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Evaluation of Gross Alpha and Beta Radioactivity in Potable Water (Tap and Borehole Sources) From Selected Areas With in Mubi-North Metropolis, Adamawa State, Nigeria

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Abstract: Ionizing radiation is a type of radiation that carries enough energy to remove tightly bound electrons from atoms, creating ions. This type of radiation includes alpha particles, beta particles, and gamma rays. Exposure to ionizing radiation can have harmful effects on living organisms, including humans, especially when ingested.

The primary objective of the work is to measure and analyze the activities of alpha and beta radiation in the water samples and then use these results to assess the water concentrations in terms of radiation levels. The study collected water samples from five different locations within Mubi-North Metropolis and analyzed them using a desktop Alpha/Beta counting machine or detector (MPG 2000B-DP).

The results of the analysis are provided for both alpha and beta radiation activities in each of the sample locations. For instance, the alpha activities ranged from 0.009844 Bq/L to 0.1821 Bq/L, while the beta activities ranged from 0.04922 Bq/L to 10.21 Bq/L, across the different locations.

The overall conclusion drawn from the results is that the alpha activities in all collected samples were below the screening levels for drinking water radioactivity, as recommended by various organizations such as EPA, WHO, and GEG-FAO. However, the beta activities in the samples, except for the one from Federal Polytechnic Reservoir, exceeded the recommended screening levels. This indicates that the beta radiation levels in those samples could pose a significant health risk to individuals consuming the water.

In summary, the study provides insights into the levels of alpha and beta radiation activities in water samples from various locations in Mubi-North Metropolis. The results indicate that while alpha radiation levels are within safe limits, beta radiation levels in some samples could potentially be hazardous to human health.

Keywords: Ionizing radiation, beta activity, alpha activity, concentration.

I Introduction

Water stands as one of the most crucial natural resources with numerous demands. Its presence traces back to the universe's origin itself, necessitating skilled water body management. Human activities, like irrigation, power generation, and domestic use, rely heavily on water. Its sources include rain and groundwater, present in various forms such as rivers, wells, dams, lakes, and streams. However, both human actions and natural processes continually contaminate these water sources, leading to a decline in water quality (Abel, 1996). The pollution emerges from improper disposal of waste, sewage, and agricultural chemicals into rivers and the environment by industries, hospitals, and farmers using fertilizers (Zaiewski, 2001). Often, these disposed substances contain radioactive elements.

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Primary water sources are usually upland or deep groundwater accessed through wells or boreholes. While the risk of chemical contamination is low, the possibility of radioactive contamination exists due to the increase in terrestrial radioactivity with depth in the Earth's crust. Naturally occurring radioactive elements like those from the Uranium and Thorium series, including their byproducts like Radium and Radon, are of particular concern (Barantta, E J (1990). They contribute to groundwater and rain radioactivity, subsequently affecting drinking water quality. Conversely, spring water and flowing water interact with rocks containing various radioactive elements, impacting the surrounding soil and plants. This water can carry these elements into wells, boreholes, and tap water through pipeline leaks (Akpa, T.C Mallam, 2004).

Crucially, certain radionuclides, such as Tritium, Potassium 40, Radium, and Radon, emit alpha, beta, and gamma radiation, posing health risks. Consequently, assessing the concentration of these radiation-emitting radionuclides in drinking water becomes essential.

II Materials and Methods

2.1 Study Area

Sources: MapAction, OCHA
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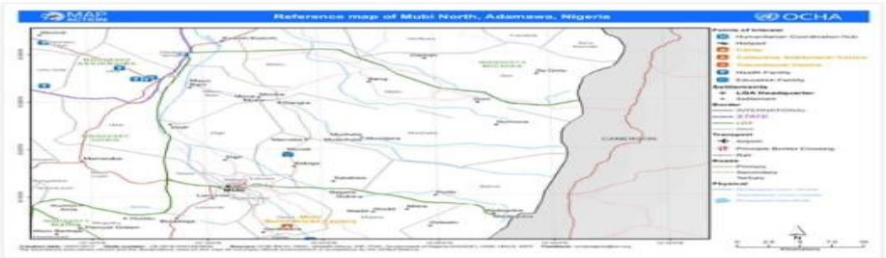

The focus of this study pertains to the urban region of Mubi-North within the local government area of Adamawa State. The research is specifically centered on sources of underground water (such as taps and boreholes) that are utilized by the community for domestic and drinking purposes. The subsequent letters of the alphabet will be employed to represent distinct areas of study.

