Evaluating the Radiological Health Risks of Water Sourced From Ogwashi-Uku Earth Dam in Ogwashi-Uku, Delta State.

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. A total of eight water samples were collected from the study area, and standard methods were employed to determine the gross alpha and gross beta activity concentrations in these samples. 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

Introduction

Water is a crucial substance for humans, animals, and all living things. It has existed since the very beginning of the universe. In fact, water makes up a significant portion of our bodies, as well as the bodies of animals (Ijabor et al. 2024).

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(Mendie, 2005,Okunola et al. 2020)

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 (Rajamannanet al., 2013, Ijabor et al, 2023). Some of the pollutants include harmful substances called radionuclides(Darko et al., 2014).

Another source of water pollution stems from secondary particles of cosmic radiation, which release radionuclides into the atmosphere. These radionuclides are subsequently carried down to the ground and surface water bodies through rainfall. Additionally, naturally occurring radioactive materials (NORMs) found in the Earth's crust, known as terrestrial radioactivity, contribute to the pollution of water sources. 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 (Okunola et al. 2020). 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.

Additionally, the presence of naturally occurring radioactive materials (NORMs) in any area can further contribute to water contamination. 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 categorized into three regions: predominantly agricultural, residential/commercial, and proposed agro industry.

Considering the activities occurring in these three regions, 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 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.

MATERIALS AND METHODS

Description of the Sampling Area

Figure 1 show 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 Km^2. Ogwashi-Uku town lies between $6^0 10'59.06''N$ and $6^0 31'27.72''E$.

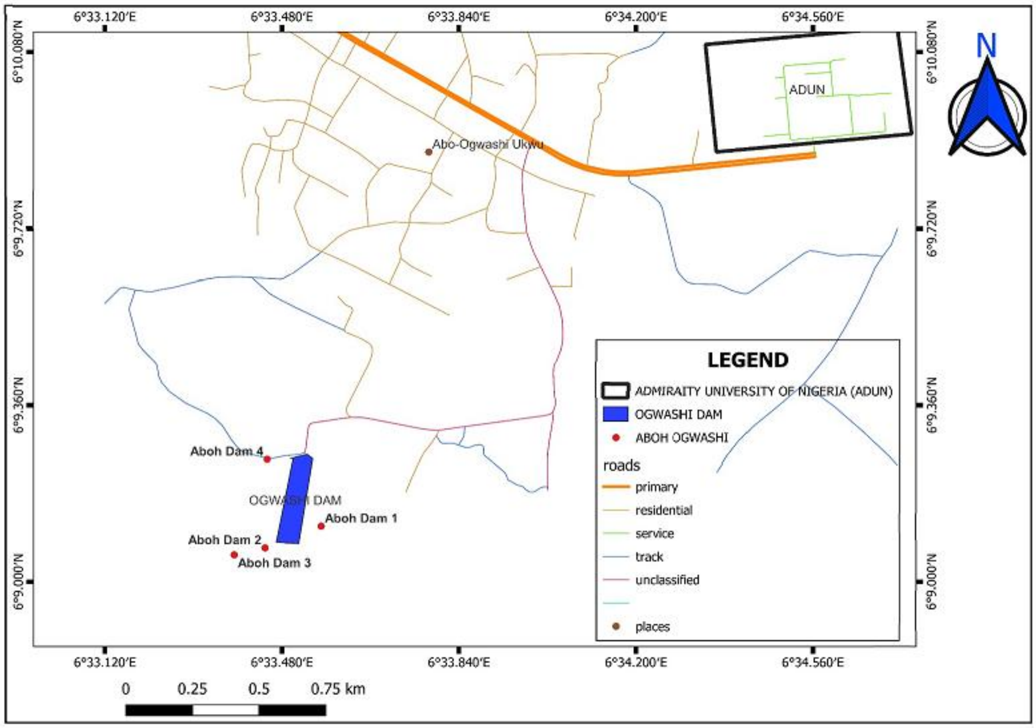

Fig. 1: Map of the study location

Sample Collection, Preparation and Analysis

Two water samples each were collected from four points to form a square of the dam 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, Ijabor et al, 2024). The samples were collected during the dry season. Following the guidelines of International Standard Organization (ISO), water samples collected were acidified with 20 ml ± 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 60^0C 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 beta radioactivity in the samples are in accordance of reports by Agbalagba et al (2021).

The levels of gross α and β activities in the water samples were determined using the relation of Ijabor et al, (2024) 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). Vs are the volume of sample aliquot (in L) and 60 is the conversionfactor.

Results and Discussion

Results

Table 1 shows the 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.

Table1.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 1 above shows the gross alpha and beta activity concentrations of the Aboh river dam water samples in Ogwashi-Uku, Aniocha Southlocal 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).

