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Estimation of Natural Occurring Radioactivity Materials (Norms) from Gross Beta Radioactivity in Potable Water from Selected Areas Within Mubi-North Metropolis, Adamawa State, Nigeria

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Abstract

This research focuses on measuring and evaluating beta radiation levels in water samples to determine the concentration of radioactive contaminants and assess their compliance with established safety standards. Water samples were collected from five different locations within the Mubi-North Metropolis and analyzed using a desktop Alpha/Beta counter (model MPG 2000B-DP). The analytical results revealed that uranium concentrations ranged from 1.334 to 20.837 Bq/L, thorium concentrations varied between 3.112 and 48.619 Bq/L, and radium concentrations ranged from 65.360 to 1021.00 Bq/L. These findings indicate that the beta radiation activity levels in all sampled water sources significantly exceeded the 1.0 Bq/L safety threshold recommended for drinking water by organizations such as the Environmental Protection Agency (EPA), the World Health Organization (WHO), and the Food and Agriculture Organization (FAO).Thus, the study concludes that the water sources examined in Mubi-North may pose potential radiological health risks to the population, underscoring the urgent need for continuous monitoring, public health interventions, and mitigation strategies to ensure water safety.

Keywords: Ionizing radiation; Beta activity; Alpha activity; Concentration

Introduction

Water stands as the most vital natural resource, essential for a wide range of human needs. Its presence traces back to the very origins of the universe, and the effective management of water bodies is crucial [1]. Every human endeavor from agricultural irrigation and electricity generation to household use depends on water [2]. This resource is supplied primarily through rainfall and groundwater sources, appearing in forms such as rivers, lakes, wells, dams, and streams [3]. However, both human activities and natural processes are steadily polluting these water sources, thereby diminishing their quality [4]. Industrial discharges, hospital wastes, and the use of fertilizers by farmers release waste, sewage, and agricultural chemicals into water bodies and the environment, contributing to this contamination [5]. Frequently, these waste materials contain radioactive substances.

The principal sources of drinking water, such as upland water or deep groundwater from wells and boreholes, are often considered safe from chemical pollution [6-9]. Yet, they remain vulnerable to radioactive contamination, primarily because terrestrial radioactivity tends to increase with geological depth [10]. Naturally occurring radioactive materials (NORMs), especially those from the Uranium and Thorium decay series, along with their by-products like Radium and Radon, are significant in this context [11]. These radionuclides elevate the radioactivity of rain and groundwater, thereby affecting the safety and quality of drinking water [12-23]. Similarly, flowing and spring waters interacting with radioactive rocks can introduce these elements into nearby soils, vegetation, and ultimately into boreholes, wells, and piped water systems via leaks and seepage [24]. Importantly, radionuclides such as Tritium, Potassium-40, Radium, and Radon release alpha, beta, and gamma radiations, which pose serious health risks. Thus, it is crucial to monitor and measure the concentrations of these radiation-emitting substances in drinking water to ensure public safety [25].

Materials and Methods

Study area (Figure 1)

The topic of this study is on the Mubi-North urban area of the local government area of Adamawa State. The research herein is particularly intended to be a study of underground water sources (such as boreholes and taps) that serve the community to drink and carry out domestic usage. The following letters of the alphabet will serve to describe varied study regions [26].

