Journal of Academia and Industrial Research (JAIR)
Volume 4, Issue 8 January 2016

ISSN: 2278-5213

RESEARCH ARTICLE

Measurement of Radon Concentration in Drinking Water of Ado-Ekiti, Nigeria

E.A. Oni[1], O.M. Oni[2], O.O. Oladapo[3], I.D. Olatunde[4] and F.E. Adediwura[5]
[1,4,5]Dept. of Physics with Electronics, Oduduwa University Ipetumodu, Ile Ife, Osun State Nigeria; [2]Dept. of Pure and Applied Physics, Ladoke Akintola University of Technology Ogbomoso, Oyo state, Nigeria; [3]Dept. of Science Laboratory Technology, Ladoke Akintola University of Technology Ogbomoso, Oyo state, Nigeria
emand1215@gmail.com*; +234 8038152523

Abstract

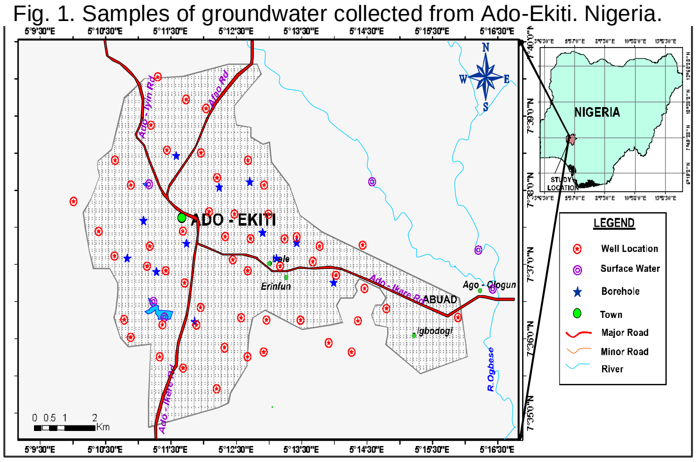
Radon is one of the significant sources of natural radiation among the decay series products. It contributes about half the radiation dose received by the general population. Human exposure to radon is through inhalation of radon gas and ingestion from water. It is of concern because it has been identified as leading cause of lung cancer among non-smokers and second leading cause of lung cancer among smokers. The death toll caused by radon in developing country like Nigeria is unknown. The activity of radon in ground water from Ado-Ekiti were collected and assayed using a well calibrated active electronic radon detector (RAD7) manufactured by Durridge Company Inc. The results obtained in this work were compared with maximum contaminant Level (MCL) of 11.1 Bq L^{-1} set by USEPA and it was noted that some samples exceeded the value.

Keywords: Radon, Ado-Ekiti, ground water, lung cancer, maximum contaminant level.

Introduction

Radon is ubiquitous and naturally occurring radionuclide, also imperceptible to human senses and can only be measured using a detector. Among the radioisotopes that contribute to natural background radiation, radon has been the main risk to human health. It can be attributed to about 55% of the annual radiation dose received by the general public (George, 2009). Additionally, it has been technically established that radon 222 is a health hazard in mining and non-mining environments (El-Gamal and Honsy, 2008). Furthermore, it has also been identified as the second leading cause of lung cancer among smokers and the major cause among non-smokers. The main source of radon is rock and soils of the earth crust (Mohammed, 2014). Radon can diffuse from rock into water from underground sources. Water containing radon is used for domestic activities; therefore, radon gas escapes from water into the air (khattak, 2011). The routes of radon to human are through inhalation of radon when its escape from water to air or through ingestion when water containing radon is consumed, therefore the quality of water is now essential, since water is indispensable in our daily activities. Due to increase in population, pollution of stream and unavailability of government portable water led to the higher demand of ground water in the study location. In addition, radon higher level has been observed in the ingenuous rock (Gilbert, 1988), which is basement rock of the study location (Omotoyinbo 1994). Keeping the above facts in view, it is then imperative to determine the quantity of radon concentration in drinking water of the study location and also to estimate the annual radon ingestion dose from the drinking water.

Fig. 1. Samples of groundwater collected from Ado-Ekiti. Nigeria.



Materials and methods

Study area: A total number of 64 samples of groundwater (deep wells and boreholes) were collected from 23 different locations in Ado-Ekiti ($7^{0}3^{1}$ and $7^{0}49^{1}$ north of the equator and longitude $5^{0}7^{1}$ and $5^{0}27^{1}$ east of the Greenwich Meridian), Ekiti State. The total population of Ado-Ekiti as recorded by the Nigerian Population Commission in 2012 is 424,340. This population is highest in the whole state. The geology of Ado-Ekiti belongs to the basement complex rock (igneous rock) of South Western Nigeria. Major lithiological rock units are basically crystalline basement rocks. These include coarse grained charnokite, fine grained granite, medium grained-granite and porphyritic biotite-hornblend granite, with superficial deposit of clay and quartzite (Omotoyinbo, 1994).

