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Assessment of Outdoor Background Ionizing Radiation of University Teaching Hospital (UPTH) of Obio/Akpor Local Government Area, Rivers State, Nigeria

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ABSTRACT

Outdoor background ionizing radiation refers to the radiation dose from natural and artificial sources in the environment that we are exposed to at all time when we are outside. The assessment of back ionizing radiation of University of Port Harcourt Teaching Hospital (UPTH) in Rivers State has been carried out using a well calibrated radiation meter. Ten (10) location within the Teaching Hospital (UPTH) was considered for the purpose of the study. The result of BIR varies from0.011 mR/h to 0.019 mR/h with mean of 0.015mR/h, absorbed dose varies from 0.964 to 1.594nGy/h with mean of 116.71 nGy/hr, Annual effective dose equivalent (AEDE) varies from 0.149 to 0.319 mSv/yr with mean of 0.20 mSv/yr while excess life cancer risk (ELCR) varies from 0.523 to 1.117×10^{-3} with a mean of 0.70×10^{-3}. The obtained mean is higher than the stipulated standard of 0.29×10^{-3}. The radiation percentage is of an increasing order of Liver, Ovaries, kidney, Lung, Whole body, Bone marrow, and the Testes. The higher percentage of radiation was obtained in the testes with eighteen percentages, while the lower percentage was obtained in the Liver with ten percentages. The results showed that the mean background ionizing radiation and absorbed dose rates were higher than the recommended world average values prescribed by UNSCEAR (2020), indicating enhanced radiation levels within some parts of the hospital environment. The elevated value of the background ionizing radiation within the environment may not pose any immediate health risk but there is need for proper monitory of the radiation level of the Teaching Hospital (UPTH) since over exposure to radiation may lead some health-related risk like the development of cancer in the near future.

Keywords: Radiation, Absorbed dose, Organ dose, Obio/Akpor and Teaching Hospital

INTRODUCTION

The assessment of background ionizing radiation in hospital environments has continued to gain global attention due to its implications for human health and environmental safety. Ionizing radiation possesses sufficient energy to remove tightly bound electrons from atoms and molecules, thereby producing ions and reactive free radicals. These reactive species can interact with biological structures, especially deoxyribonucleic acid (DNA), leading to cellular damage and disruption of normal physiological processes (Hall & Giaccia, 2019). If such DNA damage is not accurately repaired, it may result in mutations, chromosomal abnormalities, cell death, or cancer development. Consequently, prolonged exposure to ionizing radiation has been linked with increased risks of carcinogenesis and other health complications (WHO, 2023). Modern medical practice has increasingly relied on radiation-based diagnostic and therapeutic tools, including X-ray imaging, computed tomography (CT), fluoroscopy, nuclear medicine, and radiotherapy. These technologies have greatly improved disease diagnosis and treatment outcomes. However, their extensive use has raised concerns about occupational exposure of healthcare workers and environmental radiation levels within hospital facilities, particularly where radiation safety practices are not strictly enforced. Medical personnel such as radiologists, radiographers, nurses, surgeons, and other staff working in radiation-prone areas may experience repeated low-dose exposure over time, which may accumulate and increase stochastic health risks(UNSCEAR, 2020).Humans are continuously exposed to ionizing radiation from natural and artificial sources. Natural sources include cosmic rays originating from outer space and terrestrial radiation from naturally occurring radionuclides in soil, rocks, water, air, and building materials. On average, the global population receives an annual effective dose of about 2.4 mSv from natural background radiation, although this varies depending on altitude, geology, and environmental conditions. Artificial sources, particularly medical exposures, also contribute significantly to overall radiation dose in modern societies (UNSCEAR, 2020).Hospital environments are unique because they combine natural background radiation with radiation emitted from diagnostic and therapeutic equipment. As a result, continuous assessment and monitoring of radiation levels in these settings are essential for ensuring compliance with safety standards and minimizing unnecessary exposure to both workers and patients. Recent investigations have shown that background radiation levels in hospitals are generally within acceptable international limits, although localized variations may occur. Studies conducted by Omogunloye & Ilori (2025) reported that radiation levels in hospital environments were mostly within permissible limits, but slightly higher values were recorded in radiology departments due to scattered radiation from imaging equipment. The study of Anzaku & Bichi (2025) revealed that occupational exposure in radio diagnostic units contributes to cumulative radiation doses among healthcare workers, emphasizing the importance of protective measures such as shielding and adherence to safety protocols. More so, Olanrewaju et al. (2023) work on radiation levels measured around radiological sections in a teaching hospital were below recommended limits, although spatial variations were observed across different hospital zones. Additionally, Usikalu et al. (2024) demonstrated that environmental and human activities may influence background radiation distribution in surrounding areas. In general, available evidence suggests that although hospital radiation levels are typically within internationally recommended safety limits, certain areas such as radiology departments may exhibit slightly elevated values. This highlights the need for continuous radiation surveillance, strict adherence to protection principles, and regular assessment of occupational exposure to ensure safety in healthcare environments.

