INTERNATIONAL JOURNAL OF: SCIENCE RESEARCH AND TECHNOLOGY

TIMBOU-AFRICA ACADEMIC PUBLICATIONS
INTERNATIONAL JOURNAL, FEBRUARY, 2022 EDITIONS
VOL. 8 NO. 9 ISSN: 2623-7861

RADIOACTIVITY STUDIES IN SEDIMENT OF AJIWA DAM, KATSINA STATE.

***ZAHRADDEEN L. KAFINSOLI; & **SULAIMAN BELLO**

**Department of Physics, School of Basic and Remedial Studies, Ahmadu Bello University, Zaria.*
***Department of Physics, Umaru Musa Ya'adua University, Katsina.*

ABSTRACT

A radioactivity measurement was carried out in water sediments of Ajiwa Dam. The sediment samples were collected, prepared and analyzed using Atomic Absorption Spectrometry (AAS) for the activity concentration of Zn, Cd, Cr, Cu and Pb. The results obtained shows

INTRODUCTION

Radioactivity in environment comes from both natural background and man-made sources. Naturally abundant radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in the environment, and release from fertilizers, agro chemicals, research and medical facilities forms the bulk of radionuclide in ground and surface water, (Wiser, *et al*., 2003). Therefore presence of radioactivity in the environment can be attributed to naturally occurring and or artificially induced sources. Naturally occurring radioactivity due to bedrock formation which are weathered, resulting in mineral leaching that leads to contaminations (Martin *et al* ., 19995); artificial radioactivity is due to human activities like mining

average activity of Cr ($1.69x10^{-6}$µg/L) and Zn ($5.69x10^{-6}$µg/L) show the higher concentration followed by Cu ($5.25x10^{-7}$µg/L) and Cd ($7.50x10^{-8}$µg/L). the concentration of metals recorded in this study were lower than USEPA guidelines for drinking water quality Zn (5000µg/L), Cu (1300µg/L), Cr (100µg/L) and d (5µg/L). However Pb was found below the detection limit throughout the samples. The levels of Exp_{ing} observed in order Cr>Cd respectively, while Cu, Pb and Zn were not detected. The mean levels of HQ_{ing} was found to be $1.79x10^{-3}$, this indicates that the value found to be below the unity HQ_{ing}>1. The average CDI values for selected metals (Zn, Cu, Cr, and Cd) were $1.78x10^{-7}$, $1.65x10^{-8}$, $5.327x10^{-8}$ and $2.355x10^{-9}$respectively, therefore CDI indices for heavy metals in the study area were found in order; Zn>Cu>Cr>Cd.

KEYWORDS: *Radioactivity, exposure, sediment and Ajiwa Dam.*

and milling of mineral ore which exposes the earth surface. All this contamination may have health effect; that poses great danger to human and other living organism in the biosphere. Due to this reason, the protection of water resources, water quality and biosphere is very critical for global human and environmental safety.

Many radionuclides are known to decay by alpha, beta, and other form of emission which happen to pose hazard when ingested. Among which are Cesium- 137, Chromium- 51, Cobalt- 60, Iodine- 132, Lead- 210, Phosphorus- 32, Radium- 226, Radon- 222, Scandium- 46, Strontium- 90, Thorium- 232, Uranium- 238, Zinc- 65, and Zirconium- 96, (Carry, 1996).

Exposure to ionizing radiation represents a potential hazard to humans and radioactivity is known to trigger deterministic effect and probabilistic effect (Hall and Giacca, 2006).

The terrestrial component of the natural background radiation is dependent on the compositios of the soil and rocks containing natural radionuclides. The radioactivity of soil is essential for understanding changes in the natural radiation background (Wu B., 2009). Soil contains small quantities of radioactive elements Ra and Th along with their progenies. The natural radioactivity of soil and sediment depends on the soil and sediment formation and transport processes that were involve since soil and sediment formation, chemical and biochemical interactions influence the distribution patterns of uranium, thorium and their decay products (Iqbal J., 2012).

