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Indoor and Outdoor Effective Doses from Background Ionizing Radiation in Private Medical Diagnostic Centers in Bori, Rivers State

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Abstract
Humans are exposed to radiation that is everywhere in the environment without their knowledge and the exposure to natural background radiation is an unavoidable event on earth. An *in situ* measurement of the indoor and outdoor background ionizing radiation in Life hospital and Rayfield diagnostic center, Bori of Rivers State, Nigeria was carried out using two radiation meters. Each of these hospitals was divided into 10 sampling points where five readings were taken in order to have a reliable data. The mean indoor and outdoor annual effective dose of Life hospital were 0.93 ± 0.13mSv/yr and 0.23 ±0.01 mSv/yr respectively; and that of Rayfield diagnostic center were 1.22 ± 0.10mSv/yr and 0.26 ±0.02 mSv/yr respectively. The radiation levels in both hospitals were found to be slightly higher than the safe limit. The reduction coefficient calculated from the dose equivalent exceeded the limit of 1.5 at x-ray rooms of the two hospitals. These results of *in-situ* indoor and outdoor background radiation of the two hospitals in Bori show that the radiological operations did enhance the natural background radiation of the area. Therefore no immediate health hazard associated with radiation exposure in the area is expected but long term exposure could lead to radiation induced sickness and the result would serve as a baseline data for the study area.
Keywords*: Indoor, outdoor, background radiation, effective dose, reduction coefficient, Bori.*

1. Introduction

Human beings are always exposed to radiation in their environment without knowing it and the exposure to natural background radiation is unavoidable event in human environment. Health hazards associated with exposure to ionizing radiation includes; direct chromosomal transformation, indirect free radical formation, cataractogenesis, cancer induction, bone necrosis (Norman, 2008).

Medical diagnostic practices in Nigeria has improved in their technological knowhow that even microstructural defects can be identified through the use of imaging devices that uses ionizing radiation to detect hidden structures. This invention in medical fields also has some negative impact on the radiological burden of the immediate environment and the natural background ionizing radiation of the area can be enhanced.

The main sources of natural radiation are cosmic rays, primordial radionuclide from the earth' crust, ingested radionuclide and lung irradiation due to radon (^{222}Rn) and Thoron (^{220}Rn) in air, which are classified into external and internal sources (Termizi Ranli et al., 2014). The practice has been to ensure that human exposure to these radiations is as low as reasonably achievable which is known as ALARA principle.

Exposure to natural radiation from the environment is higher than the ones from man induced sources (technology) put together (UNSCEAR, 2010) and the international Atomic Energy Agency (IAEA) estimated that dose contribution to the environment shows that over 85% of the background radiation received by man is derived from natural sources while the remaining 15% is from the artificial sources (Sadia and Agba, 2011).

In Nigeria, studies have been conducted in various part of the country to measure the natural background radiation level around government hospitals. Measurement of background ionizing radiation level at Braithwaite Memorial specialist hospital, Port Harcourt was done. Indoor annual equivalent dose ranged from 0.14 ±0.01μSvhr^{-1} to 0.16±0.01μSvhr^{-1} (Okoye and Avwiri, 2013). It was also reported that the indoor equivalent dose of 2.063mSvyr^{-1} was recorded at Skane Radiological centre Jos, while the outdoor of the same diagnostic center recorded 1.84mSvy^{-1}(Jwanbot et al., 2012). In Plateau State Specialist hospital, indoor equivalent dose of radiation was 2.44msvyr^{-1} and outdoor radiation dose equivalent was 2.002mSvyr^{-1} (Jwanbot et al., 2012).
The present work aims at evaluating the indoor and outdoor effective dose of background radiation in two private diagnostic centres , Bori in order to compare the radiological burden of private and government hospitals in Rivers state. The result of this survey will serve as baseline data for future research.

2. Study Area

Geographically Bori is located at Latitude 4^{o} 40′22″N and longitude 7^{o} 22′ 13″E. Bori is a city in Khana Local Government Area of Rivers State, southern Nigeria (Human Right Watch, 2007). It is the headquarter of the Ogoni people and serve as commercial center for the Ogoni, Andoni, Opobo Annang and other ethnic nationalities of the Niger Delta Benue Congo as shown in Figure 1. Life hospital and Rayfield diagnostic center are located at Bori central. Both hospitals are equipped with medical imaging equipment like x-ray machine, CT scanner Ultra sound scanner etc. X-ray machine generates radiation during its normal operation.

