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Risk Assessment of Drinkable Water from Hand-dug Reservoirs Using Gross Alpha and Beta Radioactivity Levels in Ogwashi-Uku, Delta State

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ABSTRACT: *Over the past decade, radioactivity in drinking water has become a matter of urgent concern following reports from various scientific researches. The rapid urbanization and increase in population of Ogwashi-Uku has culminated in the increase for demand of safe and potable water hence the need for this study. A total of 10 samples were collected from the study location. Standard methods for determination of gross alpha and gross beta activity concentrations in the water samples were deployed. The measured gross alpha activity concentrations for all water samples are below 0.1 Bq/L while the measured gross beta activity concentrations in all water samples collected are lower than 1.0 Bq/L permissible limit. The mean annual dose equivalent in all the water samples for gross alpha and gross beta activity is lower than 0.1 mSv recommended dose for radionuclides in water, hence the life cancer risk assessment showed lower values, indicating the water is safe for drinking. The purpose of this study is to assess the concentration of gross alpha and beta activity levels of drinking water from hand-dug reservoirs in Ogwashi-Uku, Delta State in order to offer a scientific basis for making decisions regarding mitigating radioactive pollution and also to ensure the safety of drinking water and public health.*

KEYWORDS: gross alpha, gross beta, water, radioactivity, pollution

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INTRODUCTION

Water, being a crucial natural resource, holds immense importance. It serves as an essential element for all forms of life, including humans, animals, and their surroundings (Vanloon and Duffy, 2005). The significance of water extends to various sectors, encompassing industry, agriculture, and domestic usage. There are two primary sources of water: surface water and underground water (Mendie, 2005). However, the availability of safe and potable water has been a matter of urgent concern to scientist, government and relevant stakeholders due to reports from various scientific researches. Some contaminant that affects the quality of water includes radionuclides, heavy metals, and gaseous emission etc which are usually present in all types of drinking water source (Rajamannan et al., 2013).

One important factor that increases the exposure of humans to natural radiation is the availability of alpha and beta radiations in drinking water and the amount of radionuclides present in the rock, soils and other radionuclide material that may come in contact with the water (UNSCEAR, 2000; Darko et al., 2014). It is known that the natural radionuclides activity is influenced by the geographical location of water sources (Altıkulaç, et al., 2015). However, human activities and natural phenomena tend to contribute significantly to the degradation of water sources, leading to a decline in water quality. Water pollution commonly occurs due to the release of unwanted substances, including fertilizers used in farming into the water (Helliwell, 1975).

Following the stipulated guidelines of World Health Organization (WHO) for gross alpha activity, (0.1 Bq/L) and gross beta activity, (1 Bq/L) in drinking water (Todorović et al., 2020), the levels of radioactive pollution in the drinking water must be lower than recommended values of WHO for gross alpha and gross beta activities or as low as reasonably achievable (Benson et al., 2017).Research on Gross alpha and gross beta activity concentration in drinking water and other sources of water have been conducted in various locations in the past. However, these research were limited to specific regions, types and sources (surface and ground) water and there is no documented records or published article on the assessment of gross alpha and gross beta activity concentration in hand-dug reservoirs and its radiological implication on human health in Ogwashi-Uku or anywhere else.

Hand-dug reservoirs are essential water sources in many communities, particularly in regions where access to piped water systems is limited. These reservoirs serve as crucial sources of drinking water for irrigation and domestic use. However, concerns have been raised regarding the potential health risks associated with such reservoirs, particularly in relation to radioactivity levels. Radioactive contaminants in water, such as gross alpha and beta radioactivity, can pose significant health hazards if consumed above permissible limits.

This necessitated the need for this research in order to ascertain and quantify the radioactivity levels of gross alpha and gross beta radiations in hand-dug reservoirs water and to also evaluate

the radiological health risks associated with the consumption of this water. The gross alpha and beta counting is a relatively simple, stable, and low cost preliminary test, as stipulated in the guidelines set by WHO for water quality determination (WHO, 2004). It has also become a veritable tool for determination of relative radioactivity levels in water (Jobbagy et al., 2011; Sahin et al., 2017).

