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Assessment of Indoor and Outdoor Radiation Exposure in Nasarawa General Hospital, Nasarawa State, Nigeria

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Abstract: Radiation has been found to be beneficial on one hand and harmful on the other hand and is encountered in everyday activities in various forms and different intensities. Some of the harmful effects are: cancer, cataract, gene mutation destruction of bones and blood cells and it can cause the death of an individual This work therefore aimed at investigating the indoor and outdoor background radiation General Hospital Nasarawa, Nasarawa State, Nigeria using a hand held Inspector Alert Nuclear Radiation Monitor. A total of 10 offices were surveyed and the results obtained showed that the mean indoor and outdoor annual effective dose rate varies from 0.011 mSv/y (indoor) at LR (Laboratory Room) and 0.03 mSv/y (outdoor) at RR (Record Room) and LR (Laboratory Rom) to 0.36 mSv/y (indoor) at EA (Accident and Emergency) and 0.09 mSv/y (outdoor) at EA (Accident and Emergency) with an average value of 0.19 mSv/y and 0.05 mSv/y for indoor and outdoor respectively. The evaluated results for indoor and outdoor excess lifetime cancer risk at different offices of the Nasarawa general hospital. The mean indoor and outdoor excess lifetime cancer risk varies from 0.39×10^{-3} (indoor) at LR (Laboratory Room) and 0.11×10^{-3} (outdoor) at RR (Record Room) and LR (Laboratory Rom) to 1.26×10^{-3} (indoor) at EA (Accident and Emergency) and 0.32×10^{-3} (outdoor) at EA (Accident and Emergency) with an average value of 0.67×10^{-3} and 0.18×10^{-3} for indoor and outdoor respectively. Base on the aforementioned findings, it was deduced that radiation levels are within the permissible radiation limit as stipulated by the ICRP and UNSCEAR of 2.4 mSv/yr and thus, general Hospital Nasarawa is radiologically safe.

Keywords: Indoor and Outdoor, Background Radiation, Equivalent Dose, Effective Dose, Inspector Alert Nuclear Radiation Monitor.

1 Introduction

Radiation has been found to be beneficial on one hand and harmful on the other hand and is encountered in everyday activities in various forms and different intensities. Some of the harmful effects are: cancer, cataract, gene mutation destruction of bones and blood cells and it can cause the death of an individual as reported by [1]. Materials used for building (soil and rock) are major sources of radiation exposure to the population and also a means of migration for the transfer of radionuclide into the environment. Radon gas from the earth crust is the most abundant source of natural radiation in the environment. The radioactive disintegration of uranium-238 produces 222Rn which in turn decays with a half-life of 3.82 days according to [2]. As it is inhaled, it penetrates into the lungs and the continuous deposition and penetration of such high energy particles through the lungs leads to tissue damage and mutation which leads to incidence of lung cancer as in [3].The International Commission on Radiation Protection (ICRP) in 1990 set a worldwide annual equivalent dose rate limit of exposure to ionizing radiation to 1mSv/yr for the protection of human beings and wildlife as reported by [4] while the average effective dose rate limit of 2.4mSv/yr was set by the United Nation Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) for most indoor facilities such as research laboratories, conference halls, lecture venues, offices, etc. according to [5]. Previous studies have shown that areas with high background radiation are found in Yangjiang, China; Kerele, India; and Ramsar, Iran as in [6]; as well as in Asia, maximum outdoor measurement was recorded in Malaysia and the

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maximum indoor measurement was recorded in Hong Kong and Iran as reported by [7]. In Nigeria, outdoor background ionizing radiation profile has received much attention than indoor background ionizing radiation, even though studies have established the presence of dangerous background ionizing radiation within buildings. Indoor background ionizing radiation investigation is also important, because due to changes in lifestyle people spend more time indoors than outdoors. Surveys taken by the World Health Organization (WHO) and the International Commission on Radiological Protection (ICRP) show that residents of temperate climates spend only about 20% of their time outdoors and 80% indoors (their homes, offices, schools and other buildings) according to [8]. The implication of this statistics is obvious; the probability of exposure to dangerous radiation is higher indoors than outdoors as in [9]. Studies of the same kind have been conducted in different parts of Nigeria to measure the natural radiation level but there had never been evidence of research to measure the natural radiation level in General Hospital Nasarawa. This work will therefore investigate the indoor and outdoor background radiation General Hospital Nasarawa, Nasarawa State, Nigeria using a hand held Inspector Alert Nuclear Radiation Monitor.

