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Evaluation of Indoor Background Ionizing Radiation Profile in Some Hospitals in Jos, Plateau State-Nigeria

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Abstract

Certain types of building materials are known to be radioactive. Exposure to indoor ionizing radiation like exposure to any other type of ionizing radiation results in critical health challenges. An evaluation of the background ionizing radiation profile within the radiological departments of Skane Radiodiagnostic Centre, Plateau State Specialist Hospital, and their immediate neighbourhood were carried out. These hospitals also harbour a number of active radiation sources. The radiation levels were measured using gamma-scout (model GS2 with serial number A20). The radiation levels were: 2.063 mSv/yr for Skane Radiodiagnositic Centre indoor result and outdoor result was 1.848mSv/yr. For Plateau State Specialist Hospital indoor result was 2.444mSv/yr, outdoor result was 2.002mSv/yr.

Keywords: Radiation profile, Hospitals, Plateau State, Radiation sources and Gamma scout

1.0 Introduction

Background radiation is the radiation of man's natural environment, consisting of what comes from cosmic rays, the naturally radioactive elements of the earth and from within man's body (Ballinger, 1991). Apart from the naturally occurring radiation in the atmosphere and terrestrial deposits, human activities has gradually led to the increase of background ionising radiation(Patel,1988;Folland *et al,*1995).

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 important because:

i. Some of the materials used in the construction of buildings are known to be radioactive.

ii. Indoor air often contains the harmful radioactive gas, radon (^{222}Rn). Generally, indoor air has a higher concentration of radon than outdoor air.

iii. 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) (Chad-Umoren, 2007). The implication of this statistics is obvious; the probability of exposure to dangerous radiation is higher indoors than outdoors. Figures are not available for Nigeria; however, it is reasonable to expect that they could also be high.

Some specific localized studies on the radioactivity assessment in Nigerian environment include radionuclide content of some building materials used in Nigerian dwellings, baseline studies of terrestrial outdoor gamma dose rates levels in Nigeria(Farai and Jibiri,2000) and exposure levels around industrial area (Mokobia and Logun,2003,Funtua and Elegba,2005).

Indoor background ionizing radiation profiles for a building are, therefore, crucial since they enable us to assess the level of risk of exposure to the regular users of such buildings and the general population. It has been established that chronic exposure to an even low dose and a low dose rate of nuclear radiations from an irradiated building has the potential to induce cytogenetic damage in human beings (Mollah *et al.,* 1987).

Of particular concern for indoor background ionizing radiation is the incidence of the invisible, odourless, colourless radioactive gas ^{222}Rn which is a member of the Uranium radioactive series. Estimates show that of the 2.4mSv/yr annual exposure from all ionizing sources 40% is contributed by internal exposure to radon alone (Chad-Umoren , 2007). There is a strong correlation between radon exposure (inhalation) and the prevalence of lung cancer (UNSCEAR, 2000)

Radon-222results from the radioactivity of Uranium-238 and itself decays with a half-life of 3.82 days. When it is inhaled it penetrates into the lung. Its most dangerous daughters are the α emitters ^{218}Po and ^{214}Po which emits α particles with energy of 6.0MeV and 7.69MeV respectively. The continuous deposition and interaction of such high energy particles with the lung leads to its damage and the incidence of lung cancer. ^{222}Rn finds its way indoors through building materials, through diffusion and convection and through the soil under the building.

In this work the background ionizing radiation levels within the Radiology Departments of Plateau State Specialist Hospital Jos (PSSH), Skane Radiodiagnostic Centre (SRC), and their immediate environs are assessed to enable the determination of the level of risk to which staff, patients, and other people are exposed. This is needful because aside the regular sources of indoor background ionizing radiation mentioned earlier, the Radiology Departments of these hospitals, harbour a number of active radiation sources such as the x-ray machines. There will also be comparison of the background ionizing radiation level within and outside the radiological examination rooms of the selected hospitals, to internationally accepted standards.

