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Assessment of Gross Alpha and Beta Radioactivity in Groundwater by Liquid Scintillation

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ABSTRACT

An assessment of levels of natural radioactivity in groundwater of parts of Sheet 102, Zaria was carried out. A total of 20 groundwater samples were collected and analyzed for gross alpha and gross beta radioactivity, using a liquid scintillation counter. Results obtained showed that the gross alpha radioactivity of the groundwater ranged from <0.01 Bq/l to 0.035q/l, with a mean of 0.0149Bq/l. Gross beta radioactivity ranged from 0.06Bq/l to 0.91Bq/l with a mean of 0.3295Bq/l. Results obtained for both the gross alpha and beta for all samples studied fall within the World Health Organization (WHO) 1999 Drinking water standards of 0.1Bq/l for alpha and 1.0 Bq/l for gross beta.

KEYWORDS: Radioactivity; Gross alpha and Beta; Standard; Drinking water

1. INTRODUCTION

Non-contaminated groundwater can only contain radioisotopes originating from 3 radioactive families of ^{238}U, ^{235}U and ^{232}Th. The most abundant radioisotope in groundwater is ^{226}Ra which is a daughter to ^{238}U. In groundwater, the highest activity concentrations have been found from water containing high amounts of sodium, potassium, magnesium and calcium (saline water). Higher concentrations of radioactivity in environmental media are associated with higher radiation damage and risk to humans, indicated as kidney damage, bladder and kidney cancer, leukaemia, etc (WHO 2003).

The activity concentrations of gross alpha or beta in a drinking water could guide in determining whether the water can be used for human consumption (AOAC, 1990; EML, 1990). This has led to an increased demand for data, with the aim to addressing public concern pertaining to the quality of drinking water since most of our local people use groundwater as fetched directly from wells for domestic use.

Gross alpha is more of a concern than gross beta for natural radioactivity in water as it refers to the radioactivity of Th, U, Ra as well as Rn and its descendants. When the results of groundwater radioactivity screening is positive, it is warranted to determine the isotopic content using more sophisticated and time-consuming procedures (EPA, 1993, 2000, Garba 2008).

The World Health Organization (WHO 2003) guidelines for drinking water suggest performing an indirect evaluation of committed dose by measuring gross alpha and beta radioactivity and checking compliance to derived limit; the proposed limits are 0.1 Bq/l for gross alpha and 1.0 Bq/l for gross beta radioactivity.

The Study Area

The study area is located within the Guinea Savanna belt (Sheet 21, Zaria). The area falls between latitudes 11°00'00"N and 11°30'00"N and longitudes 7°30'00"E to 8°00'00"E, (Fig. 1).

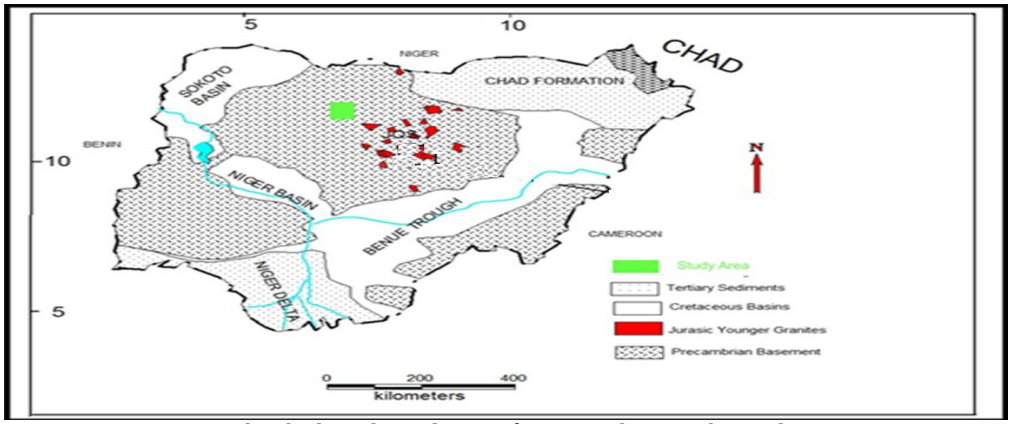

Fig. 1: Sketched Geological Map of Nigeria Showing the Study Area

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Geological map of Nigeria depicting location of the study area is presented in fig. 2. The area belongs to the Precambrian Basement Complex of the Northern Nigeria, and is composed of Precambrian gneiss, and Meta sediments (Karau- Karau schist belt) as well as the Pan African granites.

