Nigerian Journal of Physics (NJP)

ISSN: 1595-0611

Volume 32(3), September 2023

Radiometric Survey of Background Ionizing Radiation and Assessment of Radiological Health Risk on the Residents of Agbarho Kingdom, Delta State, Nigeria

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ABSTRACT

Agbarho Kingdom is one of the Kingdoms in Urhoboland and is located at the centre of Urhobo nation. Agbarho Kingdom is in Ughelli North Local Government Area of Delta State and made up of two sub-clans which are Awvredjan and Okparegbe sub-clans. Radiometric Survey and health hazard impact of background ionizing radiation (BIR) on the residents of Agbarho Kingdom, Delta State, Nigeria has been conducted using a calibrated Geiger Muller Counter (Digilert 200) and a global positioning radio System (Garmin GPS MAP 76S). The purpose of this Survey is to obtain baseline information on the study area and assess the radiological safety of the members of the public were necessary using well established radiological relations. The studied areas were delineated into fourteen zones. The mean value of the expose rate range from 0.013±0.03 to 0.019±0.08 mRh^{-1} with an average value of 0.016±0.007 mRh^{-1}. The study estimated 78.6% of the sampling area exceeded the world ambient standard levels of 0.013 mRh^{-1}. The Estimated mean result for radiation health parameters associated with BIR Shows that the mean annual effective dose equivalent (AEDE) of (0.171±0.074 $mSvy^{-1}$) is within the permissible limit of l.0 $mSvy^{-1}$. The estimated mean effective dose to different organs are all below the recommended limits of 1.0 $mSvy^{-1}$ while the mean value for absorbed dose and mean excess lifetime cancer risk (ELCR) are 139.2± 60.9 ɳGyh^{-1} and 0.598±0.26 × 10^{-1} $mSvy^{-1}$ respectively. The estimated results indicate an elevated level of BIR in the studied area and an absorbed dose higher than the admissible limits for public. Therefore, the study demonstrates an elevated level of dose rate, which might result to health effect on the resident who spends a greater percentage of their life in the study area due to accumulation of high absorbed doses. Therefore, a routine check by bodies in charge of radiation protection is very essential.

Keywords:
Background,
Radiometric,
Survey,
Agbarho,
Parameters.

INTRODUCTION

Life has evolved in a world with significant level of ionizing radiation. A radiation is ionizing when it capable of changing the chemical state of matter, subsequently causing biological damage and thus potentially harmful to the human health. The United Nations Scientific Committee on the effects of Atomic Radiation (UNSCEAR, 2000) stated that excessive and prolong exposure of radiation is radiologically detrimental to human. The impact of radiation on the environment has drawn so much interest worldwide owing to its negative effect on biological tissues. Several literatures has linked exposure to radiation to some health effects which includes, but not limited to cognitive defect, cataracts, risk of leukemia, prenatal mortality, mutation, incidence of spontaneous miscarriage, risk of neuroendocrine, cancer of organs, congenital defect (Avwiri *et al.*, 2012; Aziz *et al.*, 2014; Jibiri *et al.*, 2007; Taskin et al., 2014; UNSCEAR., 2018).

Background Ionizing radiation (BIR) is a continuous source of ionizing radiation in the environment. The sources of ionizing radiation are grouped as natural background ionizing radiation consisting of primordial, cosmogenic and terrestrial sources and anthropogenic radionuclide contributed by various activities of man termed Technically Enhanced Naturally Occurring radioactive materials (TENORM) (Fonolloss *et al.*, 2014; International Atomic Energy Agency (IAEA), 2014; Millas *et al.*, 2017). The environmental contamination from BIR arises when it exceeds public limits (Agbalagba *et al.*, 2016)

The BIR distribution in different environment depends mostly in geographical location, local geology, climatic condition and weathering processes (UNSEAR, 2008). The inverse square law relates the intensity of radiation to decreases with the square of the distance from source. (Agbalagba and Anekwe, 2021) noted the possibility of transporting radioactive material through space by air movement, hence the background radiation of an area can be enhanced by the proximity of an area to an environment high in BIR (Health Physics Society HPS., 2015).. Furthermore, the natural sources of radionuclide in the environment remain harmless to humans and living things unless upshot by some anthropogenic activities (Avwiri *et a*l., 2007;). Anthropogenic activities capable of raising the BIR levels in the environment has been reported to include though not limited to solid mineral exploration, rock blasting, construction works, Agricultural practices, borehole drilling, industrial activities, vehicular transportation, and telecommunication mask (Avwiri *et al*., 2015; United states Environmental protection Agency (EPA), 2017; Innocent, 2012; Kamunda *et al*., 2016; Mokobia *et al*., 2016).

Agbarho Kingdom is one of the Kingdoms in Urhoboland and is located at the centre of Urhobo nation. Agbarho Kingdom is in Ughelli North Local Government Area of Delta State and made up of two sub-clans which are; Awvredjan and Okparegbe sub-clans. Agbarho kingdom is a town situated around the most condensed cities in Delta state such as Warri city and Ughelli. Though the people of Agbarho kingdom are mostly business men and women, their source of livelihood is centered on agriculture, construction works, mining, marketing of quarry products, activities linked to those anthropogenic activities that has been reported by literatures capable of raising the BIR levels in the environment (Innocent., 2012). Another disturbing factor is the presence of an engineering dumpsite located in Agbarho kingdom which can also contribute to enhance the BIR of the studied area.

