World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Assessment of health risks related to natural radioactivity near the Ife iron and steel industry in Ile-Ife, Nigeria

Alexander Chinyere Nwankpa [1,*] and Samuel Nwanneamaka Nwankpa [2]

[1] *Department of Physics, Adeyemi Federal University of Education, Ondo. Nigeria.*
[2] *Department of Medical Microbiology, Anambra State, College of Health Technology, Obosi, Nigeria.*

World Journal of Advanced Research and Reviews, 2022, 16(02), 1011–1016

Publication history: Received on 15 October 2022; revised on 21 November 2022; accepted on 24 November 2022

Article DOI: https://doi.org/10.30574/wjarr.2022.16.2.1269

Abstract

The environmental risks connected to the operations of Ife Iron and Steel Nigeria Limited, Ile-Ife, located in Osun State, are examined in this paper. According to reports, the soot and other particles the company's operations release are bad for the locals' health and threaten their sources of income. In order to calculate the absorbed dose, external hazard index, and annual effective dose for the estimation of the potential biological risk/damage to the community, the radionuclides present in soil taken from the area around the industry have been identified and their activity concentrations measured. Gamma ray spectrometry with a NaI detector was used to identify the radionuclides and determine the activity content in soil samples taken from the Fashina community. The absorbed dose rates due to the terrestrial gamma rays at 1.0m above the ground in the study area are in the range of 28.85 nGy/h to 37.05 nGy/h with an average of 33.30 nGy/h which is lower than the world average value of 59 nGy/h. The external hazard index ranges from 0.167 to 0.220 with an average of 0.194 which is less than 1.0. The outdoor annual effective doses are in the range of 0.035 mSv/y to 0.045 mSv/y with an average value of 0.041 mSv/y which is lower compared with the world average value of 0.07 mSv/y. The results show that the annual effective dose from natural radioactivity around the industry has an average value lower than the natural world recommended value.

Keywords: Radioactivity; Radionuclides; Hazard; External Hazard Index; Absorbed Dose

1. Introduction

The actions of steel corporations have caused environmental deterioration in many locations throughout the world, which has had a negative impact on the health and way of life of locals who live close to these factories. In order to determine potential radiation doses in the environment, it is required to test the radionuclides content of soil samples near the Ife Iron and Steel industry in Ile-Ife, Nigeria. Numerous operations in the iron and steel sector produce enormous amounts of air pollutants, liquid effluents, and solid waste [1]. The wastes, which are often released into the environment as effluents [2], have been reported to contain significant levels of primordial radionuclides [3]. Through the food chain, these radionuclides and their offspring are passed on to man. For instance, Cock [4] chronicles the Steel Valley community's battle with steel tycoon Mittal in Gauteng, South Africa. The water table was contaminated as a result of Mittal's actions, which also directly harmed the local population's health, happiness, and means of subsistence.

The quality of the natural environment is influenced by a variety of variables that interact intricately. The quality of the natural environment is frequently lowered by a number of general reasons, including land degradation, water body pollution from effluent and industrial discharge, air pollution from particulate emissions to the atmosphere, noise pollution, and overcrowding [5]. Studies by Akporido [6] confirm that the operation of iron and steel businesses

* Corresponding author: Alexander Chinyere Nwankpa
Department of Physics, Adeyemi Federal University of Education, Ondo. Nigeria.

has major effects on the health of the environment in general and on soil and river contamination in particular, without specifically addressing human health and livelihood. Dheeba and Sampathkumar [7] assert that iron and steel industry operations that contaminate land and water bodies foretell grave consequences for human health, socioeconomic well-being, and way of life. This is due to the fact that contaminated soil affects agricultural production while contaminated water threatens freshwater fisheries and community access to water bodies [8].

2. Material and methods

2.1. Study Area

The study was carried out at Fashina Village, which is situated between the campuses of Obafemi Awolowo University and the Oduduwa University in Ile-Ife, Osun State, South West Nigeria, along the Ile-Ife/Ibadan express road. The Ife Iron and Steel industry is located in Ile-Ife, which includes the satellite village of Fashina. About 218 kilometers to the northeast of Lagos is Ile-Ife. As of 2016, 886,000 people were predicted to live in the four local government areas that make up Ife territory (Ife Central, Ife East, Ife North, and Ife South) [9]. Between the latitudes of 7°28′N and 7°45′N and the longitudes of 4°30′E and 4°34′E is Ile-Ife. [10]. Human actions like deforestation and recurrent bush burning have caused the savannah to become covered with vegetation, although some areas have dense vegetation and soil cover. The textures of the rocks range from equigranular to coarse grained [11]. Fashina village is home to primarily low-income people who work in agriculture, trade, and other commercial enterprises.

