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Investigating Background Ionizing Radiation in some selected locations in Agbor Metropolis.

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Abstract: The level of background indoor and outdoor ionizing radiation doses were measured in 15 different locations in Agbor, Delta State of Nigeria, with the aid of an inspector alert nuclear radiation meter. The recorded indoor ionizing radiation ranged from 0.114 µSv/hr to 0.271 µSv/hr with a mean value of 0.189 ± 0.04 µSv/hr. DDPA peaked at 0.271± 0.08 µSv/hr. Outdoor radiation levels on the other hand ranged from 0.110 µSv/hr to 0.256 µSv/hr with a mean value of 1.80 ± 0.05 µSv/hr. Model laboratory recorded the highest outdoor radiation dose value of 0.256 ± 0.03 µSv/hr. These values were all below the allowable limit set by UNSCEAR. Furthermore, the ambient BIR levels obtained in all the locations studied were equally below the ambient BIR allowable limit of 0.13 mR/h. The calculated annual effective dose rates value E_0 (indoor) for the locations studied were variable, while the annual effective dose rate E_1 (outdoor) obtained for all the locations studied were less than the standard limit of 1.00 mSv/yr, making the latter locations to be radiological safe for human habitation without constituting notable health hazards.

***Key words**: indoor radiation, ionizing radiation, ion oxide, outdoor radiation, radon*

1. INTRODUCTION:

Life on earth is piqued with exposed to radiation from cosmic rays, radionuclides created by the interaction of cosmic rays in the atmosphere, and radiation from natural materials. Humans are constantly exposed to external and internal sources of ionizing radiation. Internal sources of radiation include radionuclides that enter the body and are contained in the food and water we eat and the air we breathe. On the other hand, external radiation sources include cosmic radiation and ground radiation, like heat and light. Ionizing radiation is a form of energy. This includes particles and rays emitted by radioactive material, stars, and high-voltage devices. Most of these occur naturally, but some are caused by human activity. Very high doses of ionizing radiation can cause illness and death [1]. It travels as electromagnetic waves (gamma rays or X-rays) or particles (neutrons, beta or alpha rays). The spontaneous decay of atoms is called radioactivity, and the extra energy released is called ionizing radiation. Unstable elements that decompose and emit ionizing radiation are called radionuclides [2]. Ionizing radiation is a type of high-energy radiation that has the energy to

ionize atoms and molecules by removing electrons (negative particles). This action (ionization) causes chemical changes in cells and could denature DNA molecules, thereby making the cell susceptible to mutation. Most of the ionizing radiation entering the human body is surface radiation, mainly radon in the gaseous state and its decay products, which are continuously inhaled or swallowed by people.
Ionizing radiation is a part of the natural environment to which humans and other living things are constantly exposed. Ionizing background radiation has traditionally been classified as a natural source because of its properties. This has increased over the years due to human activity and has become a major source of worry due to its known effects of high-dose exposure [3]. Most variability in exposure to naturally ionizing background radiation results from inhalation of radioactive gas (radon) produced by radioactive minerals in soils and rocks. Radon concentrations depend on the uranium and thorium content in the soil of a particular region which varies widely across the country depending on the composition of the soil and rock mass. When released into the atmosphere, these radioactive gases (radon, thorium) are normally diluted in the atmosphere to harmless levels, but can become trapped, accumulate in buildings, and be inhaled by residents. This gas poses a health risk not only to uranium miners, but also to homeowners and shopkeepers who use these buildings for business purposes, and can cause lung cancer if the limit inhaled by residents exceeds the permissible dose limit.

Although the health risks associated with high exposure to radon in underground mines have long been known, some scientists in the 1970s suggested that indoor radon exposure was likely to be very high compared to the exposures faced. Little or no attention was paid to environmental radon exposure until it began to be recognized that there is a by many underground miners [4]. Reference [5] showed that when ionizing radiation penetrates living organs and tissues, some of the energy transmitted by this radiation is lost in tissue cells, leading to skin burns, radiation sickness, and low-dose cancers, tumors, genetic damage, other debilities and high-dose deaths. References [6] - [7] measured outdoor radiation levels with a thermoluminescent dosimeter in Abeokuta, Nigeria and found that the outdoor equivalent dose in the city was between 0.19 and 1. 64 mSv/year, averaged 0.45 mSv/year, and consequently reported that the average extraterrestrial radiation dose in the city was estimated to be 0.18 mSv/year. Reference [8] performed a national survey of global background radiation using *in situ* gamma-ray spectroscopy and reported an average annual effective dose of 0.27 mSv/yr. Additionally [9] measured background ionizing radiation levels at Braithwaite Memorial Hospital, Port Harcourt, Rivers State, and reported results ranging from 0.16 ± 0.01 µSv/h to 0.14 ± 0.02 µSv/h, with mean value of 0.146 ± 0.02 µSv/h for indoor measurements.

