International Journal of Advanced Health Science and Technology
Multidisciplinary : Rapid Review : Open Access Journal e-ISSN:2808-6422; p-ISSN:2829-3037

RESEARCH ARTICLE OPEN ACCESS

Manuscript received August 13, 2022; revised September 01, 2022; accepted October 26, 2022; date of publication October 30, 2022
Digital Object Identifier (**DOI**): https://doi.org/10.35882/ijahst.v2i5.148

How to cite: B. Samaila1*, Y.M Sagagi, A. Bello, M. Sadiq, A. M Imam, I. I Garba, H. Isah and R. Muhammad: "Dosimetric Study on Natural Background Ionizing Radiation and Impact Assessment on Public Health: A systematic Review in Nigeria", International Journal of Advanced Health Science and Technology, vol. 2, no. 5, pp. 335–346, October. 2022

Dosimetric Study on Natural Background Ionizing Radiation and Impact Assessment on Public Health: A systematic Review in Nigeria

B. Samaila[1*], Y.M Sagagi[1], A. Bello[2], M. Sadiq[1], A. M Imam[1], I. I Garba[1], H. Isah[1] and R. Muhammad[1]

[1]Department of Physics with electronics, Federal University Birnin Kebbi P.M.B 1157, Nigeria
[2]Department of Physics, Kebbi State University of Science and Technology Aliero P.M.B.1144, Nigeria

Corresponding author: **B. Samaila** (**e-mail**: buhari.samaila@fubk.edu.ng), ORCID: https://orcid.org/0000-0001-8428-0502

This work was supported by Department of Physics with electronics, Federal University Birnin Kebbi, Nigeria

ABSTRACT: Environmental natural background ionizing radiation contamination and degradation is a global concern because of its negative effect on public health. Public health risk continues to be one of the environmental and public concerns in Nigeria. The emission of natural background ionizing radiation from the outer space, crust of the earth, food, and water and construction materials contributed a lot to the public environmental exposure. The populations' exposure to background radiation emanated from terrestrial, cosmic, and internal radiation account for 82% which are out of control. Present work was aimed to carry out an investigational study of the natural background ionizing radiation levels, identify locations with high or low BIR and assess the health effect within Nigeria's communities based on the available data extracted from the literatures and establish a baseline data of exposure rate, absorbed dose rate, annual effective dose equivalent, and excess life cancer risk from outdoor and indoor background radiation. This dosimetric study of natural background radiation in Nigeria is important to monitor the levels of radiation to which people are exposed directly or indirectly. Recently, several studies have been done in Nigeria and different values were reported based on indoor and outdoor background radiation doses. In this paper, a review and literature survey of natural background ionizing radiation was carried out. The results (data extracted) based on indoor and outdoor revealed that Plateau, Oyo, River, Delta and Ondo, Sokoto, Kano and Niger have the highest value of dose rate compared to the world average value. The order of magnitude of the dose rate were Plateau > Oyo > Rive > Delta > Ondo and River > Plateau > Sokoto > Kano > Oyo > Ondo > Delta > Niger for Indoor and outdoor respectively. The highest outdoor & indoor annual effective doses were observed in OYO, Sokoto, Ondo, Delta, Akwanga, Plateau, and River. The results were comparatively greater than the world acceptable limit of 1.0 mSv/y. The order of magnitude of annual effective are OYO > Sokoto > Ondo > Niger Delta and Akwanga > Plateau > Delta > River for outdoor and indoor respectively. The regions with highest excess life cancer risks in Nigeria were observed in Oyo, Akwanga, Ondo, Plateau, River, Kaduna, Anambra, Port court, Abuja, Delta, Ibadan and Kano. Radiation cancer induction values obtained were remarkably high compared to world average value of 0.29×10^{-3}. The amount of radiation absorbed by individual organs exposed to high natural background radiation areas were observed to be highest in tests organ, the order of magnitude were Tests > Bone marrow > Whole body > Lung > Ovaries > Kidney > Liver. Conclusively all the estimated mean values of organs doses were remarkably lower than that of world average value. Since the mean absorbed dose rate and annual effective dose in several areas is higher than 0.084μSv/h and 1.0 mSv/year for general public in many locations. Therefore, long term exposure of the public to these radiations may lead to radiation induced health hazard such as erythema, skin cancer, genetic mutation and sterility.

INDEX TERMS: Natural background radiation, Radiation health effect, Excess life cancer risk and Organs dose

I. INTRODUCTION

Exposure to background ionizing radiation from the natural source is one of the inescapable aspects of human existence. Since environmental ionizing radiation exposure is the most common, measuring background ionizing gamma radiation is important for communities' well-being [1]. To provide a reasonable foundation for limiting natural ionizing radiation exposure in today's societies, it is essential to understand the detrimental health effects of population exposure. There were many distinct instances of this exposure, ranging from nuclear activity and accidents to environmental radioactive pollution brought on by a nation's gold ore and petroleum mining operations [2]. On the whole planet earth, natural background radiation is presents everywhere, it is continually present in the daily lives of human species from public activity, work settings, and medical settings. This implies that radiation exposure during the history of life was either safe or caused adaption to radiation exposure, which ensured survival, reproduction, and evolution [3, 4, and 5]. Scientific data on the health risks associated with ionizing radiation, particularly cancer, from low to high dose and high-dose rate of natural background radiation was made available by Japanese atomic bomb survivors and patients receiving radiotherapy. Experimental research on animals used in clinical trials consistently demonstrated that exposure to modest doses of radiation reduced the chance of developing cancer [3]. Whether more doses of naturally occurring ionizing background radiation have harmful effects is an issue that is still being explored in the scientific communities. Of fact, there aren't many opportunities to look at relevant studies that explicitly measure the negative impacts [2]. The review studies of the current literatures in countries about the health of people residing in areas with high levels of ionizing radiation from natural sources is to evaluate the radiological consequences of exposure to natural background radiation, several epidemiological studies have been carried out during the last 20–25 years. The epidemiological studies had done include analytical studies on the risk of lung cancer owing to indoor radon exposure as well as descriptive studies in Brazil, India, Iran, and China [2].

Utilizing an in-suit measuring method in the area by using various nuclear radiation detectors is the first and most important step in determining the health concerns of background gamma radiation. The measurement's results might then be used as a benchmark to determine how radiation affects populations. Cosmic and terrestrial radiation are the main sources of ionizing background radiation. The energetic particles created as a result of spallation events that took place in the outer atmosphere and travel down to the earth's atmosphere are known as cosmic ionizing radiations, and they are one of the main sources of natural background ionizing radiation. These energetic particles caused a chemical reaction in the atmosphere that might produce a cosmogenic natural radionuclide. The long-half-lived radionuclide then created terrestrial radionuclides, which are present in environmental media, such air, soils, rocks, water, and construction materials [1]. Ionizing radiation in the environment is significantly influenced by a variety of variables, including geographical location, geology, and construction materials. As a result, the intensity of background ionizing radiation varies widely. Human exposure to ionizing background radiation has been investigated by many scientific bodies worldwide. Nuclear physicists, medical physicists, and radiation scientists have worked to monitor natural background radiation both indoors and outdoors in Nigeria. Their research's findings showed that different geographical places had varying levels of ionizing background radiation. The average exposure rate is noticeably greater than the average number reported by the United Nations Scientific Commission on Effects of Atomic Radiation in numerous cities and towns [1, 5].

According to scientific studies, people spend more time indoors in their homes, schools, and offices than outside. The average amount of time spent outside is between 5 and 6 hours per day, whereas interior activities like studying, eating, sleeping, watching TV and movies, etc. take up 18 to 19 hours per day. Due to the emission agents like natural terrestrial radionuclide, environmental gamma radiations both indoors and outdoors are fundamentally different. By using the coefficient of decrease for ionizing radiation levels in residential structures and open areas, the population exposure doses are determined. The coefficient of reduction was published by the International Atomic Energy Agency (IAEA) for calculating exposure doses within buildings. Utilizing the interior dose rate and the number of hours spent engaging in outside activities; the exposure dose rates of the inhabitants are estimated. For dwellings made of concrete and wood, the coefficients of reduction have mean values of 0.4 and 0.2 and range from 0.04 to 0.4. Based on the architecture of European nations' homes and their radioactive pollution, the coefficient of reduction values were calculated [6]. Scientists must conduct a thorough research of the radiation environment and coefficient of reduction in a location in order to estimate the population dose caused by naturally occurring ionizing gamma radiation [7]. Natural background ionizing radiation's interaction with living tissues and organs necessitate alterations in the body's atoms and molecules, which ultimately led to cell destruction. These damages prohibit the cells from performing their regular duties, including reproduction [8]. The first significant occurrence as a result of the long-term effects that natural ionizing radiation has on the organs and a tissue of the body is DNA damage. According to a follow-up research on the induction of cancer caused by exposure to ionizing radiation, excessive cancer develops over time as a result of radiation exposure over a lengthy period of time [8].