The purpose of this work was to assess the background radiation levels in communities located in Agbarho kingdom in order to assess the health risk to exposed individuals. Additionally, no known gamma radiation level measurement has been reported for the study area. Hence the result of this work, may serve as a baseline data for background radiation levels in the area.

MATERIALS AND METHODS

Study Area

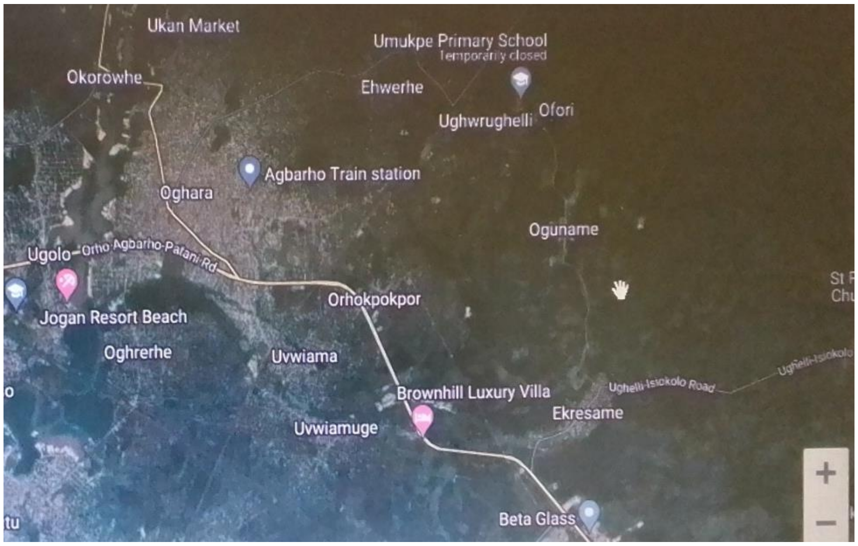

Figure 1: Map of the Study Area.

The Study area Agbarho kingdom is located in Ughelli North Local Government Area of Delta State, Southern Nigeria as shown in figure 1. The area lies within longitude 5°, 55' 7" East of Greenwich meridian and latitude 5° 35' 59" North of equator .According to the 2006 census, it has a population of 178,000 and a land mass of around 818 km².

An in situ approach of background ionizing radiation measurement was employed in this research to retain the inherent environmental properties of the samples and access precise and representative data on the background radiation level of the research area (Agbalagba *et al.,* 2016). Fourteen sampling zones were carefully marked out according to the communities situated in Agbarho Kingdom. The multi- purpose survey meter was used for precise rates measurement within the temperature range of 10 to 50°C to avoid any significant degradation in the handling of the survey meter. The GPS reading was taken at each spot where the radiation monitoring meter tube was lifted to height of 1.0 above the ground with its window facing probable source. This is to enable the radiation monitoring meter measure the maximum radiation emitting from the probable source. Three measurements were made at each sampling location in order to account for any variation in environmental parameters and fluctuating nature of radiation.

A total of 140 measurements were recorded from the fourteen sampling zones which include Orho-Agbarho, Ughwrughelli, Ehwerhe, Okah, Ikweghwu, Ophori, Oguname, Ekrerhavwe, orhokpokpor, Okrherhe, Uvwiama, Uvwamuge, Oviri and Oghara.

The detector's performance was validated prior to its use (Internet ArchieveBot, 2018) and measurements were taken between the time internal of 1,300 and 1,600 hours in accordance to National council on radiation protection (Agbalagba *et al.*, 2016;), these hours are period when the metre is most sensitive to respond to ambient radiation.

RESULT AND DISCUSSION

Discussion

The results of the average dose rate measurements of each zone from the study area is presented in the Table 1-14 and the calculated hazard indices for the fourteen delineated zones that make up the study area are presented in Table 15. The radiation hazards associated with gamma radiation levels in Agbarho kingdom were obtained using different known radiation health hazard indices (Agbalagba *et al.*, 2016; NCRP, 1993). These include; absorbed dose rates, annual equivalent dose rate, lifetime cancer risk and effective dose to different organs. Table 17 shows the results for the effective dose to some body organs.

Background Radiation Measurements

Table 1-14 shows the measurements of background ionizing radiation level in the communities of Agbarho kingdom, Delta state. The measurement values for BIR level in all the communities varied from 0.011 to 0.022 mRh-¹ with a mean value of 0.016 mRh-¹. The minimum value recorded were in Ehwerhe, Ikweghwu and ophori, this value correspond to the recommended permissible limits of 0.013 mRh-¹ (ICPR, 2007).The highest BIR exposure rate value (0.019) mRh-¹ was recorded at Uvwiamuge having a percentage increase of 46.2% against ICRP standard limit. Figure 2 shows the comparison of mean exposure of the fourteen delineated zones with ICPR, 2003 standard. The results indicate 21.4% of the study area are within the permissible BIR levels for the general public while 78.6% of the study area is exposed to BIR higher than the recommended permissible limit. This analysis depicts significant elevation of radiation exposure levels in the study area. The variation and high exposure rate level may be attributed to oil and gas activities in and within the oil producing town, Technologically Enhanced Naturally Occurring radioactive Materials (TENORM) contamination and geophysical properties of the environment which has been recognized to contain some radioactive element (Agbalagba *et al.*, 2016).

