Committed Effective Dose from Natural Radionuclides and Heavy Metal Concentrations in Dry Fish Sold at Igbokoda Market, Ondo State, Nigeria

[1]Nkiruka. E. Adesiji, and [2]Valentine B. Akinpelumi
[1]Department of Physics, Federal University of Technology Akure, Nigeria
[2]Department of Physics, Federal University of Technology Akure, Nigeria
neadesiji@futa.edu.ng | valentineakinpelumi0110@gmail.com

Received: 16-APRIL-2026; Reviewed: 28-JUNE-2026; Accepted: 05-AUGUST-2026
https://dx.doi.org/10.46792/fuoyejet.v11i3.1543

ORIGINAL RESEARCH

Abstract— Activity concentration of natural radionuclides in ten selected fish species bought from Igbokoda Market were analyzed using a Sodium Iodide detector. A total of thirty fish samples were collected from Ondo, Ilaje and Akure while ten fish species were obtained from Igbokoda Market for heavy metal analysis. The annual committed effective dose from intakes of these radionuclides; ^{40}K, ^{238}U and ^{232}Th were estimated. The concentration of Fe, Cr, Pb, Cu, Mn, Ni, Zn, Cd and Co were determined using an atomic absorption spectrophotometer. The concentration of ^{40}K,^{238}U and ^{232}Th varied from 1.86 ± 0.04 $Bqkg^{-1}$ to 140.37 ± 2.11 $Bqkg^{-1}$ with an average value of 56.13 ± 1.34 $Bqkg^{-1}$, from 0.62 ± 0.02 $Bqkg^{-1}$ to 4.61 ± 0.05 $Bqkg^{-1}$ with an average value of 2.18 ± 0.05 $Bqkg^{-1}$, and from 0.42 ± 0.02 $Bqkg^{-1}$ to 1.93 ± 0.05 $Bqkg^{-1}$ with an average value of 0.91 ± 0.03 $Bqkg^{-1}$ respectively. The highest concentration of ^{40}K and ^{232}Th was found in the tissue of *Clupea harengus* while the highest concentration of ^{238}U was found in the tissue of *Clarias gariepinus* The annual committed effective dose due to the consumption of these fish by the public ranged from 4.52 μSvy^{-1} to 16.41 μSvy^{-1}. Excess life time cancer risks for people who consume fish on a daily basis were below the permissible limit of 1.0×10^{-3}. Anova test showed that the p-values are greater than 0.05 confirming that are no significant differences between any pair of sampling sites for all radionuclides. The concentration of most of the heavy metals were within the permissible limit in most of the fish samples. However, nickel exceeded the safe limit in some of the fish samples, and chromium exceeded the permissible limit in all the fish samples with concentration ranging from 1.06 ± 0.20 to 1.92 ± 0.11mg/kg. This suggests that the exposed population might be at risk associated with the consumption of the chromium as a heavy metal.

Keywords—Aquatic pollution, Metals contamination, Radioactivity, Radiological risk

1 INTRODUCTION

It has been established that fish provides a significant amount of protein which is necessary for the body metabolism (Duran et al., 2014). According to the Food and Agriculture Organization (FAO), 3.32 tonnes of fish is consumed by Nigerians every year (FAO, 2018). Dry fish remains a pertinent diet in Nigerian households (Onyeneke et al.,2020). The quality and quantity of salt to be applied to fish per kilogram as well as hygienic handling and the storage processes are key consideration in the production of dry fish that will result in high quality product. Radionuclides and heavy metals enter the fish ecosystem through natural and artificial source which include weathering, volcanic activity, industrial effluent, atmospheric disposition, operation of nuclear power plant and other human activities (ICRP, 2012). The presence of radionuclides in the environment can be attributed to naturally occurring and artificially induced source (UNSCEAR, 2024). Natural radionuclides reside in the Earth crust. Such primordial isotopes include uranium (^{238}U), thorium (^{232}Th) and potassium (^{40}K). Various openings that could increase the level of natural radionuclides in the aquatic environment are sediment, seafood, air, soil, foodstuff, surface and groundwater in trace amounts (Chau et al., 2011). Natural occurring radionuclides such as uranium, thorium and potassium can contaminate aquatic ecosystem and accumulate in fish leading to internal exposure and potential health risk. These radionuclides are ingested by human through the consumption of contaminated fish product. Other sources of artificially produced radionuclides are human activities which include; mining, fertilizer application, use of agrochemicals, research and medicine (Tayebi, 2018). Heavy metals are also pervasive and their presence in the environment can be increased as a result of anthropogenic activities. Heavy metals are metallic chemical elements that has relatively high density and are toxic even at low concentration (Srivastava and Goyal, 2010). High concentrations of heavy metals in aquatic environment are treated as contaminant (Duruibe et al., 2007). Some metals such as Calcium (Ca), Magnesium (Mg), Iron (Fe), Potassium (K) etc. are macro- nutrient mineral because they are required in large quantity for the body metabolism. While some other elements such as Manganese (Mn), Copper (Cu), Zinc (Zn), Chromium (Cr) are among the essential micronutrient metal that are needed in small quantities. Excessive and inadequate supply of these minerals can

Corresponding Author:
Section F- OTHER SCIENCES
Can be cited as:
Adesiji N. E., and Akinpelumi V. B. (2026). Committed Effective Dose from Natural Radionuclides and Heavy Metal Concentrations in Dry Fish Sold at Igbokoda Market, Ondo State, Nigeria. FUOYE Journal of Engineering and Technology (FUOYE**JET), 11(3), 575-582.**
https://dx.doi.org/10.46792/fuoyejet.v11i3.1543

