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Case Report

Determination of Percentage Concentration of Alpha and Beta Radioactivities in Drinking Water from Mubi-North Metropolis, Adamawa State, Nigeria

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Abstract

Increasing levels of radioactivity in drinking-water are a growing public-health concern because ingestion of radionuclides can produce both short- and long-term adverse effects. Routine screening for gross alpha and gross beta activity provides a rapid means to identify water sources that may require more detailed radiochemical and dose-assessment investigations. To determine the relative contributions (percentage concentrations) of gross alpha and gross beta radioactivity in drinking-water from selected locations within Mubi North metropolis and to evaluate whether further radiological assessment is warranted. Five drinking-water samples were collected by convenience sampling from five distinct locations in Mubi North metropolis. Samples were analyzed at the Centre for Energy Research and Training (CERT), Zaria, using the MPC2000D-Phosphate system to quantify gross alpha and gross beta activities. Results are reported as the percentage of total detected radioactivity attributable to alpha and beta emissions at each sampling location. Gross alpha contributions ranged from 0.13% to 10.43% across the five sampling locations, while gross beta contributions ranged from 89.57% to 99.87%. Location B exhibited the lowest proportion of alpha activity and the highest proportion of beta activity; conversely, Location D had the highest alpha fraction and the lowest beta fraction. The data indicate that beta-emitting radionuclides dominate the measured radioactivity in these samples. The low percentage contribution of gross alpha activity suggests a relatively minor role for alpha-emitting radionuclides in the total radioactivity budget of the sampled waters. However, the predominance of beta activity warrants further investigation. Specifically, we recommend: (1) quantifying absolute activity concentrations (e.g., Bq·L−1) for gross alpha and gross beta and comparing them with national and international guideline values; (2) performing radionuclide-specific analyses (e.g., for 40K, 90Sr, 137Cs, uranium isotopes and radium isotopes) to identify the primary beta emitters; and (3) expanding the sampling program using systematic, representative sampling to better characterize spatial variability and potential exposure pathways. These follow-up actions are necessary to determine whether the observed beta activity poses a radiological health risk and to inform any remedial or public-health measures.

Keywords

Gross alpha, Gross beta, Radioactivity, Drinking water, Concentration, Percentage.

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Introduction

The occurrence of radioactivity in drinking water is among the major issues of global concern in this century especially in under-developed countries, where the agencies in charge are not giving much attention to the level of radioactive elements as well as the quality of drinking water [1]. The importance of water to human is numerous such that its availability in quantity and quality becomes crucial to human survival. Water is one of the essentials that support all forms of plant and animal life and it is obtained from two principal natural sources; surface water such as fresh water lakes, rivers, streams and ground water such as borehole water and well water [2].

However, the availability of quality water is of interest to the scientist, government and relevant stakeholders. Some contaminants that affect the quality of water includes heavy metals, radionuclides and gaseous emission etc. The natural radionuclides and their decay products are usually present in all types drinking water sources [3].

Availability of Alpha and beta radiations known as high Linear Energy

Transfer (LET) radiations in drinking water is considered to be an important factor in increasing the natural radiation exposure in humans [4]. These dependent upon the amount of radionuclides present in source rock, soils, and other natural and artificial radionuclide materials that the water comes in contact [5]. Therefore, there is the need to determine the concentration of alpha and beta radiations in water. The gross alpha and beta counting is the preliminary test, as stipulated in the World Health Organization guideline for water quality determination [6]. Also, due to its relatively stability, low costs and simplicity, it has become a veritable tool for determination of relative radioactivity levels in water [7].

In addition, heavy metals become toxic when their concentrations are above the threshold recommended thereby damaging the life functions of an organism [8]. Metals in natural waters can exist in truly dissolved colloidal and suspended forms. The proportion of these forms varies with metals and for different water bodies.

Natural Alpha and Beta

Natural alpha and beta are found in air, rocks, soil, water and oceans, in our building materials and even found in humans as by-products of our environment. Most food has some small amount of alpha and beta in it. The common radio nuclides in food are Potassium–40 (^{40}K) Radium– 226 (^{226}Ra) and Uranium-238(^{238}U) and the associated progeny. Ingestion of these radioactive elements by humans is toxic and dangerous especially the radioactive elements found in the common foods materials such as potassium-40 (^{40}K), radium-226 (^{226}Ra).

Materials and Methods

The materials, the reagents and the analysis are showed below;

Apparatus

The following laboratory equipment was employed in the analysis:
Laboratory beakers
Petri dishes
Hot plate
Infrared radiator lamp
Digital weighing balance
Planchets
Cotton wool
2-liter polyethylene containers
Fume cupboard

Reagents

The reagents used included:
Acetone
Vinyl acetate
Nitric acid (HNO_3)

Sampling Procedure

A random sampling procedure was adopted for this research, where five groundwater samples were collected from different locations within Mubi North metropolis. The collection sites were:

A. Shagari low cost bore hole close to jumma'a mosque.
B. Wurogude behind river bore hole.
C. ADSU faculty of management tap water.
D. Lokuwa bore hole adjacent emir palace.
E. Federal polytechnic Mubi water reservoir.

All samples were collected from boreholes and treated with nitric acid to preserve the radionuclides.

Sample Collection Procedure

The water samples were collected directly into 2-liter polyethylene containers that had been thoroughly washed and rinsed with the water to be sampled. To each sample, 10 ml of concentrated nitric acid (HNO_3) was added to reduce the pH to below 2, preserving the radionuclides and preventing their adsorption onto the container walls. Proper care was taken to avoid stagnant water, and lake water samples (if collected) were taken away from shorelines, following WHO guidelines. For borehole water, the taps were run for three minutes at full capacity to purge any stagnant water before collection [9].