Table 1. Radon measurements in ground water samples of Ado-Ekiti, Nigeria.

Sample	Location	No. of samples	Water type	Radon conc. (Bq/L)	Annual effective dose by ingestion
1	Ekute street	3	Well	15.53±1.55	1.133×10^{-4}
2	CAC road location 1	3	Well	14.71±1.43	1.074×10^{-4}
3	Dele road	3	Well	16.53±1.69	1.207×10^{-4}
4	CAC road location 2	3	Well	6.94±1.10	5.069×10^{-5}
5	Parish road, Ekute	3	Well	8.55±1.17	6.247×10^{-5}
6	Off Police station, Ekute Quarters	3	Well	12.81±1.55	9.357×10^{-5}
7	Ikeere road location 1	3	Well	3.42±0.79	2.502×10^{-5}
8	Ikeere road location 2	2	Well	3.55±0.81	2.502×10^{-5}
9	Ikeere road location 3	2	Well	3.09±1.30	2.258×10^{-5}
10	Ikeere road location 4	2	Well	8.35±1.17	6.101×10^{-5}
11	Oke-Bola location 1	3	Well	32.03±2.32	2.338×10^{-4}
12	Aba Igbira location 1	2	Well	17.54±3.91	1.281×10^{-4}
13	Aba Igbira location 2	3	Well	19.82±1.88	1.447×10^{-4}
14	Iyin road	3	Well	9.78±1.34	7.142×10^{-5}
15	Ikeere road location 5	3	Borehole	9.34±2.44	6.818×10^{-5}
16	Oke-Bola location 2	3	Borehole	24.62±2.10	1.798×10^{-4}
17	Aba Igbira location 3	3	Borehole	25.43±1.88	1.857×10^{-4}
18	Olukayode stadium	3	Borehole	18.70±2.37	1.365×10^{-4}
19	Fajuyi area	3	Borehole	19.97±1.83	1.458×10^{-4}
20	Seventh Day Adventist hospital	2	Borehole	16.28±5.73	1.189×10^{-4}
21	Ilawe road	3	Borehole	6.42±1.28	4.687×10^{-5}
22	Iworoko	3	Borehole	8.22±3.75	6.004×10^{-5}
23	Oja-Oba	3	Borehole	10.98±1.22	8.018×10^{-5}
	Average	64		13.59	9.921×10^{-5}

Experimental analysis: Water samples were collected directly from the source into a clean 1.5 L bottle previously rinsed with distilled water. During water collection, conscious effort was taken to prevent bubbling of the water, so as not to allow escape of dissolved radon in the water. A total of 64 samples of water were collected from the study area and were assayed using a well calibrated active electronic detector (RAD7) connected to a RAD-H_2O accessory (Durridge, 2013). The RAD7 detector was used for measuring radon in water by connecting it with a bubbling kit which enables it to degas radon from a water sample into the air in a closed loop. Within the closed loop is desiccant to dry the air before entering the detector for radon concentration measurement. The detector uses alpha spectrometry technique. RAD7 is capable of accurately measuring radon concentration in a water sample within 20 min. The time is very short compared with the 3.8 d half life of radon, thereby making RAD7 superior to many other detectors for radon in water measurement (Oni *et al.,* 2014).

Average annual radon dose estimation: It seems that the radiation dose to the public from radon transport by water is a very serious threat than other water pollutants. Radon in drinking water can deliver a radiation dose to the stomach through ingestion. To calculate the annual mean effective dose of radon from ingestion, the established parameters by UNSCEAR (2000) are suitable. Therefore, we use the formula below:

$$\text{EWI (mSva}^{-1}\text{)} = \text{CRnW} \times \text{CW} \times \text{EDC}$$

Where, EWI is effective dose for ingestion, CRnW is the radon concentration in water (kBq.m-3or Bq/L), CW is the estimated weight of used water (60 L/y) and EDC is the effective dose coefficients for ingestion (3.5 nSv BqL^{-1}).