Radon is a colorless, odorless, tasteless, natural radioactive gas that undergoes radioactive decay and emits ionizing radiation (EPA 1994)[10]. Radon is formed by the destruction of radioactivity of uranium and thorium (radionuclides) in soil, rocks, and groundwater. When radon gas leaves soil and water, it enters the air and decomposes to produce more radioactive particles [11]. Most people are exposed to radon at home, where they spend most of their time, but indoor workplaces can also contribute to exposure [11]. Cement is primarily used for construction purposes and is mainly produced from limestone and other materials such as ionic oxides, clays and oil shale ash. Limestone contains gypsum-like substances with ionizable silicates and aluminates. According to [12] one of the potential causes of indoor exposure is the crustal materials used in the construction of inhabited houses. The crust is a major source of natural radiation. This is facilitated by natural radiation "uranium, thorium, potassium". They also explained that small amounts of ionizing radiation (radon gas) are emitted from the natural decay of these radioactive elements (U, Th and K).

Agbor is a rapidly urbanizing city that is currently experiencing vigorous business activities. High migrant cases occasioning a population explosion had been recorded over the past decade due to significant increase in urbanization and human capital development. Consequent upon this, many modern homes, schools, shops, plazas, shopping malls and even places of worship use cement made from limestone and other building materials to accommodate the growing population. Some of these building materials contain radioactive materials that emit ionizing or harmful radiation into the environment and enter the human body through inhalation or ingestion. Such ionizing radiations become dangerous when accumulated in large amounts in cells and organs of the body. This study intends to estimate the inherent dose rates of ionizing radiations emitted from the above sources and subsequently determine their lethal potentials.

Reference [13] had recommended the use of 0.8 and 0.2 as standards for the indoor and outdoor occupancy factor for populations. Accordingly, it is assumed that 80% of the populace spends 24hrs indoor while 20% stays outdoor respectively. The occupancy factor was given as the proportion of the total time during which a particular populace is exposed to radiation field. Furthermore, eight thousand, seven hundred and sixty hours per year (8760 hrs/yr) was used in converting readings in hours to years [7]. For the purpose of converting the indoor and outdoor average readings to annual equivalent dose rate (AED) in mSv/yr, [7] gave the equations below and is employed in this research.

$E_0 = \{z\ (\mu Sv/hr)\ \ x8760\ hrs/yr\ \ x\ \ 0.8\ \} / 1000$ I

$E_1=\{q\ (\mu Sv/hr)\ \ x\ 8760\ hrs/yr\ \ x\ \ 0.2\ \} / 1000$..................... II

Where, E_0 is annual effective dose rate in mSv/yr indoor; E_1 is annual effective dose rate in mSv/yr outdoor; z is the indoor meter reading and q is the outdoor meter reading.

Agbor is the capital of Ika South Local Government Area of Delta State. It lies within the latitude and longitude of 6° 15' 50.73" N and longitude 6° 12' 67.78" E. It has a population in excess of about 240,000 people and a land mass of 650 km^2 and is located along a major route connecting southeastern and northwestern Nigeria. Consequently, it is a flourishing center of trade and agriculture [14]. The inhabitants are mainly farmers, hunters, civil servants, artisans, business men and women. The city plays host to the University of Delta Agbor amongst others.

Research Elaborations

Fifteen locations within the metropolis were selected for this study, and the precise locations of these areas were determined using a geographical positioning system device (GPS). The baseline ionizing radiation levels (BIR) were measured by employing the use of a special kind of radiation meter known as ‘inspector alert nuclear radiation meter (S.N 35440, manufactured by SE International, Inc U.S.A). For the purpose of high degree accuracy, the inspector alert nuclear radiation meter was held 1 m above the sea level, and at every location where measurement was taken, ten indoor and ten outdoor readings were recorded respectively. The ten indoor/outdoor readings were taken in each of the fifteen selected locations in other to account for any error which may arise due to fluctuations in the environmental factors [15].

