Preliminary results in: Simultanious determination of ^{210}Bi, ^{210}Po, ^{226}Ra and ^{228}Ra with spontaneus deposition on various surfaces by liquid scintillation counting

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Abstract

The accurate determination of naturally occurring radionuclides, such as ^{226}Ra, and its decay products - ^{210}Pb, ^{210}Bi, and ^{210}Po - is essential in environmental, geological, and radiological research, including ^{228}Ra, which plays a crucial role in assessing groundwater dynamics and long-term radiological exposure. These isotopes act as important tracers and dating tools: ^{210}Pb is used for recent sediment and soil dating, ^{210}Bi and ^{210}Po help study short-term aerosol and environmental processes. The measurement of ^{210}Po is also important on its own, as it is highly carcinogenic. $^{226, 228}$Ra indicate natural radioactivity and long-term exposure risks. Their precise measurement supports radioprotection, environmental monitoring, and the understanding of both natural and artificial processes.

The determination of ^{226,228}Ra is most commonly performed using gamma or alpha spectrometry. Gamma spectrometry offers the advantage of minimal chemical preparation; however, it is limited by relatively high detection limits. In contrast, alpha spectrometry provides significantly lower detection limits, but requires labor-intensive and time-consuming radiochemical separation procedures. A similar situation applies to ^{210}Pb, which is typically measured by gamma spectrometry despite its low gamma yield or by liquid scintillation counting in oxalate form. Given that ^{210}Pb reaches secular equilibrium with its decay products, ^{210}Po and ^{210}Bi, within approximately two years, it can be indirectly quantified through the measurement of these daughter isotopes. Overall, these conventional methods often involve considerable delays and may not always yield precise or efficient results.

To overcome these challenges, we developed an improved methodology based on LSC coupled with spontaneous ion deposition techniques. This approach allows for the rapid and sensitive determination of ^{210}Po, ^{210}Bi, with minimal sample preparation. The method adapts the classical ^{210}Po disk deposition technique by using **wires** (made of different shapes and materials) instead of a disk, enabling direct immersion in the scintillation cocktail. This innovation enhances counting geometry in the LSC spectrometer, reduces quenching, and eliminates shadowing effects.

In parallel, ^{226}Ra and ^{228}Ra from water samples were measured by spontaneous deposition onto manganese dioxide-coated polyamide forms, which were directly introduced into the LSC cocktail. This adaptation enabled efficient and reproducible ^{226}Ra detection without extensive chemical processing.

Deposition was tested on copper wire and subsequently on **silver-coated** copper and **nickel** wire, as these materials exhibit different properties influencing radionuclide deposition behavior. Additionally, wires were shaped into **spirals** to assess potential improvements in deposition efficiency. Testing with copper wires of various diameters (0.75mm - 3mm) revealed that the highest efficiency (65.85 ± 5.17%) was achieved using a 3 mm wire. The efficiency of the nickel wire was significantly lower compared to the others (42.21 ± 5,36%). Silver coating further increased the efficiency (72.93 ± 6.07%), while the spiral form offered no additional gain (64.29 ± 2.99%). Time-resolved measurements confirmed the co-deposition of ^{210}Bi and ^{210}Po, with ^{210}Po depositing more efficiently on silver. Their equilibrium in natural systems allows simultaneous deposition to lower detection limits to 7–12 mBq.

To demonstrate applicability, the method was tested on peat moss from Crveni Potok (Tara National Park, Serbia), yielding 78.28% efficiency (±7.09%). With ~13% overall uncertainty, it is well-suited for low-level, multi-isotope environmental analyses.