ASSESSMENT OF RADIATION EXPOSURE LEVELS IN SOME SELECTED BUILDINGS IN BAGAJI VILLAGE, KEFFI, NIGERIA

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Abstract

It is observed by both United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) and International Commission on Radiation Protection (ICRP, 1991) that there could be some exposure in some homes which would require regulatory control but is not really considered. This study is therefore, to assess the ambient outdoor radiation levels of some selected buildings (new and old) in Bagaji village Keffi, Nasarawa State. The inspector alert nuclear radiation meter was used for these assessments, where it was held at the abdominal level and readings were taken in different houses in mR/hr and in count per minute. The exposure levels at ten different houses (new and old) were measured and it was found that the annual dose rate ranges from (1.98±1.09 mSv/yr) to (1.27±1.04 mSv/yr).The exposure rate were converted to annual equivalent dose and annual effective dose rate in order to compare it with the public exposure limits by ICRP, it was found that the annual effect dose rate is between 0.58 mSv/yr – 0.66 mSv/yr for new houses and 0.76 mSv/yr – 0.98 mSv/yr for the old houses which is below the public exposure limits and may not necessarily result to any hazard.

Keywords: *Exposure, equivalent dose, ambient, effective dose, radiation.*

INTRODUCTION

Natural background radiation and radioactivity in the environment provides the major source of collective human exposure to all sources. All types of ionizing rays cause the same primary physical processes of ionization or excitement of atoms or molecules in the irradiated material. This is independent of whether they are of natural or artificial origin. If the radiation exposures are indicated in sievert, they are directly comparable, irrespective whether natural or artificial, internal or external radiation exposure is involved (Gasty & Lamarre, 2004). Terrestrial radiation comes from the natural radioactive substances which exist in various concentrations everywhere on earth. The dose rate resulting from terrestrial radiation depends on the geological formations of the subsoil and therefore varies from one location to another. In Germany, an average external radiation dose of 0.5 mSv per year results due to terrestrial radiation; in some parts of Brazil and India these values are ten times higher (Duval *et al.*, 2009).

Sources of Background Radiation

Background radiation (which scientists call "ubiquitous background radiation") is emitted from both natural and human–made radioactive chemicals (*radionuclides*). Some naturally occurring radio nuclides are found in the earth beneath our feet, while others are produced in the atmosphere by radiation from space. Human–made radionuclides have entered activities entailing radiation exposure are justified (ICRP, 1991).

the environment from activi–ties such as medical procedures that use radionuclides to image the body and electricity generation that uses radioactive uranium as fuel (Man, 1989). Humans are continuously irradiated by sources outside and inside their bodies. Outside sources include *space radiation* and *terrestrial radiation*. Inside sources include the radionuclides that enter our bodies in the food and water people ingest and the air they breathe. Whatever its origin, radiation is everywhere (or "ubiquitous") in the environment (Man, 1989).

Radiation Hygiene

Findings and measurements to identify and evaluate biological radiation effects in human beings, measures for radiation protection and related technical questions regarding medical and non–medical application of ionizing radiation as well as principles on the indication of ionizing radiation applications (HPS, 2001).

Radiation Protection

Radiation protection deals with the protection of individual persons, their descendants and the population as a whole against the effects of ionizing radiation. The aim of radiation protection is to avoid deterministic radiation effects and to limit the probability of stochastic effects to values considered acceptable. An additional task is to ensure that

Dose from Background Radiation

A person receives a radiation dose from exposure to radiation sources outside the body (for example, external radiation from uranium in concrete used to build homes) and inside the body (for example, internal radiation from radioactive potassium absorbed by the cells when a person eats food). Here the term "dose" is used to mean *effective dose*, which describes the amount of radiation energy absorbed by the body.

When scientists describe dose, they use the units of *sievert* (Sv), one–thousandth of a sievert (millisievert or mSv), or one–millionth of a sievert (microsievert or μSv), much in the way units of meters are used to describe distance. Another dose unit is the *gray* (Gy) and one–trillionth of a gray (nanogray or nGy), (Gasty & Lamarre, 2004). Each year, a resident of the United States receives an average total dose from background radiation of about 3.1 mSv. The sources of this dose are shown in Figure 1 and are discussed in detail following. Note that the annual dose values given here are averages for the United States. Some people receive less (although no one receives zero), some people receive more, and a few per–cent of the population receive much more (Gasty & Lamarre, 2004).

