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Radiological Risk Assessment of Uranium, Thorium and Potassium in Siluriformes and Oreochromis Niloticus in Baga, Borno State

***Sudaise, I. M., Balami, D. S., Bukar, M. I., Adamu, A., Yakubu, N. and Rawagana, M.**

Department of Physics, University of Maiduguri, P. M. B. 1069, Maiduguri, Nigeria

[*]Corresponding author's email: Sudaisem18@gmail.com Phone: +2348030431755

ABSTRACT

The study of radiological risk assessment plays a crucial role in understanding the potential impact of radioactive elements on the environment and human health. Uranium, thorium, and potassium are naturally occurring radioactive elements commonly found in various geological formations worldwide. Their presence in aquatic ecosystems, such as rivers, lakes, and reservoirs, raises concerns regarding potential exposure and associated risks to aquatic organisms and humans (Ajayi *et al*., 2018; Syarbaini *et al*., 2014; Hamidalddin *et al*., 2016). In October 2023, two fish samples were obtained from Baga, Kukawa, Borno State. Sample A was catfish, while Sample B was tilapia. The amounts of uranium, thorium, and potassium were the main topics of the radiological risk assessment performed on the samples. Following a seven-day sun-drying process, the fish were ground into a powder and carefully sent to the Obafemi Awolowo University's Centre for Energy Research and Development in Ile-Ife, Osun State. The findings showed that both catfish and tilapia contain certain radionuclides (uranium, thorium, and potassium), their anticipated annual effective dose rates from consumption are relatively modest. It was discovered that the computed dose rates for tilapia (Sample B) and catfish (Sample A) were significantly lower than the global average for the yearly effective dosage limit for the general public, which is normally set at 1 millisievert (mSv) annually. In particular, the estimated annual effective dose rate were 3.190758 µSv/year and 4.021574 µSv/year for Sample A and B respectively. These results imply that eating tilapia and catfish is unlikely to expose the general public to radiation levels higher than dose recommended by international agreements. The investigation concludes that eating tilapia and catfish is compliant with international standards for radiation exposure from food. Nevertheless, maintaining ongoing food safety procedures depends on constant observation and adherence to changing regulations.

Keywords:
Siluriformes,
Oreochromis Niloticus,
Catfish,
Tilapia.

INTRODUCTION

The study of radiological risk assessment plays a crucial role in understanding the potential impact of radioactive elements on the environment and human health. Uranium, thorium, and potassium are naturally occurring radioactive elements commonly found in various geological formations worldwide. Their presence in aquatic ecosystems, such as rivers, lakes, and reservoirs, raises concerns regarding potential exposure and associated risks to aquatic organisms and humans (Ajayi *et al*., 2018; Syarbaini *et al*., 2014; Hamidalddin *et al*., 2016). The study of radiation levels in fish is essential for monitoring the safety of fish consumption and ensuring the health of the local population (Yoshida *et al*., 2012; Burger *et al*., 2001). In this research, we aim to provide an in-depth analysis of the radiological risk assessment of uranium, thorium, and potassium in catfish and tilapia in Borno State. Fish consumption is a common dietary practice in Nigeria, and catfish and tilapia are two of the most popular types of fish consumed in the country (Kaleem *et al.*, 2021; Gomna *et al.*, 2011). However, it is important to recognize that fish can accumulate radionuclides in their tissues, which can pose a health risk to humans who consume them (Görür, 2012). Radionuclides such as uranium, thorium, and potassium are naturally occurring elements found in the environment and can be present in fish due to contamination from water or sediment

(Erenturk, 2014). In Borno State, Nigeria, where natural resources are abundant, it becomes essential to conduct a comprehensive radiological risk assessment of specific fish species, namely Siluriformes and Oreochromis Niloticus. These species are widely consumed by the local population and form a significant part of their diet. Therefore, understanding the levels of uranium, thorium, and potassium in these fish species is crucial for evaluating potential radiological risks and ensuring the safety of both the environment and human consumers (Fasae, 2018). Therefore, it is essential to conduct a radiological risk assessment to evaluate the potential health risks associated with consuming these types of fish (Ankley, 2010).

