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GROSS ALPHA AND BETA ACTIVITIES OF SAND SEDIMENTS AND HEAVY METAL CONCENTRATION IN SELECTED RIVERS OF ANIOCHA SOUTH, DELTA STATE

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ABSTRACT

The concentrations of gross alpha and gross beta radioactivity were analyzed in Aniocha South LGA of Delta State. Sediments were collected from randomly selected points on three major rivers in the LGA characterized by human activities, overpopulation, and industrialization. Standard methods were deployed for determination of gross alpha and gross beta radioactivity ineach sample by using an eight channel gas flow proportional counter and also to determine the concentrations of Cd, Pb, Cu and As in the water samples were done using chemical fraction method. The results show that the range of gross alpha and gross beta activity in the river sand sediment is 0.00014-0.00020 Bq/kg and 2.68-5.20 Bq/kg respectively. These results appear to be lower when compared with values from previous studies throughout the world, and WHO recommended limit. The results in this study showed that Pb, Cu, and As in the three river water samples are below the WHO recommended limit of 0.05, 1.5 and 0.05 ppm except for the value of Cd which is higher than the recommended limit of 0.005 ppm in one river water respectively. The pH level for the water samples was below World Health Organization (WHO) limit of 8.0. Similarly, the study could be a reference data for future research related to radiological mapping or environmental monitoring in the area.

Keywords: Contamination, Heavy Metal, Health Risks, River, Sand Sediment, Delta State.

INTRODUCTION

Radiation is ubiquitous in our environment and the amount of radiation reaching humans as a result of its contamination of our environment varies based on the type of radioactive substance present, the extent of contamination, and how far the contamination has spread Ogundare and Adekoya (2015) The recent increase in the levels of radiation pollution in the environment has been attributed and or directly linked to human activities such as milling and processing of uranium ores, and mineral sands, mining, smelting of metalliferous ores, crude exploration and refining, and the continuous and excessive use of fertilizers Topcuoğlu et al. (2010); Ogundare and Adekoya(2015); Avwiri and Ebeniro (1998); Foland et al .(1995); Pujol and Sanchez-Cabeza (2000).

Gross alpha and gross beta activity concentration in sand sediment samples is defined as the total radioactivity of all alpha and beta emitters in the samples Agbalagba et al. (2021). The geological formation of the area, the concentration of mineral components and the nature of human activities in the area are factors that determine the amount of gross activity as a result of these alpha emitters in sand sediment Ogundare and Adekoya (2015). Natural isotopes, 40K, 210Pb and 228Ra are the cause of gross beta activity in sand sediment Bunotto and Bueno (2008); Gruber et al. (2009). Although the effects of alpha and beta particles can be hazardous to human health when inhaled or ingested, their penetration power is lesser when compared to gamma radiations Ogundare and Adekoya (2015); Mokobia et al. (2020).

Water sediments are incredibly important in the water environment, because of their geological and chemical makeup. They serve as a pathway connecting the land, sea and atmosphere, allowing for the movement and exchange of substances between these different parts of the ecosystem Kurt et al. (2016).

Researchers, governments and relevant stakeholders have channeled their resources towards assessment of gross activities in river sand sediments following radiological hazards arising from increasing human population and activity, increased industrial activities.This is to ensure that the Reference Dose Level (RDL) of 1.0 mSv/yr for soil and sediments is maintained Avwiri and Agbalagba (2007).