2.0 Materials and Method

In collecting the data, gamma-scout was used. The background radiation were measured both indoor and outdoor of the selected hospitals. The data obtained indoors with the gamma-scout oriented vertically upwards. The data obtained outdoors with the gamma-scout oriented vertically upwards and also oriented vertically downwards towards the bare ground.

Two target areas were delineated (outline) for this work. These are the Radiology Departments of Plateau State Specialist Hospital (PSSH) and Skane Radiodiagnostic Centre (SRC) all in Jos metropolis. These were chosen for comparative purposes. To adequately cover the designated areas 20 readings were taken for indoors and outdoors in each area. The selection switch of the gamma-scout was adjusted to the right hand side (that is $\alpha + \beta + \gamma$) in order to detect the types of radiation in μSv/hr. The data measured were read on the display screen of the gamma-scout.

3.0 Results

Tables 1-6 below show the results obtained from the selected hospitals

3.1 Skane Radiodiagnostic Centre (SRC) Indoor Results of the Examination Room

Dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

3.2 *Outdoor Results*

Dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

3.3 *Plateau State Specialist Hospital (PSSH) Indoor Results of the Examination Room*

Dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

3.4 Outdoor Results

Dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

4.0 Discussion

From the results obtained of the mean dose equivalent of the two targeted areas, it shows that the background ionizing radiation level within these targeted areas is higher than outside of the immediate environment as seen below each table of data above. The minimum dose equivalent obtained from SkaneRadiodiagnostic Centre indoor results was 1.402 mSv/yr(0.16 μSv/hr) and the maximum was 2.540 mSv/yr (0.29 μSv/hr). The outdoor minimum dose equivalent when the gamma-scout sensor was oriented vertically upward was 1.402 mSv/yr (0.16 μSv/hr) and the maximum was 3.154 mSv/yr (0.36 μSv/hr). When the gamma-scout sensor was oriented vertically downward, the outdoor minimum dose equivalent was 1.402 mSv/yr(0.16 μSv/hr) and the maximum was 2.803 mSv/yr (0.32 μSv/hr). The minimum dose equivalent obtained from Plateau State Specialist Hospital indoor results was 1.402mSv/yr (0.16 μSv/hr) and the maximum was 3.241 mSv/yr (0.37 μSv/hr). The outdoor minimum dose equivalent when the gamma-scout sensor was oriented vertically upward was 1.402 mSv/yr (0.16 μSv/hr) and the maximum was 2.540 mSv/yr (0.29 μSv/hr). The outdoor minimum dose equivalent when the gamma-scout sensor was oriented vertically downward was 1.314 mSv/yr(0.15 μSv/hr) and the maximum was 2.716 mSv/yr (0.31 μSv/hr). These minimum and maximum radiation levels indicate that the background radiation was not evenly distributed in all points of measurement. There are possible reasons for the maximum values for the indoor dose equivalent may include the following: The anomalous presence of the energetic particles (α and β) and γ –radiation after a spontaneous decay of relevant atoms, emanate from previous mining activities. This may expose or reconcentrate radiogenic minerals like zircon, monazite, uranite, pitchblende potassium, feldspars, biotite from the ubiquitous silicic host rocks (granites, syerites, granodiorites, diorites e.t.c) and building (earth) materials of the health centres and also the presence of radon gas in the air within the hospitals. These high radiation levels may causes ailments such as gene mutation, destruction of bone n cancer, cataract and a host of others.

5.0 Recommendation

i) Regular and periodic monitoring of the background ionizing radiation level to be carried out to assess the health risks of staff, patients and the general public which may be exposed to in the future.

ii). In a subsequent work, the evaluation of indoor background
Ionizing radiation of other hospitals, apart from those in this research work should be carried out.

iii).In addition to the building materials, proper environmental impact assessment should be ascertained before sitting relevant health centres and the like.

6.0 Conclusion

This work shows that there was a higher level of harmful ionizing radiation within the two hospitals than outside, i.e. around their immediate environs. However, staff, patients, and others that use the hospitals radiology departments, their immediate neighbourhood are exposed to significant health risks as the values of the mean dose equivalent in this work are consistently more than the1mSv/yr the Internationally acceptable limit for general public (UNSCEAR, 2000).