By conducting this study, we aim to determine the levels of uranium, thorium, and potassium in catfish and tilapia in Borno State and assess the associated radiological risks. This assessment will provide valuable insights into the potential health hazards posed by consuming these fish species and contribute to the overall understanding of the radiological status of fish in the region. The findings from this research will inform policymakers, health professionals, and the local population about the safety of fish consumption and facilitate the development of appropriate measures to ensure the well-being of the community. In conclusion, this study focuses on the radiological risk assessment of uranium, thorium, and potassium in catfish and tilapia in Borno State. By evaluating the potential health risks associated with consuming these fish species, we aim to contribute to the existing knowledge base and promote the safety of fish consumption in the region. It is our hope that this research will facilitate informed decision-making and contribute to the well-being of the local population.

This study aims to assess the radiological risk associated with the presence of uranium, thorium, and potassium in Siluriformes and Oreochromis Niloticus in Borno State. By determining the concentration levels of these radioactive elements in the selected fish species, we can evaluate the potential radiological hazards they pose to human health and the environment. Additionally, this research will provide valuable insights into the overall radiological status of aquatic ecosystems in the region, contributing to the development of effective management and mitigation strategies. This study not only addresses the current knowledge gap regarding radiological risk in fish species within Borno State but also contributes to the broader scientific community's understanding of the radiological status of aquatic ecosystems. The findings from this research will aid in formulating effective regulatory measures, ensuring the sustainable utilization of natural resources, and safeguarding human health in the region.

Therefore, this research seeks to provide valuable insights into the radiological risk assessment of uranium, thorium, and potassium in Siluriformes and Oreochromis Niloticus in Borno State. By comprehensively evaluating the presence of these radioactive elements in fish species, we can better understand the potential risks they pose to the environment and human consumers. This knowledge will contribute to the development of appropriate strategies and policies aimed at mitigating radiological risks and ensuring the sustainable management of aquatic ecosystems.

MATERIALS AND METHODS

Study Area

Baga is a town in the north-eastern Nigerian state of Borno, close to Lake Chad, and lying northeast of the town of Kukawa. It is located within the Kukawa Local Government Area. The town is approximately 196 km from Maiduguri, the capital of Borno State. The "Doron Baga" fish market, as of 2000, was located about six kilometres from the town. Baga used to lie on the border of Lake Chad and was a fishing center itself in the 1960s and 1970s, but the diminishing size of the lake has caused fishermen to move, and others have turned to subsistence farming.

Baga's importance in the context of a radiological risk assessment stems from its possible exposure to naturally radioactive materials such as uranium, thorium, and potassium. The closeness of the research region to Lake Chad and its surrounding environment has a direct impact on the concentration and distribution of these components in aquatic species such as catfish and tilapia.

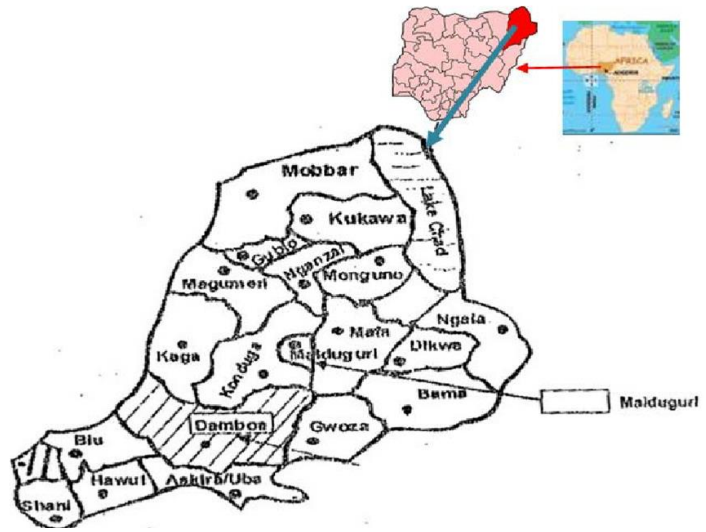

Figure 1: Map of Borno of State (Bernard, 2021)

Sample Collection and Preparation

Sample A and Sample B were taken in October 2023 from Baga, Kukawa, Borno State. Catfish is represented by Sample A, whereas tilapia is represented by Sample B, as shown in the figures below. The samples came from a specific area. Following collection, both catfish and tilapia samples were subjected to a consistent process that included sun-drying for seven days until completely dehydrated. Using specialised milling equipment, the dried materials were finely milled into a powder. Following that, the powdered catfish and tilapia samples were carefully wrapped in plastic bags for safe transit to the laboratory of Obafemi Awolowo University's Centre for Energy Research and Development in Ile-Ife, Osun state. When the powdered samples arrived at the laboratory, they were measured and sealed in separate containers, presumably a Marinelli beaker. About 500 gm of powdered materials were weighted in a dry clean Marinelli beaker, then sealed with plastic tape and kept for three weeks to allow gaseous -i2Rn (half-life, 3.8 days) and its short-lived decay products (214Pb & 214Bi) to attain secular equilibrium. This standardised approach provides uniformity and makes further tests of radiation levels or particular radioactive components in certain fish species easier with long lived 238U for gamma analysis.

