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EFFECTS OF COVERINGS ON RADIATION EXPOSURE RATE IN SOME INDOOR ENVIRONMENTS

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ABSTRACT

The effects of covering materials used for the interior building surfaces; the walls, ceilings and floors of some buildings in Ogbomoso on the radiation exposure rates have been investigated in this work using an accurately calibrated scintilometer. The combinations of covering materials assessed in this work are of three categories: A – tex-coat paint, asbestos and carpet; B – emulsion paint, asbestos and bare floor and C – ceramic tiles, asbestos and carpet. The dose rate values obtained varied between 4.04±0.05 x 10^{-5} µSv h^{-1} to 5.12±0.05 x 10^{-5} µSv h^{-1} for A, 4.04±0.04 x 10^{-5} µSv h^{-1} to 5.60±0.04 x 10^{-5} µSv h^{-1} for B and 4.61±0.04 x 10^{-5} µSv h^{-1} to 6.66±0.05 x 10^{-5} µSv h^{-1} for C. The data obtained showed that the dose rate values are highest in the C – type buildings while the lowest values are obtained in the B – type buildings. The mean effective dose for A, B and C buildings are 0.3400±0.0018 µSv y^{-1}, 0.3520±0.0019 µSv y^{-1} and 0.3735±0.0019 µSv y^{-1} respectively.

Key words: interior building surfaces, exposure rates, health risk.

INTRODUCTION

Technology advancement has given rise to improvements in building construction, such as the use of industrially made paints, tiles, asbestos and wall papers which are used to protect, preserve, decorate, add color or functionality to an object or surface by covering it with a pigmented coating. Many minerals that are usually found in the earth's crust contain small measurable amounts of naturally occurring radioactive materials (NORM) including the air, soil and water. Such radioisotopes include potassium-40 (^{40}K), uranium-238 (^{238}U), thorium – 232 (^{232}Th) and their decay products. These radioisotopes emit radiation which will be reabsorbed by the human body that is subjected to such irradiation. It may be dangerous to health depending on the magnitude of the dose upon exposure. The primary hazard comes from inhalation or ingestion. Symptoms do not show up until many years after exposure.

The effects of typical covering materials used in Hong Kong on the radon exhalation rates from concrete surfaces have been studied in the laboratory (Yu, 1993). These materials include wall paper, plaster, ceramic mosaic and glazed ceramic. Results obtained from the study showed that some covering materials could satisfactorily inhibit the radon exhalation and reduce the corresponding indoor radon concentration. The study however remarked that care should be taken in transferring the results to real building situations, when such materials are applied to the internal surface.

Naturally occurring radioactivity is found in greater quantity in some areas of the country than others. This is accounted for by taking radiation readings both outdoors and indoors and calculating the percentage change. Indoor exposures are normally due to the use of radioactive building materials. Several studies have investigated the radiation exposure rate in both indoor and outdoor environments in many parts of the country, in which exposures to environmental gamma radiation were assessed with thermoluminescent dosimeters, TLDs, placed inside dwellings made of stone, gravel, concrete, brick, etc. at Akure (Ajayi, 2000). The results of this study showed that houses made of soil bricks gave the least exposures to the dwellers. Akinloye et al. (2004) measured the indoor radiation exposure rates in some buildings in Ogbomoso. The exposure rate values reported from a total of one hundred buildings selected for measurement range from 1.57 – 1.89 µRh^{-1}. Buildings constructed with local mud recorded the highest exposure rate of 1.89 ± 0.25 µRh^{-1}. The radionuclide contents of some building materials such as sand, cement and gravel were measured and the dose equivalent values determined (Farai and Ademola, 2005). The indoor annual effective dose for a dwelling of dimension 3.6 x 3.6 x 3.0 m^3 was reported from the study to be 0.81 mSv. Annual equivalent dose rates in the indoor environments of some dwellings in Ibadan have been estimated to vary from 0.318 – 0.657 mSv y^{-1} (Ademola and Oguneletu, 2005). The level of background radiation have been evaluated for some indoor environments in Port Harcourt (Chad-Umoren et al., 2006). Warehouse in Nigeria have been assessed for indoor radon concentration (Okeji and Agwu, 2011).

Monitoring radiation levels involves both *in situ* and laboratory methods. The particular method to be employed depends on several factors. For fast estimates, the *in situ* method is more suitable as this allows for quick results, preventing further exposure to the public; the results obtained will then serve the basis for any future monitoring and recommendations. In this work, the gamma exposure rates in dwellings with different combination of covering materials on the walls, ceilings and floor were measured.

