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Mapping environmental radioactivity: integrating portable gamma-ray spectrometry into experiential science education

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Natural radioactivity constitutes an intrinsic characteristic of the terrestrial environment, subjecting the biosphere to a continuous flux of ionizing radiation. However, conventional pedagogical frameworks frequently neglect empirical engagement with environmental radioactivity, thereby failing to mitigate prevalent misconceptions regarding nuclear physics. This failure represents a significant barrier to fostering student interest in scientific careers, which is essential for sustainable development. This work details an experiential learning framework implemented at the INFN National Laboratory of Frascati (LNF), wherein students employed the CAEN GammaEDU system to characterize the spatial distribution of natural environmental radioactivity.

Seventy-one *in situ* gamma-ray measurements were acquired across a 0.12 km^2 footprint using the CAEN GammaEDU system equipped with a 3" NaI(Tl) scintillator. Real-time energy spectra were analyzed to quantify abundances of Potassium (K), equivalent Uranium (eU), and equivalent Thorium (eTh) over an integration time of 420 seconds per point, with concurrent logging of geospatial and visual data. The measurement campaign stratified the study area into seven distinct surface types (asphalt, bricks, cement, grass, gravel, porphyry, and playground) with a 70 cm diameter field-of-view. Spatial distribution maps were subsequently generated via collocated Co-kriging, a multivariate interpolation technique leveraging the spatial autocorrelation of sparse radiometric data and its cross-correlation with surface classification.

It resulted that the average concentrations in the area (7.0 ± 0.5 μg/g for eU, 40.5 ± 5.8 μg/g for eTh, and 2.7 ± 0.4% for K) are significantly exceed global soil abundances (2.9 ± 0.3 μg/g for eU, 8.0 ± 0.7 μg/g for eTh, and 1.20 ± 0.07% for K. The average total activity concentration in the area is 1087 ± 215 Bq/kg with the highest values (1896 ± 192 Bq/kg) in asphalt and the lowest concentration (417 ± 265 Bq/kg) in the bricks surface type.

This experiential approach gave students direct access to professional scientific instrumentation, allowing them to navigate the entire experimental lifecycle from data acquisition to geostatistical analysis. This process helped solidify their conceptual understanding of environmental radioactivity and highlighted the vital role technological literacy plays in developing future talent. By effectively bridging the gap between abstract theory and applied research, the project successfully increased student motivation and engagement with the subject matter.