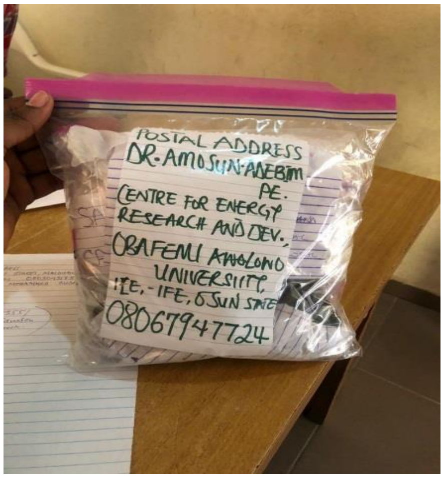

Figure 2: showing samples wrapped in plastic bags for safe transit to the laboratory

Measurement Procedure Using Sodium Iodide Detector

To guarantee consistency and simplicity of measurement, the catfish and tilapia samples were properly dried and powdered into a fine powder and to avoid any mistake throughout the measurement procedure, both Sample A (catfish) and Sample B (tilapia) were clearly labelled and properly recognised.

Calibration of Instruments**:** The sodium iodide detector was calibrated meticulously using standardised reference materials. This process ensured the detector's precision and accuracy in detecting and measuring gamma radiation generated by the samples. The detector obtained initial readings without any samples present to create a baseline for background radiation levels. This baseline test offered a good indication of the natural radiation levels in the environment. Each powdered samples (A and B) were put in the detector's measuring region separately. For a predetermined period of time, the detector methodically collected data in order to catch and analyse the gamma radiation released by both samples and it recorded the energy spectrum of the gamma radiation produced by Samples A (catfish) and B (tilapia) in great detail. The acquired data was analyzed by identifying and evaluating certain energy peaks in the spectrum that corresponded to radioactive isotopes contained in each fish sample.

The amounts and kinds of radioactive elements contained in catfish (Sample A) and tilapia (Sample B) were quantified using spectral analysis. This analysis revealed exact information on the radioactivity levels of each fish species.

Samples A and B's measurements and spectrum analyses were rigorously compared in order to identify any inconsistencies or differences in radioactivity levels or the kinds of radioactive elements discovered between catfish and tilapia samples.

Annual Effective Dose Rate

The estimation of annual effective dose due to ingestion of ^{238}U, ^{232}Th and ^{40}K in Catfish and Tilapia samples was done in order to evaluate the radiation hazards were calculated by using the activity concentrations of radionuclides according to the relation given by ICRP, 1996.

$D = \sum(Ci \times Ri \times DCFi)\ldots$ (1)

Where: D is the annual effective dose rate in µSv/year, C_i is the activity concentration of radionuclide in Bq/kg., *Ri* is the ingestion dose conversion factor for radionuclide in Sv/B, *DCFi* is the dose conversion factor for radionuclide in µSv/Sv.

The conversion variables for ingestion dosage (*Ri)* for the radionuclides Potassium (K), Thorium (Th), and Uranium (U) are generally provided by WHO,2022 as 6.3×10−9 Sv/Bq, 1.7×10−7 Sv/Bq and 1.0×10−7 Sv/Bq respectively. And the dose conversion factor (*DCFi*) for converting from Sv to µSv was given by

$DCF = 1.0 \times 106\ \mu Sv/Sv.$ (2)

RESULTS AND DISCUSSION

Table 1: Activity Concentration of ^{238}U, ^{234}Th and ^{40}K in Catfish and Tilapia at Baga, Borno State

Samples	^{238}U Bq/kg ±SD	^{234}Th Bq/kg ± SD	^{40}K Bq/Kg ± SD
A	9.04±0.07	2.28±0.07	301.66±5.79
B	7.29±0.07	2.237±0.07	461.98±7.16
Mean concentration	**8.1685±0.07**	**2.2528±0.07**	**381.82±6.475**

Table 2: Annual Effective dose Rate due to intake of ^{238}U, ^{232}Th and ^{40}K in Catfish and Tilapia from Baga, Borno State

