

Radionuclides in underground waters at the former uranium and radium mining region of Sabugal, Portugal.

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Uranium ore was extracted for radium and uranium production in the county of Sabugal, central region of Portugal. Several mines were in operation there during the first half of the 20th century and one mine, Bica Mine, was in operation until the late 80s. After the close out of mines there has been no environmental remediation works to cover the mining and milling waste heaps left on site. Recent concerns with the potential radiological hazards posed by the uranium mining and milling wastes were the rational for radioactivity measurements in underground waters of this region. Water samples collected in the former uranium mines, in irrigation wells nearby, and in drinking water supplies to villages in the region were analyzed for uranium series radionuclides by radiochemistry and alpha spectrometry. Physical-chemical parameters of the waters were measured also. Water from the Bica Mine contained 4.4 Bq/L, 1.5 Bq/L, and 0.48 Bq/L of dissolved ^{238}U , ^{226}Ra and ^{210}Po , respectively, and these were the highest concentrations measured in waters from the region. Water samples from other mines were under 150 mBq/L of ^{238}U and ^{226}Ra and even less for other dissolved radionuclides. Water from irrigation wells in the region generally displayed concentrations under 50 mBq/L both for ^{238}U and for ^{226}Ra , although water from several wells near the Bica Mine displayed enhanced concentrations of dissolved uranium, reaching 820 mBq/L of ^{238}U , but not enhanced concentrations of other radionuclides such as ^{226}Ra , ^{210}Po and ^{230}Th . Drinking water from public water supplies in the villages and towns of this region contained ^{238}U , ^{226}Ra , ^{230}Th , ^{210}Po and ^{232}Th below 50 mBq/L each, and total alpha radioactivity generally less than 0.1 Bq/L as recommended for drinking water. Only one water supply from a local spring to a village exceeded the recommended limit for alpha radioactivity in drinking water with 230 mBq/L of ^{238}U . The overall assessment of radioactivity in water at this uranium mining region indicates that water resources were not significantly contaminated by the historic uranium mining activity. Nevertheless, mine waters from Bica Mine still require acid treatment to prevent dispersal of the acid and radionuclides into the aquifer.