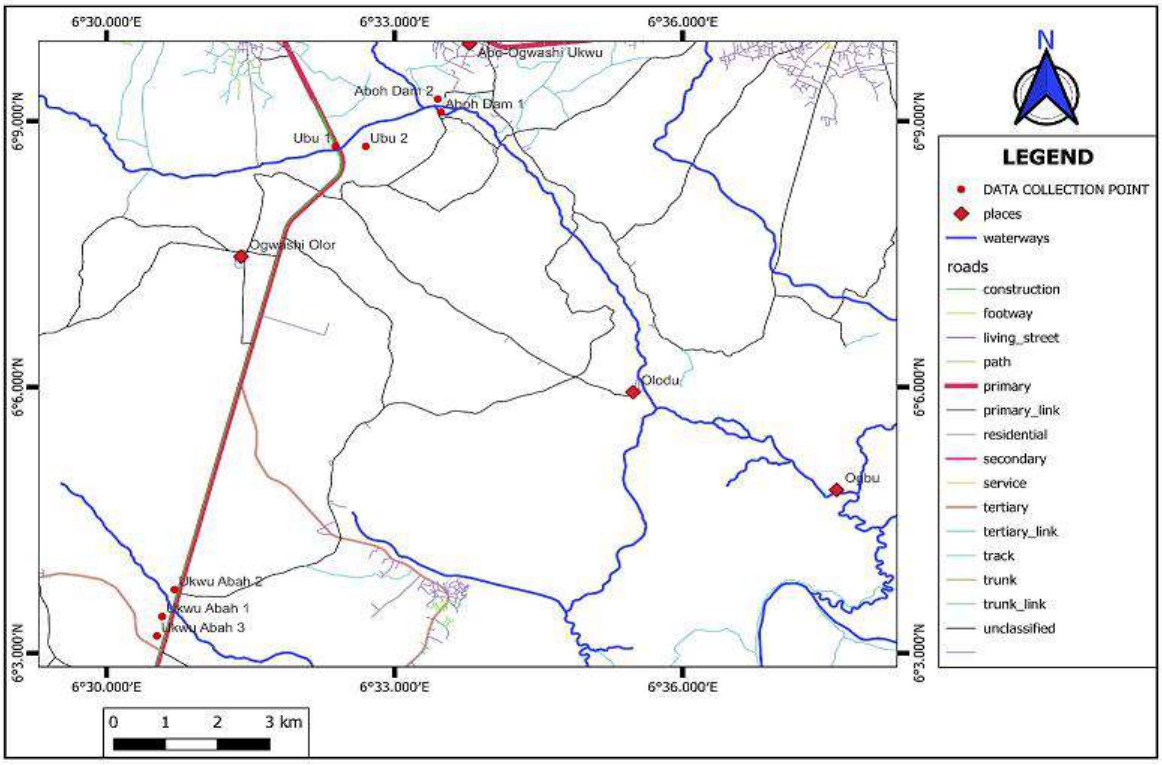
The objective of this study is to assess the gross alpha and beta activity concentration in sediment and its natural remediation effect. This is to ascertain the safety of sediments for use as building material in the study area. The health implications of the river water usage in the study area.

MATERIALS AND METHODS

Description of Study Area

The study area as shown in Figure 1 lies within latitude 6˚ 08′ N and longitude 6˚ 29′ E West of the Niger, Delta state of Nigeria. Aniocha South Local Government shares boundaries with Oshimili South to the North, Aniocha North to the Northeast, Ika Southeast to the South and Ndokwa West to the Southeast.

Figure 1: Map of the study area showing the sampling points.



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Sampling and Preparation Techniques

Sediment Sampling:

Three cardinal points were used to collect samples, this is to enable a wider coverage of the river when collecting samples and in each of the sampled river, three sand sediments were collected from each river and average obtained. Collection of samples was carried out during the wet season in all the sampling sites.

Samples were collected and prepared in accordance with the guideline of International Atomic Energy Agency (IAEA) (1996). Sediment samples were collected at the bottom of the river using hand steel. The auger was first cleaned with acid, and then washed with detergent before rinsing with tap water. All samples were collected into properly labeled black polythene bags after water content had been filtered out from the samples. Samples were immediately transported to the laboratory where they were kept in a slow-air flow drying cabinet that will allow the drying process to take place without loss of radionuclides from the samples.

All dried samples were crushed using a mortar and pestle and then they were sieved through a100-mesh sieve. After that, the prepared samples were sent to be compressed into pellets using a hydraulic compressor machine. The pelleted samples were then kept in desiccators and stored in the laboratory before counting.

Water Sampling

Water samples were collected along the shoreline of each sampled river at varying intervals. A 250 mL container was used to collect samples which was first washed with detergent and then rinsed several times with sampled water. Standard methods as suggested by Ogola et al.(2011); Ijabor et al. (2024) were employed to determine the pH and conductivity of the samples.

Counting Equipment

The gross alpha and gross beta activity rates of all samples were measured using a calibrated gas-flow proportional counter [Eurisys Measure IN20 low-background multiple (eight) channel counter] at Centre for Energy Research and Training (CERT) Material Laboratory, Ahmadu Bello University Zaria (ABU) Nigeria. The description of the gross alpha and gross beta counting equipment has been described elsewhere Agbalagba et al.(2021).

