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SHORT COMMUNICATION

DOSE RATES OF NATURAL RADIONUCLIDES IN FISHES FROM RIVERS IN SAGAMU OGUN STATE NIGERIA

Sowole O
Department of Physics and Mathematical Sciences
Tai Solarin University of Education, Ijagun, Ijebu-Ode, Ogun State, Nigeria

ABSTRACT

Radioactivity concentrations and dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in fishes as internal dose rates from major rivers in Sagamu, Ogun State Southwest of Nigeria had been determined by gamma spectrometry using NaI (TI) detector coupled with a pre-amplifier base to a multiple channel analyzer (MCA). 15 samples of fishes were collected from three rivers: Majowopa, Ibu and Eruwuru. *Tilapia zilli* had the highest mean concentrations of ^{40}K and ^{226}Ra of values 89.13 ± 6.83Bq/kg and 3.06 ± 0.26Bq/kg respectively. The highest mean concentration of ^{228}Ra was found in *Papyrocranus afer* with value 3.12 ± 0.29Bq/kg. The highest dose rates of ^{40}K and ^{226}Ra were obtained form *Tilapia zilli* with values of 0.00801mGy/yr and 5.36 x 10^{-7}mGy/yr respectively. For ^{228}Ra, *Papyrocranus afer* had the highest dose rate of value 3.50 x 10^{-13}mGy/yr. The average dose rate of the radionuclides in the fishes was calculated to be 1.74 x 10^{-3}mGy/yr which is below the 0.4 mGy/yr limit recommended by NCRP (1991) as reported by Blaylock *et, al* (1993) which has no negative radiological health implication to the aquatic animals.

Keywords: Radionuclides, radionuclide concentration, dose rate, gamma spectrometry, radioactivity concentration.

INTRODUCTION

Radionuclides are chemical elements with unstable atomic structures called radioactive isotopes. The unstable structures breakdown to release or emit radiation energy from the nucleus or other parts of the atom. Three types of radiation can be released: alpha particles, beta particles and gamma rays (photons). Most naturally occurring radionuclides are alpha particle emitters (uranium and radium-226), but some beta particle emitters also occur naturally (radium-228 and potassium-40). Manmade radionuclides are mainly beta and photon (gamma) emitters. Tritium is a beta particle emitter that may be formed naturally in the atmosphere or by human activities (OEPA, 2005). Radiation being energy emitted when a radionuclide decays. It can affect living tissue only when the energy is absorbed in that tissue. Radionuclides can be hazardous to living tissue when they are inside an organism where radiation released can be immediately absorbed. They may also be hazardous when they are outside of the organism but close enough for some radiation to be absorbed by the tissue. Radionuclides move through the environment and into the body through many different pathways: through the air, in water (both groundwater and surface water), and through the food chain. Knowing these pathways make it possible to take necessary control measure to reduce their intake by aquatic animals, terrestrial animals and human beings to minimal levels.

Uptake of ^{226}Ra by *Nymphaea* species from fresh water in Australia was the subject of a study by Twining (1993), he found that ^{226}Ra concentrations in the root and rhizome are higher than in foliage, this being due primarily to surface accumulation. Little radium reached the pith of the rhizomes. Uptake of radium by the foliage was found to be primarily from the water rather than by translocation from the roots. For samples collected in the field, the distributions of radium and calcium concentrations in the foliage were strongly correlated. However, analysis of the ratio of radium to calcium in the plant, compared to extractable concentrations in the water and sediment, showed no correlation between foliage and supporting media, suggesting that different mechanisms were involved in accumulation of radium and calcium. The study of the radionuclide concentration levels in soil and water samples in Eagle, Atlas and rock cement companies in Port Harcourt was carried out by Avwiri (2005) soil and water samples collected from the respective premises were analyzed using the gamma -ray spectrometry. The average absorbed dose rates of the soil samples were 49.27nGy/h, 45.21nGy/h and 42.33nGy/h for Eagle, Atlas and Rock cements respectively while the water values were 22.16nGy/h, 20.75nGy/h and 19.37nGy/h for the respective companies. Mean dose rate equivalents of 0.18mSv/y and 0.39mS/y were obtained for the water and soil samples. These results are lower than the International Commission on Radiological Protection (ICRP, 1992) maximum permitted limit and therefore,

Corresponding author email: segunsowole@yahoo.com

have no significant radiological health burden on the environment and the populace.

This research work is to determine the radioactivity concentrations and dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in fishes from major rivers at Sagamu in Ogun State, Southwest of Nigeria.

MATERIALS AND METHODS

The method of gamma spectrometry was adopted for the analysis of the samples collected in order to obtain data on ^{40}K, ^{226}Ra and ^{228}Ra. 15 samples of fishes from three rivers in the study area were collected and 9 species were obtained as shown in table 1. This was done by the use of fishing nets and hooks of fishermen after which they were preserved in 40% formaldehyde in labelled containers. They were identified and grouped in to their species putting into consideration their locations. The groups were then oven dried at 80°C (Akinloye *et al*., 1999). The dried animal samples were later pulverized, weighed, packed 110.0g by mass in plastic containers and carefully sealed for 4 weeks in order to establish secular radioactive equilibrium between the natural radionuclides and their respective progenies.