In order to address the issue of indoor and outdoor radiation, scientific groups have recently given background ionizing radiation studies in Nigeria a great deal of attention. According to several radiation scientists in the nation like Nigeria, indoor ionizing radiation evaluation does not raise many issues [9]. As a result of ignorance of the hazard involved, this was overlooked.

Residents of the structures are exposed to the poisonous gas that the radon element, which is set up in the structure factors, emits. Inner air is generally more concentrated than outside air [9]. People are living more ultramodern lives and altering their cultures daily, which causes them to spend more time indoors than outdoors. Survey by transnational associations like WHO and ICRP showed that people who live in temperate areas spend 80% of their time indoors and 20% outside. The clear conclusion from these figures is that inner exposure to dangerous radiation is more likely than outside exposure [9]. Exposure to elevated position of both inner & out-of-door ionizing gamma radiation led to various dangerous effects in public health similar as mutation and cancer of different types and various types of ailments [10, 11]. Ionizing radiation that's naturally being around the world varies greatly from place to place. Natural radionuclides like uranium, thorium, and potassium as well as their progenies like radon and radium are to regard for population exposure [2]. The variations of natural background radiation in our nation, Nigeria, are explained in a number of papers. The gaps observed in the previous research is that many articles did not captured health implications of natural ionizing radiation and estimation of radiation absorbed by individual organs of the residents in Nigeria. The purpose of these review studies was to examine the dosimetry and counter-accusations of ionizing radiation from natural sources in published works, estimate the findings, and pinpoint implicit areas with high radiation situations and their effects on human health [2]. Contributions of this study involve the followings:

- Identifications of high background radiation areas in Nigeria with their implications on dwellers
- Data generated serve as base line for future studies in Nigeria

II. METHODS

Ionizing radiation exists in our everyday terrain as natural background radiation and an artificial radiation used for medical and industrial settings. Natural background radiation is the ionizing radiation in the terrain that all living species are exposed to every day. The largest source of radiation exposure comes from natural radioactivity in rocks and soil, and the inhalation of radon gas that seeps from the Earth's crust into the air. There are also contributions from cosmic radiation, which comes from external space, and naturally being radioactivity in food and the human body. The exposure to cosmic radiation depends on the altitude and the places with high altitude have high radiation doses, in some regions, the actuality of quarries, springs and type of construction materials used in structures increased the dose rate of background radiation.

A. TERRESTRIAL BACKGROUND IONIZING RADIATION

Natural radionuclides of terrestrial origin are always present in varying amounts in all environmental media, including the human body. These material media include natural radionuclide with substantial amounts of their isotope products and lengthy half-lives that are similar to the age of the earth. Gamma radiation released by naturally occurring radionuclide and their decay series, such as the 238U, 232Th, and 40K series, is the primary cause of the population's external exposures. Because they are also found in the body, natural radionuclide exposes various organs to gamma, beta, and alpha radiation. The irradiation of the human body is only little impacted by the environmental presence of the 235U series, 87Rb, and 176Lu.

B. ENVIRONMENTAL RADIATION EXPOSURE

Outdoors

Igneous rocks like granite have higher radiation levels, while sedimentary rocks have lower radiation levels. However, there are notable outliers since some shale and phosphate rocks contain radionuclide in quite high concentrations. Numerous studies have been conducted to ascertain the radioactive background concentrations in soils, which might be connected to the airborne dose rates that are absorbed. These findings offer an even more thorough examination of the background exposure levels in various nations, and the latter is simply evaluated directly. All of these spectrometric studies show that the three elements of the external radiation field—the gamma-emitting radionuclide in the 238U, 232Th, and 40K series—contribute almost equally to the dose of gamma radiation that is externally incident on people.

Indoors

If earth elements were employed in the building, the source geometry indoors shifts from half-space to a more surrounding arrangement, making indoor gamma exposure intrinsically higher than outside exposure. Even greater significance is given to indoor exposure when the length of residency is taken into account. Wooden structures do not significantly increase interior exposures, which may be equivalent to outside exposures. Assessments of absorbed dose rates in indoor air are less thorough than surveys conducted outside. The national values range from 0.02 to 0.2 µSv/h, with the population-weighted average being 0.084 µSv/h. The United States, New Zealand, and Iceland all have values below 0.04µSv/h, which is likely due to the prevalence of wood-frame homes in these countries. The countries with the highest BIR were Hungary, Malaysia, China, Albania, Portugal, Australia, Italy, Spain, Sweden, and Iran, which must reflect wide use of stone or masonry materials in buildings [13].

C. EFFECTS OF NATURAL BACKGROUND IONIZING RADIATION ON PUBLIC HEALTH

Ionizing radiation injects energy into the body's tissues, potentially interfering with molecular structure. This energy transfer in living things has the potential to alter cell of genetic makeup and disrupt or destroy cellular activities (somatic impact cancer, both deadly and non-fatal) (hereditary effect). Accordingly, deterministic (acute) consequences won't happen until there is a significant radiation dosage. Damage to a single cell may result in stochastic repercussions such as cancer and genetic effects [12, 13]. More and more cells are harmed when the radiation dose to the tissue rises from a low level, increasing the likelihood that stochastic consequences may occur. Natural background Ionizing radiation damages human tissue in two different ways: non-stochastic (deterministic) effects and stochastic effects [13].

D. DETER MINISTIC (NON-STOCHASTIC) EFFECTS

Deterministic effects are characterized by non-linear dose-responses, with a threshold dose below which the impact is not observable, and often only manifest after high-dose (acute) exposure. Radiation therapy is where deterministic effects are most important, thus normal tissue therapy doses are kept to a minimum to prevent the effects. Deterministic effects are believed to result from the death of huge populations of cells in the tissues in question, impairing the function of the organs. Deterministic effects often manifest days or weeks after exposure such effects include prodromal syndrome, gastrointestinal syndrome, central nervous system syndrome, hematopoietic syndrome, and pulmonary syndrome, however certain deterministic effects such as cataracts and hypothyroidism are manifest only over periods of years [13].

Skin erythema and epilation

One to twenty-four hours after receiving 2.0 Sievert, erythema may appear. After receiving 15 Sievert, the skin's surface starts to degrade about four weeks later. Epilation happens three weeks after exposure and is reversible after 3 Sievert but irreversible after 7 Sievert [13].

Cataract

Cataracts develop when there is a buildup of damaged or dead lens cells that cannot be normally removed. After receiving 2 to 10 Grey, cataract develops but may take years to appear.

Sterility

Radiation exposure can affect oocyte function, which can affect or prevent conception. Age-related declines in total oocyte counts result in a reduction in the radiation dose necessary to produce this effect. Similar to this, radiation exposure to the testes can cause azoospermia to be either transient or permanent [13].

Radiation illness/sickness

The symptoms of radiation sickness, also known as acute radiation syndrome, include nausea, vomiting, and diarrhea can appear hours or even minutes after a radiation exposure. This is brought on by deterministic effects on the Central Nervous System, Gastro-intestinal tract, and bone marrow [13].

Fetal Death

Effects of deterministic radiation exposure during pregnancy are influenced by both the radiation dose and the gestational age at which it occurred. The embryo is radiosensitive throughout its organogenesis (two to eight weeks) and neural stem cell proliferation stages but somewhat radioresistant during its preimplantation phase (eight to 15 weeks). After this time, fetal radio-sensitivity decreases [13]. Growth retardation, particularly microcephaly, can result from high radiation exposure during pregnancy.

E. STOCHASTIC EFFECTS

According to current thought, a linear no-threshold hypothesis governs the occurrence of stochastic effects. The risk of impact occurrence grows linearly with radiation dose, even though there is no threshold level for these effects. The main long-term health impacts that are anticipated in populations exposed to ionizing radiation are stochastic effects, whereas somatic hazards account for the majority of the total estimated health effect. The radiation dose is assumed to affect the likelihood of somatic and genetic damage occurring, but not their severity. As with deterministic effects, the dose-response may not be linear. However, for the majority of stochastic effects, it is typically more favorable than it is for deterministic effects.