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Table 1: Upward orientation of Gamma-scout sensor of SkaneRadiodiagnostic Centre Indoor Results.

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.27	0.03	11.11	2.365	0.302	12.77
0.29	0.05	17.24	2.540	0.477	18.78
0.25	0.01	4.00	2.190	0.127	5.80
0.25	0.01	4.00	2.190	0.127	5.80
0.20	-0.04	20.00	1.752	-0.311	17.75
0.25	0.01	4.00	2.190	0.127	5.80
0.26	0.02	7.69	2.278	0.215	9.44
0.23	-0.01	4.35	2.015	-0.048	2.38
0.16	-0.08	50.00	1.402	-0.661	47.15
0.25	0.01	4.00	2.190	0.127	5.80
0.22	-0.02	9.09	1.927	-0.136	7.06
0.21	-0.03	14.29	1.840	-0.223	12.12
0.22	-0.02	9.09	1.927	-0.136	7.06
0.23	-0.01	4.35	2.015	-0.048	2.38
0.27	0.03	11.11	2.365	0.302	12.77
0.23	-0.01	4.35	2.015	-0.048	2.38
0.23	-0.01	4.35	2.015	-0.048	2.38
0.25	0.01	4.00	2.190	0.127	5.80
0.23	-0.01	4.35	2.015	-0.048	2.38
0.21	-0.03	14.29	1.840	-0.223	12.12

Mean dose equivalent, DE=2.063 mSv/yr

Table 2: Upward orientation of Gamma-scout sensor of Skane Radiodiagnostic Centre Outdoor Results.Dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.16	-0.05	31.25	1.402	-0446	31.81
0.29	0.08	27.59	2.540	0.692	27.24
0.23	0.02	8.70	2.015	0.167	8.29
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.23	0.02	8.70	2.015	0.167	8.29
0.20	-0.01	5.00	1.752	-0.096	5.48
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.22	0.01	4.55	1.927	0.079	4.10
0.19	-0.02	10.53	1.664	-0.184	11.06
0.36	0.15	41.67	3.154	1.306	41.41
0.30	0.09	30.00	2.628	0.780	29.68
0.24	0.03	12.50	2.102	0.254	12.08
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18
0.18	-0.03	16.67	1.577	-0.271	17.18

Mean dose equivalent, DE=1.848 mSv/yr

Table 3: Downward orientation of Gamma-scout sensor of Skane Radiodiagnostic Centre Outdoor Results.

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.21	-0.01	4.76	1.840	-0.096	5.22
0.18	-0.04	22.22	1.577	-0.359	22.76
0.21	-0.01	.4.76	1.840	-0.096	5.22
0.18	-0.04	22.22	1.577	-0.359	22.76
0.23	0.01	4.35	2.015	0.079	3.92
0.25	0.03	12.00	2.190	0.254	11.60
0.18	-0.04	22.22	1.577	-0359	22.76
0.21	-0.01	4.76	1.840	-0.096	5.22
0.29	0.07	24.14	2.540	0.604	23.78
0.21	-0.01	4.76	1.840	-0.096	5.22
0.18	-0.04	22.22	1.577	-0.359	22.76
0.31	0.09	29.03	2.716	0.780	28.72
0.32	0.10	31.25	2.803	0.867	30.93
0.23	0.01	4.35	2.015	0.079	3.92
0.18	-0.04	22.22	1.577	-0359	22.76
0.23	0.01	4.35	2.015	0.079	3.92
0.16	-0.06	37.50	1.402	-0534	38.09
0.25	0.03	12.00	2.190	0.254	11.60
0.23	0.01	4.35	2.015	0.079	3.92
0.18	-0.04	22.22	1.577	-0.359	22.76

Mean dose equivalent, DE=1.936 mSv/yr

Table 4: Upward orientation of Gamma-scout sensor of Plateau State Specialist Hospital Indoor Results.

