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Evaluation of Gross Alpha and Beta Radioactivity in Underground Water Within Makurdi Metropolitan City

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Abstract

An evaluation of gross alpha and beta radioactivity in ground water in Makurdi Metropolis has been studied. In this work, samples were drawn at random from 12 underground water sources. The samples were drawn in two liters of plastic containers; 10ml of nitric acid was added to acidify the water and preserve most trace metals and minimize absorption on the walls of the container. The samples were evaporated to dryness at room temperature and the residue transferred into planchett. They were then counted for gross alpha and beta radioactivity in one-channel gas filled proportional counter. The detector was characterized for background limit. Results obtained from the analysis shows that the alpha activity in the samples ranges from 0.15 $\pm$ 0.03 BqL^{-1} to 0.68$\pm$ 0.06 BqL^{-1} and the beta activity ranges from 0.37 $\pm$ 0.03 BqL^{-1} to 1.22 $\pm$ 0.04 BqL^{-1}. The results show that the maximum alpha activity of 0.68$\pm$ 0.06 BqL^{-1} is slightly above the acceptable screening radioactivity level of 0.5 BqL^{-1} set by International commission on Radiological Protection and World Health Organization. Also the maximum measured beta activity of 1.22 $\pm$ 0.04 BqL^{-1} is above the safety limit of 1 BqL^{-1} set by International commission on Radiological Protection and World Health Organization. We do recommend that for drinking purpose, it will be safer to treat some of the underground drinking water using reverse osmosis in order to reduce the activity levels.

Keywords**:** radiological parameters, underground water, radioactivity and biological risk.

1.0 Introduction

Radioactivity is caused by the presence of radioactive substances also known as radionuclide's [1]. These substances are introduced from the atmosphere or are washed out of soils and rocks. Natural radioactive isotopes, such as ^{40}K, ^{226}Rn and ^{238}U can be present in the ground water [2]. Natural water is not completely free from radioactive isotopes due to the presence of beta and beta emitters from natural decay series of uranium, thorium, actinium and other isotopes, there are many possible source of radionuclide that is why it is impossible to entirely eliminate radioactive contamination from aquatic systems [3]. Most radionuclide in ground water results from interactions with rocks. The content of these elements in ground water and thus the level of radioactivity depend on the combination of several factors, including concentrations of these elements in the aquifer rocks, chemical reactions and the physical process of decay along the water-rock interface [4]. The first factor that determines the occurrence of radioactive ground water is the geology and high abundance of parent elements of one or several radionuclide in the associated ground water [5].

Radioactive minerals usually occur in the bedrock of wells. Radionuclide dissolves easily in water [6]. In some bedrock of wells, the concentration of these minerals, exceed the concentration established in public drinkable water standard. The standard for the permissible amount of radioactivity in drinking water are called maximum contaminant level (MCL), the United State Environmental Protection Agency [7] recommends drinkable water standard and has determine that certain radioactive materials such as radon, radium-226, radium-228 and Uranium are a health concern. Exposure to radioactivity increases ones risk of cancer [7]. The principle health concern associated with the regulated radionuclide in water include:

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radon gas increase the risk of lung cancer [8].

The standard or maximum contaminant level for gross beta activity is 50 pCi/L and gross alpha activity is at 15 pCi/L if the activity is below set standard the water is consider suitable however, if the activity concentration is above acceptable limit, then further assessment and remedial action is required to reduce dose [9].

Determination of the gross alpha and gross beta activities is one of the important methods for water quality monitoring. It substitutes a full radionuclide analysis and it allows an easy decision about contamination level. The standard procedure for analysis of gross alpha and gross beta activities usually make of use proportional counting or semiconductor detectors [3].

Study Area

The study area is Makurdi Metropolitan City. The population of Makurdi is approximately over 500,000 people. The inhabitants are mostly civil servants and traders with few farmers. The water they use for drinking, domestic activities and animal husbandry is mainly from wells, boreholes and sometimes tap water which are not always flowing.

Makurdi area is bounded by latitude 7^0 43' 32' N and longitude 8^0 33' 511' E. the map is shown in Fig. 1 below (Extracted from Ministry of Land and survey Benue State).