Cancer

Ionizing radiation may cause cancer, according to anecdotal evidence that has grown over time. Reliable evidence has just recently made accessible. As a result of radiation exposure, there is an elevated relative risk of developing malignancies such as leukemia, oral cavity, esophagus, stomach, colon, lung, breast, ovary, urinary bladder, thyroid, liver, non-melanoma skin, and nervous system in people who were exposed to radiation from the atomic bombs in Hiroshima and Nagasaki, according to data from the Radiation Effects Research Foundation on those people. Ionizing radiation has thus been identified as a human carcinogen by a number of organizations, including the U.S. Department of Health and Human Services [13]. There is still debate about whether the linear no-threshold concept can be extrapolated to extremely low doses given that there is no increased incidence of cancer in locations with high background radiation.

Down syndrome (Heredity effect)

Although there hasn't been any evidence of a higher incidence of inherited abnormalities in individuals exposed to radiation in Japan and Chernobyl, animal studies seem to indicate that this danger does exist. The value of 0.3 to 0.8 percent genetic defect risks per Sievert is what the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and ICRP suggest.

Impact on the digestive system

High acute radiation doses can cause noticeable gastrointestinal symptoms, notably following oral radionuclide intakes or after whole-body exposures. Salivary glands are not very susceptible to radiation, as evidenced by the high doses required to produce these effects and the lack of after-effects from dental x-rays. Structures with stratified squamous epithelial coverings close to the stomach appear to be significantly smaller.

Effects on reproduction

More radiosensitive than cells that are highly differentiated and reproduce slowly are cells that reproduce often, such as those found in intestinal crypts, bone marrow, and animal reproductive systems. The source or kind of ionizing radiation affects this radiosensitivity. Both men and females have certain reproductive tract cells that multiply at faster rates, rendering them more vulnerable to the effects of ionizing radiation. The cells that are most vulnerable to the effects of ionizing radiation in males are the spermatogonia. These are the germ cells that become spermatocytes, then spermatids, and finally mature sperm [13].

Impacts on the central nervous system (CNS)

Both mature humans and laboratory animals have extraordinarily strong radiation resistance throughout their central nervous systems. The central nervous system contains a relatively static population of cells, with cell mitosis happening seldom, if at all, compared to the gastrointestinal and hematological systems' constantly dividing cells. According to [14], a single person accidentally exposed to 200-350 rad (2-3.5 Grey) of gamma radiation experienced clinical symptoms such a lifelong headache and eyesight impairment during and after the Chernobyl nuclear power plant catastrophe.

Damage to cellular DNA caused by radiation

Double strand breaks in DNA are essential to the development of cancer. It manifests as an electromagnetic wave, and its location within the electromagnetic spectrum is determined by the frequency of the wave. At one end of the spectrum are low-frequency waves like radio waves, and at the other are high-energy, high-frequency waves like X-rays and Gamma rays. As contrast to non-ionizing radiation, these high-frequencies, high-energy waves are known as "ionizing" radiation because they have enough energy to knock an electron out of its orbit around a nucleus. The potential harm that this misplaced electron may do to DNA, which may happen directly or indirectly, is the most significant effect it will have on human tissue. When the displaced electron strikes and shatters a DNA strand, direct damage occur. When an electron interacts with a water molecule, a potent hydroxyl radical is produced, which ultimately destroys the DNA of the cell [13]. There are various effects that can result from DNA damage to a cell in either of these methods. A single-strand DNA break is often correctly repaired by the cell without any negative side effects But when both DNA strands are damaged, there is a chance for an aberrant reconnection of the strands, which most likely explains all of the harmful biological consequences of ionizing radiation on humans. First, DNA may erroneously recombine, leaving the cell nonviable and causing cell death. Second, it may rejoin as a symmetrical translocation with the possibility of oncogene expression during division (and subsequent cancer development) or with aberrant gonad division, resulting in the formation of possible hereditary diseases. The likelihood that a cell, tissue, or organ may experience damage from a radiation exposure is known as radiosensitivity [15]. High levels of mitosis or undifferentiated cells have the highest radiosensitivity. The lens cells, bone marrow, thymus, gonads, and basal epidermis are all extremely radiosensitive because of this; tissues in the muscles, bones, and neurological system are relatively radiosensitive.

F. CRITERIA OF THE STUDIES

Strategic Search Terms

The research studies that investigate natural ionizing background radiation and its radiological risks on public health were searched on the internet and retrieved from different databases such as Goggle Scholar, Academia, Science Direct, PudMed, and journal websites. The search terms include: assessment of natural background radiation, Determination of Cancer due to natural back ground radiation and Effects of natural ionizing background radiation on human. The Data were searched and retrieved throughout 2021-2022.

Inclusion And Exclusion Criteria

Inclusion Criteria

The research papers retrieved from different databases were thoroughly checked for its eligibility by applying the criteria below: research studies that investigate natural ionizing background radiation, research studies that assess the health hazards of natural ionizing back ground radiation and research studies investigating Exposure Dose rate, absorbed dose, Annual effective doses & cancer risks.

Extraction of Data

The research papers used in this work were evaluated critically and data regarding Location of the studies, nuclear radiation detector, dose rate, indoor and outdoor dose rate, indoor and outdoor annual effective dose, and some cancer risks were extracted. Analysis of extracted data was performed in order to assess the radiological hazard and Cancer risk of natural background ionizing radiation. Different types of nuclear radiation detector/meter were used in the measurement by different Nigerian researchers. The nuclear radiation detectors used include: PG-15 GM, Digilert 200, Rad Alert 100, Blue Geiger PG-15, Redeye G-10, GQ GMC-320, Radiagem 2000, RDS-30 RM, Radex RM, and GMD X5C plus (RD 1212) e.t.c. These detectors have various measurement capacities with different calibrations units such as mR/h, µSv/h, and nGy/h for dose rate survey.

Selection Of The Research Articles

About ninety nine (101) articles were downloaded from various databases and journal websites. Repeated articles were eliminated and titles and abstract of the articles were fully and thoroughly investigated. Fifty three (53) full –text articles passed the screening process and was used in this work.

Analysis of Extracted Data

A lot of studies conducted in Nigeria pay no attention on organs dose assessment due to inhalation of radon gas in indoor exposures. The organs annual effective dose, individual organ Cancer, and whole body cancer risk were analyzed using mathematical expressions incorporated into MS word Excel spread sheet and later transferred the results into MS word tables.

G. RADIOMETRIC PARAMETERS USED IN NATURAL BACKGROUND RADIATION DOSIMETRY

Exposure Dose Rate (Indoor & Outdoor)

Exposure is the amount of radiation present in the area and dose is the amount of that radiation expected to be absorbed by the person.

Absorbed Dose Rate

Absorbed dose is the quantity that better indicates the effects of radiation on human beings, and, accordingly, all the protection related quantities are based on it. It is used to assess the potential for any biochemical changes in specific tissues. It quantifies the radiation energy that might be absorbed by a potentially exposed individual. The measured BIR exposure levels were converted to radiation absorbed dose rate in air.

Occupancy And Conversion Factor

The occupancy factor is the proportion of the total time during which an individual is exposed to a radiation field [16]. Eight thousand seven hundred and sixty hours per year (8760hr/yr) were used. UNSCEAR, (1988) recommended indoor and outdoor occupancy factors of 0.8 and 0.2 respectively. The nuclear radiation meter that reading in count rate per minute (CPM) can be converted to Roentgen per hour (R/H), mathematically, we have

$$1 \text{ cpm} = 0.5 \times 104 \text{ R/h} \quad (1)$$
$$1 \text{ cpm} = 0.044 \text{ mSv/yr}$$

Annual Effective Dose (Indoor & Outdoor)

The Effective Dose refers to the radiation dose parameter which takes into account the absorbed Dose received by each irradiated organ and the organs relative sensitivity according to ICRP [17]. It is a protection level Dosimetry quantity that could be used as an approximate measure of stochastic effect. Thus for the public exposed to natural ionizing radiation, the annual effective dose for both indoor and outdoor can be expressed as

$$\text{IAEDR (mSv/yr)} = \text{Y } (\mu\text{Sv/hr}) \times 8760 \text{ (hr/yr)} \times 0.8 \div 1000 \quad (2)$$
$$\text{OAEDR (mSv/yr)} = \text{Z } (\mu\text{Sv/hr}) \times 8760 \text{ (hr/yr)} \times 0.2 \div 1000 \quad (3)$$

Where; Y and Z are the indoor and outdoor meter's readings while IAEDR and OEDR are the indoor and outdoor annual effective dose rates respectively [16].

