim CJ, Kang MJ, Park ST, 2015. Application of the dose rate spectroscopy to the dose-to-curie conversion method using a NaI(Tl) detector. Radiat. Phys. Chem. 106, 320-326.
[3] Y.Y. Ji et al., In situ gamma-ray spectrometry in the environment using dose rate spectroscopy, Radiat. Phys. Chem. 119: 90-102, 2016.