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

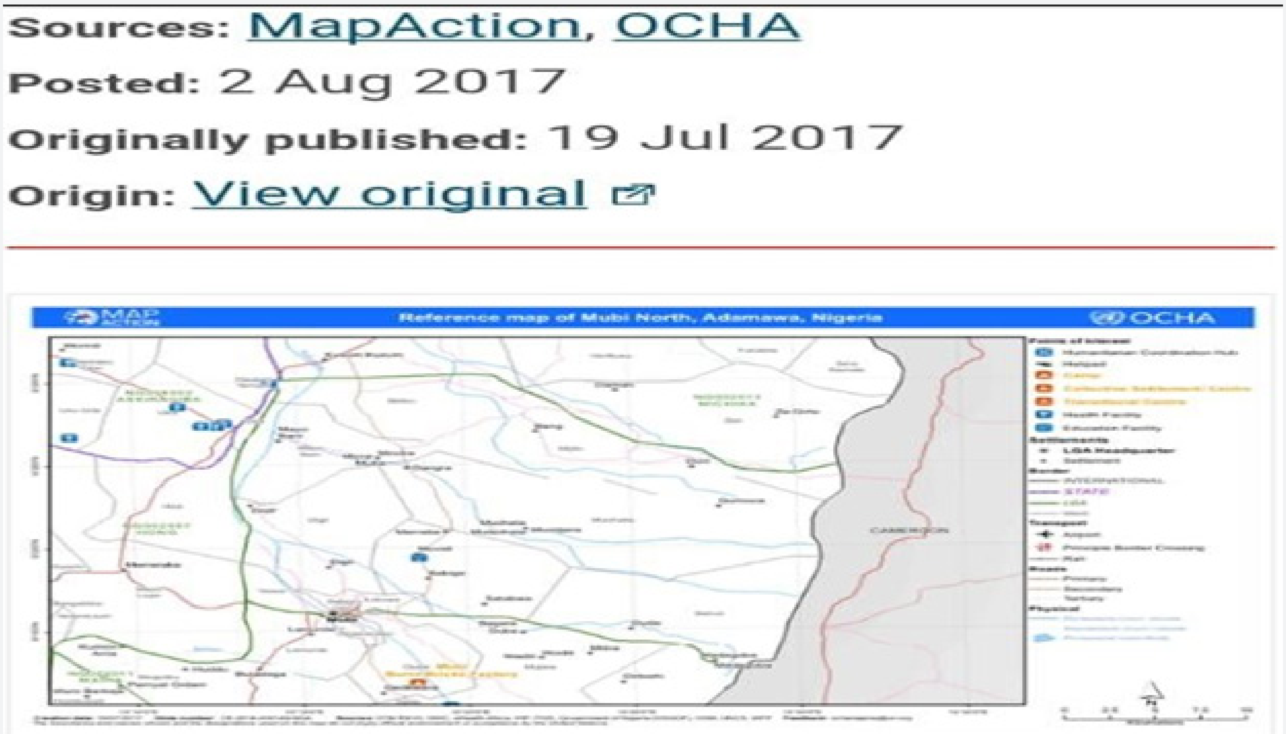

Figure 2: Web Scraping using Selenium, Chromedriver and Beautiful Soup.

Apparatus and Materials

i. Beakers (Pyrex)

ii. Gloves

iii. Oven

iv. Hotplate

v. Plastic container (1-liter container)

vi. Blunt forceps,

vii. Analytical weighing balance

viii. Spatula

ix. Fume cupboard,

x. Petri-dish (crucible),

xi. Planchet,

xii. Syringe and needle,

xiii. Police man (rubber)

Chemical Use

i. Acetone

ii. Nitric acid (HNO)

iii. Vinyl acetate

Sample selection

The sampling procedure used in this study is known as convenient sampling [27], and five (5) points of sampling were utilized.

Sampling Methodology:

The sample receptacle was washed three times with the collected water to reduce potential contamination from its

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previous contents. A 1% airspace of the container volume was allowed to account for thermal expansion. The container is graduated to indicate the 1.0L sample volume equivalent to this airspace [28]. Upon collection, 0.5ml of diluted nitric acid (HNO) was added immediately to the sample in order to lower its pH, thereby preventing precipitation, colloid formation, and adsorption of radioactivity onto the walls of the container [29]. The sample was thereafter tightly sealed with the container lid and stored in the laboratory (as per ISO, 9697, and 9698:1992a standards) for analysis.

Sample Preparation

Sample preparation involved evaporating a one-liter sample without agitation on a hot plate at 60 degrees Celsius. This took approximately twenty-four hours to finish [30]. The rest of the material was rinsed using distilled water with the assistance of a rubber scraper and then poured into a petri dish (crucible). The material was left to dry thoroughly at room temperature (approximately 25 degrees Celsius) [31] (Figures 2 & 3).