Radiation Health Risk Parameters
The followings radiation health risk parameters were used in analyzing the related radiation risk due to the over exposure to background ionizing radiation with the University Teaching Hospital of Port Harcourt.
Absorbed Dose. Absorbed dose is a physical dose quantity (D) representing the mean energy conveyed to matter per unit mass by ionizing radiation. The SI unit of measurement is joules per kilogram (J/Kg). Type equation here. Absorbed Dose= Exposure dose rate x 8.7 (nGy/hr) (1)
Annual Effective Dose Equivalent. The valueof the radiation absorb dose rate was used to determine the annual effective dose equivalent (AEDE) of the sampling Points within the Teaching Hospital. The ionizing radiation outdoor occupancy factors of 0.2and the dosage conversion factor of 0.7 Sv/Gy was used for the estimation of the AEDEBubu and Ononugbo (2023).
AEDE (mSv/yr) =Dose rate (nGy/h) ×8760 h×0.75 Sv/Gy×0.25 2

$$AEDE \frac{mSv}{yr} = Dose\ rate\ \frac{nGy}{h}\ 8760h \times 0.75\ \frac{Sv}{Gy} \times 0.25 \quad (2)$$

Excess Life Cancer Risk (ELCR)
The excess lifetime cancer risk (ELCR) is the likelihood of an individual todeveloped cancer over timedue to over exposure to radiation dose. The average duration of life is 70years and arisk factor of is 0.05 for public exposure (ICRP 2021).
ELCR=AEDE × Average Duration of Life (DL) ×RISK factor (RF) (3)

The effective dose to organs (Dorgan) is the estimated amount of radiation dose intake for the various human body organs. The effective radiation dose to human body organs due to inhalation was calculated using Equation four (4),Nwii et al. (2024).
Dorgan (mSv/yr) =AEDE X F (4)
The conversion factor (F) for the various human body organs such as lungs, ovaries, bone marrow, testes, kidney, Liver, and Whole body as given by ICRP (2021), are 0.64, 0.58, 0.69, 0.82, 0.62, 0.46, and 0.68, respectively.

Study Area
The University of Port Harcourt teaching hospital is situated in Obio/Akpor Local Government Area in Rivers State. Obio/Akpor Local Government Area is one of the twenty-three Local Government Areas of Rivers State.The Local Government Area have an estimated land area of 260 square kilometers, making it one of the moderately sized local Government areas with a population of about 464,789 people NPC, (2006).Located in the South-South Geographical zone with latitude 4.87º N and Longitude 7.03ºE and it's a major part of Port Harcourt metropolitan area, making it one of the most urbanized and economically important Local Government Area in the State. Its headquarters is situated in Rumuodomaya and it share a common boundary with Port Harcourt city, Ikwerre, Emohua, Etche and ElemeLocal Government Area. The local Government area comprises of Choba,Rumuodara,Rumuola,Rumueme,Woji, Ogbogoro and Rumuome. The land mark of Obio/Akpor includes; University of Port Harcourt (Uniport), University of Port Harcourt Teaching Hospital (UPTH),Rumuokoro Junction, Choba Market, Alakahia and Rumuodomaya.