Organ Annual Effective Dose

This is the amount of radiation received by an individual organ of the body such as lung, ovaries, tests, liver, and kidney e.t.c. Many research papers used in this study did not take into account the organ doses. The organ radiation doses due to inhalation exposure path way were computed from the annual effective data extracted using equation (4), in order to ascertain the amount of natural background radiation received by each organ over the period of one year.

$$D_{organs}(mSvy^{-1}) = AEDR_{for\ ind\&outd}(mSvy^{-1}) \times CF \quad (4)$$

Where CF is coefficient of reduction for individual organs in the body which include 0.64, 0.58, 0.69, 0.82, 0.46, and 0.68 for Lung, Ovaries, Bone Marrow, Tests, Kidney, Liver and Whole Body respectively

Cancer And Organs Cancer Risks

This is concerned with the likelihood of developing cancer throughout a lifetime for a particular degree of exposure. It is expressed as a number representing the number of cancers expected in a specific number of people after exposure to a carcinogen at a particular dose. It's worth mentioning that an increase in the ELCR leads to a corresponding increase in the risk of developing breast, prostate, or even blood cancer. Excess lifetime cancer risk (ELCR) is determined using equation.

$$ELCR = AED \times DL \times RF \quad (5)$$

Where AEDE is the Annual Equivalent Dose Equivalent, DL is the average duration of life (estimated to 70 years) and RF is the Risk Factor (Sv^{-1}), i.e., fatal cancer risk per Sievert. For stochastic effects, ICRP uses RF as 0.05 for the public 0.05. The cancer risks of individual organs were assessed using equation (6). The excess lifetime cancer risk is used in radiation protection assessment to predict the probability of an individual developing cancer over his lifetime due to low radiation dose exposure, if it will occur at all [16]

$$Cancer\ Risk_{organs} = D_{organs}(mSvy^{-1}) \times DL \times RF \quad (6)$$

In the literatures, many researchers paid no attention to organ cancer risk which is the vital aspect in determining health implications of natural background radiation in a regions or places. The organ dose calculated earlier was used to assess individual organ cancer risk.

H. SUMMARY OF DOSE RATE, ANNUAL EFFECTIVE DOSE, ORGANS DOSE AND EXCESS LIFE CANCER RISKS

Background gamma dose rates (outdoor and indoor) and corresponding annual effective dose (outdoor and indoor) were extracted from researches conducted in Nigeria were tabulated in table 1&2 as indoor and outdoor dose rate measured in µSv/hr. The average radiation dose to the world's population from natural sources of radiation is 2.4mSv/y as reported by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and International Council on Radiological Protection (ICRP), while permissible Excess lifetime cancer risk values to the populations reported to be 0.29×10^{-3}. The TABLE 1, 2, 3 & 4 shows the overview results of indoor & outdoor dose rate and indoor & outdoor annual effective dose [16]. TABLE 5-7 document the excess life cancer risk, organs annual effective dose and cancer risk for individual organs.
Some abbreviation used in the table include ES= Excavation Section, QS= Quarry Section, GC = Geiger counter, SUB =State University Bokos, LB = local Building, MB= Modern Building.

TABLE 1
Indoor Dose Rate (µSv/h)

Country	Location	Measurement Technique	IDR µSv/h	Ref
Nigeria	Plateau, SUB	gamma-scout	0.25	[18]
Nigeria	ABU Zaria Kd	RadEye G20 RM	0.13	[19]
Nigeria	Makurdi	radiation alert meter	0.002	[20]
Nigeria	FUT Owerri	Digital GMC GCA – 04	0.14	[21]
Nigeria	Burutu, Delta	Digilert 100 RM	0.02	[22]
Nigeria	OYO , LB	RDS-30 RM	0.25	[23]
Nigeria	OYO, M.B	RDS-30 RM	0.22	[23]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	0.113	[24]
Nigeria	Ibadan shops	Radeye G-10	0.14	[25]
Nigeria	Ibadan wall tiles	Radeye G-10	0.11	[25]
Nigeria	Ibadan floor Tiles	Radeye G-10	0.12	[25]
Nigeria	Ibadan,Water Closet	Radeye G-10	0.10	[25]
Nigeria	Delta, Ozoro	Blue Geiger PG-15	0.22	[26]
Nigeria	River, Emelogu	Rad Alert 100	0.24	[7]
Nigeria	Ondo	PG-15 GM	0.21	[27]
Iran	Kohgiluyeh & Boyer	GMD X5C plus	0.14	[28]
Iran	Gonabad	RDS-30 RM	0.11	[29]
Iran	Gonabad	GM detector X5C plus	0.11	[30]
	Bushehr	G.M X5C Plus	0.06	[1]
World average value			0.08	
World safety limit			0.25	

TABLE 2
Outdoor Dose Rate (µSv/h)

Country	location	Measurement Technique	ODR µSv/h	Ref
Nigeria	Ebonyi, ES	GQ GMC-320 RM	0.15	[31]
Nigeria	Ebonyi, QS	GQ GMC-320 RM	0.18	[31]
Nigeria	Plateau, SUB	gamma- scout	0.249	[18]
Nigeria	ABU , Zaria Kd	RadEye G20 RM	0.10	[19]
Nigeria	Makurdi	radiation alert meter	0.0018	[20]
Nigeria	FUT, Owerri	Digital GMC GCA – 04	0.144	[21]
Nigeria	Enugu	GQ GMC-320 RM	0.143	[32]
Nigeria	Burutu, Delta	Digilert 100 RM	0.014	[22]
Nigeria	Kano	Radiation Alert Inspector	0.227	[33]
Nigeria	OYO , LB	RDS-30 RM	0.22	[23]
Nigeria	OYO, M.B	RDS-30 RM	0.20	[23]
Nigeria	Niger, Tertiary	Digital alert RM	0.154	[34]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	0.07	[24]
Nigeria	Niger Delta	Digilert 200	0.137	[35]
Nigeria	Niger Delta	Digilert 200	0.170	[35]
Nigeria	Niger Delta	Digilert 200	0.164	[35]
Nigeria	Niger Delta	Digilert 200	0.183	[35]
Nigeria	Niger Delta	Digilert 200	0.148	[35]
Nigeria	Sokoto	Digilert 50 & GPS	0.24	[36]
Nigeria	GMB,Line 1	GM C meter	0.17	[37]
Nigeria	GMB,Line 2	GM C meter	0.18	[37]
Nigeria	Enugu Abakpa	GQ GMC-320	0.143	[32]
Nigeria	Enugu Gariki	GQ GMC-320	0.135	[32]
Nigeria	Enugu Newmarket	GQ GMC-320	0.114	[32]
Nigeria	Enugu Old Park	GQ GMC-320	0.112	[32]
Nigeria	Enugu Holy Ghost	GQ GMC-320	0.112	[32]
Nigeria	Ogun, Ijebu-Ife	Survey meter	0.05	[38]
Nigeria	Ibadan shops	Radeye G-10	0.124	[25]
Nigeria	Ibadan ,wall tiles	Radeye G-10	0.103	[25]
Nigeria	Ibadan, floor Tiles	Radeye G-10	0.11	[25]
Nigeria	Ibadan,Water C	Radeye G-10	0.098	[25]
Nigeria	Delta,Ozoro	Blue Geiger PG-15	0.20	[26]
Nigeria	River, Emelogu	Rad Alert 100	0.18	[7]
Nigeria	River Oil field	Digilert 200 & GPS	0.25	[39]
Nigeria	River, Host Com	Digilert 200 & GPS	0.26	[39]
Nigeria	Ondo	PG-15 GM	0.236	[27]
Nigeria	Niger Delta Warri	Digilert 100 & GPS	0.141	[40]
Nigeria	FCT	Radex RM (RD 1212)	0.003	[41]
Nigeria	Ebonyi,Nkalangu	GQ GMC-320 Plus	0.142	[42]
Nigeria	Rivers	Digilert 200&GPS	0.122	[43]
Nigeria	Niger, Lapai	GQ GMC-320 Plus RM	0.0002	[34]
Iran	Kohgiluyeh &Boyer	GMD X5C plus	0.149	[28]
Iran	Gonabad	RDS-30 RM	0.139	[29]
Iran	Gonabad	GM detector X5C plus	0.084	[30]
Banglades	Dhaka	Gamma-Scout	0.145	[44]
	Bushehr	G.M X5C Plus	0.052	[1]
World average			**0.084**	[5]
World Safety Limit			0.247	

