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Computed Tomography Scanners Background Radiation in Some Selected Hospitals within the Federal Capital Territory, Abuja, Nigeria

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Abstract

This study determined the Indoor and Outdoor background radiation of the Computed Tomography Scanners (CT) rooms in some selected hospitals within the Federal Capital Territory, Abuja, Nigeria. The measurements were done with the survey meters held in the CT room while the CT machine is switched off and around the department or unit outside the CT room. The data measured was read on the display screen of the survey meters. The average dose of the ten readings taken in a hospital was recorded under the area code assigned to that Hospital. The Results showed that the CT indoor doses ranged from 0.141µSv/hr ± 0.02 to 0.213µSv ± 0.03, with a mean value of 0.171µSv/hr ± 0.03. And the CT outdoor doses ranged from 0.165 µSv/hr ± 0.02 to 0.250 µSv/hr ± 0.04, with a mean value of 0.208 µSv/hr ± 0.0.03. Also, the Mean dose values for CT indoor and Outdoor were 0.171µSv/hr± 0.03 and 0.208µSv/hr± 0.03 respectively. The mean background radiation values gotten for CT indoor and outdoor doses are all within the acceptable limits for natural background radiation levels for indoor and outdoor when the machine was in operation. When the indoor and outdoor doses were added, it is about 1.56mSv per year from CT scanners when added to estimated 2mSv from radon gas. The background radiation will be 3.56mSv per year for Federal Capital Territory, Abuja, Nigeria.

Keywords: Computed tomography; Background radiation; Federal capital territory; Abuja; Nigeria; Hospitals; CT scanners.

1. Introduction

An attempt was made to determine the background radiation of the Computed Tomography Scanners (CT) rooms and compare it with that of the surrounding environment.

Background radiation is the sum of total energies from ionising and non-ionising radiation frequently released by the following sources;

I. Cosmic rays
II. Terrestrial gamma rays
III. Radionuclide in the body except radon gas
IV. Radon and its progenies

Apart from the natural radioactive elements of the earth and from within man's body, artificial man-made radiation for example; x-ray generators, cobalt 60 radiotherapy machine, Caesium source, linear accelerators, Atomic reactors, etc increase the background radiation of a place [1].

The indoor radiation comes from the materials used in the building construction. It may contain the harmful radioactive gas radon (^{222}Rn).

The international committee on radiation protection (ICRP) showed through several surveys that in countries with temperate climate, most of the people spend 80% of their time indoors. While 20% is spent outdoors. These indoors include homes, schools, offices, etc [2].

1.1. Calculations

The UNSCEAR [2] recommended indoor and outdoor occupancy factors of 0.8 and 0.2 respectively. The occupancy factor (OF) is the proportion of the total time during which an individual is exposed to a radiation field. The calculation is based on hours, as the reading gotten from the Survey meters were in µSv/hr. In a year, there are 365 days. Multiplying 365 by 24hrs to convert the Survey meter readings, which were per hour to per year to 8760hrs per year. People are expected to spend 80% of their time indoors, that is 0.8 of 1 and 20% of their time outdoors, which is 0.2 out of 1. Note that 1mSv is equal to 1000 µSv, so to convert µSv to mSv; we divide the µSv value by 1000.

The readings obtained in µSv/hr were converted to years by using these relations;

E_i = X(µSv/hr) x 8760 hrs/yrs x 0.8÷1000……………………………………1

E_o = H (µSv/hr) x 8760hrs/yrs x 0.2÷ 1000……………………………………..2

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where;
E_i is the annual equivalent dose rate for indoor in mSv/yr
E_o is the annual equivalent dose rate for outdoor in mSv/yr
X is the indoor survey meter reading
H is the outdoor survey meter reading

Table-1. standard external radiation levels and their health risk[14]

S/N	Exposure (µSv/hr)	Significance	Health Risk
1	<0.2	Background radiation	Safe; Normal levels
2	0.21	Background radiation	Safe
3	0.5	Granite walls	safe
4	1.0	airplane	Safe; short time
5	2.0	Airplane at a height	Elevated risk
6	5.0	Occupational exposure	Danger; Relocate
7	6.25	Limits of occupational exposure	Danger; Relocate
8	9.375	Limits for occupational exposure to the hands	Danger; relocate
9	20.0		High danger; radiation sickness
10	100		High danger; heighten sickness
11	1000		High danger; evacuate immediately
12	100,000		Severe; radiation poisoning
13	1,000,000		Severe; Vomiting
14	>10,000,000		Lethal ; organ failure and death within hours

Sources: [2-4].

