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Radiation Doses in Fishing Water and Coast Soil in Lagos State South West Nigeria

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Abstract: *This study investigated the radionuclide concentrations in soils and waters of the Coastline and some selected aquatic commonly consumed in this area. Radioactivity levels were evaluated in their natural occurrences in the samples of water, soil and selected aquatic life from three different locations in the Mainland part of Lagos State (Makoko, University of Lagos waterfront and Bariga). Canberra High Purity Germanium Gamma spectrometer was used for the detection of radionuclides and determines the activity. The activity concentrations of Pb-214, Pb-212, Cs-134, and K-40 in the Soil samples of Makoko were found to be 7.89±0.51, 10.20±1.21, 0.69±0.10 and 67.37±2.52 Bq/kg, respectively. From the University of Lagos waterfront, the concentrations of the Soil samples were found to be 8.22±0.51 Bq/kg for Pb-214, 10.54±1.19 Bq/kg for Pb-212, 0.57±0.15 for Cs-134. For the selected Aquatic life (Tilapia Fish, Cat Fish and Crab) from these three locations of interest. The concentrations of K-40 ; Pb-214;Pb-212 Cd-113; Ni-59 in Tilapia fish from Makoko water body was 24.63 Bq\Kg; 0.568 Bq\Kg; 0.07 Bq\Kg; 0.16 Bq\Kg and ;1.65 Bq\Kg , respectively. However recorded concentrations at the Makoko Catfish forK-40; Pb-214; Pb-212; Cd-113 and Ni-59 were 11.75 Bq\Kg; 0.20 Bq\Kg; 0.04Bq\Kg; 0.13Bq\Kg and 1.05Bq\Kg, respectively. The activity concentration showed insignificant values in the three locations based on Nigerian Basic Ionizing Radiation Regulation 2003, UNSCEAR 2008, ICRP 1983, and IAEA 2011 standards.*

Keywords: *Radioactivity, radiation exposure, gamma ray, radionuclides, activity concentration.*

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1.0 Introduction

Radiation consists of those from natural and artificial sources. However, radiation emitted from radioactive substances present in the

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ground or produced from commercial sources cannot be neglected because they contribute a substantial amount of radiation to the environment. Consequently, at all times, the entire ecosystem is exposed to a reasonable amount of one form of radiation or another This radiation comes in two forms: ionizing radiation and non-ionizing radiation. It has been realized that radiation increased rapidly with altitude, suggesting that it had extraterrestrial origins.

Nigerian coastal population consumes larger quantities of aquatic animals, Lagos state is one of the most populous states in Nigeria and begin a coastal state is a motivation for the present study. Fish is a good and high source of dietary protein while also supplying essential minerals and heart-healthy omega -3 fatty acids. Fish and other aquatic life consumption are very high in densely populated Lagos state. The essence is to protect against radiation effects that might result from the consumption of fish in locations of naturally occurring radiation materials (NORM) and technologically enhance naturally occurring radiation materials (TENORM) which could be to stochastic effect on the inhabitants.

It is critically unlikely that contemporary Lagosians knew how their life has been affected by the ecosystem. Lagos State, topographically, is in the coastal region situated in the southwest geopolitical zone, between (2˚42"- 4˚20" E, 6˚22- 6˚4"N). Lagos state covers an area of about 3,577 Km^2, hence occupying approximately 0.4% of the total land areas of Nigeria of which 17% is naturally aquatic. (Ajao, 1990). Lagos lagoon is an expanse of shallow water that in most areas is between 0.5- 2.0m with a maximum of 5m depth in the main body and 18-25m in some dredge portions of the Lagos harbor. Lagos lagoon is a relatively huge water body that expands from Lagos harbor in the south, Ikorodu in the North, Epe in the East and the University of Lagos in the West. (Irvine, 1931). Specifically, samples will be taken from Makoko at a Longitude of 3^0 23' 16" E and Latitude of 6^0 29' 46" N, and from the University of Lagos at Longitude 3^0 23' 45" E and Latitude 6^0 27' 11" N, all the location are connected to the Lagos lagoon which is linked to the Atlantic Ocean.

