Journal of Human Environment and Health Promotion

Print ISSN: 2476-5481 Online ISSN: 2476-549X

Assessment of Ionizing Radiation Levels in Scrap Market Areas of Yenagoa, Bayelsa State, Nigeria

Peter Ebibuloami Biere [a], **Kugbere Emumejaye** [b*], **Tolulope Olaide Aluko** [c]

a. Department of Physics, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.
b. Department of Physics, Southern Delta University, Ozoro, Nigeria.
c. Department of Physics Education, Federal College of Education (Tech) Akoka Lagos State, Nigeria.

***Corresponding author:** Department of Physics, Southern Delta University, Ozoro, Nigeria. Postal Code: 334111. E-mail: emumejayek@sdu.edu.ng

A R T I C L E I N F O

Article type:
Original article

Article history:
Received: 6 January 2026
Revised: 18 February 2026
Accepted: 7 March 2026
Available online: 16 March 2026

https://doi.org/10.61882/jhehp.748

Keywords:

Environment
Scrap market
Background ionizing
Radiation
Excess lifetime cancer risk

A B S T R A C T

Background: The purpose of this study was to characterize background ionizing radiation in this environment, which is essential for assessing the health risks linked to prolonged exposure. The environmental radiation levels in the Bayelsa scrap market, located on the outskirts of the capital city, were investigated to assess the potential health impacts of ionizing radiation.
Methods: Using a calibrated handheld radiation meter (Radalert-100X), measurements were taken at thirty randomly selected points within the market, which is densely populated with artisans, scrap dealers, and other stakeholders.
Results: The exposure rate, absorbed dose rate, annual effective dose, and excess lifetime cancer risk ranged from 0.009 to 0.034 mRh^{-1}, 78.3 to 295.8 $nGyh^{-1}$, 0.09 to 0.36 $mSvy^{-1}$ and (0.12 to 0.45) x 10^{-3}, respectively. The corresponding average values of 0.018 mRh^{-1}, 154.28 $nGyh^{-1}$, 0.19 $mSvy^{-1}$, and 0.25 x 10^{-3} indicate that although the average absorbed dose rate exceeds the global average, the annual effective dose equivalent and excess lifetime cancer risk remain within permissible limits. The findings suggest that scrap markets may not significantly increase public radiation exposure, and the associated lifetime cancer risk remains low.
Conclusion: This study highlights the importance of monitoring environmental radiation in scrap metal markets. Such measures are essential to mitigate the elevation of background ionizing radiation levels, thereby protecting both the environment and public health from potential radiation-induced hazards.

1. Introduction

Radiation is a ubiquitous phenomenon that presents in our environment, originating from both natural and artificial sources. Artificial radiation sources, which are man-made, and include medical applications, nuclear power plants, and industrial activities (ICRP, 2007). On the other hand, natural radiation sources account for the majority of human exposure and include cosmic rays, radon gas, and the radioactive decay of naturally occurring radioactive materials. Radiation in the human environment plays a significant role in cancer formation and growth by damaging cellular DNA, leading to genetic mutations and alterations that can disrupt normal cellular function. Ionizing radiation, such as alpha particles, X-rays, and gamma rays, can penetrate cells and damage DNA molecules, resulting in single-strand breaks, double-strand breaks, or other types of DNA lesions (Gerarda et al., 2021). This damage may include genetic mutations that initiate carcinogenesis by activating oncogenes or inactivating tumor suppressor genes. The accumulation of radiation-induced genetic and epigenetic alterations can ultimately lead to tumor formation. Furthermore, radiation may promote tumor growth by inducing angiogenesis and immune responses (Liangliang et al., 2024). The International Agency for Research on Cancer (IARC) has classified ionizing radiation as "carcinogenic to humans", highlighting its role in cancer development (IARC, 2012). Overall, ionizing radiation is a known carcinogen that

How to cite: Biere, P. E., Emumejaye, K., & Aluko, T. O. (XXXX). Assessment of Ionizing Radiation Levels in Scrap Market Areas of Yenagoa, Bayelsa State, Nigeria. *J Hum Environ Health Promot*, *XX*(X), XX-XX.

contributes to cancer development and progression. Prolonged exposure to elevated levels of ionizing radiation in the environment is strongly associated with an increased risk of cancer and other adverse health effects. Consequently, assessing and mitigating exposure to background ionizing radiation in the environment is essential for protecting public health, particularly in environments where individuals live or spend extended periods.

