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Radon Concentration in water sources in Talensi, Ghana.

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ABSTRACT

Radon is one of the most important radioactive elements which are released by natural decay of available uranium and radium in the ground. The presence of the gas is common in various drinking water sources. As a way of prevention, we have measured the activities of radon for sixty-four (64) drinking water samples collected from boreholes and hand-dug wells. This study was conducted during the dry season (December-January) of 2016. The samples were collected from sixty-four (64) water sources (boreholes and hand-dug wells). The concentration of radon was evaluated using solid state nuclear track detector LR-115 type II, with an active layer of 12 µm on a 100 µm clear base. The minimum radon concentration in the water sources was 30.17 Bq/m^3 (hand-dug well) and the maximum amount was calculated as 115.33 Bq/m^3(borehole). Based on the results, radon concentration of the drinking water sources was below the permitted levels of EPA and WHO guidelines. These activities do not present any health risk to the community.

Introduction

Environmental pollution has been a great threat to humanity since creation. It is natural for us to be sensitive and active against all the pollutants causing threats to our lives (Tabassum et al, 2012). Talensi District is a landlocked area in the Upper East Region of Ghana with a long-standing history of mining activities. The earth is the largest accessible storage of portable water and accounts for about 94% of all fresh water (Plummer and McGery, 1993, Appiah and Mensah,2017). Groundwater occurs in geological formations; however, its distribution in the earth crust is not uniform (Fetter, 1994,Appiah and Mensah,2017). The source of groundwater is rain and snow that falls to the ground and percolates down into the ground (Appiah et al, 2014). The proportion that soaks into the ground is influenced by climate, landscape, soil and rock type and vegetation (Appiah et al, 2017). Boreholes and hand-dug wells are the main sources of drinking water in the District. Radon is produced during the radioactive decay chain of uranium, found naturally in traces in the earth's crust (Nita et al, 2009&2012). Radon has a mole fraction value of 0.00125 at 37^{o}C and a half-life of 3.8 days, which is 15 times higher than that of helium or neon (Dickson, 1998 & Garba et al., 2010). Radium which emits radon is a radioactive metallic chemical element found in pitchblende and other uranium minerals. Virtually, all rocks contain some traces of uranium, and the highest amounts are found in granitic rocks. Thus, radon concentration is detected in areas underlain by granites, dark shales, pegmatites, syenites, and light-coloured volcanic rocks, sedimentary rocks that contain phosphates and metamorphic rocks derived from these rocks (Gelman et al, 2003; Otton, 1999). The uranium content of sandstone and shale is variable if the sediment is derived from different sources (Bruce et al, 1996). According to Faure (1999), shale contains more uranium on average than sandstone. At standard temperature and pressure, it has a density of 9.73kg/m^3 and freezes at 202K (Williams, D.C 2007). The amount of radon in groundwater is related to several factors including the amount of uranium in the source rocks, the location of radium atoms in the mineral gain and physical properties of the aquifer materials, e.g., porosity (Barnett et al, 2003). This noble gas produced by the decay of radium is emitted continuously from the earth's crust and can reach the earth's surface by different processes (Nita et al. 2009). Radon gas can dissolve and accumulate in groundwater. If this radon containing types of water are frequently used in the household (for showering, dishwashing and laundry), radon gas is released into the environment. People receive exposure from the naturally occurring radioactivity in soil, air, water and food (Komal et al, 2010). Radon can enter homes through cracks and openings in the foundation floor and walls (Ningappa, 2017). When radon decays and is inhaled into the lungs, it releases energy that can damage the DNA in sensitive lung tissues and cause cancer (Badhan et al., 2010). Groundwater can carry additional radon into homes and other buildings, creating a health risk. Measurement of natural radon in the soil is very important because it helps in monitoring changes in natural background activity with time as a result of any radioactivity released (Darko et al. 2015). The movement of radon through rocks under the earth largely depends on lithology, compaction, porosity and fractured and tectonic features like faults, thrust, joints or fractures (Kumar,et al.,2012Choubey et al. 1997; Joga et al, 2010; Walia, et al., 2005a). Another study by various authors confirms this fact (Choubey et al. 1999,2007, Virk and Walia 2000, Walia et al. 2003) focused on radon monitoring in water and soil for health hazards assessment and earthquake prediction research. The purpose of this study is to measure the radon level concentration of groundwater being used for drinking in the environs of Talensi and to determine the health hazards.