Fig. 1: Map of study area

3. Materials and Method

The instrument used to perform the environmental radiation survey is Radalert meter. The Radalert meter is a general purpose survey meter that measures alpha, beta, gamma and x-ray radiation. It has proven to be useful in medical, nuclear, mining, metal scrap and laundry industries. The Radalert radiation meter sets a new standard in portable Geiger counter performances and functionality. It is calibrated across a wide scale (0.01 up to 1000.00 µSv/hr). Global Positioning System (GPS) was used to measure the geographical coordinates of the sampling points.

Ten sampling points (A_1--A_{10}) were arbitrarily selected within each hospital (medical diagnostics center) areas in Bori. Outdoor background radiation readings were taken around the hospital premises away from the building. Indoor measurements were done inside the hospitals rooms and corridors. Measurement at each hospital was performed by holding the Radalert at 1m above to ground surface. Each measurement was taken three times and the average taken to represent the value for background radiation level of the hospital and standard deviations calculated to account for the errors in the measurement.

4. Estimation of Effective dose from exposure dose rate

The annual effective dose rate for both the indoor and outdoor data from each hospital were computed using equation (1) and (2) as stipulated by UNSCEAR (1988).

$E_i = D_i$ (mSv/hr) x 8760hrs / yr x 0.8 ------- (1)

$E_o = D_o$ (mSv/hr) x 8760hrs / yr x 0.2 -------- (2)

Where E_o is the outdoor annual effective dose equivalent (mSv yr^{-1}) and E_i is the indoor annual effective dose rate equivalent (mSv yr^{-1}). D_i is the indoor exposure rate (mSv/h) and D_o is the outdoor exposure rate (mSv/h) ,0.8 and 0.2 are the indoor and outdoor occupancy factors respectively.

5. Results:

Table 1 presents the equivalent dose rate (meter mean readings) and the annual effective dose equivalent for life hospital Bori. The table presents both the indoor and outdoor background radiation in life hospital, Bori. Table 2 presents the same parameter for Ray field diagnostic center, Bori. The reduction coefficient that is indoor-to-outdoor ratio (Golani et al., 2011) was computed for each of the hospitals from which the mean indoor-to-outdoor ratio for the hospital areas was computed for comparison with the 1.5 set by UNSCEAR (2010). The results indicates that in life hospital, the sampling points with maximum indoor and outdoor radiations are A_8 (X-ray room door) and A_1 (security post) respectively (Figure 2). The high value recorded at the entrance of the

X-room could be as a result of scattered X-radiations during medical diagnosis. In comparison, the annual effective doses in these areas are higher than the 1.0 mSv limit set by UNSCEAR.
Sample areas with maximum indoor and outdoor radiation in Ray field diagnostic centers are R_7 and R_4. Incidentally, R_7 recorded the maximum value of 0.30mSv/hr for indoor radiation and 0.17mSv/hr for outdoor which corresponded to an indoor an annual effective dose of 2.10 mSv and outdoor annual effective dose of 1.76mSv as shown in figure 3. The X-ray room recorded this maximum indoor radiation which could be attributed to scattered radiations from X-ray machine during diagnoses and the anomalous presence of alpha particle, beta particles and gamma radiations after a spontaneous decay of relevant atoms emanating from previous oil and gas exploration activities. This may expose or reconcentrate radiogenic minerals like zircon, monazite, uranite, pitchblende potassium, feldspars, and biotite from the ubiquitous silicic host rocks (granites, syerites, granodiorites, diorites and building (earth) materials of the health centres. Nevertheless, the radon levels in areas R_7 and R_4 also enhanced the background radiations of the two medical diagnostic centers. The mean effective doses calculated in the hospitals under study are slightly higher than the international minimum standard for the public.

The measured reduction coefficient which is the ratios of the indoor and outdoor ambient dose equivalent rates were 1.89 and 1.76 at R_7 and R_3 for Ray field diagnostic centre and 1.5 at A_8 in life hospital which is relatively higher than 1.5 recommended by UNSCEAR (2010). The results are in consonance with previous works carried out in some Nigerian hospitals reported (Okoye and Avwiri, 2013, Jwanbot et al., 2012).
Since the mean effective dose equivalent is higher than the 1.0mSv annual effective dose for general public in the study area, exposure of the public to these radiations may pose significant health hazard and therefore regular and periodic monitoring of the background ionizing radiation level should be carried out to assess the health risk of staff, patients and the public. It is also recommended that routine equipment maintenance (i.e. X-ray machine & CT scanner) and compliance with operational regulation be implemented in both diagnostic centers. It is hoped that the result of this work will serve as a baseline data for future research.