The study area, an oil-and-gas producing region with a metal scraps market, presents potential sources of radiation, including naturally occurring radioactive materials (NORM) associated with oil and gas activities, as well as possible radioactive materials in scrap metal. The scrap market, a hub of commercial activity, presents a unique environment in which vendors, customers, and workers may be exposed to background ionizing radiation. This environment may harbor elevated radiation levels due to the presence of various radiation sources. For instance, iron and steel products traded in the market may contain trace amounts of radionuclides such as potassium, thorium, and uranium, which are naturally present in the Earth's crust. Additionally, the market's proximity to industrial activities-including welding, cutting, and machining-may contribute to increased radiation levels. These industrial processes can generate radioactive particles and radiation, which can then disperse into the surrounding environment. Furthermore, construction materials used in the market structures and surrounding infrastructure may also be a source of elevated radiation. Materials such as granite, concrete, and brick can contain varying levels of naturally occurring radioactive materials (NORM). When utilized in building construction, these materials can emit radiation into the surrounding environment. Given these potential sources of radiation, it is reasonable to hypothesize that the iron market environment may exhibit elevated radiation levels, which could pose health risks to individuals who frequent the area for extended periods. Therefore, characterizing background ionizing radiation in this setting is crucial for evaluating potential health risks associated with prolonged exposure.

2. Materials and Methods

2.1 Study Area

The study area is situated behind a major dumpsite along Tombia-Amassoma Road. It is an informal industrial area on the outskirts of Yenagoa, the capital city of Bayelsa State, Nigeria. Its exact coordinates are latitude 4.9272º N and longitude 6.2833º E. Its proximity to oil and gas facilities, such as pipelines, flow stations, and drilling rigs, greatly influences its environment. The vegetation in the area is characterized by a mixture of mangrove forest, freshwater swamps, and grasslands. The geology of the area is predominantly composed of sedimentary rocks, specifically the Agbada Formation, which consists of sand, silt, and clay deposits (Iheaturu et al., 2022). The scrap market is characterized by a sprawling landscape of makeshift workshops, warehouses, and open spaces where scrap materials are collected, processed and sold. The area is densely populated with artisans, scrap dealers, and other stakeholders who engage in various activities, including metal recycling, auto repair, and fabrication. The market performs a significant function in the community's economic well-being by generating job opportunities and income for numerous individuals.

2.2 Measurement method

The RadAlert 100X was used for measurement. It is a handheld radiation alert meter designed to detect and measure ionizing radiation levels. Its application includes radiation monitoring in industrial, medical, and environmental settings and emergency responses. It features a Geiger-Muller tube detector for measuring radiation levels, a digital display showing radiation levels in counts per minute (CPM) or milliroentgen per hour (mRh^{-1}), adjustable alarm thresholds for alerting users to elevated radiation levels, a built-in speaker for audible alerts, and a compact, rugged design for field use. The meter was factory-calibrated to ensure accurate measurements. At each of the points where measurements were taken, the meter was switched on, held one meter above the ground, and the meter's window was directed to face the point of measurement. The displayed values were read and recorded in mRh^{-1}. A total of thirty sampling points in all were randomly selected within an area of 1682000000 m² for measurements. The selection process accounted for inaccessible areas within the study area to ensure a representative spatial distribution of sampling locations.

