

Uranium concentrations in NORM efflorescences formed in a phosphogypsum legacy site determined by PIXE

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In the vicinity of the town of Huelva (south-western coast of Spain) the restoration of a NORM legacy site covering some tens of hectares and accumulating around 10^8 tons of phosphogypsum (PG) is planned. This PG was generated during near 50 years as a by-product in the production of phosphoric acid in a big industrial complex located in the vicinity.

The legacy site is located on a salt-marsh area, on the margins of the Tinto river mouth and actually is, from a radioactive point of view, not a closed system because it presents direct and diffuse pollution points (leachates) to the surrounding compartments mainly generated by rainwater and tidal influences.



Phosphogypsum disposal site

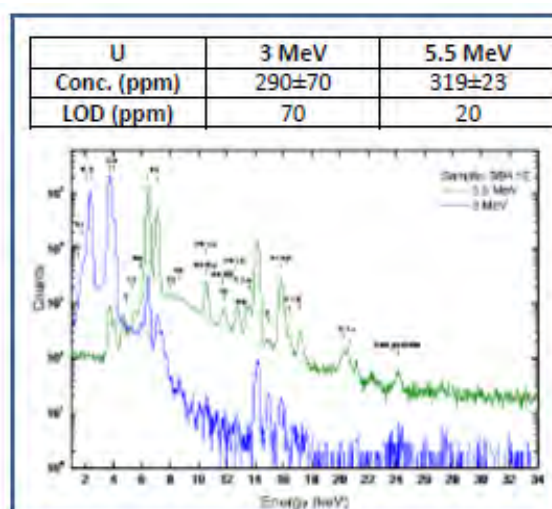
The landfill leachates are the source of efflorescences: precipitated crystallized salts in zones where the water drainage that has left the phosphogypsum piles has been evaporated. The efflorescent salts sequester acidity, metals and radionuclides temporarily and later release them during rain or melting events, thereby provoking the delayed dissemination of contaminants. Thus, the knowledge of efflorescent salt composition is needed for a proper evaluation of the environmental impact of the phosphogypsum stacks nowadays, and the design of the different countermeasures to be adopted associated to the restoration plans.

In this work we will present the uranium concentrations obtained by Proton Induced X-ray Emission (PIXE) in a wide range of efflorescences samples coming from the phosphogypsum disposal site. In particular, 28 samples of efflorescences have been analysed through this non-destructive and multielemental analytical technique. Typical analysis takes few minutes and does not need

chemical sample preparation (the samples only need to be powdered and homogenised before be pressed in pellets of 11mm diameter with a substratus of boric acid).

Analysis were performed with the 3 MV Tandem accelerator at CNA (Sevilla) in vacuum chamber with ion beam intensities of 2-2.5 nA and 3 mm spot diameter. The detector employed was a Si(Li) at 135° degrees with respect the beam direction. Quantification was done using SRM Montana 2710 (NIST).

The measurement of uranium concentrations in the interval of 10 - 10^2 ppm is not trivial, for this reason the optimization of the technical issues was needed. Experiments with protons at different energies were carried out to decrease the limit of detection for uranium as much as possible.



PIXE spectra obtained at different experimental conditions

In this study, in addition to the majority elemental composition, other trace elements have been determined as for example: Se, Rb, Zr, Cd, Ba and Ra. To know the efflorescences composition is mandatory for a proper assessment of the environmental impact of the phosphogypsum stacks.

Finally, to validate the uranium measurements, an internal intercomparison between the uranium results obtained by PIXE and by alpha spectrometry has been performed. The Uranium content quantified by both techniques are in excellent agreement