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

negatively impact human health. Some metals such as mercury (Hg), Lead (Pb), Cadmium (Cd) and Arsenic (As) are non-essential metals toxic in trace quantities (Bibi et al., 2023). The concentration of heavy metals in aquatic environment depends on habitat preferences, feeding habit, trophic level, dosage, exposure duration and metabolic process (Tchounwou et al., 2012). High concentration of heavy metals in dry fish can be influenced by water body, preservation and handling (Alquezar et al., 2006). Once these heavy metals bioaccumulate beyond the permissible limit, they become toxic even at low concentration. (Jaishankar et al., 2014). People living in community located around Igbokoda river, Ondo state are prune to radionuclides and heavy metals pollution as a result of environmental effects emanating from oil and gas exploration. There is trepidation that continuous exploration could affect the quality and safety of dry fish sold in this region. Dried fish species sold in Igbokoda Market could be exported to different region both within and outside the state posing a potential heavy risk to Nigeria population. Several studies in Nigeria have indicated the presence of natural radionuclides in the environmental matrices such as soil, sediment and fish (Sowole et al., 2019., Sunday et al., 2025., Ilori, et al., 2024) and heavy metals concentration in fish from riverine and urban market (Awugo et al., 2024, Olurin, 2024). In Ondo state, previous studies has focused on the radioactivity concentration on fresh fish species (Arojojoye et al., 2017) and heavy concentration in cold room fish (Okunade et al., 2022). Most of these studies reported radioactivity and heavy concentration were within the safe limit. There are limited studies that combined both natural radionuclides and heavy metals concentration for different fish species sold at Igbokoda Market. This study addresses the research gap by estimating the annual committed effective dose due to natural radionuclides and heavy metals concentration in dried fish sold in Igbokoda Market in ilaje metropolis.

2 MATERIAL AND METHODS

2.1 STUDY AREA

Igbokoda is a thriving fishing community which plays significant role in local, regional, interstate and international trade. For radionuclides analysis, fish samples bought from Igbokoda Market were confirmed and purchased from three locations in the South-West Geopolitical region of the Federal Republic of Nigeria as shown in Appendix A. These areas are characterized by high population densities. The first sampling site was Igbokoda market in Ilaje town with a longitude 5.166667^0E and latitude of 7.366667^0N. The second sample site was Oja Oba in Akure town with a latitude of 7.2571^0N and longitude of 5.2059^0N. It is the largest city as well as the state capital of Ondo State. The third sampling site was Igele Maroko in Ondo city with a latitude of 7.0667^0N and longitude of 4.7833^0N. For heavy metals analysis, fish samples were selected directly from Igbokoda market in Ilaje. The sampled fish species represent different trophic level, dietary preference and how ecological factors influence the annual the committed effective dose and heavy metal concentration.

2.2 SAMPLE COLLECTION AND PREPARATION

Ten commercially important and consumed fish species were collected in each sampling site. For radionuclides concentration analyses, the fish samples were dried and pulverized. 200 grams of each sample was stored for approximately 28 days in a non-reactive plastic container sealed with adhesive tape to prevent escape of daughter radionuclides in order to attain a secular equilibrium with their parents (Orosun et al., 2018). Gamma ray spectrometric was carried out on a Canbera multi-channel analyzer equipped with 7.6cm x 7.6cm NaI(TI) BICRON detector The prepared samples were counted using a Sodium Iodide NaI(TI) detector. The detector was shielded with lead to reduce background radiation. The system was calibrated for energy using IAEA certified reference source with reference number IAEA-MA-B-3/RN with known concentration for fish samples while the efficiency used Atlantic standard source 48722-3560 traceable to a gamma radiation source. The linearity of the detector was also confirmed. The Sodium Iodide detector doped with Thallium was preferable to High purity Germanium detector (HPGe) due to its higher counting efficiency, lower cost, room temperature operation, making them useful of assessing environmental samples where peak separation is not significant. The minimum detectable activity was determined using a blank sample consisting of a 1-liter Marinelli beaker with the same geometry as the sample measurements. The time taken for a complete counting is 5 hours. The analysis took place at Centre of Energy Research Development Laboratory at Obafemi Awolowo University Ile-Ife, Osun State Nigeria.

For heavy metals analysis, ten fish species were used. One sample per species. The fish samples were pulverized to guarantee consistency and homogeneity. 5 grams of each fish sample was weighed inside the crucible and ashed in the muffle furnace at 510°C for 3 hours. The crucible was removed from the furnace and then allowed to cool in a desiccator for 3 hours. 10ml of 10 % of hydrogen chloride (HCL) was added and filtered through a Whatman filter paper (110 mm). The filtrate was made up to 100 ml of distilled water. The solution is then ready for analysis by using a standard procedure. The samples were analysed at the Department of Chemistry Research Laboratory Federal University of Technology Akure.

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

http://.doi.org/10.46792/fuoyejet.v11i3.1543 engineering.fuoye.edu.ng/journal

2.3 STATISTICAL ANALYSIS

Radionuclides data were analyzed using SPSS 16 while heavy metals concentration were analyzed using Microsoft Excel 2013. The mean and standard deviation of radionuclides in various dried fish species were calculated. Statistical analyses indicated that fish activity concentrations of radionuclides {^{40}K, ^{238}U, and ^{232}Th} did not differ significantly among Ilaje, Akure, and Ondo. Significance differences in radionuclides was examined using one-way ANOVA. Differences among the means yielded a non-significant effects at $p>0.05$ for ^{40}K, $p = 0.832$; ^{238}U, $p = 0.947$; and ^{232}Th, $p = 0.643$. Levene's tests confirmed homogeneity of variances for all isotopes (all $p > 0.05$), and Turkey's HSD post hoc comparisons found no significant pairwise differences among the samples.