2.3 Equations Used

Absorbed dose rate, D is a dose quantity which is the rate at which energy is deposited by ionizing radiation in a unit mass of a material, such as human tissue. It is a measure of the amount of radiation energy absorbed per unit time. This quantity was determined from the measured exposure rate in mRh^{-1}, using equation 1 (Omogunloye et al., 2021).

$$1mRh^{-1} = 8.7nGyh^{-1} \quad (1)$$

Annual effective dose equivalent (AEDE) is the total effective dose of ionizing radiation received by an individual over a period of one year. It takes into account the radiation exposure from various sources. Measured absorbed dose rates, dose conversion factor of 0.7 Sv/Gy and an occupancy factor of 0.2 for outdoor were used to calculate the annual effective dose equivalent received by people in the surveyed area. It was calculated using equation 2 (Ngassa et al., 2024) Excess lifetime cancer risk (ELCR).

$$AEDE = D \times 8760h \times 0.7SvGh^{-1} \times 0.2 \times 10^{-3} \quad (2)$$

This is the additional risk of developing cancer over a lifetime due to exposure to ionizing radiation. It is a measure of the probability of radiation-induced cancer incidence above the natural cancer incidence. Based on calculated values of AEDE, excess lifetime cancer risk was calculated using equation 3 (Dankawu et al., 2021).

$$ELCR = AEDE \times DL \times RF \quad (3)$$

Where, DL is the duration of life or life expectancy (55.2yrs) in Nigeria (WHO, 2018) and RF is the risk factor for low dose background radiation, which is considered to produce stochastic effects, ICRP 60 used values of 0.05 Sv^{-1} for the public (Taskin et al., 2009).

3. Results and Discussion

The measurements carried out in this study are presented in tabular and pictorial forms in this section. Table 1 presents the values of the measured exposure rates and their radiological parameters at the study area, and Table 2 provides a statistical analysis of radiological parameters. The results are also presented in different charts. Figure 1 shows the background ionizing radiation (BIR) values plotted against the world average; Figure 2 shows the absorbed dose (AD) plotted against world average; Figure 3 presents the AEDE values compared with the world average; and Figure 4 shows the excess life cancer risk (ELCR) values compared with the world average.

Table 1. Measured Outdoor Exposure Dose Rate and Calculated Hazard Indices

Location	BIR (mRh^{-1})	D ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR ($x10^{-3}$)
1	0.012	104.4	0.13	0.157
2	0.015	130.5	0.16	0.196
3	0.009	78.3	0.09	0.118
4	0.021	182.7	0.22	0.275
5	0.028	243.6	0.29	0.366
6	0.015	130.5	0.16	0.196
7	0.021	182.7	0.22	0.275
8	0.034	295.8	0.36	0.445
9	0.010	87.0	0.11	0.131
10	0.024	208.8	0.26	0.314
11	0.014	121.8	0.15	0.183
12	0.015	130.5	0.16	0.196
13	0.019	165.3	0.20	0.249
14	0.014	121.8	0.15	0.183
15	0.021	182.7	0.22	0.275
16	0.011	95.7	0.12	0.144
17	0.014	121.8	0.15	0.183
18	0.009	78.3	0.09	0.118
19	0.029	252.3	0.31	0.379
20	0.024	208.8	0.26	0.314
21	0.019	165.3	0.20	0.249
22	0.019	165.3	0.20	0.249
23	0.017	147.9	0.18	0.222
24	0.014	121.8	0.15	0.183
25	0.022	191.4	0.23	0.288
26	0.026	226.2	0.28	0.34
27	0.016	139.2	0.17	0.209
28	0.014	121.8	0.15	0.183
29	0.011	95.7	0.12	0.144
30	0.015	130.5	0.16	0.196

Table 2. Statistical analysis of radiological parameters

	BIR (mRh^{-1})	D ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR (x10-3)
Average	0.018	154.3	0.19	0.25
Min	0.009	78.3	0.09	0.12
Max	0.034	295.8	0.36	0.45