Table 1: Indoor and Outdoor Background Radiation in Life Hospital

Area code	Sampling point	GPS reading	D_i ($mSvh^{-1}$)	D_0 ($mSvh^{-1}$)	$AEDE_i$ ($mSvy^{-1}$	$AEDE_0$ ($mSvy^{-1}$	R = D_i/D_o
A1	security	N04° 40′ 37.7″ E007°21′59.5″	0.15±0.01	0.17±0.01	1.05	0.30	0.88
A2	Garage	N04° 40′ 37.7″ E007°21′59.3″	0.10±0.01	0.15±0.01	0.70	0.26	0.67
A3	Water pump	N04° 40′ 37.2″ E007°21′58.9″	0.12±0.01	0.12±0.01	0.84	0.21	1.00
A4	Behind pump	N04° 40′ 37.2″ E007°21′59.0″	0.17±0.01	0.14±0.01	1.19	0.25	1.21
A5	Beside p. house	N04° 40′ 37.7″ E007°21′59.5″	0. 15±0.01	0.11±0.01	1.05	0.19	1.36
A6	Back of p. house	N04° 40′ 37.7″ E007°21′59.5″	0.09±0.02	0.14±0.01	0.63	0.25	0.64
A7	Power house	N04° 40′ 36.6″ E007°21′59.5″	0.12±0.01	0.09±0.01	0.84	0.16	1.33
A8	Dust bin site	N04° 40′ 36.5″ E007°21′59.5″	0.18±0.01	0.12±0.01	1.26	0.21	1.50
A9	Near dust bin	N04° 40′ 36.5″ E007°21′59.5″	0.15±0.01	0.14±0.01	1.05	0.25	1.07
A10	Entrance	N04° 40′ 37.8″ E007°21′59.0″	0.10±0.01	0.14±0.01	0.70	0.25	0.71

Table 2: Indoor and Outdoor Background Radiation in Rayfield Diagnostic Center

Area code	Sampling point	GPS reading	D_i ($mSvh^{-1}$)	D_0 ($mSvh^{-1}$)	$AEDE_i$ ($mSvy^{-1}$	$AEDE_0$ ($mSvy^{-1}$	R = D_i / D_o
R1	Gate entrance 1	N04° 40′ 23.4″ E007°22′20.0″	0.14±0.01	0.15±0.01	0.98	0.26	0.93
R2	Gate entrance 2	N04° 40′ 53.2″ E007°22′19.8″	0.13±0.01	0.17±0.01	0.91	0.30	0.76
R3	Garage	N04° 40′ 22.2″ E007°22′19.9″	0.17±0.01	0.09±0.01	1.19	0.16	1.89
R4	water pump	N04° 40′ 24.3″ E007°21′19.3″	0.23±0.01	0.16±0.01	1.61	0.28	1.44
R5	Small yard	N04° 40′ 24.4″ E007°22′18.7″	0. 17±0.01	0.17±0.01	1.19	0.30	1.00
R6	Near power house	N04° 40′ 24.4″ E007°22′18.5″	0.18±0.02	0.16±0.01	1.26	0.28	1.13
R7	Power house	N04° 40′ 24.4″ E007°22′18.2″	0.30±0.01	0.17±0.01	2.10	0.30	1.76
R8	Pharmacy section 1	N04° 40′ 24.6″ E007°22′17.4″	0.13±0.01	0.16±0.01	0.91	0.28	0.813
R9	Section 2	N04° 40′ 24.7″ E007°22′16.5″	0.11±0.01	0.10±0.01	0.77	0.17	1.10
R10	Reception	N04° 40′ 24.7″ E007°22′16.5″	0.18±0.01	0.14±0.01	1.26	0.25	1.29

