PRINT ISSN 1119-8362
Electronic ISSN 2659-1502

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (2) 449-457 February 2024

Assessment of Naturally Occurring Radionuclides and Heavy Metals Level and Health Risks in Commonly Consumed African catfish, White Catfish and Nile Tilapia Fish Species from Epe Waterside Region of Lagos, Nigeria

OLURIN, TO

Department of Food Science & Technology, Bells University of Technology, Ota. Nigeria.

**Corresponding Author Email: toolurin@bellsuniversity.edu.ng; tayeolurin@gmail.com; Tel: +234803 068 9565*
ORCID ID: https://orcid.org/0000-0002-2691-7146

ABSTRACT: Elevated levels of radionuclides and toxic metals in water can potentially influence the growth of fish during their mature stages, posing a risk of human exposure through the consumption of contaminated fish. This investigation assessed the levels of health risk of naturally occurring radionuclides and heavy metals in commonly consumed African catfish, White catfish and Nile tilapia fish species in the Epe Waterside region of Lagos, Nigeria, using a sodium iodide detector and an atomic absorption spectrometer. The activity concentrations (Bq/kg) of ^{40}K (29.1±21.0-823.5±18.2) were higher than ^{226}Ra (27.1±87.8-202.7±50.3) and ^{232}Th (52.9±7.4-600.2±7.0), with mean values exceeding the permissible limits set by WHO. The mean committed effective dose rate is above the 50 mSv recommended by ICRP. The mean annual intake and cancer risks for people who consume fish on a weekly basis (nutrition statistics for seven, five, three, and one day per week) were relatively high, surpassing the permissible limit of 1.0×10-6 as recommended by WHO. The concentrations of heavy metals (Zn: 0.026-1.344, Cu: 0.008-0.055, and Cd: 0.048-0.250 mg/kg) exhibited mean values that fell within the acceptable limits defined by FAO/WHO, with the exception of Pb, which recorded a higher concentration ranging from 2.51 to 3.39 mg/kg. The fish's natural habitats (lagoon) have been contaminated by toxins, likely originating from industries, waste disposal activities, agrochemicals, rusty pipes, and other fittings. Encouraging the cultivation of fishes in domesticated ponds around the study area can reduce the risk of consuming contaminated fish and other seafood.

DOI: https://dx.doi.org/10.4314/jasem.v28i2.17

Cite this paper as: OLURIN, T. O. (2024). Assessment of Naturally Occurring Radionuclides and Heavy Metals Level and Health Risks in Commonly Consumed African catfish, White catfish and Nile tilapia Fish Species from Epe Waterside region of Lagos, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (2) 449-457

Dates: Received: 28 December 2023; Revised: 02 February 2024; Accepted: 20 February 2024 Published: 28 February 2024

Keywords: Radionuclides; heavy metals; concentration; permissible limits; effective dose.

The Earth's crust consists of naturally occurring radioactive elements in abundance, and human beings are constantly in contact with these radionuclides through soil, crops, food, water, and air (Ademola and Ehiedu, 2010; Merrill and Tom, 1990). Natural radionuclides are absorbed from the soil and water alongside other nutrients that plants and animals need for their normal metabolism because they share similar chemical characteristics. Elements such as thorium, cesium, and uranium are insoluble in water and can easily be transmitted within the marine habitat, contaminating aquatic life (Khandaker *et al*., 2013; UNSCEAR, 2000). Naturally occurring radionuclide sources in the environment include uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K), along with their decay by-products (Kessaratikoon and Awaekechi, 2008). Although low levels of radioactivity are considered safe, high radionuclide exposures in food, soil, and water can adversely affect the health of humans and other living things,

**Corresponding Author Email: toolurin@bellsuniversity.edu.ng; tayeolurin@gmail.com*
Tel: +234803 068 9565
ORCID ID: https://orcid.org/0000-0002-2691-7146

potentially causing cancer (Sathyapriva *et al*., 2017; Hernandez *et al*., 2004). According to USEPA (2008), the ingestion of natural radionuclides can lead to cancers of the lungs, head, bones, blood, and lymphatic tissues in exposed individuals. Radionuclide ingestion may be complemented by heavy metal-contaminated water and food, leading to chronic diseases or lethality. Heavy metals are toxic at low concentrations and have relatively high densities (Ojo *et al*., 2021; Koraltan *et al*., 2023). They are naturally present in the Earth's crust and can enter the human body through air, water, and food. Lead, cadmium, and mercury are the most common environmental pollutants that have significant adverse health impacts (Kabata-Pendias and Szteke, 2019; Duran *et al*., 2014). Heavy metals leach into water bodies through leachates from dumpsites, agrochemicals, industrial and agricultural activities, automobile emissions, and deforestation (Yushin*et al*., 2023; Ojo *et al*., 2021; Alam *et al*., 2019). Heavy metal concentrations in fishes depend on fish species, habitat, feeding habits, growth rate, body metabolism, and ecological factors (Nofal*et al*., 2019; Afshan *et al*., 2014; Benaduce *et al*., 2008). The body metabolism of fish depends on crucial metals such as manganese, zinc, copper, and iron. Non-essential metals like cadmium, nickel, lead, and mercury commonly accumulate in fish organs through ingestion, depending on the period of exposure and level of water contamination, as well as other environmental factors such as water temperature, salinity, alkalinity, pH, oxygen concentration, hardness, and organic matter (Ebrahimi and Taherianfard, 2011; Linbo *et al*., 2009).

