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Work Place Assessment of Ambient Background Gamma Exposure Level of Some Radiological Facilities in FCT Abuja, Nigeria

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Abstract: In this study, the indoor and outdoor background exposure levels of some radiological facilities in FCT Abuja metropolis, Nigeria were assessed. Rados (RDS-31) radiation survey meter was used to measure the indoor and oudoor exposure level. A total of five radiological facilities were systematically selected and recruited for this study. The indoor measurements comprise of examination room when X-ray machine is ON, control console room and patient waiting area. The outdoor background measurement was carried out in the surroundings of the hospital visited. The indoor (outdoor) exposure rate, absored dose rate, annual effective dose equivalent and excess lifetime cancer risk are 0.12 to 4.65 μSv〖.hr〗^(-1) (0.11 to 0.15 μSv.hr^(-1)), 143.3 to 1653 nGy.hr-1 (130 to 140 nGy.hr-1), 0.66 to 8.11 mSv.yr-1 (0.16 to 1.17 mSv.yr-1), and 2.46 to 28.38 (0.56 to 0.60) respectively. These values are within the standard recommended by ICRP and UNSCEAR. However, regular radiation monitoring is required as part of radiation safety culture in the radiological facilities.

Keywords: Background radiation, exposure rate, radiological facilities, annual effective dose equivalent, and excess life time cancer risk.

1 Introduction

The activity of natural radionuclides: ^{238}U (^{226}Ra) series, ^{232}T series and ^{40}K that are present in the earth's crust, has exposed human beings to natural radiation. These natural sources of radiation can be found in air, water, food, building materials, and the human body [1,2]. The major contributors of outdoor terrestrial natural radiation is the soils. The radionuclides are not uniformly distributed in soil, sand, and rock, understanding of their distribution are key in radiation protection and measurement [3]. The associated gamma radiation emitted from these radionuclides depend on the geological conditions and varies from one region to another in the world. There is no boundaries for atomic radiation and the injuries and clinical symptoms induced by exposure to ionizing radiation include; indirect free-radical formation, direct chromosomal transformation, radiation cataractogenesis, bone necrosis, cancer induction, etc. [4] . The practice has to be in accordance with the ALARA (as low as reasonably achievable) principle.

High exposure levels of radiation is known to cause cancer [5]. However, very low doses of radiation such as the doses from background radiation, are very hard to determine because, there are so many other factors that can mask or distort the effects of radiation [6, 7]. The objective of this study is to determine the background radiation levels of some radiological facilities in FCT Abuja metropolis, Nigeria.

2 Materials and Method

2.1 Study Area

The federal capital territory, Abuja has an area of 2,824 square miles (7,315 square km). It is located north of the Niger and Benue rivers confluence . The west, northwest, northeast, south, and southwest of Abuja are bordered by Niger, Kaduna, Nassarawa, and Kogi respectively. The planned modern city, Abuja is located at the centre of the territory. The region is blessed with crystalline rocks consisting of gneisses and granites. The savanna is the main vegetation with limited forest areas.

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The economic mainstay, agriculture produces millet, yams, corn (maize), beans and sorghum. The population consist of the Ganagana, Gwari, Gwandara, Koro, Afo, and Bassa ethnic groups which are predominantly dairy farmers. Also living in the territory are the Hausa and Fulani. Mineral resources include clay, tin, iron ore, feldspar, lead, gold, marble, and talc. Abuja has major road connections and an airport.