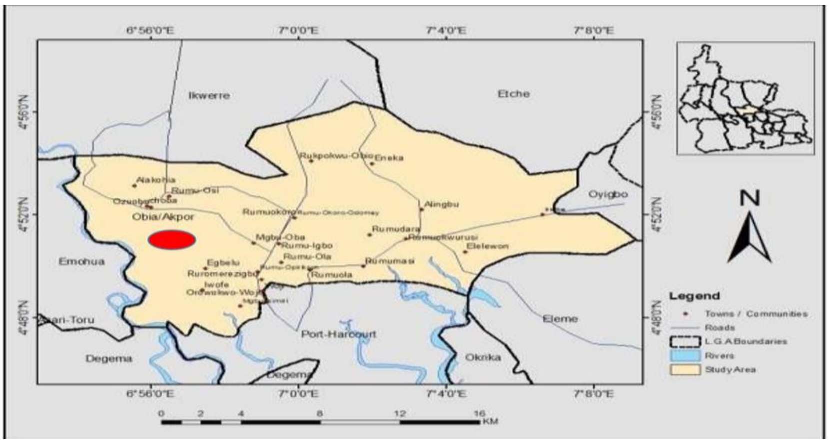

Figure 1: Map of the Study Area

MATERIALS AND METHODS
A well calibrated Radiation meter (Digilert 200) with FCC ID: A8TBM71S2, IC: 12246A-BM71S2 CEO197, M103493 and a temperature range of 10^0- 50^0C was used in measuring the background ionizing radiation of the construction sites within Eleme local Government Area of Rivers State. The Radiation meter is good and capable in detecting of alpha, beta, and gamma radiation within the environment and the Radiation readings detected are displaced on the liquid crystal display (LCD). The Radiation meter measurement unit is controlled by using the mode button which record in counts per minute (cpm), mRh^{-1}, micro Sievert per year (uSv/hr) or accumulated counts. The Radiation meter (Digilert 200) operate effectively for the measurement background ionizing radiation while in operation, the red count light flashes each time radiation is detected. The Digilert 200 uses a Geiger-Muller tube to detect radiation levels. The screen is open at the top of the Meter; the open area is called the window. It permits alpha and beta at low energy and gamma passes through itsICRP (2020). The in-situ approach for the measurement of the background ionizing radiation was adopted for accurate radiation measurement within the sampling points the University Teaching Hospital. The Radiation metre (Diglert 200) was raised at a standard height of 100 cm above the ground level in order to obtain accurate readings of radiation dosewithin the Teaching Hospital. Three (3) different readings were taken at each of the selected sampling points within the University Teaching

Hospitalusing Diglert 200radiation meter. The Radiation average reading was taken and recorded at an interval of 5 minutes at each of the sampling points of the University Teaching Hospital (UPTH).ICRP, (2021)

RESULTS AND DISCUSSION

Table 1: Background Ionizing Radiation (BIR) Level of Port Harcourt Teaching Hospital (UPTH)

S/N	Sampling Points	GPS Reading	Exposure Dose Rate (mR/hr)	Absorbed Dose Rate (nGy/hr)	AEDE (mSv/y)	ELCR 10^{-3}
1	NDDC Sign Post	N040˚55.915’’ E006˚55.710”	0.014±0.004	121.8	0.149	0.523
2	Reserved Packing Space	N040˚55.931’’ E006˚55.709”	0.015±0.003	130.5	0.160	0.560
3	Entrance Point	N040˚55.695’’ E006˚55.709”	0.015±0.001	130.5	0.160	0.560
4	Dental Centre	N040˚55.963’’ E006˚55.663”	0.015±0.003	130.5	0.160	0.560
5	Family Medicine Dept	N040˚55.972’’ E006˚55.643”	0.012±0.002	104.4	0.17	0.60
6	Dept Community Packing space	N040˚55.005’’ E006˚55.035”	0.019±0.004	165.3	0.319	1.117
7	Emergency medicine Unit	N040˚55.030’’ E006˚55.635”	0.016±0.001	134.6	0.25	0.770
8	Accident and Emergency Dept	N040˚55.007’’ E006˚55.720”	0.019±0.002	139.2	0.319	1.117
9	Radiology Annex	N040˚55.931’’ E006˚55.645”	0.011±0.002	95.7	0.117	0.411
10	Resuscitation Room	N040˚55.934’’ E006˚55.647”	0.017±0.003	147.9	0.230	0.810
	Mean		0.015±0.003	116.71	0.2034	0.703
	UNSCEAR	(2020)	0.013	84.0	1.0	$0.29x10^{-3}$