Fig.: 1 The Map of the Coastal line of Lagos

One of the factors that cause an increase in humans' exposure to ionizing radiation on earth is certain radioactive materials that occur naturally (Mohammed, 2010). These naturally occurring radioactive materials are cancer induces agents when accumulated in the human body system. According to International Agency for Research on Cancer (2014), it was declared that 8.2 million deaths in 2012 worldwide is caused by Cancer. Cancer is the second largest cause of death in the world (Madhusudhan and Middleton, 2005). Cervical cancer is the third most common malignancy in women worldwide, and it remains the cause of cancer-related death for women in developing countries, where more than 80% of cervical cancer occurs, according to National Cancer Institute. Globally the incidence of cancer is rising. (Kolawole, 2011).

Over the past decades, more interest in minimizing the health hazards caused by ionizing radiation from aquatic species consumption has arisen significantly in many different parts of our daily lives. Ajayi and Ibikunle, 2013 in their work on the

radioactivity of surface soils from Oyo state, South Western Nigeria concluded that the mean annual outdoor effective dose values of the collected samples of the study areas are higher than the world average annual outdoor terrestrial radiation value of 0.07 mSv y^{-1} reported by the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR 2000). The investigation by Seyda, et al, (2011): on naturally occurring K-40 radioisotope in beach sand and sea Water samples of Sarımsaklı beach at the Aegean coastal region of Turkey and its effects on natural radioactivity. With the aid of gamma spectroscopy the mean radioactivity concentration was found to be 1093.00 ± 115.07 Bq kg^{-1} for the beach sand; and 14.08± 3.50 Bqkg^{-1} for the seawater. The average external effective dose rate of beach sand was determined in the air at 1 m above the ground as 45.58 ±4.80 nGy h^{-1}, which is consistent with the world seawater K-40 radioactivity level given as 11.84 Bq L^{-1}; while that of sand is higher than the population-weighted average concentration of K-40. Natural radioactivity affects aquatic life to a different degree. Baseline radiation exposure evaluation of the local population of aquatic life is an essential prerequisite for assessment of the external and internal radiation dose to the human populace. The growing rate of human activities in both nuclear and non-nuclear fields calls for the evaluation of human exposure to low levels of radiation. Through the consumption of aquatic life, humans are exposed to radiation that has a direct relationship with internal dose, hence it is essential for radiation protection.

2.0 Materials and Methods

Tight plastic containers were used to convey Soil samples to prevent cross-contamination. Initially, Soil samples were allowed to dry in open air then preceded to moisture removal that might have been left before using an oven at 110 degrees Celsius temperature until a constant weight was achieved. In processing the Soil sample further, pulverize was used to crush the Soil samples to powder level and as well as using a sieve of 2 mm mesh (ASTM 2005). 400g of oven-dried and pulverized Soil sample was filled into a Marinelli beaker and the sample identification was labeled for spectrum collection, the samples were kept for thirty days to attain secular equilibrium between radionuclides of interest and their short-lived progenies. In the case of the Water samples, one liter of each of the water samples from each of the locations was sealed airtight against leakage from the samples in the Marinelli beakers and the sample identification was labeled. Before spectrum collection, the samples were kept for thirty days so that secular equilibrium would take place between radionuclides and their short-lived progenies. Fresh Catfish, Tilapia and crab were bought from the fishermen before embarking on sales to the retailers from the riverside at Makoko and the University of Lagos waterfront. Five grams (5.0 g) of each of the fish were washed and oven-dried then made into powder form for digestion separately. Five (5) grams of the samples were digested in 20ml 10% hydrochloric acid (HCL) on a heating mantle which shows thick brown fumes as it burned off the hydrocarbon content to become white.

2.1 Gamma-ray spectroscopy using (HPGe)

Gamma-ray spectrometry offers a convenient analytical method for the identification of isotopes due to the discrete energy of gamma rays. The procedure is not only qualitative but also quantitative. In the present study, HPGe gamma-ray spectrometer was used for the identification and measurement of the activities of radionuclides in soil and water samples. Hyper purity germanium detectors (HPGe) are one of the major and appropriate devices for photon detection due to their high resolution. HPGe detectors require a cooling system, commonly liquid nitrogen at 77 K in a 25 L Dewar. The ambient temperature around the detector was relatively stable at 16°C during the period of measurement. A coaxial cylinder

(78 mm in diameter and 69.8 mm in length), p-type high purity germanium (HPGe) detector, with a relative efficiency of 80%, and an energy resolution (FWHM) of 2.3 KeV for the 1.33 MeV reference transition of ^{60}Co, was utilized for the measurements.