Ajiwa Dam is generally used for irrigation, fishing, household activities and source of drinking water for livestock.

Uses of agrochemicals, fertilizer and some of the human activities that are very common in the area these may contribute to the inducement of radionuclides contamination in the Dam reservoir. High concentration of radioactive substance in the Dam may endanger the health of human, animals, plants and also affects the suitability of crops and water for human consumption (De Miguel E., 2007)

MATERIALS AND METHOD

Sample collection

Samples of sediments were collected randomly from 12 reference points for the analysis. The sediments were packed into 2ml bottles at a depth of approximately 0.6m to 0.8m and then treated with 2 drops of nitric acid to reduce the PH and minimize precipitation on container wall.

Sample Preparation for Atomic Absorption Spectrometry (AAS)

Sediment samples were air-dried at ambient laboratory temperature. The samples were grounded to pass through 2mm sieve and stored for

TIJSRAT
ISSN: 2623-7861

chemical analysis. With the aid of weighting bottle, 1 gram of each sample was obtained using high sensitive chemical balance. This was placed in a Teflon beaker and transferred to a fume-cupboard for digestion. The digestion was carried out using concentrated nitric (10ml) and concentration per chloric (5ml) acid in the ratio 2:1 and the oven was maintained at 2000C. After one hour, the mixture was allowed to cool before leaching the residue with 5cm3 of 20% HNO3. Digested samples were then filtered and made up to 100ml with deionize water. A blank determination was treated in the Atomic Absorption Spectrometry but without sample. Solution of samples were then taken and aspirated in to Atomic Absorption Spectrometer for the analysis of metals. Blank determination was also described above except for the omission of the sample. A calibration graph was plotted for each element using measured absorbance and the corresponding concentration. The calibration curve was used to determine the concentration of the metals (Zn, Cu, Cr, Cd and Pb).

Human Health Risk Indices

Health risk assessment of the metals in water of Ajiwa Dam was examined via ingestion and dermal route to the recipients based on the USEPA risk assessment methodology (USEPA, 2004). The exposure doses are calculated using equations (3.6) and (3.7) adopted from the US Environmental Protection Agency (USEPA, 1989).

Table 2.1 Parameters for estimating exposure assessment of metals in water samples used in the present study (Wu B., 2009).

Exposure Factors	Unit	Values
Concentration of metals in water (C_{water})	µg/L	-
Water ingestion rate (IR)	L/day	2.2

Exposure frequency (EF)	Days/year	360
Exposure duration (ED)	Year	30
Average body weight (BW)	Kg	70
Averaging time (AT)	Days	10,950
Exposed skin area (SA)	Cm^3	28,000
Exposure time (ET)	h/day	0.6
Dermal permeability coefficient (K_p)	-	-
Zn	Cm/h	0.0006
Cu	Cm/h	0.001
Cd	Cm/h	0.001
Cr	Cm/h	0.002
Pb	Cm/h	0.004

$$Exp_{ing} = \frac{\text{Cwater x IR x EF x ED}}{BW\ x\ AT} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

$$Exp_{derm} = \frac{\text{Cwater x SA x Kp x ET}\ x\ EF\ x\ ED\ x\ CF}{BW\ x\ AT} \ldots\ldots\ldots\ldots\ldots\ldots . (2.2)$$

Where Exp_{ing} is the exposure dose through ingestion of water (µg/kg); Exp_{derm} is the exposure dose through dermal absorption (µg/kg). The parameters for estimating human health risk assessment through different pathways are listed in table 2.1

The human health risk assessment for metals and non-carcinogens were performed by comparison of the calculated contaminant for each exposure route (ingestion, dermal) with reference the reference dose (RfD) in order to develop hazard quotient (HQ), using equation

(2.3) [USEPA, 1989]. HQ>1, there might be concern for no-carcinogenic effects.

$$HQ_{\frac{ing}{derm}} = \frac{Exp_{\frac{ing}{derm}}}{RfD_{\frac{ing}{derm}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

Where $HQ_{ing/derm}$ is hazard quotient via ingestion or dermal contact (unit less); and $RfD_{ing/derm}$ oral /dermal reference dose (µg/kg) [Iqbal. J, 2012].

