(CIJST) 3007-3847 (Online) Vol. 1(1)

CAVENDISH INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY (CIJST)

RESEARCH ARTICLE

BACKGROUND IONIZING RADIATION DOSE LEVELS AND EXCESS LIFETIME CANCER RISK IN ASHAKA CEMENT PLC, ASHAKA, GOMBER STATE, NIGERIA

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Vol. 1(1):
https://journals.cavendish.ac.ug/index.php/cjst/article/view/23/20

August, 2024

Abstract

Background: Radiation monitoring is crucial for assessing environmental safety and public health, particularly in areas with industrial activities such as cement production. Ionizing radiation exposure can have significant health implications, making it essential to evaluate dose levels and associated risks regularly.
Methods: This study focuses on the radiation dose levels and excess lifetime cancer risk at multiple locations within Ashaka Cement Plc, situated in Ashaka, Gombe State, Nigeria. By measuring radiation levels and analyzing cancer risk, the research aims to ensure the safety of the environment and the well-being of workers and nearby communities. A Geiger counter rate meter was used to measure the radiation dose level 1 m above the ground level.
Results: The results showed that the dose rates ranged from 0.1100 to 0.3467 μSv/h, with an average of 0.2496 μSv/h. The mean annual equivalent dose was 0.43728 mSv/y, lower than the 1 mSv/y limit, and the mean annual effective dose was 0.3061 mSv/y, higher than the 0.07 mSv/y, global average but lower than the 1 mSv/y limit. The excess lifetime cancer risk was 1.53×10^{-3}, which is higher than the world average of 1.45×10^{-3}.
Conclusion: Generally, background ionizing radiation levels are safe and pose no immediate health risk. Low-level radiation doses may have long-term health effects over a lifetime (70 years), as per excess lifetime cancer risk values.

Keywords: *Ashaka Cement, Dose Rate, Effective Dose, Equivalent Dose, Excess Lifetime Cancer Risk.*

INTRODUCTION

Background

It is an unavoidable aspect of living on Earth that humans are typically exposed to ionising radiation from natural sources every day (UNSCEAR, 2000). The background radiation that affects humans originates from together natural and artificial sources. Commonly, natural radionuclides of both terrestrial and cosmogenic basis account for 85% of a person's annual total radiation dosage (UNSCEAR, 2000, Belivermis, *et. al.,* 2010). Over the course of life on Earth, living things have been subjected to radiation from both naturally occurring compounds found in both living and non-living components of the biosphere and radionuclides created by cosmic rays in the atmosphere. Humans are affected by the ionising radiation that is sent into the environment from both manmade and primordial cosmic sources (Essien, *et. al.,* 2017). Ionizing radiation exposure typically results from man-made or natural sources. Many different types of geological formations contain natural radiation sources, such as soils, rocks, plants, water, and air. According to (Abubakar, *et. al.,* 2017). radioactive nuclides from the Earth's crust that make up a significant amount of background radiation are from 238 Uranium, 232 Thorium, or 40 Potassium, with occurrence levels that depend on the geology, altitude, and construction materials.

Radiation that can form ions that can interfere with biological functions is known as ionising radiation. Non-ionizing radiation can have a variety of negative effects on human health, yet it cannot produce ions. Because of the very nature of their surroundings, humans are subject to variable degrees of ambient radiation with or without consent (Farai and Vincent Uchechukwu., 2006).

It is essential to comprehend the effects of radon and its by-products on health. The natural ambient radiation level that originates from the ground, air, water, food, or building materials can be used to calculate the dosage limits of public exposure (Ononugbo, *et. al.,* 2015, El-Taher, 2012). By monitoring the absorbed dose rates in air, one can directly compute the worldwide annual mean exposure to natural radiation sources due to external and internal doses received by a population from background radiation coming from radioisotopes in soils. This is a simple method of determining the influence of exposure levels that humans experience both directly and indirectly through pathways of ingestion and inhalation in various contexts, such as indoor and outdoor spaces. The radionuclide content and activity concentration in the ground, which vary depending on the kind of bedrock and soil, are related to the outdoor levels (Sara Almgren., 2008, Tayyeb, *et. al.,* 2012 and Moontaha *et. al.,* 2018).