Table 2: Radiation Dose to Different Body Organ of Port Harcourt Teaching Hospital (UPTH)

S/n	Lungs	Ovaries	Bone Marrow	Testes	Kidney	Liver	Whole Body
1	0.095	0.086	0.103	0.122	0.092	0.069	0.101
2	0.102	0.093	0.110	0.131	0.099	0.074	0.109
3	0.102	0.093	0.110	0.131	0.099	0.074	0.109
4	0.102	0.093	0.110	0.131	0.099	0.074	0.109
5	0.109	0.099	0.117	0.139	0.105	0.078	0.116
6	0.149	0.135	0.161	0.191	0.144	0.107	0.158
7	0.160	0.145	0.173	0.205	0.155	0.115	0.170
8	0.149	0.135	0.161	0.191	0.144	0.107	0.158
9	0.075	0.068	0.080	0.096	0.073	0.054	0.080
10	0.153	0.138	0.165	0.196	0.148	0.110	0.162
Mean	0.1196	0.109	0.129	0.153	0.116	0.086	0.127

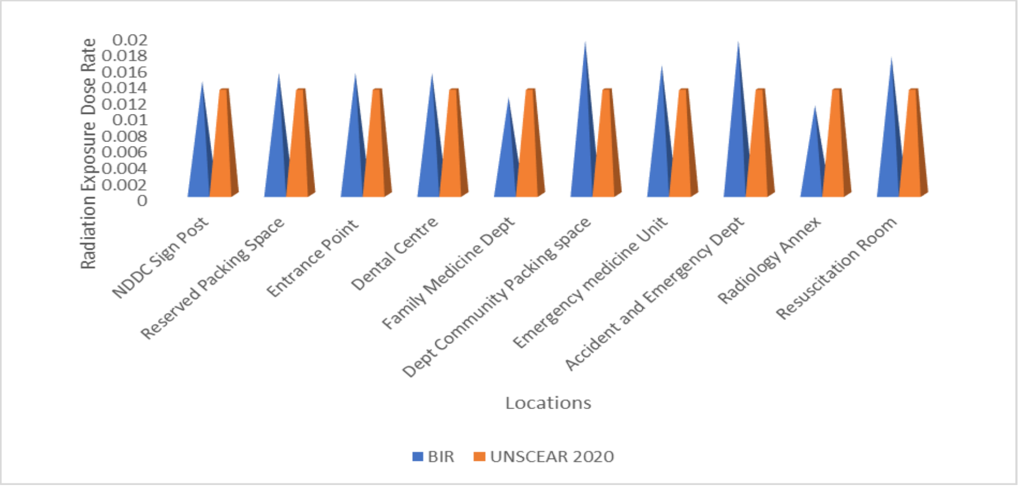

Figure 2: Comparison of Radiation Exposure of Teaching Hospital (UPTH) with Standard