3.0 Result and Discussions

Soil and water samples were collected from three different locations of interest to this study. The average activity concentrations in (Bq\Kg) of the selected radionuclide were obtained and recorded.

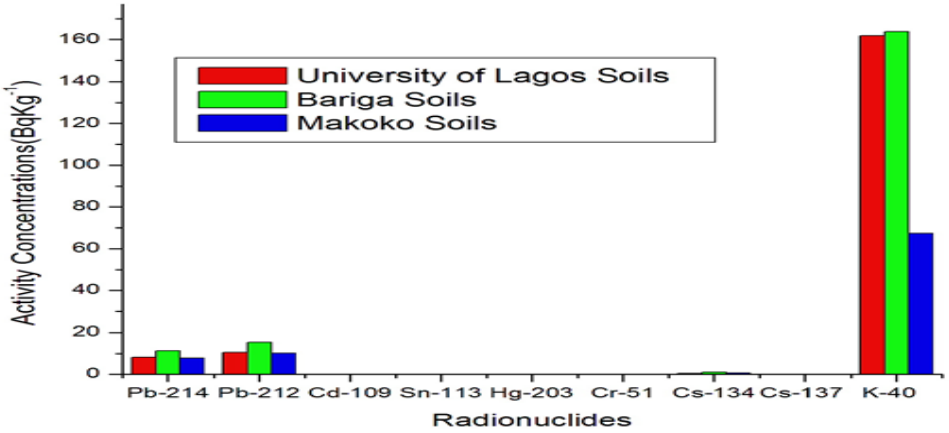

Fig.: 2 Radionuclide concentrations in soils samples from the three locations

From Fig. 2 it can be deduced that, in Makoko soil, Cd-109, Sn-113, Hg-203 and Cs-137 were not detected. However, Pb-214 and Pb-212 exhibited concentrations of 7.89±0.51Bq/Kg and 10.20±1.21 Bq/Kg respectively, Cs-134 was noted to have the least activity concentration (0.69±0.10 Bq/Kg) while K-40 displayed the highest activity concentration (67.37±2.52 Bq/Kg). However, soil samples from the Bariga station have concentrations of Pb-214 and Pb-212 to include 11.02±0.61 Bq/Kg and 15.37±1.43 Bq/Kg respectively, Cd-109, Sn-113, Hg-203 and Cs-137 were not detected. Cs-134 with the least activity concentration of 1.02±0.12 Bq/Kg while K-40 showed the highest activity concentration of 163.85±4.43 Bq/Kg. Soil samples from the University of Lagos waterfront indicated the presence of, Pb-214 and Pb-212 with activity concentrations of 8.22±0.51 Bq/Kg and 10.54±1.18 Bq/Kg respectively while Cd-109, Sn-113, Hg-203 and Cs-137 were not detected. However, Cs-134 with the least activity concentration of 0.57±0.15 Bq/Kg and K-40 with the highest activity concentration of 161.78±4.38 Bq/Kg.

In comparing the activity concentration of the Soil samples from the three locations, the University of Lagos Soil sample has the least activity concentration of Cs-134 radionuclide against the highest from Bariga. For Pb-212 and 214 respectively Makoko has the least activity concentration against the highest from Bariga. For K-40, Bariga has the highest activity concentration against the lowest from Makoko.

The K-40 activity concentrations recorded were very significant in all three locations of study,163.85±4.43 Bq\Kg, 161.78±4.38 Bq\Kg, 67.37±2.52 Bq\Kg from Bariga, University of Lagos waterfront respectively. The reason for this significant activity is very obvious because of the low level of farming going on around the waterside, most of the farmers might be using artificial fertilizers for improved cropping in the area. The commonly used artificial fertilizer in this area is Potassium. In Fig. 3 the energy spectra of the soil samples from the three locations indicate

that the background spectrum (0 – 3500 KeV) collected for five hours. Makoko and Bariga have the most pronounced spectra of the samples collected, this reflects the background radiation levels from the locations as recorded

