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ESTIMATION OF ANNUAL EFFECTIVE DOSE DUE TO RADON CONCENTRATION IN GROUNDWATER IN BAUCHI NORTH, NIGERIA.

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ABSTRACT

Radon monitoring has been on increase worldwide because it poses significant health hazard to human being. In this study, radon concentration in wáter was measured to assess the corresponding radiological health implication in the study area. Sixty (60) samples of wáter were analyzed using RAD7, electronic radon detector with special accessory. The measured radon concentration in water samples rangess from 1.8 ± 0.2Bql^{-1} to 17.2 ± 1.3Bql^{-1} with mean value of 7.2 ± 1.8 Bql^{-1}. The annual effective dose exposure to individual due to the measured radon concentration was found to be 0.020 mSv y^{-1}, which is lower than the recommended safe limit of 0.1 mSvy^{-1} set by WHO and EU council. The level of radon activity concentration in the study area is still within the normal range, thus should not pose any significant health risk to the population.

Keywords: Radon, RAD7 detector, Health hazard, Annual effective dose

INTRODUCTION

Radon is naturally occurring radionuclide noble gas, which is not perceivable to our sense. It's an alpha emitter that produced by the decay of immediate parent nuclide ^{226}Ra which a half- life of 1600 years, which is a member of the ^{238}U decay series [1].The nuclei of ^{222}Rn decay by emitting 5.49MeV of alpha particles into a series of other radionuclide, the descendants which are ^{214}Po and ^{218}Po are responsible for over 90% to the total dose received due to radon exposure [2]. Higher concentration of radon is observed usually in the area sorrounded by granites and other similar rocks that contain uranium [3].
^{222}Rn atoms are continuously generated in rocks and soils in the natural decay series of ^{238}U. The radon is present in a large amount in soil, water and rock, can be transferred to the indoor either through its diffusion from soil gas or during various domestic activities, such as flushing toilet, washing clothes and showering, which will greatly enhance high concentration of radon to the people living in the dwellings [4]. Soil and water are the major sources that enhanced high radon concentration to the indoor environment [5]. Radon poses a significant health risk to populace, because it contributed to high percentage to the public exposure to ionizing radiation [6]. There two diseases that might cause when radon is exposed to human body, which are lung cancer from inhalation of radon daughters, and stomach cancer as a

result of drinking water [7]. When radon inhaled it will either cause mutation (DNA damage) or tumour (cell multiplication) [8].

Generally, surface water does not contain the significant level of radon with activities below 4 Bq l^{-1}. However, appreciable levels are observed in groundwater, especially when it passed through granite rocks [9].Water is very essential to human life; it also has a great potential for transmitting disease if contaminated by radioactive isotopes, as such the Environmental Protection Agency of United Stated has established a radon limit in water, which is 11 Bq l^{-1} [10].The assessment of radiological health hazard of radon is very important for maintaining good health among people, especially with regard to drinking water. The drinking water should be free from any contamination that will potentially endanger the users. it will be of paramount importance to conduct a research in Bauchi north in order to identify areas that are at risk, so that the government can take measures to mitigate the effect, which will eventually reduce the significant health hazard to the inhabitants.

MATERIALS AND METHODS

Geology of the Study Area

Bauchi north is located in the Bauchi state in northern Nigeria, which a coordinates 12°300″N and10°450″E. It has a total land mass of 1630 km^2 and population of 1602,985 [11]. Bauhi north comprised of seven local govenment namely; Giade, Gamawa, Itas-Gadau, Jama'are, Katagum, Shira and Zaki. The zone has three geological type which are quartenary sedimentary, sandstone and intracrusals.