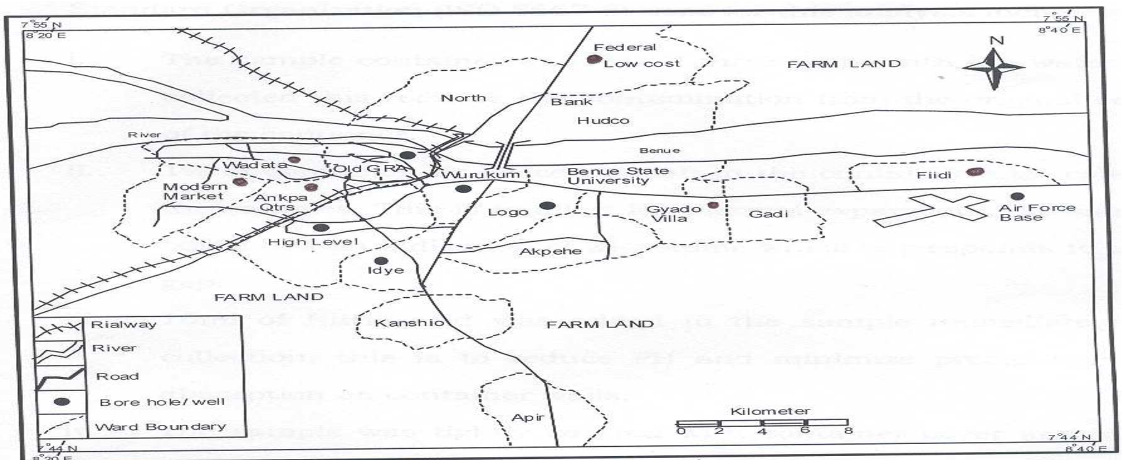


Fig. 1 Map of Makurdi Town Showing Sample Locations.

Materials and Method

The gross alpha and beta counting equipment used for this research is an MPC 2000 Gas Flow Detector Dual Phosphor. It is a low background single (one) Channel gas flow proportional detector with 80μgm/cm^2 entrance window of diameter 2.25 inch. This operates on P-10 counting gas (90 % argon, 10% methane).

The sampling procedure which is in accordance with the international standard organization (ISO 5667-3) used for this analysis include:

(i) The sample container was rinsed three times with the water being collected to minimize contamination from the original content of the sample container.

(ii) The amount of water collected was such that an air space of about 1% of container capacity was left for thermal expansion. The sampling bottle has a mark on it that gives the 2L-volume of sample, corresponding to the air gap.

(iii) About 10ml of nitric acid was added to the sample immediately after collection to reduce the pH and to minimize precipitation and absorption on container walls.

(iv) The samples were tightly covered with container cover and kept in the laboratory until analysis.

Evaporation was done using hot plate without stirring in an open 500ml beaker at room temperature. It took an average of two and half days to complete the evaporation of a two-liter sample. The residue was washed and transferred into a Petri-dish with the help of a rubber policeman.

The sample was completely dried on the Petri-dish under the sample temperature. The residue was then transferred to a 7.1cm^2 counting planchett with the help of a spatula.

Sample preparation efficiency was derived by taking the weight of empty Petri-dish, W_p and weight of Petri- dish plus sample after evaporation, W_{p+s}. The difference between W_{p+s} and W_p gave the weight of the sample, the content of the Petri dish was then transferred to the counting planchett and the weight of the Petri-dish was taken again, W_{p-s}. The difference between W_{p-s} and W_p gave the total weight of the residue (sample) unrecovered from the Petri-dish. The under listed formula was used to calculate the sample efficiency.

$$\text{Sample efficiency} = \frac{(W_{p+s}-W_{p})-(W_{p-s}-W_{p})}{(W_{p+s}-W_{p})} \times 100\% \qquad (1)$$

$$= \frac{weight\ recovered}{total\ weight} \times 100\%$$

The calculation formulae for count rate, activity and other parameters for a given sample are shown below.

Count rate:

$$\text{Rat } (\propto,\beta) = \frac{Raw\ (\alpha,\beta) count}{count\ time} \quad (2)$$

In all modes except mode alpha then beta

Activity:

$$\text{Activity } (\propto,\beta) = \frac{Rate\ (\alpha,\beta) - bgd(\alpha,\beta)}{sample\ effienciency \times channel\ efficiency \times volume} \quad (3)$$

Sample Standard Deviation:

The error associated with the measurement was computed as shown. Therefore the standard deviation (δ) is given by

$$\delta = \frac{\sqrt{Raw + \frac{T^2}{Tbdg} - bdg}}{T} \text{ x } \frac{Unit\ Coefficient}{Sample\ Volume\ X\ Channel\ Efficiency\ X\ Sample\ Efficiency} \quad (4)$$