2.2. Sample Preparation and Sampling

Six areas around the Ife Iron and Steel industry had soil samples taken from them. At each sampling zone, four samples were taken at distances of 100, 200, 300, 400, 500, and 600 meters from the Ife Iron and Steel Industry. To eliminate dead organic materials, the samples were taken at a depth of 5 cm [12] and were then bulked separately in plastic bags. The soil samples were crushed to pass through a 2-mm mesh filter after being completely dried at room temperature to constant weight. Each sieved soil sample weighed 250 g, which was then transferred and sealed into customized plastic containers with measurements of 6.0 cm in diameter by 7.0 cm in height and made to fit within the sodium iodide gamma spectrometer. It takes 28 days for the soil samples to reach a state of secular radioactive equilibrium before gamma-spectrometry, which is the appropriate amount of time [13]. The control soil samples were taken 30 km away from the industry site, in an area of uncultivated land. The control soil samples received the same treatment.

2.3. Gamma Spectrometric Analysis.

Using gamma ray spectroscopy, the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K were determined. The measurement system comprises of a scintillation detector sealed with a photo multiplier tube coupled to a Canberra series 10 plus multi-channel analyzer through a preamplifier base (MCA). A 3 cm 3 cm NaI(Tl) detector with the model number 3M3/3 is used. At 0.662 MeV of ^{137}Cs, the detector has a resolution of around 8%. The Radiochemical Centre, Amersham, England-prepared reference standard source (IAEA-444) was used to calibrate the system's detecting energy [14]. The concentration of ^{40}K in the various samples was ascertained using the 1460.75 KeV gamma of ^{40}K. The concentration of ^{238}U in the samples was determined using the gamma transition of ^{214}Bi, which has an energy of 1764.5 KeV, and the concentration of ^{232}Th using ^{208}TI, which has an energy of 2614.7 KeV [15]. Data was collected after each sample had been counted for eight hours. The MAESTRO software application automatically looked for the peak, assessed the peak position relative to energy, and identified the radionuclides by using a nuclide library. The activity concentration in the chosen units is then displayed once the background count and net peak areas have been calculated. For 17 hours, the background-filled empty container was counted, and then the values were subtracted.

3. Results

The results of activity concentration, the radium equivalent activity, the absorbed dose rate in air, the external hazard index, and the outdoor annual effective dose are presented in tables 1 and 2.

Table 1 Range and Mean Activity Concentrations of Radionuclides in Zones. (Bqkg-1)

Zone/Distance from Industry (m)	Number of Samples	Range/Mean	^{226}Ra (^{238}U)	^{228}Ra (^{232}Th)	^{40}K
1 (100)	4	Range	14.1 – 22.8	23.1 – 29.8	143.5 – 454.7
		Mean	18.00 ± 2.15	26.84 ± 3.29	298.09 ± 17.16
2 (200)	4	Range	26.6 – 31.0	23.6 – 34.6	141.5 – 153.1
		Mean	28.83 ± 3.49	28.80 ± 3.51	146.87 ± 21.36
3 (300)	4	Range	10.5 – 35.4	12.1 – 37.5	107.7 – 420.8
		Mean	18.18 ± 1.26	25.03 ± 2.11	244.78 ± 15.45
4 (400)	4	Range	9.0 – 19.5	10.6 – 30.0	99.0 – 343.6
		Mean	13.81 ± 1.18	22.33 ± 2.06	213.56 ± 16.93
5 (500)	4	Range	9.8 – 27.6	22.2 – 28.0	124.5 – 394.1
		Mean	17.89 ± 1.23	25.45 ± 2.65	221.91 ± 21.82
6 (600)	4	Range	10.5 – 32.7	11.6 – 35.3	115.2 – 331.1
		Mean	11 ± 2.0217.	23.72 ± 3.67	190.46 ± 16.36
Average			18.97	25.36	219.28
Control Soil Sample (30 km)	4	Range	7.5 – 12.2	15.2 – 22.5	95.1 – 145.0
		Mean	9.31 ± 1.32	17.11 ± 1.81	119.0 ± 12.17
World Average			35	35	370

(a) There are variations in the distribution of ^{226}Ra, ^{232}Th, and ^{40}K. Radium equivalent activity (Raeq) in Bq/kg has been used to establish uniformity with regard to radiation exposure in order to compare the particular activity of materials containing various concentrations of ^{226}Ra, ^{232}Th, and ^{40}K. This relation [16] is used to compute it:

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.07C_{K} \quad \text{………………..(1)}$$

Where;
C_{Ra}, C_{Th}, and C_K are, respectively, the activities of ^{226}Ra, ^{232}Th,
^{40}K expressed in Bq/kg.