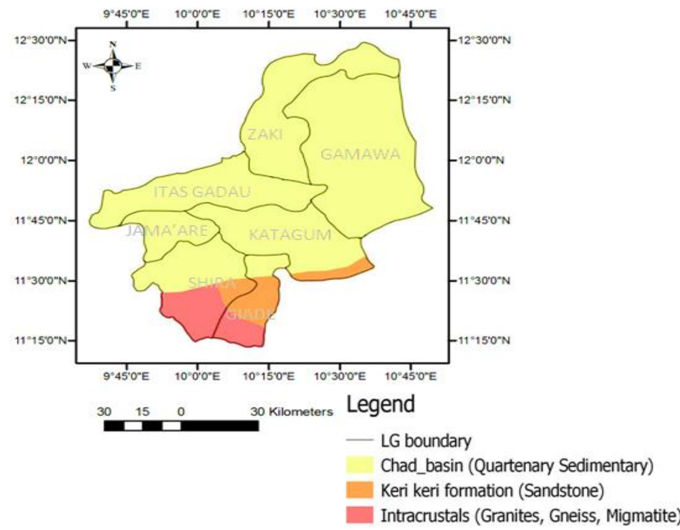

Figure 1. Geological map of the study area

Sixty (60) samples of water were from collected from underground water sources (Hand-dug well and Borehole) across the study area. In each local government 9 samples of water were collected from the three ward, with the exception of zaki where six samples were collected. The samples were taken to the laboratory for preparation and analysis. The water samples were filtered with filter paper to remove impurities that might contaminate the water. The samples were then analysed using RAD7, a semiconductor detector. RAD7 is a semiconductor detector that converts alpha radiation from the decay of ^{222}Rn to electric signal. This is developed for measurements of radon in any kind of air; indoor air, outdoor air, soil air and water. The RAD7 amplifies, filters and sorts the signal according to their strength.

Radon concentrations in water samples were measured using a RAD-H_2O technique. RADH_2O technique consists of RAD7 coupling with a closed-loop aeration system that extracted radon from water [12]. In this system, the radon extracts continuously from the water until a state of equilibrium is reached. The system takes 5 minutes to reach the equilibrium state, at this stage the RAD7 stops extracting radon from water. After pumping for five minutes, the coupling process repeats for four five minutes cycles, altogether it took 30mins to complete the analysis and get accurate results [13]. The RAD7 was purged for some minute before every measurement, to free radon from previous measurement. Throughout the experiment a WAT 250 that calculates the radon concentration in 250 ml along with grab mode was adopted.

The RAD-H_2O technique are comprised of three components, as shown in the figure 2, The RAD7, Aerotor assembly is the component that contains water sample, is capable of extraction of radon from the water sample, the radon extract from the water until a state of equilibrium is reached.The Drying tube is the component that is supported by the retort stand and is responsible for lowering the relative humidity (R.H) below 6%, which will eventually increase the efficiency of the system [14].

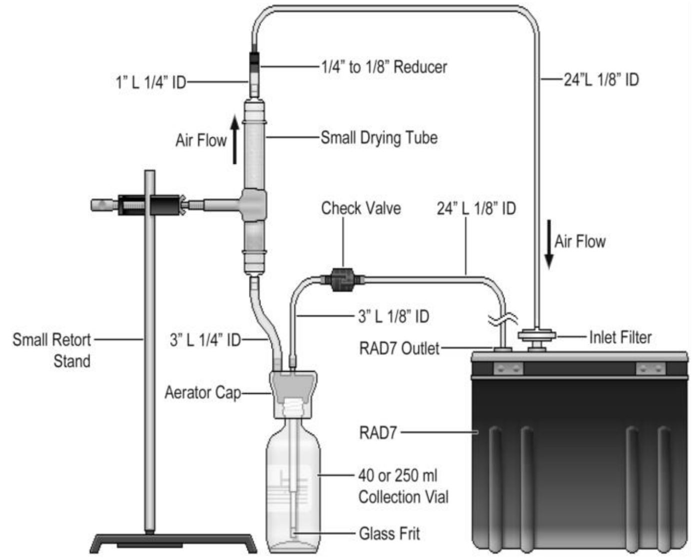

Figure 2: Set up of measurement radon in water samples using RAD7

In some cases where in situ measurements of water samples were not possible, and the measurements were made after 10 h of the collection of samples, the measurements were corrected for the decay time by employing a decay correction factor (DCF) in the measured values, using the equation: $DCF = e^{\lambda T}$

where T is the time difference between sampling time and measurement time in hours and λ (0.00756 h^{-1}) is the decay constant of ^{222}Rn.