The presence of toxins in soil and water makes its way into the food chain, increasing the toxicity effects on human diets (Núñez *et al*., 2018; Ademola *et al*., 2015; Looi *et al*., 2014).In Nigeria, a high quantity of fish is consumed by a large percentage of the human population, and through this process, radionuclides and heavy metals reach humans from contaminated fish. According to the Food and Agriculture Organization (FAO, 2018), Nigerians consume approximately 3.32 million metric tons of fish annually. Therefore, it is necessary to evaluate the concentrations of toxic metals and radionuclides in fish to manage the toxin levels in human diets. This evaluation also aids in formulating regulations for the processing and packaging of seafood. Fish is a valuable source of proteins, fatty oils, calcium, vitamins, and other minerals for humans and is found worldwide in aquatic environments. Consumption of seafood exposed to toxic metals and radionuclides could be hazardous to human health (Ulyantsev *et al*., 2023; Ademola *et al*., 2015). Although the three most commonly consumed fish species in Nigeria are catfish, tilapia, and salmon (mackerel), catfish and tilapia are mainly raised in the Lagos Lagoon. Catfishes comprise more than half of the aquaculture activities in the lagoon, ponds, and tanks of Epe waterside, while tilapia fish make up less than 40% of the total fish population.The most prevalent variety of freshwater catfish in Nigeria is the African catfish (*Clariasgariepinus*). It grows fast and possesses long-based dorsal and anal fins, giving it the appearance of an eel. The fish feeds on dead and living small animals and agricultural by-products. The Nile tilapia fish (*Oreochromis niloticus*) belongs to the category of most tilapia fishes; herbivores with omnivore inclinations. They are also prevalent in the diet of most Nigerians and are frequently consumed in local dishes.

Toxic metals and radionuclides have high impacts on animals, plants, and humans, making it crucial to determine their daily intakes and track their toxicity levels in the food chain (Rahman *et al*., 2017; Núñez *et al*., 2018). High concentrations of toxic elements can lead to poisoning (Looi *et al*., 2014), and the most common symptoms of human-related metal poisoning are pneumonia, convulsions, paralysis, ataxia, and vomiting (McCluggage, 1991). Over the years, substantial amounts of solid, agricultural, mining, and other industrial wastes containing radioactive elements and heavy metals have seeped into water bodies alongside oil spills and nuclear weapon wastes. As a result of these activities, marine habitats have become toxic to aquatic life and human health (Duran *et al*., 2014; Kupeli *et al*., 2014). Radionuclides pose long-term effects on living things at low concentrations, entering the human body through inhalation and ingestion and releasing alpha and beta particles, and gamma rays that interact with the water in the body cells, causing mutation. Heavy metals ingested by a human through fish consumption could endanger human health and result in several diseases and maladies. This is why the radionuclides and heavy metals in the catfish and tilapia consumed in Epe, a major fishing community in the Southwest of Nigeria, are crucial because they will be a benchmark for figuring out how safe fish harvested in the waterways are to consume. Therefore, the objective of this paper was to assess the levels and health risks of naturally occurring radionuclides and heavy metals in commonly consumed African catfish, White catfish and Nile tilapia fish species from Epe Waterside region of Lagos, Nigeria.

MATERIALS AND METHODS

The African catfish (*Clarias gariepinus*) typically features a dark grey or black back that gradually fades to a white belly (Figure 1a). This catfish species is characterized by a broad mouth, a slender body, a bony head, and four barbs. Remarkably, they demonstrate the ability to survive on land for extended periods and are predominantly found in reservoirs, rivers, swamps, ponds, and lakes with low to moderate water currents. The white catfish (*Ameirus catus*) lacks scales and palatine teeth. Notably, it possesses two nasals and eight barbells on its head (Figure 1b). The Nile tilapia fish (*Oreochromis niloticus*) inhabits shallow water bodies and sustains itself by consuming higher plants and plankton. This species exhibits various skin colors, including regular, vertical, and distinctive stripes extending to the caudal fin (Figure 1c).

Fig. 1: African catfish (1a); White catfish (1a); Nile tilapia fish (1c)

*The Study Area:*The Epe Waterside Market, also known as Oluwo Market(Fig. 2),is situated in the Epe Local Government Area of Lagos State, Nigeria, positioned between latitude 6° 55' 3" N and longitude 3° 57' 11" E. The African catfish (*Clarias gariepinus*), White catfish (*Ameirus catus*), and Nile tilapia (*Oreochromisniloticus*) were procured, placed in plastic containers, and promptly transported to the laboratory for analysis.