MATERIALS AND METHODS

Study area and Samplimg location

Ogwashi-Uku is the headquarters of Aniocha South Local Government Area in Delta State, Nigeria. The Local Government has an area of about 868 Km^2. The coordinates of Ogwashi-Uku town lies between $6^0$10' 59.06" N and $6^0$31' 27.72" E. Ogwashi-Uku shares borders with Igbuzo to the north, Asaba to the northeast, Ubulu-Uku to the south, Ubulu-Uno to the southeast and Issele-Azagba to the west.

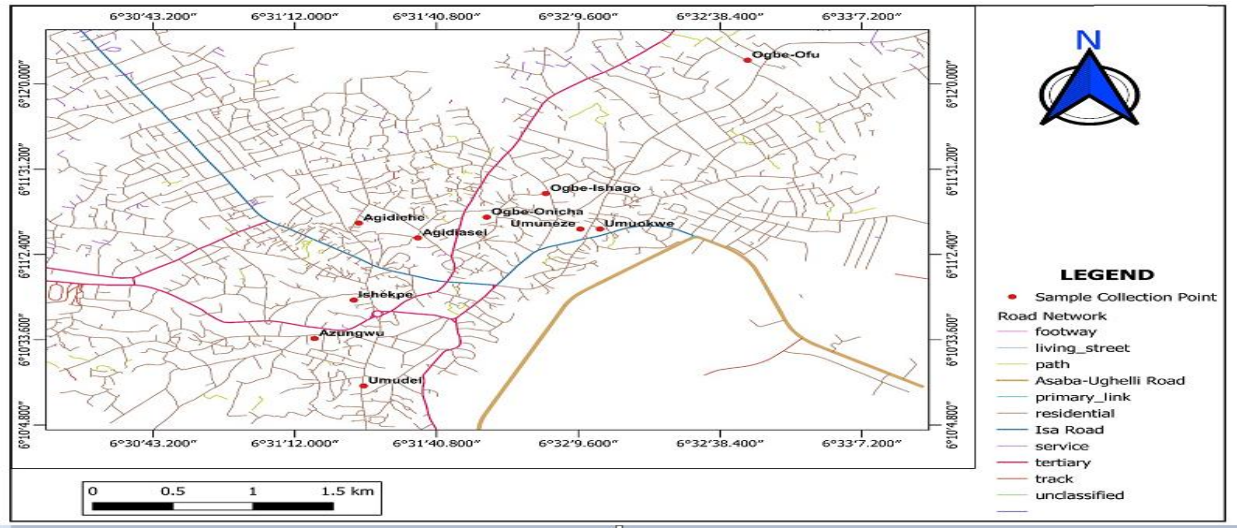

Figure 1: Map of the study area showing the sampling points.

2.2 Sample Collection, Preparation and Analysis

Two water samples each were collected from hand-dug reservoirs in ten quarters in the host communities using a 2-litres plastic container which was initially rinsed using diluted water and also rinsing the container twice with sample water to reduce contamination, and 1% of air space left in the container for thermal expansion (Agbalagba et al, 2021). The samples were collected during the wet season. Following the guides of International Standard Organization (ISO), water samples collected were acidified with 20 ml $\pm$ 1 of nitric acid per litre to minimize the absorption of radionuclides into the walls of the containers. This was done at the point of collection (Agbalagba et al, 2021).

The samples were then tightly sealed and immediately sent to the laboratory for analysis. At the laboratory, the sample were placed in a furnace of temperature of about 60 ^{0}C and were slowly evaporated own to a 50 ml volume. The residues were then dried on a stainless-steel which were then dried. A further detailed procedure for counting technique to determine gross alpha and gross beta radioactivity in the samples are in accordance of reports by Nwoke (2006), Onoja et al. (2007), and Agbalagba et al (2021).

The gross alpha and beta activities of the water samples were estimated according to Saleh and Shayeb (2014) as shown in Eq. (1)

$$A_{\alpha,\beta} = \frac{N}{60 \times \frac{Eff_{\alpha,\beta}}{100} \times V_s} \quad (1)$$

RESULTS AND DISCUSSION

The results show that the measured radioactivity levels of gross alpha and gross beta in the hand-dug reservoir water of the town are lower than the recommended limit set by WHO. So it was assumed that the lower gross alpha and gross beta values were caused by influence rainfall as majority of the hand-dug reservoir users collect water directly from rain by connecting their roofs to the reservoirs and the fact that the study was conducted during the wet season. The results indicated that the city's drinking water sources have not been radioactively contaminated and were at a normal background level, however, it is still necessary to strengthen protection and mitigation measures as Ogwashi-Uku is a town known to buy water from sellers during dry season and they get this water from rivers and drilled bore holes.