Results and discussion

The results for radon concentrations in drinking water samples collected in Ado-Ekiti of Ekiti State, Nigeria were reported in Table 1. The radon concentration values in samples from Ado-Ekiti were in the range of 3.09±1.30 BqL^{-1} to 32.03±2.32 BqL^{-1} with an average value of 13.59 BqL^{-1}. The recorded value of radon concentrations are within the recommended safe limit of 4-40 BqL^{-1} suggested by United Nation Scientific Committee on the Effect of Atomic Radiation. All the radon concentration values were found to be below the recommended action level of 100 BqL^{-1} set by the European Commission for drinking purpose. The US Environment Protection Agency has proposed that the allowed maximum contamination level (MCL) for radon concentration in water is 11 BqL^{-1} in which about 53% of samples were above the maximum contamination level. The higher value of radon concentration can be ascribed to the nature of basement rock in the study locations and also could be linked to hilly nature of the area. Comparing the result of this study with the other part of the world in Table 2, it can be noticed that the radon concentration taken for Ado Ekiti is lower than the radon concentrations from places like Romania, parts of Jordan, outer Himalayas and Finland, but higher compared to radon concentrations from India, Turkey, Lebanon, some parts of Jordan, Algeria, Northern Venezuela and USA.

Table 2. Comparison of radon concentration of ground water samples used for drinking in Ado-Ekiti with other parts of the world.

Location	Radon concentration (Bq/L)
India	2.63
Turkey	9.28
Romania	15.4
Jordan (many locations)	2.8-116
Lebanon (many locations)	11.3
Tassili, South-east Algeria	0.67-21.25
Eastern Doon Valley, outer Himalayas	20-95
Northern Venezuela	0.1-5.76
Finland	630
United States of America	5.2
Ado-Ekiti, Nigeria (Present study)	13.59

Annual effective dose by ingestion from the corresponding measured radon concentrations were estimated for different locations of study. It was found out that the annual effective dose by ingestion varies from 2.258×10^{-5} mSv/y to 2.338×10^{-4} mSv/y with an average value of 9.921×10^{-5} mSv/y. All values for the annual effective dose by ingestion were below the recommended ICRP intervention level of 3-10 mSv/y.

Conclusion

The present study showed that the radon concentration in the ground water samples from Ado-Ekiti has been observed to have radon concentration above the maximum limit set by USEPA which call for immediate action for radon reduction. Also comparing the result with the value of 0.1 BqL^{-1} set Standard Organization of Nigeria (SON), it was observed that all the water samples assayed for radon concentration are not safe for domestic purposes and consumption. Hence the data in the study could be used for the study location, since this work pioneer the determination of radon in ground water in the study location.

References

1. El-Gamal, A. and Honsy, G. 2008. Assessment of lung cancer risk due to exposure to Radon from coaster sediment. *East. Med. Health J*. 14(6): 1257-1269.
2. George, A.C. 2009. World history of radon research and measurement from the early 1900's to today. *26th Avenue Bayside NY 11360 US,* pp.201-207.
3. Gibert, J. 1998. Indoor Radon 222 measurement in Sweden with the solid state nuclear track technique. *Health Phy.* 54(3): 271-281.
4. Mohammed, W.M. 2014. Measurement and study of radioactive radon gas concentrations in the selected samples of water for AL-Shomaly. Proc. book of ICETSR, 2014, Malaysia hand book on the emerging trends in scientific research. ISBN: 978-969-9347-16-0.
5. National Research Council. *Risk Assessment of Radon in Drinking Water*; National academy press, National research council: Washington, DC, USA, 1999 retrieved Feb 13, 2015, from http://www.nap.ed/chapter/1.
6. Omotoyinbo, O.S. 1994. Geology of Ado-Ekiti. (Unpublished thesis) Ekiti State University Ado- Ekiti.
7. Oni, M.O., Oladapo, O.O., Amuda, D.B., Oni, E.A., Adelodun, A.O., Adewale, Y.K. and Fasina, M.O. 2014. Radon concentration in groundwater areas of high background radiation level in Southwestern Nigeria. *Niger. J. Physics*. 25(1): 64-67.
8. United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR). 2000. The General Assembly with scientific annex. United Nation, New York.Retrieved May 2010, from http://www.unscear.org/docs/reports/2000/11 80076.
9. United Nations scientific committee on the effects of atomic radiation (UNSCEAR, 1993). Sources and effects of ionizing radiation, UNSCEAR report to the general assembly with scientific annexes, UN, New York. Retrieved May 2010from http://www.unscear.org/reports.
10. United State Environmental Protection Agency (USEPA) 1991. National primary drinking water regulations for radionuclide. US Government printing office, Washington D.C. EPA/570/991/700.