

Examining the Radiological Health Risks Associated with Water Sourced from the Ogwashi-Uku Earth Dam in Ogwashi-Uku, Delta State, Nigeria

ABSTRACT

Given the increased human activities and population growth in Ogwashi-Uku, there is a possibility of potential contamination of the water in the dam with elevated levels of alpha and beta radiation. Therefore, this study aimed to assess the radiological health risks associated with water obtained from the Ogwashi-Uku Earth dam by analyzing the concentrations of gross alpha and gross beta activity in the water. The results indicate that the measured activity concentrations of gross alpha and gross beta in the water samples are below the permissible limits of 0.1 Bq/l and 1.0 Bq/l respectively. Additionally, the average annual effective dose equivalent calculated for all the water samples is lower than the recommended dose limit of 0.1 mSv for radionuclides in water. These findings suggest that the assessed life cancer risk associated with the water consumption is low, indicating that the water from the Ogwashi-Uku Earth dam is safe for consumption.

Keywords: Gross alpha; gross beta; radioactivity; water; effective dose; Delta State.

1. INTRODUCTION

Water is a crucial substance for humans, animals, and all living things. In fact, water makes up a significant portion of our bodies, as well as the bodies of animals [1].

The importance of water extends across various areas of life, including industry, agriculture, and everyday household use. There are two primary sources of water: rain and groundwater. Groundwater can be found deep underground in wells and boreholes, or on the surface in rivers, seas, oceans, lakes, and streams. Surface water can be collected, purified, and distributed through pipes as tap water, which is the most convenient source of drinking water in Nigeria [2,3].

However, water sources face constant pollution from both human activities and natural occurrences, which has a detrimental effect on water quality. Pollution of water arises from the disposal of waste and sewage from industries, hospitals, and the runoff of fertilizers used in farming into rivers and streams [4,5]. Some of the pollutants include harmful substances called radionuclides [6].

Another source of water pollution stems from secondary particles of cosmic radiation, which release radionuclides into the atmosphere.

These materials emit alpha, beta, and gamma radiations and are typically elements in the uranium and thorium series. Deep groundwater tends to have a higher concentration of these radioactive materials compared to surface water [3]. They directly contaminate water bodies with their radionuclide products. Furthermore, Radon and Thoron gases, produced by these materials, can solidify and become aerosols that attach themselves to the air, indirectly affecting water sources. Some of these pollutants are radioactive in nature and their intake into the human body can pose health risks.

In Ogwashi-Uku, the Aboh river dam plays a significant role in irrigation, fishing, water supply for purification and distribution as bore-hole water for the dwellers, and as a source of drinking water for livestock. Moreover, it will serve as a major water supply for the Delta State industrial agro park. The settlements around the Aboh river dam can be split into three categories: predominantly agricultural, residential/commercial and proposed agro industry.

Considering the activities occurring into three purposes, it is possible that the water in the Aboh river dam may be contaminated with high levels of alpha and beta radiation. Therefore, it is crucial to assess the concentrations of alpha and beta radioactivity, as well as the specific activities

of radionuclides, in water samples from these three categorical regions of the Aboh river dam. By comparing the concentrations in each region, it would be possible to identify which region's activities pose radiological hazards to the inhabitants of Aboh-Ogwashi through the Aboh river dam.

2. MATERIALS AND METHODS

2.1 Description of the Sampling Area

Fig. 1 shows the location of the river dam and sampling points. Ogwashi-Uku, a town located in the northern part of Delta State and the headquarters of Aniocha South Local Government Area in Delta State, Nigeria. The Local Government has an area of about 868 Km². Ogwashi-Uku town lies between and $6^{\circ}31'27.72''E$.

2.2 Sample Collection, Preparation and Analysis

"Each of the two water samples was collected from four different points to form a square of the dam using a 2-litres plastic container which was initially rinsed using diluted water. Thereafter container was rinsed twice again with the sample water to reduce contamination leaving 1% of air space for thermal expansion" [1,7]. "The samples were collected during the dry season. Following the guidelines of International Standard Organization (ISO), water samples collected were acidified with 20 (± 1) ml 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" [7].