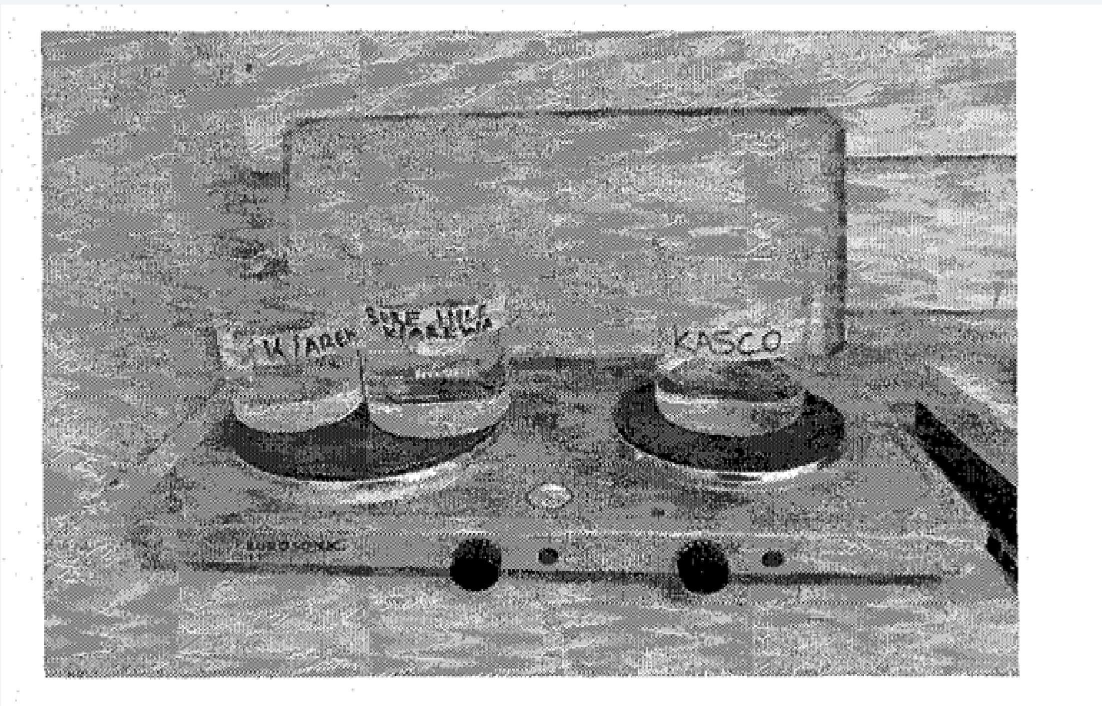

Figure 2: Web Scraping using Selenium, Chromedriver and Beautiful Soup.

The residue and the dish were weighed and recorded on the analytical weighing balance. The weight of the residue by itself was also determined and recorded [31]. To extract the residue from the Petri dish, it was carefully scraped with a spatula and emptied into a sterilized 9/16 planchet. This planchet, which contained the residue, was then put in an analytical digital weighing balance to achieve the necessary weight, which was approximately 77mg [32] (Figure 4).

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 [33] (Figure 5). The planchet's specimens were inserted into the drawer of the MPC-2000B-DP for the purpose of tallying [34] (Figure 6).

Counting

The counting device is automatic. It entails inputting predetermined time intervals, recording voltage, and tracking the number of count cycles [35]. One also inputs data about the counter characteristics (i.e., efficiency and background noise), sample volume, and sampling efficiency. Results are shown in raw counts (count per millimeter), count rates, and activity levels [27]. The data acquisition was simultaneous in both alpha and beta modes, and the choice of the counting mode was optional. The equations for the calculation of the count rate, activity, and other parameters for a specific sample are presented below:

a) Count Rate

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

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

Where,

De = the detector's efficiency.

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

$$A(U,Th,Ra)=\frac{A\beta}{R} \quad 3.6$$

$$A(U)=\frac{A\beta}{0.49} \quad 3.7$$

$$A(Th)=\frac{A\beta}{0.21} \quad 3.8$$

$$A(Ra)=\frac{A\beta}{0.01} \quad 3.9$$

Where:

i. A (U,Th,Ra) = Activity concentration of Uranium, Thorium, and Radium combined.

ii. A (U), A (Th), A (Ra) = Activity concentration of Uranium, Thorium, and Radium individually.

iii. βA= Measured beta activity.

iv. R = Conversion factor for combined activities.