The same gamma dose rate has been assumed for the production of 370 Bq/kg of ^{226}Ra, 259 Bq/kg of ^{232}Th, and 4810 Bq/kg of ^{40}K when defining Raeq activity according to Eq. (1).

(b) Using the measured activities of ^{226}Ra, ^{232}Th, and ^{40}K in soil and the assumption that other radionuclides, such as ^{137}Cs, ^{90}Sr, and the ^{235}U series, can be disregarded because they contribute very little to the total dose from environmental background, the external gamma absorbed dose rate in the air at l.0m above ground level was calculated.

The calculations were carried out using the equation shown below [16]:

$$D = 0.462C_{Ra} + 0.604C_{Th} + 0.042C_{K} \quad \text{…………………(2)}$$

Where,
D is the dose rate in nGy/h and C_{Ra}, C_{Th}
C_K are the specific activities (Bq/kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

(c) The external hazard index, H_{ex}, is defined as [16]:

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_{K}/4810 \quad \text{………………… (3)}$$

Where;

C_{Ra}, C_{Th} and C_K are the specific activities (Bq/kg) of ^{226}Ra, ^{232}Th and ^{40}K, respectively.

(d) The conversion coefficient from absorbed radiation in air to effective dose (0.7SvG/y) and an outdoor occupancy factor (0.2) suggested by UNSCEAR, [16], are utilized to estimate annual effective dose rates. As a result, the formula given in [16] was used to get the yearly effective dosage rate (mSv/y):

$$E_D(mSv/y) = D(nGy/h) \times (24 \times 365)(h) \times 0.7 \times 0.2 \times 10^{-6} \qquad \ldots\ldots\ldots\ldots (4)$$

Table 2 Radium Equivalent Activity, Absorbed Dose Rate, External Hazard Index and Annual Effective Dose for Soil Samples at Different Locations in Fashina Community around Ife Iron & Steel Industry

Zone	**Radium Equivalent Activity Ra_{eq} (Bq/kg)**	**Absorbed Dose Rate, D (nGy/h)**	**External Hazard Index. H_{ex}**	**Annual Effective Dose, E_D (mSv/y)**
1	77.25	37.05	0.215	0.045
2	80.29	36.89	0.220	0.045
3	71.11	33.80	0.197	0.041
4	60.69	28.85	0.167	0.035
5	69.83	32.96	0.187	0.040
6	64.36	30.24	0.178	0.037
Average	70.59	33.30	0.194	0.041
Control Sample	42.1	19.63	0.116	0.024
Recommended Value	370	59	1.000	0.070

4. Discussion

4.1. Activity Concentration of Radionuclides

The findings of the gamma ray examination of soil samples taken from the Fashina community near the Ife Iron and Steel industry to determine radionuclide activity concentrations are shown in table1.The ^{226}Ra concentrations in soil range from 13.81 ± 1.18 – 28.83 ± 3.49 Bq/Kg with an average of 18.97 ± 1.7 Bq/Kg. The mean specific activities for ^{232}Th in soil range from 22.33 ± 2.06 – 28.80 ± 3.51 Bq/Kg with an average of 25.36 ± 2.1 Bq/Kg. The mean specific activities for ^{40}K in soil ranged from 146.87 ± 21.36 – 298.09 ± 17.16 Bq/Kg with a mean of 219.28 ± 23.6 Bq/Kg. These values are within the world average ranges, 35(10-50) Bq/Kg for ^{226}Ra, 35(7-50) Bq/Kg for ^{232}Th and 370(100-700) Bq/Kg for ^{40}K respectively. [16].

4.2. Risk Assessment

The radium equivalent activity, the absorbed dose rate, the external hazard index, and the annual effective dose rate were derived from the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K as shown in table 2 in order to evaluate the health consequences on residents of the study area.

According to Table 2, the average radium equivalent activity in the soil samples was 70.59 Bq/kg, which is less than the 370 Bq/kg allowed limit and below the range of 60.69 to 80.29 Bq/kg that is considered safe. The research area's average absorbed dose rates from terrestrial gamma rays at 1.0m above the ground are 33.30 nGy/h, ranging from 28.85 to 37.05 nGy/h. This is less than the 59 nGy/h global average value [16]. The external danger index has an average value of 0.194 and a range of 0.167 to 0.220. The radiation hazard must remain negligible if the value of this index is greater than unity [17]. The external danger index can have a maximum value of 1.0. The average outdoor annual effective dose is 0.041 mSv/y, which is lower than the global average of 0.07 mSv/y [16]. The outdoor annual effective doses range from 0.035 mSv/y to 0.045 mSv/y. Despite public anxiety, this research did not indicate increased radioactivity in the neighborhood of the Ife Iron and Steel business.

