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MEASUREMENT OF INDOOR BACKGROUND IONIZING RADIATION IN SOME SCIENCE LABORATORIES IN UNIVERSITY OF JOS, JOS- 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. Measurement of the background ionizing radiation profile within the Chemistry Research Laboratory and Physics Laboratory III all of the University of Jos and their immediate neighbourhood were carried out. These science laboratories 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: The Chemistry Research Laboratory indoor result was 2.111mSv/yr and the outdoor result was 2.081mSv/yr, Physics Laboratory III indoor result was 2.733mSv/yr and the outdoor result was 2.435mSv/yr. The health implications of the results obtained were discussed.

Keywords: Gamma-scout, Radiation profile, ionizing radiation, Nigeria.

INTRODUCTION

Encountered in everyday activities in various forms and different intensities is radiation. Radiation has been found to be beneficial on one hand and harmful on the other hand. Some of the harmful effects are: cancer, cataract, gene mutation destruction of bones and blood cellsand it can cause the death of an individual (Jwanbot, 2011). These radiations come from three main sources namely: cosmic radiation, terrestrial radiation and radioactivity in the human body (Ike, 2003). It is the spontaneous decay of the nuclei of heavy isotopes that leads to emission of radiation. Some of these decays include:

$$^{222}_{86}Rn \rightarrow ^{222}_{88}Ra + 2\ ^{0}_{-1}e + \text{energy;}$$

$$^{234}_{90}Th \rightarrow\ ^{234}_{91}Pa + ^{0}_{-1}e + \text{energy;}$$

$$^{238}_{92}U \rightarrow\ ^{230}_{90}Th + 2\ ^{4}_{2}He + 2\ ^{0}_{-1}e + \text{energy}$$

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:

Some of the materials used in the construction of buildings are known to be radioactive (Hayumbu *et al*., 1995). Indoor air often contains the harmful radioactive gas, radon (^{222}Rn). Generally, indoor air has a higher concentration of radon than outdoor air.

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, other buildings) (Chad-Umoren *et al.,* 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.

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. It has been established that chronic exposure to even low dose rate of nuclear radiations from an irradiated building has the potential to induce cytogenetic damage in human beings (Chad-Umoren *et al.,* 2007). Of particular concern for indoor background ionizing radiation is the incidence of the invisible, odourless, colourless radioactive gas ^{222}Rnwhich 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 *et al.,* 2007). A strong correlation between radon exposure (inhalation) and the prevalence of lung cancer have also been reported (Chad-Umoren*et al.,* 2007; Anyakorah, 2010).

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 Chemistry Research Laboratory and Physics Laboratory III of University of Jos and their immediate environs are assessed to enable the determination of the level of risk to which staff, students and other people are exposed and compared to International accepted levels. This is needful because beside the regular sources of indoor background ionizing radiation mentioned earlier, Chemistry Research Laboratory and Physics Laboratory III harbour a number of active radiation sources such as the x-ray machines.

MATERIALS AND METHODS

In collecting the data, gamma-scout(model GS2 with serial number A20) was used. The background radiation were measured both indoor and outdoor of the selected laboratories. 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. For this work 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.

RESULTS

The Tables 1-5 show the results obtained from the science laboratories.

Chemistry Research Laboratory

Indoor: Table 1 shows the dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

TABLE 1. UPWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF CHEMISTRY RESEARCH LABORATORY INDOOR RESULTS.