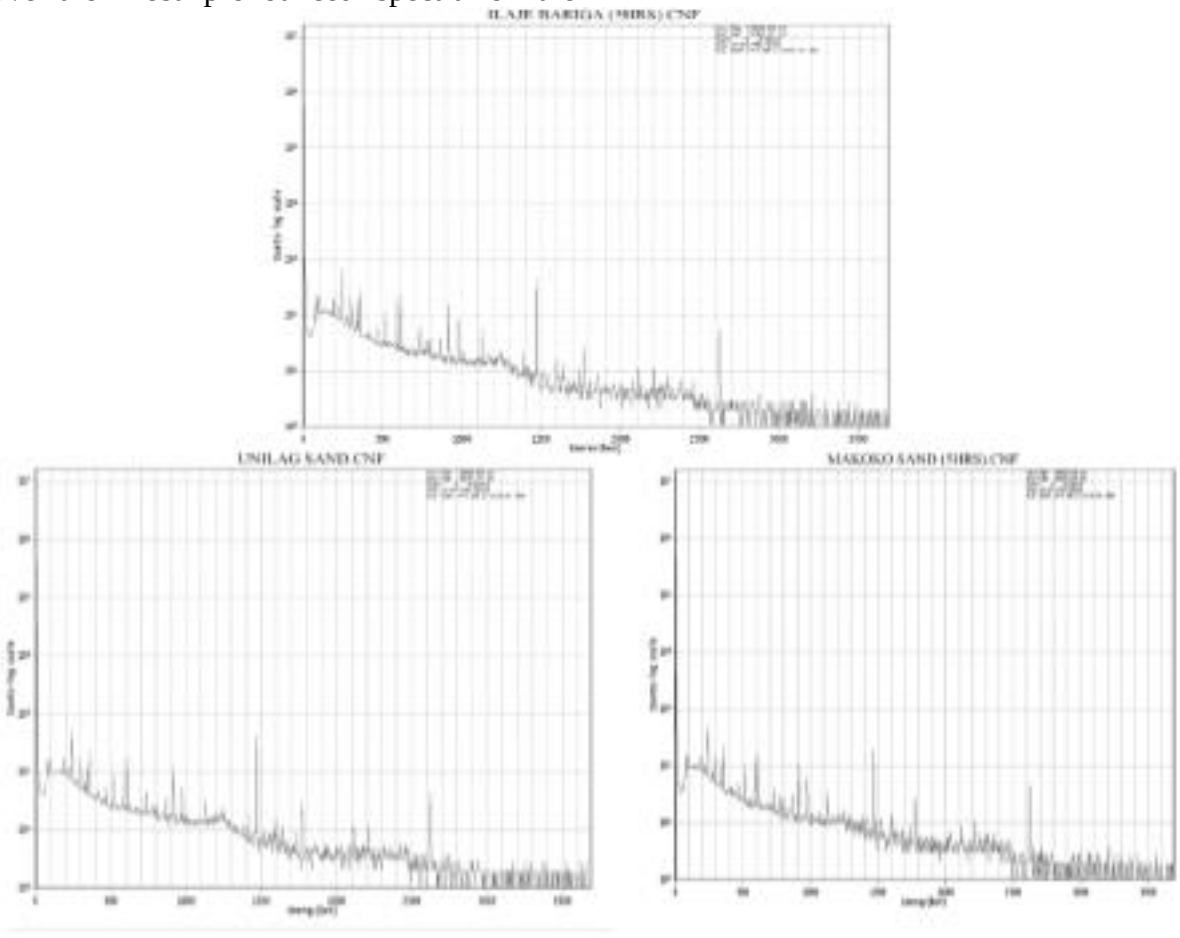

Fig.: 3 The Energy Spectra of Soil Sample from three locations.

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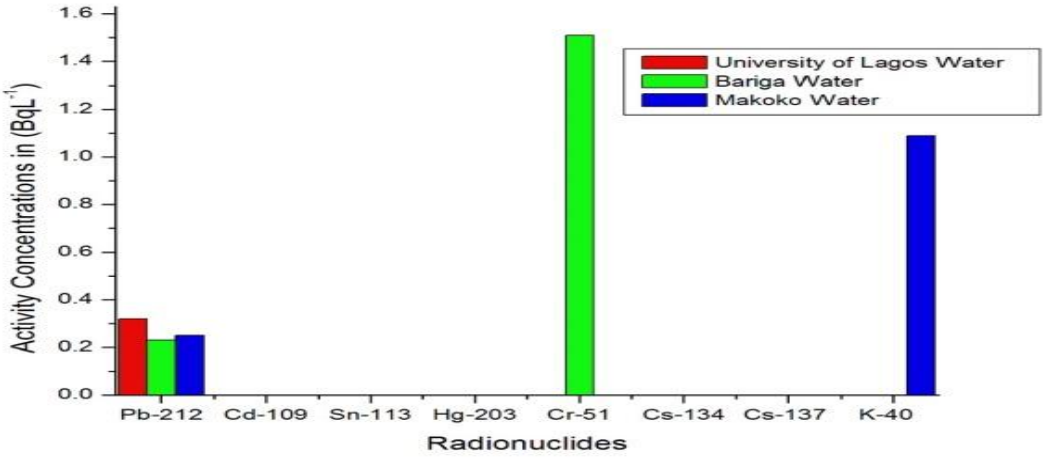