2. Methodology

In collecting the background radiation data, Radex survey meter was used, to guide as a check Radalert 100 nuclear radiation monitor with serial number S0919, made in USA by Iospecta-International medcom, inc. was also used. The Survey meters were calibrated with Caesium 137. Their accuracy is typical ± 15% relative to Cs 137. Radex Survey meter has 2014 Factory Calibration Cerficate. The background radiations were measured for both the CT rooms and the environs. For this work, ten readings were taken for CT rooms and ten for the environments. The survey meters batteries were checked and cross checked before switching on the meters. The mode or setting was adjusted to background radiation and the unit to µSv/h.

The measurements were done with the survey meters held in the CT room while the CT machine was switched off. Ten readings were taken at the same time for both meters and recorded against that particular Area Code. After which, the two meters' readings were taken inside the Radiology Department outside the CT scanner room. The data measured were read on the display screen of the survey meters. The data measured were recorded for the Hospital Area code assigned to it. At the end of taking the measurements the average dose of the ten readings taken the two meters were recorded for the CT indoor radiation dose and the CT outdoor radiation dose. The mean background radiation doses gotten from the two meters were added up and divided by 2 to get an average reading for CT indoor and outdoor background radiation doses in µSv/h. This mean background radiation dose value was recorded for that particular area code in another Table B. This process was repeated for the rest of the nine Area codes listed below. Their mean background radiation doses in µSv/h from the two survey meters were recorded against the area codes assigned to the Health institutions. The meters used are shown in Plate 3.1

The Health Institutions having CT scanners were assigned area codes for easy data analyses and identification. They are as follows;

Area Code	Name of Health Institution
F1	Garki Hospital Abuja, Garki District
F2	LifeBridge Diagnostic Centre, Garki District
F3	State House Clinic, Aso Rock
F4	Image Diagnostics, Maitama District
F5	Abuja Clinics, Maitama District
F6	Gwagwalada Hospital, Gwagwalada
F7	Medicaid Radiodiagnostic, Wuse District
F8	Asokoro Hospital, Asokoro District
F9	Kings Care Hospital, Zone 4, Wuse District
F10	Zankli Hospital, Utako District

2.1. Calculations

From the Literature Review page 11, UNSCEAR, 1988 recommended 1 or 100% to Occupancy Factor. That is the proportion of the total time during which an individual is exposed to a radiation. That people spend 80% of their time indoors, that is 0.8 of 1 and 20% of their time outdoors, which is 0.2 out of 1. The international values used for background radiation doses for indoors and outdoors were stated in mSv/yr. But the readings gotten from the two meters were in µSv/h. There is a need to convert the readings in µSv/h to mSv/yr using the equations 2.1 and 2.2

In a year, there are 365 days. Multiplying 365 by 24 hrs to convert the survey meter readings which were in per hour to per year. This will give 8760 hrs per year.

E_i = X(µSv/hr) x 8760 hrs/yrs x 0.8 ÷ 1000………………………………………1

E_o = H (µSv/hr) x 8760hrs/yrs x 0.2÷ 1000…………………………………..…..2

Where;

E_i is the annual equivalent dose rate for indoor in mSv/yr

E_o is the annual equivalent dose rate for outdoor in mSv/yr

X is the indoor survey meter reading

H is the outdoor survey meter reading

I mSv is equal to 1000 µSv, so to convert µSv to mSv; we divide the µSv value by 1000.