2 Materials and Methods

2.1 Materials

The indoor and outdoor background radiations of Nasarawa General Hospital were surveyed using Inspector Alert Nuclear Radiation Meter. Biro and exercise book was used to record all dada taken from the study areas.

2.2 Method

2.2.1 The Study Area

Nasarawa is a Local Government Area in Nasarawa State, Nigeria. Its headquarters are in the town of Nasarawa, located at $8^0$32'N $7^0$42'E, with a population of 30,949 (2016). The Local Government area has an area of 1,600 km^2 and a population of 189,835 at the 2006 census.

2.2.2 Method Data Collection

The radiation meter was held one meter above the ground to capture the average exposure level (height) of the human body and oriented vertically upward during the measurement of readings so as to expose the window of the device to incoming radiation. The effective dose readings were taken in milliRöentgen per hour (mR/hr) directly from the display screen of the radiation meter. The results were then converted to micro-Sievert per hour (µSv/hr) and then finally converted to micro-Sievert per year (µSv/yr).

2.2.3 Sample Population

Ten offices were selected within the study area and in each of the offices. Outdoor background radiation readings were taken in open fields that are away from buildings and Indoor measurements were conducted inside the buildings. To account for errors in the data, ten readings were taken, five indoors and five outdoors in each sample area and the standard deviation of each data was obtained.

2.2.4 Method of Data Analysis

As recommended by [10], indoor and outdoor occupancy factors are 0.8 and 0.2 respectively. This occupancy factor is the proportion of the total time during which an individual is exposed to a radiation field. Eight thousand seven hundred and sixty hours per year (8760hr/yr) were used. Equation (1) converts from Gamma Activity in milliRöentgen per hour to Exposure Dose Rate in micro – Sievert per hour, equation (2) converts the Exposure Dose Rate in micro – Sievert per hour to Indoor Annual Effective Dose Rate in milliSievert per year, equation (3) converts the Exposure Dose Rate in micro – Sievert per hour to Outdoor Annual Effective Dose Rate in milliSievert per year, equation (4) evaluates the Indoor Excess Lifetime Cancer Risk, while equation (5) evaluates the Outdoor Excess Lifetime Cancer Risk.

$$10 \text{ mR/hr (GA)} = 1 \text{ µSv/hr (EDR)} \quad (1)$$

$$\text{IAEDR mSv/yr} = (\text{EDR}) \times 8760 \text{ hr/yr} \times 0.8 \div 1000 \quad (2)$$

$$\text{OAEDR mSv/yr} = (\text{EDR}) \times 8760 \text{ hr/yr} \times 0.2 \div 1000 \quad (3)$$

$$\text{IELCR} = \text{IAEDE} \times \text{DL} \times \text{RF} \quad (4)$$

$$\text{OELCR} = \text{OAEDE} \times \text{DL} \times \text{RF} \quad (5)$$

3 Results and Discussion

3.1 Results

The row data gotten from the Nasarawa general hospital were presented in table 1.

Table 1 Data Collected from General Hospital Nasarawa.

Sample Points	Sample Code	GA (mR/h)
XR	P1	0.16
	P2	0.77
	P3	0.27
	P4	0.24
DO	P1	0.17
	P2	0.69
	P3	0.12
	P4	0.13
RR	P1	0.32
	P2	0.11
	P3	0.24
	P4	0.10
LR	P1	0.07
	P2	0.09

	P3	0.10
	P4	0.36
AER	P1	0.10
	P2	0.97
	P3	0.48
	P4	0.49

Where XR, DO, RR, LR and EA are X-Ray Room, Doctor's Office, Record Room, Labour Room and Accident and Emergency Room respectively.

Table 1 Data Collected from General Hospital Nasarawa.

Sample Points	Sample Code	GA (mR/h)
NO	P1	0.11
	P2	0.80
	P3	0.06
	P4	0.07
CW	P1	0.61
	P2	0.04
	P3	0.09
	P4	0.05
FW	P1	0.64
	P2	0.09
	P3	0.09
	P4	0.06
MW	P1	0.27
	P2	0.33
	P3	0.04
	P4	0.46
PR	P1	0.03
	P2	0.43
	P3	0.54
	P4	0.15

Where NO, CW, FW, MW and PR are Nurses Office, Children's Ward, Female Ward, Male Ward and Pharmacy Room respectively.