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Study area

Talensi district is in the Upper East Region of Ghana. It is located between latitudes 10^o 15' and 10^o 60'N and longitudes 00^o 31 and 01^o 05'W. The latitude and longitude of sampling location and elevation above sea level were recorded by GPS. The geology of the area falls within the Birimian, Tarkwaian and Voltaian rocks of Ghana (kesse, 1985). The Birimian rocks (meta-volcanic and meta-sedimentary rocks) are intruded by granitoid. The meta-sedimentary rocks are mostly phyllites, schist and greywackey and are intruded by granitoid and pegmatite (Horton, J.D., 2017). The meta-volcanic rocks consist of meta-basalt, meta-dacites, meta-rhyolite and volcaniclastics, which are intruded by belt-type granitoid (http://www.ghanadistricts.gov.gh/. Accessed 16/02/18). In the research results of radon measurements in borehole drinking water and hand-dug, well water samples are presented. Almost all of these water samples are used both as drinking water and for other domestic chores by the inhabitants in the area. The study area experiences a maximum temperature of 45^o C in the month of April and a minimum of 12^oC in December. The vegetation is that of guinea savannah or modified guinea savannah (Dickson and Benneh, 1988).

Materials and Method

The main drinking water sources in the area under study are Borehole, and Hand-dug well. A total of 64 samples from different locations in the Telensi District were collected from boreholes and hand-dug wells with the permission of the community leaders and landowners. The locations of the sampling points are indicated in the map as shown in figure 1.

The water samples were collected from groundwater sources (boreholes and hand-dug wells) in seventeen (17) different communities in the Talensi District of Ghana. The study of radon levels in groundwater in the environs of Talensi was carried out using solid state nuclear track detector films (LR-115 type II) in the form of thin- film of active layer of thickness of 12µm on a clear 100 µm polythene base. The water sample were collected in 250 ml plastic containers, 250 g of each sample was weighed and poured into a tightly sealed polythene bottles, leaving a gap between the surface of the water and detector for a period of three months. This was to allow enough accumulation of radon gas from the water samples, to attain a secular equilibrium with its daughter. Alpha particles generated by radon (decay radon products in proximity to the detecting material) strikes the detecting material to produce microscopic area of damage called latent alpha tracks. After the three months of exposure, the detectors were removed and subjected to chemical etching in 2.5 M analytical grade NaOH solution at 60^o C$\pm1^o$ C for half an hour in a constant temperature bath to enlarge the latent produced by the alpha particle from the decay of radon. The detectors were washed with running cold water, rinsed with distilled water, and dried in air for about 30 minutes. Having dried the exposed film (1cm × 1cm) for some minutes, the detectors were ready for track counting. Many techniques of track revelation are known, for example grafting (Choubey et al.1997 & Choubey et al. 2007) the most frequently used is the chemical etching in which tracks are made visible under the optical microscope after chemical amplification via etching. The measurement of radon values depends on the exact counting of tracks produced by the alpha particles on these detectors. These tracks were viewed through using an image acquisition commercial scanner (Epson Perfection V600). The photomicrographs of revealed alpha tracks in these detectors were taken using the J software at 200X magnification. The track density recorded on the detector was used to calculate the radon concentration, C using the relation:

$$\mathbf{C\ (Bqm^{-3}) = \frac{\rho - \rho_B}{\varepsilon T}}$$

where

$\boldsymbol{\rho}$ **− track density**

$\boldsymbol{\rho_B}$ **− background track density**

$\boldsymbol{\varepsilon}$ **− calibration factor**

T − exposure time in hours

The radon concentration was calculated from track density in units Bqm^{-3} using a calibration constant/ factor 3.96 tracks.