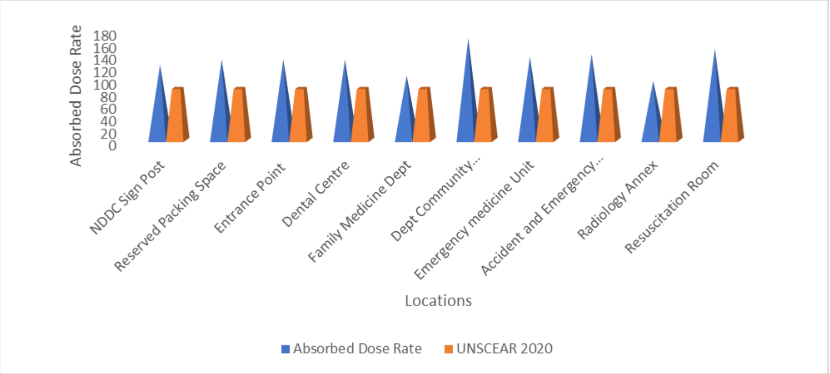

Figure 3: Comparison of Absorbed Dose Rate of Teaching Hospital (UPTH) with Standard

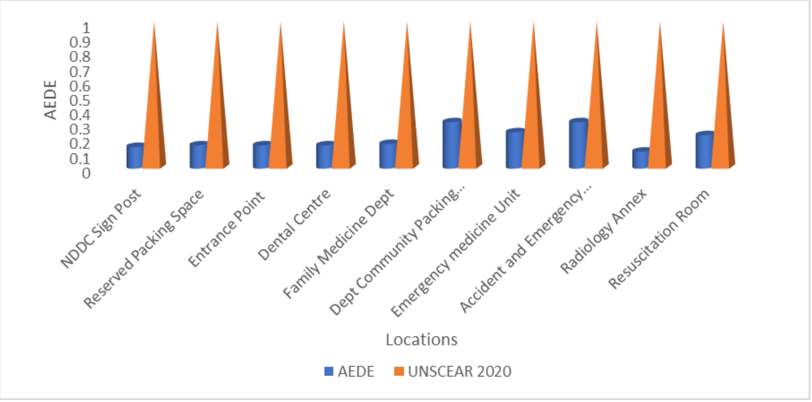

Figure 4: Comparison of AEDE of Teaching Hospital (UPTH) with Standard

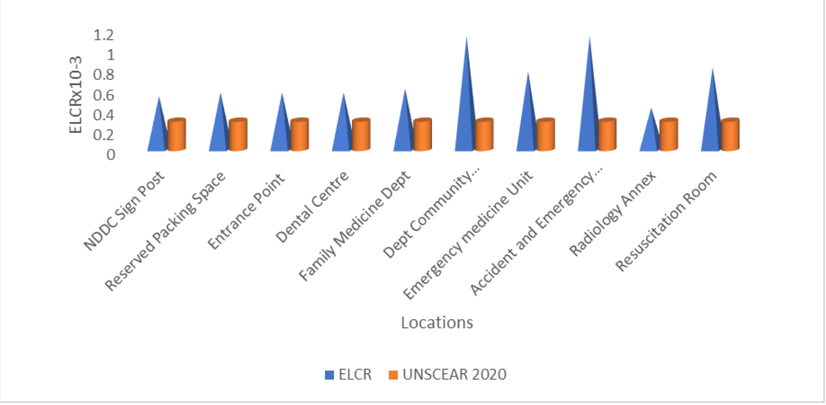

Figure 5: Comparison of ELCR of Teaching Hospital (UPTH) with Standard

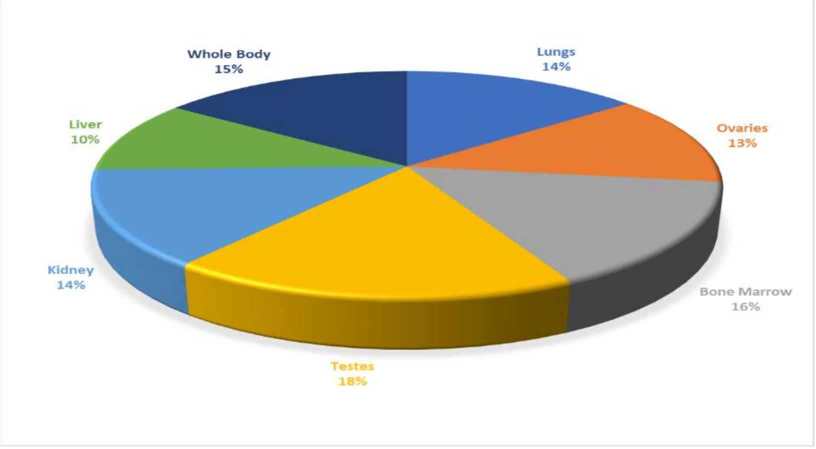

Figure 6: Percentage of Radiation Dose to Different Body Organ Teaching Hospital (UPTH)

