Seasonal Variation and Radiological Risk Assessment of Naturally Occurring Radionuclides in Water and Fish from Gold Mining regions of the Lake Victoria Goldfields, Tanzania

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Background: Limited data exists on the occurrence of naturally occurring radionuclides (NORs) and their potential radiological health implications to human and aquatic ecosystems within the Lake Victoria Goldfields, Tanzania where surface water and groundwater are extensively used for drinking and other domestic purposes, raising concerns about possible radiological exposure to local communities.

Objective: This study aimed to assess the activity concentrations of uranium isotopes (^{234}U, ^{235}U, ^{238}U), thorium isotopes (^{230}Th, ^{232}Th), ^{226}Ra, ^{210}Po, and ^{210}Pb in fish (African Lungfish, Catfish and Tilapia) and water samples collected from selected sites during both rainy and dry seasons. The study further evaluated seasonal variations, bioaccumulation patterns in fish tissues (flesh, gills, and bones), and estimated ingestion doses for infants, children, and adults through drinking water and fish consumption.

Methods: Surface water and groundwater samples, along with commonly consumed fish species, were collected from mining-affected regions within the Lake Victoria Goldfields (LVGF). Radiochemical separation techniques were applied, followed by activity concentration determination using Alpha Spectrometry and a low background gas-flow proportional counter. Bioaccumulation factors (BAFs) were determined for different fish tissues, and committed effective ingestion doses for various age groups were estimated based on ICRP-recommended dose coefficients.

Results: Preliminary findings indicated seasonal variability in activity concentration of uranium isotopes and ^{226}Ra in water samples, with generally higher concentrations found in dry season compared to wet season. Groundwater concentrations reached up to 3102.1 ± 822.67692 mBq L^{-1} for ^{238}U, 7383 ± 1950 mBq L^{-1} for ^{234}U and 107.59± 0.59 mBq L^{-1} for ^{226}Ra. In surface water, maximum concentrations were 932.35± 100 mBq L^{-1} (^{238}U), 1661.8 ± 176.6 mBq L^{-1} (^{234}U) and 46.628 ± 0.57 mBq L^{-1} (^{226}Ra). The activity concentrations of ^{210}Po and ^{210}Pb in fish samples also showed notable variability ^{210}Pb ranged from 15.20 ± 2.66 to 62.94 ± 9.65 Bq/kg (dry weight), with the highest concentration recorded in Catfish bones (62.94 ± 9.65 Bq/kg). ^{210}Po concentrations varied from 0.53 ± 0.47 to 3.43 ± 0.97 Bq/kg (dry weight), with the highest value observed in tilapia gills (3.43 ± 0.97 Bq/kg). Estimated annual ingestion doses from drinking water exceeded the WHO recommended guidance level of 0.1 mSv y^{-1} for infants and children at several sites, in both seasons. Fish consumption contributed to annual radiological exposure, with bones exhibiting the highest activity concentrations of radionuclides among the analyzed tissues.

Conclusion: This study provides the first comprehensive dataset on natural radionuclide levels in aquatic systems within the gold mining areas of Tanzania, highlighting potential radiological health risks, particularly for vulnerable groups relying on untreated water and locally sourced fish. The results of this study underscore the need for continuous environmental monitoring and the development of appropriate radiological protection measures in gold mining-affected regions.