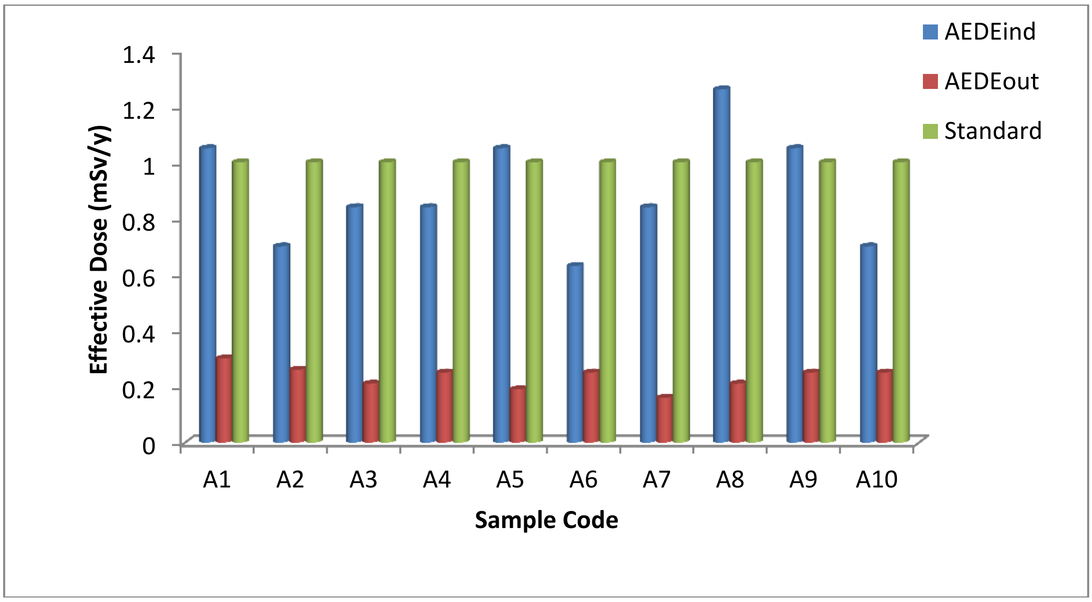

Fig. 2: Comparison of Indoor and outdoor Effective dose equivalent with standard [3] in Life hospital Bori.

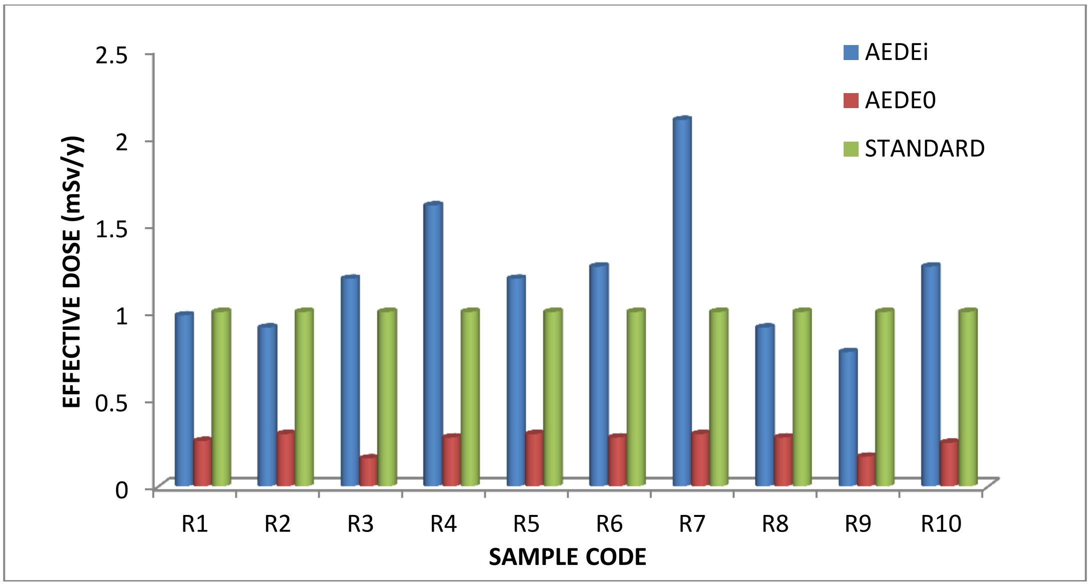

Fig. 3: Comparison of Indoor and outdoor Effective dose equivalent with standard [3] in Rayfield Diagnostic Center, Bori

5. Conclusion

The in-situ background radiation measurement in life hospital and Ray field diagnostic centre, all in Bori, Rivers state has been carried out for the first time using nuclear radiation meter. The radiation exposure rate of life hospital were slightly higher than ICRP safe levels of0.013mR/hr while than of Rayfield diagnostic center recorded high indoor exposure rate. The indoor radiation equivalent doses of the two hospitals were found to be higher than the outdoor radiation equivalent doses due to radiological diagnosis in both hospitals. The indoor exposure rates measured were compared with other results obtained from other hospitals in Nigeria which showed similar trend. The reduction coefficient calculated in both hospitals exceeded the limit only in radiological laboratory (X-ray rooms). Since the mean effective dose equivalent is higher than the 1.0mSv annual effective dose for general public in the study area, exposure of the public to these radiations may pose significant health hazard and therefore regular and periodic monitoring of the background ionizing radiation level should be carried out to assess the health risk of staff, patients and the public. The result shows that the normal background radiation level has been impacted by the radiological activities of both hospitals. The result provides the essential baseline information for the assessment of any environmental radioactivity of the area in future.

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