Table 1: BIR exposure levels in Orho-Agbarho,

S/No	**1Reading** mRh-¹	**2Reading** mRh-¹	**3Reading** mRh-¹	**Average** mRh-¹
1	0.015±0.001	0.016±0.001	0.017±0.003	0.016
2	0.020±0.004	0.016±0.004	0.018±0.002	0.018
3	0.014±0.002	0.019±0.002	0.016±0.005	0.016
4	0.017±0.003	0.016±0.003	0.017±0.007	0.017
5	0.016±0.001	0.019±0.004	0.015±0.002	0.017
6	0.016±0.002	0.017±0.006	0.018±0.003	0.017
7	0.015±0.006	0.015±0.002	0.019±0.004	0.016
8	0.020±0.002	0.017±0.003	0.018±0.001	0.018
9	0.018±0.003	0.015±0.004	0.016±0.003	0.016
10	0.017±0.001	0.014±0.003	0.015±0.006	0.015
Mean	0.017±0.003	0.016±0.003	0.017±0.004	0.017

Table 2: BIR exposure levels in Ughwrughelli

S/No	**1Reading** mRh-¹	**2Reading** mRh-¹	**3Reading** mRh-¹	**Average** mRh-¹
1	0.017±0.003	0.015±0.001	0.012±0.001	0.015
2	0.014±0.004	0.014±0.004	0.015±0.003	0.014
3	0.016±0.009	0.016±0.003	0.016±0.004	0.016
4	0.013±0.022	0.013±0.001	0.014±0.001	0.013
5	0.014±0.001	0.013±0.001	0.016±0.002	0.014

6	0.015±0.005	0.011±0.007	0.014±0.001	0.013
7	0.016±0.001	0.014±0.004	0.013±0.003	0.014
8	0.015±0.002	0.014±0.002	0.015±0.001	0.015
9	0.010±0.003	0.012±0.006	0.014±0.001	0.012
10	0.015±0.002	0.013±0.004	0.015±0.002	0.014
Mean	0.015±0.005	0.014±0.003	0.014±0.002	0.014

Table 3: BIR exposure levels in Ehwerhe.

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.013±0.003	0.014±0.009	0.013±0.004	0.013
2	0.012±0.002	0.013±0.005	0.014±0.005	0.013
3	0.011±0.005	0.015±0.007	0.013±0.002	0.013
4	0.014±0.002	0.011±0.002	0.012±0.005	0.012
5	0.016±0.001	0.014±0.003	0.014±0.002	0.015
6	0.011±0.006	0.012±0.005	0.015±0.004	0.013
7	0.012±0.002	0.013±0.005	0.013±0.008	0.013
8	0.012±0.001	0.014±0.007	0.014±0.006	0.013
9	0.011±0.006	0.013±0.002	0.015±0.001	0.013
10	0.014±0.007	0.014±0.001	0.013±0.004	0.014
Mean	0.013±0.004	0.013±0.005	0.014±0.004	0.013

Table 4: BIR exposure levels in Okah

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.015±0.005	0.017±0.011	0.016±0.006	0.016
2	0.016±0.010	0.014±0.007	0.018±0.012	0.016
3	0.013±0.012	0.016±0.006	0.017±0.010	0.015
4	0.017±0.007	0.015±0.012	0.015±0.006	0.016
5	0.018±0.008	0.015±0.016	0.017±0.004	0.017
6	0.014±0.004	0.018±0.007	0.016±0.006	0.016
7	0.016±0.009	0.015±0.010	0.017±0.007	0.016
8	0.016±0.007	0.017±0.005	0.015±0.003	0.016
9	0.015±0.003	0.014±0.006	0.017±0.002	0.015
10	0.013±0.011	0.015±0.009	0.014±0.008	0.014
Mean	0.015±0.008	0.016±0.009	0.016±0.06	0.016

Table 5: BIR exposure levels in Ikweghwu

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.012±0.021	0.013±0.005	0.014±0.004	0.013
2	0.014±0.017	0.015±0.004	0.013±0.001	0.014
3	0.014±0.005	0.014±0.002	0.013±0.003	0.014
4	0.011±0.004	0.012±0.004	0.014±0.005	0.012
5	0.014±0.010	0.013±0.006	0.015±0.002	0.014
6	0.013±0.007	0.016±0.005	0.014±0.001	0.014
7	0.012±0.003	0.013±0.011	0.015±0.001	0.013
8	0.011±0.004	0.011±0.007	0.012±0.002	0.011
9	0.013±0.007	0.013±0.012	0.014±0.005	0.013
10	0.012±0.003	0.014±0.004	0.013±0.003	0.013
Mean	0.013±0.008	0.013±0.006	0.014±0.003	0.013

Table 6: BIR exposure levels in Ophori

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.014±0.006	0.014±0.006	0.012±0.007	0.013
2	0.013±0.021	0.013±0.011	0.015±0.004	0.014
3	0.011±0.004	0.013±0.003	0.012±0.003	0.012