Results and Discussions

The results of the radon concentration in the various water samples are shown in table 1. The radon concentration values in the samples range from 30.17 - 115.33 Bqm^{-3}, for borehole and 30.17- 40.50 Bqm^{-3} for hand-dug well. The high concentration for hand-dug well and borehole recorded can be arrogated to the geology of the area which is mainly granitoids and also lack aeration and agitation of the water in the wells. This result is consistent with similar works studied in other areas with similar geology by Asumadu–Sakyi et al, 2012. The uranium content, grain size and permeability of the host rock and the nature and extent of fracturing in the host rock may be contributed to the high radon concentration. The boreholes have the highest concentrations (48.28 to 115.33Bqm^{-3}) because there may be little or no loss of radon because there is a lack of aeration and the water is more stagnant. Similar reasons could be assigned to the higher concentrations of samples from the hand-dug well (30.17 - 40.65 Bqm^{-3}). According to the USPA (United States Environmental Protection Agency) regulations, the maximum contamination level for radon in drinking water is 11 Bq/L (USEPA, 1999) which implies that the measured values for different samples are lower and consequently safe for drinking purposes.

Conclusion

The radon concentration content of Talensi District, Ghana has been measured using the passive detectors LR-115 type II films.

Water samples from 12 different communities were analyzed using LR-115 type II alpha track detector. The stagnant nature of boreholes and hand-dug wells prevents the loss of radon because of the lack of aeration. Radon concentrations in drinking water of Talensi, Ghana are well below the WHO recommended safe limit values. The variations in levels of radon appear because of the geology of the area, aeration and agitation of water.

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Authors' contributions

Conceived and designed the experiments: Philip Kwasi Mensah, Seth Appiah, and Daniel Gyasi-Antwi

Performed the experiments: Philip Kwasi Mensah, Seth Appiah , and Daniel Gyasi-Antwi

Analyzed the data: Philip Kwasi Mensah, Seth Appiah, and Daniel Gyasi-Antwi

Wrote the paper: Philip Kwasi Mensah, Seth Appiah, and Daniel Gyasi-Antwi

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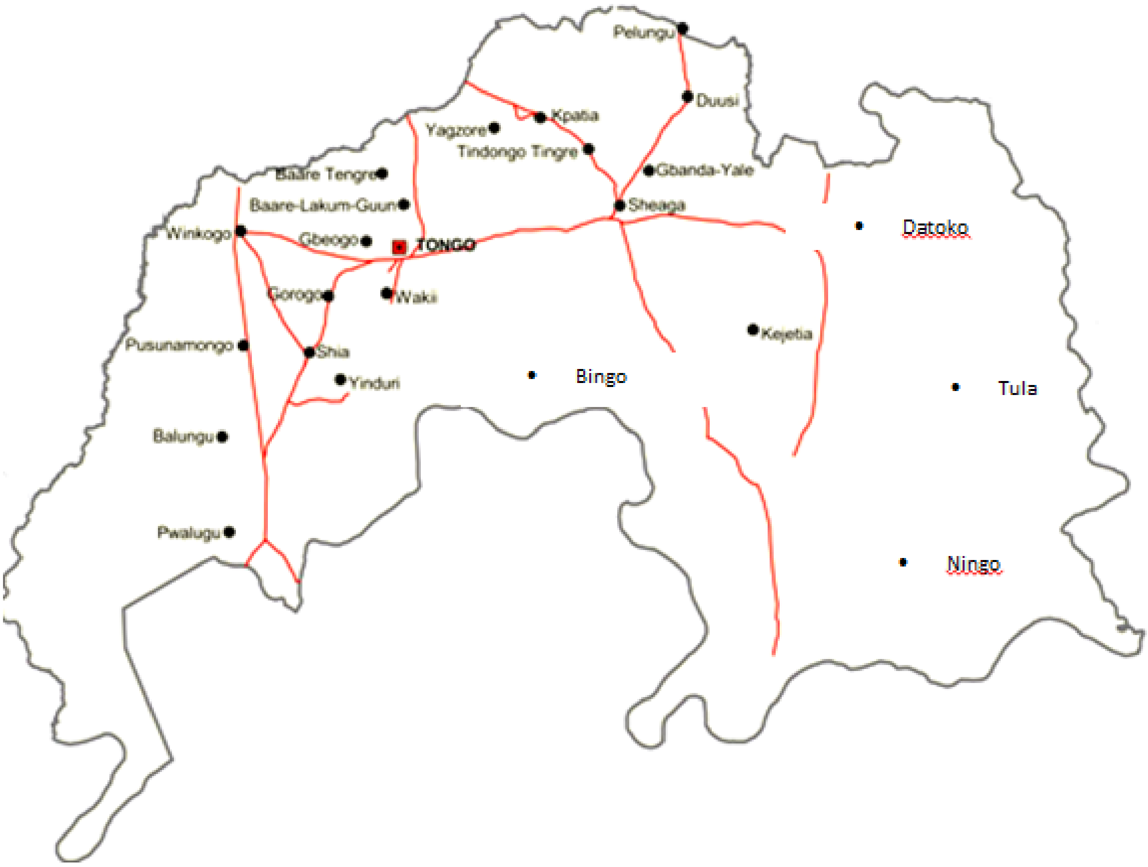

Figure 1. Location points of the sampling in Talensi District

Table 1. Concentration of Rn-222 in the water sources.