Fig. 4: The radionuclide concentrations levels in the water samples from the three locations.

Figure 4 shows the activity concentrations in (Bq/L) of radionuclides detected in water samples from the three locations. From the University of Lagos waterfront, the water

sample collected, indicated the absence of Cd-109, Sn-113, Cs-134 and Cs-137 Pb-214, Hg-203 and K-40 while Pb-212 was noted to have an activity concentration of 0.32±0.12 Bq/L. The results from the Bariga water samples show that Pb-214, Cd-109, Hg-203, Cs-134 and Cs137 were also not detected. Also, the measured concentration of K-40 was below the detectable limit while Pb-212 and Cr-51 were detected with average activity concentrations of 0.23±0.10Bq/L and 1.51±1.10Bq/L respectively. Makoko's location indicates that the radionuclide in the water sample does not contain Pb-214, Cd-109, Sn-113, Hg-203, Cr-51, Cs-134 and Cs-137 but concentrations of Pb-212 and K-40 were 0.25±0.10 Bq/L and 1.09±0.09 Bq/L respectively. In our studies, we also investigated the activity of radionuclides in some selected aquatic life that is commonly consumed in the locality here in Lagos. The following results were obtained from our investigations. From the three samples location (Bariga, University of Lagos waterfront and Makoko fish outlets) we collected freshly caught Tilapia Fish, Catfish and Crab from the lagoon for assessments.

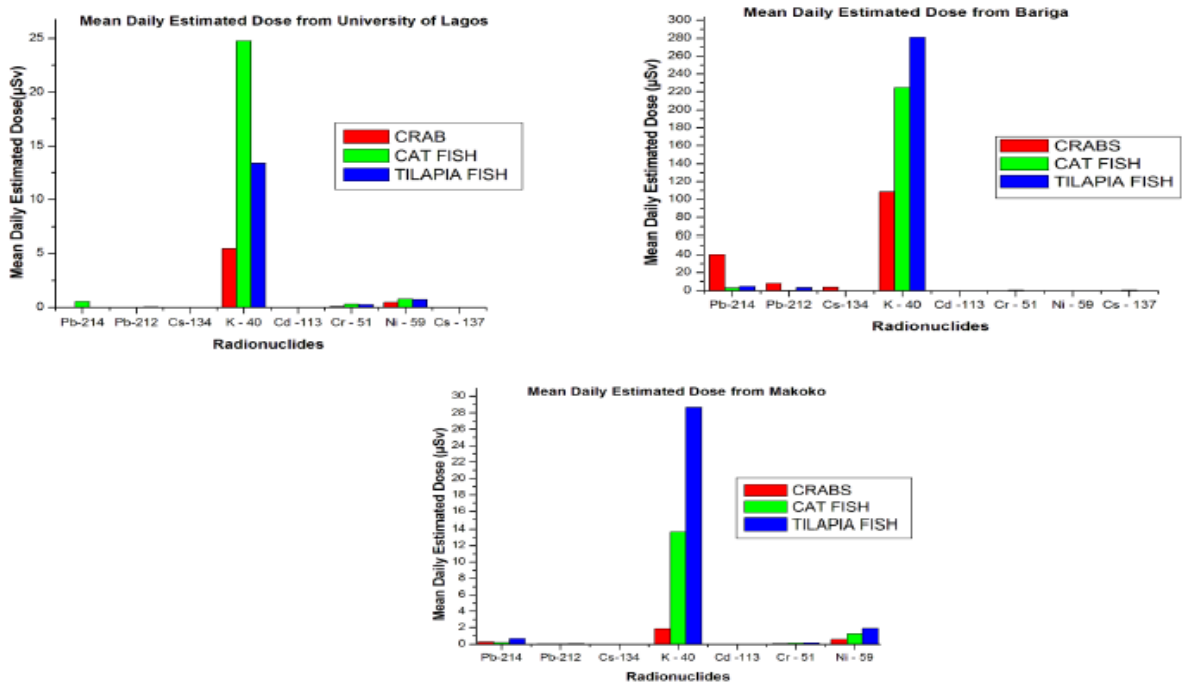

Fig. 5: The radionuclide concentrations in part per million (Bq\Kg) from the three sample locations of interest