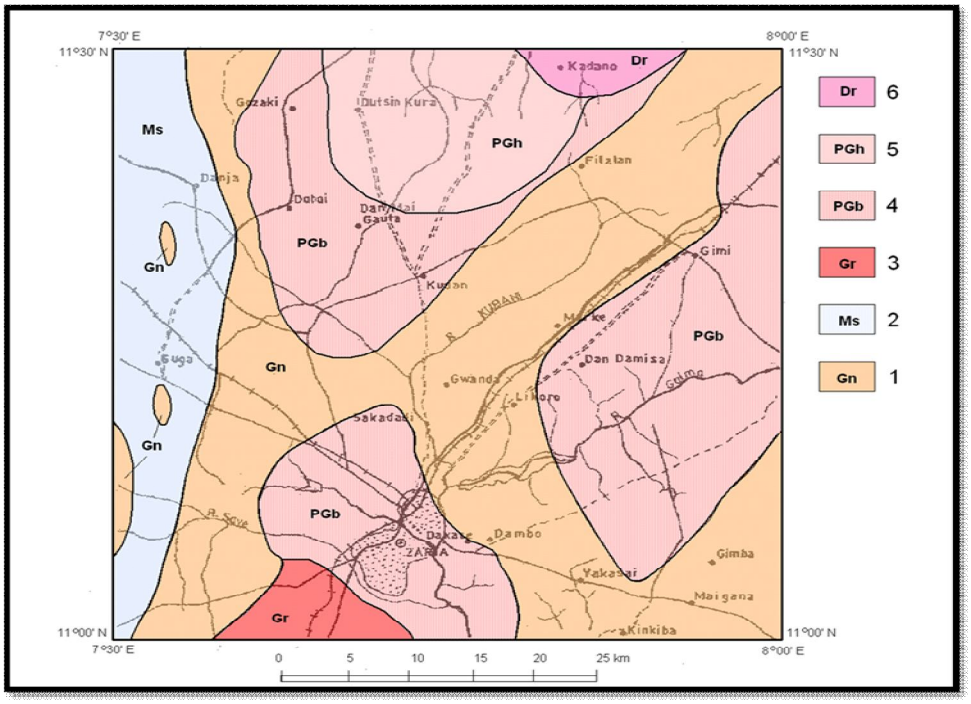

Fig. 2: Geological Map of the Study Area (1- Gneiss, 2: Metasediments, 3- Fine to Medium Grain Granite, 4- Porphyritic Biotite Granite, 5- Porphyritic Hornblende Granite, 6- Diorite)

MATERIALS AND METHODS

For this work, a total of 20 groundwater samples were collected in a 1 liter low density plastic bottles that were thoroughly rinsed with the water to be sampled before finally filling, air tightening and labeling the bottles. In the field, pH and total dissolved solids (TDS) measurements were undertaken before the samples were acidified using 2 ml of 1N HNO_3 to minimize the lost of radiation to the containers wall.

In the laboratory, 100 ml of each sample was collected and poured into special plastic containers. The samples were then reduced to a little less than 10 ml using a microwave freeze drier and quantitatively transferred into a plastic scintillation vial. After rinsing of the containers in which the samples were compressed, the total sample after the transfer was almost 10 ml. To each sample, 10 ml of scintillation cocktail (Lumagel) was added and well shaken before refrigerating for 24hours prior to counting.

RESULTS AND DISCUSSION

Table 1 show the statistical analysis of the results which indicates that the range of alpha activity is between 0.035 Bq/l to <0.01 Bq/l, while for the beta radiation, it ranged from 0.91 to 0.01 Bq/l (slightly above the World Health Organization drinking water limit to not detected). A graphical presentation of both alpha and beta radioactivity is also given in Fig. 3. This results as contoured further shows that the gross activity of both alpha and beta radiations tend to concentrate towards the eastern part of the study area (Fig. 4 and 5), which is a pegmatite rich area (MC curry 1973, Garba 2008).

The low level gross alpha and gross beta results might be indicative of low level concentration of the parent radionuclides in the aquifer material, since for an elevated gross alpha radiation to occur, the parent radionuclide uranium and radium must occur in elevated concentration in the parent rock that constitute the aquifer. Alternatively, the low activity might be due to the adsorption of ^{226}Ra by Fe oxide surface or its precipitation, as reported by Wanty and Nordstrom (1993).

In general, anomalous radionuclide concentrations are related to rock composition, mineralogy, geologic structures and groundwater chemistry (Asikainen and Kahlos, 1989), (Wanty and Nordstrom, 1993).