Sample No.	Location	Source	Concentration(Bqm^{-3})
BTO-1	Baare-Tengre	Borehole	54.77
BTO-2	Baare-Tengre	Borehole	115.33
GBO-1	Gbeogo	Borehole	72.07
GBO-2	Gbeogo	Borehole	52.96
GRO-1	Gorogo	Borehole	55.53
PNO-2	Pusunamongo	Borehole	54.66
TTO-2	Tindongo- Tingre	Borehole	66.17
YZO-2	Yagzore	Borehole	55.18
GBA-2	Gbanda-Yale	Borehole	68.57
KEJ-2	Kejetia	Borehole	61.55
PEL-1	Pelungu	Borehole	50.62
PEL-2	Pelungu	Borehole	70.32
KPA-1	Kpatia	Borehole	103.23
KPA-2	Kpatia	Borehole	48.28
GRO-2	Gorogo	Borehole	57.53
PNO-1	Pusunamongo	Borehole	56.73
TTO-1	Tindongo-Tingre	Borehole	60.15
YZO-4	Yagzore	Borehole	60.25
DUU-4	Duusi	Borehole	54.63
GBA-3	Gbanda-Yale	Borehole	58.32
GBA	Gbanda-Yale	Borehole	65.72
PEL-3	Pelungu	Borehole	30.17
SHE-3	Shiega	Borehole	58.52
PWG-1	Pwalugu	Borehole	64.25
PWG-2	Pwalugu	Borehole	70.56
BGO-1	Bingo	Borehole	58.62
BGO-2	Bingo	Borehole	62.30
TUL-1	Tula	Borehole	56.47
NIG-1	Ningo	Borehole	61.46
NIG-2	Ningo	Borehole	58.54
DTK-1	Datoko	Borehole	76.15
DTK-2	Datoko	Borehole	68.54
GRO-2	Gorogo	Hand-dug well	36.89
PNO-1	Pusunamongo	Hand-dug well	33.14
TTO-1	Tindongo-Tingre	Hand-dug well	32.14
YZO-1	Yagzore	Hand-dug well	41.50
DUU-1	Duusi	Hand-dug well	34.25
DUU-2	Duusi	Hand-dug well	36.18
KJE-1	Kejetia	Hand-dug well	39.92
SHE-1	Shiega	Hand-dug well	38.00
SHE-2	Shiega	Hand-dug well	31.57
BTO-3	Baare-Tengre	Hand-dug well	36.52
BTO-4	Baare-Tengre	Hand- dug well	40.65
GBO-3	Gbeogo	Hand-dug well	32.25
GBO-4	Gbeogo	Hand-dug well	33.60
GRO	Gorogo	Hand-dug well	32.48
PNO-4	Pusunamongo	Hand-dug well	34.20
TTO-4	Tindongo-Tingre	Hand-dug well	34.46
DUU-3	Duusi	Hand-dug well	37.43
GBA-4	Gbanda- Yale	Hand-dug well	37.43
KEJ-3	Kejetia	Hand-dug well	30.17
PEL-3	Pelungu	Hand-dug well	37.12
PEL-4	Pelungu	Hand-dug well	38.43
KPA-3	Kpatia	Hand-dug well	38.81
KPA-4	Kpatia	Hand-dug well	36.54
PWG-3	Pwalugu	Hand-dug well	38.46
PWG-4	Pwalugu	Hand-dug well	37.52
BGO-3	Bingo	Hand-dug well	34.52
TUL-2	Tula	Hand-dug well	36.15
TUL-3	Tula	Hand-dug well	35.25
NIG-3	Ningo	Hand-dug well	38.16
NIG-4	Ningo	Hand-dug well	34.64
DTK-3	Datoko	Hand-dug well	41.52
DTK-4	Datoko	Hand-dug well	38.46