For Area Code 1, which is Garki Hospital Abuja; from Table B, the mean background radiation dose for CT indoor dose is 0.14 µSv/h and for the CT outdoor is 0.17 µSv/h. These background radiation dose values were used to calculate the CT indoor and outdoor background radiation per year using the equation 2.1 and 2.2;

E_i = X(µSv/hr) x 8760 hrs/yrs x 0.8 ÷ 1000………………………………………1

E_i = 0.14 (µSv/hr) x 8760 hrs/yrs x 0.8÷ 1000

E_i = 0.98 mSv/yr

E_o = H (µSv/hr) x 8760hrs/yrs x 0.2÷1000……………………………………...2

E_o = 0,17 (µSv/hr) x 8760 hrs/yrs x 0.2 ÷ 1000

E_o = 0.30 mSv/ yr

This calculation was also done for the rest of the nine other area codes to determine their annual CT indoor and outdoor background radiation doses.

The average of CT indoor and outdoor background radiation doses for all the Health institutions was calculated. These values were summed up to give the background radiation dose coming from Computed tomography scanners in the Federal Capital territory, Abuja, Nigeria.

The mean values of the assigned area codes were correlated and put in a table form. The statistical analysis was done to determine the p-values and percentage errors. From the table, the mean value of the mean of all the assigned area codes was calculated. The above mean value becomes the background radiation contributed from the CT indoor and outdoor radiation dose per annum measurements. The total background radiation dose from the computed tomography in the Federal Capital Territory, Abuja is the sum of the CT indoor and outdoor radiation dose per annum measurements.

3. Results

The results of the survey meters readings of the CT indoor and outdoor doses of different hospitals in the FCT are shown in Table 2

Table-2. Results of Survey meters readings of the CT indoor and outdoor doses

Area code	Name of Institution	CT Indoor doseχ(µSv/hr)	CT outdoor η(µSv/hr)	CT outdoor dose per year Eo (mSv/yr)	CT indoor dose per year Ei (mSv/yr)
F1	Garki Hospital Abuja	0.141 ±0.02	0.165 ± 0.02	0.289 ± 0.04	0.988 ± 0.15
F2	Life Bridge Diagnostic Centre	0.187 ± 0.03	0.250 ±0.04	0.438 ±0.07	1.310 ± 0.20
F3	State House Clinic	0.155 ± 0.02	0.200 ± 0.03	0.350 ± 0.05	1.086 ± 0.16
F4	Image Diagnostic Centre	0.150 ± 0.02	0.165 ± 0.02	0.290 ± 0.04	1.051 ± 0.16
F5	Abuja Clinics	0.167 ± 0.03	0.210 ± 0.03	0.368 ± 0.06	1.170 ± 0.18
F6	Gwagwalada Hospital	0.191 ± 0.03	0.221 ± 0.03	0.387 ± 0.06	1.339 ± 0.20
F7	Medicaid Diagnostics	0.213 ± 0.03	0.241 ± 0.04	0.422 ± 0.06	1.493 ± 0.22
F8	Asokoro hospital	0.176 ± 0.03	0.193 ± 0.03	0.338 ± 0.05	1.233 ± 0.18
F9	Kings care hospital	0.181 ± 0.03	0.244 ± 0.04	0.427 ± 0.06	1.268 ± 0.19
F10	Zankli Hospital	0.148 ± 0.02	0.190 ± 0.03	0.333 ± 0.05	1.037 ± 0.16
	Average Dose	0.171 ± 0.03	0.208 ± 0.03	0.360 ± 0.05	1.198 ± 0.18