4	0.009±0.011	0.011±0.001	0.013±0.001	0.011
5	0.015±0.022	0.014±0.001	0.013±0.003	0.014
6	0.012±0.009	0.014±0.006	0.012±0.005	0.013
7	0.014±0.006	0.013±0.010	0.014±0.002	0.014
8	0.013±0.001	0.015±0.010	0.014±0.008	0.014
9	0.016±0.005	0.014±0.009	0.015±0.006	0.015
10	0.014±0.001	0.013±0.006	0.015±0.007	0.014
Mean	0.013±0.009	0.013±0.006	0.014±0.005	0..013

Table 7: BIR exposure levels in Oguname

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.015±0.004	0.013±0.022	0.014±0.001	0.014
2	0.012±0.009	0.014±0.007	0.014±0.006	0.013
3	0.014±0.006	0.014±0.004	0.013±0.011	0.014
4	0.013±0.015	0.012±0.007	0.015±0.020	0.013
5	0.013±0.004	0.014±0.012	0.015±0.001	0.014
6	0.014±0.018	0.015±0.009	0.017±0.003	0.015
7	0.015±0.011	0.016±0.021	0.013±0.010	0.014
8	0.012±0.006	0.013±0.017	0.014±0.009	0.013
9	0.015±0.002	0.014±0.011	0.016±0.003	0.013
10	0.011±0.004	0.012±0.005	0.012±0.001	0.012
Mean	0.013±0.008	0.014±0.012	0.014±0.007	0.014

Table 8: BIR exposure levels in Ekrerhavwe

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.021±0.004	0.019±0.005	0.016±0.001	0.019
2	0.017±0.009	0.016±0.003	0.015±0.006	0-016
3	0.019±0.006	0.015±0.006	0.018±0.011	0.017
4	0.024±0.015	0.017±0.003	0.020±0.020	0.020
5	0.018±0.004	0.015±0.010	0.017±0.001	0.017
6	0.015±0.018	0.016±0.006	0.018±0.003	0.016
7	0.017±0.011	0.016±0.001	0.015±0.010	0.016
8	0.020±0.006	0.018±0.010	0.016±0.009	0.018
9	0.016±0.002	0.017±0.004	0.015±0.003	0.016
10	0.015±0.004	0.015±0.006	0.016±0.001	0.015
Mean	0.018±0.008	0.016±0.005	0.017±0.007	0.017

Table 9: BIR exposure levels in Orhokpokpor

S/No	**1 Reading** mRh-1	**2 Reading** mRh-1	**3 Reading** mRh-1	**Average** mRh-1
1	0.014±0.007	0.013±0.001	0.015±0.004	0.014
2	0.015±0.001	0.014±0.005	0.012±0.005	0.014
3	0.013±0.002	0.013±0.002	0.011±0.009	0.012
4	0.016±0.010	0.016±0.009	0.014±0.002	0.015
5	0.017±0.009	0.015±0.004	0.013±0.003	0.015
6	0.014±0.006	0.015±0.003	0.014±0.004	0.014
7	0.015±0.002	0.014±0.002	0.013±0.008	0.014
8	0.013±0.001	0.015±0.005	0.014±0.021	0.014
9	0.015±0.006	0.013±0.005	0.012±0.011	0.013
10	0.016±0.007	0.014±0.002	0.015±0.007	0.015
Mean	0.015±0.005	0.014±0.004	0.013±0.007	0.014

Table 10: BIR exposure levels in Orherhe

S/No	**1 Reading** mRh-¹	**2 Reading** mRh-¹	**3 Reading** mRh-¹	**Average** mRh-¹
1	0.018±0.003	0.015±0.005	0.016±0.017	0.016
2	0.016±0.011	0.016±0.003	0.019±0.006	0.017
3	0.013±0.006	0.012±0.006	0.014±0.001	0.013
4	0.017±0.009	0.015±0.010	0.013±0.004	0.015
5	0.014±0.021	0.017±0.007	0.017±0.006	0.016
6	0.015±0.017	0.016±0.004	0.015±0.002	0.015
7	0.021±0.001	0.019±0.008	0.017±0.009	0.019
8	0.014±0.002	0.013±0.001	0.015±0.015	0.014
9	0.017±0.009	0.016±0.005	0.015±0.019	0.016
10	0.014±0.002	0.015±0.007	0.016±0.004	0.015
Mean	0.016±0.008	0.015±0.006	0.016±0.008	0.016

Table 11: BIR exposure levels in Uvwiama

S/No	**1 Reading** mRh-¹	**2 Reading** mRh-¹	**3 Reading** mRh-¹	**Average** mRh-¹
1	0.009±0.002	0.011±0.009	0.014±0.023	0.011
2	0.014±0.010	0.015±0.004	0.016±0.011	0.015
3	0.015±0.002	0.020±0.011	0.018±0.018	0.018
4	0.019±0.020	0.017±0.007	0.015±0.009	0.011
5	0.013±0.009	0.016±0.005	0.015±0.007	0.014
6	0.017±0.005	0.014±0.002	0.017±0.005	0.016
7	0.018±0.022	0.015±0.006	0.016±0.014	0.016
8	0.015±0.012	0.019±0.003	0.018±0.019	0.017
9	0.015±0.003	0.017±0.004	0.019±0.020	0.017
10	0.018±0.018	0.018±0.004	0.017±0.008	0.018
Mean	0.015±0.010	0.016±0.006	0.017±0.013	0.016

