



Radon Concentration Analysis of Borehole and Well Water Sources in Lapai, Using Liquid Scintillation Counter

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ABSTRACT

Liquid Scintillation Counter was used to analyse water samples collected from Lapai metropolis, to determine the concentrations of radon-222. The result obtained showed that there was radon gas in all of the water samples. The mean concentration of the gas in borehole water was 14.51Bq/L, while that of well water was 14.30Bq/L. One sample suspected to contain high quantity uranium gave the highest value of radon gas, 18.75 Bq/L. This is not safe for drinking. The world average for radon concentration in water is 10 Bq/L. One sample had value below this, while all other are higher. The values are also above Maximum Concentration Limit of 11.1 Bq/L, and hence, were considered not safe for drinking. The average annual effective dose calculated was 2.83mSv/a. This is above maximum permissible level for non-occupational public exposure and therefore water in the area should not be consumed continuously for a long time to avoid stochastic effect of radiation.

Keywords: Radon, Lapai, water, radiation, stochastic, scintillation

INTRODUCTION

Drinking water that has been contaminated with significant quantity of radon-222 has been reported to lead to lung and stomach cancer in many people (USEPA, 1999). According to the United States Environmental Protection Agency, radon is the second most frequent cause of lung cancer, after cigarette smoking, causing 21,000 lung cancer deaths per year in the United States. About 2,900 of these deaths occur among people who have never smoked. While radon is the second most frequent cause of lung cancer, it is the number one cause among non-smokers, according to EPA estimates (Wikipedia, 2016)

Radon-222 is a naturally occurring, radioactive noble gas that is present in the environment in water, air and soil. Radon is a colourless, odourless radioactive gas that is a daughter element in the decay chain of uranium-238. It is an alpha particle emitter with a half life of 3.82 days.

It is known that radon-222 produces about 50% of natural radiation exposure to the general public. The mean value of annual exposure of the population at Lebanon caused by natural radiation amounts to 2.5mSv. About 1.3mSv is caused by radon-222 and its daughter product (Abdallah, *et al.*, 2007). Water drawn from surface supplies does not generally contain

appreciable levels of radon, which are expected to be on the order of 0.01 Bq/L. Water for human consumption should be free from chemical, microbiological and radiological contamination. But unfortunately in developing countries most people are not opportune to have access to such safe drinking water.

In Lapai, Nigeria, most of the populace rely heavily on untreated ground water from borehole and well as only source of drinking water. It is important to investigate the activity concentration of radon-222 in the water samples from such sources. This is necessary to create awareness among Lapai people about the presence of radon-222 concentration in water and realize the need to treat the water before drinking. Policy makers will also be able take necessary action to reduce the risk of exposure and the effect of exposure to ionizing radiation. Lapai is located within latitude 9°02'E, it is about 18km west of old Lapai near the tributary of river Gurara along Suleja road which is also about 56km East of Minna, Niger state capital. Lapai covers an area of about 373km² whose

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population was estimated to be about 18,600. It is located in the southern part of Niger state on a geological base of indifferent basement complex of mainly gneiss, magmatite and schist. The area is characterized by continuous protruding imposing rocks, hills and mountains interrupted with guinea savanna plains forming attractive landscape. The landform generally tilted south-eastwards thereby directing most of the drains towards River Gurara which flows southwards.

METHODOLOGIES

Water samples were collected from various wells and boreholes at different locations within Lapai metropolis. Each of them was labelled as shown in table 1.