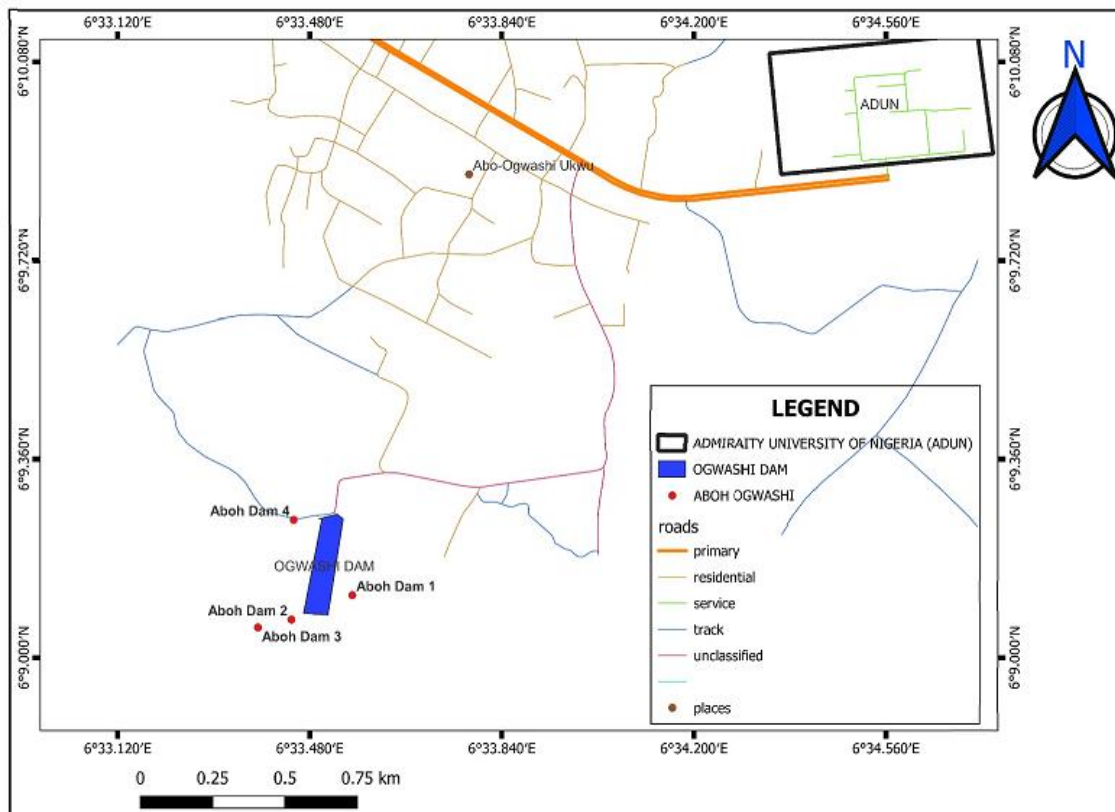


Fig. 1. Map of the study location

"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°C and were slowly evaporated until it expands to 50 ml volume. The residues were then dried on a pre-dried stainless-steel container. A further detailed procedure for counting technique to

determine gross alpha and beta radioactivity in the samples is in accordance of reports by [7].

The levels of gross α and β activities in the water samples were determined using the relation of [1] as shown in Eq. (1)

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

where N is the net gross alpha or beta count rate (cpm), $Eff_{\alpha,\beta}$ is gross alpha or beta counting efficiency (in percent). V_s are the volume of sample aliquot (in L) and 60 is the conversion factor.

3. RESULTS AND DISCUSSION

3.1 Results

Table 1 shows different points where water samples were collected along the river dam with their GPS coordinates and the different activity concentrations for gross alpha and gross beta.

Table 1 shows the gross alpha and beta activity concentrations of the Aboh river dam water samples in Ogwashi-Uku, Aniocha South local government area of Delta state. The gross alpha activity concentration ranged from 0.004 to 0.017 Bq/L with 0.017 Bq/L as the maximum value for gross alpha while the gross beta activity concentration ranged from 0.064 to 0.253 Bq/L with maximum value obtained in sample from Aboh Dam 3 (AD3).

3.2 Effective dose Equivalent and Lifetime Risk Assessment

The levels of radiation exposure to individuals were assessed by calculating the effective dose equivalent (DRW), total effective equivalent dose (TEED) and lifetime risk index. These calculations were based on the measurements of gross alpha and beta activity concentrations, following the guidelines provided by ICRP [8] and UNSCEAR [9].

$$DRW_{(\alpha\beta)} = Aw_{(\alpha\beta)} \times DCF_{(\alpha\beta)} \times CRW \quad (2)$$

where $DRW_{(\alpha\beta)}$ is the dose equivalent effective (Sv/yr), $Aw_{(\alpha\beta)}$ is activity (Bq/L),

$DCF_{(\alpha\beta)}$ is the dose conversion factor for ingestion of the individual natural radionuclides for adult, $\alpha = 2.80 \times 10^{-4} \text{ mSv/Bq}$ and [10].

CRW is the consumption rate of drinking water with a daily water intake of 2 L according to WHO [11].

The conversion factors and annual consumption rate of water for the different age groups used in arriving at the AED were taken from the publications of ICRP [12] and World Health Organization (WHO) [11] as presented in Table 2.