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2. RESULTS

The results obtained in this study are presented in Tables 1, 2 &3 and in figures 1 & 2.

Table I. Sample location and geographical location

S/N	Sample Location	Geographical Location(gps)
1.	General hospital	N6^{0}25’49.92”, E6^{0}18’30.63”
2.	Zenith bank plc	N6^{0}27’62.33”, E6^{0}23’38.77”
3.	Twins oil and gas	N6^{0}24’24.29”, E6^{0}16’58.36”
4.	Edike market	N6^{0}26’61.33”, E6^{0}19’14.90”
5.	Model laboratory	N6^{0}25’51.47”, E6^{0}19’90.68”
6.	Alihame Iwan	N6^{0}24’22.29”, E6^{0}16’60.74”
7.	Baleke market	N6^{0}25’64.50”, E6^{0}18’97.58”
8.	DDPA	N6^{0}26’53.17”, E6^{0}22’30.30”
9.	Agbor-Obi	N6^{0}27’44.08”, E6^{0}13’11.97”
10.	Victory Plaza	N6^{0}25’19.95”, E6^{0}19’36.49”
11.	Shanker shopping mall	N6^{0}24’55.60”, E6^{0}18’77.57”
12.	C.G.M Zone II	N6^{0}26’10.00”, E6^{0}20’56.28”
13.	Unique Nursing Home and Maternity	N6^{0}26’48.67”, E6^{0}20’42.45”
14.	Ewuru	N6^{0}25’16.98”, E6^{0}14’54.85”
15.	G&G Cosmeticsplaza	N6024’84.33”, E6016’95.19”

Table II. Indoor and Outdoor meter readings for sample locations (mSv/h).

S/N	Sample Location	Indoor meter reading z(µSv/hr)	Outdoor meter reading q(µSv/hr)
1.	General hospital	0.243±0.01	0.182±0.03
2.	Zenith bank plc	0.201±0.02	0.110±0.06
3.	Twins oil and gas	0.175±0.04	0.188±0.05
4.	Edike market	0.193±0.02	0.157±0.08
5.	Model laboratory	0.213±0.02	0.256±0.03
6.	AlihameIwan	0.224±0.09	0.215±0.07
7.	Baleke market	0.157±0.01	0.201±0.03
8.	DDPA	0.271±0.08	0.246±0.06
9.	Agbor-Obi	0.182±0.07	0.157±0.04
10.	Victory Plaza	0.114±0.08	0.125±0.06
11.	Shanker shopping mall	0.188±0.01	0.178±0.07
12.	C.G.M Zone II	0.133±0.03	0.128±0.09
13.	Unique nursing home	0.210±0.08	0.219±0.01
14.	Ewuru	0.189±0.04	0.186±0.01
15.	G&G Cosmetics plaza	0.141±0.07	0.150±0.07
	Mean	0.189± 0.04	0.180±0.05
	Range	0.114 – 0.2710	0.110 – 0.256

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Table III. Indoor and Outdoor meter readings for sample locations (mR/h).

S/N	Sample locations	Indoor meter reading in mR/h	Outdoor meter reading in mR/h
1.	General hospital	0.026 ± 0.001	0.020 ± 0.003
2.	Zenith bank plc	0.022 ± 0.002	0.012 ± 0.006
	Twins oil and gas	0.019 ± 0.004	0.020 ± 0.005
3.	Edike market	0.021 ± 0.002	0.017 ± 0.009
4.	Model laboratory	0.023 ± 0.002	0.027 ± 0.003
5.	Alihame Iwan	0.024 ± 0.010	0.023 ± 0.008
6.	Baleke market	0.017 ± 0.001	0.022 ± 0.003
7.	DDPA	0.029 ± 0.009	0.026 ± 0.006
8.	Agbor-Obi	0.019 ± 0.008	0.017 ± 0.004
9.	Victory Plaza	0.012 ± 0.009	0.013 ± 0.006
10.	Shanker shopping mall	0.020 ± 0.001	0.019 ± 0.006
11.	C.G.M Zone II	0.014 ± 0.003	0.014 ± 0.010
12.	Unique nursing home	0.023 ± 0.009	0.023 ± 0.001
13.	Ewuru	0.020 ± 0.004	0.020 ± 0.001
14.	G&G Cosmetics plaza	0.015 ± 0.008	0.016 ± 0.008
	Range	0.012 - 0.029	0.012 - 0.027