2.4 EQUATION FOR RADIONUCLIDES ANALYSIS

Daily radionuclide intake (D_{in}) of dry fish in Bq/day was calculated using equation (1)

$$D_{in} = \frac{A_c \times A_{ig}}{Y_d} \quad (1)$$

where A_c is the activity concentration of radionuclides in Bq/kg, A_{ig} is the per capital per year consumption of fish which is estimated to be 13.3 kg (FAO, 2018) and Y_d is the days in a year. (ICRP, 2007). Committed effective dose was calculated using Equation (2) (Alam & Mohamed 2011). $E_{ing} = D_{in} \times D_{cf} \times 365$ (2)

where E_{ing} is the annual committed effective dose in (μSvy^{-1}), D_{in} is the daily intake of fish (Bq/day), and D_{cf} is the ingestion dose conversion factor of the natural radionuclide ^{40}K= 0.0062 μSv/Bq, ^{232}Th = 0.23 μSv/Bq, ^{238}U = 0.045 μSv/Bq (ICRP, 2012). Equation (3) gives the total committed effective dose.

$$D_{eff}^{total} = \sum_{i=K-40,U-238,Th--232} E_{ing}(i) \quad (3)$$

where D_{eff}^{total} is the total committed effective dose

The excess lifetime cancer risk is expressed as shown in equation (3) (ICRP, 2007):

$$ELCR = D_{in} \times R_{cf} \times A_{is} \times 365 \quad (4)$$

Where D_{in} is the daily intakes of radionuclides (Bq/day), A_{is} is the average span of life (70years), R_{cf} is the mortality cancer coefficient (Bq^{-1}) for the ingestion of food. The ingestion mortality cancer coefficient of 5.89×10^{-10} Bq^{-1} for ^{40}K, 9.56×10^{-9} Bq^{-1} for ^{238}U and 2.45×10^{-9} Bq^{-1} for ^{232}Th were used to estimate the ELCR (USEPA, 1999).

3 RESULTS AND DISCUSSION

3.1 MEAN ACTIVITY CONCENTRATION OF RADIONUCLIDES IN THE FISH SPECIES

The sample ID, scientific names, local names and the English name are presented in Table 2. The analysis of radionuclides in species revealed this varying level of concentration. As shown in Table 1, the concentration of ^{40}K vary from 1.86 ± 0.04 $Bqkg^{-1}$ to 140.37 ± 2.11 $Bqkg^{-1}$ with an average value of 56.13 ± 1.34 $Bqkg^{-1}$; the concentration of ^{238}U ranged from 0.62 ± 0.02 $Bqkg^{-1}$ to 4.61 ± 0.05 $Bqkg^{-1}$ with an average value of 2.18 ± 0.05 $Bqkg^{-1}$, while the concentration of ^{232}Th ranged from 0.42 ± 0.02 $Bqkg^{-1}$ to 1.93 ± 0.05 $Bqkg^{-1}$ with an average value of 0.91 ± 0.03 $Bqkg^{-1}$. As shown in Fig 1, the highest concentration of ^{40}K and ^{232}Th was found in the tissue of species B while that of ^{238}U was found in species F. The overall mean activity concentration of ^{40}K, ^{238}U and ^{232}Th in Table 1 were compared to those in previous studies. The activity concentration ^{40}K falls below the values in Ado-Ekiti, Nigeria (Fasae & Isinkaye 2018), USA (Billa et al., 2016), Iraq (Aswood et al., 2018), but surpassed those reported in Ilorin, Nigeria (Orosun et al., 2018), Malaysia (Khandaker et al., 2015) and India (Patra et al., 2014). The result of ^{232}Th in Malaysia (Khandaker et al., 2015) slightly matched with the result from this study. The mean activity concentration of ^{40}K and ^{232}Th were below the values reported by United Nation for Scientific Committee for Atomic Radiation (UNSCEAR, 2000). Table 3 showed the annual committed effective doses (μSvy^{-1}) for ^{40}K, ^{238}U and ^{232}Th. The average total committed effective dose due to the ingestion of natural radionuclides through the dried fish species has been estimated to be 8.66 μSvy^{-1}. This estimated value fall below the world average radiation dose of 290 μSvy^{-1} per person through the ingestion of natural radionuclides for food consumption reported by UNSCEAR 2000. The radiation dose through the consumption of these dried fish species has no significant health effect to the population from a radiation-based context. As shown in Figure 2a.

Table 1. Activity Concentration of Radionuclides in 30 Fish Samples and their sampling sites

