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Assessment Of Background Ionising Radiation And Excess Lifetime Cancer Risk In Selected Mining Sites In Jos South, Plateau State, Nigeria

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ABSTRACT

This study assessed background ionising radiation levels and associated long-term cancer risks in eight mining sites in Jos South, Plateau State, Nigeria. Radiation measurements were obtained using a calibrated Gamma Scout detector and used to calculate the Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) in Eight (8) mining sites. Absorbed dose rates ranged from 0.197 to 0.630 $\mu\text{Sv/h}$, exceeding the UNSCEAR (2000) global average of 0.059 $\mu\text{Sv/h}$. Calculated AEDE values varied between 0.2416 and 0.7726 mSv/year, approximately three to eleven times higher than the recommended global outdoor average of 0.07 mSv/year. ELCR values ranged from 0.000758 to 0.002415, all above the global reference level of 0.00029, indicating elevated lifetime cancer risk. Site 2 consistently recorded the highest values, revealing areas of greater radiological impact. These findings suggest that prolonged exposure to elevated background radiation in these mining environments may pose long-term health risks, hence the need for continuous monitoring and improved safety practices.

Keywords: Background ionising radiation (BIR), Mining activities, Annual effective dose equivalent (AEDE), Excess Lifetime Cancer Risk (ELCR)

INTRODUCTION

Ionising radiation is radiation with sufficient energy to remove tightly bound electrons from atoms, creating ions (WHO, 2020). According to Mollah et al. (2021), ionising radiation can damage DNA in living cells, increasing the risk of cancer and other biological effects, particularly after prolonged or high-dose exposure. Natural background radiation is the main source of exposure for most people, while occupational exposure is higher in environments such as mining, oil and gas extraction, and phosphate fertilizer production. Naturally occurring radioactive materials (NORM) are present in soils, rocks, mineral ores, and various industrial waste streams (Chambers, 2013). Mining activities in Jos and its environs have been ongoing for over a century, contributing to redistribution of NORM and elevated background radiation in soil, water, and air (Masok et al., 2015; Ademola, 2008; Jibiri et al., 2007; Olise et al., 2014). In Jos South, largely unregulated mining practices have resulted in continuous radiological impacts, indicating the need for radiation risk assessment and monitoring to protect miners, nearby communities and the environment (Atipo et al., 2020).

MATERIALS AND METHODS

The study was conducted at eight mining sites in Jos South Local Government Area, Plateau State, Nigeria. Background ionising radiation (BIR) levels were measured in $\mu\text{Sv/h}$ using a calibrated Gamma

Scout detector. The Annual Effective Dose Equivalent (AEDE) was calculated using the UNSCEAR (2000) formula:

$$AEDE \text{ (mSv/y)} = D \text{ (nGy/h)} \times T \times F \times Q \times 10^{-6} \quad (1)$$

where D = absorbed dose rate, T = 8760 h/year, F = outdoor occupancy factor (0.2), Q = dose conversion coefficient (0.7 Sv/Gy), and 10^{-6} = conversion from nGy to mSv.

While the Excess Lifetime Cancer Risk was estimated using:

$$ELCR = AEDE \times DL \times RF \quad (2)$$

where DL = average life expectancy in Nigeria (54.9 years, WHO, 2024) and RF = fatal cancer risk per sievert (0.057).

RESULT

Table 1 presents the estimated absorbed dose rate, annual effective dose equivalent and excess lifetime cancer risk obtained at the selected mining sites. Figure 1 shows a graphical comparison of the estimated AEDE for the selected sites with the recommended value by UNSCEAR (2000), while Figure 2 illustrates the ELCR for the selected sites compared with the UNSCEAR (2000) reference value.

Table 1 Average BIR, Calculated ADR, AEDE and ELCR Values for each Mining Site

Site	Average BIR ($\mu\text{Sv/h}$)	Absorbed dose rate (ADR) (nGy/h)	AEDE (mSv/year)	ELCR
Site 1	0.437 ± 0.021	437	0.5359	0.001672
Site 2	0.630 ± 0.024	630	0.7726	0.002415
Site 3	0.372 ± 0.023	372	0.4562	0.001428
Site 4	0.263 ± 0.047	263	0.3225	0.001010
Site 5	0.197 ± 0.011	197	0.2416	0.000758
Site 6	0.273 ± 0.066	273	0.3348	0.001047
Site 7	0.261 ± 0.075	261	0.3201	0.001003
Site 8	0.305 ± 0.103	305	0.3741	0.001172

