A Preliminary Study on the Washout Effect of Particulate Radionuclides using Be-7 in the Atmosphere

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1. Introduction

Particulate radionuclides can be dispersed into the atmosphere due to radiation or nuclear accidents. This dispersion causes fallout with rain thereby causing radionuclides to be deposited onto the ground surface. This radionuclide deposition can increase levels of radiation exposure to the public. Therefore, understanding of the washout effect of particulate radionuclides can be helpful for making successful strategies for environmental radioactivity monitoring or pre-estimation of radiation exposure for radiation protection purposes. There have been researches related to aerosol fallout using Be-7 because of its suitable half-life (53.1 days) and adequately detectable radiation level [1- 4]. However, in order to obtain the correlation of wet deposition of the particulate radionuclides by the washout effect, more detailed study on the deposition relation according to the rainfall is needed.

This study aims to take an initiative (preliminary step) and to have a better knowledge of washout effect of particulate radionuclides using natural Be-7 as a representative radionuclide in the atmosphere. Approaching methods for this study and preliminary results with discussions are presented.

2. Methods and Materials

In this study, rain water was collected, pretreated, and Be-7 in the samples was analyzed using gamma-spectrometry.

Rain water was collected during two rain events using a 0.49 m^2 galvanized steel collector installed at the Korea Institute of Nuclear Safety (36˚22’25’’N, 127˚22’9’’E). A group of rain water samples collected on 29/07/2017 was specified as the first event and second group of rain water samples collected on 06/08/2017 specified as the second event. First event sample enabled to collect high concentration of Be-7 with attached aerosols. Each sample of rain water with its precipitation is shown in Table I. Then, rain water samples were evaporated using 3L glass beaker on hot plates. When the volume of the samples was sufficiently reduced, the rain water was transferred to 100 ml glass beakers to dry out completely. During transferring and evaporating of the 100 ml glass beakers, they were thoroughly rinsed with HCl acid in order to recover ^{7}Be inside the beaker. Finally, the rainwater in the beaker was completely dried and sealed with sealing film to prevent any contamination.

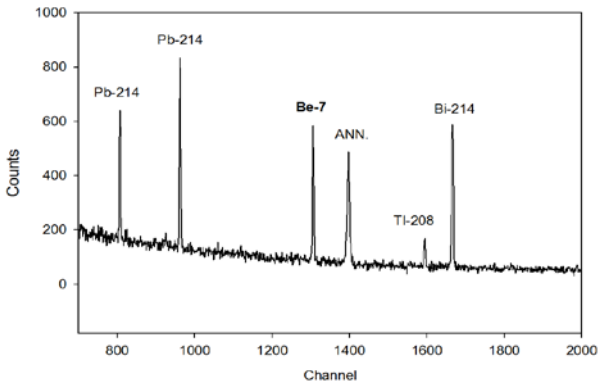
Table I: Rain water sampling information

Sampling number		Sample volume (L)	Accumulated amount of precipitation (mm)
1st Event	1	3.02	6.2
	2	3.54	13.4
2nd Event	1	4.23	8.6
	2	3.50	15.8
	3	3.48	22.9
	4	3.42	29.8

Each prepared sample was measured using a coaxial type of HPGe (High Purity Germanium) detector with 30% relative efficiency for 150,000~300,000 seconds considering the standard counting uncertainty. Then, gamma-ray count rates of Be-7 from each gamma-ray energy spectra were obtained with decay correction to each sampling start date and normalized to the first collected samples, one for each rainfall event, in order to derive the variation tendency of wet deposition rates as precipitation increases.

3. Results and Discussion

As shown in Fig. 1, the Be-7 gamma-ray was measured with Rn progenies such as Bi, Pb and Tl radioisotopes by washout effect. These radionuclides



can be a major factor in the increase of the ambient gamma-ray dose rate during the wet fallout.

Fig. 1. Gamma-ray energy peaks of particulate radionuclides

measured from rain water sample.

Fig. 2 shows that the counting rates of Be-7 from the 1st to the 2nd events are appreciably decreased due to washout effect, and the normalized count rates of Be-7 in 2nd events found to be exponentially decreasing relative to accumulated precipitation in mm. The data set plotted by normalized count rate(C) vs. accumulated precipitation (R) was fitted with an exponential equation

$$\mathrm{C} = c_0 + \mathrm{a}\, e^{-b\,R} \qquad (1)$$

and the fit parameters were assigned as follows: $c_0 = 0.35$, $\mathrm{a} = 1.64$ and $b = 0.07$ with correlation coefficients, with $R^2 = 0.9986$ in this study. This shows that most of the particulate radionuclides can be washed out in the first rains. The dilution effect [4] of radioactivity concentration in the rainfall samples can be well explained with the wash out effect with precipitation.

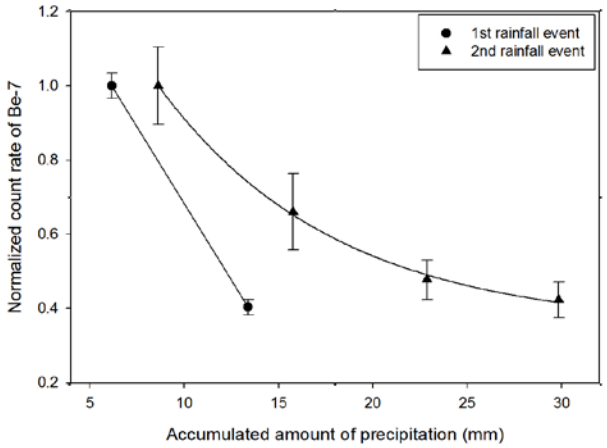


Fig. 2. Variation of Be-7 concentration in rain water with the accumulated amount of precipitation.

4. Conclusions

This preliminary study was conducted to take an initiative steps and for more understanding of the washout effect of particulate radionuclides in the atmosphere, using Be-7 as a representative particulate radionuclide, which can potentially give rise to the level of exposure to the public. Be-7 concentration in count rates was obtained in two rain events and showed that wet fallout rate of Be-7 exponentially decreasing phenomena relative to rainfall events. This result can provide useful evidence for making effective strategies of environmental radioactivity monitoring and pre-estimation of radiation exposure for radiation protection purpose. However, it is needed more extensive experiments to obtain the transmission coefficients between the precipitation and wet deposition of particulate radionuclides in the atmosphere. The approaching method and results presented in this paper can be helpful for further study on the washout effect or wet deposition of particulate radionuclides for planning, implementing, and evaluating of environmental radioactivity monitoring.

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