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

http://.doi.org/10.46792/fuoyejet.v11i3.1543 engineering.fuoye.edu.ng/journal

SAMPLE ID	^{40}K(Bqkg^{-1})	^{238}U(Bqkg^{-1})	^{232}Th (Bqkg^{-1})	LOCATION
SP-A1	14.33±0.12	1.55±0.05	0.44±0.02	Ilaje
SP-A2	13.17±0.28	2.28±0.06	0.54±0.02	Akure
SP-A3	21.23±1.90	2.13±0.06	0.97±0.03	Ondo
MEAN	**16.24±0.77**	**1.99±0.06**	**0.65±0.03**	
SP-B1	131.16±3.75	3.13±0.07	1.93±0.05	Ilaje
SP-B2	140.37±2.11	1.53±0.05	0.91±0.03	Akure
SP-B3	109.75±1.77	2.61±0.06	1.49±0.04	Ondo
MEAN	**127.09±2.54**	**2.42±0.06**	**1.44±0.04**	
SP-C1	88.05±3.44	1.80±0.05	1.43±0.04	Ilaje
SP-C2	94.61±1.77	2.49±0.06	1.11±0.04	Akure
SP-C3	12.27±0.27	1.38±0.04	0.76±0.03	Ondo
MEAN	**64.977±1.76**	**1.89±0.05**	**1.10±0.04**	
SP-D1	5.91±0.31	2.81±0.07	0.99±0.03	Ilaje
SP-D2	17.17±0.36	1.48±0.04	1.03±0.03	Akure
SP-D3	49.81±0.94	1.65±0.05	0.95±0.03	Ondo
MEAN	**24.297±0.54**	**1.98±0.05**	**0.99±0.03**	
SP-E1	53.97±1.01	2.16±0.06	0.60±0.02	Ilaje
SP-E2	89.64±4.15	0.58±0.02	1.06±0.03	Akure
SP-E3	26.79±0.55	2.69±0.06	0.78±0.02	Ondo
MEAN	**56.80±1.90**	**1.81±0.05**	**0.81±0.02**	
SP-F1	8.16±0.18	2.01±0.05	0.92±0.03	Ilaje
SP-F2	1.86±0.04	4.61±0.05	0.45±0.02	Akure
SP-F3	30.64±2.98	1.93±0.09	0.8±0.03	Ondo
MEAN	**13.55±1.07**	**2.85±0.06**	**0.72±0.03**	
SP-G1	34.22±0.68	2.75±0.07	0.85±0.03	Ilaje
SP-G2	11.54±0.25	1.98±0.05	0.56±0.02	Akure
SP-G3	30.84±0.62	2.38±0.06	0.92±0.03	Ondo
MEAN	**25.53±0.52**	**2.37±0.06**	**0.78±0.03**	
SP-H1	81.22±1.40	1.88±0.05	0.42±0.02	Ilaje
SP-H2	87.01±1.48	2.05±0.05	0.49±0.02	Akure
SP-H3	23.13±0.48	2.33±0.06	0.75±0.03	Ondo
MEAN	**63.79±1.12**	**2.09±0.05**	**0.55±0.02**	
SP-I1	99.96±1.65	2.39±0.06	1.14±0.04	Ilaje
SP-I2	127.03±1.97	2.74±0.06	0.93±0.04	Akure
SP-I3	63.77±1.16	1.80±0.05	0.75±0.03	Ondo
MEAN	**96.92±1.59**	**2.31±0.06**	**0.94±0.04**	
J1	60.54±3.95	0.62±0.02	0.69±0.03	Ilaje
J2	22.68±0.47	2.05±0.05	1.11±0.04	Akure
J3	120.16±1.08	3.39±0.07	1.35±0.04	Ondo
MEAN	**67.79±1.83**	**2.02±0.05**	**1.05±0.04**	
OVERALL MEAN	**56.13± 1.34**	**2.18±0.05**	**0.91±0.03**	
OVERALL MEAN	**56.13± 1.34**	**2.18±0.05**	**0.91±0.03**	

Table 2. Identification of Dry Fish Species

Sample ID	Local name	Scientific name	No of samples	English names
SP-A	Epiya	*Oreochromis niloticus*	3	Tilapia
SP-B	Shawa	*Clupea harengus*	3	Herring
SP-C	Abo	*Cynoglossus browni*	3	Tongue Sole fish
SP-D	Doje	*Trichurus leptunus*	3	Large head hair tail
SP-E	Oluroro	*Pentanemus quinquarius*	3	Royal threadfin

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

http://.doi.org/10.46792/fuoyejet.v11i3.1543 engineering.fuoye.edu.ng/journal

SP-F	Eja Olopa	*Clarias gariepinus*	3	Africa Mud catfish
SP-G	Efolo	*Ethmalosa fimbriata*	3	Bonga
SP-H	Pokun	*Pseudotothilus senegalenses*	3	Croaker
SP-I	Ayo	*Scromber scrombrus*	3	Mackerel
SP-J	Abori	*Heterobranches bidosalis*	3	African sharptooth catfish

The highest total committed effective dose value was found in *Clupea harengus* while the lowest was found in *Oreochromis niloticus*. The percentage dose contribution in relation to the fish species followed this order :*Clupea harengus* > *Scromber scrombrus* > *Heterobranches bidosalis*> *Cynoglossus browni* > *Pentanemus quinquarius* > *Pseudotothilus senegalenses*> *Trichurus leptunus*> *Ethmalosa fimbriata*> *Clarias gariepinus*> *Oreochromis niloticus* while the dose contribution in relation to radionuclides for ^{40}K, ^{238}U and ^{232}Th are 53%, 15% and 23% respectively. The overall mean total committed effective doses of ^{40}K, ^{238}U and ^{232}Th in Table 1 were compared to those in previous studies. The total average committed effective doses for consumers in this study surpassed the result obtained by other researchers for different location e.g 0.76 μSvy^{-1} for USA (Billa et al., 2016), 0.396 μSvy^{-1} for Ado-Ekiti (Fasae and Isinkaye 2018) and 0.80 μSvy^{-1} for Canada (Chen et al., 2014) but fall below 26.72 μSvy^{-1} for South Iraq (Aswood et al., 2018) and 104 μSvy^{-1} for Ibadan (Ajayi et al., 2021). The values of the average excess lifetime cancer risk are presented in Table 3. These values ranged from 8.91×10^{-6} to 3.72 × 10^{-5} for ^{40}K, 2.51 × 10^{-5} to 1.61 × 10^{-5} for ^{238}U and 3.22 × 10^{-6} to 1.22 × 10^{-6} for ^{232}Th and were found to be low compared with the acceptable Excess lifetime cancer risk (ELCR) limit of 10^{-3} for radiological risk in general (Patra et al., 2013).

