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Analysis of Environmental Radioactivity Level in Suwon and Southern Gyeonggi Province after North Korea's 6th Nuclear Test

So Yoon Lee, Jin O Lee, Kwang Pyo Kim*
Nuclear Engineering Dep.t,Kyung Hee Univ., Gyeonggi-do, Korea
**Corresponding author: kpkim@khu.ac.kr*

1. Introduction

On September 3th, 2017, an underground nuclear test had been carried out in Punggye-ri, North Korea. A nuclear explosion generates tremendous amounts of radioactive particles and gases to the external environment. Xenon released after North Korea's nuclear test was detected in the atmosphere of Korea. Therefore, it is necessary to evaluate the presence of radioactive contamination due to nuclear test in the atmosphere in Republic of Korea.

The purpose of this study was to evaluate the level of environmental radioactivity fluctuation due to the nuclear test in the surveillance area based on the results of environmental radioactivity monitoring in southern Suwon and Gyeonggi region.

2. Materials and Methods

2.1 Sample selection

Table 1 shows monitoring plan for environmental radioactivity levels in Suwon and southern Gyeonggi province. Samples comprised airborne dust and precipitation. Artificial radionuclides including fission products were selected for analysis. Sampling took place over a week and it was done again after the earthquake at nuclear test site was detected.

Table 1: Environmental radioactivity monitoring plan

Sample type	Nuclide	Sampling frequency
Airborne dust	^{95}Zr, ^{103}Ru, ^{137}Cs, ^{141}Ce	3 times/week
Precipitation		Each time

2.2 Collection and pre-treatment

Airborne dust was collected using high volume air sampler and glass fiber filters 3 times in a week. The specifications are indicated in Table 2. Filters were vacuum packed for gamma analyses. Precipitations were collected using automatically precipitation sampler. Samples were collected at each precipitation. The collected precipitation placed in a 1L marinelli beaker for gamma analyses

Figure 1: High volume air sampler

Table 2: Specifications for high volume air sampler

Characteristics	Minimum requirements
Airflow	700 L/min
Collection time	> 48 h
Filter	Wattman 41(5A)-8x10"

2.3 *Gamma-ray spectrometry*

The activities of radionuclides in samples, including airborne dust and precipitation, were measured by gamma spectrometry. High Purity Germanium detector system (GC2520, Canberra) with 25% relative efficiency and resolution of 2.0 keV at 1.33 MeV was used for the measurement. The measurement times were 5 hours for airborne dust and 12 hours for precipitation measurement. One of the most important requirements for radionuclide analysis is minimum detectable activity (MDA). The MDA was calculated using the Currie-formula (Currie, 1968) with an ROI of ± 3.0 FWHM around the center of the hypothetical peak.

Table 3: Specifications for gamma-ray spectrometry

Characteristics	Minimum requirements
Measurement mode	HPGe high resolution gamma spectrometry
Relative efficiency	25%
Resolution	2.0 keV at 1.33 MeV
Data availability	95%
Measurement time for airborne dust	5 hour
measurement time for precipitation	12 hour
Background measurement time	150,000 sec

3. Results and Discussion

The results from the gamma-ray spectrometry analysis are presented in Table 4 and Table 5. It shows radioactivity concentrations of ^{95}Zr, ^{103}Ru, ^{137}Cs, and ^{141}Ce in airborne dust and precipitation. The gray celss in the table are measurement results after the nuclear test site earthquake.
The radionuclides of ^{95}Zr, ^{103}Ru, ^{137}Cs, and ^{141}Ce were not detected in the samples. Overall radioactivity was detected below MDA. The measured value of ^{95}Zr, ^{103}Ru, ^{137}Cs, and ^{141}Ce below MDA. It means that there is no radioactivity in Suwon and southern Gyeonggi province. Therefore it can be noted that radioactivity in two types of samples has no fluctuation in atmosphere after North Korea's 6th Nuclear Test.

Table 4: Radioactivity concentration of airborne dust

Date	^{95}Zr (μBq/m3)	^{103}Ru (μBq/m3)	^{137}Cs (μBq/m3)	^{141}Ce (μBq/m3)
2017-09-04	< 390[a]	< 197[a]	< 231[a]	< 261[a]
2017-09-06	< 495[a]	< 250[a]	< 300[a]	< 315[a]
2017-09-08	< 407[a]	< 199[a]	< 223[a]	< 279[a]
2017-09-11	< 317[a]	< 160[a]	< 189[a]	< 209[a]
2017-09-25	< 236[a]	< 122[a]	< 135[a]	< 166[a]
2017-09-27	< 346[a]	< 173[a]	< 203[a]	< 236[a]

[a]MDA

Table 5: Radioactivity concentration of precipitation

Date	^{95}Zr (μBq/m3)	^{103}Ru (μBq/m3)	^{137}Cs (μBq/m3)	^{141}Ce (μBq/m3)
2017-09-11	< 579[a]	< 305[a]	< 325[a]	< 415[a]
2017-09-13	< 367[a]	< 177[a]	< 209[a]	< 228[a]
2017-09-27	< 1,696[a]	< 842[a]	< 977[a]	< 1,182[a]

[a]MDA

The reason why Xenon was measured but no other radioactive materials were detected on the atmosphere is, for underground nuclear explosions, noble gases are more likely to be released into the atmosphere than suspended particulates.

4. Conclusions

In this study we performed environmental radioactivity monitoring in Suwon and southern Gyeonggi province after North Korea's 6th Nuclear Test. According to monitoring results, any radionuclides associated with nuclear test was not detected. Therefore it can be noted that radioactivity in atmosphere has no fluctuation after North Korea's 6th Nuclear Test.

The database of environmental radioactivity level analysed in this study can be used for basic data of accident impact assessment to local residents of Suwon and southern Gyeonggi province.

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