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Indoor Exposure to Environmental Gamma Radiation in Selected Locations in Ibadan, Southwestern Nigeria

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ABSTRACT

Indoor exposure to gamma radiation was investigated in some selected location in Ibadan, Southwestern Nigeria to determine and compare the levels of exposure to radiations in houses built with differing materials. Measurements were obtained using the LiF Thermoluminescent Dosimeters (TLDs). LiF TLD was used because of its general resistance to corrosion and water, good response to gamma radiation and because they have no radiation – induced thermoluminescence (TL) which interferes with measurements of low exposures.

Results show that average absorbed dose in cement-sand building is $0.0285 \pm 0.0055 \mu Sv/h$, average absorbed dose in houses built with soil or mud is 0.0200 ±0.0035 μSv/ h and that of baked clay is 0.024 ± 0.002 μSv/ h.

It was observed from the results that the total annual effective absorbed dose equivalence in each of the three building types is less than the global minimum permissible dose.

***Keywords:** Indoor Exposure, Thermoluminescent Dosimeter, Absorbed Dose*

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INTRODUCTION

The Earth and all the living things on it are constantly been bombarded by radiation from space, similar to the drizzle of rain. Charged particles from the sun and stars interact with the earth's atmosphere and magnetic field to produce a shower of radiation. The dose from this source varies from place to place due to the differences in elevation and the effect of the magnetic field.

Radiation plays a very significant part in our day to day life because the world is naturally a radioactive ambience in which everyone is exposed to certain amount of naturally occurring radiation**.** Radioactive substances could be in the air we breathe, the water we drink, the soil on which we plant our crops; in the building materials for our houses as well as within our bodies. Most of the exposure to radiation comes from natural sources which may be terrestrial and extra-terrestrial. Terrestrial radiations are emitted from radioactive nuclides present in trace amounts throughout the earth's crust including soils and rocks. Extraterrestrial radiations come from outer space as primary cosmic rays and gets to the atmosphere. Terrestrial radiations are also emitted from those nuclides which are transferred to man through food chains or by inhalation and eventually get deposited in his tissues. Everyone on the earth planet is constantly exposed to ionizing radiation from natural sources (Abdalsattar K H, 2015).

Cosmogenic radionuclides with long half life form the terrestrial radionuclides that are present in the air, soil, rocks, and water and building materials. With respect to absorbed dose in human, the terrestrial predominant radionuclides are ^{232}Th, ^{238}U and ^{40}K (Mahmoud P. et al., 2014). Some of these radioactive materials are ingested with food and water, while others, such as radon, are inhaled.

Gamma radiation from radionuclides, such as ^{40}K and the ^{232}Th and ^{238}U series and their decay products, represents the main external source of irradiation to the human body. External exposures to gamma radiation outdoors arise from terrestrial radionuclides occurring at trace levels in all rock formations. Therefore, the natural environmental radiation mainly depends on geological and geographical conditions (Florou, H. and P. Kritidis, 1992). These have direct effect by modifying the soil composition and natural radioactivity concentration levels; and hence the level of absorbed dose received at a locality.

Higher radiation levels are associated with igneous rocks, such as granite and lower levels with sedimentary rocks. There are exceptions, however, as some shale and phosphate rocks have relatively high content of radionuclides (U.N, 1993).

In most places on the earth, the natural radionuclides varies only within narrow margins, but in some places there are wide deviations from normal levels because of the abundance of minerals with high radioactivity such as monazites, zircons and granite [Abiama P.E et al.,2010; UNSCEAR, 2000.]. The specific levels are related to the types of rock from which the soils originate. Higher radioactivity in soil samples may be linked to the contribution of the parent materials that constitute the soil type. The soil derived from granite will have a higher radioactivity than the soil from the other rock types [Aziz S. M et al, 2013; Rani, A. and S. Singh, 2005.].

The reason for the recent curiosity on this subject is the possibility of exposure to ionizing radiation emanating from naturally occurring radionuclides such as Potassium -40, Thorium – 232, and Uranium – 238 which accounts for about 50% of the average annual dose to human beings from all radiation sources (UNSCEAR, 1982).

Researchers have shown that these naturally occurring radionuclides are present in our water, food, air, bodies as well as in building materials like cement, tiles, brick, muds e.t.c (Mollah et al, 1996, Ajayi et al, 1996).

The naturally occurring radionuclides present in building materials constitutes a radiative environment to live in. The climate and weather, natural ventilation of living environment, local geology and the drainage pattern determine the extent of exposure to the radioactive environment.

Since exposure to ionizing radiation is undesirable at all levels, it is therefore very important and imperative to investigate and determine the exposure level to natural radiation in any inhabited family dwelling. The knowledge of the presence of radioactivity in building materials helps us to assess any possible radiological hazard to those living in houses built with such materials.