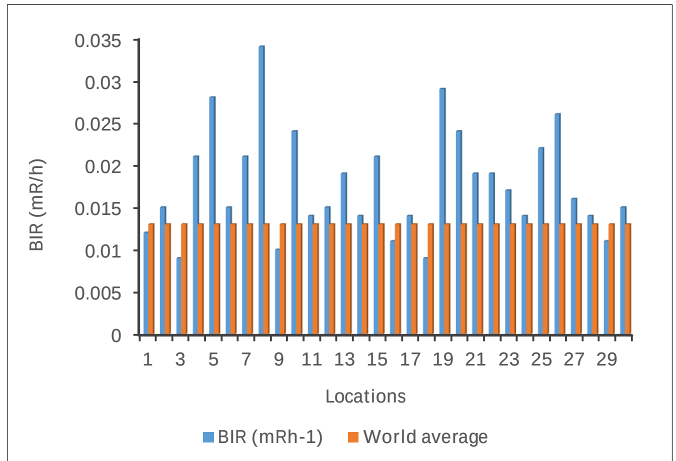

Figure 1. BIR Values against the world average

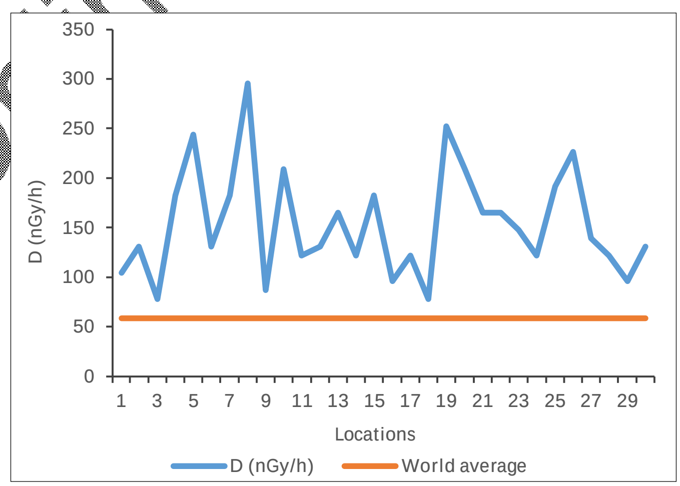

Figure 2. Absorbed dose against world average

The outdoor data obtained from measurements at thirty points shows that exposure rates range between 0.009 and 0.034 mRh^{-1}, with an average of 0.018 mRh^{-1}. Approximately 80% of the measurement points recorded values above the world average. However, the overall average recorded in the study area is close to the world average of 0.013 mRh^{-1} (UNSCEAR, 2000). The absorbed dose ranges from 78.3 to 295.8 $nGyh^{-1}$, with a mean value of 154.28 $nGyh^{-1}$. These values are similar to those reported by Olanrewaju et al. (2020) for a blacksmith environment; however, they are lower than the values reported by Ononugbo and Anekwe (2020) in a normal market environment. All absorbed dose values in this study area are above the world average of 59.0 $nGyh^{-1}$ (UNSCEAR, 2000). The AEDE for the garden ranges from 0.09 to 0.36 $mSvy^{-1}$, with an average of 0.19 $mSvy^{-1}$. All values are lower than the permissive limit. This suggests that activities in the scrap market may not significantly impact the radiation doses received by the public, particularly since the people spend about 6 hours in the market. These values are lower than the UNSCEAR recommended limits of 1.0 mSvy^{-1} for the public and 20 mSvy^{-1} for occupationally exposed workers (UNSCEAR, 2020). The ELCR for the study area ranges from (0.12 to 0.45) x 10^{-3}, with an average of 0.25 x $10^{-3,}$ which is lower than the world average of 0.29 x 10^{-3} (Qureshi et al., 2014). Figures 1, 2, 3 and 4 give pictorial views of the data presented in tables. The results of this study were also compared with those of similar studies, as presented in Table 3.

Although the ELCR values indicate a relatively low risk, the limitations of the measurement tools used must be considered. It is important to state that the primary constraints of the RadAlert 100X detector (which employs a Geiger-Mueller tube) stem from its inability to discriminate radiation energy levels, diminished accuracy for specific radiation types and elevated dose rates, and the susceptibility of its mica window to damage. However, the results give policymakers an overview of the potential hazards in the environment and the immediate populace.