Where

T=10,000 which is the present

bdg= background count in CPM

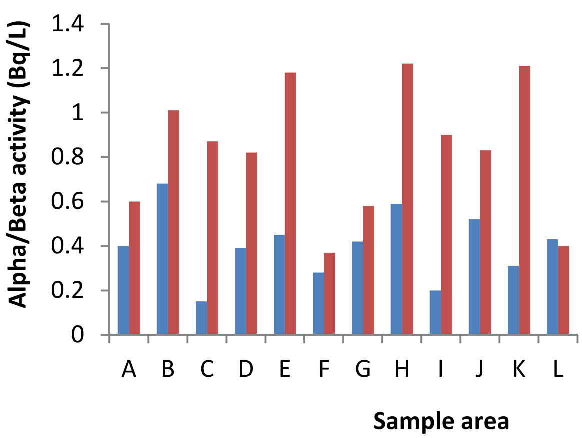
Tbdg= Present count time for background

Results and Discussion

The results of the average measured alpha and beta distribution in the sampled area from wells and boreholes are presented in Table 1 and Fig. 2 respectively.

Table 1. Measured activity concentration

S/No	**Sample ID**	**Alpha activity (Bq/L**	**Beta activity (Bq/L)**
1*	A	0.40±0.07	0.60±0.08
2*	B	0.68±0.06	1.01±0.07
3+	C	0.15±0.03	0.87±0.04
4*	D	0.39±0.03	0.82±0.04
5+	E	0.45±0.04	1.18±0.06
6*	F	0.28±0.02	0.37±0.03
7+	G	0.42±0.06	0.58±0.06
8*	H	0.59±0.04	1.22±0.04
9+	I	0.20±0.03	0.90±0.05
10*	J	0.52±0.06	0.83±0.04
11+	K	0.31±0.02	1.21±0.06
12*	L	0.43±0.03	0.40±0.03



*Signifies samples from Boreholes
+Signifies samples from wells.

A → Nigeria Air force Base Makurdi
B → New Government Residential Area (NGRA)
C → Wurukum
D → High Level
E →Hudco Quarters
F → Old Government Residential Area
G → Gyado Villa
I → Wadata
J → Fiidi
K → Federal Low Cost
L → Modern Market Area.

Fig.2. Alpha/Beta activity for each of the sample area

The results obtained in Table 1, shows that the means alpha activity has highest mean value of 0.68±0.06Bqly in a borehole located at New Government Residential Area Makurdi, the mean value is slightly more than the recommended safety screening level of 0.5 Bgl-1 set by ICRP [10] for the screening of drinking water. The borehole also has a corresponding beta activity of 1.01±0.07BqL^{-1} which is also almost slightly above the 1.0BgL^{-1} safety standard recommended by ICRP [10]. These values are likely due to the presence of dissolved natural radionuclide in the earth layers of the measured vicinity. The presence of alpha and beta radionuclide in an amount beyond the recommended screening levels could pose as a potential bioeffect to man since when ionizing radiation interacts with water, it may break the bonds that hold the water molecule together, producing fragments such as hydrogen (H) and hydroxyls (OH). These fragments may recombine or may interact with other fragments or ions to form compounds such as water, which would not harm the cell. However, they could combine to form toxic substances, such as hydrogen perioxide (H_2O_2), which can contribute to the distraction of the cell [6]. Also from the results, the beta activities have a high value of 1.22±0.04BqL^{-1} in the borehole water located at Gyado Villa. This high activity indicates that the earth layer around the vicinity has relatively high amount of dissolved radionuclides. The measured water source recording the lowest activity level is the well water at Wadata area with of 0.90±0.05BqL^{-1}. Both activities could be seen to be below the recommended screening level in 0.5BqL^{-1} drinking water. Thus aside possible bacterial concentration in the water, the water can be said to be safe for drinking. The next water source with the lowest activity level is the borehole located at Old Government Residential Area with alpha activity of 0.28±0.02 BqL^{-1} and beta activity of 0.37±0.03 BqL^{-1}, both values are below the recommended screening levels for drinking water.

Conclusion

The measurements of natural radioactivity in ground-water within Makurdi Metropoli were performed. Most of that water was boreholes while some were hand-dug wells, all the water analyzed were used for drinking and domestic purposes. Thus the result shows that most of the ground-water has activity concentration within the recommended safety screening level of 0.5 BqL^{-1} for alpha and 1.0 BqL^{-1} for beta concentration in drinking water. Only few boreholes have activity concentration beyond the recommended screening level. For such cases reverse osmosis is recommended for the treating of drinking water from those sources.

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