A = Shagari low cost bore hole close to jumma'a mosque

B = Wurogude behind river

C = ADSU water (faculty of Mag. Sci)

D = Lokuwa water adjacent emir palace

E = Federal polytechnic reservoir.

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2.2 Equipment's and Materials

Beakers(Pyrex), Gloves, Oven, Hotplate ,Plastic container (1-liter container), Blunt forceps, Analytical weighing balance, Spatula, Fume cupboard, Petri-dish(crucible), Plan chet, Syringe and needle, Police man(rubber)

2.3 Reagents Use

Acetone, Nitric acid (HNO), Vinyl acetate

2.4 Sample Selection

The sampling technique used in this study is known as convenient sampling (Williams, 1977), and a total of five (5) sampling points were utilized.

Sampling Methodology:

- The sample receptacle was washed thrice with the collected water to limit potential contamination from its previous contents.
- A 1% air allowance of the container's capacity was established to account for thermal expansion. The container is marked to indicate the 1.0L volume of the sample that corresponds to this airspace.
- Following collection, 0.5ml of diluted nitric acid (HNO) was promptly introduced to the sample to lower its pH, thereby reducing the likelihood of precipitation, colloid formation, and the absorption of radioactivity onto the container walls.
- The sample was securely covered with the container lid and stored in the laboratory (following ISO, 9697, and 9698:1992a standards) for subsequent analysis.

Sample Preparation

Sample preparation involved evaporating a one-liter sample without stirring on a hot plate set to 60 degrees Celsius. This process took approximately twenty-four hours to finish. The remaining substance was rinsed using distilled water with the assistance of a rubber scraper, then moved into a petri dish (crucible). The material was left to thoroughly dry at room temperature (around 25 degrees Celsius) (Alabi, .A. 2001).

Figure 1: Water Sample for Evaporation

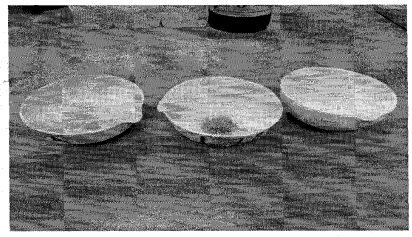

Figure 2: Residue obtained after evaporation

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The analytical weighing balance was utilized to measure and document the combined weight of both the dish and the residue. Additionally, the weight of the residue by itself was determined and recorded. To extract the residue from the Petri dish, it was carefully scraped with a spatula and subsequently transferred into a sterilized 9/16 plan chet. This plan chet, containing the residue, was then positioned inside an analytical digital weighing balance to achieve the desired weight, which was approximately 77mg.

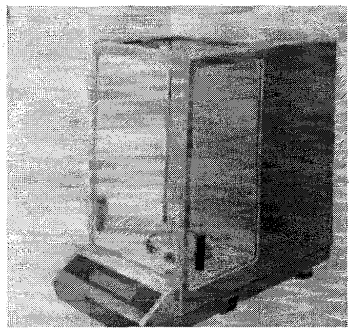

Figure 3: Analytical Digital Weighing Balance

Vinyl acetate was applied onto the residual material within the sample holder in order to eliminate any remaining moisture and prevent moisture absorption from the surrounding atmosphere. The prepared samples are now ready for the counting process.

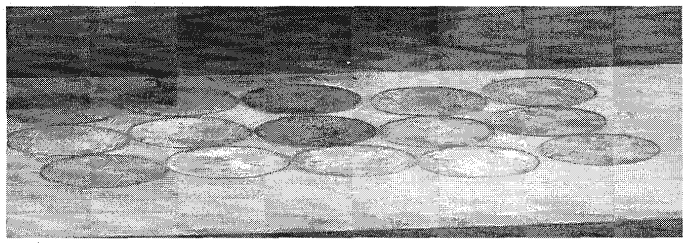

Figure 4: Prepared Water Sample Ready for Counting

The plan chet's specimens were inserted into the drawer of the MPC-2000B-DP for the purpose of tallying.

