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Indoor and Outdoor Gamma Dose Rate Exposure Levels in Major Commercial Building Materials Distribution Outlets in Jos, Plateau State-Nigeria

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Abstract

Certain types of building materials are known to be radioactive. Exposures to indoor and outdoor radiation like exposure to any other type of ionizing radiation result in critical health challenges. The measurements of the indoor and outdoor gamma dose rate exposure levels of various types of building materials in the major commercial building materials distribution outlets in Jos Plateau was carried-out. A total number of 56 shops where building materials are sold were surveyed using gamma-scout (model GS2 with serial number A20). The range of the radiation levels were: (0.258 - 0.264) mSv/yr and (0.218 - 0.226) mSv/yr for floor titles indoor and outdoor respective, (0.226 – 0.25 –0.250) mSv/yr and (0.210 - 0.214) mSv/yr for PVC ceiling indoor and outdoor respectively. The average total annual effective doses due to outdoor and indoor gamma exposures were 1.80mSv (floor tiles) and 1.64mSv (wall tiles) while for wash hand basin was 1.69mSv/yr, white cement and PVC pipes materials recorded the lowest annual effective dose amongst all the others, which is above 1mSv/yr (the acceptable limit for the general public). Hence these could pose some health hazards to the occupants of these store/shops.

Keywords: Dose rate, Building materials, Indoor gamma exposure, Outdoor gamma exposure, exposure lev level.

1. Introduction

Radioactive materials containing radionuclides of natural origin are known as NORM (Naturally Occurring Radioactive Materials). Some minerals have significant levels of natural radionuclides that are extracted and processed with other elements. Some industries involve processes that concentrate natural radionuclides and then may cause some risk to people if their exposure are not under control. These naturally radioactive materials that are concentrated by some industries are known as TENORM (Technological Enhanced Naturally Occurring Radioactive Materials). Although there is a conceptual difference between NORM and TENORM, sometimes the term NORM is used referring to TENORM. TENORM is found in some effluent flows and waste from non-nuclear industries, for example in metal residues, scales sludge and fluid. The materials, the by-products and final products from processes may enhance the exposure of workers and members of the public. The most important radioactivity source in TENORM is due to the presence of isotope produces of the Uranium and Thorium decay chain. All building materials contain various amounts of natural radioactive nuclides. Materials derived from rocks and soils contain mainly natural radionuclides of uranium ^{238}U and Thorium Th series, and their radioactive isotope of potassium ^{40}K. The external radiation exposure is caused by the gamma emitting radionuclide which is the uranium series mainly belonging to the decay chain segment starting with ^{226}Ra. The internal (inhalation) radiation exposure is due to ^{222}Rn and marginally to ^{220}Rn and their short lived decay products, exhaled from building materials into the air.

Naturally occurring radioactive materials a widespread substance that can be found everywhere in the environment including rocks, soil water, air and also tissues of living things. There are no ways to avoid the presence of natural radionuclide since its presence is from the formation of the earth. Man is continuously exposed to ionizing radiation from naturally occurring radioactive materials. The origin of these materials is the earth crust, but they find