RESULTS AND DISCUSSION

The mean radon concentration measured and total annual effective dose due ingestion and inhalation from 60 samples of drinking water taken from underground water sources are presented in Table 1.

Table 1. Radon concentration in water in Gadau district

S/N	Radon conc. (Bql^{-1})	Annual mean effective dose (μSvy^{-1})		
		Ingestion	**inhalation**	**Total**
Gamawa				
1	8.7 ± 2.7	1.83	21.92	23.75
2	1.8 ± 0.8	0.38	4.54	4.92
3	6.2 ± 1.9	1.30	15.62	16.92
Giade				
4	9.2 ± 1.7	1.93	23.18	25.11
5	4.1 ± 1.6	0.86	10.33	11.19
6	3.3 ± 1.4	0.69	8.32	9.01
Itas-Gadau				
7	12.6 ± 2.3	2.65	31.75	34.40
8	8.4 ± 2.1	1.76	21.17	22.93
9	17.2 ± 1.3	3.61	43.34	46.95
Jamaare				
10	8.6 ± 1.8	1.81	21.67	23.48
11	6.3 ± 2.2	1.32	15.88	17.20
12	7.5 ± 1.9	1.56	18.90	20.46
Katagum				
13	6.8 ± 0.9	1.43	17.14	18.57
14	2.9 ± 1.4	0.61	7.31	7.92
15	8.4 ± 2.9	1.76	21.17	22.93
Shira				
16	5.3 ± 1.6	1.11	13.35	14.46
17	4.0 ± 1.3	0.84	10.08	10.92
18	2.6 ± 0.7	0.55	6.55	7.10
Zaki				
	10.8 ± 2.9	2.23	27.22	29.45
	9.3 ± 2.5	1.95	23.44	23.39
Average	7.2 ± 1.8	1.51	18.14	19.65

From table 1, the measured radon concentration in water samples range from 1.8 ± 0.2Bql^{-1} to 17.2 ± 1.3Bql^{-1} with mean value of 7.2 ± 1.8 Bql^{-1}. Radon concentration in all water samples is found within the recommended by 11Bql^{-1} set by USEPA, with the exception of one ward in Itas-Gadau with has a value of 17.2 ±

1.3Bql^{-1}, the higher value of radon concentration can be attributed to the quartenary sedimentary geological type of the area, but all samples water are within the safe limit of 4-40 Bql^{-1} recommended by UNCEAR. Table 2 shows the comparison of ^{222}Rn concentration in water of present study with the studies conducted in different countries. It is clearly shown that the study in India is in close agreement with the present study.

Table 2: Comparison of radon concentration in water of present work with other studies

Country	**Radon concentration in water (Bq L^{-1})**		**References**
	Range	**Average**	
Turkey	0.11 – 0.71	1.73	(Erees, *Mouner*, 2006)
India	0.03 – 2.28	0.43	(Mehra and Bala, 2014)
Malaysia	0.54 – 2.54	−	(Muhammad, *B. Jafar*, 2012)
Saudi Arabia	0.76 – 4.69	2.80	(El-Taher, 2012)
India	0.94 – 16.4	8.3	(Mittal *et al*., 2015)
Nigeria	0.77 – 28.37	12.43	(Garba, 2011)
Turkey	0.21 – 5.82	2.5	(Tabar and Yakut, 2014)
Greece	0.8 − 24	5.4	(Nikolopoulos and Louizi, 2008)
Brazil	0.95 – 36.00	2.35	(Marques, Binesh, 2004)
Bauchi north	0.2 – 17.2	7.2	This study