MATERIALS AND METHODS

Thirty-three dwellings were selected in an indigenous area of Ogbomoso, Oyo State, Nigeria. The selected sites were grouped into three based on the covering material on the wall, ceiling and floor respectively. Group A consisted of buildings with internal wall surfaces covered with tex-coat paint, with asbestos ceiling and carpet floor, group B comprised buildings with internal wall surfaces covered with emulsion paint, with asbestos ceiling and bare floor while group C were buildings with internal wall surfaces covered with ceramic tiles, with asbestos ceiling and carpet floor. These are hereafter referred to as A, B and C. The common combination of covering materials in this area are those of A and B with very large sample size. The C combination is rare and was chosen to represent one of the rare cases with limited or very small sample size. Fifteen buildings each were selected for A and B, while only three were selected for C; only certain rooms from each building were assessed and the average values were recorded.

The equipment used for measurements in this work is the scintillometer, a Geometrics product of Sunnyvale, California, United States of America with the following characteristics; Model Number: GR 101A, Serial Number: 10388, Voltage Requirement: 3V (Direct Current), Current: 100mA. The equipment was calibrated at the National Institute of Radiation Protection and Research (NIRPR) located in the Department of Physics, University of Ibadan, Ibadan. The calibration formula obtained is given as:

$$Y = 19514E \ldots\ldots\ldots 1$$

where Y is in counts/second and E is the Dose in μSvh[1].

Measurements were carried out three times daily at 6am, 12pm and 6pm for two weeks in the rooms of each building. The scintillometer was positioned 1m away from the ground surface and 1m from the wall and measurements were taken from the indicating meter of the instrument after the moving spindle had remained stable. This was undertaken three times to generate an average value, E, for each measurement taken.

Annual Effective Dose

Using an occupancy factor of 80% for indoor environments, the annual effective dose H_E (μSvy^{-1}) was calculated with equation 2.

$$H_E = E \times T \ldots\ldots\ldots 2$$

where E is the measured exposure rate values (in μSvh[1]), T is the occupancy time.

The occupancy time is given in equation 3:

$$T\,(\text{in } h\,y^{-1}) = \text{occupancy factor} \times 24\ \text{h} \times 365.25\ d \ldots\ldots 3$$

RESULTS AND DISCUSSION

The mean exposure rates per day in the indoor environment of the buildings assessed in this work are recorded in Table 1. The values obtained ranged from (4.57±0.92 – 5.12±0.89) x 10^{-5} μSv h^{-1} for A, (4.72±0.50 – 5.29±0.14) x 10^{-5} μSv h^{-1} for B and (5.04±0.14 – 6.15±0.51) x 10^{-5} μSv h^{-1} for C. Figures 1, 2 and 3 show the exposure rates at 6am, 12noon and 6pm respectively.

The mean exposure rates estimated for the A, B and C are 4.85±0.16 x 10^{-5} μSv h^{-1}, 5.02±0.27 x 10^{-5} μSv h^{-1} and 5.33±0.31 x 10^{-5} μSv h^{-1}. The higher values obtained in the present study compared to 4.18 x 10^{-5} μSv h^{-1} obtained in the previous study (Akinloye et al., 2010) where there were no covering materials, show that the covering materials may have contributed to the exposure rate in these indoor environment (Yu et al., 2000). The radionuclide content of the materials used for these buildings is another important factor (Akinloye and Abodunrin, 2008).

In order to determine the significance of the difference in mean exposure values obtained, *t test* analysis was performed on the data. The results (Table 2) showed the significance level (%) for the difference in the exposure rate values for the different combination of covering materials. It is observed that the exposure rate within the indoor environment of buildings with the combination of covering materials in A, B and C are closely the same. Hence the residence of C will be exposed to equal amount of gamma radiations as observable in A and B.

Annual effective dose equivalent to the population from these indoor environments derived from the mean exposure rate values using the occupancy factor of 80% were estimated as 0.3400±0.0018 μSv y^{-1}, 0.3520±0.0019 μSv y^{-1} and 0.3735±0.0019 μSv y^{-1} for A, B and C.

The values from this study are below the dose limit of 1 mSv y^{-1} recommended by ICRP (1991).

CONCLUSION

The effects of different combinations of covering materials used in the interior part of some buildings on the exposure rates in some indoor environments have been investigated in this work. The buildings were grouped into three based on the covering materials on the wall, ceiling and floor. Buildings with a combination of tex-coat paint, asbestos and carpet were designated A, emulsion paint, asbestos and bare floor, B and C for ceramic tiles, asbestos and carpet. A well calibrated scintillation counter was used as the detector for the measurements.

The mean exposure rates estimated for A, B and C were 4.85 x 10^{-5} μSv h^{-1}, 5.02 x 10^{-5} μSv h^{-1} and 5.33 x 10^{-5} μSv h^{-1} respectively. The mean values obtained from these measurements showed that gamma-ray exposure rates in the indoor environment of buildings with coverings are higher compared with buildings without coverings. The results also indicated that buildings with C-type combination of covering recorded the highest indoor exposure rates while B-type recorded the lowest. However, the effective dose values of 0.3400±0.0018 μSv y^{-1}, 0.3520±0.0019 μSv y^{-1} and 0.3735±0.0019 μSv y^{-1} obtained respectively for A, B and C in this work are lower than the recommended dose limit of 1 mSvy^{-1}.