Table 1. Gross alpha and beta radioactivity in various points of the River Dam

S/N	Location	Mean Activity of Gross Alpha (Bq/L)	Mean Activity of Gross Beta (Bq/L)	Coordinates	Code
1	Aboh Dam 1	0.014	0.204	6.63 E, 6.17 N	AD 1
2	Aboh Dam 2	0.004	0.064	6.71 E, 6.16 N	AD 2
3	Aboh Dam 3	0.017	0.253	6.62 E, 6.19 N	AD 3
4	Aboh Dam 4	0.007	0.109	6.63 E, 6.19 N	AD 4

Table 2. Dose conversion factor and annual water consumption rate for different age groups

Dose conversion factor for different age groups (mSv/yr)		Annual water consumption rate (L/yr)	Age Group (yrs)
Gross alpha (α)	Gross beta (β)		
2.80×10^{-4}	6.90×10^{-4}	200	0 – 1
2.80×10^{-4}	6.90×10^{-4}	260	1 – 2
2.80×10^{-4}	6.90×10^{-4}	300	2 – 7
2.80×10^{-4}	6.90×10^{-4}	350	7 – 12
2.80×10^{-4}	6.90×10^{-4}	600	12 – 17
2.80×10^{-4}	6.90×10^{-4}	730	> 17

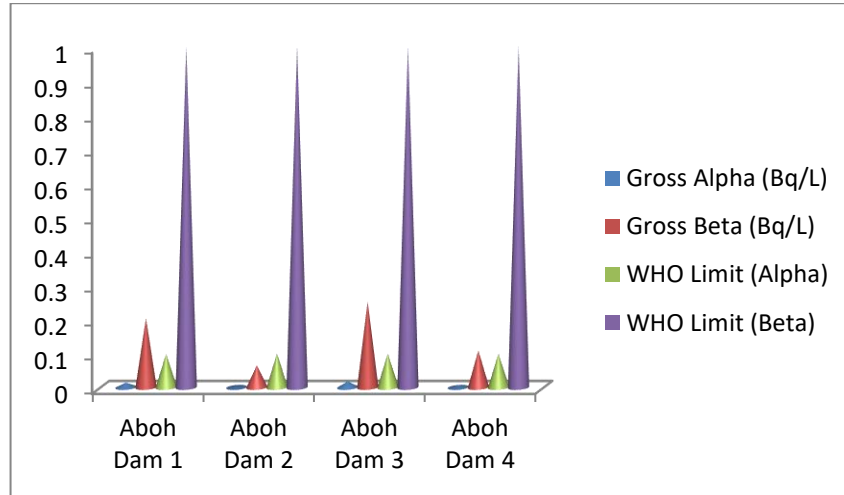


Fig. 2. Gross alpha/beta activity conc. compared with WHO limit in the study locations

$$Total\ Equivalent\ Dose\ (mSv)\ (TEED_{(\alpha+\beta)}) = DRW_{\alpha} + DRW_{\beta} \quad (3)$$

$$Lifetime\ Risk\ (LR_{\alpha/\beta}) = DRW_{(\alpha/\beta)} \times DL \times RF \quad (4)$$

where DL is duration of life (70 years) and RF is risk factor recommended as $7.3 \times 10^{-2} Sv^{-1}$ [8].

Fig. 2 shows a general low distribution of gross alpha and beta activity concentration in all points from where samples were collected when compared with World standards [13] limits of 0.1 Bq/L and 1 Bq/L for gross alpha and beta activity respectively. Hence, the results obtained in this study revealed that the measured activity concentrations of gross alpha and beta in the water samples from Aboh Dam as analyzed are lower than the recommended limit.

“Comparison of gross alpha and beta concentrations obtained in this study with literatures is presented in Table 3. The table shows that the activity concentration of gross alpha and beta are lower than reported studies in Nigeria” [14,17]. 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 [6,18,20,21 and 22] respectively as shown in Table 3. 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.

The radiological risk indexes of different sampling points of the river dam are presented in Table 4 which includes the annual effective dose equivalent, lifetime cancer risk and total equivalent effective dose. The estimated annual effective dose equivalent, total equivalent effective dose equivalent and lifetime risk assessment due to concentration of gross alpha and beta in water samples collected from different points of the Aboh river Dam in Ogwashi-Uku, Delta State are given in Table 4. As shown in Table 4, the estimated average annual effective dose equivalent (AEDE) (DRW) ranged from 0.0005 to 0.0020 Sv/yr for $DRW_{(\alpha)}$ and 0.0179 to 0.0710 Sv/yr for $DRW_{(\beta)}$.

The average total equivalent effective dose equivalent (TEED) estimated, ranged from 0.0233 to 0.0729 mSv. The value obtained in this study is lower than values reported by [7 and 23] and those recorded by [3].