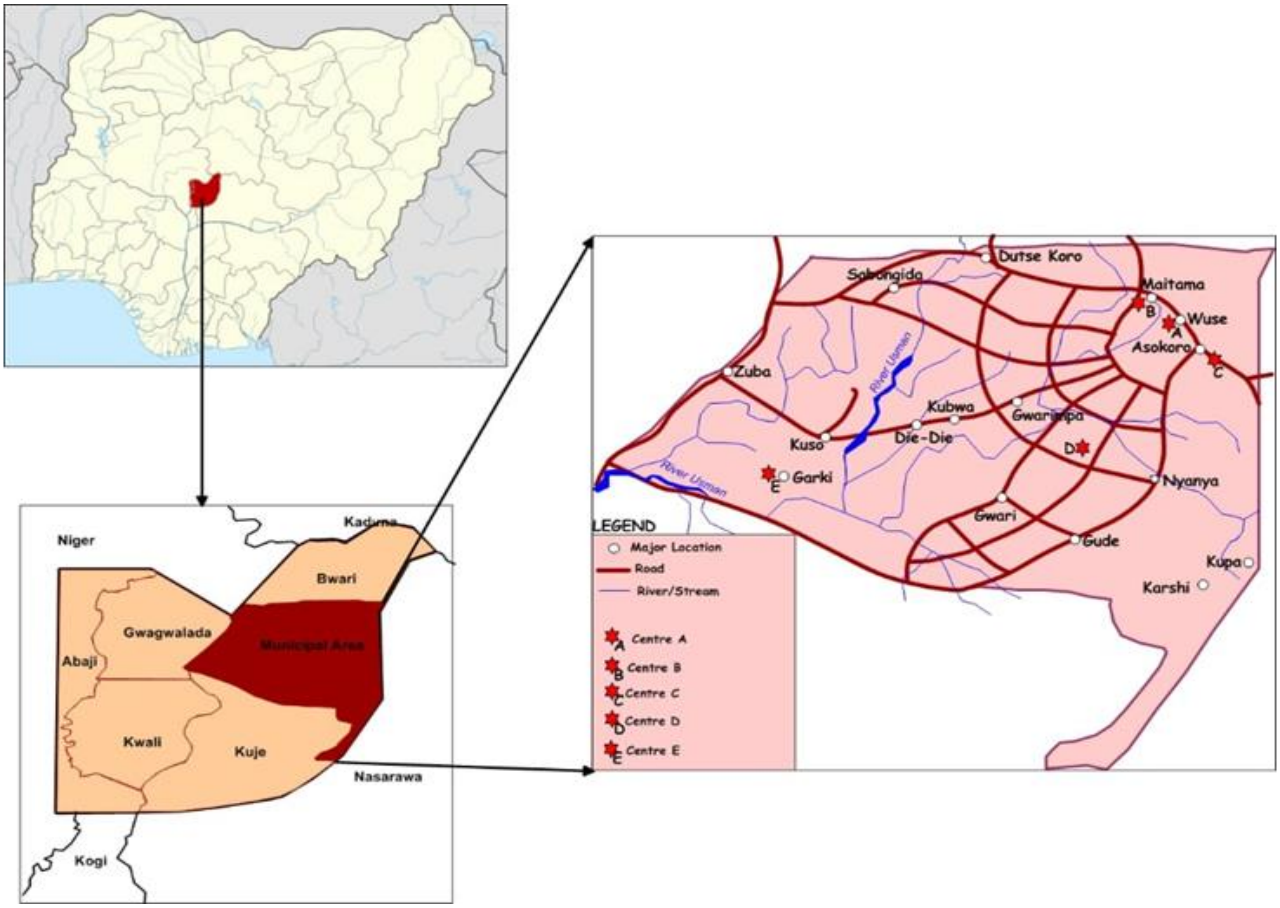

Fig. 1: Map of Study Area.

2.2 Sampling and Measurement

The indoor and outdoor exposure levels measurement of some seleced radiological facilities in some selected hospitals in FCT Abuja was done using Rados (RDS-31) Radiation survey meter calibrated at National Institute of Radiation protection and research in Ibadan in year 2021. It is a small hand held, battery operated survey instrument using an energy compensated GM-tube as primary detector.

A total of five (5) hospital facilities (Wuse District Hospita (A), Maitama District Hospital (B), Gwarinpa General Hospital (C), Asokoro District Hospital (D) and Garki Hospital (E)) in FCT Abuja metropolis were systematically selected. The indoor background exposure rate measurements were carried out in the examination room when X-ray machine is ON, control console room and patient waiting area. The outdoor background exposure rate measurement was carried out in the surroundings of the hospitals visited. It is recommended by the National Council on Radiation Protection and Measurements that measurements taken between the hours of 12.00pm and 4.00 pm give maximum reposnse and was adopted [1, 8]. An in-situ measurement with the standard practice of raising the detector tube 1.0 m above ground level was adopted with its window facing the point under investigation. The selected hospitals locations were determined using a geographical positioning system (GPS). The quantitative assessessment of the radiation health risk to the people working in the hospital both health and non-health workers was performed by a number of radiological health hazard indices calculations using well established mathematical relations.