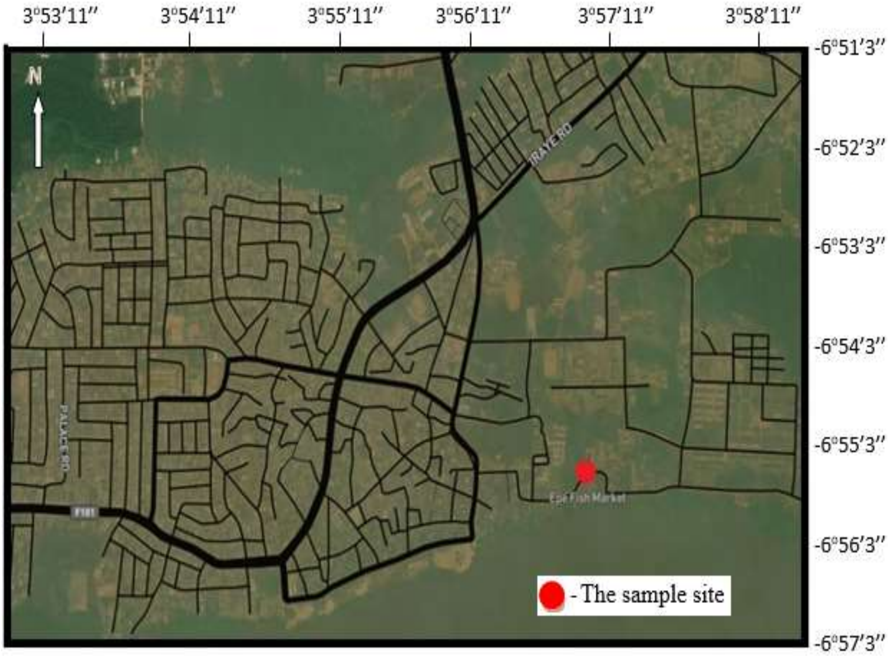

Fig. 2. Map of Epe, Lagos State showing the study area

Sample Collections: The fish species commonly purchased for consumption at Oluwo market, Lekki-Epe waterways in Lagos, include African and white catfishes and Nile tilapia fish. Six fish samples, comprising two samples of each fish species, were randomly selected from the lagoon. These samples were promptly transferred for the determination of natural radionuclide activity concentrations using a Sodium Iodide NaI(Tl) detector. The analysis took place at the Department of Department of Physics, Federal University of Agriculture, Abeokuta. Ogun State, Nigeria .Furthermore, six fish samples were randomly harvested from the lagoon, two samples of each species, for the purpose of conducting a heavy metals analysis. The Department of Food Science and Technology at Bells University of Technology in Ota, Ogun State, received these samples. The analytical technique known as Atomic Absorption Spectrometry (AAS) was used to analyse the heavy metals.

Sample Preparation and Analyses for Natural Radionuclide: The fish samples were weighed, oven-dried at 80 °C for 24 hours (Ademola and Ehiedu, 2010; Dougherty and Ng, 1982), and subsequently crushed and sieved to obtain finely powdered samples. The sieved samples were then stored for approximately 28 days in non-reactive plastic containers, securely sealed with adhesive tape to prevent the escape of daughter radionuclides (Ojo, 2022; Orosun *et al*., 2018). Table 1 presents the weights of both wet and dried fish in grams (g) for natural radionuclide and heavy metal concentrations. A Canberra multi-channel analyzer, coupled with a Sodium Iodide (NaI(Tl)) detector (BICRON) measuring 7.6×7.6 cm² through a preamplifier, was used to determine the activity concentrations of natural radionuclides in the prepared fish samples. The NaI(Tl) detector was shielded with a 10 cm thick lead (Pb) on all four sides and 5 cm on the top to reduce background radiation. The linearity of the detector was examined, and energy calibration was performed according to the IAEA recommended values, reference number IAEA-MA-B-3/RN, with known concentrations for fish samples (Gilmore, 2011; IAEA, 1989). The detection efficiency was calibrated using the standard gamma source with number 48722-3560 by Atlantic Inc., Atlanta, GA, USA, traceable to a gamma source.

Table 1: The samples wet and dry weightsfor radionuclideand heavy metal measurements

	Natural Radionuclide		**Heavy Metals**	
Samples	Wet weight (g)	Dry weight (g)	Wet weight (g)	Dry weight (g)
African Catfish 001	170	146.540	570	170
African Catfish 002	60	47.657	330	70
White Catfish 001	220	198.711	820	220
White Catfish 002	70	59.202	330	100
Tilapia fish 001	220	197.572	930	220
Tilapia fish 002	100	87.211	220	60

The concentration of natural radionuclides in the fish samples was determined by first measuring the background counts of an empty container with similar dimensions for 3600 seconds. The resulting counts were then subtracted from the gross counts to obtain the net counts, and the background radiations were adjusted accordingly. Genie 2K software was utilized to determine the concentrations of ^{226}Ra, ^{232}Th, and ^{40}K radionuclides based on their corresponding peaks.