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

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 (1991) and UNSCEAR (2000).

$$DRw_{(\alpha/\beta)} = Aw_{(\alpha/\beta)} \times DCF_{(\alpha/\beta)} \times CRw \qquad 1$$

where $DRw_{(\alpha/\beta)}$ is the dose equivalent effective (Sv/yr), $Aw_{(\alpha/\beta)}$ isactivity (Bq/L), $DCF_{(\alpha/\beta)}$ is thedose conversion factor for ingestion of the individual natural radionuclidesfor adult, $\alpha = 2.80\times10^{-4}\, mSv/Bq$ and $\beta = 6.90\times10^{-4}\, mSv/Bq$ (WHO, 2004). *CRw*is the consumption rate of drinking waterwith a daily water intake of 2 L according to WHO(2011).

The conversion factors and annual consumption rate of water for the different age groupsused in arriving at the AED were taken from the publications of ICRP (1996) and World Health Organization (WHO) (2011) as presented in Table 2.

$$TotalEquivalentDose(mSv)(TEED_{(\alpha+\beta)}) = DRw_{\alpha} + DRw_{\beta} \quad 2$$

$$LifetimeRisk(LR_{\alpha/\beta}) = DRw_{(\alpha/\beta)} \times DL \times RF \quad 3$$

where DL is duration of life (70 years) and RF is risk factor recommendedas $7.3 \times 10^{-2} Sv^{-1}$ (ICRP, 1991).

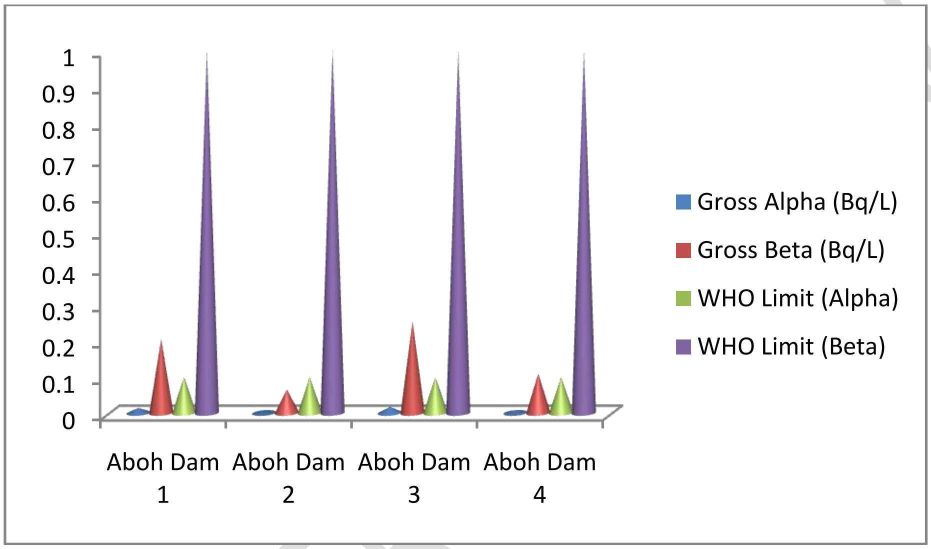

Fig. 2: Gross Alpha/Beta Activity Conc. compared with WHO limit in the study locations

Figure 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 (SON, 2007; WHO, 2012) 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.

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	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 3. 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, RiverandBorehole/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) andDarko et al. (2014)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.

Table 4. The Annual Effective Dose Equivalent, Lifetime Risk Assessment and total equivalent effective dose for river dam

Sample Location	Annual Effective Dose Equivalent $DR_{W(\alpha)}$ (Sv/yr)	$DR_{W(\beta)}$ (Sv/yr)	Total Equivalent Effective Dose TEED (mSv)	Lifetime Cancer Risk $LR_{(\alpha)}$ (mSv/yr)	$LR_{(\beta)}$ (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

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/yrfor $DRw_{(\beta)}$. The average total equivalent effective dose equivalent (TEED) estimated, ranged from 0.0233 to 0.0729 mSv. The value obtained in this study is lowerthan values reported by Agbalagba et al. (2013),Ogundare and Adekoya, (2015) and those recorded by Okunola et al. (2020).

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 3was found to be slightly above this limit. This is an indication of possible health risks to consumers of this river dam water for the stated age group in Ogwashi-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 betarecorded 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.

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 showed that the water from Aboh River is below the recommended values for gross alpha and beta activity butthe 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 the permitted limit recommended by World Health Organization (WHO). Although these result pose no immediate health threat to the increasing population of the town but continuous consumption of this water especially for the age groups12 – 17 yrs and >17 yrs may be detrimental to their health. 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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