The method of gamma spectrometry was adopted for the analysis of the samples collected in order to obtain data on ^{40}K, ^{226}Ra and ^{228}Ra. The spectrometer used was a Canberra lead shielded 7.6cm x 7.6cm NaI (Tl) detector coupled to a multichannel analyzer (MCA) through a preamplifier base. The spectrometer was calibrated using a standard fish sample Ref. No IAEA-MA-B-3/RN (AQCS, 1998) of known concentrations and of the same geometry as the samples.

The resolution of the detector is about 10% at 0.662MeV of ^{137}Cs. According to Jibiri and Farai (1998) the value is good enough for NaI detector to distinguish the gamma ray energies of most radionuclides in samples. For the analysis of ^{40}K, ^{226}Ra and ^{228}Ra, the photo peak regions of ^{40}K (1.46 MeV), ^{214}Bi (1.76 MeV) and ^{208}TI (2.615 MeV) were respectively used.

The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x 7.6cm NaI (TI) detector. High level shielding against the environmental background radiation was achieved by counting in a Canberra 10cm thick lead castle. The counting of each sample was done for 10hrs because of suspected low activities of the radionuclides in the samples. The areas under the photo-peaks of ^{40}K, ^{226}Ra and ^{228}Ra were computed using the Multichannel Analyzer system.

Table 1. Name of rivers, number of samples and species collected.

River Name	Number of Samples	Name of Specie
ERUWURU	5	*Alectis ciliaris*
		Barbus callipterus
		Tilapia mariae
		Papyrocranus afer
		Sarotherodon galilaeus
IBU	5	*Tilapia zilli*
		Papyrocranus afer
		Tilapia mariae
		Sarotherodon galilaeus
		Brycinus longipinnis
MAJOWOPA	5	*Sarotherodon galilaeus*
		Tilapia mariae
		Hepsetus odoe
		Papyrocranus afer
		Sarotherodon melanotheron

Theoretical Consideration and Calculations

The concentrations of the radionuclides were calculated based on the measured efficiency of the detector and the net count rate under each photopeak over a period of 10 hours using equation 1.0

$$C = \frac{N(E_\gamma)}{\varepsilon(E_\gamma) I_\gamma M t_c} \qquad 1.0$$

Where:
$N(E_\gamma)$ = Net peak area of the radionuclide of interest
$\varepsilon(E_\gamma)$ = Efficiency of the detector for the γ- energy of interest
I_γ = Intensity per decay for the γ- energy of interest
M = Mass of the sample
t_c = Total counting time in seconds (36000s)

The dose rates of the radionuclides in the aquatic species were calculated using the equation of Blaylock *et al* (1993):

$$D = 5.76 \times 10^{-4}\, E\, n\, \Phi C \qquad 2.0$$

Where:
E is the average emitted energy for gamma radiations (MeV)
n is the proportion of transitions producing an emission of energy E
Φ is the fraction of the emitted energy absorbed
C is the concentration of the radionuclide of consideration
D is the dose rate of the radionuclide of consideration

RESULTS AND DISCUSSION

Radioactivity concentrations of radionuclides in the fishes from the study area are shown in table 2. Ranges, mean

Table 2. Radioactivity concentrations of radionuclides in fishes.

River	Sample	Specie	Radioactivity Concentration of Radionuclides in Fishes (Bq/kg)		
			^{40}K	^{226}Ra	^{228}Ra
ERUWURU	A1	*Alectis ciliaris*	56.83 ± 4.97	0.45 ± 0.07	BDL
	A2	*Barbus callipterus*	21.63 ± 1.78	1.32 ± 0.65	1.13 ± 0.47
	A3	*Tilapia mariae*	45.91 ± 4.89	5.71 ± 0.47	2.75 ± 0.46
	A4	*Papyrocranus afer*	89.27 ± 6.89	3.19 ± 0.65	2.13 ± 0.40
	A5	*Sarotherodon galilaeus*	87.68 ± 6.42	BDL	3.58 ± 0.65
IBU	B1	*Tilapia zillii*	89.13 ± 6.83	3.06 ± 0.26	1.16 ± 0.14
	B2	*Papyrocranus afer*	25.46 ± 2.87	2.10 ± 0.56	BDL
	B3	*Tilapia mariae*	34.84 ± 4.98	1.09 ± 0.36	6.23 ± 0.45
	B4	*Sarotherodon galilaeus*	28.24 ± 3.76	2.20 ± 0.27	2.45 ± 0.17
	B5	*Brycinus longipinnis*	56.73 ± 5.74	BDL	BDL
MAJOWOPA	C1	*Sarotherodon galilaeus*	34.45 ± 4.71	3.31 ± 0.02	BDL
	C2	*Tilapia mariae*	28.31 ± 3.78	1.82 ± 0.55	BDL
	C3	*Hepsetus odoe*	86.57 ± 6.36	1.23 ± 0.98	1.12 ± 0.20
	C4	*Papyrocranus afer*	56.24 ± 5.35	1.36 ± 0.03	7.22 ± 0.48
	C5	*Sarotherodon melanotheron*	67.58 ± 5.21	BDL	BDL