The amount of ^{226}Ra was measured using a ^{214}Bi gamma-ray with a mass of 1.764 MeV. The concentration of ^{232}Th was calculated using the gamma-ray energy of the daughter compound ^{228}Ac, which is 911.07 keV, while the concentration of ^{40}K was determined using the gamma-ray of ^{40}K in the sample at 1.460 MeV. The sample activity concentrations were measured using Equation 1

$$A_C = \frac{R}{lPM} \qquad (1)$$

Where A_C is the activity concentration of the naturally occurring radionuclide in Bq/Kg, R is the count rate under the corresponding peak, ℓ is the detector's efficiency at a given gamma-ray energy, P is the absolute transition probability of that particular gamma-ray, and M is the mass of the sample in kg.

Effective Dose Rate: The effective dose rate (E) in mSv for the samples was calculated using Equation 2 (Asaduzzaman*et al*., 2015).

$$E = A_C \times A_i \times CF \qquad (2)$$

Where A_i is the annual intake of fish, and CF is the dose conversion factor of the natural radionuclide, ^{40}K=0.0417, ^{232}Th=0.604,^{226}Ra=0.462 (UNSCEAR,2008).

Daily and Annual Intakes of Radionuclides: According to Alam and Mohamed (2011), the daily radionuclide intake (D_{in}) as a result of fish consumption is given by Equation (3).

$$D_{in} = \frac{A_C \times A_P \times F_R}{M_P \times 365} \qquad (3)$$

Where A_P is the annual production of fish in Nigeria according to FAO (2018), F_R is the fraction of the fish consumed (approximately 0.7), and M_p is the population number in millions (NPC,2022).The annual intake (A_i)of radionuclide based on nutrition statistics of daily intake in Bq/year for categories of people who consume fish on 7 days/week, 5 days/week, 3 days/week, and 1 day/week, the yearly intake of radionuclide from fish consumption was determined.

*Excess Cancer Risk:*The excess cancer risks(CR) were estimated using Equation (4).

$$CR = A_i \times A_{is} \times RF \qquad (4)$$

Where A_{is} the average life expectancy (70 years) and RF is is the risk factor of $0.055 Sv^{-1}$(Ademolaand Adeniyi, 2021).

*Sample Preparation and Analyses Heavy Metal Concentrations:*The fish samples were prepared for heavy metal (Pb, Zn, Cu, and Cd) analysis using the analytical technique of AAS with a wet digestion approach (Kazemi *et al*., 2022; Duran *et al*., 2014). The samples were soaked for 24 hours in dilute nitric acid (HNO_3) in glassware rinsed with distilled deionized water. A mixture of 193 mL of HNO_3 acid and 128 mL of water was prepared, and 62.07 mL of perchlorate ($HClO_4$) was added to approximately 17.93 mL of water. The resulting $HClO_4$ and HNO_3 were poured into a 50 mL beaker containing a 5 g dry-weight sample. The mixture was heated until the reactions between the samples, $HClO_4$, and HNO_3 ceased. About 10 mL of nitric acid was added to the mixture and then gradually heated until the mixture turned black at a temperature between 120 and 150°C. The beaker was allowed to cool, and hydrogen peroxide (H_2O_2) was added until the sample became clear. The mixture was diluted with distilled water in a 50 mL volumetric flask until the desired solution was reached. The entire process was carried out in the fume hood (Elmer, 1996), and for each sample, the process was repeated twice to minimize errors. The spectrometer was calibrated using standard solutions (Ojo *et al*., 2021). The concentrations (C) of Pb, Zn, Cu, and Cd in the fish samples were determined using Equation (5).

$$C = \frac{A}{W_S} \times 100 \qquad (5)$$

Where A is the AAS values and W_S is the weight of the dried samples (Table 1).

Average Daily Dose and Health Risk Index: The health risk index (HRI) is the ratio of the average daily dose (AD) in mg/kg of the body weight per day of heavy metals to an oral reference dosage (RfDo) in mg/kg/day. The RfDo (Equation 6) refers to the maximum daily consumption of certain heavy metals that do not have any adverse consequences on human health, and the values for Cu, Zn, Cd, and Pb are 0.04, 0.3, 0.001, and 0.004 mg/kg/day, respectively (USEPA 1999).

$$AD = \frac{C_m}{W} \times D \qquad (6)$$

Where C_m is the geometric mean concentration of the heavy metals in the samples, W is the average adult weight of 70 kg, and D is the average daily intake of heavy metals from the samples in mg/day, and were estimated from the acceptable daily intake per 70 kg weighted adult (FAO/WHO, 1999).
The HRI is used to assess the health risks associated with ingesting of the heavy metals into human body and can be estimated using Equation (7).

$$HRI = \frac{AD}{RfDo} \qquad (7)$$

IfHRI>1, potential human health risk is high and the samples are not safe for consumption. This happens when $AD > RfDo$ for a particular heavy metal.

*Statistical Analyses:*Distributive statistics were carried out using Microsoft Excel program (version 2016). The mean, geometric mean, and standard deviation for each parameter concentration were estimated. The mean concentrations were compared with the permissible limits as recorded by FAO/WHO (1999).

