Activity Concentration of Radon in Soils Before Building in Southwestern Region of Nigeria.

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Abstract

Extensive radon research has been done in many parts of the world in family dwellings while investigation of radon situation in soils before building is sparse. Therefore a survey on radon in different areas of Southwestern Region of Nigeria has been conducted to assess the activity concentration of radon in soils before building family dwelling, workplace or office. Assessment of activity concentration was done using a high-resolution gamma spectrometric system. Measured radon activity concentration ranged from 1.2±0.5 Bq l^{-1} to 104.4±2.5 Bq l^{-1}. The results showed that high radon activity concentrations were obtained in areas with rocky terrains in the region.

Key Words: radon survey; family dwelling; activity concentration; soil; dose.

INTRODUCTION

The internal exposure of humans to nuclear radiation due to inhalation of radon constitutes about 50% of the worldwide average annual effective dose of 2.4 mSv y^{-1} (UNSCEAR, 2000). Radon is a colourless and odourless inert gas which emanates from soil – its major source, and decays into radioactive metal ions by α-decay in the air. Only two of its three isotopes, radon-222 (half life 3.83 days) and radon-220 (half life) can be found in significant quantity in our environment. The occurrence of radon in our environment is associated tieh the presence of uranium (^{238}U) and thorium (^{232}Th) in the earth's crust. Some soils contain more ^{238}U and ^{232}Th than others. Soil is an important environmental material used for building raw materials and products, for streets and playgrounds and for land filling. If ^{238}U and ^{232}Th occur in building raw materials made from soil, radon occurs too, they add to the indoor exposure. The level of exposure depends, among other factors, on local geology. The inflow of radon indoor and its concentration depends on ventilation of the indoor environment and the underlying soil permeability of the ground materials.

Inhalation of radon and its decay products has negative effect on human health. Epidemiological studies on uranium miners reveal that inhalation of radon and its decay products is associated with high risk of lung cancer (ICRP, 2000, Lubin et al. 1994). A lot of indoor radon surveys in dwelling have been done in many parts of the world but radon surveys in soils before building are very few. Knowledge of the activity concentration levels of radon in soil is essential for accurate assessment of the level of internal exposure due to inhalation of radon that will emanate from the soil after building a dwelling or work place on the soil and possible radiological risks to human health. This is important in the southwestern region of Nigeria where a very significant percentage of the population still live in houses built on bare ground without floor tiles or concrete or other materials that can reduce the amount of radon emanating from the bare soil. They are exposed to radon emanating from cracks in the soil without any 'shield' material.

This study was carried out to determine the activity concentration of ^{222}Rn in surface soil samples collected from 38 cities randomly selected in the southwestern region of Nigeria.

MATERIALS AND METHODS

Environmental setting of the study area

The southwestern region of Nigeria selected for this study extends form latitudes 6°30′N to 8°45′N and from longitudes 3°0′E to 5°40′E covering the Western Plains and Ranges in which Basement Complex, igneous and metamorphic rocks, have been eroded to form rolling, undulating and dissected plains and hills. The soils cover a belt of about 79000 km^2 land area and runs in north and east directions from Lagos, Nigeria. The soil maps reveal generally a repetitive, complex soil pattern, reflecting frequent changes of soil morphology as a result of frequent changes of parent rock and topography over short distances (Wessel, 1969). The soils are of three types: highly ferruginous soils that contain moderate to high levels of minerals and that are associated with areas of savannah woodland; ferralilitic soils that cover deep-red and yellow-red soils found in the rain forests; and hydromorphic soils which occur in the floodplains of large rivers and in coastal swamp areas. The soil types include clayey sand, silty clay, fine and gravely sand, sandy clay, sandy and clay. A large percentage of the land is cultivated and over 70% of the population earn a living by farming (African Atlases, 2002). About 95% of the cocoa produced in Nigeria comes from this study area (Wessel, 1969). The farmers and Fulani cattle rearers use the grassy portions of the land area as pasture for grazing animals especially during the dry season (November – March) when there is little grass in the Northern part of the country.

Sampling and activity concentration measurement

Thirty eight soil samples were collected from randomly selected cities in the southwestern region of Nigeria at a depth of about 5 cm. The samples were dried at room temperature of about 28°C to constant dry weight. Each dry sample was ground into fine powder and sieved to obtain fine-grained soil sample. The fine-grained samples were packed into plastic bag and tightly sealed to prevent the escape of radon. The sealed samples were stored for about 30 days to allow ^{214}P and ^{214}Bi to attain secular equilibrium with ^{222}Rn before gamma analysis was performed. The gamma-ray spectra of the samples were measured using high-resolution HPGe detector having a relative efficiency of 50% and energy resolution of 2.4 keV at 1.33 MeV of ^{60}Co. Detector energy and efficiency calibration and spectra analysis technique are described in Ajayi (2009).