3.1.1 Results Analysis

Equations (1) – (5) were used to evaluate the Exposure Dose Rate (EDR), Indoor Annual Effective Dose Rate (IAEDR), Outdoor Annual Effective Dose Rate (OAEDR), Indoor Excess Lifetime Cancer Risk (IELCR) and Outdoor Excess Lifetime Cancer Risk (OELCR) and are presented in table 2.

general hospital. The mean gamma activity varies from 0.16 mR/h at LR (Laboratory Room) to 0.51 mR/h at EA (Accident and Emergency) with an average value of 0.27 mR/h.

Table 2 also presented the evaluated results for exposure dose rate at different offices of the Nasarawa general hospital. The mean exposure dose rate varies from 0.016 µSv/h at LR (Laboratory Room) to 0.051 µSv/h at EA (Accident and Emergency) with an average value of 0.027 µSv/h.

Similarly, table 2 presented the evaluated results for indoor and outdoor annual effective dose rate at different offices of the Nasarawa general hospital. The mean indoor and**Table 2:** Indoor and Outdoor Hazard Parameters in General Hospital Nasarawa.

Room Code	GA mR/h	EDR µSv/h	IAEDR mSv/y	OAEDR mSv/y	IELCR×10^{-3}	OELCR×10^{-3}
XR	0.36	0.036	0.25	0.06	0.88	0.21
DO	0.28	0.028	0.20	0.05	0.70	0.18
RR	0.19	0.019	0.13	0.03	0.46	0.11
LR	0.16	0.016	0.11	0.03	0.39	0.11
AER	0.51	0.051	0.36	0.09	1.26	0.32
NO	0.26	0.026	0.18	0.05	0.63	0.18
CW	0.20	0.020	0.14	0.04	0.49	0.14
FW	0.22	0.022	0.15	0.04	0.53	0.14
MW	0.28	0.028	0.20	0.05	0.70	0.18
PR	0.29	0.029	0.20	0.05	0.70	0.18
Mean	0.27	0.027	0.19	0.05	0.67	0.18

outdoor annual effective dose rate varies from 0.011 mSv/y (indoor) at LR (Laboratory Room) and 0.03 mSv/y (outdoor) at RR (Record Room) and LR (Laboratory Rom) to 0.36 mSv/y (indoor) at EA (Accident and Emergency) and 0.09 mSv/y (outdoor) at EA (Accident and Emergency) with an average value of 0.19 mSv/y and 0.05 mSv/y for indoor and outdoor respectively.

Finally, table 2 presented the evaluated results for indoor and outdoor excess lifetime cancer risk at different offices of the Nasarawa general hospital. The mean indoor and outdoor excess lifetime cancer risk varies from 0.39 × 10^{-3} (indoor) at LR (Laboratory Room) and 0.11 × 10^{-3} (outdoor) at RR (Record Room) and LR (Laboratory Rom) to 1.26 × 10^{-3} (indoor) at EA (Accident and Emergency) and 0.32 × 10^{-3} (outdoor) at EA (Accident and Emergency) with an average value of 0.67 × 10^{-3} and 0.18 × 10^{-3} for indoor and outdoor respectively.

3.1.1.1 Comparison of Results with United Nation Scientific Committee on Effect of Atomic Radiation (UNSCEAR)

In this section, the results presented in Table 2 are used to plot charts in order to compare the results of the present study with United Nation Scientific Committee on Effect of Atomic Radiation.

3.1.1.2 Comparison of Indoor and Outdoor Annual Effective Dose Rate with UNSCEAR

The data presented in Table 2 was used to plot a chart in order to compare the result of indoor and outdoor annual effective dose rate with indoor and outdoor annual effective dose rate with United Nation Scientific Committee on Effect of Atomic Radiation. This chart is presented in Figure 1.

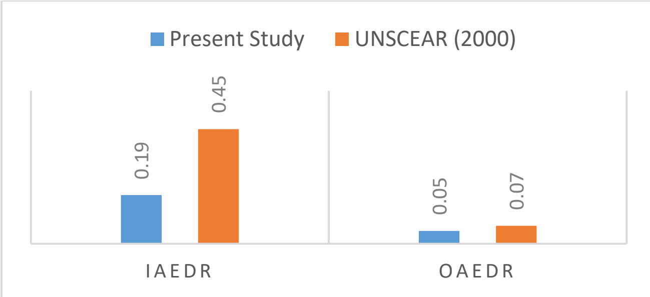

Fig.1: Indoor and Outdoor Annual Effective Dose Rate with UNSCEAR

It is observed from Figure 1 that the Indoor and Outdoor Annual Effective Dose Rate for all the areas is found to be lower than that of United Nation Scientific Committee on Effect of Atomic Radiation.

