AMS and ICP-MS for measurement of low level radionuclides

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Plutonium and its isotopes in the environment are concerned by public because of its chemical and radiological toxicity and fissile material. Researchers in the fields of atmospheric chemistry, chemical oceanography and others have been interesting in plutonium isotopes ($^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu) in the environment as a unique transient tracer of atmospheric, oceanic, terrestrial and biogeochemical processes. Since explosions of the New Mexico and Nagasaki atomic bombs in 1945, global environment has contaminated with plutonium as a result of atmospheric nuclear weapons tests, satellite accidents and nuclear reactor accidents. Especially, large quantities of plutonium were released during atmospheric tests of nuclear weapons conducted by USA and former Soviet Union mainly during the 1950s and early 1960s. Atmospheric behaviour of plutonium has been frequently studied during the past 50 years. As a result, during the large-scale nuclear weapons tests of hydrogen bombs, radioactive debris including plutonium reached the stratosphere, which became then the main reservoir of plutonium. The stratospheric plutonium was transported into troposphere as an apparent stratospheric residence time of 1–2 years due to exchange processes between the stratosphere and the troposphere [1]. Although the stratospheric plutonium decreased to negligible level after 1990, plutonium has been detected in dust and deposition samples collected in Japan, Europe and US, in which current levels of $^{239, 240}$Pu are 0.1–10 nBq m$^{-3}$, 0.05–10 mBq m$^{-2}$Mon$^{-1}$ for surface airborne dust and deposition, respectively. Sources of the atmospheric plutonium since 1990 are considered to be resuspension of deposited plutonium, including plutonium-bearing soil particles blew up by storms [2] and large-scale biomass burning.

Plutonium in environmental samples has been measured by alpha spectrometry. Recent development of mass spectrometric measurements such as ICP-MS, AMS and others allows us to determine $^{240}$Pu/$^{239}$Pu and $^{241}$Pu/$^{239}$Pu atom ratios in the environmental samples [3], which depend on scale of nuclear explosion and sources such as nuclear reactor accident. As results of measurement of archived samples, we have new knowledge about long-term variation of $^{240}$Pu/$^{239}$Pu atom ratios in the atmospheric samples (deposition and dust). This knowledge is important to have better understanding of terrestrial and oceanic processes of plutonium.

References
long-lived radionuclides. Among various inorganic mass spectrometric methods, inductively coupled plasma mass spectrometry (ICP-MS) and accelerator mass spectrometry (AMS) are two most popular used mass spectrometry techniques for the measurement of radionuclides, especially long-lived radionuclides. With the improvement of ICP-MS technique and more instruments to be installed, the application of this technique is becoming more popular tool for measurement of radionuclides. By hyphenation with automated separation system, ICP-MS will play a critical role in rapid determination of radionuclide for emergency analysis. AMS is the most sensitive analytical technique for many long-lived radionuclides, the new development of this techniques, especially the miniaturization of AMS system significantly reduce the cost of instrument as well as maintenance and operation, this stimulated and enhanced the application of this technique in the environmental researches. This work present the application of ICP-MS and AMS in the measurement of most important radionuclides, such as $^{99}$Tc, $^{129}$I, $^{135}$Cs, $^{236}$U, $^{237}$Np, $^{239}$Pu, $^{240}$Pu, especially the new progress in the analytical methods of these radionuclides for environmental researches.

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FUKUSHIMA-DERIVED RADIOCESIUM IN THE WESTERN NORTH PACIFIC IN 2014

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Accident of Fukushima-Dai-ichi Nuclear Power Plant on 11 March 2011 resulted in a large amount release of radiocesium into the North Pacific Ocean. Since just after the accident, the Government of Japan, Tokyo Electric Power Co., and lots of oceanographers from countries of the North Pacific Rim have been measured concentration of dissolved radiocesium in seawater. They found that along surface currents between 40°N and 50°N approximately the released radiocesium had been transported eastward and reached the west coast of the North American Continent by April 2015. On the other hand, some of it were conveyed southward due to subduction of the subtropical mode water (STMW). Maximum of radiocesium concentration in subsurface layer (200–400 m depth), which is derived from the subduction of STMW, should be spreading in the subsurface layer (200–400 m depth), which is derived from the subduction of STMW. Maximum of radiocesium concentration in subsurface layer (200–400 m depth) rose from about 2 to 5 Bq/m³ between June 2012 and December 2014. These temporal changes in the activity concentration of $^{137}$Cs suggest that Fukushima-derived radiocesium has been spreading southward through the subsurface layer along circulation of STMW in the subtropical area.