Table 12: BIR exposure levels in Uvwiamuge

S/No	**1 Reading** mRh-¹	**2 Reading** mRh-¹	**3 Reading** mRh-¹	**Average** mRh-¹
1	0.024±0.011	0.020±0.020	0.019±0.007	0.021
2	0.021±0.009	0.019±0.001	0.017±0.010	0.019
3	0.019±0.004	0.022±0.008	0.018±0.011	0.020
4	0.018±0.009	0.019±0.017	0.016±0.004	0.018
5	0.015±0.012	0.018±0.006	0.020±0.009	0.018
6	0.021±0.006	0.019±0.004	0.019±0.002	0.020
7	0.023±0.010	0.019±0.001	0.020±0.010	0.021
8	0.019±0.007	0.021±0.008	0.019±0.017	0.020
9	0.016±0.001	0.018±0.003	0.015±0.015	0.016
10	0.022±0.006	0.019±0.012	0.024±0.004	0.022
Mean	0.020±0.008	0.019±0.008	0.019±0.009	0.019

Table 13: BIR exposure levels in Oviri

S/No	**1 Reading** mRh-¹	**2 Reading** mRh-¹	**3 Reading** mRh-¹	**Average** mRh-¹
1	0.019±0.004	0.017±0.007	0.016±0.032	0.017
2	0.017±0.007	0.018±0.005	0.016±0.006	0.017
3	0.018±0.012	0.016±0.014	0.019±0.008	0.018
4	0.016±0.001	0.019±0.006	0.015±0.021	0.017
5	0.015±0.007	0.016±0.009	0.020±0.003	0.017
6	0.020±0.009	0.019±0.001	0.017±0.015	0.019
7	0.018±0.003	0.015±0.005	0.018±0.011	0.017
8	0.020±0.003	0.018±0.022	0.016±0.013	0.018
9	0.019±0.005	0.016±0.006	0.018±0.007	0.018
10	0.017±0.004	0.020±0.010	0.019±0.006	0.019
Mean	0.018±0.06	0.017±0.009	0.017±0.012	0.018

Table 14: BIR exposure levels in Oghara

S/No	**1 Reading** mRh-¹	**2 Reading** mRh-¹	**3 Reading** mRh-¹	**Average** mRh-¹
1	0.017±0.020	0.014±0.001	0.018±0.004	0.016
2	0.013±0.009	0.015±0.004	0.018±0.020	0.015
3	0.015±0.012	0.019±0.010	0.020±0.006	0.018
4	0.020±0.003	0.018±0.007	0.014±0.009	0.017
5	0.017±0.011	0.020±0.010	0.019±0.007	0.019
6	0.019±0.022	0.016±0.005	0.018±0.010	0.018
7	0.016±0.009	0.017±0.011	0.016±0.001	0.016
8	0.019±0.015	0.015±0.020	0.017±0.003	0.017
9	0.015±0.011	0.014±0.009	0.016±0.008	0.015
10	0.018±0.008	0.017±0.001	0.018±0.002	0.017
Mean	0.017±0.012	0.017±0.08	0.017±0.07	0.017

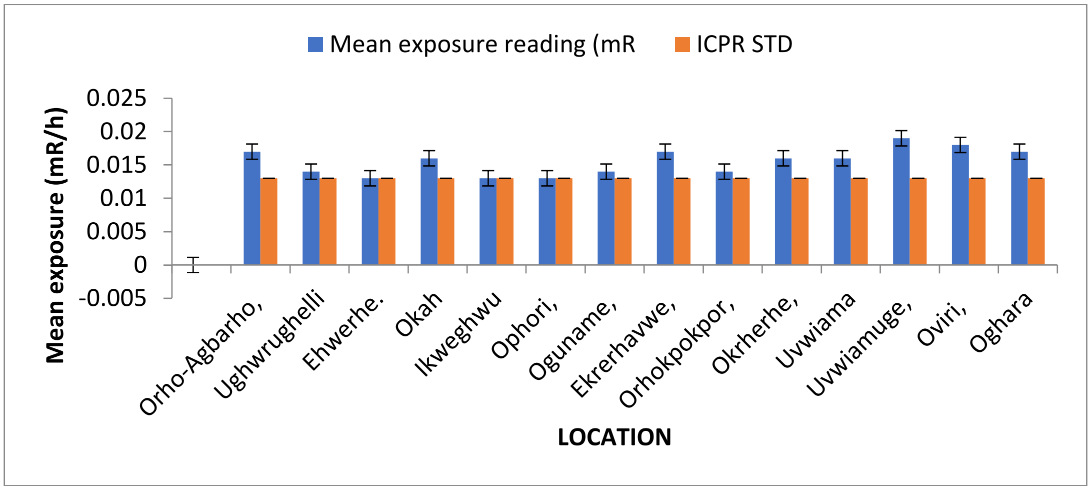

Figure 2: Comparison of mean exposure levels of all the fourteen zones in the studied area with ICPR Standard

Absorbed Dose Rate (ADR) in Air

When radiations transit through a material, some portion of the energy will be transferred to the material. The radiation energy that might be absorbed by a person who is potentially exposed is qualified by the term "absorbed dose". According to international Atomic Energy agency (lAEA, 2018) absorbed dose is used to estimate the biological radiation effects of the dose uptake.