3.1.1.3 Comparison of Indoor and Outdoor Excess Lifetime Cancer Risk with UNSCEAR.

The data presented in Table 2 was used to plot a chart in order to compare the result of excess lifetime cancer risk with United Nation Scientific Committee on Effect of Atomic Radiation. This chart is presented in Figure 2.

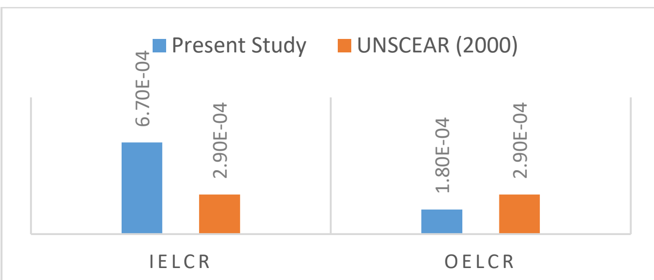

Fig.2: Indoor and Outdoor Excess Lifetime Cancer Risk with UNSCEAR

It is observed from Figure 1 that the Indoor Excess Lifetime Cancer Risk was found to be higher compare to United Nation Scientific Committee on Effect of Atomic Radiation while Outdoor Excess Lifetime Cancer Risk was found to be lower compare to United Nation Scientific Committee on Effect of Atomic Radiation.

3.2 Discussion

On indoor and outdoor annual effective dose rate, finding of this study have revealed that the mean indoor and outdoor annual effective dose rate for Nasarawa general hospital are 0.19 mSv/y and 0.05 mSv/y. Which implies that the level of radiation in those areas in terms of indoor and outdoor annual effective dose rate is less than 0.45 mSv/y and 0.07 mSv/y as agreed by Basic Safety Standard (BSS) and may not cause radiological hazard to the public and workers. This finding is in line with the finding of [11] and [12]. But not in line with the findings of [9] who investigated the indoor and outdoor ionizing radiation level at Kwali General Hospital, Abuja Nigeria using a well calibrated Geiger Muller counter and found the average annual effective dose rate as 0.750± 0.020 mSv/yr and 0.189±0.005 mSv/yr for indoor and outdoor measurements respectively. Also not in line with the findings of [8] who assessed the background ionizing radiations at Biochemistry, Chemistry, Microbiology and physics laboratories of Plateau State University Bokkos using Gamma-scout Radiometer and found the mean annual effective dose rate of the laboratories for indoor and outdoor to be 1.54 mSv/yr and 0.44 mSv/yr respectively.

On indoor and outdoor excess lifetime cancer risk, finding of this study have revealed that the mean indoor and outdoor excess lifetime cancer risk for Nasarawa general hospital are 0.67×10^{-3} and 0.18×10^{-3}. Which implies that the level of radiation in those areas in terms of indoor excess lifetime cancer risk is greater than 0.29×10^{-3} as agreed by Basic Safety Standard (BSS) and may cause radiological hazard to the public and workers, while outdoor excess lifetime cancer risk was found to be less than 0.29×10^{-3} as agreed by Basic Safety Standard (BSS) and may not cause radiological hazard to the public and workers. This finding is in line with the finding of [11] and [12-16]. But not in line with the findings of [9] who investigated the indoor and outdoor ionizing radiation level at Kwali General Hospital, Abuja Nigeria using a well calibrated Geiger Muller counter and found the average excess lifetime cancer risk as 2.63×10^{-3} and 0.66×10^{-3} for indoor and outdoor measurements respectively. Also not in line with the findings of [8] who assessed the background ionizing radiations at Biochemistry, Chemistry, Microbiology and physics laboratories of Plateau State University Bokkos using Gamma-scout Radiometer and found the mean excess lifetime cancer risk of the laboratories for indoor and outdoor background radiation level to be 1.54 mSv/yr and 0.44 mSv/yr respectively.

4 Conclusions

To quantify and evaluate the damages done by radiation is not a simple problem. This work shows the preliminary net that is chosen to analyze the Nasarawa general hospital. From the findings presented, it can be concluded that the background radiation in Nasarawa general hospital is not an issue of health concern except when accumulated over long period of time which may cause cancer to the indoor members on approximately seventy years of exposure. Therefore, this is an indication that the Nasarawa general hospital may not appear to have much impact on the radiation burden of the environment. It is therefore recommended that regular radiation monitoring exercise should be conducted on the area from time to time in order to checkmate both the workers and the members of public from high radiation exposure.

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