Even at low doses, ionising radiation can induce cancer and genetic disorders. Because of their probabilistic nature and the presumption that any exposure may have an impact, these effects are known as stochastic effects (UNSCEAR, 2000). Furthermore, research has shown that there may be a higher chance of dying from radon exposure indoors (at home or at work) than there is outside, and that there may be a higher estimated risk of lung cancer from radon exposure than there is from all other combined causes (UNSCEAR, 2000). Ionising radiation can alter a material's chemical state, which can have biologically significant effects on the immune system, growth rate, and behavioural fallout from central nervous system injury. High radiation doses have been linked to a number of side effects, including cancer (IAEA, 2005, James et, al., 2015).

Study Area

Ashaka Cement Company is located at 10°55′10" N and 11°30'00"E. The Company was established in 1974 at the initiation of the Nigeria Industrial Development Bank with the encouragement and participation of the Federal Government of Nigeria and north-eastern state governments (Bauchi, Borno, and Gongola State)

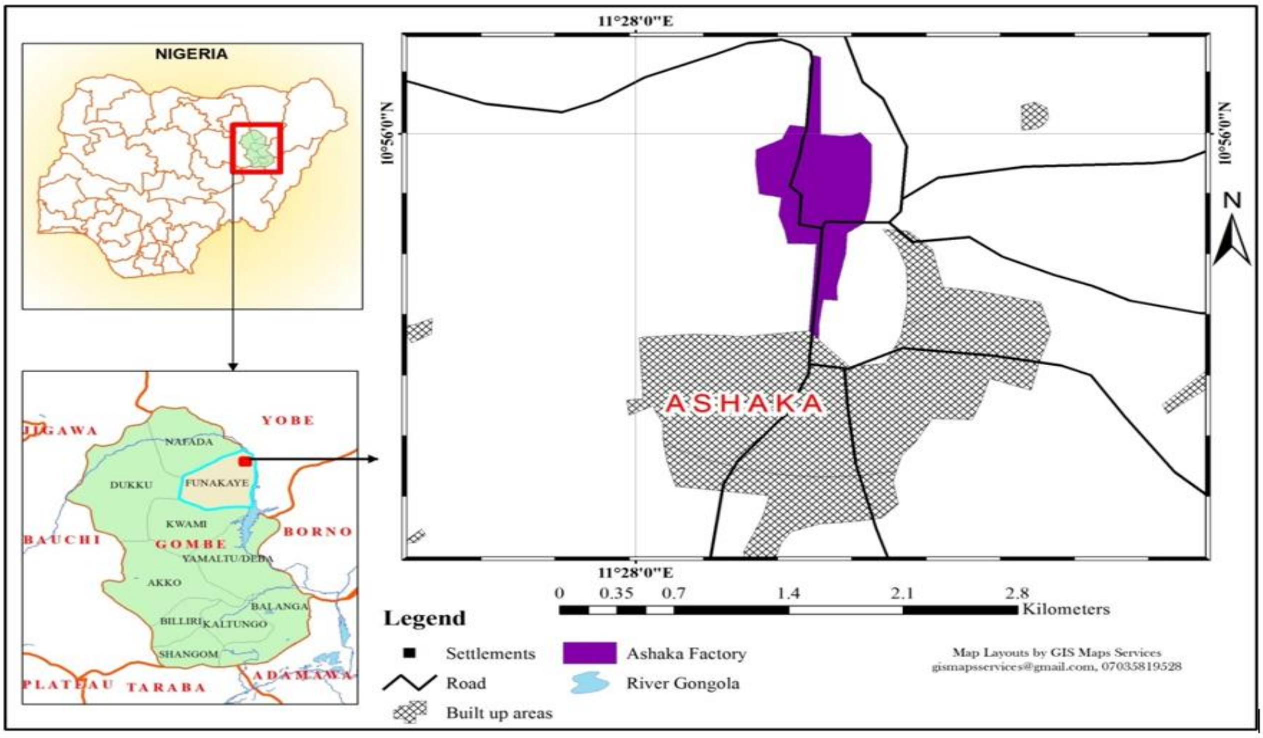

Fig 1 Map showing the location of the study area (Ashaka Cement Company PLC and Ashaka Town