3.2 HEAVY METALS CONCENTRATION IN DRY FISH SAMPLES SOLD AT IGBOKODA MARKET IN ILAJE METROPOLIS

The result of the heavy metals concentration in the fish samples are presented in Table 4. The concentration of Fe ranged from 1.29-9.52 mg/kg, while the concentration of chromium (Cr) ranged from 1.06 - 1.92 mg/kg. Cu ranged from 0.09-1.35 mg/kg, while manganese (Mn) ranged from 0.38-1.78 mg/kg. The concentration level of nickel (Ni) ranged from 0.30-1.02 mg/kg, zinc (Zn) ranged from 0.94 mg/kg-4.95 mg/kg, cadmium (Cd) ranged from 0.01-0.81 mg/kg. Lead (Pb) was recorded only in species A and cobalt was not detected in the samples analyzed. As shown in Table 4, the mean concentration of heavy metals in the dry fish samples followed this order Fe>Zn>Cr>Mn>Ni>Cu>Cd>Pb.

Table 3. Committed Effective Dose and Excess Life Time Cancer Risk Due to the Consumption of Fish Species

	Daily intakes of Radionulides (Bq/d)			Annual Committed Effective (μSvy^{-1})				Excess Lifetime cancer risk		
SAMPLE ID	^{40}K	^{238}U	^{232}Th	^{40}K	^{238}U	^{232}Th	Total	^{40}K	^{238}U	^{232}Th
SP-A	0.591	0.0725	0.0237	1.34	1.19	1.99	4.52	8.91×10^{-6}	1.77×10^{-5}	1.45×10^{-6}
SP-B	4.628	0.0925	0.0524	10.48	1.52	4.41	16.41	6.97×10^{-5}	2.26×10^{-5}	3.2×10^{-6}
SP-C	2.366	0.0688	0.0401	5.36	1.13	3.37	9.86	3.56×10^{-5}	1.68×10^{-5}	2.45×10^{-6}
SP-D	0.885	0.0721	0.036	2.00	1.18	3.03	6.21	1.33×10^{-5}	1.76×10^{-5}	2.2×10^{-6}
SP-E	2.068	0.0659	0.0295	4.68	1.08	2.48	8.24	3.11×10^{-5}	1.61×10^{-5}	1.8×10^{-6}
SP-F	0.493	0.1038	0.0262	1.12	1.7	2.2	5.02	7.43×10^{-6}	2.54×10^{-5}	1.6×10^{-6}
SP-G	0.93	0.0863	0.0284	2.11	1.42	2.37	5.9	1.4×10^{-5}	2.11×10^{-5}	1.74×10^{-6}
SP-H	2.323	0.0761	0.02	5.26	1.25	1.68	8.19	3.5×10^{-5}	1.86×10^{-5}	1.22×10^{-6}
SP-I	3.529	0.0841	0.0342	7.99	1.38	2.88	12.25	5.31×10^{-5}	2.06×10^{-5}	2.09×10^{-6}
SP-J	2.468	0.0736	0.0382	5.59	1.23	3.21	10.03	3.72×10^{-5}	1.8×10^{-5}	2.34×10^{-6}
MEAN	2.028	0.08	0.0382	4.59	1.31	2.76	8.66	3.05×10^{-5}	1.94×10^{-5}	2.01×10^{-6}
WORLD AVERAGE (UUNSCEAR, 2000)				170	120	120	290		10^{-3}	

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

http://.doi.org/10.46792/fuoyejet.v11i3.1543 engineering.fuoye.edu.ng/journal

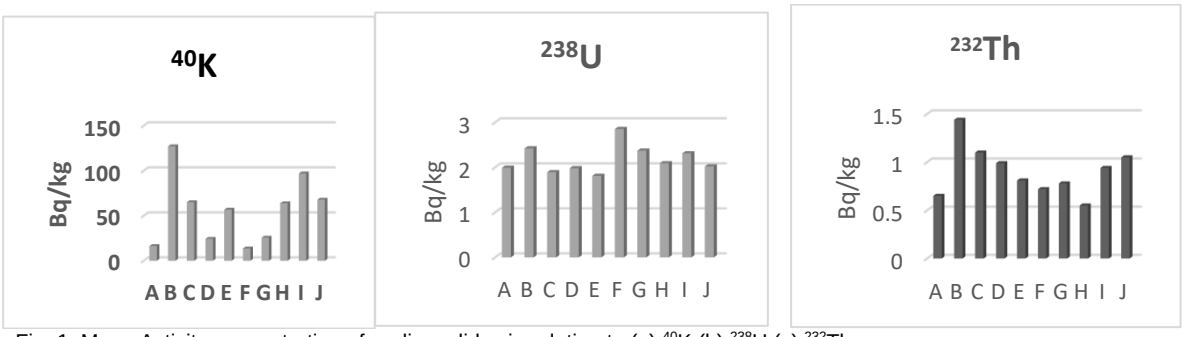
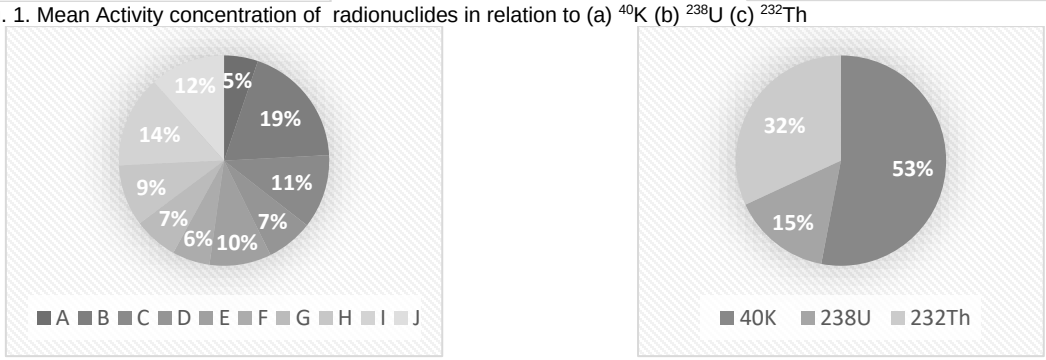


