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Design and construction of a gamma-ray spectrometer with water shielding for low-level natural occurring radioactive material measurement

Gamma-ray spectrometer with a single HPGe or NaI:Tl detector shielded with lead is often used to measure the activity concentration of radionuclides in soil samples. A passive water shield to reduce background radiation reaching the detectors was designed using GEANT4 Monte Carlo simulations and then constructed. IAEA-375 soil and beach sand each placed in Marinelli beaker were measured for 48 hours using two LaBr3:Ce detectors placed inside the constructed water shield. The samples were also measured for 24 hours using a NaI:Tl detector inside the constructed water shield and HPGe shielded with lead and copper to compare and validate the results from measurements with the LaBr3:Ce detectors. Both the simulated and measured results show that the water shield attenuates the 2614.5 keV gamma rays by over 90 % and energies lower than the 2614.5 keV by far above 90 %. The activity concentration of K-40 radionuclide in IAEA-375 soil and beach sand measured using the LaBr3:Ce detectors was below the minimum detectable activity (MDA) due to the internal activity of the detector. The measured activity concentrations of U-238 and Th-232 series and K-40 radionuclides in IAEA-375 soil were comparable with certified values to within measurement uncertainties. The activity concentrations of U-238 and Th-232 series radionuclides in beach sand were determined using all the measurement geometries and consistent to within 1σ to 2σ level.

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