Table IV. Annual equivalent dose rate E_0 and E_1 (mSv/yr) for Indoor and Outdoor readings

S/N	Sample Location	E_0(mSv/yr)	E_1(mSv/yr)
1.	General hospital	1.703±0.07	0.315±0.05
2.	Zenith bank	1.409±0.14	0.193±0.11
3.	Twins oil and gas	1.226±0.280.	0.329±0.09
4.	Edike market	1.352±0.14	0.275±0.14
5.	Model laboratory	1.493±0.14	0.449±0.05
6.	Alihame Iwan	1.570±0.63	0.377±0.12
7.	Baleke market	1.100±0.07	0.352±0.05
8.	DDPA	1.899±0.56	0.431±0.11
9.	Agbor-Obi	1.275±0.49	0.275±0.07
10.	Victory Plaza	0.799±0.56	0.219±0.11
11.	Shanker shopping mall	1.318±0.07	0.312±0.12
12	CGM zone II	0.932±0.21	0.224±0.16
13.	Unique nursing home	1.472±0.56	0.384±0.02
14.	Ewuru	1.325±0.28	0.331±0.05
15.	G & G cosmetics plaza	0.988±0.49	0.263±0.12
	Range	0.799 – 1.899	0.193 – 0.449
	Mean	1.325±0.31	0.315±0.09

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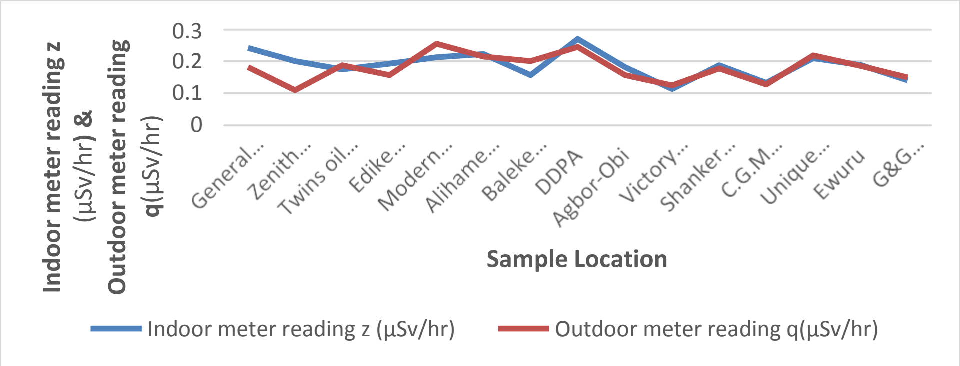

Fig 1. Indoor and outdoor meter reading (µSv/hr) for sample locations.