their way into building materials, air, water, food and human body itself. Measurement of activity concentrations of radionuclides in building materials is important in the assessment of population exposure, as most individuals spend 80% of their time indoors(Mustonen, 1985). In many parts of the world, building materials containing radioactive materials have been used for generations. As individuals spend more than 80% of their time indoors, the internal and external radiation exposure from building materials creates prolonged exposure situations (ICRP, 1999). Recycled industrial by-products containing Technologically Enhanced Natural Occurring Radioactive materials are extensively used in the construction industry. Coal ash produced as waste in the combustion of coal, is used as an additive to cement in concrete and in some countries bricks are made from fly ash. Coal slag is used in floor structures as insulating filling material. Phosphogypsum, a by-product in the production of phosphorous, fertilizer is used as building material and red mud, a waste from primary aluminum production is used in bricks, ceramics and tiles (Stranden, 1983; Somlai, 2008). Building materials cause direct radiation exposure because most of them contain naturally occurring radioactive materials mainly radionuclides from ^{226}Ra and ^{232}Th decay chains and ^{40}K .The world wide average indoor effective dose due to gamma rays from building materials is estimated to be about 0.4 mSv per year (UNSCEAR, 1977; 1993). Elevated indoor external dose rates may arise from high radionuclide content in building materials (Chen and Lin, 1996; Stoulos *et al.*, 2003; Ahmed, 2005; Righi and Bruzzi, 2006; Brigido *et al.*, 2008). Generally natural building materials reflect the geology of their site of origin. However, elevated levels of natural radionuclides causing annual doses several mSv have been identified in some regions around the world e.g. in Brazil, France, India, Nigeria and Iran (UNSCEAR, 1977; 1993; 2000). This external radiation exposure caused by gamma emitting radionuclides in building materials can be assessed either by direct exposure measurements in the existing buildings or by radionuclide analyses of building materials with dose rate modeling.

2. Materials and Method

The Rwang-Pam building material shops in Jos North and that of Building Materials, Bukuru in Jos South were selected for this study because they are the largest building materials distribution outlets in Plateau State. It is always full of daily activities for customers who come from different towns in the State and also from neighboring States to buy different building materials for construction purposes. These building materials are usually displayed at the front of their shops while their warehouses filled with the materials are located inside the shops. The implication of this system of business which is generally practiced by both small and medium size business involves long business hour stay time with these materials. Hence, the exposure scenario is of concern given that these materials have element of natural radioactive materials with their accompanying nuclear particle emissions. Of greater concern is the confine space and poor ventilation that characterized most of these shops and this may lead to high radioactive build up especially radon gas concentration. The different shops housing different brands of building materials sold at Rwang-Pam Street and Building materials market Bukuru were covered in the measurement. The instrument use to perform the environmental radiation survey is a gamma scout. The Gamma Scout is a general purpose survey meter that measures alpha, beta, gamma and x-ray radiation. It has proven to be useful in medical, nuclear, mining, metal scrap and laundry industries. The gamma scout sets a new standard in portable Geiger counter performances and functionality. The gamma scout is calibrated across a wide scale (0.01 up to 1000.00 µSv/hr). Measurement at each shop/store was performed by holding the gamma-scout at 1m above to ground surface. Each measurement was taken three times and the average taken to represent the value for the shops/stores.

3. Results and Discussion

The results are as presented in Tables 1 and 2. Exposure of persons due to the presence of these building materials in each shops was assessed assuming that exposure was uniformly distributed through-out the year based on 12 hours a day, 6 days a week and 52 weeks in a year for salesmen/saleswoman and shopkeepers that stay at their sales point from morning to evening and for six days in a week. This is the typical daily routine peculiar to the traders at the market. The range and mean values of the indoor and outdoor gamma dose exposure dose rate levels at the various shops are presented in Table1, while the annual effective dose values are presented in Table 2. The background values in Table 1 indicates that the environment dose rate outside the building of the shop while the outdoor values are the dose values where the building materials are usually displayed for sales to prospective buyers. From Tables 1 and 2 it could be seen that the indoor doors rates were higher than the outdoor and background values. This is a clear indication of the radiation dose contribution due to these building materials that are always in close proximity with the store keeper in their shops. As could be seen from the Table 2, the floor tiles and wall tile shops exhibit higher dose rate compared to other types of shops.