Gross Alpha Counting

For gross alpha counting, samples were counted for 13 cycles of 180 seconds per cycle with voltage set at 1650 V. The results were displayed as raw counts; count rate (count/min), activity and standard deviation. The data were acquired by setting the counter at alpha only mode displaying the alpha count rate R_α as well as alpha activity A_α was calculated using the formula:

$$R_\alpha = \frac{Raw \propto Count}{Count\ time} \quad (1)$$

$$A_\alpha = \frac{(R_\propto\ background)\times(unit\ coefficient)}{(chennel \propto efficiency)\times(sample\ efficiency)\times(sample\ volume)} \quad (2)$$

The gross alpha activity concentration C_α is calculated using the formula ISO 9696:1992 (E) International Organization for Standardization (1992)

Gross Beta Counting

For gross beta counting, the voltage was set at 1700 V, a difference of 50 V from that of gross alpha counting. Here the samples were counted for 180 seconds per cycle for 25 cycles in beta only mode. The count rate and the activity were calculated using the formula.

$$R_\beta = \frac{Raw\ \beta\ Count}{Count\ time} \quad (3)$$

$$A_\beta = \frac{(R_\beta\ background)\times(unit\ coefficient)}{(chennel\ \beta\ efficiency)\times(sample\ efficiency)\times(sample\ volume)} \quad (4)$$

The gross beta activity concentration C_β is calculated using the formula ISO 9697:1992(E) International Organization for Standardization (1992).

Measurement of heavy metals concentrations

To analyze heavy metals in water samples, the following steps were taken:

First, the water samples were filtered and treated with 10 mL of concentrated nitric acid, which was mixed with 200 mL of the water sample. The resulting solutions were then evaporated in a beaker on a hot plate to produce the volume to around 5 mL. Afterwards, the solutions were filtered into a 20 mL standard flask and topped up with double distilled water Ugbede et al.(2020).

The digested samples were subjected to analysis for the presence of heavy metals namely Copper (Cu), Lead (Pb), Cadmium (Cd), and Nickel (Ni). This analysis was performed using an Atomic Absorption Spectrophotometer (AAS) of model Varian FS240AA, manufactured by Agilent Technologies. The AAS, which utilized an air-acetylene flame as a fuel source, was accessed at the Springboard Research laboratories in Awka, Nigeria.

To establish a baseline, a calibration blank was prepared using all the necessary reagents except for the metal stock solutions. Calibration curves were then generated for each metal by plotting the absorbance of solutions against their known concentrations. The analysis was performed multiple times to ensure accuracy, and the average values were recorded.

Health risk assessment

Estimation of average daily dose (ADD), hazard quotient (HQ) and hazard index (HI) of metals

Dermal contact, inhalation, and ingestion pathways are some of the various known means by which heavy metals enter the human body Mokobia et al.(2020). However, oral ingestion is most noteworthy as compared to other pathways. To estimate the potential human health risk levels of selected heavy metals in the water samples, the average daily dose (ADD), in mg/kg/day, through oral ingestion was calculated for both children and adults using equation 5 Ugbede et al.(2020).

$$ADD = \frac{C_m \times IRW \times EF \times ED}{BW \times AT} \quad (5)$$

Where C_m is the average heavy metal concentration in water (mg/L); IR is ingestion rate of water (L/day) taken to be 1.0 L for children and 2.0 L for adults Bortey-Sam et al.(2015); Mgbenu and Egbueri, (2019). EF is exposure frequency equal to 365 days/year; ED is duration of exposure, which is 6 and 70 years for children and adults respectively. BW represents body weight, which was considered to be 15 and 70 kg for children and adults respectively. AT is the average exposure time for life expectancy. AT for adults is 25,550 days while for children it is 2190 days Bortey-Sam et al. (2015); Mgbenu and Egbueri, (2019). Hazard quotient (HQ) was used to evaluate the non-

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carcinogenic risk posed by the metals. This was achieved using equation 6Akoto et al.(2020);Mgbenu and Egbueri (2019).

$$HQ = \frac{ADD}{RfD} \quad (6)$$

Where RfD indicates the reference dose of individual metal (mg/kg/day).

The RfD is used to estimate the chances of an individual developing or not developing cancer over a lifetime as a result of exposure to individual metal Bhutiani et al.(2016)

This means that exposures below the RfD for individual metal are unlikely to produce an adverse health effect, but above the RfD values an exposed individual may be at risk of any adverse health effect. Rfd values for Cu (0.04), Pd (0.0035), Cd (0.0005), and Ni (0.02) were obtained from Ugbede et al.(2020) as suggested by USEPA(USEPA, 2015).

RESULTS AND DISCUSSION

Gross Alpha and Gross Beta Activity in Sand Sediment

The results of the analysis for gross alpha and beta activity concentration in the river sand sediment samples are presented in Table 1. The table also shows the different coordinates where sand sediment samples were collected along the respective rivers.