Samples	Annual Effective dose Rate (µSv/year)		
	^{238}U	^{232}Th	^{40}K
A	0.9040	0.3864	1.9005
B	0.7290	0.3792	2.9135
Mean	**0.8165**	**0.3828**	**2.4070**
WHO limit	1000	1000	1000

Table 3: Comparison of mean concentrations of ^{238}U, ^{232}Th and ^{40}K in Catfish and Tilapia from Baga, Borno State with other Studies

Study area	Mean concentration (Bq/kg ±SD)			Reference
	^{238}U	^{232}Th	^{40}K	
Ado Ekiti	17.8±0.6	3.5±0.4	533.3±37.0	Fasae, 2018
Ondo	21.4±3.6	40.7±64.4	462±7.92	Ademola & Ehiedu, 2010
Kainji	37.2±0.1	94.8 ±0.03	618±2.00	Adamu etal., 2013
Niger Delta	85.9±2.2	11.0±0.06	37±4.00	Bolaji etal., 2015
Illorin	8.08±2.71	11.73±2.51	37.90±2.83	Orosun etal.,2023
Borno	**8.1685±0.07**	**2.2528±0.07**	**381.82±6.475**	This study

Discussion

In this study we have estimated the yearly effective dose rate from ingesting these fishes, a formula using the radionuclide concentrations, dose conversion factors, ingestion rate, and exposure factor were employed. The calculated annual effective dose rates were compared to global standards for radiation safety in food intake. The findings for tilapia (Sample B) and catfish (Sample A) show that the projected yearly effective dose rates from eating these fish are relatively low because they contain specific radionuclides (uranium, thorium, and potassium). Both the catfish and tilapia computed dose rates are far lower than the yearly effective dosage limit for the general public, which is usually set at 1 millisievert (mSv) per year, excluding medical exposure, according to international standards.

From table 3 above, we have seen that the mean concentration for potassium gotten from this study is lower than that reported by Fasae., 2018, Adamu etal., 2013 and Ademola & Ehiedu, 2010 which are 533.3±37.0, 618±2.00 and 462±7.92 Bq/kg respectively, but it is higher than that of Bolaji etal 2015 and Orasun etal, 2023 whose mean concentration were 37±4.00 and 37.90±2.83 Bq/kg. Furthermore, the mean concentration for both the Uranium and Thorium from this study were lower when compared with that reported from the other studies

Specifically, the estimated annual effective dose rate for catfish (Sample A) is approximately 3.190758μSv/year and that of tilapia (Sample B) is approximately 4.021574μSv/year with a mean of 0.8165, 0.3828 and 2.4070 for ^{238}U, ^{232}Th and ^{40}K respectively. Based on the facts and calculations presented, our findings imply that eating catfish and tilapia is unlikely to expose the general public to radiation levels higher than those set forth in international guidelines. It's crucial to remember that any unique local or regional norms and guidelines, as well as any modifications to worldwide recommendations that may have happened since my last knowledge update in January 2022, should be taken into account when interpreting these results. Furthermore, differences in the values may arise depending on local conditions and geographic location, as they are based on assumptions and data presented.

The estimated yearly effective dose rates for tilapia and catfish are both significantly lower than the global guideline for radiation exposure from food intake. The goal of the worldwide standard is to guarantee that the general public's total radiation exposure including exposure from a variety of sources remains within tolerable bounds.

Based on the calculated annual effective dose rates, the consumption of catfish and tilapia is consistent with international standards for radiation exposure through food consumption, indicating that the radiation exposure from these samples is within acceptable limits for the general public.

CONCLUSION

The study's findings imply that, in light of the information at hand, eating tilapia and catfish is compliant with international guidelines for the amount of radiation that can be consumed through food. Nonetheless, to guarantee continued food safety in consuming behaviours, constant observation and adherence to changing rules are necessary.

Therefore, regular monitoring programs to continually assess radionuclide concentrations in Catfish and Tilapia from Baga and other regions in Borno State which will enable prompt detection of any emerging trends or deviations from established safety standards and conduct of public awareness campaigns to inform local communities about the radiological risk associated with consuming fish is crucial. It is also recommended that Borno State government should provide guidance on safe practices, including appropriate cooking methods and moderation in consumption. Implementing these recommendations will contribute to the ongoing efforts to safeguard public health and ensure the sustainable consumption of fish in Baga and the broader region.

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