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Estimation of Annual Dose Rate of Natural Radionuclides in Man from Crabs in River Odeomi Ijebu Waterside Ogun State Nigeria

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ABSTRACT

Radioactivity concentrations and dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in crabs from river Odeomi, 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). 10 samples of crabs were collected from the river having three species. *Callinectes pallidus* had the highest mean concentration and dose rate of ^{40}K of values 120.34 ± 12.78Bqkg^{-1} and 0.0108mGyhr^{-1} respectively. The highest mean concentration and dose rate of ^{228}Ra was found in *Cardiosoma armatum* with values 9.57 ± 3.34Bqkg^{-1} and 1.14 x 10^{-12} mGyhr^{-1} respectively. ^{226}Ra was not detected in the samples. The average dose rates of ^{40}K in the crabs was calculated to be 0.0101mGyhr^{-1} and that of ^{228}Ra was 9.93 x 10^{-13}mGyhr^{-1} which are below the 0.4mGyhr^{-1} limit recommended by NCRP (1991) as reported by Blaylock *et a*l (1993). The annual dose rate in man consuming the aquatic animal species was estimated to be 0.068mSv y^{-1} which was below the recommended limit of 1 mSvyr^{-1}. All the values obtained show that there is no negative radiological health implication to the aquatic animals and man that consumes them.

Keywords: *Radionuclides, Crabs, Radionuclide concentration, Dose rate, Gamma spectrometry.*

1. INTRODUCTION

Sources of radioactivity in the aquatic environment like rivers include naturally occurring radionuclides, fallout from the atmosphere, runoff from watersheds that have received atmospheric deposition, and radioactive effluents from medical, industrial, and nuclear facilities released either accidentally or routinely. Radionuclides are a special class of environmental substances. They are the unstable configurations of chemical elements which undergo radioactive decay, emitting radiation in the form of alpha or beta particles, or gamma rays. The interaction of radiation with biological materials causes energy to be released to these materials which may result in a variety of harmful effects if beyond limit. Radiation is thus a potential hazard to man, although it may also be used in many beneficial ways, as in medical diagnosis and treatment, in industrial and consumer products and in the generation of electricity with nuclear reactors. 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). In the aquatic environment, radionuclides may accumulate in bottom sediment or remain in the water column in the dissolved state (Blaylock *et al*, 1993). With this, they can subsequently accumulate in biota and be transferred through the aquatic food chain.

The study of the radionuclides: ^{40}K, ^{226}Ra and ^{228}Ra 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^{-3}mGyhr^{-1} which was below the limit of 0.4mGy 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.

This research work is to determine the radioactivity concentrations and dose rates of ^{40}K, ^{226}Ra and ^{228}Ra in crabs from River Odeomi Ijebu waterside area of Ogun State Nigeria, also to estimate the annual dose rate of the radionuclides in man that consumes them.

2. 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. 10 samples of crabs from the river in the study area were collected and 3 species were obtained. They were preserved in 40% formaldehyde in labelled containers. They were identified and grouped into 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 120.0g 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 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 river, samples collected and species

RIVER	SAMPLES	SPECIES
ODE OMI	A_1	Cardiosoma armatum
	A_2	Callinectes pallidus
	A_3	Callinectes amnicola
	A_4	Callinectes amnicola
	A_5	Callinectes pallidus
	A_6	Callinectes pallidus
	A_7	Cardiosoma armatum
	A_8	Cardiosoma armatum
	A_9	Callinectes pallidus
	A_{10}	Callinectes pallidus

3. 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

The annual dose rate of the radionuclides in man consuming the aquatic animal species was estimated using the expression:

Annual Dose Rate (Sv yr^{-1}) = Radionuclide intake (Bq yr^{-1}) x Dose Conversion Factor (Sv Bq^{-1})

Where:

Radionuclide intake = Radionuclide conc. (Bq kg^{-1}) x Consumption rate (kg yr^{-1})

4. RESULTS AND DISCUSSION

Radioactivity concentrations of radionuclides in the crabs from the study area are shown in table 2. Ranges, mean values of radioactivity concentrations of ^{40}K and ^{228}Ra, and their dose rates in aquatic species are shown in tables 3 and 4 respectively. For ^{40}K, *Callinectes pallidus* had the highest mean concentration and dose rate of values 120.34 ± 12.78Bqkg^{-1} and 0.0108mGyhr^{-1} respectively.