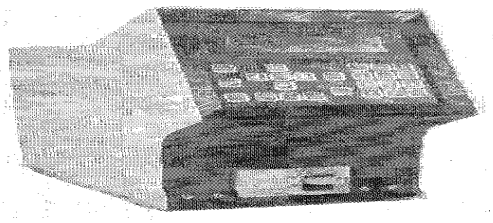

Figure 5: MPC-2000B-DP (Dual Phosphate)

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2.5 Counting

The tallying apparatus operates automatically. The procedure consists of inputting predefined time intervals, recording voltage levels, and tracking the number of counting cycles. Additionally, one must input details about the counter's attributes (such as its efficiency and background noise), the sample's volume, and its sampling efficiency. The outcomes are presented as unprocessed counts (count per millimeter), count rates, and activity levels. The data acquisition occurred simultaneously in both alpha and beta modes, with the choice of counting mode being discretionary. The equations for computing the count rate, activity, and other metrics for a specific sample are presented below:

a) Count Rate

$$\text{Rate } (\alpha, \beta) = \frac{Raw\ (\alpha,\beta) count}{Count\ time} \quad \text{.....3.4}$$

b) $$\text{Activity } (\alpha,\beta) = \frac{Net\ count(cpm)}{De \times 60 \times pellet\ weight} \quad \text{.....3.5}$$

Where,

De = the detector's efficiency.

Net counts (α, β) = Raw (α, β) counts (CPM)- Background (α, β) (CPM)

III Discussion of Results

Table 1 Gross Alpha and Beta Radioactivity in Drinking water

Sample id	activity	Mean	Std. Deviation	N
A	Alpha (bq/l)	.0664500	.	1
	Beta(b/l)	4.3740000	.	1
	total	2.2202250	3.04589782	2
B	Alpha (bq/l)	.0098440	.	1
	Beta(b/l)	7.7910000	.	1
	total	3.9004220	5.50210817	2
C	Alpha (bq/l)	.0590700	.	1
	Beta(b/l)	10.2100000	.	1
	total	5.1345350	7.17779144	2
D	Alpha (bq/l)	.1821000	.	1
	Beta(b/l)	1.5640000	.	1
	total	.8730500	.97715086	2
E	Alpha (bq/l)	.0492200	.	1
	Beta(b/l)	.6536000	.	1
	total	.3514100	.42736120	2
Total	Alpha (bq/l)	.0733368	.06460139	5
	Beta(b/l)	4.9185200	4.06170380	5
	Total	2.4959284	3.72224462	10

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The alpha and beta radioactivity of drinking water in Mubi North metropolis is presented in the provided Table 1.

