Title: Environmental Investigation of Natural Radioactivity and Health Risk Assessment in Basaltic Volcanic Building Materials

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Abstract: This study presents an integrated geological and environmental radiological analysis of basaltic volcanic rocks, which have been characterized by their suitability and potential for risk when used as construction materials. A total of thirty-five representative basaltic samples from the environment of studied area, located in the Northern Eastern Desert of Egypt, were utilized for this study. The rocks were then analyzed by means of HPGe high-resolution gamma-ray spectrometry methods. The petrographic studies show that the basalt samples were composed mostly of three main minerals: plagioclase, olivine, and pyroxene. In addition, these rocks have a significant degree of secondary alteration products, including sericite, epidote, and zoethite. For uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K), the average activity concentration measured 53 ± 20 Bq kg^{-1}, 54 ± 14 Bq kg^{-1}, and 1178 ± 269 Bq kg^{-1}, respectively. Using the current global reference limits, all the measured values are above acceptable levels for the radionuclides ^{238}U, ^{232}Th, and ^{40}K. The radiological indices calculated for each of the basalt volcanic samples measured radium equivalent activity (Ra_{eq} = 221 Bq kg^{-1}), external hazard index (H_{ex} = 0.60), internal hazard index (H_{in} = 0.74), gamma index (Iγ = 0.84), and annual effective dose (AED = 0.52 mSv y^{-1}) indicate that the radiological hazard values of these samples are acceptable, unlike several samples, where values are near or exceed the accepted standards for indoor hazards. The most significant finding of this study reveals that the major contributions in the environment from radiological risk can be attributed to radionuclides ^{238}U and ^{40}K based on correlation analysis, hierarchical clustering, and PCA analyses, and this study establishes the first multivariate perspective of how radiogenic materials controlled by the environment can affect basaltic rocks. Therefore, this study creates an important baseline for future environmental monitoring and states that caution is warranted when using basalt as a finished material for constructed environments, and for using basaltic products as raw materials in indoor environment.

Keywords: basaltic volcanic rocks; uranium-thorium-potassium; environmental risk; statistical analysis; building materials

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