The measured BIR exposure converted to absorbed dose in air using equation (Agbalagba 2017).

$$1\ \mu Rh^{-1} = 8.7\ \eta Gyh^{-1} = \left(\frac{8.7}{\left(\frac{1}{8760}\right) y \times 10^{3}}\right) \mu Gyy^{-1} \quad (1)$$

Converting to mRh^{-1}

$$1\ mRh^{-1} = 8.7\times10^{3}\ \eta Gyh^{-1} \quad (2)$$

The results of the gamma radiation absorbed dose rates for the fourteen communities in Agbarho kingdom are presented in column 5 of Table 15. The results obtained indicate mean value of 139.2±60.9 ɳGyh^{-1} and an absorbed dose rate ranging from 113.1±52.2 to 156.6±78.3 ɳGyh^{-1}.The highest radiation level of 165.3±69.6 ɳGyh^{-1} was recorded at Uvwiamuge. The high radiation level associated with this area might be due to its condensed population, presence of engineering dumpsites, mining activities and partly a function of geology and geographical activities of the area. Lowest value was recorded at Ophori, Ehwerhe and Ikweghwu. This low value can be linked to the remote state of the communities and absence of Industrial activities around the area.

The dose rate results obtained from BIR exposure in the different communities comprising the studied area are higher than the recorded world average of 84.0 ɳGyh^{-1} (UNSCEAR 2008) for outdoor exposure as shown in figure 2. The values obtained for the absorbed dose rates is an indication that the environment has been contaminated by radiation and may pose health hazard to the body in the long-term due to accumulated doses.

Table 15: Calculated Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) within Agborho kingdom.

S/No	Location	Mean exposure rate (mRh^{-1})	RANGE (mRh^{-1})	Absorbed dose rate(ηGyh^{-1})	AEDE ($mSvy^{-1}$)	ELCR $\times 10^{-3}$
1	Orho-Agbarho,	0.017±0.003	0.015-0.018	147.9±26.1	0.181±0.032	0.634±0.011
2	Ughwrughelli	0.014±0.003	0.012-0.016	121.8±26.1	0.149±0.032	0.523±0.011
3	Ehwerhe.	0.013±0.003	0.011-0.014	113.1±26.1	0.139±0.032	0.485±0.011
4	Okah	0.016±0.006	0.014-0.017	139.2±52.2	0.171±0.064	0.598±0.022
5	Ikweghwu	0.013±0.006	0.011-0.014	113.1±52.2	0.139±0.064	0.485±0.022
6	Ophori,	0.013±0.007	0.011-0.015	113.1±60.9	0.139±0.074	0.485±0.026
7	Oguname,	0.014±0.009	0.012-0.015	121.8±78.3	0.181±0.096	0.634±0.034
8	Ekrerhavwe,	0.017±0.007	0.015-0.020	147.9±60.9	0.181±0.074	0.634±0.026
9	Orhokpokpor,	0.014±0.008	0.012-0.015	121.8±69.6	0.149±0.085	0.523±0.030
10	Okrherhe,	0.016±0.007	0.014-0.019	139.2±60.9	0.171±0.074	0.598±0.026
11	Uvwiama	0.016±0.010	0.011-0.018	139.2±87.0	0.171±0.107	0.598±0.037
12	Uvwiamuge,	0.019±0.008	0.016-0.022	165.3±69.6	0.203±0.085	0.710±0.030
13	Oviri,	0.018±0.009	0.017-0.019	156.6±78.3	0.192±0.096	0.672±0.034
14	Oghara	0.017±0.009	0.015-0.019	147.9±78.3	0.181±0.096	0.634±0.034
	Mean value	**0.016±0.007**	**0.013-0.017**	**139.2±60.9**	**0.171±0.074**	**0.598±0.026**

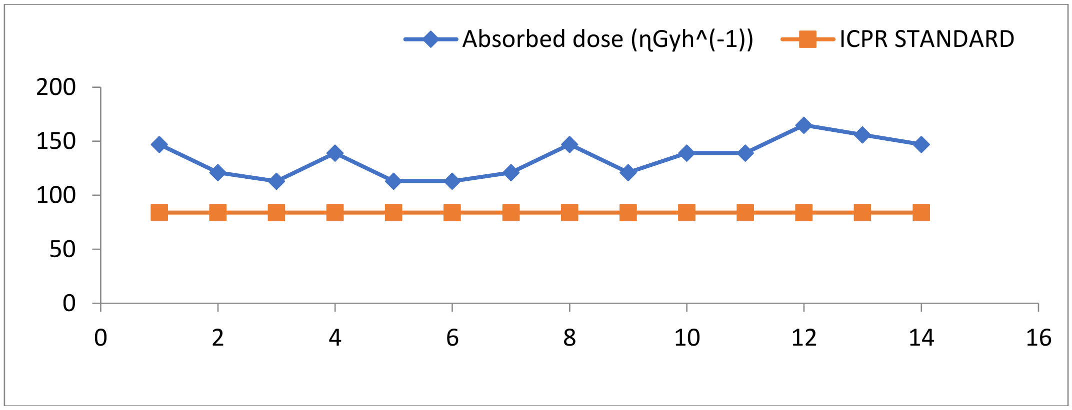

Figure 3: Graph of estimated absorbed dose rate within Agborho Kingdom

Annual Effective Dose Equivalent

The AEDE is a measure of the radiation dose received by an individual in a year. It is used to assess the potential for long-term effects that might occur in the future. The absorbed dose can be considered in terms of the AEDE from outdoor terrestrial gamma radiation which is converted from the absorbed dose by taking into account two factors, namely the conversion coefficient from absorbed dose in air to effective dose and the outdoor occupancy factor (UNSCEAR, 2008).