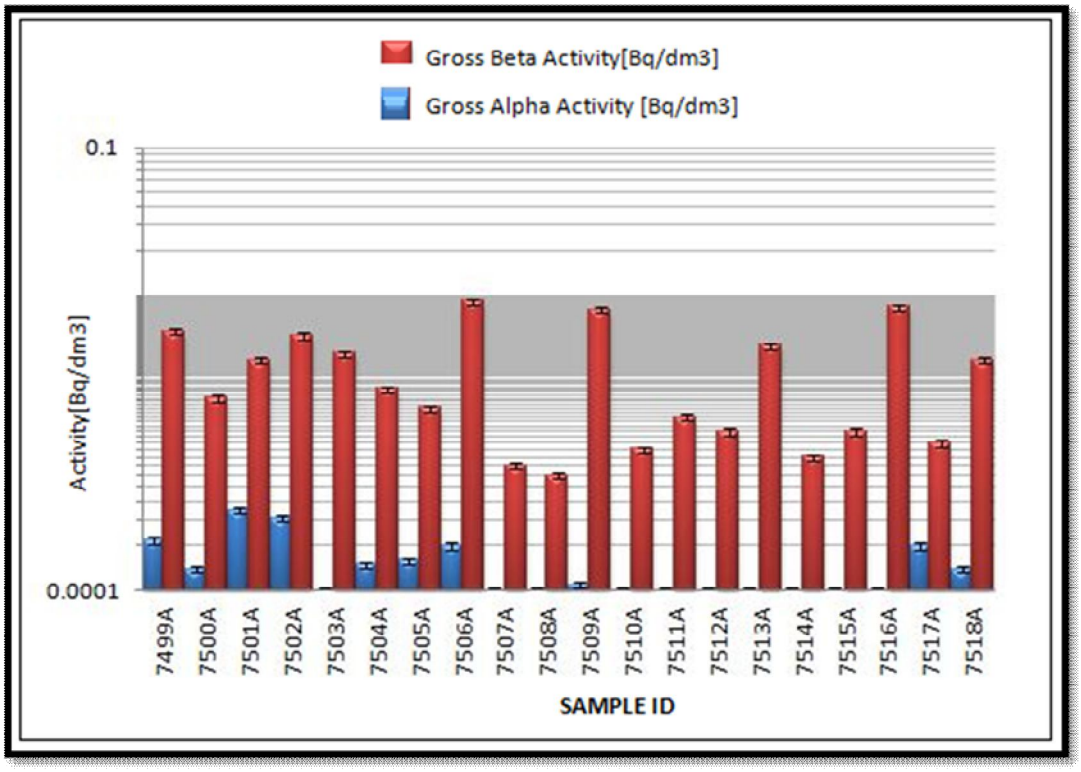

Fig. 3: A plot of gross alpha and beta activity of the studied water samples

Table 1: Results of quality assurance measurement of gross alpha and beta activity in the studied samples

Laboratory Number	Sample Location Latitude	Longitude	TDS (mg/l)	pH	Temperature (^{o}C)	Gross Alpha Activity [Bq/dm^3]	Gross Beta Activity [Bq/dm^3]
7499A	11.180^0	07.675^0	343	5.0	28.9	0.022 ± 0.005	0.57 ± 0.14
7500A	11.209^0	07.791^0	60.4	5.0	28.4	0.014 ± 0.003	0.20 ± 0.05
7501A	11.261^0	07.839^0	118	5.0	29.7	0.035 ± 0.008	0.36 ± 0.09
7502A	11.274^0	07.783^0	249	5.5	29.6	0.031 ± 0.007	0.53 ± 0.13
7503A	11.278^0	07.872^0	387	5.0	28.5	0.010 ± 0.002	0.40 ± 0.10
7504A	11.366^0	07.993^0	104	5.0	30.5	0.015 ± 0.004	0.23 ± 0.05
7505A	11.396^0	07.860^0	81.4	5.0	28.9	0.016 ± 0.004	0.17 ± 0.04
7506A	11.497^0	07.818^0	464	5.0	30.9	0.020 ± 0.005	0.91 ± 0.22
7507A	11.379^0	07.731^0	786	5.0	28.2	< 0.010	0.07 ± 0.02
7508A	11.451^0	07.691^0	299	4.5	29.0	< 0.010	0.06 ± 0.02
7509A	11.455^0	07.644^0	1160	7.0	28.2	0.011 ± 0.003	0.79 ± 0.19
7510A	11.289^0	07.687^0	137	4.0	28.5	< 0.010	0.09 ± 0.02
7511A	11.262^0	07.648^0	477	6.0	27.6	< 0.010	0.15 ± 0.04
7512A	11.075^0	07.671^0	64.8	4.5	28.1	< 0.010	0.12 ± 0.03
7513A	11.095^0	07.503^0	310	6.0	27.6	< 0.010	0.45 ± 0.11
7514A	11.047^0	07.636^0	38.9	5.0	28.0	< 0.010	0.08 ± 0.02
7515A	11.084^0	07.691^0	132	4.0	27.9	< 0.010	0.12 ± 0.03
7516A	11.166^0	07.950^0	1010	6.5	27.7	< 0.010	0.83 ± 0.20
7517A	11.068^0	07.755^0	31.4	4.0	28.2	0.020 ± 0.005	0.10 ± 0.02
7518A	11.077^0	07.779^0	201	5.0	27.5	0.014 ± 0.003	0.36 ± 0.09