The gross alpha activity concentration ranged from 0.00014 to 0.00020 Bq/kg with 0.00020 Bq/kgas the maximum value for gross alpha while the gross beta activity concentration ranged from 2.68 to 5.20 Bq/kgwith maximum value obtained in samples from Ubu River (AD3).

Table 1: Gross alpha and beta activity concentration in sand sediments from sampled rivers in Ogwashi-Uku, Delta State

S/N	Location	Mean Activity of Gross Alpha (Bq/Kg)	Mean Activity of Gross Beta (Bq/Kg)	Coordinates	Code
1	Ukwu Abah	0.00014	2.68	6.61 E, 6.14 N	UA
2	Aboh Dam	0.00020	3.22	6.63 E, 6.17 N	AD
3	Ubu River	0.00018	5.20	6.60 E, 6.25 N	UR

Since there is no established regulatory standard for river sand sediment radiological pollutants, the results obtained in this study are compared with those in other areas as presented in Table 2.

Table 2: Comparison of gross alpha and beta activity concentration in this study to other studies.

Concentration of gross alpha (Bq/Kg)	Concentration of gross beta (Bq/Kg)	Sediment Sources	Reference
218	579	River	Önce, and Kam. 2019
0.782 – 4.596	0.482-10.372	River	Ozlem et al. 2009
26.2 – 33.7	396 - 489	Niger Delta	Agbalagba et al. 2021
0.00014-0.00018	2.68 – 5.20	River	This Study

Comparison of gross alpha and beta concentrations obtained in this study with literatures is presented in Table 2. The table shows that the activity concentration of gross alpha and beta are lower than reported studies in Nigeria (Agbalagba, 2021). For reported studies outside Nigeria (Rivers) the activity concentration of gross alpha and beta are lower than reports of Aytas et al. (2012), Ozlem et al. (2009) and Once and Kam (2019).The lower activity concentrations of gross alpha and beta in this study compared to other studies may be due to the geological properties of the river and the activities carried out around the river.

Table 3: Concentration of Elements and Physiochemical Properties of Water Sample for the Selected Rivers

Parameters	Ubu River	Aboh River	Ukwu Abah River
pH	6.94	7.12	6.78
Dissolved oxygen mg/l	19.60	22.40	18.10
Conductivity mg/l	16.80	17.3	16.50
Temperature ^oC	29.40	29.00	28.50
Nitrate abs	0.202	0.815	0.220
Conc mg/l	4.165	17.526	4.536
Copper (ppm)	BDL	BDL	0.114
Lead (ppm)	0.046	0.006	0.025
Cadmium (ppm)	0.019	0.018	0.010
Nickel (ppm)	0.006	0.003	0.002

Cu – Copper, Pb – Lead, Cd – Cadmium, Ni – Nickel   BDL: Below Detection Limit

The concentration of elements and physiochemical properties of water samples from selected river in the study area is presented in table 3. The results in this study showed that Cu, Pb and Ni in the three river water samples are below the WHO recommended limit of 1.5, 0.05 and 0.05 ppm except for the value of Cd which is higher than the recommended limit of 0.005 ppm in one river water respectively. The Electrical Conductivity (EC) which is directly proportional to the salinity of the water has values ranging from 16.50 to 17.3 mg/l. These values are below the stipulated guideline of 70 mS/m set by DWAF (1996) for domestic use (DWAF, 1996).

The highest pH value of 7.12 was obtained in Aboh river and this value is below the WHO recommended limit of 8.0 (WHO, 2003).

Table 4: Summary of ADD, HQ and HI of heavy metals in water samples of the various river

ADD	**Ubu River**		**Aboh River**		**Ukwu Abah River**	
Metal	**Children**	**Adults**	**Children**	**Adults**	**Children**	**Adults**
Copper (Cu)	0.0000	0.0000	0.0000	0.0000	0.007	0.003
Lead (Pb)	0.003	0.001	0.003	0.0001	0.002	0.0007
Cadmium (Cd)	0.001	0.0005	0.001	0.0005	0.0007	0.0003
Nickel (Ni)	0.0004	0.002	0.0002	0.0001	0.0001	0.0001
HQ						
	0.000	0.000	0.000	0.000	0.175	0.075
	0.875	0.286	0.857	0.029	0.571	0.2
	0.2	0.1	0.2	0.1	0.14	0.06
	0.02	0.1	0.01	0.005	0.005	0.005
HI						
	1.077	0.486	1.067	0.134	0.891	0.34

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The concentrations of heavy metal in water samples were used to determine the average daily dose (ADD) through oral exposure. This analysis was conducted for both children and adults, and the findings presented in Table 4. To assess the potential risks associated with these exposures, the calculations included comparing the measured concentrations to the reference dose (RfD) for each specific metal. Based on these comparisons, the hazard quotients (HQ) and hazard index (HI) were calculated.