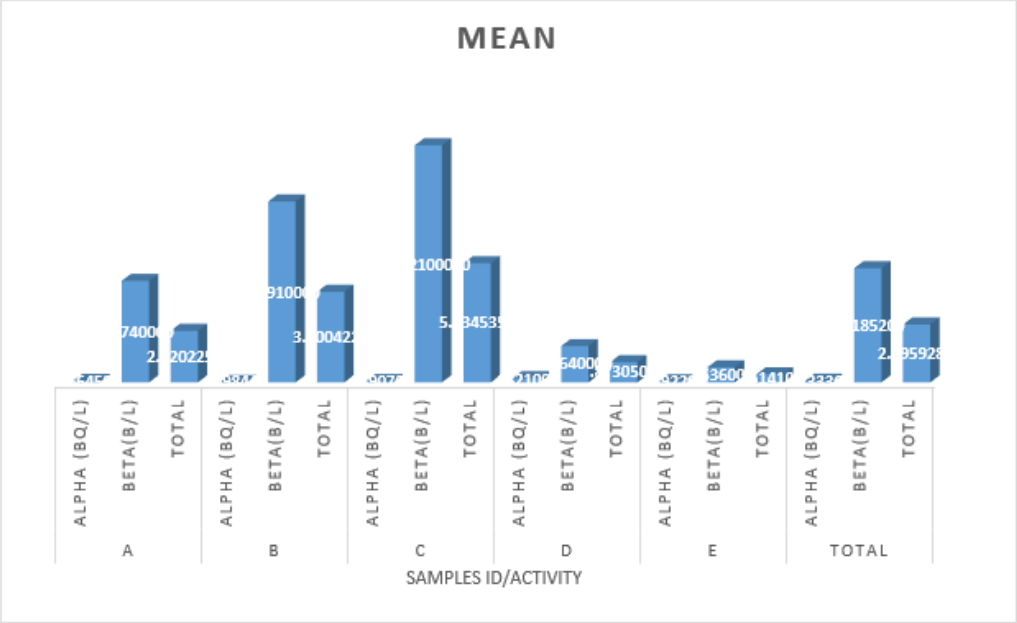

Figure 1 Alpha and Beta Radioactivity in water sample

The findings depicted in the previous figure indicate that the concentration of activity for both alpha and beta radiation at the five sampling locations in Mubi North metropolis, Adamawa State, had varying results. Specifically, the highest alpha activity reading, 0.1821 Bq/L, was recorded in Lokuwa water supply, which was lower than the highest reading of 0.2256 Bq/L observed in Dakzangk Dam in Plateau State. Conversely, the lowest alpha activity reading, 0.009844 Bq/L, was recorded in Wurogude, which was also lower than the lowest reading of 0.00058 Bq/L from Anguldi in Jos.

In terms of beta activity, the highest value, 7.791 Bq/L, was measured in Wurogude, surpassing the maximum value of 7.0772 Bq/L found in Dakzangk Dam in Plateau State. The lowest beta activity reading, 0.6536 Bq/L, was obtained from Federal Polytechnic Mubi, which exceeded the minimum reading of 0.1088 Bq/L from Ramapol 3 in Plateau State (Ahmed, 2014).

It's important to note that the alpha activity results for both locations were below the screening limit of 0.5 Bq/L. However, the beta activity values, except for those from Federal Polytechnic Mubi and Rapomoll, exceeded the screening limit of 1.0 Bq/L set by CEC-FAO and WHO.

In summary, the study's results indicate varying levels of alpha and beta radiation activity at the sampled locations. Given that some beta activity levels exceeded established screening limits, it's crucial to consider potential implications for public health and environmental safety. Further investigations and measures might be necessary to address these concerns.

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IV Conclusion and Recommendation

Conclusion

In this project, we conducted measurements on the gross alpha and beta activities present in tap and borehole drinking water. Our findings indicated that the alpha activity ranged from 0.009844 to 0.1821 Bq/L, falling below the screening threshold of 0.5 Bq/L. On the other hand, beta activity ranged from 0.6536 to 7.791 Bq/L, surpassing the screening limit of 1.0 Bq/L, except for the case of the federal polytechnic Mubi, where additional assessment of beta activity is required.

To summarize, the water quality in the specified areas met the recommendations set by the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA) for alpha activity. Consequently, there is no necessity for further screening in this regard.

Recommendations

1. It is essential to conduct a comprehensive survey encompassing not just Mubi-North but the entirety of Mubi town.
2. The sample preparation technique should undergo enhancements as there is a requirement to accurately measure the total dissolved substances, resulting in a minimal residue on the counting plate.
3. Individuals utilizing water from the aforementioned location are encouraged to file complaints with the Ministry of Health to initiate further screening for beta radiation.
4. Additionally, it may be prudent to perform gamma radiation determinations on the water samples.
5. To broaden the scope of the study, it is advisable to include the evaluation of surface water sources such as sea ponds and river water. This is vital because other artificial sources might contribute to increased radioactivity levels in water, potentially posing health risks to the population.

Contribution to the Field of Knowledge

As far as I am aware, there is currently no existing data regarding the levels of gross alpha and beta radioactivity in drinking water across any region within Mubi-North. Therefore, this information could serve as fundamental groundwork for future data development and analysis.

Possible Directions for Additional Research.

Several regions within Mubi-North, such as Digil and Vimtim, along with Mubi-South and adjacent villages, present opportunities for similar investigations. It is also worth considering neighboring local governments like Hong and Michika as potential areas for study, allowing for data comparison.

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