TABLE 3
Outdoor Annual Effective Dose (Msv/Yr)

Country	Location	Measurement Technique	OAED mSv/yr	Ref
Nigeria	Niger Delta Warri	Digilert 100 & GPS	0.17	[40]
Nigeria	Sokoto	Digilert 50 & GPS	2.01	[36]
Nigeria	Ebonyi, ES	GQ GMC-320	0.27	[31]
Nigeria	Ebonyi QS	GQ GMC-320	0.31	[31]
Nigeria	Anambra, Nnewi	CRM 100 RM	0.228	[45]
Nigeria	Plateau, SUB	Gamma-scout	0.44	[18]
Nigeria	ABU, Zaria	RadEye G20 SM	0.18	[19]
Nigeria	Makurdi	Radiation alert meter	0.016	[20]
Nigeria	Keffi, Nasarawa	Alert Nuclear RM	0.04	[46]
Nigeria	Rivers	Digilert 200&GPS	0.33	[43]
Nigeria	Niger, Lapai	GQ GMC-320 Plus RM	0.170	[34]
Nigeria	Enugu	GQ GMC-320 RM	0.153	[32]
Nigeria	Ebonyi, Nkalangu	GQ GMC-320 Plus	0.145	[42]
Nigeria	Akwanga	Geiger-Muller RM	0.44	[47]
Nigeria	Delta, Burutu	Digilert 100 RM	0.635	[22]
Nigeria	Kano	Radiation Alert	0.397	[33]
Nigeria	FCT	Radex RM (RD 1212)	0.000086	[41]
Nigeria	Kokano	Radex RM (RD 1212)	0.0274	[48]
Nigeria	Nasarawa	Radex RM(RD 1212)	0.0166	[48]
Nigeria	Toto	Radex RM(RD 1212)	0.0227	[48]
Nigeria	Port Harcour	GM radiation Detector.	0.728	[9]
Nigeria	OYO , LB	RDS-30 RM	2.40	[23]
Nigeria	OYO, M.B	RDS-30 RM	2.40	[23]
Nigeria	Niger, Tertiary	Digital alert RM	0.27	[34]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	0.087	[24]
Nigeria	Niger Delta	Digilert 200	0.961	[35]
Nigeria	Niger Delta	Digilert 200	1.193	[35]
Nigeria	Niger Delta	Digilert 200	1.146	[35]
Nigeria	Niger Delta	Digilert 200	1.281	[35]
Nigeria	Niger Delta	Digilert 200	1.034	[35]
Nigeria	GMB,Line1	GM C meter	0.48	[37]
Nigeria	GMB,Line2	GM C meter	0.23	[37]
Nigeria	Enugu Abakpa	GQ GMC-320	0.153	[32]
Nigeria	Enugu Gariki	GQ GMC-320	0.144	[32]
Nigeria	Enugu Newmarket	GQ GMC-320	0.122	[32]
Nigeria	Enugu Old Park	GQ GMC-320	0.120	[32]
Nigeria	Enugu Holy Ghost	GQ GMC-320	0.119	[32]
Nigeria	Ogun, Ijebu-Ife	Survey meter	0.03	[38]
Nigeria	Ibadan shops	Radeye G-10	0.112	[25]
Nigeria	Ibadan , wall tiles	Radeye G-10	0.37	[25]
Nigeria	Ibadan, floor Tiles	Radeye G-10	0.46	[25]
Nigeria	Ibadan,Water Closet	Radeye G-10	0.33	[25]
Nigeria	Delta, Ozoro	Blue Geiger PG-15	0.27	[26]
Nigeria	River, Emelogu	Rad Alert 100	0.48	[7]
Nigeria	River Oil field	Digilert 200 & GPS	0.35	[39]
Nigeria	River, Host Com	Digilert 200 & GPS	0.33	[39]
Nigeria	Ondo	PG-15 GM	1.56	[27]
Outdoor worldwide average			**0.07**	
ICRP safety limit			**1.00**	

TABLE 4
Indoor Annual Effective Dose (mSv/yr)

Country	Location	Measurement Technique	IAED mSv/yr	Ref
Nigeria	Anambra, Nnewi	CRM 100 RM	0.8060	[45]
Nigeria	Plateau, SUB	gamma- scout	1.54	[18]
Nigeria	ABU, Zaria	RadEye G20 SR	0.91	[19]
Nigeria	Makurdi	Radiation alert meter	0.083	[20]
Nigeria	Keffi, Nasarawa	Alert Nuclear RM	0.17	[46]
Nigeria	Akwanga	Geiger-Muller RM	1.75	[47]
Nigeria	Burutu, Delta	Digilert 100 RM	1.135	[22]
Nigeria	Port Harcour	GM radiation Detector.	0.87	[9]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	0.556	[22]
Nigeria	Ibadan shops	Radeye G-10	0.097	[25]
Nigeria	Ibadan , wall tiles	Radeye G-10	0.42	[25]
Nigeria	Ibadan, floor Tiles	Radeye G-10	0.520	[25]
Nigeria	Ibadan,Water Closet	Radeye G-10	0.367	[25]
Nigeria	Delta, Ozoro	Blue Geiger PG-15	1.09	[26]
Nigeria	River, Emelogu	Rad Alert 100	1.06	[7]
	ICRP		**1.0 mSv/y**	

TABLE 5
Excess Life Cancer Risk

Country	Location	Measurement Technique	ELCR $\times 10^{-3}$	Ref
Nigeria	Ebonyi, ES	GQ GMC-320 RM	0.94	[31]
Nigeria	Ebonyi, QS	GQ GMC-320 RM	1.07	[31]
Nigeria	Anambra, Nnewi	CRM 100 RM	2.82	[45]
Nigeria	Anambra, Nnewi	CRM 100 RM	0.79	[45]
Nigeria	Makurdi	Radiation alert meter	0.055	[20]
Nigeria	Makurdi	Radiation alert meter	0.289	[20]
Nigeria	Keffi, Nasarawa	Alert Nuclear RM	0.60	[46]
Nigeria	Keffi, Nasarawa	Alert Nuclear RM	0.14	[46]
Nigeria	Rivers	Digilert 200&GPS	0.72	[43]
Nigeria	Enugu	GQ GMC-320 RM	0.534	[32]
Nigeria	Burutu, Delta	Digilert 100 RM	1.729	[22]
Nigeria	Burutu, Delta	Digilert 100 RM	0.394	[22]
Nigeria	FCT, Abuja	Radex RM (RD 1212)	0.306	[41]
Nigeria	Kokona	Radex RM (RD 1212)	0.096	[48]
Nigeria	Nasarawa	Radex RM (RD 1212)	0.058	[48]
Nigeria	Toto	Radex RM (RD 1212)	0.0795	[48]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	1.945	[24]
Nigeria	Abuja, Sheda S&T	Radiagem 2000	0.304	[24]
Nigeria	GMB,Line1	GM C meter	0.83	[37]
Nigeria	GMB,Line2	GM C meter	0.80	[37]
Nigeria	Ebonyi, Nkalangu	GQ GMC-320 Plus	0.612	[42]
Nigeria	Enugu Abakpa	GQ GMC-320	0.53	[42]
Nigeria	Enugu Gariki	GQ GMC-320	0.50	[42]
Nigeria	Enugu Newmarket	GQ GMC-320	0.43	[42]
Nigeria	Enugu Old Park	GQ GMC-320	0.42	[42]
Nigeria	Enugu Holy Ghost	GQ GMC-320	0.42	[42]
Nigeria	River, Emelogu	Rad Alert 100	4.21	[7]
Nigeria	Plateau, SUB		1.54	[18]
Nigeria	ABU, Kaduna		0.63	[19]
Nigeria	Niger, Lapai		0.59	[34]
Nigeria	Kano		1.37	[33]
Nigeria	OYO , LB		8.40	[23]
Nigeria	OYO, M.B		8.40	[23]
Nigeria	Niger, Tertiary		0.95	[34]
Nigeria	Ogun, Ijebu-Ife		0.11	[38]
Nigeria	Ibadan, shops		0.39	[25]
Nigeria	Ibadan, wall tiles		1.29	[25]
Nigeria	Ibadan, floor Tiles		1.61	[25]
Nigeria	Ibadan,Water Clos		1.16	[25]
Nigeria	Delta, Ozoro		0.95	[26]
Nigeria	River, Oilfield		1.29	[39]
Nigeria	River, Host Com		1.16	[39]
Nigeria	Ondo		5.46	[27]
Nigeria	Akwanga		6.125	[47]
Nigeria	Port court		3.045	[9]
Worldwide average			**0.29**	