Fig. 1. Mean Activity concentration of radionuclides in relation to (a) ^{40}K (b) ^{238}U (c) ^{232}Th



(a) (b)

Fig. 2. Committed effective dose contribution (a) in relation to fish species (b) in relation radionuclides

The result also revealed that the elevated level of chromium in the fish species corroborates with the result reported in Ondo state (Okunade et al., 2022). Also, Nickel exceeded the upper threshold limit range set by FAO/WHO in six out of ten species. The mean concentration of chromium exceeded the permissible limit established by Food and Agriculture Organisation and World Health Organisation. This high level of chromium in all the fish species is of public health concern because frequent dietary exposure can result in DNA damage, gastrointestinal disorder and elevated level of digestive tract due to bioacummulation through food chain. (Shin et al., 2023). Contamination occurs via bioaccumulation from polluted water affected by industrial discharge (Anisha et al., 2023). Further contamination can occur during open-air drying and poor handling (Alquezar et al., 2006).

Table 4. Concentration of Heavy Metals in the Fish Samples in milligram per kilogram (mg/kg)

	Fe	Cr	Pb	Cu	Mn	Ni	Zn	Cd
Species A	4.926.±0.04	1.055±0.20	0.104±0.09	0.089±0.00	1.326±0.07	0.466±0.04	2.21±0.01	0.812±0.10
Species B	5.595±0.15	1.144±0.14	ND	0.283±0.02	1.642±0.00	0.299±0.26	2.275±0.00	0.071±0.13
Species C	1.753±0.02	1.238±0.21	ND	0.248±0.03	1.298±0.02	0.534±0.09	3.221±0.03	0.092±0.01
Species D	1.287±0.06	1.108±0.04	ND	0.238±0.02	0.526±0.03	0.603±0.20	3.695±0.06	0.041±0.02
Species E	2.65±0.04	1.608±0.04	ND	0.301±0.07	0.647±0.00	0.854±0.30	2.404±0.03	0.031±0.41
Species F	2.718±0.11	1.482±0.02	ND	0.332±0.00	0.711±0.09	0.708±0.02	4.59±0.091	0.018±0.02
Species G	9.515±0.14	1.77±0.17	ND	0.339±0.01	1.77±0.02	0.882±0.30	2.412±0.03	0.005±0.01
Species H	1.715±0.03	1.095±0.15	ND	1.352±0.05	0.376±0.00	0.833±0.18	0.934±0.01	0.022±0.07
Species I	2.223±0.03	1.917±0.11	ND	0.848±0.01	0.621±0.00	0.931±0.16	1.919±0.11	0.015±0.01
Species J	2.401±0.00	1.913±0.23	ND	0.449±0.05	0.757±0.07	1.017±0.22	1.46±0.00	0.014±0.00
MEAN	3.478±0.05	1.433±0.13	0.104±0.09	0.448±0.05	0.967±0.05	0.713±0.15	2.512±0.05	0.112±0.05
GEO-MEAN	2.88	1.4	0.104	0.104	0.35	0.67	2.3	0.04
Standard limit	30 FAO 2012	0.5 FAO/WHO 2012	0.5 FAO/WHO 2012	30 FAO/WHO 2012	10 FAO/WHO 2011	0.5-0.6 FAO/WHO 2011	30 FAO/WHO 2012	0.5 FAO/WHO 2011

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

http://.doi.org/10.46792/fuoyejet.v11i3.1543 engineering.fuoye.edu.ng/journal

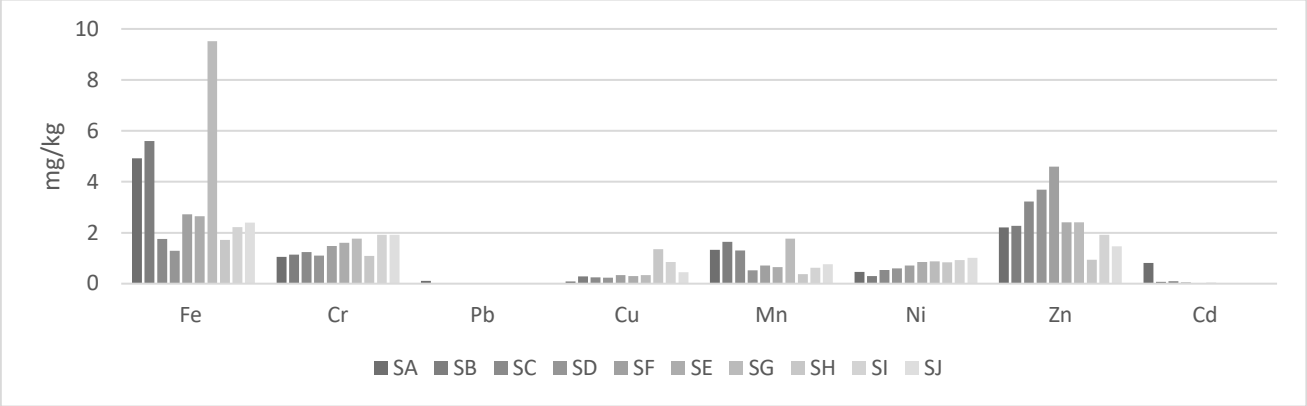
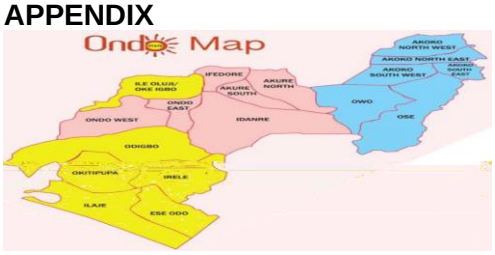