The annual effective dose (AEDE) of the studied area was estimated using equations 3 (Turban & Gundiz., 2008; Agbalagba., 2017) as given below:

$$AEDE\ (mSvy^{-1}) = D\ (\eta Gyh^{-1}) \times 8760\ h \times 0.7\ SvGy^{-1} \times 0.2 \qquad (3)$$

The result of AEDE for the studied area is presented in column 6 of Table 15. The result obtained indicates a range in annual effective dose of 0.139±0.064 to 0.203±0.085 $mSvy^{-1}$ with a mean annual effective dose of 0.171±0.074 $mSvy^{-1}$ .This mean annual effective dose is within ICRP and UNSCEAR recommended permissible limits of 1.00 $mSvy^{-1}$ for the general public (ICRP, 2007, UNSCEAR, 2008).However, when compared to world average value of 0.07 $mSvy^{-1}$, the mean annual effective dose is considered higher (ICRP, 2007, UNSCEAR, 2008). This is an indication that the studied area might be radiologically contaminated but may or may not have presently constituted any immediate and visible radiological health effects on the residents in the studied area. Nevertheless, there is need for monitoring various anthropogenic activities around the study area that might elevate radiation level. The annual effective dose evaluated in this study are similar to those reported by Ugbede and Benson (2018) Emene industrial layout of Enugu state Nigeria and lower than 0.205±0.017 mean value observe in Idu industrial area of Abuja, Nigeria by James *et al* (2013).

Effective Dose of Different Body Organ (D_{organ})

The effective dose to organ (D_{organ}) estimate the amount of radiation dose deposited to various body organ and tissue. Equation 3 gives D_{organ} of body due to inhalation (Darwish *et al*, 2015)

$$D_{organ}\ (mSvy^{-1}) = AEDE \times F. \quad (4)$$

Where F is the conversion factor of organ dose from air dose ICRP (1961). The conversion factor for seven organs are listed in Table (16)

Table 16: Conversion factor of organ/tissue dose

Organ	Conversion Factor
Lungs	0.67
Ovaries	0.58
Bone Marrow	0.69
Testes	0.82
Kidney	0.62
Liver	0.46
Whole Body	0.68

The estimated mean D_{organ} values for the lungs, ovaries, bone marrow, testes, kidney, liver and whole body due to radiation exposure and inhalation in the study area are recorded as 0.109, 0.099, 0.112, 0.0.14, 0.106, 0.079 and 0.116 $mSvy^{-1}$ respectively as shown in table 17. The obtained results are all below the international permissible limits of 1.0 $mSvy^{-1}$ annually (Darwish et al, 2005) as shown in Figure 3. The results obtained also show that the testes have the highest sensitivity to radiation while lower sensitivity was recorded from liver and ovaries. The estimated higher dose to the Testes may be due to its higher sensitivity to radiation and conversion factor. The results obtained show a negligible indication of an immediate likely hood of developing cancerous cells in the organs of adult living in the study area. Similar observation was also reported by Ugbede and Benson (2018), Darwish et al (2015).

Table 17: Dose to different organs of the body in Agborho Kingdom

S/No	Location	Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole body
1	Orho-Agbarho,	0.116	0.105	0.125	0.148	0.112	0.083	0.123
2	Ughwrughelli	0.095	0.086	0.103	0.122	0.092	0.069	0.101
3	Ehwerhe.	0.089	0.081	0.096	0.114	0.086	0.064	0.095
4	Okah	0.109	0.099	0.112	0.140	0.106	0.079	0.116
5	Ikweghwu	0.089	0.081	0.096	0.114	0.086	0.064	0.095
6	Ophori,	0.089	0.081	0.096	0.114	0.086	0.064	0.095
7	Oguname,	0.116	0.105	0.125	0.148	0.112	0.083	0.123
8	Ekrerhavwe,	0.116	0.105	0.125	0.148	0.112	0.083	0.123
9	Orhokpokpor,	0.095	0.086	0.103	0.112	0.092	0.069	0.101
10	Okrherhe,	0.109	0.099	0.112	0.140	0.106	0.079	0.116
11	Uvwiama	0.109	0.099	0.112	0.140	0.106	0.079	0.116
12	Uvwiamuge,	0.130	0.118	0.140	0.166	0.126	0.093	0.138
13	Oviri,	0.123	0.111	0.132	0.157	0.119	0.088	0.130
14	Oghara	0.116	0.105	0.125	0.148	0.112	0.083	0.123
	Mean value	**0.109**	**0.099**	**0.112**	**0.140**	**0.106**	**0.079**	**0.116**

