AMS and ICP-MS for measurement of low level radionuclides

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Published in:

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
PLUTONIUM IN ATMOSPHERIC ENVIRONMENT
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Keywords: plutonium, plutonium isotope ratio, atmosphere, temporal variation, nuclear explosion

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

AMS AND ICP-MS FOR MEASUREMENT OF LOW LEVEL RADIONUCLIDES
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Keywords: AMS, ICP-MS, mass spectrometry, long-lived radionuclides, environmental radioactivity

Radionuclides are conventionally measured by detecting their characteristic radiation using alpha spectrometry, beta counting including liquid scintillation counting and gamma spectrometry depending on their decay modes, these methods are high sensitive for short half-lived radionuclides. Mass spectrometry, typically used to measure isotopes of elements, can be also used for measurement of radionuclides. In these methods, the atoms of the radionuclide of interest are directly measured. Therefore, mass spectrometry methods are normally sensitive for the measurement of
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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Keywords: radiocesium, Fukushima Dai-ichi Nuclear Power Plant accident, North Pacific