Fig 3.3. Heavy metals concentration in fish samples

4 CONCLUSION

This work has successfully estimated the level of radionuclides (^{40}K, ^{238}U and ^{232}Th) and heavy metals in commonly consumed dry fish species in Ondo State, Nigeria. Gamma ray spectrometry and atomic absorption spectrometry were used. The study revealed that the calculated annual committed effective dose was significantly below the international safety limits. The total average committed effective dose 8.66 μSv/y was far below the global average limit of 290 μSvy^{-1} and the excess life time cancer risk values were within the recommended safe limit. However, the study also revealed that most heavy metals were within the permissible limits, while chromium and nickel exceeded the safety thresholds. Chromium contamination was severe and represents the most significant findings of this study in all the fish species. The concentration of chromium observed indicate a potential health hazards through dietary exposure. This confirmed that the dry fish are radiologically safe for human consumption but could pose a health risk from the accumulation of chromium. However, Immediate monitoring and source investigation of chromium in Igbokoda dry fish is recommended due to it severity, alongside broader public awareness and expanded future studies. Further research work requires broader sampling, mechanistic studies of bioaccumulation and socioeconomic assessment of consumer risk to guide evidence-based management.

APPENDIX



Appendix A: map of Ondo State showing the sampling locations

ACKNOWLEDGEMENT

The author gratefully acknowledged the assistance of Fisheries Laboratory, Federal University of Technology Akure in identifying the fish species

REFERENCES

Ajayi, O.S., Ibikunle, S.B., Ajilu, F. S, and Isinkaye, M. O. (2021). Dose from natural radionuclides in farm raised and wild catfish in Ibadan Nigeria". *Radiation Protection and Dosimetry*, Vol. 193 No 1 pp1-7. http://doi.org/10.1093/rpd/ncaboll.

Alam, L., & Mohamed, R. (2011). Natural radionuclide of Po-210 in the edible seafood affected by coal-fired power plant industry in Kapar coastal area of Malaysia. *Environ. H.* (10) 43-52 https://doi.org/10.1186/1476-069X10-43.

Alquezar, R., Markich, S. J., & Booth, D.J. (2006). Metal accumulation in the smooth toadfish, (Tetractenos glaber), in estuaries around Sydney, Australia. Environmental Pollution, 142 (1):123–13.

Anisha, P., Santhosh, A., Anagha, B., Emmanuel, P. C., Prabakaran, K.R. and Rajaram, R. (2023). Occurrence of heavy metals in dried fishes from major fishing villages in Kerala coast, Southwest India. *Journal of Hygiene and Environmental Health* (6) 100051, 2773-0492. https://doi.org/10.1016/j.heha.2023.100051.

Arojojoye, O., Oyagbemi A., & Afolabi, J. (2017). Toxiological assessment of heavy metals bioaccumulation and oxidative stress biomarkers in *clarias gariepinus* from Igbokoda river in South western Nigeria. *Journal of Bulletin of Environmental Contamination and Toxicology*, Vol.. 100 No 6, pg 765-771, DOI:10.1007/s00128-0182341-5.

Aswood, M.S., Al-Hamzawi, A.A., & Khadayeir, A.A. (2018). Natural radionuclides in six selected fish consumed in south Iraq and their committed effective doses. *SN Appl*. Sci. 1, 21 https://doi.org/10.1007/s42452-018-0019-6.

Awugo, V.E., & Igejongbon, T. F (2024). Determination of Heavy Metals Concentration in African pike (Hepsetus odoe) from Alape River Southwestern Nigeria. *Marine Development Journal* 2:8 DOI:org/10.1007/s44312-024-00030-5

Billa, J., Han, F., Didla, S., Yu, H., Dimpah, J., & Brempng, O. (2016). Radioactivity studies on farm raised and wild catfish produced in Mississippi, USA. *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 307 pg 203-210.

Bibi, M., Samiullah., Behlil, F., Afzal, S., & Sahifa. (2023). Essential and non essential heavy metals sources and impact on human

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.
This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)

health and plant. *Journal of Pure Appl. Biol.*, 12(2): 835-847 doi.org/10.19045/bspab.2023.120083

Chau, N.D., Dulinski, M., Jodlowski, P., Nowak, J., Rozanski, K., Sleziak, M., & Wachniew, P. (2011). Natural radioactivity in groundwater – a review. *Isotopes in Environmental and Health Studies* Vol. 147 No 4. 415–437.

Duruibe, J.O., Ogwuegbu, M. C., & Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Science,* Vol.. 2 No 5. Pp. 112-118.

FAO. (2018) Fisheries and Aquaculture Department of the Food and Agriculture Organization of the United Nations. *Fishery and Aquaculture Country Profiles*. DOI:https://doi.org/10.4060/ca9229en 2018.