Study Aim:

This study focused on the radiation dose levels and excess lifetime cancer risk at multiple locations within Ashaka Cement Plc, situated in Ashaka, Gombe State, Nigeria

Materials and Methods:

Materials

The materials utilized for this research include a Geiger counter rate meter, GPS device, measuring tape, pen, and notebook.

Methods

A Geiger Counter Rate Meter, Model AP1884-002, was utilized for the detection and measurement of the dosage rate. The radiation dose measuring approach was adopted. Initially, the Geiger counter was calibrated to identify and quantify radiation exposure rate in counts per meter (CPM). Gamma, beta, and X-ray radiation are all monitored by the portable Geiger counter. First, the calibration factor of the device and the meter's zero inaccuracy were confirmed and noted. To prevent contamination or interference on the ground surface, the Geiger counter was positioned at each key location within the study area at a height of one meter (Olanrewaju *et, al.,* 2023).

The average values were obtained for each of the fifteen (fifteen) study locations that were selected inside the site after the readings were taken three times at each location. At each point, the total count was recorded for 60 s.

Estimation of Dose Rate $DR\ (\mu Svhr^{-1})$

Each count was converted to micro–Sievert per hour $(\mu Svhr^{-1})$ using Equation 1.

$$1\,CPM = 0.01\,\mu Svhr^{-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (1)$$

Estimation of Annual Equivalent Dose $\boldsymbol{A_{equi.}\ (mSvy^{-1})}$

The annual equivalent dose (AED) was calculated using the formula:

$$A_{equi.}\,(mSvy^{-1}) = \sigma \times \mu \times 24 \times 365 \times 10^{-3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . \ldots (2)$$

Where $\sigma = (\mu Svhr^{-1})$, $\mu = 0.2$ (outdoor occupancy factor) (UNSCEAR, 2000).

Annual Effective Dose $\boldsymbol{A_{eff.}\ (mSvy^{-1})}$ and External Dose $\boldsymbol{ED\ (nGyhr^{-1})}$

In this study, the annual effective dose is calculated by employing the outdoor external dose, occupancy factor, or proportion of the total outdoor time that an individual is exposed to the radiation $\mu = 0.2$ of $8760\,hr$ within a year, and the conversion factor $(CF) = 0.7\,(SvGy^{-1})$ for converting the absorbed dose in air to an effective dose.

The equations given by UNSCEAR, 2000 and Qureshi et al. 2014 are as follows:

$$A_{eff.}\,(mSvy^{-1}) = ED\,(nGyhr^{-1}) \times 0.2 \times 8760\,hr \times 0.7\,SvGy^{-1} \times 10^{-3} \ldots\ldots\ldots (3)$$

Where

$$ED\,(nGyhr^{-1}) = \frac{DR\,(\mu Svhr^{-1})}{Q} \times 10^{-3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where Q is equal to 1

Estimation of Excess Lifetime Cancer Risk (ELCR)

To assess the cancer risk of the workers resulting from BIR exposure, excess lifetime cancer risk (ELCR) was estimated by using equation (5) Abdulkareem *et al.* 2023.

$$ELCR = A_{equi.} \times \mathrm{DL} \times \mathrm{RF} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$A_{equi.}$ Is the Annual Equivalent Dose, DL is the average Duration of Life and is approximately equal to$70\ years$ RF, is the Risk Factor or fatal cancer risk measured in per sievert(Sv^{-1}). For stochastic effects from low-dose background radiation, ICRP 2007. A value of 0.05 for public exposure.

Results:

The background ionizing radiation and excess lifetime cancer risk were estimated from fifteen (15) different locations and the results were obtained using the Geiger Muller counter, the Annual Equivalent Dose $(A_{equi.})$, External dose (ED), and annual effective dose ($A_{eff.}$) and Excess Lifetime Cancer Risk (ELCR) for each location with a Global Positioning System (GPS) were determined and are presented in Table 1.