Dose from Radionuclides in the Body

Inhaled radionuclides include cosmogenic radionu–clides and terrestrial radionuclides that become air–borne. Of all sources of background radiation, radon (the gas emitted by uranium and thorium in soil and rocks) and its decay products result in the greatest dose to humans. Yet indoor radon concentrations are also the most variable dose components, since they depend on how a house is built, the soil it is built on, where in the house the radon is measured, and more. Even granite countertops can contribute to the radon levels in a house, but this contribution is typically very small com–pared to the radon from the soil under the house. The average dose from all inhaled radionuclides is about 2.3 mSv per year, which is about 73 percent of the average total dose from background radiation. People ingest radionuclides when they eat food grown in soil that contains uranium, thorium, potassium, and rubidium; drink milk from animals fed crops that grow in the soil; and drink water containing dissolved terrestrial radionuclides. The average dose from all ingested radionuclides is about 0.3 mSv per year (about 9 percent of the average total dose from background radiation), (Gasty & Lamarre, 2004).

Radiation Exposure, Natural

In Germany the natural radiation exposure for most of the inhabitants amounts to 1 to 6 mSv/yr with an average value of 2.1 mSv/yr. External radiation exposure contributes to one third, and internal radiation exposure to two thirds of the effective dose from all natural radiation sources. The dose due to external irradiation comes in nearly equal proportions from cosmic radiation, potassium–40 and nuclides of the uranium and thorium chain. Approximately three quarters of the effective dose due to incorporated radionuclides is made up of radon–222 and radon–220 and in particular their short–lived decay products, followed by potassium–40 and polonium–210 (NCRP, 2009).

Table 1: Contributions of various sources of natural radiation exposure in Germany

Exposure by Cosmic radiation:	**Annual effective dose(mSv)**		
	External irradiation	**Internal irradiation**	**Total**
at sea level:			
Ionizing component	0.24		} 0.27
Neutrons	0.03		
at 1,000 m altitude:			
Ionizing component	0.32		} 0.4
Neutrons	0.08		
Cosmogenic radionuclides		0.02	0.02
Primordial radionuclides:			
• K–40	0.18	0.17	0.35
U–238–chain			
U–238 –> Ra–226	} 0.12	0.02	
Rn–222 – > Po–214		1.1	} 1.3
Pb–210 –> Po–210		0.05	
Th–232–chain:		0.01	
Th–232 –> Ra–224		0.07	0.2
Rn–220 –> Tl–208	}0.14		
Total	**0.7**	**1.4**	**2.1**

Radiation Exposure, Dose Limit

Dose value of an ionizing radiation fixed by the legislator as a maximum to which a person may be exposed based on recommendations from scientific committees. Different dose limit values are fixed for different groups of persons. When handling radioactive substances and ionizing radiation the principle that any unnecessary radiation exposure is to be avoided must be observed and if unavoidable it is to be kept as low as possible, even when within the legal limit values. The German Radiation Protection Ordinance and the X–Ray Ordinance fixes the limit values for occupationally exposed persons as listed in the table. Lower values apply for occupationally exposed pregnant women and apprentices (Gasty & Lamarre, 2004).

Table 2a: Dose limits for occupationally exposed persons

Tissue or Organ	Limit
Effective dose	20 mSv/yr
Organ dose:	
Bone marrow (red), gonads, uterus	50 mSv/yr
Adrenals, bladder, brain, breast, lens of the eye, small intestine, upper large intestine, kidney, liver, lung, muscle, oesophagus, pancreas, spleen, stomach, thymus	150 mSv/yr
Bone surface, thyroid	300 mSv/yr
Ankles, feet, forearms, hands, skin	500 mSv/yr

The effective dose for members of the public must not exceed 1 mSv/yr. The limit for the lens of the eye is 15 mSv/yr and for the skin 50 mSv/yr.

Nuclear power plants must not exceed radioactive emissions from exhaust air or waste water which result in:

Table 2b: Dose limits for occupationally exposed persons

Tissue or Organ	Limit
Effective dose and dose for gonads, uterus, bone marrow (red)	0.3 mSv/yr
Dose for adrenals, bladder, brain, breast, small intestine, upper large intestine, kidney, liver, lung, muscle, oesophagus, pancreas, spleen, stomach, thyroid, thymus	0.9 mSv/yr
Dose for bone surface, skin	1.8 mSv/yr

These dose limits shall be observed at the most unfavorable point of effect, taking account of all relevant load paths, the dietary and lifestyle habits of the reference person in addition to any possible prior contamination by other plants and facilities (Gasty & Lamarre; 2004).

Radiation Exposure, Building Materials

The building material used for house building influences the radiation dose of human beings due to natural radioactive substances. The radiation within buildings made of bricks or concrete is higher than in buildings made of wood or some type of pre–assembled units since this building material contains less natural radioactive substances (Lee *et al.*, 2004).