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.23	-0.05	21.74	2.015	-0.429	21.29
0.29	0.01	3.45	2.540	0.096	3.78
0.28	0.00	0.00	2.453	0.009	0.37
0.29	0.01	3.45	2.540	0.096	3.78
0.33	0.05	15.15	2.891	0.447	15.46
0.30	0.02	6.67	2.628	0.184	7.00
0.27	-0.01	3.70	2.365	-0.079	3.34
0.31	0.03	9.68	2.716	0.272	10.01
0.37	0.09	24.32	3.241	0.797	24.59
0.25	-0.03	12.00	2.190	-0.254	11.60
0.34	0.06	17.65	2.978	0.534	17.93
0.21	-0.07	33.33	1.840	-0.604	32.83
0.30	0.02	6.67	2.628	0.184	7.00
0.16	-0.12	75.00	1.402	-1.042	74.32
0.25	-0.03	12.00	2.190	-0.254	11.60
0.23	-0.05	21.74	2.015	-0.429	21.29
0.32	0.04	12.50	2.803	0.359	12.81
0.32	0.04	12.50	2.803	0.359	12.81
0.26	-0.02	7.69	2.278	-0.166	7.29
0.27	-0.01	3.70	2.365	-0.079	3.34

Mean dose equivalent, DE= 2.444 mSv/yr

Table 5: Upward orientation of Gamma-scout sensor of Plateau State Specialist Hospital Outdoor Results.

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.24	0.01	4.17	2.102	0.100	4.76
0.27	0.04	14.81	2.365	0.363	15.35
0.20	-0.03	15.00	1.752	-0.250	14.27
0.27	0.04	14.81	2.365	0.363	15.35
0.25	0.02	8.00	2.190	0.188	8.58
0.23	0.00	0.00	2.015	0.013	0.65
0.20	-0.03	15.00	1.752	-0.250	14.27
0.23	0.00	0.00	2.015	0.013	0.65
0.17	-0.06	35.29	1.489	-0513	34.45
0.16	-0.07	43.75	1.402	-0.600	42.80
0.24	0.01	4.17	2.102	0.100	4.76
0.23	0.00	0.00	2.015	0.013	0.65
0.17	-0.06	35.29	1.489	-0.513	34.45
0.18	-0.05	27.78	1.577	-0.425	26.95
0.25	0.02	8.00	2.190	0.188	8.58
0.25	0.02	8.00	2.190	0.188	8.58
0.29	0.06	20.69	2.540	0.538	21.18
0.21	-0.02	9.52	1.840	-0.162	8.80
0.29	0.06	20.69	2.540	0.538	21.18
0.24	0.01	4.17	2.102	0.100	4.76

Mean dose equivalent, DE=2.002 mSv/yr

Table 6: Downward orientation of Gamma-scout sensor of Plateau State Specialist Hospital Outdoor Results.

Dose rate, R (μSv/hr)	ΔR (μSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE(mSv/yr)	ΔDE%
0.23	-0.01	4.35	2.015	-0.092	4.57
0.31	0.07	22.58	2.716	0.609	22.42
0.21	-0.03	14.29	1.840	-0267	14.51
0.30	0.06	20.00	2.628	0.521	19.82
0.26	0.02	7.69	2.278	0.171	7.51
0.25	0.01	4.00	2.190	0.083	3.79
0.30	0.06	20.00	2.628	0.521	19.82
0.23	-0.01	4.35	2.015	-0.092	4.57
0.15	-0.09	60.00	1.314	-0.793	60.35
0.23	-0.01	4.35	2.015	-0.092	4.57
0.18	-0.06	33.33	1.577	-0.530	33.61
0.25	0.01	4.00	2.190	0.083	3.79
0.20	-0.04	20.00	1.752	-0.355	20.26
0.18	-0.06	33.33	1.577	-0.530	33.61
0.27	0.03	11.11	2.365	0.258	10.91
0.28	0.04	14.29	2.453	0.346	14.11
0.28	0.04	14.29	2.453	0.346	14.11
0.18	-0.06	33.33	1.577	-0.530	33.61
0.27	0.03	11.11	2.365	0.258	10.91
0.25	0.01	4.00	2.190	0.083	3.79

Mean dose equivalent, DE=2.107 mSv/yr