Measurements of $^{236}U/^{239}Pu$ mass ratio using Inductively Coupled Plasma Mass Spectrometry in cryoconite samples on glaciers of western Norway

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Atmospheric nuclear weapon tests, together with releases from nuclear fuel reprocessing facilities and nuclear reactor accidents are major sources of artificial radionuclides in the environment. Among those, radioisotopes of plutonium and uranium are measured to assess the possible sources of radioactive contamination in different elements of the global ecosystem, including cryosphere. Cryoconite, dark and granule-shaped debris commonly found on glacier surfaces, is known for exceptionally high accumulation of radioactive isotopes, making it a remarkable matrix for studying radioactive contamination in the environment. Among plutonium isotopes, ^{239}Pu and ^{240}Pu are commonly measured and used in determination of $^{240}Pu/^{239}Pu$ mass ratio, whose value depends on several factors such as type of release (nuclear weapons or reactors) providing more information regarding contamination sources. Out of uranium isotopes, ^{236}U is produced via neutron caption on ^{235}U and while occurs naturally, the better part of this radioisotope on Earth has anthropogenic origin. Due to low concentrations of ^{236}U in the environment, it causes high analytical demands and thus is not commonly reported in the literature. In this study we utilize newly developed, indirect measurement method using inductively coupled plasma mass spectrometry (ICP-MS) to determine the $^{236}U/^{239}Pu$ ratio in cryoconite samples from glaciers of western Norway. In order to avoid analytical problems with the direct determination of the ^{236}U concentration, the utilized method consists of three stages: (i) determining ^{235}U concentration, (ii) determining ^{236}U concentration from ^{235}U and $^{236}U/^{235}U$ ratio, (iii) measuring ^{239}Pu concentration and ultimately determining $^{236}U/^{239}Pu$. Thanks to separate plutonium measurement, the $^{240}Pu/^{239}Pu$ is also determined and further information regarding radioactive contamination sources is obtained. Besides utilizing brand new ICP-MS measurement method, our study reports radioactive pollution in western Norway and shows further potential threats of environmental contamination.

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