Table 1: Sample location and identification codes

Location	Sample ID
Soje Area	WW1
Federal Lowcost	WW2
Student Villa	WW3
Badeggi market	BH1
Magaji Primary School	BH2
Junior Secondary School	BH3
University Main Campus	BH4

They were collected in dry-cleaned plastic sample bottles. The samples were analyzed as soon as possible after collection without allowing them to stay long (maximum of three days), to achieve maximum accuracy. 10ml

each of the samples were added into a scintillation vial containing 10ml of the instagel scintillation cocktail. Having been sealed tightly, the vials were shaken for more than two minutes to extract ²²²Rn in water phase into the organic scintillator. The samples were allowed to stay for three hours after preparation, so that radioactive equilibrium between ²²²Rn and its daughter progeny will be reached. In order to avoid leakage of ²²²Rn gas, measurements were carried out within 24 hours after preparation. Liquid scintillation counter (Tri-Carb-LSA1000) was used for the analysis of the samples collected. The activities of the samples in count per minute were obtained, and the concentration of ²²²Rn was calculated with the following equation

$$Rn(Bq/L) = \frac{100 \times (SC - BC) \exp(\lambda t)}{60(CF) \times (D)} \tag{1}$$

The annual effective doses due to the intake of radon were calculated from the mean activity concentration A_{Rn} using the following equation:

$$E_{(Rn)} = D_{e(Rn)} \cdot I_w \cdot A_{(Rn)} \tag{2}$$

where D_{e(Rn)} is the effective dose per unit intake of radon in water for adults, taken as 10 – 8 Sv/Bq (UNSCEAR, 1993) and I_w is the water consumption rate, taken to be 2 litres per day.

RESULTS AND DISCUSSIONS

The raw result of the activity of ²²²radon counted in the water samples collected from different wells and boreholes, using liquid scintillation machine is presented in table 2. Also presented in the table are the radon concentration and the corresponding annual effective doses.

Table 2: Activity concentration of radon-222 and the corresponding annual effective dose in groundwater samples from Lapai.

S/N	Sample ID	Sample Activity Count/minute	Radon Concentration (Bq/L)	Annual Effective Dose (mSv/year)
1	WW1	128.58	13.94 ± 1.13	2.7
2	WW2	127.15	09.55 ± 1.12	1.9
3	WW3	149.13	18.75 ± 1.22	3.7
4	BH1	136.35	15.73 ± 1.16	3.1
5	BH2	128.68	14.60 ± 1.13	2.8
6	BH3	132.07	15.09 ± 1.14	3.0
7	BH4	124.68	13.30 ± 1.11	2.6

From the results, sample WW2 has the lowest activity of 9.55Bq/L, which is less than the Maximum Concentration Limit (MCL) of 11.1Bq/L set by USEPA (1991). It is also less than the assumed world average value of 10Bq/L (WHO, 1996; UNSCEAR, 1993). Samples BH2 and BH4 with activity of 13.94Bq/L and 13.30Bq/L respectively are slightly higher than the set limits. Also samples WW1, BH1 and BH3 with concentrations of 14.60Bq/L, 15.73Bq/L and 15.09Bq/L respectively have values that are slightly higher than the standard values. The sample with highest radon concentration is WW3, with activity of 18.75Bq/L, which is clearly above the maximum concentration limit and therefore poses a threat to the people around the area. The mean ^{222}Rn concentration for the well water samples was 14.51Bq/L while that of borehole was 14.30Bq/L. All of the values are compared in figure 1.

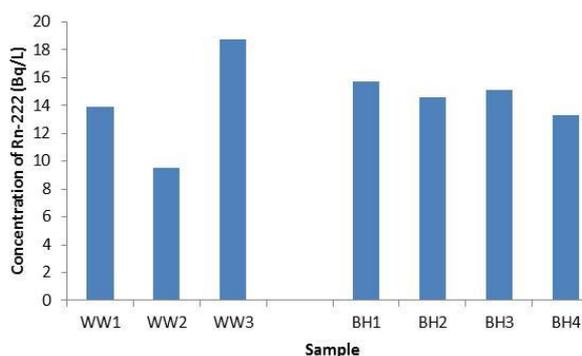


Figure 1: Comparing activity concentrations of Radon-222 in the water samples

In figure 1, there are little variations in the values of ^{222}Rn concentration for borehole water, whereas the variations are much between values obtained for well water. The borehole water samples were obtained from very deep sources and the similarities in the results indicates that there are similar types of basement rock across Lapai metropolis. As for surface water from shallow wells, there is indication that a great variation exists in the type of soils and minerals at different locations within the metropolis. A mineral deposit containing significant level of naturally occurring radioactive material, such as uranium ore is suspected to be present at location of WW3, where abnormally high value of 18

.75Bq/L was recorded. Geological survey of the area will provide more insight to this.