Fig. 5 shows the activity concentration in part per million (Bq\Kg) of the radionuclides detected from each of the sample locations for the fish species and crab. Samples from the University of Lagos waterfront had concentrations of Cd-113, Cs-134, Cd-113, and Pb -212 in catfish below the detectable limit, while Ni-59, Cr-51, K-40 and Pb-214 were 0.660, 0.249, 21.250 and 0.468 Bq\Kg respectively. In crab, samples, Cs- 134, Cd-113 and Cs-137 concentrations were also the experimentally detectable limit in crab. However, concentrations of Ni-59, Cr-51, K-40, Pb-212 and Pb-214 were 0.716, 0.112, 8.750, 0.005 and 0.019 Bq\Kg respectively. So also for Tilapia fish from the university of Lagos water (Fig. 5) reveals concentrations of Cd-113,Cs-137 and Cs-134 below the detection limit but Ni-59,Cr-51,K-40,Pb-212 and Pb-214 activity concentrations were

0.608, 0.228, 11.500, 0.032 and 0.008 Bq\Kg respectively. The results from samples taken from the water in the Makoko location indicated that catfish displayed Cd-113, Cs-134 and Cd-113 concentrations below the detection limits while Ni-59, Cr-51, K-40, Pb-214 and Pb-212 concentrations were 1.052, 0.249, 0.219, 11.750, 0.201 and 0.035 Bq\Kg respectively. Cs-134, Cd-113 and Cs-137 were also below the experimentally detectable limit for crab samples but detected concentrations of Ni-59, Cr-51, K-40, Pb-212 and Pb-214 were 0.880, 0.139, 3.001, 0.079 and 0.475 Bq\Kg respectively. In tilapia fish, Cd-113, Cs-137 and Cs-134 were not detected but Ni-59, Cr-51, K-40, Pb-212 and Pb-214 displayed the following concentrations; 1.652, 0.156, 24.630, 0.073 and 0.568 Bq\Kg respectively.

