The importance of correction factors for the measurement of some radionuclides in sediment and coastal sand samples by HPGe detector

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Introduction:

Sediment is a natural part of rivers, lakes and sea-marine ecosystems. Thus changes to the sediment balance can cause to variations in these ecosystems. Hence, the study of sediments helps to improve the understanding on coastal pollution as sediments act as a sink for inorganic (such as radionuclides and heavy metals) and organic contaminants from various sources [1]. In this context, nuclear analytical techniques are the important tools for providing information on the spatial and temporal trends of radioactive pollutants. They also serve as a dating method for the estimation of their ages. For instance, the use of unsupported ^{210}Pb(^{210}Pb$_{exc}$) is still far off from being a well-established dating tool for recent sediments, up to 20-150 years[2,3]. However, the key issue still seems an accurate activity determination of such radionuclides in sediment analysis. Therefore, in this study, it is aimed to estimate the effect of self-absorption(F_s), true coincidence summing factors(F_{coi}) and spectral interference(F_{csi}) for the activity determination of some gamma-emitting radionuclides such as ^{210}Pb, ^{238}U(^{234}Th), ^{226}Ra, ^{232}Th(^{228}Ac), ^{137}Cs and ^{40}K in lake and stream sediments, and sand samples when a high resolution gamma-ray spectrometry was used.

Methods: A p-type, well(ϕ16mmx40mm depth) geometry HPGe detector with a 44.8% relative efficiency (Canberra GCW 4023) and a n-type HPGe detector with a 78.5% relative efficiency was used in the measurements. Each detector is shielded in a 10 cm thick-Pb lined with 1 mm Sn and 1.6 mm Cu. The spectrometers were calibrated using multinuclide standard sources in cylinder and Marinelli beaker geometry, respectively.

In sample preparation procedure, dry weights of all samples of 2-5 g were determined at 105°C in an oven for overnight(~14h) to remove moisture. Then, powdered samples were filled in plastic beakers(ϕ5.5 cm x 3.54 cm filling height) and a 450 ml Marinelli beakers, and they are sealed tightly, using silicon glue. The samples were counted between at ~2 to 4 days. From the measured peak area, the net counts of peak was determined by peaked-background method, based on blank-background measurement of ~7 days.

Results:

In this work, the experimental detection efficiencies were also validated with those of calculated ones by using GESPECOR software. For certified reference sediment materials, the correction factors, F_s and F_{coi} were then estimated for the given matrices and counting geometry using GESPECOR software. As described in our previous studies [4,5,6], the spectral interference factors, F_{csi}, were calculated for a variety of the analytical peaks used. Then, the measured radioactivity of ^{210}Pb, Uranium (^{238}U), Thorium (^{232}Th),^{226}Ra,^{137}Cs and ^{40}K contained in some lake and stream sediments, and coastal sand dune samples were reported.

Discussion:

The results for correction factors are, respectively tabulated for lake and stream sediments and coastal sand samples. As expected, (1) the magnitude of F_s actors are remarkable higher for 46.5 keV (^{210}Pb) and 63.3 keV(^{234}Th) because of containing heavy element contents such as Fe, Zr in coastal sand dune samples

(2) the magnitude of F_s factors ranged from 1.40-2.25 for 46.5 keV (^{210}Pb), and 1.25-1.85 for 63.3 keV peak (^{234}Th) are relatively smaller in lake and stream sediments.

(3) The true coincidence summing F_{coi} factors varied from 19-30% for 583.2 keV (^{208}Tl) and 18-25% for 609.3 keV (^{214}Bi) analytical peaks, respectively. These results indicate that F_{coi} factors cannot be neglected in the accurate activity measurements depending on type o of radionuclide and counting geometry since this is a case of a close counting geometry, i.e. the sample is counted on the endcap.

(4) Finally, it is worth noting that higher spectral interference F_{csi} factors were estimated for 186.2 keV(^{226}Ra) and 1460.8 keV (^{40}K), due to ^{235}U and ^{232}Th contributions.

The measured results will be presented in detail.

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