Dose rate, R (µSv/hr)	ΔR (µSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE (mSv/yr)	ΔDE%
0.25	0.01	4.00	2.190	0.079	3.61
0.29	0.05	17.24	2.540	0.429	16.89
0.27	0.03	11.11	2.365	0.254	10.74
0.23	-0.01	4.35	2.015	-0.096	4.76
0.27	0.03	11.11	2.365	0.254	10.74
0.22	-0.02	9.09	1.927	-0.184	9.55
0.27	0.03	11.11	2.365	0.254	10.74
0.23	-0.01	4.35	2.015	-0.096	4.76
0.23	-0.01	4.35	2.015	-0.096	4.76
0.22	-0.02	9.09	1.927	-0.184	9.55
0.23	-0.01	4.35	2.015	-0.096	4.76
0.30	0.06	20.00	2.628	0.517	19.67
0.24	0.00	0.00	2.102	-0.009	0.43
0.23	-0.01	4.35	2.015	-0.096	4.76
0.25	0.01	4.00	2.190	0.079	3.61
0.18	-0.06	33.33	1.577	-0.534	33.86
0.20	-0.04	20.00	1.752	-0.359	20.49
0.21	-0.03	14.29	1.840	-0.271	14.73
0.25	0.01	4.00	2.190	0.079	3.61
0.25	0.01	4.00	2.190	0.079	3.61

Mean dose equivalent, DE=2.111 mSv/yr

Outdoor: Tables 2 and 3 shows the dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

TABLE 2. UPWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF CHEMISTRY RESEARCH LABORATORY OUTDOOR RESULTS.

Dose rate, R (µSv/hr)	ΔR (µSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE (mSv/yr)	ΔDE%
0.21	-0.03	14.29	1.840	-0.241	13.10
0.17	-0.07	41.18	1.489	-0.592	39.76
0.25	0.01	4.00	2.190	0.109	4.98
0.27	0.03	11.11	2.365	0.284	12.01
0.27	0.03	11.11	2.365	0.284	12.01
0.26	0.02	7.69	2.278	0.197	8.65
0.23	-0.01	4.35	2.015	-0.066	3.28
0.28	0.04	14.29	2.453	0.372	15.17
0.23	-0.01	4.35	2.015	-0.066	3.28
0.28	0.04	14.29	2.453	0.372	15.17
0.23	-0.01	4.35	2.015	-0.066	3.28
0.20	-0.04	20.00	1.752	-0.329	18.78
0.20	-0.04	20.00	1.752	-0.329	18.78
0.28	0.04	14.29	2.453	0.372	15.17
0.25	0.01	4.00	2.190	0.109	4.98
0.27	0.03	11.11	2.365	0.284	12.01
0.21	-0.03	14.29	1.840	-0.241	13.10
0.25	0.01	4.00	2.190	0.109	4.98
0.21	-0.03	14.29	1.840	-0.241	13.10
0.20	-0.04	20.00	1.752	-0.329	18.78

Mean dose equivalent, DE=2.081 mSv/yr

TABLE 3. DOWNWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF CHEMISTRY RESEARCH LABORATORY 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	-0.079	3.92
0.25	0.01	4.00	2.190	0.096	4.38
0.27	0.03	11.11	2.365	0.271	11.46
0.25	0.01	4.00	2.190	0.096	4.38
0.25	0.01	4.00	2.190	0.096	4.38
0.25	0.01	4.00	2.190	0.096	4.38
0.21	-0.03	14.29	1.840	-0.254	13.80
0.21	-0.03	14.29	1.840	-0.254	13.80
0.25	0.01	4.00	2.190	0.096	4.38
0.27	0.03	11.11	2.365	0.271	11.46
0.23	-0.01	4.35	2.015	-0.079	3.92
0.25	0.01	4.00	2.190	0.096	4.38
0.20	-0.04	20.00	1.752	-0.342	19.52
0.26	0.02	7.69	2.278	0.184	8.08
0.25	0.01	4.00	2.190	0.096	4.38
0.27	0.03	11.11	2.365	0.271	11.46
0.23	-0.01	4.35	2.015	-0.079	3.92
0.21	-0.03	14.29	1.840	-0.254	13.80
0.21	-0.03	14.29	1.840	-0.254	13.80
0.23	-0.01	4.35	2.015	-0.079	3.92