TABLE 6
Organs Annual Effective Dose (mSv/y)

S/N	Lung	Ovaries	BM	Tests	Kidney	Liver	WB	REF
1	0.516	0.467	0.556	0.67	0.37076	0.371	0.548	[45]
2	0.986	0.8932	1.0626	1.2628	0.7084	0.708	1.047	[18]
3	0.582	0.5278	0.6279	0.7462	0.4186	0.419	0.619	[19]
4	0.053	0.04814	0.05727	0.06806	0.03818	0.038	0.056	[20]
5	0.109	0.0986	0.1173	0.1394	0.0782	0.078	0.116	[46]
6	1.120	1.015	1.2075	1.435	0.805	0.805	1.190	[47]
7	0.726	0.6583	0.78315	0.9307	0.5221	0.522	0.772	[22]
8	0.557	0.5046	0.6003	0.7134	0.4002	0.400	0.592	[9]
9	0.356	0.32248	0.38364	0.45592	0.25576	0.256	0.378	[24]
10	0.062	0.05626	0.06693	0.07954	0.04462	0.045	0.066	[25]
11	0.269	0.2436	0.2898	0.3444	0.1932	0.193	0.286	[25]
12	0.333	0.3016	0.3588	0.4264	0.2392	0.239	0.354	[25]
13	0.235	0.21286	0.25323	0.30094	0.16882	0.169	0.249	[25]
14	0.698	0.632	0.752	0.89	0.5014	0.501	0.741	[26]
15	0.018	0.015	0.019	0.0225	0.017	0.013	0.019	[48]
16	0.010	0.009	0.0115	0.0136	0.0103	0.008	0.011	[48]
17	0.0145	0.0132	0.0157	0.0186	0.0141	0.011	0.016	[48]
18	0.678	0.614	0.7314	0.8692	0.4876	0.488	0.721	[7]
M.	**0.407**	**0.369**	**0.439**	**0.521**	**0.293**	**0.292**	**0.432**	
World Average				**1.0**				

TABLE 7
Excess Life Cancer Risks for Individual Organs and Whole Body (10^{-3})

S/N	Lung	Ovaries	BM	Tests	Kidney	Liver	Whole Body	Ref
1	1.81	1.63	1.95	2.31	1.29	1.298	1.92	[45]
2	3.44	3.12	3.72	4.42	2.48	2.479	3.66	[18]
3	2.03	1.84	2.19	2.61	1.46	1.465	2.17	[19]
4	0.18	0.16	0.20	0.24	0.13	0.134	0.19	[20]
5	0.38	0.34	0.41	0.49	0.27	0.274	0.40	[46]
6	3.92	3.55	4.22	5.02	2.82	2.818	4.16	[47]
7	2.54	2.30	2.74	3.25	1.83	1.827	2.70	[22]
8	1.94	1.76	2.10	2.49	1.40	1.400	2.07	[9]
9	1.24	1.12	1.34	1.59	0.89	0.895	1.32	[24]
10	0.21	0.19	0.23	0.28	0.16	0.156	0.23	[25]
11	0.94	0.85	1.01	1.21	0.68	0.676	0.99	[25]
12	1.16	1.05	1.25	1.49	0.84	0.837	1.24	[25]
13	0.82	0.74	0.88	1.05	0.59	0.591	0.87	[25]
14	2.44	2.21	2.63	3.13	1.76	1.755	2.59	[26]
15	0.06	0.06	0.07	0.08	0.06	0.044	0.065	[48]
16	0.03	0.03	0.04	0.05	0.05	0.027	0.04	[48]
17	0.05	0.04	0.06	0.07	0.05	0.037	0.05	[48]
18	2.37	2.15	2.55	3.04	1.70	1.707	2.52	[7]
Mean	**1.42**	**1.29**	**1.53**	**1.82**	**1.02**	**1.023**	**1.51**	
World Average				**0.29×10^{-3}**				

IV. DISCUSSION

Impact Assessment is a process to estimate the health effects that might result from exposure to natural background ionizing radiation [51]. According to a study in 2013 classified radiation areas as low (less than 5mSv), medium (5-10 mSv), high [20-50 mSv] and very high (greater than 50 mSv) [49, 50]. A study in 2014 revealed that any exposure to ionizing radiation has the tendency to change the biological make-up of the human body which may result in radiation induced health effects [52]. The indoor radiation measurement was conducted in different geographical locations of Nigeria. The geographical locations with high indoor radiation dose are Plateau state (State University Bokos), Oyo (local buildings), River (Emelogu), Oyo (Modern buildings), Delta (Ozoro), and Ondo [18, 23, 7 & 26]. The natural background radiation doses in those areas as shown in table 1, were remarkably greater than the value obtained in Iran (Kohgiluyeh & Boyer and Gonabad) and Bushehr [1, 28, 29, 30]. The indoor dose rate reviewed in this work apart from being greater than other country's values were also higher than the world average value of 0.084 μSv/h, but equivalent to the world safety limit of 0.247μSv/h. The order of magnitude of indoor dose rate were found to be Plateau > Oyo > Rive > Delta > Ondo. The outdoor dose rate reviewed so far and extracted from literatures were higher in River state (Host Communities & Oil field), Plateau (State University Bokos), Kano, OYO, Sokoto, Ondo Niger and Delta, (Ozoro) [18, 23, 26, 33, 36, 27, 35 & 39]. The results were remarkably higher than that of Iran [29, 30] Bangladesh [44] and Bushehr [1]. Comparatively, outdoor dose rate were greater than the world average value but lower than world safety value of 0.247μSv/h. In order of magnitude of outdoor dose rate were River > Plateau > Sokoto > Kano > Oyo > Ondo > Delta > Niger. The highest outdoor annual effective doses were observed in OYO (Local and Modern Building), Sokoto, Ondo and Niger Delta. The results were comparatively higher than outdoor world average value and safety limit issued by ICRP. The highest outdoor annual effective doses were observed in OYO (Local and Modern Building), Sokoto, Ondo and Niger Delta. The results were comparatively higher than outdoor world average value and safety limit issued by ICRP as indicated in table 3. Other studies conducted in Nigeria were found to be higher than the average values but lower than safety limit (table 3). Order of magnitude of the results were OYO > Sokoto > Ondo > Niger Delta. For indoor, the highest annual effective dose were in Akwanga, Plateau, Delta and River as indicated in table 4. The results were comparatively greater than the world acceptable limit of 1.0 mSv/y. The magnitude of the results was in order of Akwanga > Plateau > Delta > River.

The excess life cancer risk extracted and the one estimated from the studies conducted in Nigeria were found to be highest in an areas like Oyo (in local and modern buildings), Akwanga, Ondo, Plateau (State University Bokos), River (Emelogu), Kaduna, Anambra (Nnewi), Port court, Abuja (Sheda Science &Technology), Delta (Burutu), Ibadan (floor Tiles) and Kano [7, 18, 19, 23, 25, 26, 27 & 47]. Both extracted and analyzed results were remarkably beyond the world average value of 0.29×10^{-3}. The order of magnitude of the excess life cancer risks involved Oyo > Akwanga > Ondo > Plateau > River > Kaduna > Anambra > Port court > Abuja > Delta > Ibadan > Kano. The highest amount of radiation absorbed by the organs exposed to natural background radiation were in order of Tests > Bone marrow > Whole body > Lung > Ovaries > Kidney > Liver. But all the estimated mean values were remarkably lower than that of world average value as indicated in table 6, but this does not mean that there's not effect at all. The mean value of organs cancer risk as tabulated in table 7 were all beyond the world average value of 0.29. These are the indications of organs sensitivity to natural background ionizing radiation present in a particular location in the country. Since the mean annual effective dose in several areas is higher than 1.0 mSv/year for general public in many locations, long term exposure of the public to these radiations may lead to radiation induced health hazard such as erythema, skin cancer, genetic mutation and sterility etc [51].