Discussion

The results of University of Port Harcourt Teaching Hospital outdoor background ionizing radiation range from0.011 mR/h to 0.019 mR/h with mean of 0.015mR/h. The obtained mean is greater than the recommended safe value of 0.013 mR/h as stipulated by UNSCEAR (2020) and also within the ranged reportedbyNwii et al. (2024). Thought, some of theselected locationswere greater than the stipulatedlimit except that of the Family medicine and Radiology Annex area which are below the recommended safe limit of 0.013mR/h. This variation within the locations might be due to the alteration in the concentration natural background ionizing radiation through the application of some relatedmedical equipment which is capable emitting gamma radiation or due to the increased human activities and the proximity of diagnostic and treatment facilities.The results for absorbed dose range from 0.964 to 1.594nGy/h with a mean of 116.71 nGy/hr, the obtained mean is greaterthan the recommended safe limit of 84nGy/hr as stipulated by UNSCEAR (2020) and lower the reported work ofNwii et al. (2025). The results of the Annual effective dose equivalent (AEDE) varies from 0.149 to 0.319 mSv/yr with mean of 0.20 mSv/yr. The obtained mean for the (AEDE) is lower than the reported work of Abdulkareem et al. (2024) and also below the recommended safe limit of 0.48 mSv/yr as stipulated by ICRP (2020). Whileexcess life cancer risk (ELCR) varies from 0.523 to 1.117×10^{-3} with a mean of 0.70×10^{-3}. The obtained mean is higher than the stipulated standard of 0.29×10^{-3} as recommended by UNSCEAR (2020).The results agree with the findings of Garba et al. (2024**)** and Omogunloye et al. (2025). The variation in the ELCR within the study area might be due to the alteration in the natural radionuclide within the University of Port Harcourt Teaching Hospital through consistence utilization medical equipment which is capable of altering the concentration of natural and artificial background ionizing radiation within the study area. This high value of ELCR implies that the workers, visitors and individual who may work for a long time with theTeaching Hospital may developed cancer due to over exposure to high radiation dose during working hours.The Table2 shows the radiation dose to different body organs. The radiation percentage is of an increasing order of Liver, Ovaries, kidney, Lung, Whole body, Bone marrow, and the Testes. The higher percentage of radiationwas obtained in the testes with eighteen percentages**,**while the lower percentage was obtained in the Liver with ten percentages. The testes, bone marrow, whole body and lungs received relatively higher doses and this might be due to their biological sensitivity to radiation.

CONCLUSION

This study assessed the background ionizing radiation levels and associated radiological health risks within the University of Port Harcourt Teaching Hospital (UPTH). The results showed that the mean background ionizing radiation and absorbed dose rates were higher than the recommended world average values prescribed by UNSCEAR (2020), indicating enhanced radiation levels within some parts of the hospital environment. These elevated values may be attributed to the continuous use of medical diagnostic equipment, hospital activities, and the presence of radiation-related facilities. The annual effective dose equivalent (AEDE) was found to be within the recommended safety limit, suggesting that the current level of radiation exposure does not pose an immediate radiological threat to workers, patients, and visitors. However, the excess lifetime cancer risk (ELCR) exceeded the recommended global reference value, indicating a potential long-term health risk associated with prolonged exposure to the prevailing radiation levels. The assessment of organ doses revealed that the testes, bone marrow, lungs, and whole body received relatively higher radiation doses compared to other organs, reflecting their greater sensitivity to ionizing radiation. Nevertheless, the elevated absorbed dose rates and excess lifetime cancer risk highlight the need for continuous radiation monitoring, strict adherence to radiation protection principles, and regular radiological safety assessments to ensure the protection of hospital staff, patients, and visitors.

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