RESULTS AND DISCUSSION

*Natural Radionuclide Concentrations in Samples:*The concentrations of natural radionuclides in the fish samples (measured in Bq/kg and shown in Table 2) showed that ^{40}K was more abundant than ^{226}Ra and ^{232}Th, correlating with recent findings by Orosun *et al*. (2018), Ademola and Ehiedu (2010), and Hernandez *et al*. (2004). ^{226}Ra concentrations ranged from 27.187.8 Bq/kg (Tilapia Fish 002) to 202.750.3 Bq/kg (White Catfish 002), with an overall mean concentration of 80.1565.4 Bq/kg. Concentrations of 232Th varied from 52.9±7.4 (Tilapia Fish 001) to 600.2±7.0 Bq/kg (African Catfish 002), with a mean value of 245.8±7.7 Bq/kg. Meanwhile, concentrations of 40K ranged from 29.1±21.0 (White Catfish 001) to 823.5±18.2 Bq/kg (African Catfish 002), with a mean value of 282.7±17.9 Bq/kg.

Total activity concentrations ranged from 140.6±28.6 (White Catfish) to 1471.5±114.7 Bq/kg (African

Catfish), with a mean activity concentration of 608.7±91 Bq/kg. In comparison to similar studies, the activity concentrations of radionuclides ^{226}Ra, ^{232}Th, and ^{40}K were 3.5, 533.3, and 17.8 Bq/kg, respectively, in Ado-Ekiti, Nigeria (Fashae and Ishinkaye, 2018); 11.0, 37.4, and 85.9 Bq/kg in the Niger Delta, Nigeria (Bolaji *et al*., 2015); 94.8, 384.9, and 37.2 Bq/kg in Kanji Lake, Nigeria (Adamu *et al*., 2013); 0.02, 319.0, and 0.6 Bq/kg in Turkey (Erenturk *et al*., 2014); and 0.9, 99.0, and 0.4 Bq/kg in the USA (Billa *et al*., 2016).The mean activity concentration of ^{40}K in this study (282.7±17.9) surpasses the results obtained in these study areas. The highest concentration of ^{40}K was observed in African Catfish 002 within the study samples, and the mean concentration obtained (282.7±17.9) exceeded those observed in studies from Ado-Ekiti, the Niger Delta, Kanji Lake, Turkey, and the USA.

Table 2:Activity Concentrations of Natural Radionuclide in the Samples

Samples	^{226}Ra	^{232}Th	^{40}K	Total Activity
African Catfish 001	-	114.00±7.10	72.70±19.90	186.70±27.00
African Catfish 002	47.80±89.50	600.20±7.00	823.50±18.20	1471.50±114.70
White Catfish 001	-	111.50±7.60	29.10±21.00	140.60±28.60
White Catfish 002	202.70±50.30	394.60±8.40	359.30±17.90	956.60±76.60
Tilapia Fish 001	43.00±33.90	52.90±7.40	88.10±13.20	184.00±54.50
Tilapia Fish 002	27.10±87.80	201.40±8.70	323.60±17.30	552.10±113.80
Mean	80.15±65.40	245.80±7.70	282.70±17.90	608.70±91.00

*Radionuclide Effective Dose, Annual and Daily Intakes, and Excess Cancer Risks:*Table 3 presents the effective dose rate (E), daily intake (D_{in}), annual intake (A_i), and the associated cancer risk (CR) linked to the ingestion of contaminated fish. The E values ranged from 184.23 to 1390.90 mSv, with a mean value of 613.93 mSv. This value exceeds the recommended limit of 50 mSv per annum for the public set by the International Commission on Radiological Protection (ICRP, 2007; 1990). The high effective dose rate recorded by this study can be attributed to human and industrial activities around Lekki-Epe Free Trade Zone, making aquatic foods harvested in this environment unsafe for human consumption. This finding is also consistent with previous studies by Kalipci *et al*. (2023), Koraltan *et al*. (2023), and Kazemi *et al*. (2022).

The D_{in} values ranged between 0.0014 and 0.02 mBq/yr, with a mean value of 6.68×10-3 mBq/yr. The range of A_i for the radionuclide in the consumption pattern was seven days/week (0.0002-0.00136 Bq/yr), five days/week (0.00028-0.004 Bq/yr), three days/week (0.000467-0.00667 Bq/yr), and one day/week (0.0014-0.02 Bq/yr). The mean values were 9.55×10-4, 1.34×10-3, 2.23×10-3, and 6.68×10-3 Bq/yr, respectively. The estimated CR values ranged from 101.33 to 764.99 (7 d/wk), 141.86 to 1070.99 (5 d/wk), 236.43 to 1784.98 (3 d/wk), and 709.29 to 5334.95 (1 d/wk). These values did not fall within the recommended range of 1.0×10-6 to 1.0×10-4 by the World Health Organization (WHO, 2007).