Sample Preparation

The water samples were prepared and analyzed at the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Kaduna State. Each sample was acidified with 10 ml of nitric acid immediately after collection to reduce the pH, prevent precipitation, and minimize absorption of radionuclides on the container walls.

Evaporation Process

The equipment used, including beakers, crucibles, planchets, and spatulas, was thoroughly cleaned, rinsed, and sterilized with acetone. A 500 ml aliquot of each water sample was measured into a beaker and placed on a hot plate at a temperature just below boiling point to allow gradual evaporation, ensuring no excessive loss of the residue. The remaining 50 ml was transferred to a petri dish and evaporated to dryness under an infrared lamp, a process known as surface drying [5].

The initial weight of the empty petri dish was recorded, and the weight of the dish with the residue was measured using a digital analytical weighing balance. For samples with residues greater than or equal to 0.0770 g, the sample efficiency was considered 100%. For samples with residue less than 0.0770 g, the efficiency was calculated using the following formula;

$$Sample\ eff. = \left(\frac{Weight\ of\ residue}{0.0770g}\right) \times 100\% \quad (1)$$

$$\text{Percentage concentration} = \frac{A_{\alpha/\beta}}{A_{\alpha}+A_{\beta}} \text{x}\, 100\% \quad (2)$$

Table 1: Percentage Concentration for Alpha and Beta Radioactivities.

ID	Alpha Activity(Bq/L)	Beta Activity(Bq/L)	Total	Alpha % concentration	Beta% concentration
A	0.06645	4.37400	4.44045	1.5	98.50
B	0.009844	7.79100	7.800844	0.13	99.87
C	0.0590700	10.2100	10.26907	0.58	99.42
D	0.182100	1.56400	1.7461	10.43	89.57
E	0.0492200	0.653600	0.70282	7.00	93.00

Sample Analysis

The analysis followed the International Standards Organization (ISO) procedures ISO 9696 and ISO 9697:2014 E for measuring gross alpha (α) and gross beta (β) activity in water samples. This method involves evaporating a known volume of water to dryness and measuring the activity of the residue, providing a screening technique for gross alpha and beta radioactivity in water sample from some selected area in Mubi. For gross alpha radiation, special attention was given to samples with high total dissolved solids (TDS), as this could affect the sensitivity of the method.

Results and Discussion

The results obtained for the percentage concentrations of Alpha and Beta radioactivities are showed in the table below;

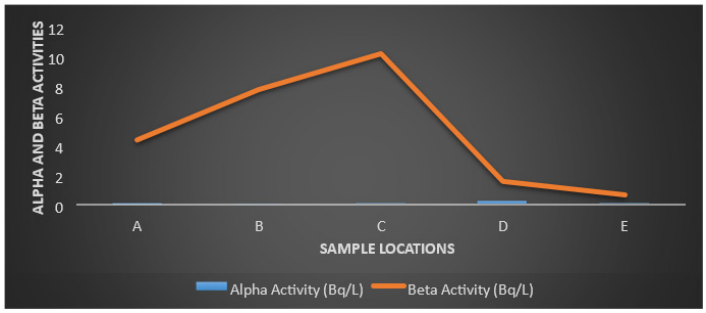

Figure 1: Alpha and Beta Radioactivities in the sample locations.

The graph above showed that in locations A, B, C and E, the Alpha radioactivities were almost zero, this signified that the locations were free from Alpha contaminations and good for drinking and some domestic activities, location C, recorded the highest Beta radioactivity. The results showed that all the locations concentrations were below the screening limit of 0.5Bq/L, with exception of Location E for Alpha radioactivity concentration, while all the locations recorded above screening limit of 1.0Bq/L for Beta with exception of location E.

Table 2: Locations with percentage concentrations and WHO standard.

Sample ID	Alpha% concentration	Beta% concentration	WHO%
A	1.5	98.50	100
B	0.13	99.87	100
C	0.58	99.42	100
D	10.43	89.57	100
E	7.00	93.00	100

From the figure above, the percentage concentrations for Alpha radioactivity were far below the screening limit 100% by WHO and will not poses any detriment effect for Alpha activity, while for Beta activity the percentage concentrations were almost equivalent to the recommended limit, this meant that Beta activity in all the locations might be liable for posing detriment effect.

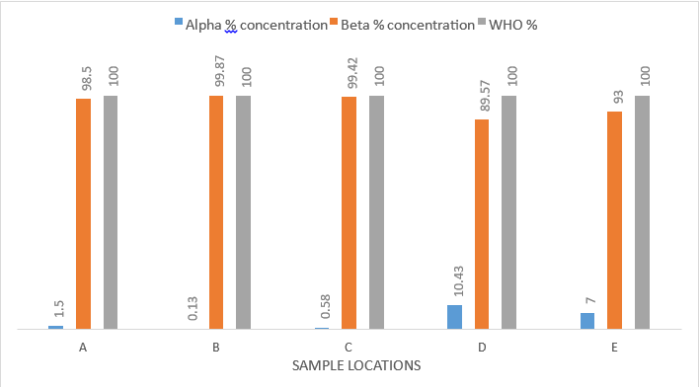

Figure 2: Alpha and Beta percentage concentration with WHO.

Conclusion

This research determined the percentage concentrations for both Alpha and Beta radioactivities, it was found out all the Alpha Percentage concentrations were far below the screening limit and therefore were all good for drink inking and domestic activities, for Beta percentage concentrations were slightly equal to the screening limit, therefore the water from the locations were subjected for further screening.

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