The annual effective dose values fall within a range of 1.9mSv/a to 3.7mSv/a, with average of 2.83mSv/a. These are higher than 1mSv/a maximum permissible dose for non-occupational public exposure, as recommended by the International Commission for Radiological Protection (ICRP). The maximum value of effective dose obtained here, 3.7mSv/a, is not sufficient to cause any known early biological effect of radiation. However, continuous ingestion of ^{222}Rn will lead to cumulative effective dose over an extended period of time. The minimum cumulative effective dose that is known to cause radiation sickness is 100mSv. Living in Lapai for 35 years will expose one to this amount of radiation dose. There is tendency therefore that inhabitant of Lapai who drink water from these sources for more than thirty-five years will experience stochastic effects of radiation.

Conclusion

The ^{222}Rn concentrations in ground water sources from Lapai were determined with liquid scintillation counting method. The result showed that the mean ^{222}Rn concentration of 14.51Bq/L in borehole water and 14.30Bq/L in well water were slightly higher than world average of 10Bq/L and Maximum Concentration Limit of 11.1Bq/L. The concentration of ^{222}Rn in borehole water was fairly constant across the city, while those of well water vary greatly from one part of the city to another, and it was deduced that there could be a mineral deposit at location of the sample with highest concentration of ^{222}Rn . The mean annual effective dose of 2.83 obtained is higher than 1mSv/a maximum permissible dose for non-occupational public exposure recommended by ICRP. Although, the maximum value of 3.7mSv/a obtained is not sufficient to cause any known early biological effect of radiation, it can be responsible for stochastic effects of radiation for a person that spend more than thirty-five years in the area.

REFERENCES

- Abdallah, S.M., Habib, R.R., Nuwayhid, R.Y., Malek C., Katul, G. (2007). Radon Measurement in Wells and Springs in Lebanon. *Elsevier Journal of Radiation Measurement* 42, 218-303.

Darko, E.O., Adukpo, O.K., Fletcher, J.J. (2010). Preliminary Studies on ^{222}Rn Concentration in Groundwater from Selected Areas of the Accra Metropolis in Ghana. *Journal of Radioanalytical and Nuclear Chemistry* 283, 507-512.

Dewayne Cecil, L., Gesell, T.F. (1992). Sampling and Analysis for ^{222}Rn Dissolved in Groundwater and Surface Water. *Journal of Environmental monitoring and Assessment* 20.

Farai, I.P., Sanni, A.O. (1992). Yearly Variability of ^{222}Rn in a Groundwater System in Nigeria. *Journal of African Earth Science* 15(314), 399-403.

Prichard, H.M., Gessel, T.F. (1977). Rapid measurements of ^{222}Rn Concentrations in Water with a Commercial Liquid Scintillation Counter, *Health Physics*, pp 33:577-81.

Selvasekarapandian, S., Sivakumar, R., Manikandan, M., Rajjunath, V.M., Kannan, V., Rajanan, S. (2002). A Study on the Radon Concentration in Water in Connor-India, *Journal of Radio Analytical and Nuclear Chemistry*. 252(2), 345-347.

United Nations Scientific Committee on the Effects of Atomic Radiation (1993). Sources and Effects of Ionizing Radiation, UNSCEAR Report to the General Assembly with Scientific Annexes, United Nations, New York.

United State Environmental Protection Agency (1999). Health Risk Reduction and Cost Analysis for Radon in Drinking Water. Federal Register 64(38), 9559 Washington D.C.

United State Environmental Protection Agency (1991). National Primary Drinking Water Regulations for Radionuclides. US Government Printing Office, Washington D.C, EPA/570/9-91/700.

World Health Organization (1993). Guidelines for drinking water quality vol.1 (2nd ed.).

Wikipedia (2016). Radon. <https://en.wikipedia.org/wiki/Radon>