^{210}Po determination in sandy soils by alpha-particle spectrometry

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Introduction

^{210}Po is a naturally occurring radionuclide, which can be considered one of the most radiotoxic natural radioactive isotopes known by man due to its high specific activity and its emission of high linear energy transfer (LET) alpha radiation.

^{210}Pb ($T_{1/2}$ = 22.3 y) is the parent nuclide of ^{210}Po and is formed by the decay of radon (^{222}Rn) in the uranium series. Radon gas exists in atmospheric air, originated from exhalation from the ground, being its formed daughters (e.g. ^{210}Pb and ^{210}Po) wet and dry deposited onto terrestrial surface and surface of the seas where they can be incorporated into the food chain. Hence, man is exposed to radioactive polonium by natural processes, mainly from the oral intake of foodstuff.

Because ^{210}Pb is a soft beta emitter with an additional low-energy gamma emission (its direct radiometric measurement is no trivial), the ^{210}Pb determination, particularly in soils, is performed in many cases by the measurement of its daughter ^{210}Po, pure alpha emitter, by alpha-particle spectrometry, assuming secular equilibrium. These determinations are useful for example to study potential transfer factors soil to plants in radioecological studies or in the evaluation of erosion rates in environmental studies and requires assuring the complete dissolution of the sample, especially in soils with a high proportion of sand where a fraction of this radionuclide can forms part of the crystalline structure.

In this work a couple of radiochemical methods for ^{210}Po determinations by alpha-particle spectrometry in sandy soils has been tested and validated based in the complete digestion of the treated aliquots and the self-deposition of the liberated ^{210}Po onto copper or silver discs.

Materials and Methods

The activity concentrations of ^{210}Po in all the samples analyzed have been determined by applying the high-resolution alpha-particle spectrometric technique. In particular, an alpha-particle spectrometric system, Alpha-Analyst from Canberra Co., formed by a total of eight independent chambers working in parallel, each one equipped with a PIPS type silicon detector (450 mm^2 active area), has been employed, being reached typical minimum detectable activities in the order of 10^{-1}mBq.

The application of this technique implies the previous isolation and deposition in thin layers of the radioelement of interest in order to avoid interferences in the measurements. The two radiochemical methods tested for ^{210}Po determination are based in the complete microwave digestion of sandy soils aliquots with mixture of acids (nitric, hydrochloric and hydrofluoric acids), differing in the posterior treatment of the obtained solution: in one case the solution is directly conditioned for the posterior self-deposition of the ^{210}Po onto silver discs without any previous radiochemical isolation, while in the other case the solution obtained from the microwave digestion is submitted to a liquid-liquid extraction procedure in order to isolate the Po from other elements or radionuclides, being afterwards the isolated Po fraction self-deposited onto copper discs.

The second radiochemical method, more laborious due to the application of a liquid-liquid separation procedure, allows the sequential obtention of another fraction containing the U-isotopes isolated.

Results and Discussion

The ^{210}Po determinations performed in aliquots of sandy soil samples for the two described procedures indicate that both give results in good agreement between them and reproducible, allowing to conclude that when the only alpha emitter of interest to be determined is the ^{210}Po, the most simple method based in its direct self-deposition from the solution obtained from the digestion (after conditioning) can be applied with confidence. The use of the more laborious method could be considered as an alternative when in addition to the ^{210}Po, the determination of the U-isotopes alpha emitters (^{234}U, ^{235}U and ^{238}U) is needed. Both methods conduit to obtain high radiochemical yields and clean deposits, allowing a complete separation of the ^{210}Po and the ^{209}Po (used as chemical tracer) peaks in the alpha-spectra.

In the sandy soils analyzed, the ^{210}Po levels found are in agreement with the levels of ^{238}U and ^{234}U determined sequentially also by alpha-particle spectrometry, and with the levels of ^{226}Ra determined by gamma-ray spectrometry,with a High Pure Germanium Detector 35 % efficiency and 1.75 % photopeak resolution for ^{60}Co, indicating the existence of secular equilibrium along all the uranium series in the analyzed samples, and giving additional confidence about the methods proposed. These sandy soils present, as expected, a negligible fraction of atmospheric ^{210}Pb, because the deposited atmospheric fraction of this radionuclide is fixed in a minimum proportion in soils with very little content of organic matter.