

Assessment Of The Global Fallout Of Plutonium Isotopes In The Topsoil Of Qatar: Establishing A Baseline Concentrations Of ^{238}Pu , ^{239}Pu , And ^{240}Pu

[10.5339/qfarc.2014.EEPP0270](https://doi.org/10.5339/qfarc.2014.EEPP0270)

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Abstract

A radio-analytical technique for determination of plutonium (Pu) isotopes in soil samples is tested against NIST and IAEA standard reference materials to determine its accuracy and precision for reliable results. The technique is then used in the investigation of 132 topsoil samples, collected from the natural environment of Qatar, to assess the effect of global fallout accumulation of these radionuclides in the region. Plutonium was sequentially leached from 1000 g of each soil sample using nitric and hydrochloric acids. The residual fine particles were separated by filtration and centrifuge. The solution was reduced to 1 ml by evaporation in dry oven and measured directly by CRC-ICP-MS/MS without prior chemical separation of Pu.

The concentrations of ^{238}Pu in the collected soil samples vary from $< 0.026 - 0.058 \text{ fg/g}$ ($< 0.0160 - 0.0266 \text{ Bq/kg}$) with a mean value of 0.034 fg/g (0.0195 Bq/kg) and a median value of 0.032 fg/g (0.0195 Bq/kg). The concentrations of ^{239}Pu fall in the range $5.67 - 166.09 \text{ fg/g}$ ($0.014 - 0.381 \text{ Bq/kg}$) with a mean value of 67.33 fg/g (0.154 Bq/kg) and a median value of 63.21 fg/g (0.145 Bq/kg). The concentrations of ^{240}Pu fall in the range $1.48 - 28.21 \text{ fg/g}$ ($0.013 - 0.240 \text{ Bq/kg}$) with a mean value of 11.46 fg/g (0.098 Bq/kg) and a median value of 10.835 fg/g (0.093 Bq/kg).

The isotopic and activity concentrations ratios of $^{238}\text{Pu}/^{239}\text{Pu}$, $^{240}\text{Pu}/^{239}\text{Pu}$, and $^{238}\text{Pu}/^{239+240}\text{Pu}$ can be used to identify the source. The main isotope ratios of $^{238}\text{Pu}/^{239}\text{Pu}$ in Qatari soils is $(3.33 \pm 1.02) \times 10^{-4}$. A reported global and Chernobyl fallouts isotope ratio of $^{238}\text{Pu}/^{239}\text{Pu}$ are 1.77×10^{-4} and 4.3×10^{-3} , respectively. The main isotope ratio of $^{240}\text{Pu}/^{239}\text{Pu}$ in Qatari soils is 0.1749 ± 0.0211 . A reported global and Chernobyl fallouts isotope ratios of $^{240}\text{Pu}/^{239}\text{Pu}$ are $0.18-0.19$ and $0.34-0.57$, respectively.

The average isotopic and activity ratios of $^{238}\text{Pu}/^{239,240}\text{Pu}$ in Qatari soils are $(2.856 \pm 0.881) \times 10^{-4}$ and 0.0505 ± 0.0032 , respectively. The activity ratio $^{238}\text{Pu}/^{239+240}\text{Pu}$ in releases from nuclear fuel reprocessing plants, nuclear tests, weapons grade, and Chernobyl fallout are about 0.25 , 0.026 , 0.014 and 0.47 , respectively. Accordingly, it is difficult to identify the source, but it may be due to the contribution of more than one source. The most probable sources are both Chernobyl fallout of Pu isotopes and several decades of fallout Pu accumulation due to nuclear weapons testing.

Novel Aspect

New data base was established for the concentration and isotope ratios of Pu isotopes (^{238}Pu , ^{239}Pu , and ^{240}Pu) in Qatar topsoil.