Mean dose equivalent, DE=2.094 mSv/yr

Physics Laboratory III

Indoor: Table 4 shows the dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

TABLE 4. UPWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF PHYSICS LABORATORY III INDOOR RESULTS

Dose rate, R (µSv/hr)	ΔR (µSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE (mSv/yr)	ΔDE%
0.33	0.02	6.06	2.891	0.158	5.47
0.27	-0.04	14.81	2.365	-0.368	15.56
0.29	-0.02	6.90	2.540	-0.193	7.60
0.36	0.05	13.89	3.154	0.421	13.35
0.35	0.04	11.43	3.066	0.333	10.86
0.35	0.04	11.43	3.066	0.333	10.86
0.35	0.04	11.43	3.066	0.333	10.86
0.25	-0.06	24.00	2.190	-0.543	24.79
0.29	-0.02	6.90	2.540	-0.193	7.60
0.28	-0.03	10.71	2.453	-0.280	11.41
0.34	0.03	8.82	2.978	0.245	8.23
0.28	-0.03	10.71	2.453	-0.280	11.41
0.28	-0.03	10.71	2.453	-0.280	11.41
0.34	0.03	8.82	2.978	0.245	8.23
0.33	0.02	6.06	2.891	0.158	5.47
0.33	0.02	6.06	2.891	0.158	5.47
0.35	0.04	11.43	3.066	0.333	10.86
0.33	0.02	6.06	2.891	0.158	5.47
0.31	0.00	0.00	2.716	-0.017	0.63
0.23	-0.08	34.78	2.015	-0.718	35.63

Mean dose equivalent, DE=2.733 mSv/yr

OUTDOOR

Tables 4 and 5 shows result for dose rate (R), dose equivalent (DE), deviation from mean dose rate (ΔR) and dose equivalent (ΔDE) and percentage deviations from mean (ΔR%, ΔDE%).

TABLE 5. UPWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF PHYSICS LABORATORY III OUTDOOR RESULTS.

Dose rate, R (µSv/hr)	ΔR (µSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE (mSv/yr)	ΔDE%
0.26	-0.02	7.69	2.278	-0.157	6.89
0.24	-0.04	16.67	2.102	-0.333	15.84
0.37	0.09	24.32	3.241	0.806	24.87
0.29	0.01	3.45	2.540	0.105	4.13
0.32	0.04	12.50	2.803	0.368	13.13
0.35	0.07	20.00	3.066	0.631	20.58
0.35	0.07	20.00	3.066	0.631	20.58
0.25	-0.03	12.00	2.190	-0.245	11.19
0.23	-0.05	21.74	2.015	-0.420	20.84
0.21	-0.07	33.33	1.840	-0.595	32.34
0.29	0.01	3.45	2.540	0.105	4.13
0.25	-0.03	12.00	2.190	-0.245	11.19
0.25	-0.03	12.00	2.190	-0.245	11.19
0.33	0.05	15.15	2.891	0.456	15.77
0.32	0.04	12.50	2.803	0.368	13.13
0.29	0.01	3.45	2.540	0.105	4.13
0.31	0.03	9.68	2.716	0.281	10.35
0.14	-0.14	100.00	1.226	-1.209	98.61
0.24	-0.04	16.67	2.102	-0.333	15.84
0.27	-0.01	3.70	2.365	-0.070	2.96

Mean dose equivalent, DE=2.435 mSv/yr

TABLE 5. DOWNWARD ORIENTATION OF GAMMA-SCOUT SENSOR OF PHYSICS LABORATORY III OUTDOOR RESULTS.