5. Conclusion

This study aims to shed light on the environmental effects of operational practices of smaller businesses like the Ife Iron and Steel Company and how they affect people's lives and means of subsistence. The research area's ^{226}Ra, ^{232}Th, and ^{40}K activity concentration ranges and averages are lower than the global values of 35 Bq/kg, 35 Bq/kg, and 370 Bq/kg, respectively. The average absorbed dosage rate (33.30 nGy/h) was significantly lower than the global average (59 nGy/h). The yearly effective dose equivalent limit has been set at 1.0 mSv/y for the general public and 20 mSv/y for radiation workers by the International Commission on Radiological Protection. As a result of natural radioactivity, the outdoor annual effective dosage has an average value that is less than the level that is advised by the natural world, according to the data. There is a need to continuously monitor discharges of radioactive elements to ensure that they are within the permitted limit, even if it may not be possible to directly link radionuclide contamination of the environment with the health harms caused by outdoor exposure to it. However, this investigation offers preliminary information that can be used to support a later assessment of the radiation impact of the iron and steel companies on their near environment.

Compliance with ethical standards

Acknowledgments

For their kind assistance and support throughout the analyses of the soil samples, the authors are grateful to Prof. F.A. Balogun and the personnel of the Center for Energy Research and Development at Obafemi Awolowo University, Ile-Ife.

Disclosure of conflict of interest

The authors have no conflict of interest to disclose in this article.

References

[1] Bhargava, O.P. Waste Management and Pollution Prevention Opportunities in the Iron and Steel Industry. Canada. Canadian Chemica News. 1997

[2] World Bank. Pollution Prevention and Abatement: Mixed Fertilizer Plants, Draft Technical Background Document. Washington, DC . Environmental Department, 1996

[3] Otokunefor, T. and Obiukwu, C. Impact of refinery effluent on the physicochemical properties of a water body in the Niger Delta. Applied Ecological and Environmental Resource. 2005; 3: 61-72.

[4] Cock, J. Sustainable development or environmental justice: Questions or the South African Labour movement from the Steel Valley struggle. Labour, Capital & Society. 2007; 40 (1&2): 36-55.

[5] Iyalomhe, F., Cirella, G., Russo, A., Jensen, A. and Idogho, P. Environmental management system for Nigeria's Higher Education: Two-Year pilot analysis. Consilience. 2017; 18: 84-110.

[6] Akporido, S.O., Agbaire, O.P. and Ipeaiyeda, R.A. Effect of steel production on the quality of soil around Udu section of Warri river in the vicinity of a steel plant, Nigeria. Asian Journal of Applied Sciences 2014; 7(7): 552-567.

[7] Dheeba, B. and Sampathkumar, P. Evaluation of heavy metal contamination in surface soil around industrial area, Tamil Nadu, India. International Journal of Chemical Technology Resource. 2012; 4: 1229-1240.

[8] Avwiri, G.O., Nte, F.U and Olarewaju, A.I. Determination of Radionuclides Concentration of Landfill at Eliozu, Port Harcourt, Rivers State, Nigeria. Scientia Africana. 2011; 10 (1): 46-57.

[9] National Population Commission, (NPC). Nigeria Population Projection. Abuja: National Population Commission. 2016

[10] Saka, L. and Busari, D. State, Industries and Regulations in Nigeria; Ife Iron and Steel Company and environmental Pollution. Journal of Management and Social Sciences. 2020; 9(1): 750 - 768

[11] Olusiji, S.A. The Geology, Stream Sediment Geochemical Survey and Ground Water Quality Evaluation of Okemesi Area, Southwestern Nigeria. International Journal of Geology, Earth and Environmental Sciences. 2011; 1(1): 73 - 97

[12] International Atomic Energy Agency (IAEA). Measurement of Radionuclides in Food and the Environment. A Guide Book. Vienna. Technical Report. Series No. 295; 1989

[13] Hinshaw G.D. and Trenholm A.R. Hazardous Waste Incineration Emission in Perspective. Waste Management. 2011; 21: 471-475.

[14] Nwankpa, A.C. Calibration of High Purity Germanium (HPGe) Detector. Journal of Applied Sciences. 2004; 7 (3): 4351 – 4360

[15] Gilmore, G. Practical Gamma – Ray Spectrometry. New York. John Wiley and Sons. 2002

[16] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and Effects of Ionizing Radiation (Report to the General Assembly). New York. United Nations. 2000

[17] Nwankpa, A.C. Determination of Natural Radioactivity in Soil Around Ajaokuta Iron and Steel Industry of Nigeria. Academic Journal of Science. 2015; 04(03): 323 – 328.