The ADD values for Cu, Pb and Ni in all the river water samples for both children and adults were below their RfD values. However, ADD values for Cd in Ubu River and Aboh River for adults (0.0005) are the same as the RfD value while in Ukwu Abah River, for children has value (0.0007) higher than the RfD value. HQ values for all the metals are less than unity which suggests the non-vulnerability of individuals to metal toxicity in the sampled river water.

Generally, the hazard index (HI) value for all metals was found to be lower than unity except for Ubu River (1.077) and Aboh River (1.067) which have their values of HI for children higher than unity.

CONCLUSION

An analytical approach to assess the gross alpha and beta activities in sand sediments and heavy metals in three rivers in Aniocha South LGA was carried out. The results obtained in this study, clearly showed that all samples from the respective rivers are below the recommended values for gross alpha and beta activity and below the permissible limit set by WHO for heavy metals in water. Although these result pose no immediate health threat to the increasing population of the town although the continuous usage of sand from these rivers for building and construction purposes and water for domestic and agricultural purposes may be detrimental to human health as radiation and metals tend to accumulate in human lungs and body with prolonged exposure. The health risk assessment shows that Pb and Cd are the metals of increasing pollution profile. The hazard index revealed that children are vulnerable to non-cancer effects through oral intake. This study further revealed that continuous consumption of the river water especially by children may be detrimental to their health. This therefore calls for urgent attention of relevant government agencies to make available potable water supply for the community.

REFERENCES

Agbalagba, E.O., Egarievwe, S.U., Odesiri-Eruteyan, A.O. & Drabo, M.L. (2021). Evaluation of Gross Alpha and Gross Beta Radioactivity in Crude Oil Polluted Soil, Sediment and Water in the Niger Delta Region of Nigeria. Journal of Environmental Protection. 12(2).

Avwiri, G.O.,& Agbalagba, E.O. (2007) Survey of Gross Alpha and Gross Beta Radionuclide Activity in Okpare-Creek Delta State Nigeria. Asian Journal of Applied Science, 7, 3542-3546. https://doi.org/10.3923/jas.2007.3542.3546

Avwiri, G.O.,& Ebeniro, J.O. (1998) External Environmental Radiation in an Industrial Area of Rivers State. Nigerian Journal of Physics, 10, 105-107.

Akoto, O., Gyimah, E., Zhan, Z., Xu, H., & Nimako, C. (2020). Evaluation of health risks associated with trace metal exposure in water from the Barekese reservoir in Kumasi, Ghana, Hum. Ecol. Risk Assess: An Int. J. 26 (4) (2020) 1134–1148, doi: 10.1080/10807039.2018.1559033.

Bhutiani, R., Kulkarni, D.B., Khanna, D.R.,& Gautam, A. (2016). Water quality, pollution source apportionment and health risk assessment of heavy metals in groundwater of an industrial area in North India, Expo. Health. 8: 3–18, doi: 10.1007/s12403-015-0178-2.

Bortey-Sam, N., Nakayama, S.M., Ikenaka, Y., Akoto, O., Baidoo, E., Mizukawa, H., &Ishizuka, M. (2015). Health risk assessment of heavy metals and metalloid in drinking water from communities near gold mines in Tarkwa, Ghana, Environ.

Monit. Assess. 187 (7) 397, doi: 10.1007/s10661- 015- 4630- 3.

Bunotto, D.M. & Bueno, T.O. (2008). The Natural Radioactivity in Guarani Aquifer Groundwater, Brazil. Applied Radiation and Isotopes, 66, 1507-1522.https://doi.org/10.1016/j.apradiso.2008.03.008

DWAF (DEPARTMENT OF WATER AFFAIRS AND FORESTRY, SOUTH AFRICA). (1996) South Africa Water Guidelines. Vol. 1-5 (2nd Ed.). Holmes S (Ed), CSIR, Environmental Services, Pretoria, South Africa.

Foland, C.K., Kirland, T.K.,& Vinnikoov, K. (1995) Observed Climate Variations and Changes (IPCC Scientific Assessment). Cambridge University Press, New York, 101-105.