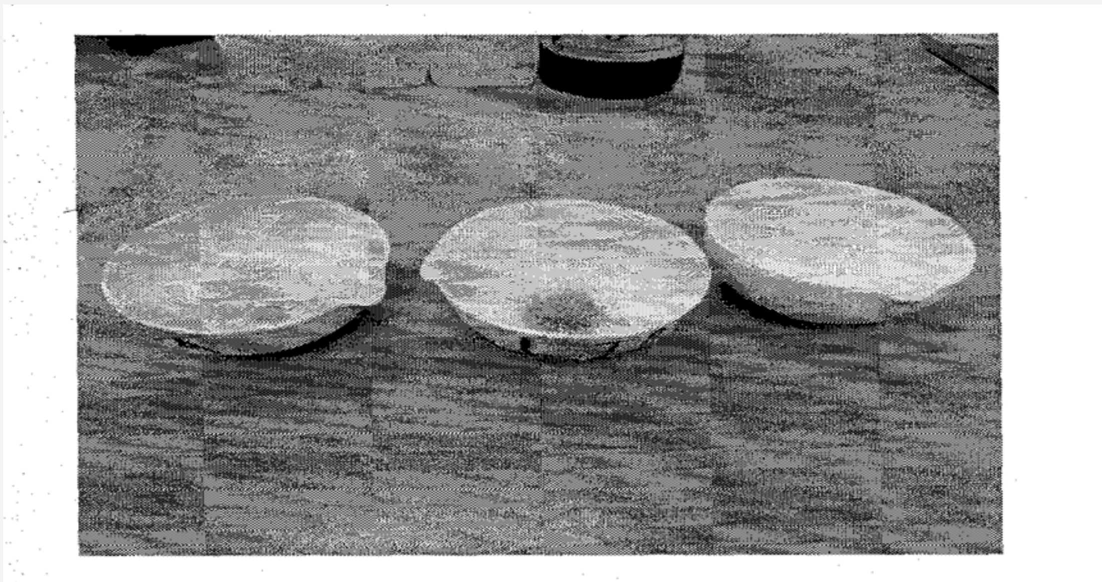

Figure 3: Residue obtained after evaporation.

Discussion of Results (Table 1)

The analysis of the results presented in the table reveals critical findings regarding the radioactivity levels in water samples from different locations. Location C exhibited the highest concentration of beta activity, indicating that this site has the most significant presence of radioactive substances among all the sampled points. Specifically, Location C recorded the highest emissions of Radium (Ra), Thorium (Th), and Uranium (U) three naturally occurring radioactive elements known for their potential health risks when present in drinking water [35].

Radium, for example, is a potent alpha and beta emitter and can cause serious health issues such as bone cancer when ingested over a prolonged period. Thorium and Uranium are similarly hazardous, with Uranium also having chemical toxicity that affects kidney function apart from its radiological hazards. The elevated presence of these radionuclides at Location C suggests possible geological influences (such as uranium-rich bedrock) or anthropogenic sources like industrial discharge or improper waste disposal [36].

On the opposite end, Location E showed the lowest concentration of beta activity and correspondingly lower levels of Radium, Thorium, and Uranium. Despite having the least contamination, the measured beta activity at Location E still surpassed the screening level of 1.0 Bq/L set by international standards, such as those from the World Health Organization (WHO), the Environmental Protection Agency (EPA), and the Food and Agriculture Organization (FAO) guidelines. The screening level is a benchmark above which a detailed radiological analysis is recommended, and corrective actions may be necessary to protect public health [37].

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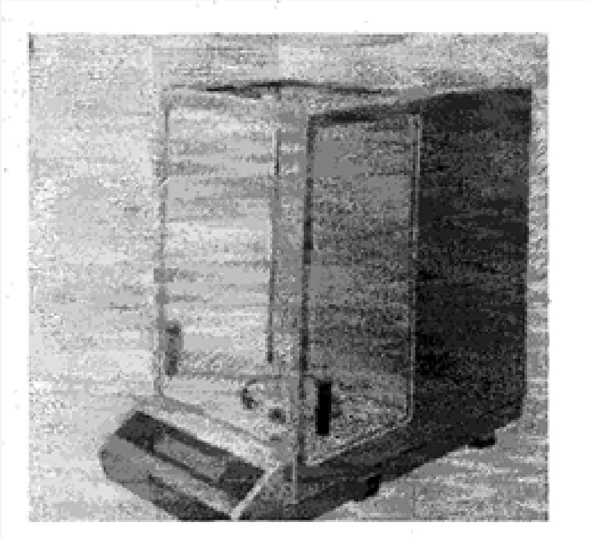

Figure 4: Analytical Digital Weighing Balance.

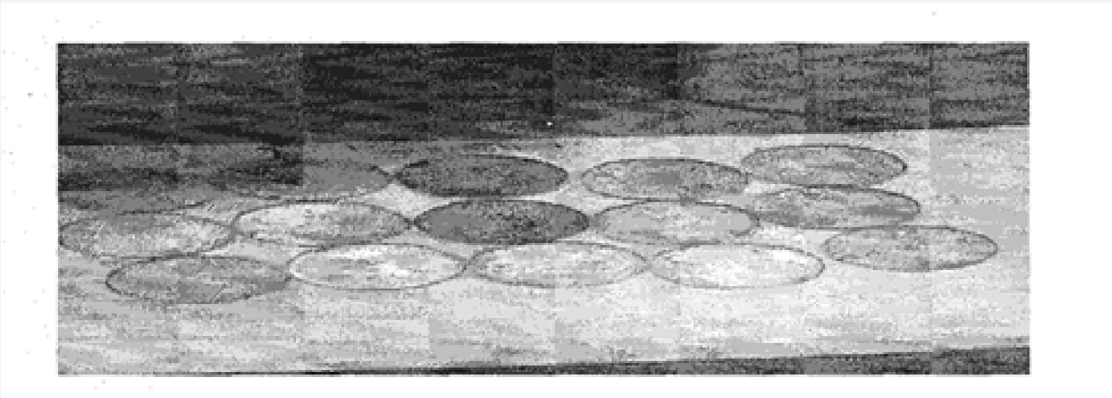

Figure 5: Prepared Water Sample Ready for Counting.

