Estimation of Annual Effective Dose and Excess Lifetime Cancer Risk from Background Ionizing Radiation at Udege Mbeki Abandoned Excavated Mining Site, Nasarawa State, Nigeria

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Abstract

This study evaluates the radiological health implications of human exposure to background ionising radiation (BIR) at the mining site, with particular emphasis on the Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR). Soil samples were collected from four distinct zones; dumps, farmland, surface soil and the processing site, and analyzed using a gamma-ray spectrometer to determine the activity concentrations of naturally occurring radionuclides ^{40}K, ^{226}Ra, and ^{232}Th. Radiological hazard indices, including absorbed dose rate, AEDE, and ELCR were subsequently computed. At the processing site, mean activity concentrations of ^{40}K, ^{226}Ra, and ^{232}Th were 218.58 Bq kg^{-1}, 114.35 Bq kg^{-1}, and 420.06 Bq kg^{-1}, respectively. These elevated radionuclide levels resulted in a mean absorbed dose rate of 315.66 ± 9.72 nGy h^{-1}, corresponding to a mean AEDE of 161.30 ± 4.97 mSv y^{-1} and a mean ELCR of 564.56 × 10^{-3}. The highest values were recorded at sample point P7, with AEDE and ELCR reaching 387.03 mSv y^{-1} and 1354.59 × 10^{-3}, respectively. In the dumps, mean AEDE and ELCR were 148.81 ± 4.49 mSv y^{-1} and 520.83 × 10^{-3}, respectively, while farmland soils showed comparatively lower values with mean AEDE of 67.12 ± 2.67 mSv y^{-1} and ELCR of 234.92 × 10^{-3}. Surface soils exhibited intermediate radiological characteristics, with mean AEDE and ELCR of 121.49 ± 3.48 mSv y^{-1} and 425.22 × 10^{-3}, respectively. Overall, the estimated AEDE and ELCR values across the studied locations exceeded internationally recommended safety limits for public exposure, indicating significant radiological risk, particularly within the processing and dump sites. The elevated ELCR values suggest an increased probability of cancer development over a lifetime of exposure. These findings underscore the need for continuous environmental monitoring, restriction of prolonged human activities within high-exposure zones of the mined area to mitigate long-term health risks and enforcement of land reclamation agreement to restore excavated mining sites into usable land for agriculture or residential purposes.

Keywords: Mining; Exposure; Radiological hazards; Ionizing radiation; Mine tailings.