Figure-1. Annual Indoor Dose

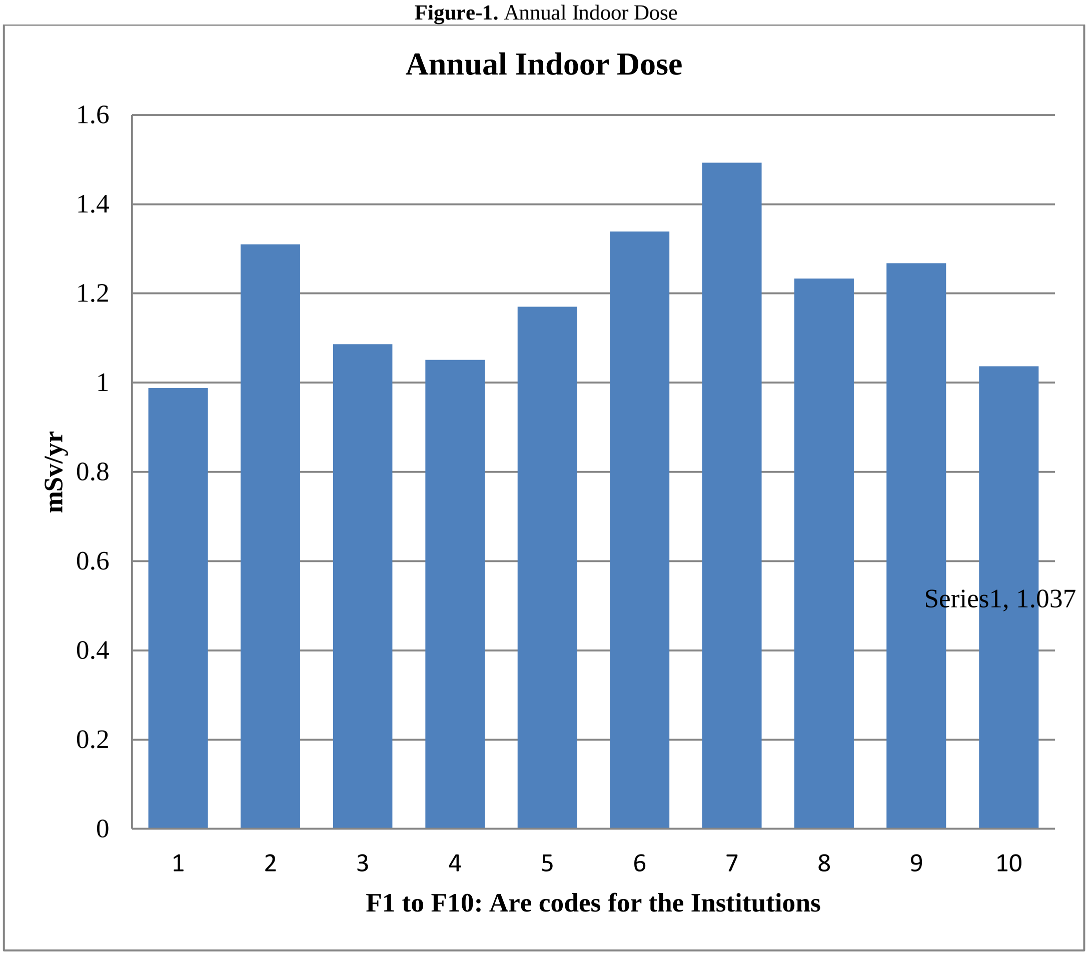
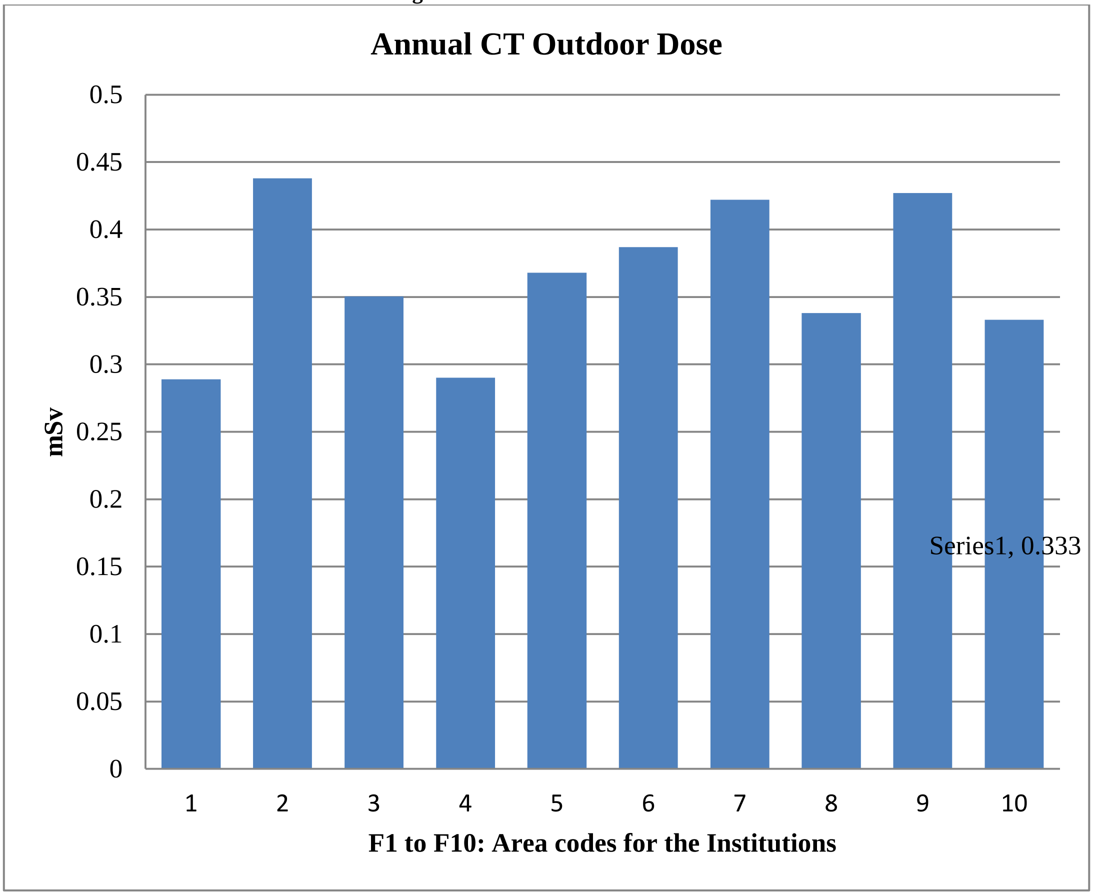


