Analysis of the Natural Radionuclides Concentrations of Atmospheric PM_{10} Aerosols of Jeju Gosan Site in 2015

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1. Introduction

In this study, we have measured radioactivity concentrations of the natural radionuclides (^{40}K, ^{232}Th and ^{238}U) contained in the atmospheric PM_{10} aerosols which were collected at the Jeju Gosan site in 2015.

2. Materials and methods

2.1 Air sampling locations

Air sampling for aerosols was conducted at the Jeju Gosan site. The site serves as a natural background site for characterizing the air pollution in Korean peninsula since the atmosphere in the area is relatively very little affected by artificial airborne matters. Chemical composition analyses have usually been conducted for the atmospheric aerosols collected at the site [1]. The samples were collected for 24 hours using a PM_{10} sampler at approximately 3-day intervals throughout the year 2015. On collecting samples, the air flow rate was kept to about 16.7 L/min, and total air flow was calculated from the flow rate and running time. A total of 127 samples have been analyzed, of which 7 samples are those collected during Asian Dust days, 62 samples collected during normal weather days (no-event days), and the remaining samples collected during the days of haze (10 samples) and fog-mist (48 samples).

2.2 Sample Analysis

For the analysis of PM_{10} elemental species, the aerosol samples were decomposed with acids using a microwave digestion system 10 mL acid solution (5.55% HNO_3/16.75% HCl). The vessel was heated at 180℃ for 15 minutes with 1000 W microwave radiation to digest the PM_{10} aerosols. The number of elements determined by ICP-DRC-MS ((Perkin Elmer, model ELAN DRC-Ⅱ, USA) instruments was 3 species such as ^{39}K, ^{232}Th and ^{238}U. For the elemental analysis, the instrumental detection limits (IDL) of ^{39}K, ^{232}Th and ^{238}U were 27.12 μg/L, 2.98 ng/L and 3.23 ng/L, respectively.

The radioactivity concentrations of the isotopes ^{40}K, ^{232}Th and ^{238}U in the collected fine dust were calculated using the following Eq. (1) (Ref. 2):

$$A_i = \frac{\ln 2}{T_{1/2}} \times \frac{\rho_i \times m_e}{M_i} \times N \quad (1)$$

3. Results and discussion

We have measured, using the ICP-DRC-MS, radioactivity concentrations of ^{40}K, ^{232}Th and ^{238}U contained in Jeju Gosan atmospheric PM_{10} aerosols in 2015.

Table 1. The associated ^{40}K, ^{232}Th and ^{238}U concentrations of airborne PM_{10} by atmospheric phenomenon at Jeju Gosan site, 2015

Atmospheric phenomenon(n)	PM_{10} (μg/m^3)	^{40}K (pg/m^3)	^{232}Th (pg/m^3)	^{238}U (pg/m^3)
Asian Dust (7)	133.11	105.66	395.17	106.73
Haze (10)	80.75	69.42	100.48	62.62
Fog-Mist (48)	32.70	17.56	26.85	31.50
Non-Event (62)	31.72	19.22	40.85	34.80
All (127)	42.48	28.16	62.42	40.34

The mean mass concentration of PM_{10} was 42.48 μg/m^3 (Table 1). During the study period, the mean concentrations of ^{40}K, ^{232}Th and ^{238}U were 28.16, 62.42 and 40.34 pg/m^3, respectively. During Asian Dust periods (7 samples), the mean mass concentration of PM_{10} was 133.11 μg/m^3, and the mean concentrations of ^{40}K, ^{232}Th and ^{238}U were 105.66, 395.17 and 106.73 pg/m^3, respectively.

The radioactive concentrations of ^{40}K, ^{232}Th and ^{238}U were 7.47, 0.25 and 0.50 μBq/m^3, respectively (Table 2). During Asian Dust periods, the radioactive concentrations of ^{40}K, ^{232}Th and ^{238}U were 27.98, 1.60 and 1.31 μBq/m^3, respectively. Furthermore, they are lower than the world averages for the mean

atmospheric activity concentrations of ^{232}Th and ^{238}U, which are 0.5 and 1.0, respectively [3]. However, the Asian Dust period values were higher than the world average. The ^{232}Th/^{238}U activity ratio of totality was 0.500. The ^{232}Th/^{238}U activity ratio of Asian Dust period value was 1.221, which was higher than other atmospheric phenomenon period ratios.

Table 2. The radioactive concentrations in PM_{10} aerosols of Jeju Gosan site, 2015

Atmospheric phenomenon	^{40}K (μBq/m^3)	^{232}Th (μBq/m^3)	^{238}U (μBq/m^3)
Asian Dust	27.98	1.60	1.31
Haze	18.39	0.41	0.77
Fog-Mist	4.65	0.11	0.39
Non-Event	5.09	0.17	0.46
All	7.47	0.25	0.50

We are analyzing five-day backward trajectories of the air inflow into the Gosan site using the HYSPLIT4 model of NOAA.

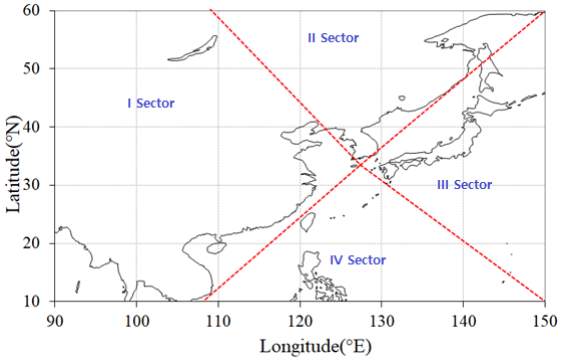

Fig. 1. Sectional classification of Northeast Asia for backward trajectory analysis based on the Jeju Gosan site.

The air movement route was classified into Sector I (China continent), II (Korean peninsula), III (Japan) and IV (North Pacific Ocean) (Fig. 1).

Table 3. Inflow pathway sectional activity concentrations of ^{40}K, ^{232}Th and ^{238}U in airborne PM_{10} at Jeju Gosan site, 2015

Sector (n)	^{40}K (μBq/m^3)	^{232}Th (μBq/m^3)	^{238}U (μBq/m^3)
I (43)	11.23	0.43	0.65
II (49)	6.28	0.19	0.40
III (19)	4.13	0.08	0.46
IV (16)	3.08	0.05	0.38
All (127)	7.47	0.25	0.50

Sector specific values are shown in Table 3. The values of sector I were higher than those of other sectors. However, they are lower than the world averages for the mean atmospheric activity concentrations of ^{232}Th and ^{238}U. The ^{232}Th/^{238}U activity ratio of sector I was 0.662, which was higher than other sector ratios.

4. Conclusions

We have measured radioactivity concentrations of the natural radionuclides contained in the atmospheric PM_{10} aerosols at the Jeju Gosan site in 2015. The radioactive concentrations of ^{40}K, ^{232}Th and ^{238}U were 7.47, 0.25 and 0.50 μBq/m^3, respectively. They are lower than the world averages for the mean atmospheric activity concentrations of ^{232}Th and ^{238}U. However, the Asian Dust period values were higher than the world average. The ^{232}Th/^{238}U activity ratio of Asian Dust period value was 1.221. The values of sector I (China continent) were higher than those of other sectors. As a result, it was confirmed that the ratio of each nuclide was slightly different according to the inflow route. It is expected that this will be a preliminary data for analyzing the sources and various weather phenomena of fine dust on the peninsula. It is judged that the results become a preliminary data on the impact of fine dust from China, which has been recently intensified, on the Korean Peninsula.

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