Table 1: Dose Rate (µSv/h.), Annual Equivalent Dose (mSv/y), External Dose (nGy/h.), Annual Effective Dose (mSv/y) and Excess Lifetime Cancer Risk Rate (ELCR X 10^{-3})

Location	Latitude	Longitude	CPM	DR (µSv/h.)	$A_{equi.}$ (mSv/y)	ED (nGy/h.)	$A_{eff.}$ (mSv/y)	ELCR X 10^{-3}
Kiln Site	10.9308	11.4781	24	0.2400	0.4205	0.00024	0.2943	1.4717
Coal Pack	10.9322	11.4792	19	0.1900	0.3329	0.00019	0.2330	1.1651
Coal Mill	10.9308	11.4800	32	0.3200	0.5606	0.00032	0.3924	1.9622
Training Scholl Workshop	10.9306	11.4281	23	0.2267	0.3972	0.00023	0.2780	1.3901
Crusher	10.9322	11.4778	34	0.3400	0.5957	0.00034	0.4170	2.0849
Reclaimer	10.9322	11.4972	28	0.2800	0.4906	0.00028	0.3434	1.7170
Raw Mill	10.9319	11.4803	24	0.2430	0.4257	0.00024	0.2980	1.4901
Coal Power Plant Area	10.9308	11.4775	35	0.3467	0.6074	0.00035	0.4252	2.1260
Power house (New)	10.9325	11.4603	11	0.1100	0.1927	0.00011	0.1349	0.6745
Power House (Old)	10.9328	11.4442	16	0.1600	0.2803	0.00016	0.1962	0.9811
Cement Mill	10.9308	11.4778	26	0.2633	0.4613	0.00026	0.3229	1.6146
Gypsum Pack	10.9308	11.4781	30	0.3033	0.5314	0.00030	0.3720	1.8598
Raw mill Silo	10.9311	11.4775	28	0.2767	0.4848	0.00028	0.3393	1.6967
Compressor Room	10.9317	11.4947	18	0.1833	0.3211	0.00018	0.2248	1.1240
Parking Plant	10.9333	11.5058	30	0.3033	0.5314	0.00030	0.3720	1.8598

Discussion:

Table 1 presents the results of the radiation index parameters. The Dose Rate mean value varied between 0.1100 µSv/h and 0.3467 µSv/h. The power house (new) recorded the lowest value of 0.1100 µSv/h, while the coal power plant area yielded the highest value of 0.3467 µSv/h. The Annual Equivalent Dose has a mean value of 0.1927 mSv/h and a maximum value of 0.5957 mSv/h reported from the crusher. The minimum value was 0.1927 mSv/h recorded from the power house (new). The range of external dose rates is 0.00011 nGy/h to 0.00034 nGy/h. The minimum value of 0.00011 nGy/h was recorded from the power house (new), and the maximum value of 0.00034 nGy/h was from the crust. The mean value of the annual effective dose ranged from 0.1349 mSv/y to 0.4252 mSv/y; the minimum value of 0.1349 mSv/y was recorded from the power house (new), and the maximum value of 0.4252 mSv/y was recorded from the coal power plant area. All of these values fall below the suggested allowable levels, which are 1.0 mSv/y for the general population and 20.0 mSv/y for occupational workers. ICRP 2007.

The mean value of the excess lifetime cancer risk ranged from 0.6745X 10^{-3} to 2.0849 X 10^{-3}, the power plant (New) recorded the lowest value of 0.6745 X 10^{-3}, while the coal plant area recorded the highest value of 2.0849 X 10^{-3}. The United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000, has established that the obtained ELCR values are more than the global average, which is 0.29×10^{-3}. These numbers represent the likelihood of developing cancer throughout a 70-year lifespan.