Table 1: Mean Exposure Rate Values (μSv h^{-1} x 10^{-5}) per day

DAY	A	B	C
1	4.70±0.39	4.78±0.29	5.04±0.14
2	4.76±0.81	4.72±0.50	5.30±0.59
3	4.78±0.29	4.95±0.30	5.12±0.52
4	5.12±0.89	5.29±0.14	5.21±0.82
5	4.87±0.44	4.95±0.26	5.04±0.39
6	4.87±0.26	4.87±0.44	5.21±0.39
7	4.70±0.15	4.87±0.48	5.12±0.52
8	4.87±0.44	4.59±0.44	5.21±0.15
9	4.76±0.62	5.12±0.00	5.12±0.52
10	5.04±0.54	5.47±0.30	5.81±0.29
11	4.76±0.81	5.04±0.14	5.30±0.59
12	4.95±0.59	5.21±0.39	5.47±0.30
13	4.57±0.92	4.95±0.29	5.47±0.30
14	5.12±0.89	5.47±0.30	6.15±0.51
MEAN	**4.85±0.16**	**5.02±0.27**	**5.33±0.31**

Table 2: The significance level (%) of the difference in exposure rate values for the different combinations of covering material

Comparison between	Significance level (%)
A and B	95.98
B and C	99.21
A and C	99.99

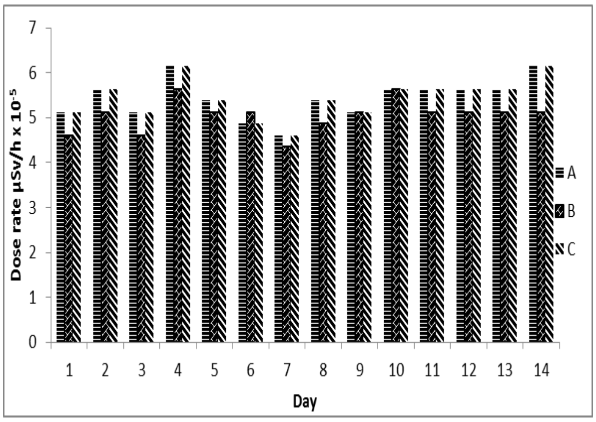

Figure 1: Comparison of the mean dose rates from A, B and C buildings at 6am, for 14days

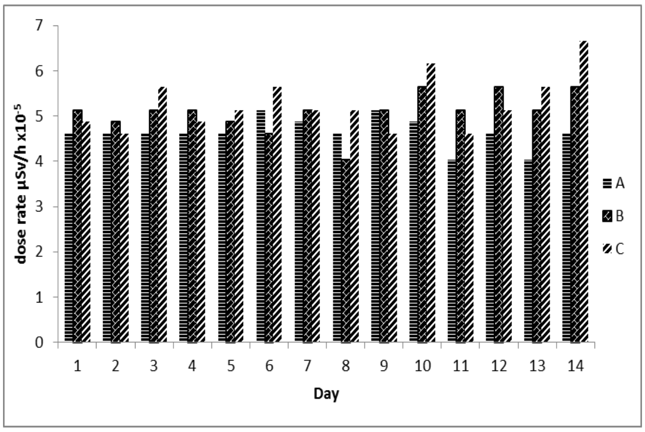

Figure 2: Comparison of the mean dose rates from A, B and C buildings at 12noon, for 14days

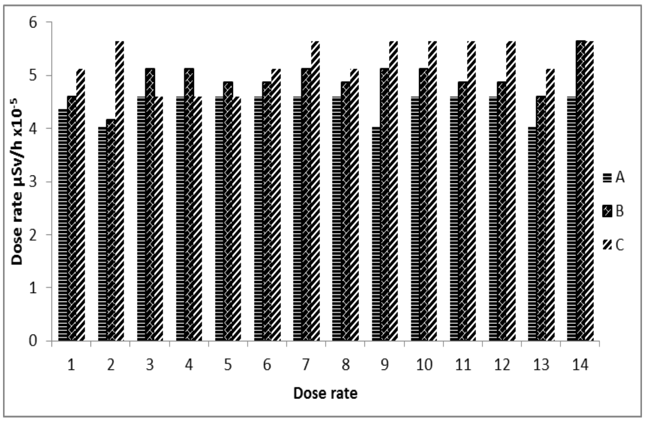

Figure 3: Comparison of the Mean dose rates from A, B and C buildings at 6pm, for 14days

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