Table 2: Radioactivity concentrations of radionuclides in crabs

RIVER	SAMPLE	SPECIE	RADIOACTIVITY CONCENTRATIONS OF RADIONUCLIDES IN CRABS (Bqkg^{-1})		
			^{40}K	^{226}Ra	^{228}Ra
ODEOMI	A_1	Cardiosoma armatum	115.26 ± 12.34	-	8.12 ± 2.93
	A_2	Callinectes pallidus	123.45 ± 13.24	-	7.84 ± 2.15
	A_3	Callinectes amnicola	109.13 ± 11.67	-	10.22 ± 3.41
	A_4	Callinectes amnicola	98.63 ± 10.36	-	6.75 ± 2.69
	A_5	Callinectes pallidus	132.10 ± 13.83	-	4.64 ± 2.25
	A_6	Callinectes pallidus	125.15 ±13.37	-	6.72 ± 2.63
	A_7	Cardiosoma armatum	105.68 ± 10.46	-	11.24 ± 3.89
	A_8	Cardiosoma armatum	118.92 ± 12.64	-	9.34 ± 3.21
	A_9	Callinectes pallidus	99.72 ± 10.39	-	7.16 ± 1.97
	A_{10}	Callinectes pallidus	121.28 ± 13.08	-	8.37 ± 3.03

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

SPECIE	RANGE (Bqkg^{-1})	MEAN (Bqkg^{-1})	DOSE RATE (mGyhr^{-1})
Cardiosoma armatum	105.68 – 118.92	113.29 ± 11.81	0.0102
Callinectes pallidus	99.72 - 132.10	120.34 ± 12.78	0.0108
Callinectes amnicola	98.63 – 109.13	103.88 ± 11.02	0.0093

Table 4: Ranges, mean values of radioactivity concentrations of ^{228}Ra and dose rates in crabs

SPECIE	RANGE (Bqkg^{-1})	MEAN (Bqkg^{-1})	DOSE RATE (mGyhr^{-1})
Cardiosoma armatum	8.12 – 11.24	9.57 ± 3.34	1.14×10^{-12}
Callinectes pallidus	4.64 - 8.37	6.95 ± 2.41	8.29×10^{-13}
Callinectes amnicola	6.75 – 10.22	8.49 ± 3.05	1.01×10^{-12}

Cardiosoma armatum had the highest mean concentration value and dose rate of ^{228}Ra with values 9.57 ± 3.34Bqkg^{-1} and 1.14×10^{-12} mGyhr^{-1}. The average dose rates of ^{40}K in the crabs was calculated to be 0.0101mGyhr^{-1} and that of ^{228}Ra was 9.93×10^{-13}mGyhr^{-1} which are below the 0.4mGyhr^{-1} limit recommended by NCRP (1991) as reported by Blaylock *et a*l (1993).

5. CONCLUSION

The study had revealed that the average dose rates of ^{40}K in the species of crab was calculated to be 0.0101mGyhr^{-1} and that of ^{228}Ra was 9.93×10^{-13}mGyhr^{-1} which are below the 0.4mGyhr^{-1} limit recommended by NCRP (1991) as reported by Blaylock *et a*l (1993). The annual dose rate in man consuming the aquatic animal species was estimated to be 0.068mSv y^{-1} which was below the recommended limit of 1 mSvyr^{-1}. All the values obtained show that there is no negative radiological health implication to the aquatic animals and man that consumes them.

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