Table 3: Radiation exposure due to building materials

Building material	Additional radiation exposure (mSv/yr)
Wood	0.2 – 0
Chalky sandstone, sandstone	0 – 0.1
Brick, concrete	0.1 – 0.2
Natural stone, technically produced gypsum	0.2 – 0.4
Slag brick, granite	0.4 – 2

Health Effects of Background Radiation

Exposure to high levels of radiation is known to cause cancer. But the effects on human health from very low doses of radiation such as the doses from background radiation are very hard to determine because there are so many other factors that can mask or distort the effects of radiation. For example, among people exposed to high radon levels, cigarette smokers are much more likely to get lung cancer than non– smokers. Lifestyle choices, geographic locations, and individual sensitivities are difficult to account for when trying to understand the health effects of back–ground radiation (EPA, 2002).

A United Nations committee concluded that exposure to varying levels of background radiation does not significantly affect cancer incidence. A committee of the National Academy of Sciences suggested that while there may be some risk of cancer at the very low doses from background radiation, that risk is small (UNSCEAR, 2000). Still, while the overall risk is low for all cancers, it is not zero and it is greater for some types of cancer than others. For lung cancer caused by breathing radon (and its decay products), the Environmental Protection Agency estimates that there are about 21,000 deaths each year, which is about 13 percent of all lung–cancer deaths. There is no evidence of increased risk of diseases other than cancer (UNSCEAR, 2000).

MATERIALS AND METHODS

Assessment of radiation levels of some selected buildings was done using inspector alert nuclear radiation monitor (sn: 35440) with halogen–quenched GM – tube of effective diameter 45 mm and mica window density of 1.5 – 2.0 mg/cm^2 . The meter was held above sea level and ten different readings at different angles were obtained in mR/hr and in CPM. To compute the exposure dose rate and further estimate equivalent dose, the following relationships were used.

(a) Count dose rate (CPM)

$$C.D = \sum \frac{N}{N} \text{ ....(1)}$$

(b) Annual dose rate (Sv/yr)

$$A.D = \sum \frac{NN.DN.HN.NM.S.OF}{NM.NS} \text{ ....(2)}$$

Where

$\sum N$ is the sum of all readings taking at each point of the investigation area

N is the frequency of values

DN is the number of days in a year

HN is the number of hours in a day

NM is the number of minute in an hour

NS is the number of seconds in a minute

OF is the Occupancy factor of the outdoor = 0.2.

(c) Effective dose rate

Effective dose rate (mSv/yr) = Dose rate (nGy/hr) x 8760 h x 0.2 x 0.7 Sv/Gy x 10^{-6}

Where

0.7 Sv/Gy is the conversion coefficient from absorbed dose in air.

0.2 is the occupancy factor proposed by UNCEAR.

(d) Effective dose to Tissue or organ.

Effective dose ((mSv/yr)

$$E = \sum H \times wT \text{ ....(3)}$$

H = D x wR..(4)

D = f x X ....(5)

Where

H is equivalent dose

D is absorbed dose

wR is radiation weighting factor

wT is tissue weighting factor

E is effective dose

X is exposure

F is conversion coefficient.

RESULTS AND DISCUSSION

The method described above was used to measure the radiation level in various houses and the results of the investigation are shown in table 4 and 5 below.

Table 4: Average background readings for new buildings

Code	Nature of the house	Exposure rate (mR/hr)	Annual dose rate (C/kg/yr)	Count rate (C.P.M)	Annual dose rate (mSv/yr)	Annual equivalent dose rate (mSv/yr)	Effective dose rate (mSv/yr)
N1	New	0.16±0.05	$4.759x10^{-4}$	54.0±11.00	1.78±1.14	9.518	0.66
N2	New	0.19±0.08	$6.119x10^{-4}$	59.2±13.00	1.27±1.04	12.238	0.72
N3	New	0.17±0.03	$4.532x10^{-4}$	47.8±10.00	1.84±8.10	9.064	0.58
N4	New	0.16±0.05	$4.754x10^{-4}$	47.8±10.00	1.81±8.10	9.518	0.58
N5	New	0.18±0.06	$5.439x10^{-4}$	54.3±15.50	1.15±9.54	10.878	0.66

Table 5: Average background readings for old buildings

Code	Nature of the house	Exposure rate (mR/hr)	Annual dose rate (C/kg/yr)	Count rate (CPM)	Annual dose rate (mSv/yr)	Annual equivalent dose rate (mSv/yr)	Effective dose rate (mSv/yr)
O1	Old	0.18±0.03	$4.136x10^{-4}$	62.2±13.00	1.98±1.09	8.272	0.76
O2	Old	0.16±0.04	$4.347x10^{-4}$	62.1±16.50	1.70±1.08	8.694	0.76
O3	Old	0.22±0.06	$5.515x10^{-4}$	62.1±16.50	1.75±1.09	11.03	0.76
O4	Old	0.21±0.07	$5.513x10^{-4}$	61.2±11.00	1.60±1.07	11.02	0.76
O5	Old	0.23±0.08	$6.105x10^{-4}$	80.4±14.50	1.91±1.41	12.21	0.98