Table 3: Effective Dose (E), Annual Intake (A_i), Daily Intake (D_{in}) and Cancer Risk (CR) of Radionuclide

Specimen	E (mSv)	D_{in} (mBq/yr)	A_i(Bq/yr) 7 d/wk	A_i(Bq/yr) 5 d/wk	A_i(Bq/yr) 3 d/wk	A_i(Bq/yr) 1 d/wk	CR×10^{-6} (7 d/wk)	CR×10^{-6} (5 d/wk)	CR×10^{-6} (3 d/wk)	CR×10^{-6} (1 d/wk)
A	238.67	1.90×10^{-3}	2.71×10^{-4}	3.80×10^{-4}	6.33×10^{-4}	1.90×10^{-3}	131.27	167.07	278.45	835.345
B	1390.90	0.02	2.86×10^{-3}	4.00×10^{-3}	6.67×10^{-3}	0.02	764.99	1070.99	1784.98	5334.95
C	227.62	1.40×10^{-3}	2.00×10^{-4}	2.80×10^{-4}	4.67×10^{-4}	1.40×10^{-3}	125.191	175.27	292.11	876.337
D	1151.93	9.50×10^{-3}	1.36×10^{-3}	1.90×10^{-3}	3.17×10^{-3}	9.50×10^{-3}	633.56	886.99	1478.31	4434.93
E	184.23	1.80×10^{-3}	2.57×10^{-4}	3.60×10^{-4}	6.00×10^{-4}	1.80×10^{-3}	101.33	141.86	236.43	709.29
F	490.23	5.48×10^{-3}	7.83×10^{-4}	1.10×10^{-3}	1.83×10^{-3}	5.48×10^{-3}	269.63	343.16	571.94	1715.805
Mean	613.93	6.68×10^{-3}	9.55×10^{-4}	1.34×10^{-3}	2.23×10^{-3}	6.68×10^{-3}	337.66	464.22	773.70	2316.28

Where; African catfish 001 = A; African catfish 002 = B; White catfish 001= C; White catfish = D; Tilapia Fish 001 = E; Tilapia 002 = F

*Heavy Metals Concentrations in Fish Species:*Heavy metals in fishes vary greatly due to several variables, such as fish species, habitats, and the nature of food consumed, fishing techniques, processing methods, and potential equipment contamination. As shown in Table 4, it presents the concentrations of heavy metals in the samples, along with their permissible limits, mean, and geometric mean concentrations. The concentration of Pb ranged from 2.51 (African Catfish 002) to 3.39 mg/kg (Tilapia Fish 002), while Zn concentrations ranged from 0.026 (White Catfish 002) to 1.344 mg/kg (Tilapia Fish 001). Cu concentrations in the samples ranged between 0.008 (African Catfish 001 and Tilapia Fish 002) and 0.055 mg/kg (African Catfish 002), while Cd concentrations ranged from 0.048 (White Catfish 002) to 0.25 mg/kg (African Catfish 001). The heavy metal concentrations were within the permissible limits recommended by

FAO/WHO (1999), except for Pb, which exceeded the recommended values. Pb is a non-essential metal for the normal metabolism of fish, and the spike in Pb concentrations may be attributed to contamination from industrial, agricultural, and domestic wastes, soil, or fishing materials.

Table 4: Concentrations of Heavy Metals in Samples

Samples	Pb (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Cd (mg/kg)
A	3.23±0.17	ND	0.008±3.03	0.251±0.02
B	2.51±0.16	ND	0.055±0.11	0.171±0.02
C	3.02±0.00	ND	0.014±0.00	0.157±0.02
D	3.02±0.00	0.026±0.00	0.012±0.00	0.048±0.02
E	2.83±0.13	1.344±0.00	0.017±0.002	0.207±0.02
F	3.39±0.13	ND	0.008±0.002	0.085±0.02
Mean	3.00±0.15	0.685±0.00	0.019±0.79	0.153±0.02
Geometric mean	3.05	0.19	0.014	0.13
FAO/WHO (1999)	0.5	40	30	0.5

ND: Not Detected; Where; African catfish 001 = A; African catfish 002 = B; White catfish 001= C; White catfish = D; Tilapia Fish 001 = E; Tilapia 002 = F

*Health Risk Assessments in Consuming the Fishes:*Table 5 indicated the values of D, AD, and HRI in estimating the health risks associated with consuming the fish species. The HRI values were below unity, except Pb with a value greater than 1, and this indicated that the fish species were highly contaminated with Pb and not edible for consumption as it could lead to potential adverse health risks.

Table 5: The D, AD and HRI in consuming the fishes

Heavy metals	D (mg/day)	AD (mg/kg/day)	HRI
Pb	0.500	0.022	5.500
Zn	30.000	0.814	0.270
Cu	0.400	7.714×10^{-5}	1.929×10^{-3}
Cd	0.070	1.300×10^{-4}	0.130

*Conclusion:*An evaluation of the Epe Waterside Lagoon in Lagos has uncovered concerning levels of pollution in fish caused by naturally occurring radionuclides and heavy metals originating from several sources, including oil spillage, corroded pipes, waste disposal, agrochemicals, and industrial operations. The presence of this contamination presents possible risks to both marine organisms and human consumers. Prompt measures are required to tackle these ecological obstacles to safeguard the welfare of the species and the local populace. The presence of elevated levels of radioactive substances and significant contamination of fish with lead (Pb) underscores the importance of a campaign to ensure the safety of water bodies for fish breeding. Due to the substantial reliance of Nigerians on fish intake, it is imperative to raise awareness of the hazards associated with consuming fish contaminated with pollutants. To mitigate the potential consumption of contaminated fish and other seafood in the research area, it is advised to confine fish-rearing activities to controlled domesticated ponds.

