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High Resolution Simultaneous Measurements of Airborne Radionuclides

Takuya Abe[a], Yoshiko Yamaguchi[a, b], Kiwamu Tanaka[a], and Kazuhisa Komura[a]

[a] Low Level Radioactivity Laboratory,
Institute of Nature and Environmental Technology, Kanazawa University, Japan
[b] RI Center, Osaka City University, Japan

Abstract

Introduction

Airborne radionuclides have been used as valuable tracers to investigate environmental processes such as movement of air mass, residence times and removal processes of airborne contaminants and so on. Studies on air filter and/or rain water samples containing long-lived ^{210}Pb (physical half-life: 22.3 y) and ^{7}Be (53.3 d) by non-destructive gamma spectrometry have been widely performed to analyze atmospheric processes whose time scale are comparably long (1 week ~ 1 month). In such studies, it is necessary to use radionuclides having half lives suited to the time scale of environmental processes to be studied. Therefore, in order to observe relationship between variation of airborne radionuclides and rapid climate changes (~ several hours), monitoring at shorter sampling interval (high time resolution) using shorter-lived nuclides is considered to be imperative. In addition, simultaneous measurement at multiple sampling points has the potential to give us information on the transportation and mixing of air masses. However, such measurements have not been performed so far because of the difficulty in measurements due not only to low concentration of long-lived radionuclides but also to the fast decay of short-lived ones.

In this work, since the problem described above was overcome by using 16 extremely low-background Ge detectors in Ogoya Underground Laboratory (OUL), we have taken notice of short lived ^{212}Pb (half life 10.6 hr) which is expected to have valuable information on drastic change of the atmosphere.

Study areas

High resolution and simultaneous measurements of airborne ^{212}Pb along with ^{210}Pb and ^{7}Be were performed at three monitoring points viz, 1) Low Level Radioactivity Laboratory (LLRL), Kanazawa Univ., 2) Shishiku Plateau (640 m MSL), and 3) Hegura Island (located about 50 km from Noto Peninsula in the Sea of Japan).

Materials and Methods

Airborne dust samples were collected on silica fiber filter (ADVANTEC QR-100) by using high volume air sampler (Sibata HV-1000F) operated at flow rate of 900 L min^{-1} with 3 hrs of sampling intervals. After sampling, filters were compressed to required geometry to prepare counting sources for gamma spectrometry and were subjected to measurement as early as possible in order to measure short-lived ^{212}Pb for 4-12 hrs at LLRL or at OUL depending on expected activity levels of each of the samples. After the measurements of ^{212}Pb, all samples were re-measured for long-lived ^{210}Pb and ^{7}Be for 2-4 days at OUL.

Results and Discussions

Activity levels and variation patterns of long-lived ^{210}Pb and ^{7}Be were found to be similar independent of the monitoring points. Additionally, during the time just before the approach and passing over of cold front or typhoon, drastic decreases of concentration were observed for both nuclides simultaneously at three points. Since physical half-lives of these nuclides are sufficiently longer than residence time of airborne dust (~ 10 days), their atmospheric concentrations might be homogeneous in the air mass over the monitoring points.

On the other hands, activity levels and variation patterns of short-lived ^{212}Pb were quite different among the monitoring points. Activity levels were 3-38 mBq m^{-3} and 4-52 mBq m^{-3} at Shishiku Plateau and at Hegura Island, respectively, which were only 1/4 of that at LLRL (11-205 mBq m^{-3}). The differences are explained by not only dilution by the mixing of air mass but also by radioactive disintegration of short-lived ^{212}Pb in elapse time during movement from main source of ^{212}Pb to the monitoring point. In addition, pronounced phase differences of the diurnal variation patterns were observed between LLRL and Shishiku Plateau.

These result seemed to have valuable information on sub-regional (~100 km for horizontal or ~1000 m for vertical) movements of the atmosphere and airborne particulate matters.