Each soil sample and background were measured for 86,400 s using the same geometry. ^{222}Rn activity concentration in all soil samples were determined from the average activity concentrations of its decay products ^{214}Bi (gamma peak at 609.3 keV) and ^{214}Pb (gamma peak at 351.9 keV) under the assumption that secular equilibrium was reached between them and their parent (^{222}Rn). The activity concentrations in each sample were calculated using (Ajayi, 2009)

$$A_c(^{A}X) = \frac{C}{mP_\gamma \varepsilon} \quad \ldots \quad (1)$$

where A_c is the activity concentration of the radionuclide ^{A}X in the sample, C is the count rate obtained under the corresponding peak (s^{-1}), m is the sample mass (kg), P_γ is the emission probability, and ε is the detection efficiency at a specific energy.

RESULTS AND DISCUSSION

The results of the activity concentration measurements are presented in Table 1 with their counting errors.

Table 1. Activity concentration (Bq kg^{-1}) of ^{222}Rn in the soil samples

S/No	Sample location	Activity concentration of ^{222}Rn
1.	Saki	36.9±1.6
2.	Oyo	26.4±1.4
3.	Fiditi	34.2±1.5
4.	Ibadan	19.0±0.9
5.	Egbeda	7.8±0.5
6.	Igbeti	47.7±1.8
7.	Ogbomoso	40.3±1.7
8.	Eruwa	70.5±2.1
9.	Obalende	1.2±0.5
10.	Owode	56.5±2.1
11.	Agege	21.8±0.9
12.	Victoria Island	4.1±0.5
13.	Berger	19.9±0.8
14.	Ojota	27.8±1.5
15.	Ikoyi	39.4±1.4
16.	Ogbagi	24.5±1.2
17.	Ugbe	42.1±2.0
18.	Oba 1	39.5±1.2
19.	Oba 2	90.5±2.8

20.	Irun	28.1±0.9
21.	Ogbese	35.4±1.5
22.	Ikare	104.4±2.5
23.	Owo	8.9±0.6
24.	Ilaro	24.5±1.4
25.	Ago-Iwoye	12.8±0.8
26.	Ijebu Waterside	27.9±1.1
27.	Ogbere	6.6±0.8
28.	Ijebu	16.3±0.8
29.	Atan	26.8±1.2
30.	Sagamu	16.1±0.9
31.	Ede	32.5±1.0
32.	Ikire	26.0±1.1
33.	Ijebu Jesa	30.9±1.4
34.	Ile Ife	43.3±1.2
35.	Osu	19.5±1.0
36.	Ejigbo	18.5±1.0
37.	Okuku	24.6±1.2
38.	Ikirun	13.0±0.5
	Range	1.2 - 104.4
	Mean	30.5
	Standard deviation	21.5

The table shows that activity concentrations of ^{222}Rn in the soils of the region vary from 1.2±0.5 Bq kg^{-1} to 104.4±2.5 Bq kg^{-1} with a mean value of 30.5 Bq kg^{-1} and a standard deviation of 21.5 Bq kg^{-1}. Only about 40% of the soil samples show ^{222}Rn concentration of 30 Bq kg^{-1} and above.

We note that the activity concentrations of ^{222}Rn are significantly higher in Ikare, Oba 2 and Eruwa when compared with those obtained in other sampling towns. Both Ikare and Oba 2 are in Akoko area of the study region. Notable geological features of the Akoko area are steep-sided giant outcropping of rocks that dominate the landscape. Numerous studies such as those undertaken by Rahaman (1976, 1988), Oshin and Rahaman (1985) have shown the presence of radioactive minerals such as zircon, allanite, apatite and monazite in the rocks (from which the soils originate) of this area together with high potassium feldspars. This correlates with the ^{222}Rn activity concentration measured in Ikare, Oba 2 and Eruwa.

Radon activity concentration and radon dose are two terms used in communicating radon and its health risks the members of the public. While radon activity concentration is normally measured in Bq m^{-3}, radon dose, which gives energy deposition from radon and its decay products per unit mass of absorber (e.g human body, trachea or lung), is measured in mSv. A conversion factor is used to assess radon dose from radon activity concentration such as measured in this work.

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