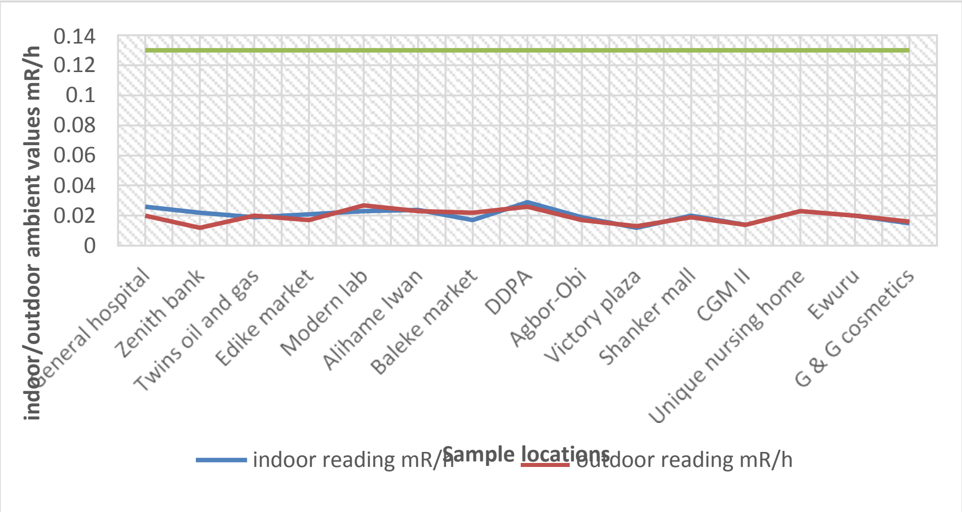

Fig 2. Indoor/outdoor ambient value in comparison with UNSCEAR

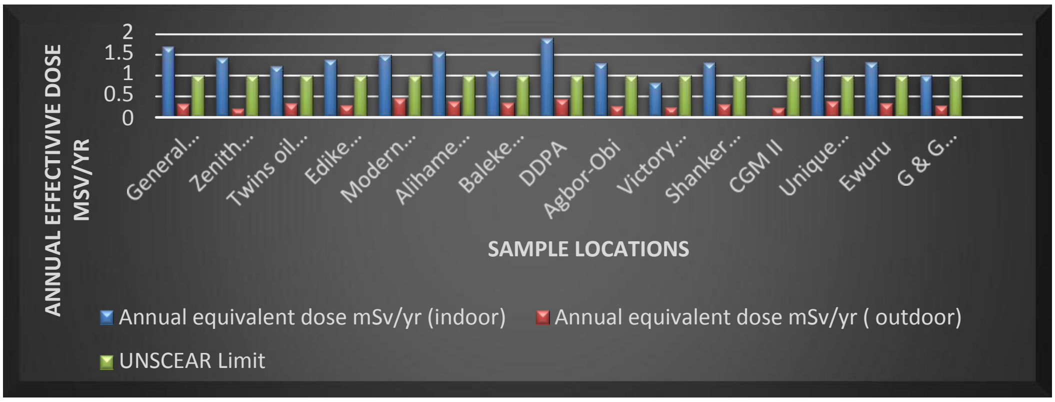

Fig 3: Annual equivalent dose in mSv/yr (indoor/outdoor) in comparison with UNSCEAR limit.

The baseline ionizing radiation in some selected locations in Agbor metropolis was investigated using the special inspector alert radiation meter and values obtained were recorded accordingly. Table I Showed the precise geographical locations where samples were located using the global positioning system device (gps). All samples location lies between latitude 6° 15' 50.73" N and longitude 6° 12' 67.78" E. With these positions recorded and documented, subsequent review can be carried out at these same locations using same coordinates and results compared with the findings of this work for future decision making in terms of radiation protection policies as it affects the health of the people in this part of the world.

Tables II & III presented readings obtained from indoor and outdoor meter readings in both µSv/hr and mR/h for the 15 locations studied, while using the special inspector alert radiation meter. The graphical presentations of these values were presented in Fig 1.0. From the results obtained, the indoor ionizing radiation values ranged from 0.114 µSv/hr to 0.271 µSv/hr with Victory Plaza recording the least ionizing radiation value of 0.114±0.08 µSv/hr in comparison to DDPA that recorded the highest value of 0.271±0.08 µSv/hr. In addition, the mean value obtained from the indoor ionizing radiation level for the locations was 0.189± 0.04 µSv/hr. Furthermore, the outdoor radiation levels obtained in the study ranged from 0.110 µSv/hr – 0.256 µSv/hr with a mean value of 1.80 ± 0.05 µSv/hr. Comparatively, Model laboratory recorded the highest outdoor radiation dose value of 0.256±0.03µSv/hr while the least outdoor radiation was obtained in CGM II. This high outdoor value obtained in Model laboratory might be due to the high geographical altitude which characterize the topology of the location and some other human activities that are high in its axis. However, the ambient BIR levels obtained in all the locations studied as seen in Table III and Fig 2 are well below the ambient BIR allowable limit of 0.13 mR/h, in agreement with [9].

Table IV showed the calculated annual effective dose values obtained for the various sample locations investigated. These results were also recorded in Fig 2.0, where the annual effective dose obtained for the indoor ionizing radiation levels ranged from 0.799 mSv/yr to 1.899 mSv/yr with an average value of 1.325±0.31 mSv/yr. DDPA recorded the highest value while Victory Plaza has the least indoor annual effective dose. Furthermore, the results showed that apart from G & G cosmetics, CGM II and Victory Plaza (0.988±0.49 mSv/yr, 0.932±0.21 mSv/yr and 0.799±0.56 mSv/yr respectively), all the other locations studied recorded dose limits higher than the recommended limit of 1.00 mSv/yr by UNSCEAR. However, the annual effective dose (outdoor) obtained ranged from 0.193 – 0.449 mSv/yr were quite below the standard dose limit of 1.00 mSv/yr and were in agreement with [7].