The average lifetime risk (LR) values estimated for gross alpha and gross beta ranged from 0.0023 to 0.0100 mSv/yr and 0.0913 to 0.3621 mSv/yr respectively. Although the average value of TEED for all sample location are below the recommended limit of 0.1 mSv/yr set by WHO, the TEED values obtained for the following age groups (>17 yrs) for sample location AD 1 and (12 – 17 yrs, >17 yrs) for sample location AD 3 was found to be slightly above this limit. This is an indication of possible health

Table 3. 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	Reference
0.001-0.038	0.991-2.685	Dam water	[14]
0.005-0.012	0.035-1.511	Well water	[14]
0.0002-0.015	0.0252-0.2644	Tap water	[15]
31.46	50.14	Bottle water	[16]
0.0157-0.1427	0.0893-0.400	Borehole/Well	[6]
1299	582	Groundwater	[17]
45.9	91.2	Natural spring	[18]
1.57	1.62	Groundwater	[19]
0.006-0.125	0.001-0.667	Tap and River	[20]
0.11-16	0.10-16.90	Thermal spring	[21]
0.782	0.816	River	[22]
0.001-0.023	0.017-0.172	River Dam	This Study

Table 4. The annual effective dose equivalent, lifetime risk assessment and total equivalent effective dose for river dam

Sample Location	Annual Effective Dose Equivalent		Total Equivalent Effective Dose TEED (mSv)	Lifetime Cancer Risk	
	DR _{W(α)} (Sv/yr)	DR _{W(β)} (Sv/yr)		LR _(α) (mSv/yr)	LR _(β) (mSv/yr)
AD1	0.0008	0.0281	0.0289	0.0041	0.1432
	0.0010	0.0366	0.0376	0.0051	0.1869
	0.0011	0.0422	0.0433	0.0060	0.2152
	0.0013	0.0492	0.0505	0.0070	0.2511
	0.0024	0.0844	0.0868	0.0123	0.4302
	0.0029	0.1026	0.1118	0.0150	0.5238
Average	0.0016	0.0572	0.0598	0.0083	0.2917
AD2	0.0002	0.0088	0.0091	0.0010	0.0450
	0.0003	0.0114	0.0117	0.0015	0.0583
	0.0003	0.0132	0.0433	0.0015	0.0675
	0.0004	0.0155	0.0159	0.0020	0.0791
	0.0007	0.026	0.0267	0.0036	0.1329
	0.0008	0.0322	0.0330	0.0041	0.1650
Average	0.0005	0.0179	0.0233	0.0023	0.0913
AD3	0.0009	0.0350	0.0359	0.0046	0.1786
	0.0012	0.0454	0.0466	0.0061	0.2318
	0.0014	0.0524	0.0538	0.0072	0.2674
	0.0017	0.0610	0.0627	0.0087	0.3120
	0.0029	0.1050	0.1079	0.0150	0.5351
	0.0035	0.1269	0.1304	0.0179	0.6475
Average	0.0020	0.0710	0.0729	0.0100	0.3621
AD4	0.0004	0.0150	0.0154	0.0020	0.0767
	0.0005	0.0195	0.02	0.0026	0.0995
	0.0006	0.0230	0.0236	0.0031	0.1180
	0.0007	0.0263	0.027	0.0036	0.1342
	0.0012	0.0451	0.0463	0.0061	0.2300
	0.0014	0.0549	0.0563	0.0072	0.2808
Average	0.0008	0.0306	0.0314	0.0041	0.1565

risks to consumers of this river dam water for the stated age group in Ogwas'hi-Uku. All estimated values for the Lifetime risk are higher than WHO recommended limit of 0.29×10^{-3} which is a

reason for worry as the Aboh river dam plays a significant role in irrigation, fishing, water supply for the dwellers, and as a source of drinking water for livestock.

The lower activity concentrations of gross alpha and gross beta recorded in this study compared to other studies maybe due to the geological properties of the river dam and the activities carried out around the water source.

Generally, the results have revealed that there is no immediate health risk that may arise from the consumption of the water from Ogwashi-Uku river dam [23].

4. CONCLUSION

An analytical approach to assess the gross alpha and beta activities in water samples from Aboh river dam of Ogwashi-Uku was carried out. The results obtained in this study, clearly indicated that the water from Aboh River is below the recommended values for gross alpha and beta activity. However, for certain age groups (>17 yrs) at sample location AD 1 and (12 – 17 yrs and >17 yrs) at sample location AD 3, TEED values were slightly above the permitted limit set by World Health Organization (WHO). While these findings do not pose an immediate health risk to the growing population of the town, continuous consumption of this water, particularly for the age groups of 12 – 17 yrs and >17 yrs, may have detrimental effects on their health. It is important to note that water pollution alone cannot account for the large number of cancer cases observed in the country. Other factors, such as tobacco smoking and exposure to radon gas also contribute significantly to the high rates of cancer diagnosis and mortality. Finally, the data obtained from this study will serve as a baseline data for future evaluations of water-related studies in the area and assess any changes in water quality over time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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