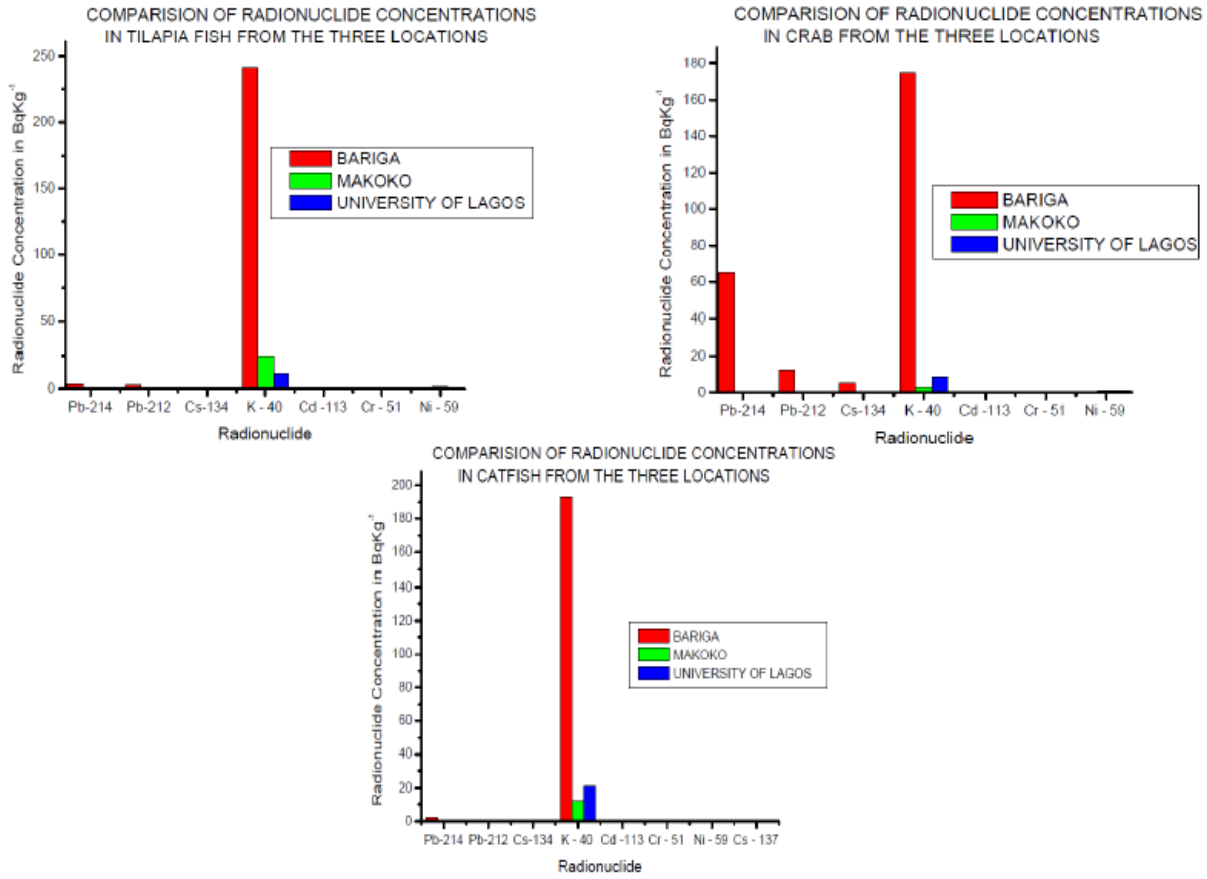

Figure 6: illustrate the comparison of radionuclide concentrations (Bq\Kg) in Tilapia fish, Catfish and Crab from the three locations of interest

Samples from the Bariga location (Fig. 5) indicated that Cd-113, Cd-113 were not detected in crabs. Also, concentrations of Ni-59 and Cr-51were below the experimentally detectable limit but; K-40, Cs-134, Pb-214 and Pb-212 concentrations were 174.94, 5.42, 12.56 and 65.01Bq\Kg respectively. In Catfish, Cs-134 concentration was also below the experimentally detectable limit while Cd-113 and Ni-59 were also not detected. However, Cs-137, Cr-51, K-40, Pb-212 and Pb-214 concentrations were 0.60, 0.79, 241.41, 2.75 and 3.91 Bq\Kg respectively. In Tilapia fish, the results obtained indicated that Cd-113, Cs-137, Ni-59 and Cs-134 concentrations were below the detection limits but measured

concentrations of Cr-51, K-40, Pb-212 and Pb-214 were 0.06, 241.41, 2.75, and 3.90 Bq\Kg respectively. Of all the three sampling from the University of Lagos sample station. Crab samples showed the highest concentration of Ni-59 activity concentrations and also, the lowest concentration of Cr-51. However, Catfish samples displayed have the highest activities for K-40, Cr-51 and Pb-214 while the lowest was recorded for Pb-214 in tilapia. Samples from the Bariga sampling stations showed the highest concentrations of Cr-51 and Cs-137 in catfish while crabs displayed the highest activity concentrations for Cs-134 and Pb-214 and tilapia had for K-40.. Samples from the Makoko station showed that tilapia has the highest activity concentration of Pb-214, K-40, Cr-51 and Ni-59 while crab and catfish Had the least.

4.0 Conclusion

In comparing the three Water samples from the three different locations the results show that AAC of Pb-212 is the highest from the university of Lagos waterfront and lowest in Makoko location. However, there is slight variation in the radioactivity content in soil as observed in different locations worldwide mainly due to soil. The mean absorbed dose rate obtained in the present study (66.64±6.81 nGy/ h) is comparable to the world average (55 nGy/h). The calculated annual effective dose with an average value of 0.082 mSv is lower than the world average value (0.480 mSv). The measured values of the external hazard index found in this study range from 0.33 - 0.47, which means that at the time of the investigation, the radiological health impact on the population living in the investigated area, is reasonable.

5.0 Acknowledgement

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6.0 Reference

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Authors Contributions

Dr. Ogungbemi did data analysis and draft of the paper. Williams Igoniye did sampling, data collection and analysis and Dr. Ibitoye did first prove reading and corrections ; while Dr. Adedokun did analysis and prove reading, Dr. Oyebola carried out the final prove reading of the paper.