Calculation of Radiological Hazard Indices

i. Absorbed Dose Rate (ADR) in air

The determination of the potential for any changes in biochemical process in specific tissues is termed absorbed dose rate. It quantifies the energy of radiation that might be absorbed by an exposed individual [9]. The measured outdoor background exposure levels were converted to radiation absorbed dose rate in air using Equation 2 according to Idris *et al*. [1]:

$$1\, nSvh^{-1} = 8.7\, \eta Gyh^{-1} = \frac{8.7x10^{-3}}{(1/8760y)}\, nGyy^{-1} \qquad (1)$$

This implies that:

$$1\mu Sv.h^{-1} = 8.7\, \eta Gyh^{-1}\, x\, 10^3 = 8700\, nGyh^{-1} \qquad (2)$$

ii. Annual Effective Dose Equivalent (AEDE)

The determination of radiation assessment and protection to quantify absorbed dose of the the whole body per year is termed annual effective dose equivalent [10]. It is used to assess the long-term effects that might potentially occur in the future. The AEDE per year received by workers and the population is obtained from equation 3 [5].

$$AEDE(mSv.y^{-1}) = D(nGy.h^{-1})x\, 8760h\, x\, CF\, x\, OFx10^{-3} \qquad (3)$$

where D is the absorbed dose rate in $nGyh^{-1}$, 8760h is the total hours in a year, OF is the occupancy factor, CF is the dose conversion factor from absorbed dose in air to the effective dose in Sv/Gy (CF = 0.7 Sv/Gy), the expected period the members of the population would spend within the study area. OF = 0.8 and 0.2 for indoor and outdoor as it is expected that human beings would spend 80% and 20 % of their time indoors and outdoors respectively as recommended by UNSCEAR [7].

iii. Excess Lifetime Cancer Risk (ELCR)

The ELCR was evaluated using the AEDE values as shown in Equation 4 according to Idris *et al*. [1]:

$$ELCR = AEDE\ (mSvy^{-1})\ x\ DL\ x\ RF \qquad (4)$$

where DL is average duration of life (70 years) and RF is the fatal cancer risk factor per sievert (Sv^{-1}). For lowdose background radiation, which is considered to produce stochastic effects, ICRP 103 uses a fatal cancer risk factor value of 0.05 for public exposure [10-14].

3 Results and Discursion

The results of the indoor and outdoor background exposure level measurements and the related radiological hazard parameter are presented in Table 1, 2, 3, and 4. Table 1 and 2 shows the measured exposure rate ($\mu Sv.hr^{-1}$) of five selected hospitals in Abuja metropolis for indoor and outdoor measurements respectively. The indoor background exposure rate measurements are carried out in the examination room when X-ray machine is ON, control console room and patient waiting area. The outdoor background exposure rate measurement was carried out in the surroundings of the X-ray facilities visited. The coordinate of facilities location was also recorded in Table 1 and 2. Table 3 and 4 shows the results for the radiological hazards parameters for indoor and outdoor exposure rate measurements respectively. The different radiological hazard parameters used in evaluating the radiation health status of the studied environment are absorbed dose rate (ADR), annual effective dose equivalent (AEDE) and the excess lifetime cancer risk (ELCR).

The mean outdoor exposure rate level measured for outdoor background radiation of the five selected centres A, B, C, D and E in Abuja metropolis are 0.145, 0.135, 0.140, 0.140, and 0.145 $\mu Sv.hr^{-1}$ respectively. The indoor exposure rate are measured in examination room when x-ray machine is ON (I1), the control console area (I2), and the waiting area (I3). The indoor exposure rate ranged from AI1 (4.65mRh^{-1}) to CI1 (0.19 mRh^{-1}), DI2 (0.50) to BI2 (0.11), and DI3 (0.13 $\mu Sv.hr^{-1}$) to BI3 (0.120) for examination room, control console room and patient waiting area respectively. The indoor and outdoor exposure rate measured in five radiological centres exceed the recommended permissible limit of 0.013 $\mu Sv.hr^{-1}$. The high exposure rate level is attributed to poor radiation shielding, the different hospital activities, sampling radiation locations and their geophysical characterization.