Gruber, V., Maringer, F.J. &Landstetter, C. (2009) Radon and Other Natural Radionuclides in Drinking Water in Austria: Measurement and Assessment. Applied Radiation and Isotopes, 67, 913-917. https://doi.org/10.1016/j.apradiso.2009.01.056

Guidance for Dermal Risk Assessment), Washington, DC, 2014 https:// www.epa.gov/sites/production/files/2015-09/documents/part_e_final_revision_10-03-07. pdf.

IAEA (International Atomic Energy Agency) (1996) International Basic SafetyStandards for Protection against Ionizing Radiation and for the Safety of RadiationSources. International Atomic Energy Agency, Vienna.

Ijabor B.O., Nwabuoku, A.O., Okpilike, J.C., Erhuvwuada, R. & Mallam-Obi, C.U. (2024). Risk assessment of drinkable water from hand-dug reservoirs using gross alpha and beta radioactivity levels in ogwashi-uku, delta state. British Journal of Environmental Sciences. 12(1):34-42.

International Organization for Standardization (1992) Water Quality-Measurement of Gross α Activity in Non-Saline Water-Thick Source Method. International Organization for Standardization, London.

Kurt, D., Kam, E., &Yumun, Z. U. (2016). Distribution of Gamma Radiation Levels in Core Sediment Samples in Gulf of İ zmir: Eastern Aegean Sea, Turkey. – International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering 10: 375-379.

Mgbenu, C.N. & Egbueri, J.C. (2019). The hydrogeochemical signatures, quality indices and health risk assessment of water resources in Umunya district, south- east Nigeria, Appl. Water Sci. 9: 22, doi: 10.1007/s13201- 019- 0900- 5.

Mokobia, C.E., Nwabuoku, A.O., & Igbeka, C. (2020). Indoor radon concentration measurements in houses of selected communities in Delta Central of Delta State. Nigerian Journal of Science and Environment, Vol.18 (2): 71-81.

Ogola, J.S., Mundalamo, H.R., & Brandi, G. (2011). Investigation of the origin and distribution of heavy metals around Ebenezer Dam, Limpopo Province, South Africa. http://www.wrc.org.za

Ogundare, F.O. & Adekoya, O.I. (2015) Gross Alpha and Beta Radioactivity in Surface Soil and Drinkable Water around a Steel Processing Facility. Journal of Radiation Research and Applied Sciences, 8, 411-417. https://doi.org/10.1016/j.jrras.2015.02.009

Önce, M., & Kam, N. (2019). "Gross Alpha and Gross Beta Activity Levels of Holocene Sediments between Şarkoy and Murefte (Tekirdağ)". Journal of Engineering Technology and Applied Sciences 4 (2): 63-69.

Pujol, L. & Sanchez-Cabeza, J.A. (2000) Natural and Artificial Radioactivity in Surface Waters of the Ebro River Basin (Northeast Spain). Journal of Environmental Radioactivity, 51, 181-210. https://doi.org/10.1016/S0265 931X (00)00076-X

Ugbede, F.O., Aduo, B.C., Ogbonna, O.N., & Ekoh, O.C. (2020). Natural radionuclides,

Scientia Africana, Vol. 23 (No. 3), August, 2024. Pp 81-90
© Faculty of Science, University of Port Harcourt, Printed in Nigeria *ISSN 1118 – 1931*

heavy metals and health risk assessment in surface water of Nkalagu river dam with statistical analysis. Scientific African 8: e00439

USEPA, US Environmental Protection Agency, Risk Assessment Guidance For superfund. Volume I, Human Health Evaluation Manual (Part E, Supplemental

Topcuoğ lu, S., Ergue, H. A., Belivermis, M., &Kilic, O. (2010). Monitoring of radionuclide concentrations in marine algae, mussel and sediment samples from the Turkish marine environment during the period of 2001-2009. – J. Black Sea/Mediterranean Environment 16: 285-293.

WHO (2003). Guidelines for Drinking-Water Quality (3rd Ed.) Vol.1. World Health Organization, Geneva. 488-493.

WHO, (2011). Guidelines for Drinking-Water Quality, fourth ed. WHO Library Cataloguing in Publication Data NLM classification, Geneva, p. 675. WA.

Zorer, Ö. S., Ceylan, H., % Doğru, M., (2009). Gross alpha and beta radioactivity concentration in water, soil and sediment of the Bendimahi River and Van Lake (Turkey). Environmental Monitoring and Assessment 148: 39-46.