Figure-2. Annual CT Outdoor Dose



4. Data Analyses

4.1. CT indoor doses

The CT indoor readings obtained were lower than that of the environment. This may be attributed to the lead lining inside the CT rooms. The lead must have absorbed the radiation from the walls.

The doses obtained ranged from 0.141µSv/hr ± 0.02 to 0.213µSv ± 0.03, the mean value is 0.171µSv/hr ± 0.03. F7, which is Medicaid diagnostic in Wuse District of Abuja had the highest value. It is 24.6% higher than the mean value. The lowest is F1, which is Garki Hospital, in Garki District of Abuja.

The CT indoor dose equivalent per year is much higher than the CT outdoor doses per year. This is as a result of the occupancy factor of 0.8 for CT indoor doses. It is 1.1975mSv/yr ± 0.18, while that of outdoor is 0.360mSv/yr ± 0.04. This is 232.6% higher than that of the CT outdoor doses.

4.2. CT Outdoor Doses

The CT outdoor doses ranged from 0.165 µSv/hr ± 0.02 to 0.250 µSv/hr ± 0.04, the mean value is 0.208 µSv/hr ± 0.0.03. the highest value came from F2, which is Lifebridge Diagnostics. It is 20.2% higher than the mean dose value.

5. Interpretation of Analysis and Deductions

The Mean dose value obtained for CT indoor is 0.171µSv/hr± 0.03. When compared to the values established by the United States Nuclear Regulatory Commission for standard external radiation levels in table 1, this mean dose value is within the natural background radiation level and it is safe for people around the facility when the machine is switched off.

The mean dose value for CT outdoor is 0.208µSv/hr± 0.03. Also when compared to the values established by the United States Nuclear Regulatory Commission for standard external radiation levels in table 1; the mean dose value is also within the natural background radiation level and it is safe for the people staying outside the CT room.

The added background radiation dose for CT scanner is 1.56mSv/yr, when added to the radon gas dose of 2.0mSv/yr. The approximate background radiation dose for the Federal Capital Territory, Abuja, Nigeria is 3,56mSv/yr. this is within acceptable limit for background radiation around the World.

The mean dose equivalent for CT indoor per year is 1.1975mSv/yr. this is within the acceptable limits for dose equivalent for indoor natural background radiation doses.

6. Conclusion

The mean background radiation values obtained for CT indoor and outdoor doses are all within the acceptable limits for natural background radiation levels for indoor and outdoor when the machine is not in operation.

The lead lining in the CT rooms helped to reduce the background radiation doses in the CT rooms, especially the radiation from the painted walls of the CT rooms.

8. References

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