Note: BDL means below detectable level

Table 3. Ranges, mean values of radioactivity concentrations of ^{40}K and dose rates in fishes.

Specie	Range (Bq/kg)	Mean (Bq/kg)	Dose rate (mGy/yr)
Alectis ciliaris	-	56.83 ± 4.97	0.00450
Barbus callipterus	-	21.63 ± 1.78	0.00327
Brycinus longipinnis	-	56.73 ± 5.74	0.00778
Hepsetus odoe	-	86.57 ± 6.36	0.00512
Papyrocranus afer	25.46 – 89.27	56.99 ± 5.04	0.00607
Sarotherodon galilaeus	28.24 – 87.68	50.12 ± 4.96	0.00801
Sarotherodon melanotheron	-	67.58 ± 5.21	0.00510
Tilapia mariae	28.31 – 45.91	36.35 ± 4.55	0.00511
Tilapia zillii	-	89.13 ± 6.83	0.00194

Table 4. Ranges, mean values of radioactivity concentrations of ^{226}Ra and dose rates in fishes.

Specie	Range (Bq/kg)	Mean (Bq/kg)	Dose rate (mGy/yr)
Alectis ciliaris	-	0.45 ± 0.07	7.9×10^{-8}
Barbus callipterus	-	1.32 ± 0.65	2.31×10^{-7}
Brycinus longipinnis	-	-	-
Hepsetus odoe	-	1.23 ± 0.98	2.15×10^{-7}
Papyrocranus afer	1.36 – 3.19	2.22 ± 0.41	3.87×10^{-7}
Sarotherodon galilaeus	BDL – 3.31	1.84 ± 0.10	3.22×10^{-7}
Sarotherodon melanotheron	-	-	-
Tilapia mariae	1.09 – 5.71	2.87 ± 0.46	5.03×10^{-7}
Tilapia zillii	-	3.06 ± 0.26	5.36×10^{-7}

values of radioactivity concentration of ^{40}K and dose rates in aquatic species are shown in table 3; *tilapia zilli* had the highest mean concentration and dose rate of values 89.13 ± 6.83Bq/kg and 0.00801mGy/yr respectively.

For ^{226}Ra, *tilapia zilli* had the highest mean concentration and dose rate of values 3.06 ± 0.26Bq/kg and 5.36×10^{-7}mGy/yr respectively as shown in table 4. Concerning ^{228}Ra as shown in table 5, *papyrocranus afer* had the highest mean concentration and dose rate of values 3.12 ± 0.29Bq/kg and 3.50×10^{-13}mGy/yr respectively. The average dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in all the fishes were calculated to be 5.21×10^{-3}mGy/yr, 2.53×10^{-7}mGy/yr and 3.50×10^{-13}mGy/yr respectively.

Table 5. Ranges, mean values of radioactivity concentrations of ^{228}Ra and dose rates in fishes

Specie	Range (Bq/kg)	Mean (Bq/kg)	Dose rate (mGy/yr)
Alectis ciliaris	-	-	-
Barbus callipterus	-	1.13 ± 0.41	1.27×10^{-13}
Brycinus longipinnis	-	-	-
Hepsetus odoe	-	1.12 ± 0.20	1.26×10^{-13}
Papyrocranus afer	BDL – 7.22	3.12 ± 0.29	3.50×10^{-13}
Sarotherodon galilaeus	BDL – 3.58	2.01 ± 0.27	2.25×10^{-13}
Sarotherodon melanotheron	-	-	-
Tilapia mariae	BDL – 6.23	2.99 ± 0.30	3.35×10^{-13}
Tilapia zillii	-	1.16 ± 0.14	1.30×10^{-13}

Average dose rate of all the radionuclides in the fishes was calculated to be 1.74×10^{-3}mGy/yr. The values are below the limit of 0.4mGy/yr recommended by NCRP (1991) as reported by Blaylock *et al*. (1993).

CONCLUSION

The study of the radionuclides concentration levels had been carried out along with their dose rates in the aquatic animals. The average dose rate of all the radionuclides in the fishes was calculated to be 1.74×10^{-3}mGy/yr which is below the limit of 0.4mGy/yr recommended by NCRP (1991) as reported by Blaylock *et al*. (1993) and therefore do not pose radiological health problem to the aquatic animals.

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