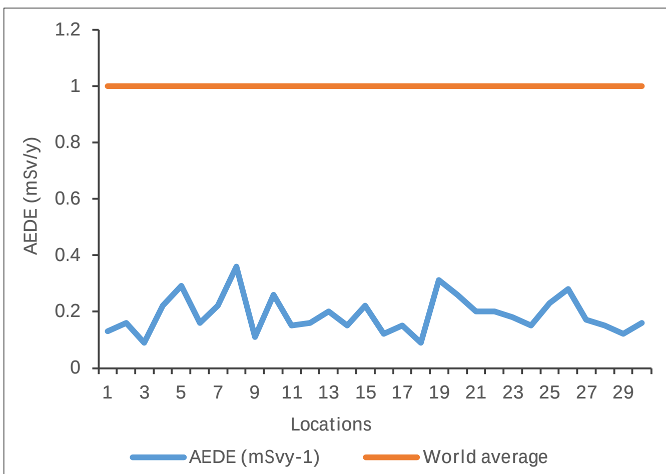

Figure 3. AEDE against world average value

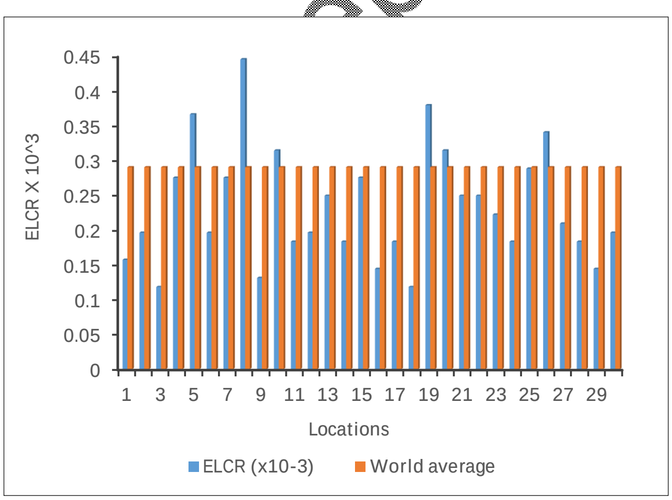

Figure 4. ELCR dose against world average

Table 3. Comparison of the present study results with other similar studies elsewhere

Country	BIR (µSv/h)	D (nGy/h)	AEDE (mSv/y)	ELCR (x10^{-3})	Reference
Tanzania	0.46	542.0	0.286	1.002	(Lugendo, 2022)
Nigeria	0.113	-	0.198	0.692	(Samaila et al., 2024)
Nigeria	0.14	121.8	0.197	0.690	(Nwii et al., 2025)
Nigeria	0.13	176.6	0.0613	0.759	(Kerinja et al., 2020)
Nigeria	0.18	154.3	0.190	0.25	Present study

4. Conclusion

This study investigated the radiological implications of scrap metal activities on the environment, revealing crucial insights into potential health and ecological risks. The results indicate that while the average outdoor radiation exposure rate in the scrap market area is within the global average background radiation value, the absorbed dose rate exceeded the world average, which could be due to the effect of other factors like the geology and the oil and gas activities. Fortunately, the AEDE were below recommended limits for both the public and occupationally exposed workers; the mean excess lifetime cancer risk values suggest a low probability of cancer development among workers and traders. Overall, the radiological assessment suggests that the scrap market environment does not pose an immediate radiological health risk to workers and the public. As the activities in the scrap market are not to significantly influence the doses received by the public. However, to mitigate potential long-term environmental and health impacts, regular monitoring of background radiation exposure levels in the scrap market area is essential. This proactive approach will help ensure that radiation exposure remains as low as reasonably achievable, thereby safeguarding both human health and the environment.

Authors' Contributions

Peter E. Biere: Conceptualization; Data collection and writing original draft. **Kugbere Emumejaye:** Data curation; Writing-review; Project administration and editing. **Tolulope O. Aluko:** Validation; Formal analysis; Methodology and writing-original draft preparation.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgments

The authors are grateful to the Department of Physics, Niger Delta University for providing the RadAlert-100X hand-meter for this research, without their assistance this study would not have been possible.

Ethical Considerations

There were no ethical considerations in this research.

Using Artificial Intelligence

The authors declare that they have not used any artificial intelligence in this research.

References

Dankawu, U. M., Shuaibu, H. Y., Maharaz, M. N., Zangina, T., Lariski, F. M., Ahmadu, M., . . . & Yakubu, A. (2021). Estimation of excess life cancer risk and annual effective dose for boreholes and well water in Dutse, Jigawa state, Nigeria. *Dutse Journal of Pure and Applied Science, 7*(4), 209-218.