Some of the places that received high levels of background natural radiations and induced cancers in Nigeria include Plateau, Oyo, River, Delta, Ondo, Sokoto, Kano, Niger and Akwanga e.t.c.[50]. It is therefore essential that activities involving radiation exposure, such as the production and use of radiation sources and radioactive materials, and the mining activities, including the management of mine-waste, be subjected to certain standards of safety in order to protect those individuals exposed to radiation. The review was limited to *in situ* BIR measurements only, all other sources was not included such as medical radiation sources.

V. CONCLUSION

The aim of this review was to carry out an investigational study of the natural background ionizing radiation levels, identify locations with high or low BIR and assess the health effect within Nigeria's communities based on the available data extracted from the literatures within Nigeria. The review has thus revealed that the radiation levels in some of the locations are low ranging while others are high ranging which has been attributed to the geological and geographical settings of the locations as well as the fertilizer and agrochemical applications within the dwellings environmental farms. The related radiation doses and lifetime cancer risk values are higher than normal world average value. These high doses may cause serious health implications such as cancer, heritable mutations, and probably other significant health effects as it was demonstrated by long term epidemiological studies of populations exposed to radiation that exposure to natural background radiation have potential to cause malignancies. This review suggests the need for Nigeria regulatory bodies on radiation to take actions against any further increase in the Background Ionizing Radiation levels of the environment and the communities reported with high natural background radiation in the country. It is therefore essential that activities involving radiation exposure such as the production of oil and gas, agrochemical & fertilizer applications, and gold mining activities be subjected to certain standards of safety in order to protect those individuals exposed to radiation

ACKNOWLEDGMENT

I wish to thanks and appreciate all those, whose their work used as guide in completing this systematic review.

REFERENCES

[1] M.P. Ali, A. Mahdi, N. Iraj, and A. Majid, "Annual effective dose from environmental gamma radiation in Bushehr city". Journal of Environmental Health Sciences & Engineering., 12(4): 1-4, 2014.

[2] H. H Jolyon, L. S. Steven, W. Andrzej, M. Sohrabi, W. Burkart, C. Elisabeth, L. Dominique, T. Margot, and H. Isamu "Human exposure to high natural background radiation: what can it teach us about radiation risks. J Radiological Protection. 29: 29–42, 2009.

[3] H. Masahiro, D.N. Eka, A. Naofumi, Y. Ryohei, M.S. Yuki Tamakuma, K. Kevin, Y. Shinji, S. Takahito, P.R. Chanis, F. Masahide, Y. Masaru, I. Kazuki, S.K. Tetsuya, M. K. Tomisato, I. Dadong, P. Eko, K. Ikuo, T. Shinji, "A unique high natural background radiation area – Dose assessment and perspectives". *Science of the Total Environment,* 750: 142-346, 2021.

[4] D.S. Ludwik, W.F. Krzysztof, and E.F. Ludwig "Cancer Mortality Among People Living in Areas With Various Levels of Natural Background Radiation". *Dose-Response: An International Journal,* 1-10, 2015.

[5] UNSCEAR "2008 report on the sources and effects of ionizing radiation" Report to the General Assembly with scientific annexes. United Nations Scientific Committee on the effect of Atomic Radiation.".. United Nations, New York, 2008

[6] International Atomic Energy Agency [IAEA],. Safety support series No.115: International Basic Safety Standards for protection against ionizing radiation and the safety of radiation sources, 1996.

[7] C.P. Ononugbo, G.O. Avwiri and G. Tutumeni, "Estimation of indoor and outdoor effective doses from gamma dose rate of residential building in Emellogu village in River State". International Research Journal of Pure and Applied Physics, 3(2): 18-27, 2015.

[8] M.B. Tavakoli, E. Kodamoradi, Z. Shaneh, "Assessment of gamma-dose rate in city of Kermanshah". J Edu Health Promot, 1:30, 2012.

[9] E.C. Yehuwdah, A. Martins, O.H. Soibi, "Evaluation of indoor background ionizing radiation profile of physics laboratory UDC546.296". FACTA UNIVERSITATIS Series: Working and Living Environmental Protection, 3(1):1 – 8, 2006

[10] A.Q Aziz, T. Shahina, U.D. Kamal, M. Shahid, C. Chiara, and W.Abdul, "Evaluation of excessive lifetime cancer risks due to natural radioactivity in the rivers sediments of Northern Pakistan". J. Radiat. Res. Appl. Sci., 7:438-447, 2014.

[11] H. Taskin, M. Karavus, P. Ay, A. Topuzoglu, S. Hindiroglu, and G. Karahan, "Radionuclide concentrations in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli". Turkey J. Environ. Radioact. 100:49–53, 2009.

[12] N. Hamada, and Y. Fujimichi,. Classification of radiation effects for dose limitation purposes: history, current situation and future prospects. Journal of Radiation Research 55(4): 629-640, 2014.

[13] A. Chaturvedi, "Effect of Ionizing Radiation on Human Health". International Journal of Plant and Environment, 5(3): 200-205, 2019

[14] A. Birioukov, M. Meurer, R.U. Peter, O. Braun-Falco, and G. Plewig, G. "Male reproductive system in patients exposed to ionizing irradiation in the Chernobyl accident". Archives of Andrology 30(2): 99-104, . 1993.

[15] A.V. Akleyev, "Normal tissue reactions to chronic radiation exposure in man". Radiation Protection Dosimetry, 171(1): 107-116, 2016.

[16] B. Samaila, M.N. Yahaya, and N. Abubakar, "Assessment of Natural Background Radiation Exposure in some States of Nigeria: A review". Journal of the Nigerian Association of Mathematical Physics, 58:197 – 202, 2020

[17] A.A. Samson, "Determination of doses and cancer risk to patients undergoing digital x-ray examinations at the Tamale Teaching hospital". M.Sc thesis submitted to School of Nuclear and Allied Sciences, University of Ghana *:10-70,* Retrieved on 8th Sept 2020, at http://ugspace.ug.edu.gh

[18] B.M. Felix, R.D. Robert, W.M. Emanuel, "Assessment of Indoor and Outdoor Background Radiation Levels in Plateau State University Bokkos Jos, Nigeria". Journal of Environment and Earth Science, 5(8): 1-5. 2015

[19] I. A. Bello, O.O. Ige, N. Kure, and A.H. Momoh, "Assessment of radiation dose level at kabba College of Agriculture, division of Agricultural colleges, Ahmadu Bello University, of Agriculture, Zaria" . FUDMA Journal of Sciences (FJS), 5(1): 524 – 528,2021

[20] O.Y. Omogunloye, A.T. Adepoju, and P. Kururimam, "Assessment of Radiation Risk from Background Radiation Exposures in Selected Hospitals within Makurdi Metropolis, North-Central, Nigeria". European Journal of Applied Physics, 3 (4): 43-47, 2021

[21] B.C. Eke, and H.U. Emelue, "Measurement of background ionizing radiation in the federal university of technology owerri, Nigeria using calibrated digital geiger counter". Int J Phys Res Appl, 3, pp. 070-074. 2020.

[22] O.E. Esi, O.E., O. Edomi, and P. O. Odedede, "Assessment of Indoor and Outdoor Background Ionizing Radiation Level in School of Marine Technology, Burutu, Delta State, Nigeria". Asian Journal of Research and Reviews in Physics, 2(3): 1-8, 2019.

[23] Z.A. Akintunde, T.O. Olawoore, O.S. Atilola, and A.O. Ojo, "Evaluation of indoor and outdoor background ionizing radiation of selected residential buildings in Ibarapa Central Oyo state". Trailblazer International Journal of Educational Research, 2(1):158-163, 2021.

[24] I.U. JAMES, I.F. MOSES, E.C. AKUECHE, and R.D. KUWEN, "Assessment of Indoor and Outdoor Radiation Levels and Human Health Risk in Sheda Science and Technology Complex and its Environ, Abuja, Nigeria" J. Appl. Sci. Environ. Manage, 24 (1):13 – 18, 2020

[25] N.J. Nnamdi, and T.Y. Sunday Obarhua "Indoor and Outdoor Gamma Dose Rate Exposure Levels in Major Commercial Building Material Distribution Outlets and Their Radiological Implications to Occupants in Ibadan, Nigeria" *Journal of Natural Sciences Research,* 3(3):.25-32, 2013.

