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Full Length Research Article

RADIOACTIVITY CONCENTRATIONS AND DOSE RATES OF NATURAL RADIONUCLIDES IN FISHES FROM MAJOR RIVERS IN IJEBU WATERSIDE SOUTH WEST, NIGERIA.

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ABSTRACT

Radioactivity concentrations and dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in fishes as internal dose rates from major rivers in Ijebu water side of 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). 12 samples of fishes were collected from two major rivers in the study area: Odeomi and Imakun. Brycinus longipinnis had the highest mean concentration and dose rate values of 87.07 ± 5.83 Bq/kg and 0.0078 mGy/hr respectively. For ^{226}Ra, Pylodictus olivaris had the highest mean concentration and dose rate of values 1.84 ± 0.63 Bq/kg and 3.22 x 10^{-7}mGy/hr respectively. Papyrocranus afer had the highest mean concentration and dose rate of ^{228}Ra with values 7.21 ± 0.49 Bq/kg and 8.08 x 10^{-13}mGy/hr, respectively. The average dose rate of the radionuclides in the fishes was calculated to be 1.64 x 10^{-3}mGy/hr which is below the 0.4 mGy/hr limit recommended by National Council on Radiation Protection (NCRP), (1991) as reported by Blaylock *et.al* (1993) which has no negative radiological health implication to the aquatic animals.

Keywords: Radionuclide, concentration, Fishes, Dose rate, Gamma spectrometry.

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-231 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: air, water (both groundwater and surface water) and 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 226Ra by Nymphaea species from fresh water in Australia was the subject of a study by Twining (1993). He found that 226Ra concentrations in the root and rhizome are higher than in foliage, this being due primarily to surface accumulation. Little amount of 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 49.27 nGy/h, 45.21 nGy/h and 42.33 nGy/h for Eagle, Atlas and Rock cements respectively while the water values were 22.16 nGy/h, 20.75 nGy/h and 19.37 nGy/h for the respective companies. Mean dose rate equivalents of 0.18 mSv/y and 0.39 mS/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, have no significant radiological health burden on the environment and the populace. Furthermore, the study of the radionuclides: 40K, 226Ra and 228Ra concentration levels were carried out by Sowole (2011) along with their dose rates in species of fish from major rivers in Sagamu, Ogun State Southwest of Nigeria. The average dose rate of all the radionuclides in the fishes was calculated to be 1.74 x 10-3mGyhr-1 which was below the limit of 0.4 mGy hr-1 recommended by NCRP (1991) as reported by Blaylock et al (1993) and therefore does not pose radiological health problem to the aquatic animals.

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. 12 samples of fishes from two major rivers in the study area were collected and 10 species were obtained. 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^{0}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 because is the type that can detect gamma radiations from the radionuclides. The spectrometer used was a Canberra lead shielded 7.6 cm x 7.6 cm 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 0.662 MeV 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}Tl (2.615 MeV) were respectively used.

The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6 cm x 7.6 cm NaI (Tl) detector. High level shielding against the environmental background radiation was achieved by counting in a Canberra 10 cm 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
ODEOMI	6	Hepsetus odoe
		Papyrocranus afer
		Sarotherodon melanotheron
		Sarotherodon galilaeus
		Tilapia mariae
		Alectis ciliaris
IMAKUN	6	Sarotherodon galilaeus
		Tilapia mariae
		Miraclestes acutidens
		Brycinus longipinnis
		Barbus callipterus
		Pylodictus olivaris

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

$$C = \frac{N(E_\gamma)}{\varepsilon(E_\gamma) I_\gamma M t_c} \qquad (1)$$

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):

$$D = 5.76 \times 10^{-4}\, E\, n\, \Phi C \qquad (2)$$

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 values of radioactivity concentration of ^{40}K and dose rates in aquatic species are shown in table 3; Brycinus longipinnis had the highest mean concentration and dose rate values of 87.07 ± 5.83 Bq/kg and 0.0078 mGy/hr respectively. For ^{226}Ra, Pylodictus olivaris had the highest mean concentration and dose rate of values 1.84 ± 0.63 Bq/kg and 3.22×10^{-7}mGy/hr respectively as shown in table 4. Concerning ^{228}Ra as shown in table 5, papyrocranus afer had the highest mean concentration and dose rate values of 7.21 ± 0.49 Bq/kg and 8.08×10^{-13}mGy/hr respectively. The average dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in all the fishes were calculated to be 4.91×10^{-3}mGy/hr, 1.74×10^{-7}mGy/hr and 2.14×10^{-13}mGy/hr respectively.