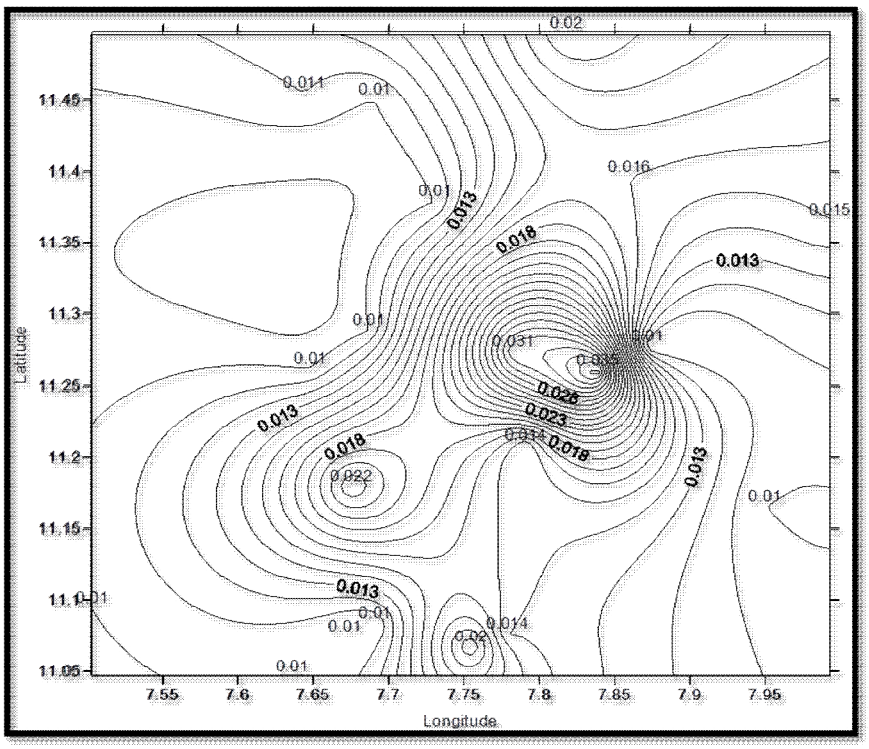

Fig. 4: Map of total alpha concentration of groundwater

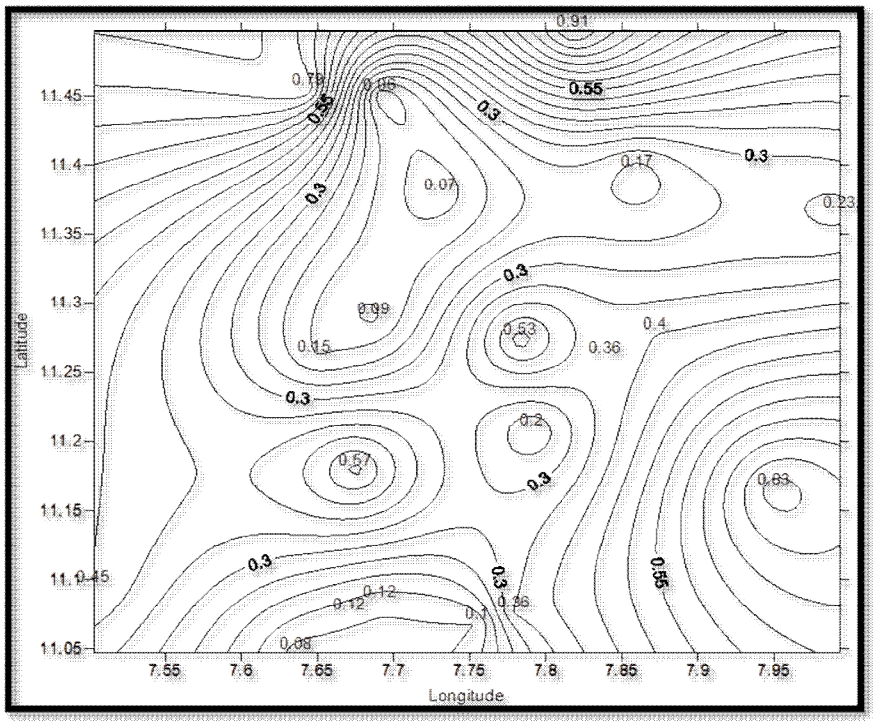

Fig. 5: Map of total beta concentration of groundwater

CONCLUSION

Results obtained depicted a low radiation level of gross alpha and gross beta in groundwater from the study area, hence certifying the portability of the water used by inhabitants of the area for their domestic activities.

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