Assessment of liquid radioactive waste characteristics and management practices in nuclear medicine facilities in Tanzania

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Abstract

Residual liquids waste generated during nuclear medicine procedures may contain radioactive materials and toxic chemicals that pose potential risks to the environment and public health. This study assessed the physicochemical properties, radionuclide activity, heavy metal concentrations and Management practices of liquid radioactive waste generated at two major nuclear medicine facilities in Tanzania: Ocean Road Cancer Institute (ORCI) and Bugando Medical Centre (BMC). A cross-sectional study was conducted over eight days at ORCI and ten days at BMC. Approximately 735 mL of liquid waste was collected at each facility and combined into three composite samples per site. Radiation levels, physicochemical parameters, and heavy metal concentrations were measured using the APHA Standard Methods for the Examination of Water and Wastewater. Heavy metal contamination was evaluated using the Contamination Factor, Degree of Contamination, Pollution Load Index, Heavy Metal Pollution Index, and Metal Index. Results were compared against World Health Organization (WHO) guideline limits.Statistical differences between facilities were assessed using the Mann-Whitney U test, while radionuclide decay was modeled using exponential regression to estimate half-lives. The results indicated rapid radionuclide decay, with estimated half-lives of 0.62, 0.83, and 0.96 days for Tc-99m and Ga-68. Ambient radiation levels ranged from 0.15-0.75 µSv/h at ORCI and 0.38-0.85 µSv/h at BMC, with eleveted readings observed in generator storage areas, hot laboratories, and gamma camera rooms. No significant differences in radiation levels were observed between the two facilities ($W = 11$, $p = 0.296$). ORCI effluents were acidic (pH 3.84 ± 0.67) with higher conductivity and TDS, while BMC effluents were near neutral (pH 7.09 ± 0.21) and exibted higher salinity and turbidity.Concentrations of Cd , Ni , and Pb exceeded WHO limits at both sites, while Zn concentrations ware significantly higher at BMC (5.98 ± 0.072 mg/L) compared to ORCI (0.87 ± 0.012 mg/L, $p < 0.001$). In conclusion, radiological risks associated with liquid waste from nuclear medicine facilities appear to be adequetely controlled; however, chemical and heavy metal contamination remains a notable environmental concern. Radiological risks associated with liquid waste from routine monitoring, wastewater treatment practices, and strengthened regulatory oversight measures are recommended to mitigate these hazards.

Keywords

Physicochemical parameters; Heavy metals; Environmental safety; Liquid radioactive wastenuclear medicine