Estimation of Mean Annual Effective Dose

The annual mean effective dose of drinking water due to ingestion and inhalation was determined by using expression established by UNCEAR. The annual effective dose due to ingestion in water ($E_{w.I_g}$), was calculated from radon concentration determined from the experiment using equation 1.0

$$E_{w.I_g}(nSvy^{-1}) = C_{Rn} \times C_w \times EDC \quad (5)$$

where $E_{w.I_g}$= effective dose for ingestion, C_{Rn} = measured radon concentration in water (Bq L^{-1}), C_w = water consumption rate (60 L y^{-1}) and EDC = effective dose coefficient for ingestion 3.5 nSv Bq^{-1}.

Table 1, shows the annual effective dose due to ingestion, which ranged from 0.38 to 3.61 µSv y^{-1} with average value 1.51 µSv y^{-1}

Likewise, for inhalation ($E_{w.I_h}$) was determined from equation 5

$$E_{w.I_h} = C_{Rn} \times R_{a.w} \times R \times O \times (DCF) \quad (6)$$

$E_{w.I_h}$ = effective dose for inhalation, C_{Rn}= measured radon concentration in water, $R_{a.w}$= Ratio of radon concentration in air to radon in tap water (10^{-4}), F = equilibrium factor between radon and its progeny, O = is the global average indoor occupancy factor (7000 h y^{-1}), DCF = Dose conversion factor (9 nSv h^{-1} $(Bqm^{-3})^{-1}$) UNSCEAR. Table 1 shows the annual effective dose due to inhalation varied from 4.54 to 43.34 µSv y^{-1} with mean value of 18.14 µSv y^{-1}.

From the table 1, the total annual mean effective dose varies from 4.92 µSvy^{-1} to 46.95µSvy^{-1} with a mean value of 19.65µSvy^{-1}, which is lower than the recommended safe limit of 0.1 mSvy^{-1} adopted from WHO and EU council.

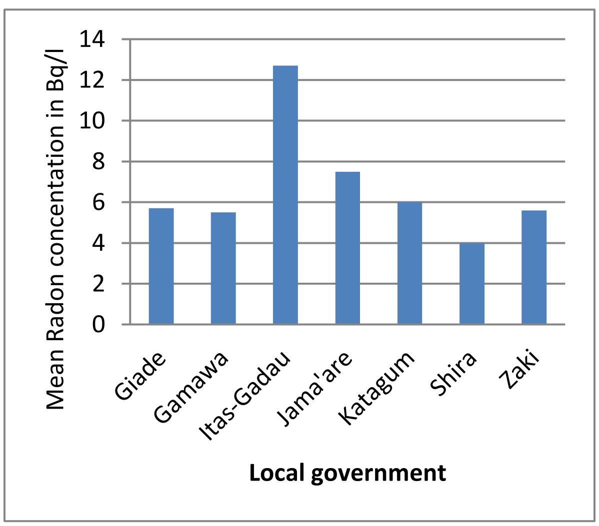

Figure 3. Mean activity concentration of ^{222}Rn in water in different Local Government in Bauchi north

CONCLUSION

This work determined the ^{222}Rn concentration in underground soureces within the study area.The measured radon concentration of all samples in Bauchi north, are found within the safe limit recommeded by USEPA (1991), with exception of ward in Itas-Gadau, which a value of 17.2 ± 1.3Bql^{-1}. The annual mean effective dose calculated is less than the recommended safe limit by WHO and EU council.The underground water sources of the study area can be used for domestic purpose without posing any significant radiological threat to the inhabitants. Based on the research findings, the following are recommended, a more detail study should be conducted to cover all geological and soil type in the entire in the Baucchi state, so as to determine the radiological potential of radon and its daughters, in order to assess the radiation safety for the populations.

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