The results obtained for the radiation dose rate in this study are quite higher than the results obtained by Achuka et al., 2019. Though there is no evidence of radioactive element occurrences, the likelihood of workers and study area residents developing cancer in this environment can be used to compute excess lifetime cancer risk (ELCR). Conferring to the Linear No Threshold (LNT) hypothesis, extrapolation from indication continuous, high-dose reactions to low-dose responses, all acute ionizing radiation exposures down to zero are harmful Sunday et. al., 2017. Establish that the radiation dose rate was found to be 0.133 Sv/h for the general public was not even close to being reached at any of the locations' indoor dose rate levels. As a result, the radiation exposure rate values in these particular departments may not suggest any possible risk to staff members or the general public. These outcomes can be used as a guide when determining the indoor background radiation levels in different places. It was determined that 2.86 × 10^{-3} is the excess lifetime cancer risk factor for the research location. That is more than the global average and higher than our finding. This is most likely produced by the rock and other building materials used, as well as the lab chemicals and medications transmitted to the new location.

Conclusion

The background ionising radiation levels and excess lifetime cancer risk were analysed in fifteen (15) distinct locations inside Ashaka Cement PLC, although the Excess Lifetime Cancer Risk (ELCR) was greater than the permissible limit, all projected radiation index parameters were within the ranges advised for both employees and the general public.

Acknowledgment

The lead author wishes to extend his heartfelt gratitude to all co-authors for their contribution to the success of the manuscript.

Competing Interests

The author declares that there are no conflicts of interest related to this study.

Reference

Abiodun Ibrahim Olanrewaju, Muhammad Nuruddeen Abdulkareem and Isiaka Onaolapo Raheem, (2023). Evaluation of outdoor background ionizing radiation level around radiological sections in Federal Teaching Hospital Gombe, Gombe State Nigeria. World Journal of Advanced Research and Reviews, 19:02, 196–203 https://doi.org/10.30574/wjarr.2023.19.2.1520

Abubakar, A., A. A, Sadiq., MG, Musa., Hassan, J. and DF, Malgwi., (2017). Assessment of Indoor Ionizing Radiation Profile in Radiology Department FMC Asaba Delta State, Nigeria, Journal of Dental and Medical Sciences (IOSR-JDMS), 16(1), 98–101 https://doi.org/10.9790/0853-16010698101.

Achuka, J.A., Usikalu, M.R., Aweda, M.A., Onumejor, C.A and Babarimisa., (2019). Background Radiation Dose in Selected X-ray Facilities in southwest Nigeria. Journal of Physics: Conf. series 1299(2019) 012103, doi:10.1088/1742-6596/1299/1/012103

Belivermis, M., Kılıç, N., Çotuk Y. & Topcuoğlu, S., (2010). The effects of physicochemical properties on gamma emitting natural radionuclide levels in the soil profile of Istanbul. Environ Monit Assess. 163:(1-4), 15–26. https://doi.org/1007/s10661-009-0812-1.

El-Taher, A., (2012). 'Assessment of natural radioactivity levels and radiation hazards for building materials used in Qassim area, Saudi Arabia', Romanian Reports of Physics, 57(3–4), 726–735

Essien, I. E., Nyong, A. B., Akankpo, A. O., Ekott, E. E., Umoh, U. A. and Inyang, A. J., (2017). Baseline Evaluation of Background Ionizing Radiation in Cocoa Plantation in Uyo Akwa Ibom, State , Nigeria, Radiation Science and Technology. 3(2), 13–17. https://doi.org/10.11648/j.rst.20170302.13

Farai, I.P. and Vincent Uchechukwu., (2006). Outdoor Radiation Level Measurement in Abeokuta, Nigeria by Thermoluminescent Dosimetry. Nigerian Journal of Physics.18 (1); 121-126. https://doi.org/10.4314/njphy.v18i1.38091

International Atomic Energy Agency, IAEA, (2005). Protection of the Environment from the Effects of Ionizing Radiation, in IAEA. Vienna, Austria: Wagramer Strasse 5, 6–10

International Commission on Radiological Protection. ICRP., (2007), Publication 103. Ann. ICRP 37:(2-4)

James, IU; Moses, IF; Vandi, JN; and Ikoh UE., (2015). Measurement of Indoor and Outdoor Background Ionising Radiation Levels of Kwali General Hospital, Abuja, Journal Applied Science Environmental Manage, 19:1, 89–93.