Table 1: Natural Occurring Radioactivity (U, Th and Ra) Activity concentration (Aβ).

Sample ID	Aβ Bq/L	A(U) Bq/L	A(Th) Bq/L	A(Ra) Bq/L
A	4.374	8.927	20.829	437.4
B	7.791	15.9	37.1	779.1
C	10.21	20.837	48.619	1021
D	1.564	3.192	7.448	156.4
E	0.6536	1.334	3.112	65.36

It is important to highlight that all locations exceeded the 1.0 Bq/L limit, albeit to varying degrees. Exceeding this threshold indicates that the water from these sites — particularly from Location C may pose significant health risks if used for drinking, cooking, or other domestic purposes without treatment. Long-term consumption of water with elevated beta-emitting radionuclides could lead to internal exposure, potentially resulting in cancers, genetic mutations, or other serious health disorders.

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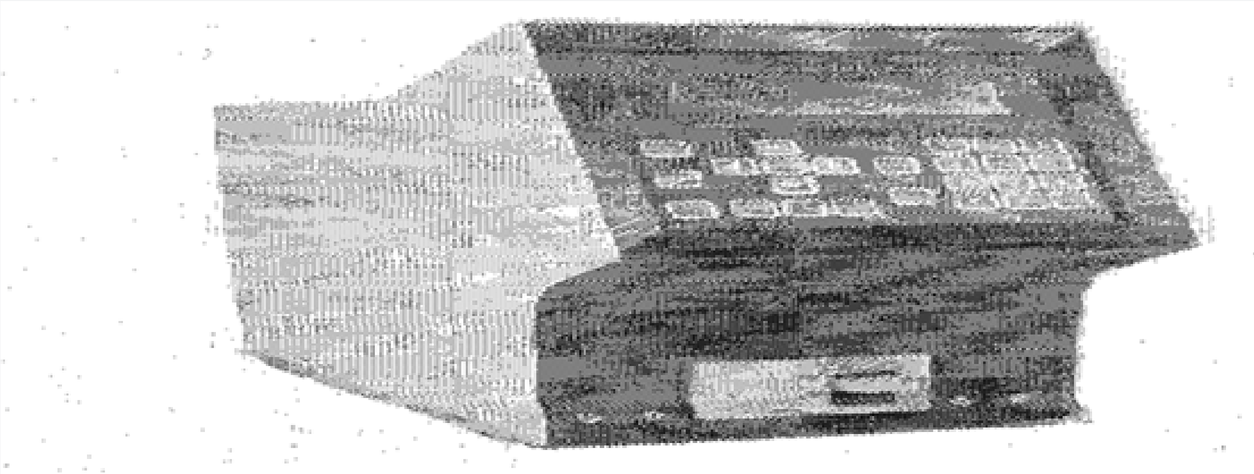

Figure 6: MPC-2000B-DP (Dual Phosphate).

Conclusion and Recommendation

Conclusion

In conclusion, while Location E appears comparatively less contaminated, none of the sampled sites meet the acceptable safety standards for drinking water, emphasizing an urgent need for remediation and continuous environmental surveillance.

The results achieved were above the recommended screening value of 1.0 Bq/L, hence are less harmful hazard.

Recommendation

i. An in-depth survey of not just Mubi-North but the entire Mubi town needs to be conducted.

ii. The method of preparing the sample should be better because one must be able to measure the dissolved material accurately in order to leave very little residue on the plate to be counted.

iii. Individuals consuming water from the source above are requested to file complaints to the Ministry of Health in a bid to initiate further beta radiation screening.

Contribution to the Field of Knowledge

To my knowledge, no data on the gross beta radioactivity levels in drinking water of any part of Mubi-North is available. Therefore, this data can serve as the foundation for future data development and analysis.

Possible directions for additional research

Some of the villages in Mubi-North, such as Digil and Vimtim, and Mubi-South and nearby villages, present the potential for such studies. Nearby local governments such as Hong and Michika also present themselves as potential areas to study, with the ability to compare data.

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