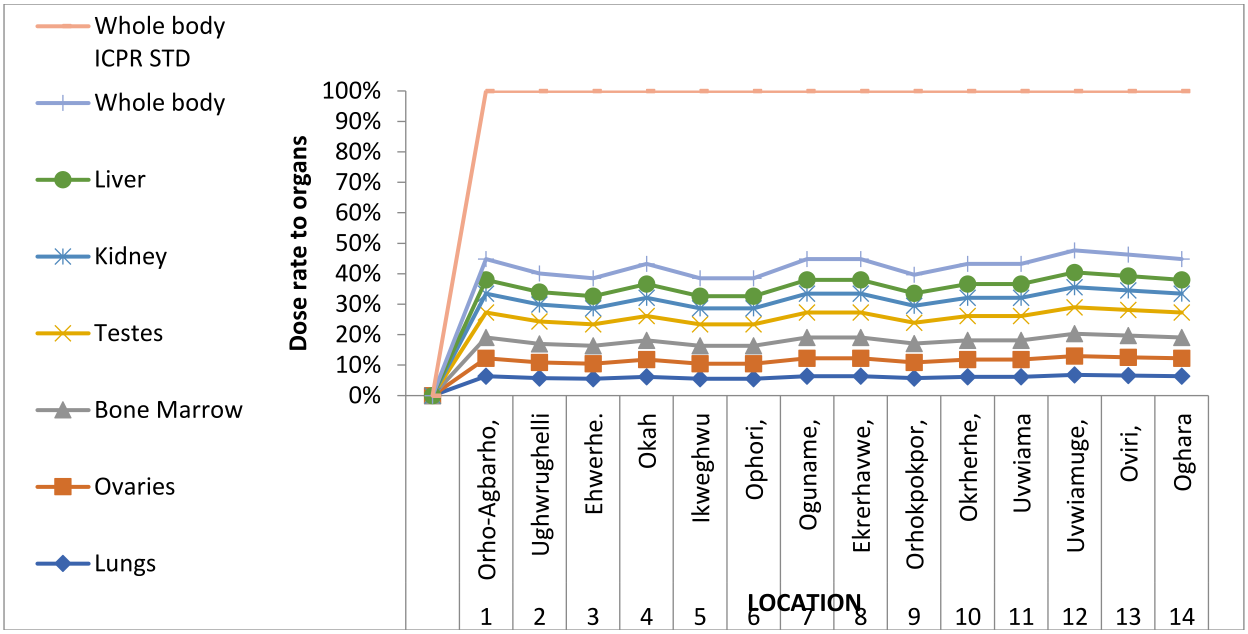

Figure 4: Effective dose rate to different organs/tissues

Excess Lifetime Cancer Risk ELCR

The probability of an individual developing the ELCR was estimated using an annual effective dose values using equation (5) according to Agbalagba (2017)

ELCR = AEDE (mSvy^{-1}) x DL x RF (5)

Where Dl and RF are average duration of life (seventy years) and the fatal cancer risk factor per sievert (Sv^{-1}) respectively. BIR which are evaluated low to produce stochastic effects, a fatal cancer risk factor value of 0.05 for public exposure is used (ICRP, 2007) .The estimated ELCR recorded ranges from (0.483 ± 0.11) $\times 10^{-3}$ to (0.710 ± 0.30) $\times 10^{-3}$ .The mean value of (0.578±0.026) $\times 10^{-3}$ was recorded , which is higher when compared with the word mean value of 0.029 x 10^{-3} .

The ELCR estimate value indicates a high possibility of cancer development for resident who may wish to spend over 70% of their lifetime in the same area. The ELCR value reported here conform with that made by Ugbede and Benson (2018) in Emene industrial layout in Enugu state and lower when compared with that reported by Avwiri et al (2016) in lake environments of Ebonyi State

CONCLUSION

The assessments of background ionizing radiation in Agbarho kingdom was carried out. Background ionizing radiation measurement was measured in the fourteen communities in Agbarho kingdom to be higher than the world mean value of 0.013 mRh^{-1}. This is an indication of active mobilization ɳGy$h^{-1}$of radioactive materials in the study area from geological formation or anthropogenic activities up shooting the natural state of the radionuclide present in the environment. The mean estimated health indices associated BIR where calculated as absorbed dose rate (159.2±0.009) and ELCR (0.558±0.26) .When compared with their respective international permissible results are higher than the recommended average by (ICRP) of 89.0 ɳGyh^{-1} and 0.025 x 10^{-3} mSvy^{-1} respectively, while the estimated value of AEDE of the study area are lower than global world average of 1.0 mSvy-^{1} for outdoor environment. This reported value is an indication of higher background radiation exposure to the people living in the study area, though its effect might not pose an immediate health hazard as demonstrated by the effective dose to some organs of the body, but may result to a higher cumulative dose to people who has been irradiated through other sources such as medical means and also can cause a long-term health hazard to the people of Agbarho kingdom due to long-term accumulation of doses. However, we hereby recommend that government agencies in charge of environment should create an isolated geological disposal method of radioactive waste to minimize the impact on the environment; there should be a regular monitoring of radiation levels in the environment by the appropriate government and radiation protection agencies; residents who have spent a greater percentage of their life in the study area are encouraged to go for routine screening exercise for early detection of any radiation induced health effects and further studies in the studied area should be carried out to ascertain the level of ingestion pathways of radionuclide to the body

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