Moontaha, S., Rahman, M. S., Islam, S. and Yeasmin, S., (2018). Real-Time Environmental Gamma Radiation Dose Rate Measurement around Major Nuclear and Radiological Facilities in Bangladesh, Journal of Scientific Research and Management (IJSRM), 06:(03), 39–49, https://doi.org/10.18535/ijsrm/v6i3.fe03

Muhammad Nuruddeen Abdulkareem, Olanrewaju Abiodun Ibrahim, Muhammad Mudassir Usman, Raheem Isiaka Onaolapo and Ibrahim Yakubu., (2023). Assessment and evaluation of residents' excess lifetime cancer risk of federal university of Kashere, Gombe State, Nigeria Department of Physics, Federal University of Kashere, Gombe State, Nigeria. World Journal of Advanced Research and Reviews, 19:01, 1499–1510 https://doi.org/10.30574/wjarr.2023.19.1.1510

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 Sciences. 4:4, 19-25. https://doi.org/10.33003/fjs-2020-0404-270.

Ononugbo, C.P., Avwiri, G.O. and Tutumeni, G., (2015). Estimation of Indoor and outdoor Effective Dose from Gamma Dose Rates of Residential Buildings in Emelogu Village in Rivers State, Nigeria, International Research Journal of Pure and Applied Physics, 3(2), 18–27.

Qureshi, A.A., Tariq, S., Din, K.U., Mauzoor, S., Calligaris, C. and Waheed, A., (2014). Evaluation of excessive lifetime cancer risk due to natural radioactivity in the rivers sediments of Northern Pakistan. Journal of Radiation Research and Applied Sciences, Elsevier 7:2. https://doi.org/10.1016/j.jrras.2014.07.008.

Sara Almgren., (2008). Studies on the Gamma Radiation Environment in Sweden with Special Reference to 137 Cs. Department of Radition Physics, University of Gothenburg, Sweden. Doctoral Thesis Available at: reprint: http://hdl.handle.net/2077/17691

Sunday Edet Etuk, Akaninyene Daniel Antia, Okechukwu Ebuka Agbasi., (2017). assesment and evaluation of excess lifetime cancer risk for occupants of university of uyo permanent campus, Nigeria International Journal of Physical Research, 5:1, 28-35· https://doi.org/10.14419/ijpr.v5i1.7564

Tayyeb, A.P., Hamed, B. and Maryam, S., (2012). Evaluation of High-Level Environmental Background Radiation Areas and its Variation in Ramsar. Iranian Journal of Medical Physics. 9:2, 87-92.

United Nation Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, (2000). Sources and Effects of Ionizing Radiation. Report to General Assembly with Scientific Annexes. United Nations; New York. 46: (A/55/46)

Zhou Q., Wu W., Yi M., Shen, Y., Goldsam, L., Alkhatib, A., Jiang, W.(2022). HIV knowledge, sexual practices, condom use and its associated factors among international students in one province of China:

Amoah, A., Korle, K., & Asiama, R. K. (2020). Mobile money as a financial inclusion instrument: What are the determinants? *International Journal of Social Economics*, *47*(10), 1283–1297. https://doi.org/10.1108/IJSE-05-2020-0271

Asongu, S. A., Biekpe, N., & Cassimon, D. (2020). Understanding the greater diffusion of mobile money innovations in Africa. *Telecommunications Policy*, *44*(8), 102000. https://doi.org/10.1016/j.telpol.2020.102000

Blumenstock, J. E., Eagle, N., & Fafchamps, M. (2016). Airtime transfers and mobile communications: Evidence in the aftermath of natural disasters. *Journal of Development Economics*, *120*, 157–181. https://doi.org/10.1016/j.jdeveco.2016.01.003

Demombynes, G., & Thegeya, A. (2012). *Kenya's Mobile Revolution and the Promise of Mobile Savings*. The World Bank. https://doi.org/10.1596/1813-9450-5988