Table 1. Gross Alpha and Beta Radioactivity in Hand-dug Reservoirs from Various Locations in Aniocha South Local Government Area of Delta State

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S/N	Location	Mean Activity of Gross Alpha (Bq/L)	Mean Activity of Gross Beta (Bq/L)	Age	Coordinates	Code
1	Ogbe-Ofu	0.023	0.106	11	6.65 E, 6.55 N	HDR 1
2	Umuneze	0.002	0.064	15	6.56 E, 6.21 N	HDR 2
3	Umuokwe	0.015	0.121	25	6.57 E, 6.21 N	HDR 3
4	Umudei	0.001	0.017	29	6.59 E, 6.21 N	HDR 4
5	Azungwu	0.003	0.050	31	6.56 E, 6.25 N	HDR 5
6	Ishekpe	0.004	0.098	11	6.59 E, 6.29 N	HDR 6
7	Agidiehe	0.004	0.172	11	6.59 E, 6.22 N	HDR 7
8	Agidiasei	0.010	0.081	30	6.62 E, 6.20 N	HDR 8
9	Ogbe-Onicha	0.005	0.075	35	6.66 E, 6.22 N	HDR 9
10	Ogbe-Ishago	0.015	0.090	12	6.54 E, 6.24 N	HDR 1
	WHO (2011)	0.1	1			

Table 1 shows the gross alpha and beta activity concentrations of the hand-dug reservoirs water samples of the selected locations in Ogwashi-Uku, Aniocha South local government area of Delta state. The gross alpha activity concentration ranged from 0.001to 0.023 Bq/L with maximum value of 0.023 Bq/L while the gross beta activity concentration ranged from 0.017 to 0.172 Bq/L with maximum value of 0.172 Bq/L the maximum values were obtained in samples from Ogbe-Ofu and Agidiehe communities. The minimum radioactivity concentrations for gross alpha and gross beta were 0.001 Bq/L and 0.017 Bq/L obtained in samples from Umudei community.

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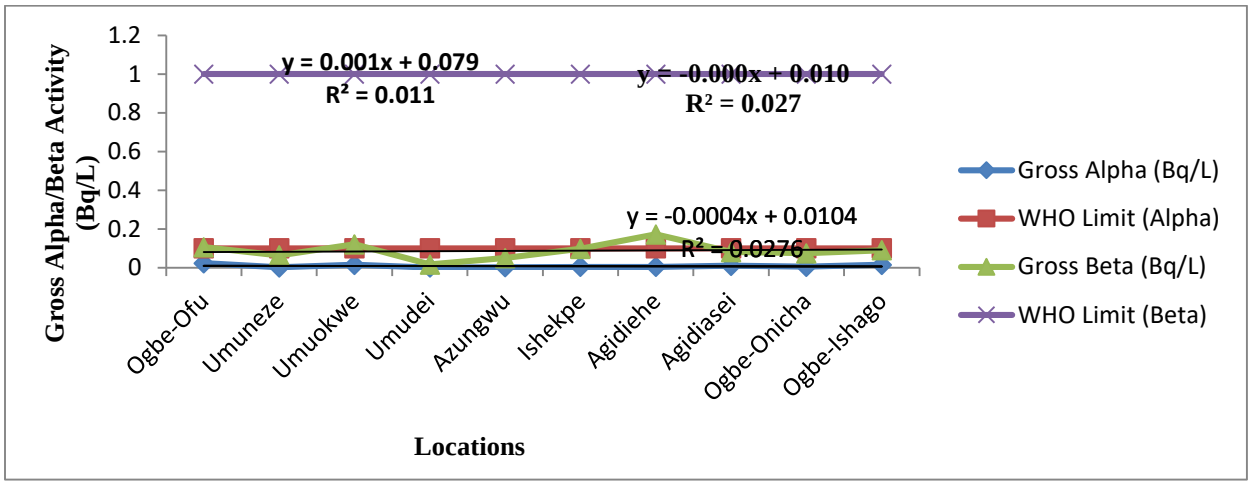

Figure 2: Gross Alpha/Beta Activity Conc. compared with WHO limit in the study locations

Examining the graph in figure 2, it shows a general low distribution of gross alpha and beta activity concentration in all communities when compared with World Health Organization (WHO, 2011) limits of 0.1 Bq/L and 1 Bq/L for gross alpha and beta activity respectively. The graph also shows a positive correlation indicating a relationship between the gross activity concentration considered and that as the gross alpha variable increases, the gross beta variables also tends to increase. Hence, the results obtained in this study revealed that the measured activity concentrations of gross alpha and beta in the water samples analyzed are lower than the recommended limit.