The average total annual effective doses due to outdoor and indoor gamma exposures were 1.80mSv (floor tiles) and 1.64mSv (wall tiles) while for wash hand basin it was 1.69mSv, white cement and PVC pipes materials recorded the lowest annual effective dose amongst all the others, these values were obtained as a result of summation of the annual mean indoor gamma dose level with the annual mean outdoor gamma dose level. Increase in effective dose in tiles and wash hand basin could be associated with the presence of TENORM in ceramics and the sources of the clay origin. The Jos Plateau is thought to be an area of young granite which intruded through an area of older granites rock, making up the surrounding state (Jwanbot, 2012). The presence of the younger granites could also be a factor leading to the increase in the effective dose; the volcanic activities of over 50 million years ago and tin mining activities that took place before and after the colonial era could also increase the exposure level to workers and other individuals of concern. Therefore the scare of tin mining is still evident in plateau state and tin city of Jos, because the State is dotted with over 4000 abandoned mining ponds, describe as very dangerous as they contained radioactive materials. Control on the radioactivity of building materials can be based on dose criteria for controls and on exemption levels. The dose criteria used for control should be defined as the excess exposure caused by building materials, that is the background dose from natural radionuclides in the local typical environment need to be subtracted for the external gamma radiation, the local typical environment can be defined either as the average dose received outdoor, or as the average dose received in a house built from materials with typical activities.. With a

median exposure level of 0.52mSv arising from building materials at Rwang Pam street market and building materials market Bukuru, a dose criterion of 0.82mSv may be considered that will not cause economically and socially intolerable situations on the market. When gamma doses are limited to levels below 1mSv/yr. it is recommended that control could be based on a lower dose criterion if it is considered that this is desirable and will not lead to impractical control. It is therefore recommended that controls should be based on doses in the range of 0.3 –1mSv/yr. This is the excess gamma dose to that received outdoors. Building materials should be exempted from all restrictions concerning their radioactivity if the excess gamma radiation originating from them increases the annual effective dose of a member of the public by 0.3mSv (Jibiri and Obarhua, 2013). This is the excess gamma dose to that received outdoors. It therefore follow that salesmen and shopkeepers at the major markets in Rwang-Pam street and building materials Bukuru, should spend less time, say, about 10 hours or less a day for 6 days in a week throughout 50 weeks in a year, in order to limit their levels of exposure.

4. Conclusion

The radiation dose levels in some selected building materials in Jos have determined using the gamma scout. The average effective dose annually received by the shop keepers due to building materials varies from (0.621 – 1.818) mSv. This suggests that some of the building materials in these shops may not have any significant radiation effect on the shop keepers while some may have some radiation effects on the shop owners.

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Table-1. The Range of Indoor and Outdoor Gamma Dose Rate Level at the Shops and Background Dose Rate Level

S/N	Types of building material	Indoor (µSv/h)		Outdoor (µSv/h)		Background (µSv/h)
		Range	Mean ±SD	Range	Mean ±SD	
	Floor tiles	0.234-0.226	0.23 ± 0.01	0.215-0.206	0.21±0.01	0.127
	Wall tiles	0.258-0.264	0.261±0.01	0.226-0.218	0.222±0.01	0.101
	Wash hand basin	0.262-0.226	0.244±0.01	0.224-0.216	0.220±0.01	0.108
	Cements			0.226-0.290	0.258±0.01	0.106
	White cement	0.290-0.255	0.272±0.01	0.220-0.206	0.213±0.01	0.108
	Paints	0.266-0.226	0.246±0.01	0.214-0.206	0.210±0.01	0.110
	PVC ceiling	0.226-0.250	0.238±0.01	0.222-0.214	0.218±0.01	0.105
	PVC Pipes	0.268-0.226	0.247±0.01	0.248-0.276	0.260±0.01	0.136
	Iron rods			0.246-0.257	0.251±0.01	0.137

Table-2. Annual indoor and outdoor effective gamma dose level

S/N	Building materials	Indoor Dose (mSv)	Outdoor (mSv)
1	Floor tiles	0.977 ± 0.09	0.831±0.01
2	Wall tiles	0.924 ± 0.04	0.823 ± 0.05
3	Wash hand basin	0.913± 0.03	0.786 ± 0.04
4	Cement	No items displayed	0.816± 0.04
5	White cement	0.804 ± 0.07	0.775 ± 0.01
6	Paints	0.846 ± 0.03	0.876 ± 0.01
7	PVC ceiling	0.827± 0.05	0.793 ± 0.01
8	PVC pipes	0.808 ± 0.01	0.778± 0.03
9	Iron rods	No items displayed	0.621 ± 0.01