According to a study carried out by the US Geological Survey (USGS 1997), it was suggested that the most of our radiation exposure comes from natural sources. Majority of the radiation dose we receive actually comes from natural radon, cosmic radiation and from the soil. All building materials are radioactive to some extent, whether from natural or artificial origin.

This study was carried out to access the level of exposure to environmental gamma radiation in a variety of family dwellings as well as its health implications.

Exposure

Exposure is defined for gamma and x- rays in terms of the amount of ionization they produce in air. The unit of exposure is called the roentgen (R). It was originally defined as that amount of gamma or x - radiation that produces in air 1 esu of charge of either sign per 0.001293 g of air. The charge involved in the definition of the roentgen includes both the ions produced directly by the incident photons as well as ions produced by all secondary electrons. Since 1962, exposure has been defined by the International Commission on Radiation Units and Measurements (ICRU) as the quotient $\Delta Q/\nabla m$, where ΔQ is the sum of all charges of one sign produced in air when all the electrons liberated by photons in a mass Δm of air are completely stopped in air. The unit roentgen is now defined as $1\,R = 2.58 \times 10^{-4} C\,kg^{-1}$ The idea of exposure applies only to electromagnetic radiation; the charge and mass used in its definition, as well as in the definition of the roentgen, refer only to air.

Absorbed Dose

The primary physical quantity used in dosimetry is the absorbed dose. It is defined as the energy absorbed per unit mass from any kind of ionizing radiation in any target. The unit of absorbed dose, J kg^{-1}, is called the gray (Gy). The older unit, the rad, is defined as 100 erg g^{-1}. It follows that

$$I\,Gy\ = 100\,rads$$

Methodology

Description of study Area

Ibadan is located in southwestern Nigeria in the southeastern part of Oyo State about 120 km east of the border with the Republic of Benin in the forest zone close to the boundary between the forest and the savanna. The city ranges in elevation from 150 m in the valley area, to 275 m above sea level on the major north-south ridge which crosses the central part of the city. The city's total area is 1,190 sq mi (3,080 km^2).The city is naturally drained by four rivers with many tributaries: Ona River in the North and West; Ogbere River towards the East; Ogunpa Riverflowing through the city and Kudeti River in the Central part of the metropolis. Ogunpa River, a third-order stream with a channel length of 12.76 km and a catchment area of 54.92 km^2.

Ibadan is the capital city of Oyo state in Nigeria. It is the largest city in West Africa and the second largest in Africa after Cairo. It exhibits the typical tropical climate of averagely high temperatures, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October. The mean temperatures are highest at the end of the Harmattan (averaging 28°C), that is from the middle of January to the onset of the rains in the middle of March. Even during the rainfall months, average temperatures are between 24°C and 25°C, while annual range of temperature is about 6°C. Rainfall figures over the state vary from an average of 1200mm at the onset of heavy rains to 1800mm at its peak in the southern part of the state to an average of between 800mm and 1500mm at the northern parts of the State.