Table 2: Comparison of the concentration of gross alpha and beta activity in this study and other studies.

Concentration of gross alpha (Bq/L)	Concentration of gross beta (Bq/L)	Water sources	References
0.001-0.038	0.991-2.685	Dam water	Oluwole et al. 2020
0.005-0.012	0.035-1.511	Well water	Oluwole et al. 2020
0.0002-0.015	0.0252-0.2644	Tap water	Damla et al. 2006
31.46	50.14	Bottle water	Ismail et al. 2009
0.0157-0.1427	0.0893-0.400	Borehole/Well	Darko et al. 2014
1299	582	Groundwater	Fasae 2013
45.9	91.2	Natural spring	Kobya et al. 2015

1.57	1.62	Groundwater	Alomari et al. 2019
0.006-0.125	0.001-0.667	Tap and River	Korkmaz et al. 2016
0.11-16	0.10-16.90	Thermal spring	Sahin et al. 2017
0.782	0.816	River	Selcuk et al. 2009
0.001-0.023	0.017-0.172	River Dam	This Study

Comparison of gross alpha and beta concentrations obtained in this study with literatures is presented in Table 2. The table shows that the activity concentration of gross alpha and beta are lower than reported studies in Nigeria (Fasae, 2013 and Oluwole et al. 2020). For reported studies outside Nigeria (Natural spring, Tap and River, Thermal spring, River and Borehole/Well) the activity concentration of gross alpha and beta are lower than reports of Kobya et al. (2015), Korkmaz et al. (2016), Sahin et al. (2017), Selcuk et al. (2009) and Darko et al. (2014) respectively as shown in Table 2. The lower activity concentrations of gross alpha and beta in this study compared to other studies is due to the geological properties of the source of water and the activities carried out around the water source.

Table 3. Effective Dose Equivalent and Lifetime Risk Assessment

S/N	Location	$DR_{W(\alpha)}$ (Sv/yr)	$DR_{W(\beta)}$ (Sv/yr)	TEDE (mSv)	$LR_{(\alpha)}$	$LR_{(\beta)}$
1	Ogbe-Ofu	0.004	0.0053	0.058	0.024	0.271
2	Umuneze	0.0004	0.032	0.032	0.021	0.164
3	Umuokwe	0.003	0.061	0.064	0.016	0. 312
4	Umudei	0.0002	0.008	0.008	0.001	0.044
5	Azungwu	0.0006	0.025	0.026	0.003	0.128
6	Ishekpe	0.0008	0.050	0.051	0.004	0.256
7	Agidiehe	0.0008	0.087	0.088	0.004	0.445
8	Agidiase	0.0002	0.041	0.041	0.001	0.210
9	Ogbe-Oni	0.001	0.038	0.039	0.005	0.194
10	Ogbe-Ishago	0.003	0.045	0.048	0.016	0.230

The estimated effective dose equivalent and lifetime risk assessment due to concentration of gross alpha and beta in water samples collected from different hand-dug reservoirs in Ogwashi-Uku,

Delta State are given in Table 3. As shown in Table 3 the total effective dose equivalent (TEDE) estimated ranged from 0.008 to 0.088 mSv with the highest value recorded from Agidiehe. The lifetime risk values estimated for gross alpha and gross beta ranged from 0.001 to 0.024 and 0.044 to 0.445 respectively. The values obtained in this study are lower than the recommended reference level of the committed effective dose equivalent of 0.1 mSv/yr.

CONCLUSION

The study was carried out in the area to determine the radioactivity levels in selected hand-dug reservoirs using the concentrations of gross alpha and gross beta activity. From results obtained in this study, it clearly showed that the water from hand-dug reservoir is below the recommended values and pose no immediate health threat to the increasing population of the town. Finally, data obtained in this study will serve as a baseline data that could be used for future evaluation of various studies on water in the area.

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