REFERENCES

Adamu, R; Zakari, YI; Ahmed, AY; Abubakar, S; Vatsa, AM (2013). Analysis of activity concentrations due to natural radionuclides in the fish of Kanji Lake. *Adv. Appl. Sci. Res*. 4(4): 283-287.

Ademola, JA; Ehiedu, SI (2010). Radiological Analysis of 40K, 226Ra and 232Th in Fish, Crustacean and Sediment Samples from Fresh and Marine Water in Oil Exploration Area of Ondo State, Nigeria. *Afr. J. Biomed. Res.* 13: 99-106.

Ademola, AK; Olaoye, MA; Abodunrin, PO (2015). Radiological safety assessment and determination of heavy metals in soil samples from waste dumpsites in Lagos and Ogun State, South-western, Nigeria. *J. Rad. Res. Appl. Sci*. 8: 148-153. DOI: https://doi.org/10.1016/j.jrras.2014.12.010

Afshan, S; Ali, S; Ameen, US; Farid, M; Bharwana SA; Hannan, F; Ahmad, R (2014). Effect of Different Heavy Metal Pollution on Fish. *Res. J. Chem.Env. Sci*. 2(1): 74-79.

Alam, L; Mohamed, CAR (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. DOI: https://doi.org/10.1186/1476-069X-10-43

Alam, R; Ahmed, Z; Howladar, MF (2019). Evaluation of Heavy Metal Contamination in Water, Soil and Plant around the Open Landfill Site, Mogla Bazar in Sylhet, Bangladesh. *Groundw. Sus. Devel*. 10: 100311. DOI: https://doi.org/10.1016/j.gsd.2019.100311

Asaduzzaman, K; Khandaker, MU; Amin, YM; Mahat, R (2015). Uptake and Distribution of Natural Radioactivity in Rice from Soil in North and West Part of Peninsular Malaysia for the Estimation of Ingestion Dose to Man. *Ann. Nuc. Ener*. 76: 85-93. DOI: https://doi.org/10.1016/j.anucene.2014.09.036

Babatunde, BB; Sikoki, FD; Hart, I (2015). Human Health Impact of Natural and Artificial Radioactivity Levels in the Sediments and Fish of Bonny Estuary, Niger Delta, Nigeria.

Challeng.6(2): 244-257. DOI: https://doi.org/10.3390/challe602024

Benaduce, APS; Kochhann, D; Flores, ÉMM; Dressler, VL; Baldisserotto, B (2008). Toxicity of cadmium for silver catfish Rhamdiaquelen (Heptapteridae) embryos and larvae at different alkalinities. *Arch Environ Contam. Toxicol*. 54: 274-282. DOI: https://doi.org/10.1007/s00244-007-9024-2

Billa, J; Han, F; Didla, S; Yu, H; Dimpah, J; Brempong, O; Adzanu, S (2016). Radioactivity studies on farm-raised and wild catfish produced in Mississippi, USA. *J. Radio-analyt. Nucl. Chem.* 307(1): 203-210. DOI: https://doi.org/10.1007/s10967-015-4159-5

Dougherty, G; Ng, CE (1982). ^{137}Cs and ^{40}K levels in marine species caught in Malaysian waters. *H. Phys*. 43: 915-919.

Duran, A; Tuzen, M; Soylak, M (2014). Assessment of trace metal concentrations in muscle tissue of certain commercially available fish species from Kayseri, Turkey. *Environ. Mon. Ass.* 186: 4619-4628. DOI: https://doi.org/10.1007/s10661-014-3724-7

Ebrahimi, M; Taherianfard, M (2011). The effects of heavy metals exposure on reproductive systems of cyprinid fish from Kor River. *IranJ. Fish Sci*. 10: 13-24.

Elmer, P (1996). Atomic Absorption Spectroscopy: Analytical Methods. The Perkin Elmer Corporation, Waltham.

Erenturk, S; Yusan, S; Turkozu, DA; Camtakan, Z; Olgen, MK; Aslani, MA; Aytas, S; Isik, MA (2014). Spatial distribution and risk assessment of radioactivity and heavymetal levels of sediment, surface water, and fish samples from Lake Van, *Tur.J. Radioanaly. Nucl. Chem.* 300(3): 919-931. DOI: https://doi.org/10.1007/s10967-014-3042-0

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

FAO/WHO (1999). Food and Agriculture Organization/World Health Organization. Joint Expert Committee on Food Additives. Summary and conclusions. 53rd Meeting, Rome. www.fao.org/fileadmin/templates/.../2 002-09-10.

Gilmore, G (2011). Practical gamma-ray spectroscopy. John Wiley & Sons.

Hernandez, F; Hernandez-Armas, J; Catalan, A; Fernandez-Aldecoa, JC; Landeras, MI (2004). Activity concentrations and mean annual effective dose of foodstuffs on the Island of Tenerife. *SpainRad.Prot.Dos.* 111(2): 205-210. DOI: https://doi.org/10.1093/rpd/nch335

IAEA (1989). Measurement of Radionuclide in Food and Environment. A Guidebook Technical Report, International Atomic Energy Agency, Series No 295, Vienna.