Gerarda, V. K., Tim, H., Roland, K., & Jeroen, E. (2021). DNA double strand break repair pathways in response to different types of ionizing radiation. *Frontier in Genetics*, *12*, 1-16.

IARC. (2012). *Some internally deposited radionuclides. Monographs on the evaluation of carcinogenic risks to humans*. International Agency for Research on Cancer (IARC).

ICRP. (2007). *The 2007 recommendations of the international commission on radiological protection*. ICRP Publication.

Iheaturu, T. C., Ideozu, R. U., Abrakasa, S., & Jones, A. E. (2022). Sequence stratigraphy and tectonic framework of the Gabo field, Niger Delta, Nigeria. *Scientia Africana, 21*(3), 19-36.

Kerinja, S. S., Ibrahim, U., Yusuf, S. D., Idris, M. M., & Mundi, A. A. (2020). Assessment of radiation exposure level from some scrap metal dumpsites in Nasarawa State, Nigeria. *Asian Journal of Research and Reviews in Physics*, *3*(2), 1-9.

Liangliang, W., Connor, L., Sean, P. P., Andras, P., Kaiting, Y., Amy, K. H., . . . & Ralp, R. W. (2024). Radiotherapy and immunology. *Journal of Experimental Medicine, 221*(7), 1-17.

Lugendo, I. J. (2022). Assessment of radiation exposure levels from selected scrap metal stores in Dar es Salaam, Tanzania. *Journal of Humanities and Social Sciences*, *10*(5), 76-87.

Ngassa, E. M. G., Guiswe, G., Ayanga, W. J. C., Ekobena, F. H. P., & Guegang, G. E. (2024). Annual effective dose equivalent and excess lifetime cancer risk of Foundjara, Cameroon. *International Journal of Current Research, 16*(1), 27019-27021.

Nwii, A. A., Gbarato, O., & Biibaloo, L. L. (2025). Assessment of background ionizing radiation levels at selected dumpsites in Obio/Akpor Local Government Area, Rivers State, Nigeria. *Faculty of Natural and Applied Sciences Journal of Applied and Physical Sciences*, *2*(2), 39-48.

Olanrewaju, A. I., AbdulKareem, N. M., & Raheem, I. O. (2020). Assessment of radiation exposure level in blacksmithing workshop in Gombe, Gombe State. *FUDMA Journal of Science, 4*(4), 19-25.

Omogunloye, O. Y., Adepoju, A. T., & Kururiman, P. (2021). Assessment of radiation risk from background exposure in selected hospitals within Markurdi metropolis, North-Central Nigeria. *European Journal of Applied Physics, 3*(4), 43-47.

Ononugbo, C., & Anekwe, U. (2020). Background gamma radiation in Nigerian market environment. *American Journal of Environmental Science, 16*(3), 48-54.

Qureshi, A. A., Tariq, S., Din, K. U., Manzoor, S., Calligaris, C., & Waheed, A. (2014). Evaluation of excessive lifetime cancer risk due to natural radioactivity in the river's sediments of Northern Pakistan. *Journal of Radiation Research and Applied Sciences, 7*(4), 438-477.

Samaila, B., Ishaku, A., & Garba, I. I. (2024). Radiological implication of some selected dumpsites in Birnin Kebbi: Natural background ionizing radiation measurement and excess life cancer risks estimation. *International Journal of Biomedical and Clinical Research, 1*(6), 1-7.

Taskin, H. K., Topuzoglu, M. A. P., & Hidiroglu, S. K. G. (2009). Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. *Journal of Environmental Radioactivity, 100*(1), 49-55.

UNSCEAR. (2000). *Sources of ionizing radiation*. United Nations Scientific Committee on Effects of Atomic Radiation, 2000 Report United Nations. https://www.unscear.org/unscear/en/publications/2000_1.html

UNSCEAR. (2020). *Sources And Effects of Ionizing Radiation*. United Nations Scientific Committee on Effects of Atomic Radiation, Report to The General Assembly, Report I Annex D. https://www.unscear.org/unscear/en/publications/2020_2021_1.html