Dose rate, R (µSv/hr)	ΔR (µSv/hr)	ΔR%	Dose equivalent, DE(mSv/yr)	ΔDE (mSv/yr)	ΔDE%
0.26	-0.03	11.54	2.278	-0.232	10.18
0.25	-0.04	16.00	2.190	-0.320	14.61
0.31	0.02	6.45	2.716	0.206	7.58
0.39	0.10	25.64	3.416	0.906	26.52
0.34	0.05	14.71	2.978	0.468	15.72
0.31	0.02	6.45	2.716	0.206	7.58
0.28	-0.01	3.57	2.453	-0.057	2.32
0.31	0.02	6.45	2.716	0.206	7.58
0.23	-0.06	26.09	2.015	-0.495	24.57
0.25	-0.04	16.00	2.190	-0.320	14.61
0.28	-0.01	3.57	2.453	-0.057	2.32
0.25	-0.04	16.00	2.190	-0.320	14.61
0.27	-0.02	7.41	2.365	-0.145	6.13
0.35	0.06	17.14	3.066	0.556	18.13
0.31	0.02	6.45	2.716	0.206	7.58
0.34	0.05	14.71	2.978	0.468	15.72
0.28	-0.01	3.57	2.453	-0.057	2.32
0.18	-0.11	61.11	1.577	-0.933	59.16
0.25	-0.04	16.00	2.190	-0.320	14.61
0.29	0.00	0.00	2.540	0.030	1.18

Mean dose equivalent, DE=2.510 mSv/yr

DISCUSSION

In Chemistry Research Laboratory, the indoor minimum dose equivalent was 1.577 mSv/yr(0.18 µSv/hr) and the maximum was 2.628 mSv/yr (0.30 µSv/hr). The outdoor minimum dose equivalent when the gamma-scout sensor was oriented vertically upward was 1.489 mSv/yr(0.17 µSv/hr) and the maximum was 2.453 mSv/yr (0.28 µSv/hr). When the gamma-scout sensor was oriented vertically downward, the outdoor minimum dose equivalent was 1.752 mSv/yr(0.20 µSv/hr) and the maximum was 2.365 mSv/yr (0.27 µSv/hr). The indoor minimum dose equivalent obtained in Physics Laboratory III was 2.015 mSv/yr(0.23 µSv/hr) and the maximum was 3.154 mSv/yr (0.36 µSv/hr). When the gamma-scout sensor was oriented vertically upward, the outdoor minimum dose equivalent was 1.226 mSv/yr (0.14 µSv/hr) and the maximum was 3.241 mSv/yr. When the gamma-scout sensor was oriented vertically downward, the outdoor minimum dose equivalent was 1.577 mSv/yr (0.18 µSv/hr) and the maximum was 3.416 mSv/yr (0.39 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 namely; the presence of radon gas in the air within the selected science laboratories, residual of radioactivity equipment such as Uranium sources which were acquired for experiments in the laboratories, building(earth) materials used in the construction of the laboratories. Also, some of the radioactive sources in the Physics laboratory include Thorium sources and the X-ray machine that have been in there for over 20 years. The rocks used for the foundation of the buildings were mostly igneous rocks which are believed to be rich in minerals like zircon, monazite uranite potassium feldspars and biotite (Solomon *et al.,* 2002; Wertz,1998).The sand and soil used for the building construction may contain traces of Uranium and Thorium since Jos-Plateau is a high background area and also because of tin tailings which are rich in monazite (Ibeanu, 2004; Jwanbot *et al*., 2010).

It is recommended that regular and periodic monitoring of the background ionizing radiation level should be carried out to assess the health risks to staff, students and the general public that may be exposed to dangerProper ventilation of Physics Laboratory III University of Jos should be carried out daily by at least opening the windows to prevent the accumulation inside the laboratories. Future work should be carried to evaluate the indoor background ionizing radiation of the remaining science laboratories apart from those covered in this research work.

It is concluded that there was a higher level of harmful ionizing radiation within the two laboratories than outside, around their immediate environs. However, staff, students and other users that use the laboratories and their immediate neighbourhood are exposed to insignificant health risks as the values of the mean dose equivalent recorded in this work are consistently less than the worldwide average dose of 2.4mSv/yr (ICRP, 1990) for a human being. Some radiation levels were higher than this recommended value, which may be due to the way the laboratory was constructed as part of the roof is made up of concrete, some of the windows are inside the building and the laboratory is almost surrounded by rocks. This allows for the built up of radon gas in the laboratory that can result to lung cancer after a long exposure.

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