In conclusion, the results showed that DDPA have the highest indoor radiation dose compared to Victory Plaza that recorded the least indoor value. Meanwhile, for the outdoor radiation doses, Model laboratory as well as Zenith Bank Plc recorded the highest and the least radiation dose values respectively. These values obtained (indoor/outdoor) when compared with the UNSCEAR standard were all within the average dose limit permissible. Furthermore, the calculated annual effective dose rate value E_0 (indoor) for all the locations studied except for Victory Plaza, CGM II and G&G Cosmetics that recorded lower values, were found to be a little higher than the permissible limit of 1.00 mSv/yr as recommended. However, the annual effective dose rate E_1 (outdoor) obtained for all the locations studied were all below the standard limit of 1.00 mSv/yr. Despite the fact that some radiations in the locations studied exceeded the world recommended average, the differences observed were not significantly lethal to make the inhabitants of these locations susceptible to health challenges arising from the effects of the radiations, in agreement with [16]. Therefore the background ionizing radiation levels found in the present circumstance in these locations were adjudged to be radiologically safe and do not pose any immediate threat to the health and wellbeing of the people in these areas.

3. REFERENCES

[1] Agency for Toxic Substances and Diseases Registry (ATSDR).U.SDepartment of Health and Human Services. Atlanta, Georgia, United States of America, 1999

[2] WHO (World Health Organization) Report. Ionizing radiation, health effectsand protection measures. https://www.who.int/facts-sheets, 2016.

[3] C.P. Ononugbo, and C.J. Mgbemere, Dose rate and annual effective dose assessment of Terrestrial gamma radiation in Notre fertilizer plant, Onne, Rivers State, Nigeria. International Journal of Emerging Research in Management and Technology 5(9):30-35, 2016

[4] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), Exposures from natural radiation sources. United Nations Scientific Committee on the effect of Atomic Radiation Report to the General Assembly, with Scientific Annexes. United Nations, New York, 2000.

[5] D.I. Jwanbot, M.M. Izam, G.G. Nyam, and R.J. Dakon, Environmental ionizing radiation distribution profile in Jos and environs. Journal of Environment and Earth Science, 3(3): 87-94, 2013.

[6] I.P. Farai and U.E.Vincent, Outdoor radiation level measurement in Abeokuta, Nigeria by Thermoluminescent dosimetry. Nigeria Journal of Physics, 18 (1), 121 – 123, 2006.

[7] A.A. Sadiq and E.H. Agba, Background radiation in Akwanga, Nigeria. FACTA UNIVASITATIS Series: Working and living environmental protection. 8 (1): 7 -11, 2011.

[8] I.P. Farai and N.N. Jibril, Baseline studies of terrestrial outdoor gamma dose rate levels in Nigeria. Radiation Protection Dosimetry 88 (3): 247 – 254, 2000.

[9] P.C. Okoye and G.O. Avwiri, Evaluation of background ionizing radiation levels of Braithwaite Memorial Specialist Hospital, Port Harcourt, Rivers State. Am. J. Sci Ind. Res. 4(4): 359 -365, 2013.

[10] EPA, (Environmental Protection Agency), A citizen's guide to radon USEPA N0 402- K92- 001. United State of America. September, 1994.

[11] WHO (World Health Organization), Radon and health.www.who.int/news-room/fact-sheet/detail/radon-and-health, 2021.

[12] J.A. Ademola and P.O. Oguneletu, Radionuclides content of concrete building blocks and radiation dose rate in some dwellings in Ibadan, Nigeria. Journal of Environmental Radioactivity. Vol.81, No 1:107 – 113, 2005.

[13] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation), Sources effects and risks of ionizing radiation. Back to reports. Report, 1988.

[14] S.B. Olobaniyi, J.E. Ogala, and N.B. Nfor, Hydrogeochemical and bacteriological Investigation of ground water in Agbor area, Southern Nigeria. *Journal of Mining and Geology, 43 (1): 79 – 89*, 2007.

[15] E.O. Agbalagba, Assessment of excess lifetime cancer risk from gamma radiation levels in Effurun and Warri city of Delta State, Nigeria. *Journal of Taibah University for Sciences*. 11: 367 – 380, 2017. Doi: https://dx.doi.org/10.1016/j.jtusci.2016.03.007,

[16] K. Eseka, C.E. Mokobia, O.C. Molua, and A.O. Ukpene, Characterization of radioactivity from primordial radionuclides in the soil of Ika South local Government area of Delta State, Nig. *FUDAMA Journal of Sciences* (FJS); 6 (1): 180-184, 2022. DOI: https://doi.org/10.33003/fjs-2022-0602-913,