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

Kabata-Pendias, A; Szteke, B (2019). Trace Elements in Abiotic and Biotic Environments. First issued in hardback, FL: CRC Press, Taylor & Francis Group, 200-301. DOI: https://doi.org/10.1201/b18198

Kessaratikoon, P; Awaekechi, S (2008). Natural Radioactivity Measurement in Soil Samples Collected from Municipal Area of Hat Yai District in Songkhla Province, Thailand. *KMITLSci. Technol. J.* 8: 52-58.

Khandaker, MU; Norfadira, BW; Amin, YM; Bradley, DA (2013). Committed effective dose from naturally occurring radionuclides in shellfish. *Rad. Phy. Chem.* 88: 1-6. DOI: https://doi.org/10.1016/j.radphyschem.2013.02.034

Linbo, TL; Baldwin, DH; Mc Intyre, J; Scholz, NL (2009). Effects of water hardness, alkalinity, and dissolved organic carbon on the toxicity of copper to the lateral line of developing fish. *Environ Toxicol Chem* 28: 1455-1461.DOI: https://doi.org/10.1897/08-283.1

Looi, LJ; Aris, AZ; Wan Johari, WL; MdYusoff, F; Hashim, Z (2014). Baseline metals pollution profile of tropical estuaries and coastal waters of the Straits of Malacca. *Mar. Pol. Bul.* 74(1): 471-476.DOI : https://doi.org/10.1016/j.marpolbul.2013.06.008.

McCluggage, D (1991). Heavy Metal Poisoning, NCS Magazine. The Bird Hospital, Columbus.

Merril, E; Tom, G (1990). Environmental Radioactivity from Natural, Industrial and Military Sources, 4th edn. Academic Press Inc, 93-96.

NPC (2022). Nigeria Population Commission Estimate. Available at: https://www.worldometers.info/world-population/nigeria-population

Nofal, MI; Zaki, VH; Ahmed, NAS; Abed-Aziz, AF; Rashad, MM (2019). Effects of heavy metal pollution on Nile tilapia in Manzala farm: oxidative stress biomarkers and histopathological findings. *Int. J. Fish Aquat. Stud.* 7: 315-328.

Ojo, AO (2022). Assessment of Naturally Occurring Radionuclide with Depths in the Soils of Selected Dumpsites, Ogun State, Southwestern Nigeria. *Jord. J. Phy.* 15(4): 383-392.

Ojo, AO; Ogunyinka, OO; Daramola, OO; Olaoye, FA (2021). Hydro-chemical and Microbial Assessments of Water Resources around Cassava Mills in a Sedimentary Formation of Ilaro, Southwest Nigeria.*Appl. W. Sci.* 11: 62. DOI: https://doi.org/10.1007/s13201-021-01384-7

Orosun, MM; Adisa, AA; Akinyose, FC; Amaechi, EC; Ige, OS; Ibrahim, BM; Martins, G; Adebanjo, GD; Oduh, OV; Ademola, OJ (2018). Measurement of Natural Radionuclides Concentration and Radiological Impact Assessment of Fish Samples from Dadin Kowa Dam, Gombe State Nigeria. *Afr. J. Med. Phy*. 1(1): 25-35.

Rahman, MS; Barua, BS; Karim, Md, R; Kamal, M (2017). Investigation of Heavy Metals and Radionuclide's Impact on Environment Due to The Waste Products of Different Iron Processing Industries in Chittagong, Bangladesh. *J. Environ. Protec*. 8(9): 974-989. DOI: https://doi.org/10.4236/jep.2017.89061

Sathyapriva, RS; Rao, DD; Prabhath RK (2017). Choosing an appropriate method for measurement of ^{232}Th in environmental samples. *Rad. Protec. Environ*. 40: 90-94.DOI : https://doi.org/10.4103/rpe.RPE_20_17

UNSCEAR (2000). United Nations Scientific Committee on the Effects of Atomic Radiation report on the Sources and Effects of Ionizing Radiation. Report to the General Assembly, (New York: United Nations). Available at: www.unscear.org›docs›publications›UNSCEAR/2000.html

UNSCEAR (2008). United Nations Scientific Committee on the Effects of Atomic Radiation report on Sources and Effects of Ionizing Radiation. Exposures of the public and workers from various sources of radiation. Report to the General Assembly with Scientific Annexes, Annex-B.

USEPA (1999). US Energy Protection Agency report on Cancer risk coefficients for Environmental Exposure to Radionuclides. Federal Guidance Report No.13; EPA 402-R-99-001.

USEPA (2008). U.S. Environmental Protection Agency report on the Environment (Final Report), Washington, D.C., EPA/600/R-07/045F (NTIS PB2008-112484).

WHO (2007). World Health Organization Guidelines on assessing the quality of herbal medicines concerning contaminants and residues, Geneva. Available at: apps. swho.int/iris/handle/10665/43510