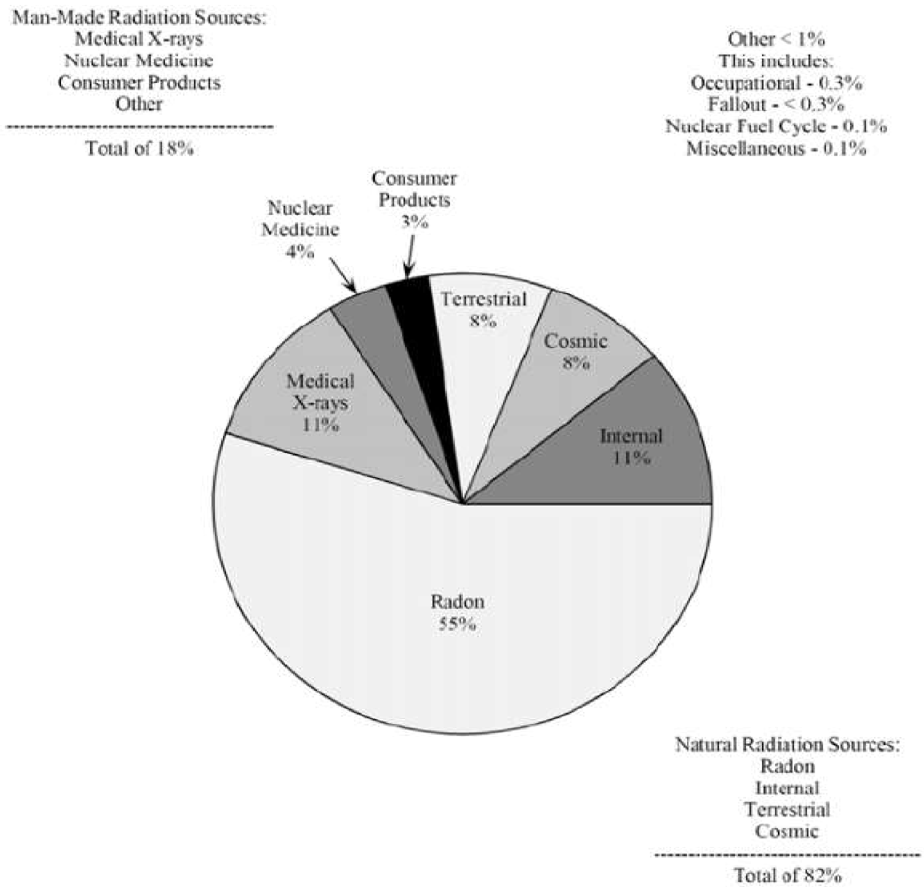


Figure2: Ionizing Radiation Exposure to the Public

Material and Method

The study area was divided into ten zones and all indoor measurements were taken in inhabited houses built with cement, mud (soil) and baked clay.

Indoor exposure to gamma radiation was investigated using LiF Thermoluminescent Dosimeters (TLDs), which were placed within some family dwellings built with cement, mud and or baked clay in some locations in Ibadan for a period of 60 days (Paschoa et al. 1990).

A total number of 75 TLDs made of LiF that gives good luminescence on heating were used to measure the indoor exposures in 75 family dwellings. LiF TLDs were used for this study because of its general resistance to corrosion and water, good response to gamma radiation and its having no radiation – induced thermoluminescence (TL) which interferes with measurements of low exposures.

The dosimeters were first heated to 300°C (573K) for about 16 hours in an annealing oven and then cooled at 80°C (353K) for 17 hours to re- establish the defect equilibrium of the thermoluminescent material so that it may be reused. The TLDs were then calibrated to read inside polyethylene sachets. The sachets were then labeled according to the zones and types of buildings in which the TLDs were hung. Codes were used to denote the zone and building material types. For instance, a TLD in a polythene bag labeled CA1 means it was numbered 1 in zone A of the Cement – Sand building. The TLDs were hung at a height of approximately 3.0 metres from the floor to avoid interfering with the day to day activities of the occupants of the houses.

Within each building, a dosimeter was hung near the wall at a height 3m. Routine checks were made on the dosimeters regularly.

After the exposure for about two months, the TLDs were removed from within the buildings and then taken to the Federal Radiation Protection Services, Department of Physics University of Ibadan, where they were read with the SOLARO 654 TLD reader.

Results and Discussion

Table 1 gives the summary of the distribution of the 75 TLDs in the ten zones into which the study area was

Table 2 gives the summary of the average absorbed dose as measured by the TLDs fixed on the walls inside different buildings in the selected locations in Ibadan. Figure 1 shows the distribution of Ionizing Radiation Exposure to the Public, Figure 2 is a picture of part of Ibadan where the study took place. Figure 3 is the Bar chart showing the variation of the Annual Effective dose in the different building materials.

For the family dwelling which the material is Cement – Sand, the average Indoor absorbed gamma dose ranged from $0.027 \pm 0.005\, \mu Sv/h$ to $0.031 \pm 0.006\, \mu Sv/h$, with the average of the averages being $0.0285 \pm 0.0055 \mu Sv/h$ in all the sampled zones.

For the buildings with soil as the material, the average indoor absorbed dose by the TLDs ranged from $0.019 \pm 0.003\, \mu Sv/h$ to $0.021 \pm 0.004\, \mu Sv/h$. For this, the average of the averages is 0.0200 ±0.0035 μSv/ h in all the sampled two zones.

The average absorbed dose in house houses with baked–clay as material is 0.024 ± 0.002 μSv/ h.

The errors quoted above are standard deviation from the mean values. This, as could be seen vary from one zone to the other depicting differences in local geology as well as the type of soil on which the houses are built or erected. (Adam and Lowder, 1964; Eisenbud, 1973).

Comparing the average absorbed doses in the three types of materials, it is observed that the absorbed dose in Cement- Sand buildings of 0.0285 ± 0.0055 μSv/ h is the highest. This is followed by the absorbed dose in buildings of Baked – Clay which is 0.024 ± 0.002 μSv/ h. The total absorbed dose in houses whose building material is soil (mud) is the lowest i.e 0.0200 ± 0.0035 μSv/ h. It is assumed in this work that an individual spend almost half of a day outdoor and the remaining 12 hours inside his house. So using occupancy factor of 0.5 the average annual effective dose equivalent in the Cement- Sand buildings, the Soil Building as well as the Baked – Clay buildings are 62.46 μSv/ y, 52.60 μSv/ y and 43.83 μSv/ yr respectively.