FAO/WHO (2011). Evaluation of certain food additives and the contaminants mercury, lead and cadmium. (JECFA). *International programme on chemical safety Seventy-third report of the Joint FAO/WHO Expert Committee on Food Additives WHO technical report series*, no. 960.

FAO.(2012). Food and Agriculture Organisation, Animal Feed Resources Information System.

Fasae, K. P. and Isinkaye F.O. (2018). Radiological Risks Assessment 0f ^{238}U, ^{232}TH and ^{40}K in fish feeds and catfish samples from selected farm in Ado-Ekiti. *Journal of radiation Research and Applied Sciences*, Vol. 11 No 4. DOI:10.1016/j.jrras.2018.05.002.

ICRP. (2007). The 2007 Recommendations of the International Commission on Radiological Protection. *ICRP Publication* 103. Ann. ICRP 37 (2-4). DOI: https://doi.org/10.1093/rpd/ncn187.

ICRP.(2012) Annals of the ICRP publication 119; Compendium, of dose coefficient based on ICRP publication 60, 41 Supplement 1 *International Commission on Radiological Protection.*

Jaishankar. M., Tseten, T., Anbalagan, N., Mathew. B.B., & Beeregowda, K.N. (2014). Toxicity, mechanism and health effects of some heavy metals. Interdisciplinary Toxicology,7 (2):60 72

Khandaker., U, Olatunji, A., Shuib, K., Hakimi, A., Nasir, M., Asaduzzaman, K, and Bradley, A. (2015). Natural radioactivity and effective dose due to the bottom sea and estuaries marine animals in the coastal waters around Peninsular Malaysia. *Radiation Protection Dosimetry* Vol. 167 pg 1-3.

Okunade, M.B., Ogundele, O.D., Anaun, T.E. & Afolabi, A.B. (2022). Heavy metals Assessment of Fish Samples Obtained from selected Cold Rooms in Ondo State of Nigeria. *Achievers Journal of Scientific Research* Vol 4 Issue 1 pg1-10

Onyeneke, R.U., Amadi, M.U., Iheanacho, S.C., Uwazie, U.I. and Enyoghasim, M.O. (2020). Consumption of different form of fish in Abakaliki metropolis of Ebonyi State, Nigeria. African. *Journal of Food Agricultural Nutrition development,* 20 (2): 15523-15537.

Orosun, M., Adisa, A. A., Akinyose, F.C., Amaechi, E.C., Ige, S.O., Ibrahim, B.M., Martins. G.A., Adebanjo, G.D., Oduh, O.V., & Ademola, O. J. (2018). Measurement of natural radionuclides concentration and radiological impact assessment of fish samples from Dadin Kowa Dam, Gombe State Nigeria. *African Journal of Medical 90-9nm9Physics, Vol.* 1 No 1, pp 25-35.

Patra, A.C., Mohapatra, S., Sahoo, S.K., Lenka, P., Dubey, J.S., Tripath, R. M., & Puranik V. D. (2013). Age-dependent dose and health risk due to intake of uranium in drinking water Jaduguda, india. *Radiat. Prot. Dosim.* 155 (2) 210-216.

Patra, A.C., S. Mohapatra, S.K., Sahoo, P., Lenka, J.S., Dubey, V.K. (2014). Assessment of ingestion dose due to radioactivity in selected food matrices and water near Vizag, India. *Journal of Radioanalytical and Nuclear Chemistry,* Vol. 300 (3), pp. 903-910.

Shin, D.Y., Lee, S.M., Jang, Y., Lee, J., Lee, C. M., Cho, E., & Seo, Y.R. (2023). Adverse Effect of Chromium by Exposure Route :A review Based on Toxicolenomic.. *International Journal of Molecular Sciences* 24(4):3410. doi:103390/ijms24043410

Sowole, O., & Egungobii, K, A. (2019). Radiological Assessment of ^{40}K, ^{238}U and ^{232}Th in the Surface Sol Samples of Igbokoda, Southwest of Nigeria. *Tanzania Journal of Science* 45(3): 307-314

Sunday, J.S., Sowunmi, A.A., Akomolafe, I. D., & Jibiri, N.N. (2025). Evaluation of Radiological Risks from Radionclides in Fish and Sediment of Eleyele Reservoir, Ibadan, Nigeria. *Journal of environmental Health Insight* Vol 19 1-18. DOI:10.1177/11786302251347017

Tayebi, L., Sobhanardakani, S., & Hosseini, S. V. (2018). Health risk assessment of Arsenic and heavy metals (Cd, Cu, Co, Pb, and Sn) through consumption of Caviar of Acipenser persicus from Southern Caspian Sea. *Environmental Science and Pollution Research* 25(3), 2664–2671.

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy Metals Toxicity and the Environment. NIH Public Access Author Manuscript, 101, 133- 164.

UNSCEAR (2000). United Nations Scientific Committee on the Effects of Atomic Radiation Exposures from Natural Radiation Sources. Report to the General Assembly, with annexes, Annex-B, United Nations, New York

UNSCEAR(2024). Sources, effect and risks of ionizing radiation . UNSCEAR 2024 Report Volume 1 Scientific annex A

USEPA.(1999). US Energy Protection Agency. Cancer risk Coefficient For Environmental Exposure to Radionuclides. *Federal Guidance Report NO*. 13 EPA 402-R-99-001.

© 2026 The Author(s). Published by Faculty of Engineering, Federal University Oye-Ekiti.

This is an open access article under the CC BY NC license. (https://creativecommons.org/licenses/by-nc/4.0/)