Application of Diffusive Gradients in Thin Films technique to the determination of polonium in natural water

Julie Champion1, Lu Liu1, Catherine Landesman1, Gilles Montavon1
1 SUBATECH, UMR CNRS 6457, IMT Atlantique/IN2P3/Université de Nantes, 4 Rue A. Kastler, BP 20722, 44307 Nantes Cedex 3, France

In a context where radioactivity in the environment is a constant concern for society, the study of the impact of radioactive elements on environmental compartments is necessary to be able to take the measures to protect ourselves. The uranium mining activity was intense in France (over 200 sites) from the 50s to the 90s. After ending the industrial operations, uranium and its decay products, which are present e.g. in tailings and in mine water, may permanently contaminate the environment around the mining sites. Highlighting on the issue of pollutant behavior and impacts, this work focuses on the quantification of polonium. It is considered as one of the main contributor of natural radioactivity affecting humans. Discovered in 1898 by Pierre and Marie Curie, Po-210 is a natural radionuclide occurring in the environment with its precursors, radium-226 and radon-222. It is one of the most abundant of the 33 isotopes of polonium and its half-life is 138.4 days. Because of its very high specific activity (1.66 $10^{12}$ Bq/g), Po-210 is a substance extremely toxic for humans: a few micrograms are enough to cause death, making this metallic substance about one million times more toxic than sodium or potassium cyanide. To understand the behavior and impact of polonium in the environment, the main scientific challenge is to identify the chemical mechanisms that control its bioavailability. In this context, the presentation will focus on the development of Diffusive Gradients in Thin Film (DGT) passive samplers for polonium in order to develop systems for concentrating and measuring these radionuclides in situ. The DGT technique is based on a simple system which accumulates the solutes by means of a "trapping agent" (a chelating resin immobilized in a thin layer of hydrogel), after passing through a hydrogel layer which acts as a diffusion layer of known thickness.

The Ra-Nucfilm Discs™, provided by TRISKEM, coating MnO₂ as a thin film onto the surface of a polyamide disc, was chosen as the resin in the DGT system because of its efficiency for adsorbing and concentrating Ra and Po. French spring water Cristalline, and Evian mineral water, and a natural water originated from a former exploited uranium mine were tested as “environmental water” model. Firstly, water chemical compositions were determined: major ion and metal concentrations were measured by ion chromatography and by ICP-MS (Inductively Coupled Plasma Mass Spectrometry) respectively; pH values were measured and conductivities are estimated by conductimetry. Secondly, the uptake capacity of Ra-Nucfilm Discs™ were determined by contacting the discs in 210Po, and 226Ra-210Po solutions and measuring them (after being dried) by alpha spectrometry in order to quantify the adsorption efficiency. This was also cross-checked by the analysis of aliquots of solutions (sampled at the beginning and the end of the experiment) and the determination of the decrease of Po activities in solution. Finally, the Ra-NucFilm Discs™ were assembled as a DGT system using APA (Agarose/PolyAcrylamide) diffusive gel (0.8 mm thick) and plastic probe housings provided by DGT Research® and a membrane (0.22 µm, Millipore®). These systems were tested in the same experimental conditions as described above. The apparent diffusion coefficients for Po are determined by applying the first Fick law: $M = \frac{CDA}{\Delta g} \times t$, where M is the mass of the accumulated element, A is the area of the exposed diffusive layer, $\Delta g$ the thickness of the diffusive gel layer, t is the deployment time, C is the bulk concentration of the solute and D is the diffusion coefficient. Finally, such developed DGT system have been deployed in situ for measuring Po concentrations in a former uranium mine site.

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REFERENCES