Table1: Distribution of TLDs in Ibadan

Wall Materials	Code	Number of Zones	Number of TLDs
Cement-Sand	CS	7	45
Soil	S	2	24
Baked Clay	BC	1	6

Total TLDs Distributed: 75

Table2: Terrestrial Gamma radiation absorbed dose levels in family dwellings in Ibadan.

Zone	Wall Material	Ave. Absorbed Dose (μSv /h)
A	CS-1	250.027 ± 0.006
B	CS-2	120.031 ± 0.005
C	CS-3	98.029 ± 0.006
D	CS-4	112.024 ± 0.004
E	CS-5	185.007 ± 0.005
F	CS-6	160.019 ± 0.003
G	CS-7	200.510 ± 0.003
H	S-1	9 0.021 ± 0.004
I	S-2	81 .024 ± 0.002
J	BC-1	60 .321 ± 0.003

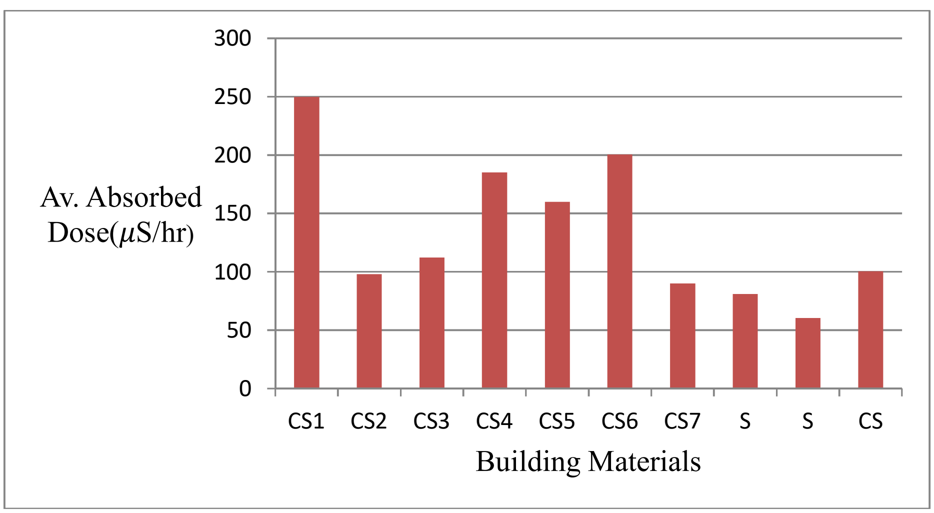
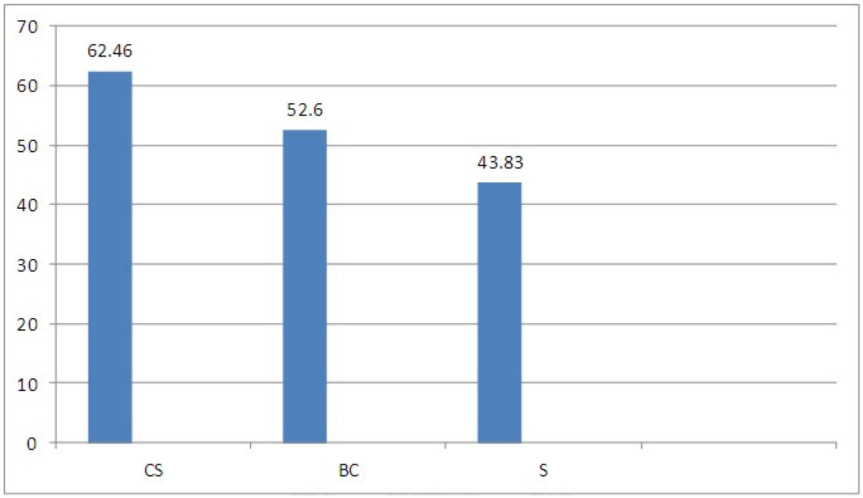


Figure3: Graph variation in the Average Annual Effective dose

Table3 – Average annual effective dose equivalent

Building Material	CS	BS	S
Average Annual Effective Dose Equivalence (μSv/yr)	62.46	52.60	43.83



Building Material

Figure3: Bar chart of variation in the Average Annual Effective dose

CS – CEMENT – SAND BUILDING **BC-** BAKED CLAY BUILDING **S –**SOIL BUILDING

Conclusion

An investigation into the level of exposure to radiation in houses built with different material in selected locations in Ibadan has been carried out. These results show that the exposure to natural radiation is highest in cement sand (CS) buildings and lowest in soil buildings (S) in the locations considered in this work. The annual absorbed dose in the three types of materials is less than the 20mSv/y permissible dose for members of the public.

This means that within the limit of our study area, it may be safer radiologically speaking to dwell in houses built with soil (or mud) .

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