Monte Carlo-Based Optimization of Occupational Radiation Protection in a Diagnostic Radiology Facility at Kitui County Level V Hospital, Kenya

Muthama Matsitsi[1]*, Linturi James[1], Jeremiah Kebwaro[2], Felix Omonya[3]

[1]Department of Physical Sciences, South Eastern Kenya University, P.O BOX 170 - 90200 Kitui, Kenya.

[2]School of Pure and Applied Sciences, Karatina University, P.O BOX 1957-10101 Karatina, Kenya.

[3]International Atomic Energy Agency P.O BOX 100, Vienna, Austria

Abstract

Accurate occupational dose estimation is essential for optimizing radiation safety and ensuring compliance with regulatory guidelines. The spatial distribution of scatter radiation in the radiography room was characterized using Monte Carlo simulations based on Geant4. A diagnostic X-ray system was accurately modeled and validated using experimental measurements to evaluate the magnitude and distribution of scattered radiation. Simulated and measured dose rates showed good agreement within ±10%, with a root mean square error of 0.08 μSv h^{-1}, indicating strong model reliability. Scatter dose exhibited a general decrease with distance from the source, approximately following the Inverse Square Law, although deviations were observed due to distributed scatter sources and attenuation in air. The scatter dose decreased from 1.51 μSv h^{-1} at 0.25 m to 0.36 μSv h^{-1} at 2.0 m from the source, representing approximately a 76% reduction. Increasing the field size from 10 × 10 cm^2 to 20 × 20 cm^2 and 30 × 30 cm^2 significantly increased scatter dose even at far-field positions. The combined use of lead protective clothing and 0.5 mm mobile lead shielding reduced scatter dose by approximately 90-96%. Overall, the estimated occupational dose levels were within internationally recommended limits. The observed distribution and variability of scatter radiation highlight the importance of continuous radiation protection optimization. The study therefore recommends routine indoor radiation monitoring, particularly for staff working in radiology departments. Strict implementation of the ALARA principle through appropriate positioning and effective shielding using lead aprons is strongly recommended.

Keywords: Occupational dose, Monte Carlo simulation, X-ray dosimetry, Scatter dose, radiation safety.