Environmental Assessment of Natural and Artificial Radionuclides in Beira Interior, Portugal: Insights for NORM Management

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In the Beira region of Central Portugal, soils are particularly enriched in lithogenic radionuclides and their progeny. Former mining activities, combined with natural rock weathering processes, contribute to concerns regarding the dispersion of radioactivity and the potential for increased population exposure. Airborne transport mechanisms facilitate both short and long-range dissemination of radioactive pollutants via atmospheric pathways. Consequently, the assessment of radionuclides in bioindicator samples is essential for understanding these transfer processes, with mosses being especially suitable due to their capacity to accumulate airborne elements. Understanding the behavior and transfer mechanisms of these radionuclides, particularly via atmospheric deposition pathways, is essential for risk assessment

This study evaluates both natural and anthropogenic radionuclides in moss samples collected across multiple sites in the Beira region. Moreover, additional sampling is planned or underway in soil, surface waters (including both spring and flowing waters), and aerosols. We collected samples in the Serra da Estrela and Beira Interior regions in Portugal, encompassing altitudes from 400 to 1500 meters. The radionuclides under investigation include ^{137}Cs, ^{7}Be, and lithogenic isotopes such as ^{226}Ra, ^{228}Ra and ^{40}K quantified using gamma and alpha spectrometry.

All sampling sites were georeferenced to enable GIS analyses. Spatial distribution maps of radioactivity levels were produced and examined for potential correlations with geological parameters, such as uranium content in the bedrock, as well as geomorphological characteristics. In addition, inter-radionuclide correlations were explored to infer mechanisms of distribution and deposition.

Preliminary findings indicate that artificial and local radionuclides exhibit distinct spatial patterns, suggesting they follow different environmental transfer pathways. These results support the hypothesis that lithogenic radionuclides are incorporated in mosses in proportion to their abundance in underlying soils. In contrast, radiocesium uptake appears to be primarily governed by atmospheric and meteorological conditions. These findings underscore the importance of integrating biomonitoring, geospatial analysis, and radiometric techniques to support radioprotection strategies and improve NORM management in geologically complex regions.