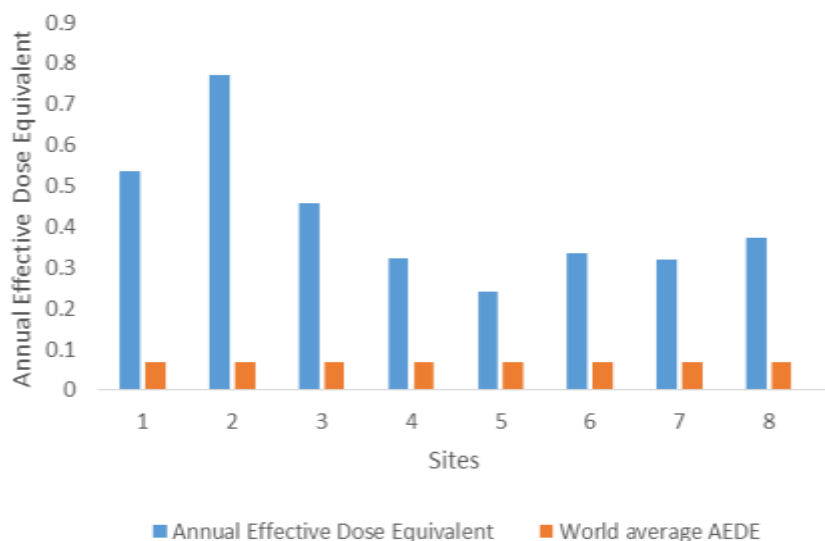


Figure 1 Estimated AEDE for Selected Sites Compared with the Recommended Value by UNSCEAR, 2000.

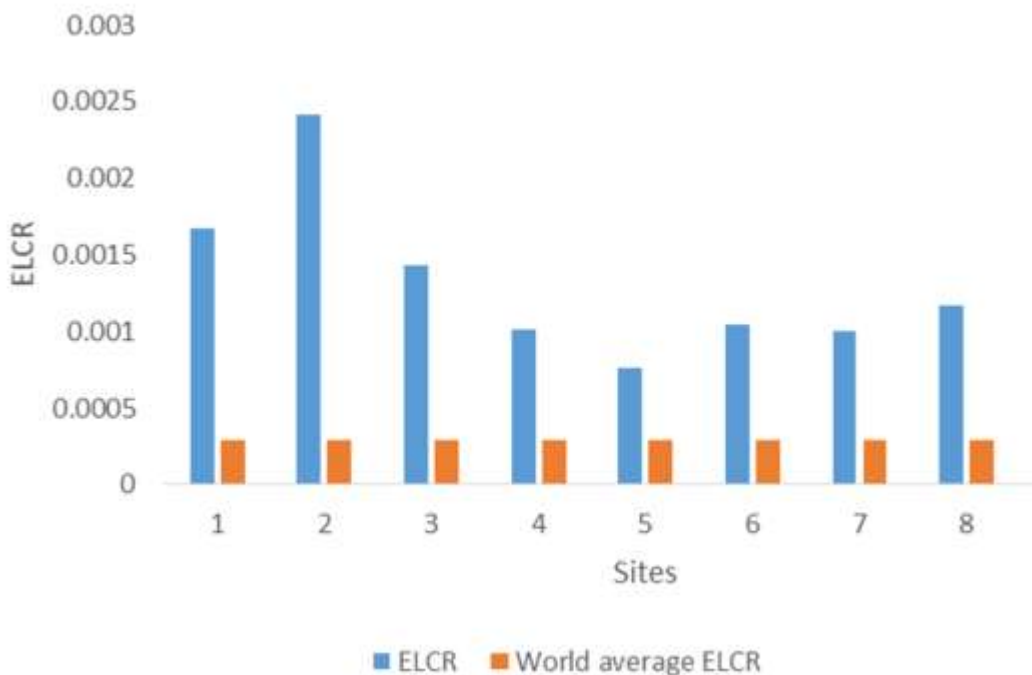


Figure 2 ELCR for Selected Sites Compared with Recommended Value by UNSCEAR, 2000.

DISCUSSION

The study covered a total of eight mining sites where radiation measurements were obtained. The average Background Ionising Radiation (BIR), measured Absorbed Dose Rate (ADR), calculated Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) values are presented in Table 1, while the graphical comparison of AEDE and ELCR with the UNSCEAR (2000) global average are shown in Figures 1 and 2, respectively. The absorbed dose rates recorded across the sites ranged from 0.197 to 0.630 $\mu\text{Sv/h}$.

All measured dose rates were higher than the UNSCEAR (2000) global average background value of 0.059 $\mu\text{Sv/h}$. Among the studied locations, Site 2 recorded the highest radiation level, indicating a greater degree of radiological impact at that site. The observed variations among the sites may be attributed to differences in mining intensity and the extent of disturbance of naturally occurring radioactive materials.

The calculated AEDE values ranged from 0.2416 to 0.7726 mSv/year, approximately three to eleven times higher than the global average outdoor exposure of 0.07 mSv/year reported by United Nations Scientific Committee on the Effects of Atomic Radiation. However, they remain below the 1 mSv/year public dose limit recommended by the International Commission on Radiological Protection (2007). Although the AEDE values are within the recommended public exposure limit, the elevated levels suggest increased radiation exposure for individuals who spend prolonged periods within the mining environment. Excess Lifetime Cancer Risk (ELCR) values obtained in this study ranged from 0.000758 to 0.002415. All values exceeded the UNSCEAR global reference level of 0.00029, indicating an increased probability of radiation-induced cancer over a lifetime. The highest ELCR value recorded at Site 2 was approximately 8.3 times higher than the global average, suggesting potential long-term health implications of unregulated mining activities in the area.

CONCLUSION

Background radiation levels in the mining sites exceeded the UNSCEAR (2000) global average. While not sufficient for emergency action, prolonged exposure poses a potential long-term health risk. These therefore reveal the need for continuous environmental radiation monitoring and improved safety measures for miners to minimise long-term radiation-related risks in the study area.

AUTHOR'S CONTRIBUTION: These authors contributed equally.

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