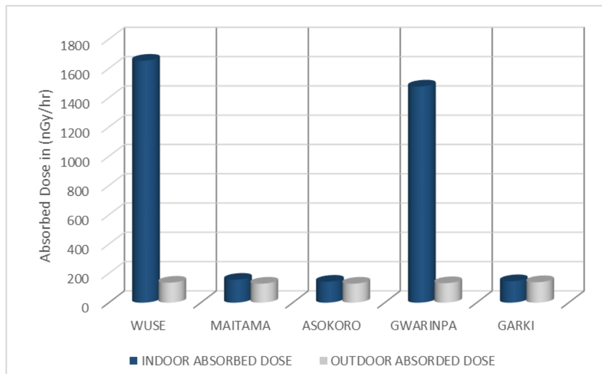

Fig. 1: Comparison between indoor and outdoor absorbed dose rate of the selected radiological facilities in FCT Abuja.

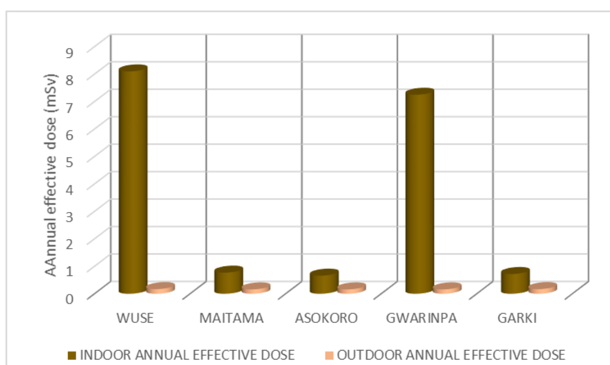

Fig. 2: Comparison between indoor and outdoor annual effective dose equivalent of the selected radiological facilities in FCT Abuja.

The absorbed dose is used to assess the biochemical changes in potential specific tissues. It quantifies the energy of radiation that might be absorbed by a potentially exposed individual. The measured indoor and outdoor exposure levels were converted to radiation absorbed dose rate in air using Equation 2 according to Idris et al. [1].

The mean absorbed dose for indoor gamma dose rate for centre A to E ranged from 143.3 to 1653 $nGyh^{-1}$. The maximum was observed in centre A (Wuse) and the minimum in centre C (Asokoro). These values were higher than the world average of 59 nGyh/hr and higher than the recommended standard of 84 nGyh/hr. Exposure to this range of ionizing radiation may affect the tissue. The outcome of this result is in line with Adeleke et al. [6]. It is

Table 1: Indoor exposure rate of some radiological facilities in FCT Abuja.

S/N	Geopoint		Centre/ Hospital	Sampling code	Sampling Location	Exposure rate (μSv/hr)
	Longiude	Lattitude				
1	9^{O}03′45.359″ N	7^{O}28′23.103″ E	Wuse	AI1	Examination room when X-ray machine is ON	4. 65
				AI2	Control console room	0.19
				AI3	Patient waiting area	0.12
2	9^{O}05′12.583″ N	7^{o}28′ 53.195″ E	Maitama	BI1	Examination room when X-ray machine is ON	0.24
				BI2	Control console room	0.11
				BI3	Patient waiting area	0.12
3	9^{O}02′46.279″ N	7^{O}31′25.025″ E	Asokoro	CI1	Examination room when X-ray machine is ON	0.19
				CI2	Control console room	0.12
				CI3	Patient waiting area	0.12
4	9^{O}04′36.144″ N	7^{O}23′54.916″ E	Gwarinpa	DI1	Examination room when X-ray machine is ON	4.15
				DI2	Control console room	0.15
				DI3	Patient waiting area	0.13
5	9^{O}02’27.724″N	7^{O}29′58.486″ E	Garki	EI1	Examination room when X-ray machine is ON	0.19
				EI2	Control console room	0.13
				EI3	Patient waiting area	0.12

Table 2: Outdoor exposure rate of some radiological facilities in FCT Abuja.