Table 2: Radioactivity concentrations of radionuclides in fishes

RIVER NAME	SAMPLE	SPECIE	RADIOACTIVITY CONCENTRATION OF RADIONUCLIDES IN FISHES (Bq/kg)		
			^{40}K	^{226}Ra	^{228}Ra
ODEOMI	X_1	Hepsetus odoe	42.65 ± 5.12	BDL	BDL
	X_2	Papyrocranus afer	56.23 ± 5.32	1.36 ± 0.03	7.21 ± 0.49
	X_3	Sarotherodon melanotheron	67.82 ± 5.89	1.09 ± 0.37	BDL
	X_4	Sarotherodon galilaeus	79.47 ± 6.20	2.10 ± 0.56	2.98 ± 0.42
	X_5	Tilapia mariae	28.31 ± 3.78	1.82 ± 0.55	BDL
	X_6	Alectis ciliaris	56.83 ± 5.74	BDL	2.45 ± 0.17
IMAKUN	Y_1	Sarotherodon galilaeus	34.84 ± 4.98	BDL	2.40 ± 0.10
	Y_2	Tilapia mariae	24.47 ± 2.52	BDL	2.49 ± 0.23
	Y_3	Miraclestes acutidens	56.67 ± 5.47	1.07 ± 0.38	BDL
	Y_4	Brycinus longipinnis	87.07 ± 5.83	1.28 ± 0.45	BDL
	Y_5	Barbus callipterus	21.82 ± 1.98	1.34 ± 0.54	1.12 ± 0.41
	Y_6	Pylodictus olivaris	72.96 ± 4.76	1.84 ± 0.63	4.37 ± 0.43

NOTE: BDL means below detectable limit

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

SPECIE	RANGE (Bq/kg)	MEAN (Bq/kg)	DOSE RATE (mGy/hr)
Hepsetus odoe	-	42.62 ± 5.12	0.0038
Papyrocranus afer	-	56.23 ± 5.32	0.0051
Sarotherodon melanotheron	-	67.82 ± 5.89	0.0061
Sarotherodon galilaeus	34.84 – 79.47	57.16 ± 5.59	0.0051
Tilapia mariae	24.47 – 28.31	26.39 ± 3.15	0.0024
Alectis ciliaris	-	56.83 ± 5.74	0.0051
Miraclestes acutidens	-	56.67 ± 5.47	0.0051
Brycinus longipinnis	-	87.07 ± 5.83	0.0078
Barbus callipterus	28.31 – 45.91	21.82 ± 1.98	0.0020
Pylodictus olivaris	-	72.96 ± 4.76	0.0066

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

SPECIE	RANGE (Bq/kg)	MEAN (Bq/kg)	DOSE RATE (mGy/hr)
Hepsetus odoe	-	-	-
Papyrocranus afer	-	1.36 ± 0.03	2.38×10^{-7}
Sarotherodon melanotheron	-	1.09 ± 0.37	1.91×10^{-7}
Sarotherodon galilaeus	BDL – 2.10	1.05 ± 0.28	1.84×10^{-7}
Tilapia mariae	BDL – 1.82	0.91 ± 0.28	1.59×10^{-7}
Alectis ciliaris	-	-	-
Miraclestes acutidens	-	1.07 ± 0.38	1.87×10^{-7}
Brycinus longipinnis	-	1.28 ± 0.45	2.24×10^{-7}
Barbus callipterus	-	1.34 ± 0.56	2.35×10^{-7}
Pylodictus olivaris	-	1.84 ± 0.63	3.22×10^{-7}

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

SPECIE	RANGE (Bq/kg)	MEAN (Bq/kg)	DOSE RATE (mGy/hr)
Hepsetus odoe	-	-	-
Papyrocranus afer	-	7.21 ± 0.49	8.08×10^{-13}
Sarotherodon melanotheron	-	-	-
Sarotherodon galilaeus	2.40 – 2.98	2.69 ± 0.26	3.02×10^{-13}
Tilapia mariae	BDL – 2.49	1.25 ± 0.12	1.40×10^{-13}
Alectis ciliaris	-	2.45 ± 0.17	2.75×10^{-13}
Miraclestes acutidens	-	-	-
Brycinus longipinnis	-	-	-
Barbus callipterus	-	1.12 ± 0.41	1.26×10^{-13}
Pylodictus olivaris	-	4.37 ± 0.43	4.90×10^{-13}

Average dose rate of all the radionuclides in the fishes was calculated to be 1.64×10^{-3}mGy/hr. The values are all below the limit of 0.4 mGy/hr 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 1.64×10^{-3}mGy/hr which is below the limit of 0.4 mGy/hr 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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