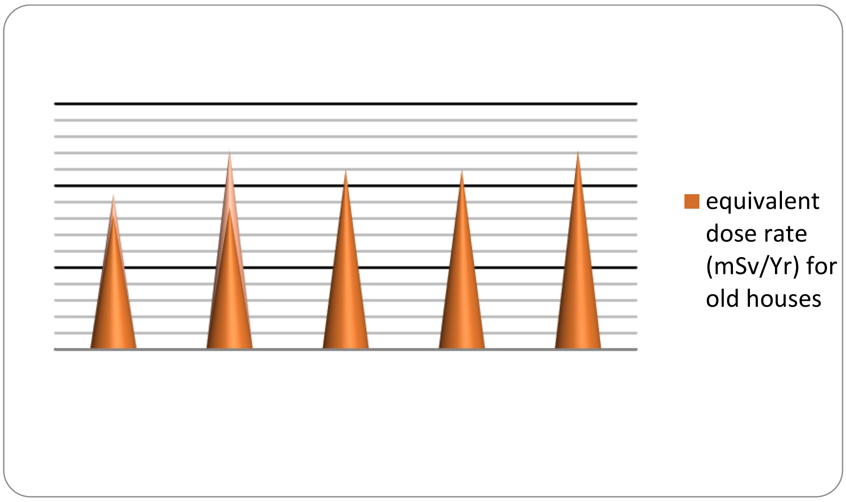

Fig 1: Showing equivalent dose rate for new and old buildings in mSv/yr

The results in table 4 and 5 established the presence of ionizing radiation in and around the buildings; this is because 500 m away from the building with the same procedure gives background readings lower than 10 m away from the building. This investigation shows that the old buildings has the highest annual dose rate (1.98±1.09 mSv/yr) and effective dose rate (0.98 mSv/yr) while the new buildings has the lowest annual dose rate (1.27±1.04 mSv/yr) and effective dose rate (0.58 mSv/yr) which signifies that the old buildings has higher radiation level compare to the new ones.

CONCLUSION

ICRP (1991) set a standard that the effective dose for members of the public must not exceed 1 mSv/yr. The equivalent does limit for the lens of the eye is 15 mSv/yr and for the skin 50 mSv/yr. The worldwide annual dose average is about 0.27 μSv h^{-1} (2.372 mSv/yr) and none of our results is up to this value which implies that the inhabitants of all buildings in Bagaji village are safe.

REFERENCES

Duval, J. S., Carson, J. M., Holman, P. B. & Darnley A. G. (2009). Terrestrial Radioactivity and Gamma–Ray Exposure in the United States and Canada. http://pubs.usgs.gov/of/2005/1413.

EPA. (2002). *Understanding Radiation,* US Environmental Protection Agency.

Gasty, R. L., Lamarre, J. R. (2004). The Annual Effective Dose from Natural Sources of Ionizing Radiation in Canada. Radiation Protection Dosimetry 108: 215–226.

HPS (2001). Answer to Questions #534 submitted to ask the experts, Health Physics Society.

http://www.epa.gov/radiation/understanding.

http://www.hps.org/publicinformation/ate/q534htm.

ICRP. (1991). Recommendation of the international commission on radiological protection, annals of the ICRP 194 (46).

IAEA (1997). Division of Public Information, International Atomic Energy Agency (A)47E, Vienna, Australia.

Lee, E. M., Menezes, G. & Finch E. C. (2004). Natural Radioactivity in Building Materials in the Republic of Ireland, Health Physics. 86 – 378.

Man, C. K. (1989). Radionuclide Contents in Building Materials used in Hong Kong, Health Physics. 57 – 397.

NCRP (2009). National Council on Radiation Protection and Measurements; Report No. 160.

Papastefanou, C., Stoulos, S. & Manolopoulou, M. (2005). The Radioactivity of Building Materials. Journal of Radiation and Nuclear Chemistry. 266 – 367.

Sorantin, H. & Steger, F. (1984). Natural Radioactivity of Building Materials in Austria, Radiation Protection Dosimetry, 7 –59.

UNSCEAR (2000). United Nation Scientific Committee on the Effects of Atomic Radiation report to the UN general assembly. New York, United Nations.