S/N	**Coordinate**		**Centre/Hospital**	**Sampling code**	**Exposure rate (μSv/hr)**
	Longitude	**Latitude**			
1	N9^{O}3′45.35964″	E7^{O}28′ 2.31032″	Wuse	AO1	0.150
				AO2	0.140
				Mean	**0.145**
2	N9^{o}5′12.58368″	E7^{O}28′ 5319552″	Maitama	BO1	0.140
				BO2	0.130
				Mean	**0.135**
3	N9^{O}2′46.27932″	E7^{O}31′25.02552″	Asokoro	CO1	0.150
				CO2	0.130
				Mean	**0.140**
4	N9^{O}4′36.144.48″	E7^{O}23′54.91644″	Gwarinpa	DO1	0.150
				DO2	0.130
				Mean	**0.140**
5	N9^{O}22.27724″	E7^{O}29′58.48688″	Garki	EO1	0.150
				EO2	0.140
				Mean	**0.145**

Table 3: Radiological hazard parameters for Indoor background radiation level of some radiological facilities in FCT Abuja.

Centre	Sampling Code	ADR (nGy/hr)	AEDE (mSv/yr)	ELCR
Wuse	AI1	4650	22.81	79.81
	AI2	190	0.93	3.26
	AI3	120	0.59	2.06
	Mean	1653	8.11	28.38
Maitama	BI1	240	1.18	4.12
	BI2	110	0.54	1.89
	BI3	120	0.59	2.06
	Mean	156.7	0.77	2.69
Asokoro	CI1	190	0.93	3.26
	CI2	120	0.59	2.06
	CI3	120	0.59	2.06
	Mean	143.3	0.66	2.46
Gwarinpa	DI1	4150	20.36	71.25
	DI2	150	0.74	2.58
	DI3	130	0.64	2.23
	Mean	1476.6	7.25	25.4
Garki	EI1	190	0.93	3.26
	EI2	130	0.64	2.23
	EI3	120	0.59	2.06
	Mean	146.7	0.72	2.51

Table 4: Radiological parameter for Outdoor background radiation level of some radiological facilities in FCT Abuja.

Centre	Sampling code	ADR (nGy/hr)	AEDE (mSv)	ELCR
Wuse	AO1	150	0.18	0.64
	AO2	140	0.17	0.60
	AO3	120	0.15	0.52
	Mean	136.7	0.17	0.59
Maitama	BO1	140	0.17	0.60
	BO2	130	0.16	0.56
	BO3	120	0.15	0.52
	Mean	130	0.16	0.56
Asokoro	CO1	150	0.18	0.64
	CO2	130	0.16	0.56
	CO3	110	0.13	0.47
	Mean	130	0.16	0.56
Gwarinpa	DO1	150	0.18	0.64
	DO2	130	0.16	0.56
	DO3	120	0.15	0.52
	Mean	133.3	0.16	0.57
Garki	EO1	150	0.18	0.64
	EO2	140	0.17	0.60
	EO3	130	0.16	0.56
	Mean	14	0.17	0.6

evident from the result that the outdoor absorbed those is far less than the indoor absorbed dose.

The mean indoor annual effective dose equivalent for the five radiological centres varied in the range of value of 0.52 to 8.11 mSv/yr. The maximum was observed in centre A and the minimum was observed in centre C (Asokoro). The indoor annual effective dose in centre B (Maitama), centre C (Asokoro) and Centre E (Garki) were lower than the recommended standard of 1 mSv/y, while the indoor annual effective dose for centre A (8.1 mSv/yr) and centre D (7.25 mSv/yr).This inconsistent might due to improper shielding in the diagnostic region of the hospitals. The outdoor annual effective dose is lower than the indoor annual effective dose this is within the recommended standard of a Unity as recommended by UNSCEAR [15].

The mean indoor excess life cancer risk for centre A to E ranged from 1.83 to 78.81. The Maximum value was observed in centre A (78.81) and the minimum value was observed in centre B (2.69). The estimated value for excess life cancer risk from centre A to E exceed the recommended standard of 1 by UNSCEAR. The outdoor annual effective dose is within the recommended standard.

4 Conclusions

The indoor and outdoor radiation exposure level investigated in this study is well within the recommended dose limits and the world average value reported by ICRP and UNSCEAR. Generally, the study shows that the faciliies investigated are radiologically safe however the background radiation level may pose risk of cancer that is not immediate on individual working in the facilities. The results from this study provides the radiological baseline information for the assessment of facilities in foreseeable near future.

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