[26] K. Emumejaye, and R.A. Daniel-Umeri, "Outdoor and Indoor Radiation Levels Measurement in Ozoro,Delta State, Nigeria" *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 12(6): 08-11, 2018

[27] B.B. Oladele, A.M. Arogunjo, and K. Aladeniyi, "Indoor and outdoor gamma radiation exposure levels in selected residential buildings across Ondo state, Nigeria." *International Journal of Radiation Research,*16 (3): 2018.

[28] B. Mahmoud, R.F. Mohammad, and A. Razzagh, "An Investigation of Natural Background Radiation and Health Risk Assessment in Kohgiluyeh and Boyer-Ahmad Province, Iran" Ann Mil Health Sci Res, 18(4): 106-801, 2020.

[29] M. Hamed, and K. Mohammad, "Assessment of Background Radiation, Annual Effective Dose and Excess Lifetime Cancer Risk in Gonabad City". *Frontiers in Biomedical Technologies*, 8(3):170-174, 2021.

[30] R. Jafaria, A. Mohammadi, and H. Zarghania, "Estimation of outdoor and indoor effective dose and excess lifetime cancer risk from Gamma dose rates in Gonabad, Iran". BRAZILIAN JOURNAL OF RADIATION SCIENCES, 05(03): 01-07, 2017.

[31] E.O. Echeweozo and F.O. Ugbede, "Assessment of Background Ionizing Radiation Dose Levels in Quarry Sites Located in Ebonyi State, Nigeria" J. Appl. Sci. Environ. Manage, 24 (10):1821-1826, 2020

[32] I.D. Benson, and F.O. Ugbed "Measurement Of Background Ionizing Radiation And Evaluation Of Lifetime Cancer Risk In Highly Populated Motor Parks In Enugu City, Nigeria". IOSR Journal of Applied Physics (IOSR-JAP), 10(3):77 - 82, 2018.

[33] J.T. Baraya, M.H. Sani, and M. Alhassan "Assessment of Indoor and Outdoor Background Radiation Levels at School of Technology, Kano State Polytechnic, Kano State-Nigeria" J. Appl. Sci. Environ. Manage, 23 (3):569-574, 2019.

[34] T.U. Yusuf, A.Y. Jibrin, Y. Ishaq, S. Bello, and M.A. Yahaya "Assessment of natural ionizing radiation in two tertiary institutions of Niger State". FUDMA Journal of Sciences (FJS), 5(4):161 – 166, 2021.

[35] C.E. Mokobia, and B. Oyibo "Determination of background ionization radiation (BIR) levels in some selected farms in Delta State". Nigeria. Nigerian Journal of Science and Environment 15(1):27-31, 2017.

[36] A.A. Ibrahim, Y.M. Ahijjo, & A. Mustapha, "In-Situ Background Radiation Measurements from Indiscriminate Dumps Sites in Sokoto Metropolis, Sokoto State, Nigeria"

International Journal of Science and Research (IJSR), 5 (11): 2016
[37] A.I. Olanrewaju, N.M. AbdulKareem, and I.O.Raheem "Assessment of radiation exposure level in blacksmithing workshop Gombe"
[38] Gombe State". FUDMA Journal of science (FJS*),* 4 (4), pp. 19 – 25. 2020
[39] P.O. Olagbaju, I.C. Okeyode, O.O. Alatise, and B.S. Bada, "Background radiation level measurement using hand held dosimeter and gamma spectrometry in Ijebu-Ife, Ogun State Nigeria" International Journal of Radiation Research,19(3), pp. 591-598, 2021.
[40] N.B. Esendu, G.O. Avwiri, and C.P. Ononugbo, "Evaluation of Background Ionizing Radiation of Nembe Clusters Oil and Gas Areas, Bayelsa State"*International Journal of Innovative Environmental Studies Research,* 9(2):33-43, 2021.
[41] A.II. Ejere, O.R. Elohor, and U.O. Osagie "Baseline Natural Radiation Level Survey of Iuleha Clan in Owan-West Local Government Area Edo State" J. Appl. Sci. Environ. Manage, 22 (7):1051 –1052, 2018.
[42] M.M. Idris, A. Ubaidullah, M.B. Sulayman, B. Abdullahi, and M.A. Sidi, "Assessment of Gamma Background Exposure Levels in some Selected Residential Houses in FCT Abuja, Nigeria" . Journal of Radiation and Nuclear Applications, 6(3):245- 248, 2021.
[43] F.O. UGBEDE, "Measurement of Background Ionizing Radiation Exposure Levels in Selected Farms in Communities of Ishielu LGA, Ebonyi State, Nigeria" J. Appl. Sci. Environ. Manage, 22 (9):1427–1432, 2018.
[44] A.A. Nwii, G.O. Avwiri, and C.P. Ononugbo, "Gamma Radiation Levels of Some Selected Government Farms in Rivers State Nigeria". Asian Journal of Physical and Chemical Sciences*,* 9(2):44-54, 2021.
[45] T. Shamsad, S.R. Mohammad, Y.Selina, M.A. Habibul, Md. Mahfuzzaman, "Real-Time Environmental Gamma Dose Rates Measurement and Evaluation of Annual Effective Dose to population of Shahbag Thana, Dhaka, Bangladesh". International Journal of Scientific Research and Management (IJSRM), 06 (04), pp. 58-69, 2018.
[46] U.C. Hyacienth, O.O. Jonathan, C.U. Daniel, D.O. Daniel, P.O. Michael, N.B. Awajimijan, K. .N. Victor, N.E. Uchenna, "Assessment of background ionizing radiation exposure levels in industrial buildings in Nnewi, Anambra State, Nigeria". International Journal of Research in Medical Sciences, 10(2):305-315, 2022.
[47] U. Rilwan, O.O. Galadima, I. Yahaya, and A,M, Rufai "Background Radiation Exposure in Keffi General Hospital, Keffi, Nasarawa State, Nigeria" Journal of Radiation and Nuclear Applications", 7 (1):79-83, 2022.
[48] A. A. Sadiq, and E.H. Agba, "BACKGROUND RADIATION IN AKWANGA, NIGERIA" FACTA UNIVERSITATIS Series: Working and Living Environmental Protection, 8(1):7 – 11, 2011.
[49] O.O. Galadima, E.O. Chikwendu, U. Rilwan, and E.O. Peter, E. Omita, "Assessment of the Effects of Radiation Exposure to Human Sensitive Organs Due to Quarry Mining in Kokona, Nasarawa and Toto of Nasarawa State Nigeria". Journal of Radiation and Nuclear Applications, 7(2):29-38, 2022.
[50] M. Sohrabi, "Recent radiological studies of high level natural radiation areas of Ramsar." Proceeding of International Conference on High Levels of Natural Radiation, Ramsar, Iran. Vienna: IAEA., 2013.
[51] P.E. Ogola, W.M. Arika, D.W. Nyamai, K.O. Osano, H.O. Rachuonyo, J. R.Wambani, R.C. Lagat, S.M. Njagi, S.W. Mumenya, A. Koteng, M.P. Ngugi, and R.O. Oduor, "Determination of Background Ionizing Radiations in Selected Buildings in Nairobi County". Kenya. J Nucl Med Radiat Ther, 7: 289, 2016.
[52] B. Samaila, B. Maidamma, B. Usman, A.I. Jega, S.A. Alhaji, "Assessment of Hazard Index and Incremental Life Cancer Risk Associated with Heavy Metals in the Soils".,Science Progress and Research, 1(4): 298 – 319, 2021.
[53] M. Ghiassi-Nejad, S. MJ. Mortazavi, J.R. Cameron., A. Niroomand-Rad, and P.A. Karam, "Very high background radiation areas of Ramsar, Iran: preliminary biological studies". Health Physics 82: 87-93, 2002.
[54] Morakinyo et *al.,* (2022) "Evaluation of background radiation of Maryland School complex, Lagos, Nigeria". *IOP Conf. Ser.: Earth Environ. Sci,* 993, pp.012-015

BIOGRAPHY OF AUTHOR

Mr. Buhari Samaila Was born in Kawara Manu Village, Maiyama Local Government, area of Kebbi State Nigeria. He pursed B.Sc and M.Sc Physics from KSUST, Aliero, Nigeria in 2013 & 2022. He is currently working as Lecturer in the Department of Physics with electronics, Federal University Birnin Kebbi, Kebbi State, since 2016. He is a member of NIP, NSPS and SASS since 2020 & 2021. He has published more than 22 research papers in national and internationals