Hazard index (HI) was introduced to evaluate the total potential for non-carcinogenic effects posed by more than one pathway, which was the sum of the HQs from all applicable pathways equations (2.4). HQ>1 showed a potential for adverse effect on human health (USEPA, 1989).

$$HI_{\frac{ing}{derm}} = \sum_{i=0}^{n} HQ_{\frac{ing}{derm}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

Where $HI_{ing/derm}$ is the hazard index via ingestion or dermal contact (unit less)

Chronic daily intake (CDI) was calculated using equation (3.10) [Muhammad S., 2011].

$$CDI = C \times \frac{DI}{BW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

Where C, DI, and BW represent the concentration of heavy metals in water (µg/L), average daily intake rate (2.2 L/day), body Wight (70kg), respectively.

Carcinogenic risk (CR) were estimated using equation (2.6) and the detailed calculating process was followed by (Wu B., 2009, Iqbal J., 2012 and De Miguel E., 2007). The incremental probability of an individual developing cancer over life time as a result of exposure to a potential carcinogen. The range of carcinogenic risk acceptable by (USEFA, 2010) was 1.0E-06 to 1.0E-04.

$$CR_{ing} = \frac{Exp_{ing}}{SF_{ing}}$$ ……………………………………………… (2.6)

WhereCR_{ing} is the carcinogenic risk via ingestion route (unit less) SF_{ing} is the carcinogenic slope factor, ingestion (µg/g). In order to show the life time carcinogenic risk to the local people, CR_{ing} values were calculated for Cd, and Cr. The SF_{ing} values for Cd and Cr are 6.1E+03 and 5.0E+02 respectively (USEPA, 1988, Viera C., 2011 and Yuf. C., 2010). SF_{ing} values for the rest of the metals were not available.

RESULT AND DISCUSSION

The concentrations of variables Zn, Cu, Cr, Cd and Pb were shown on average basis Cr (1.69E-06µg/L) and Zn (5.69E-06 µg/L) showed higher concentration followed by Cu (5.25E-07 µg/L) and Cd (7.50E-08 µg/L). The concentrations of metals recorded in this study were lower than above tabled concentrations both for National and International. However there was no Pb throughout the samples.

The total concentrations of five metals from the sediments of Ajiwa Dam at different points were presented in table 1 and figure 1 respectively.

Table 1 Concentration of metals measured in this work

Sample ID	Cu (ppm)	Zn (ppm)	Cd (ppm)	Cr (ppm)	Pb (ppm)	Cu (µg/L)	Zn (µg/L)	Cd (µg/L)	Cr (µg/L)
D1	0.027	0.118	0.009	0.199	BDL	0.00000027	0.00000118	0.00000009	0.00000199
D2	0.035	0.109	0.01	0.157	BDL	0.00000035	0.00000109	0.0000001	0.00000157
FR1	0.085	1.088	0.013	0.183	BDL	0.00000085	0.00001088	0.00000013	0.00000183
FR2	0.1	1.103	0.002	0.16	BDL	0.000001	0.00001103	0.00000002	0.0000016
FS1	0.043	0.495	0.006	0.158	BDL	0.00000043	0.00000495	0.00000006	0.00000158
FS2	0.024	0.5	0.005	0.16	BDL	0.00000025	0.000005	0.00000005	0.0000016
Average						0.000000525	5.6883E-06	7.5E-08	1.695E-06
Min.						0.00000025	0.00000109	0.00000002	0.00000157
Max.						0.000001	0.00001103	0.00000013	0.00000199

BDL: below detection limit

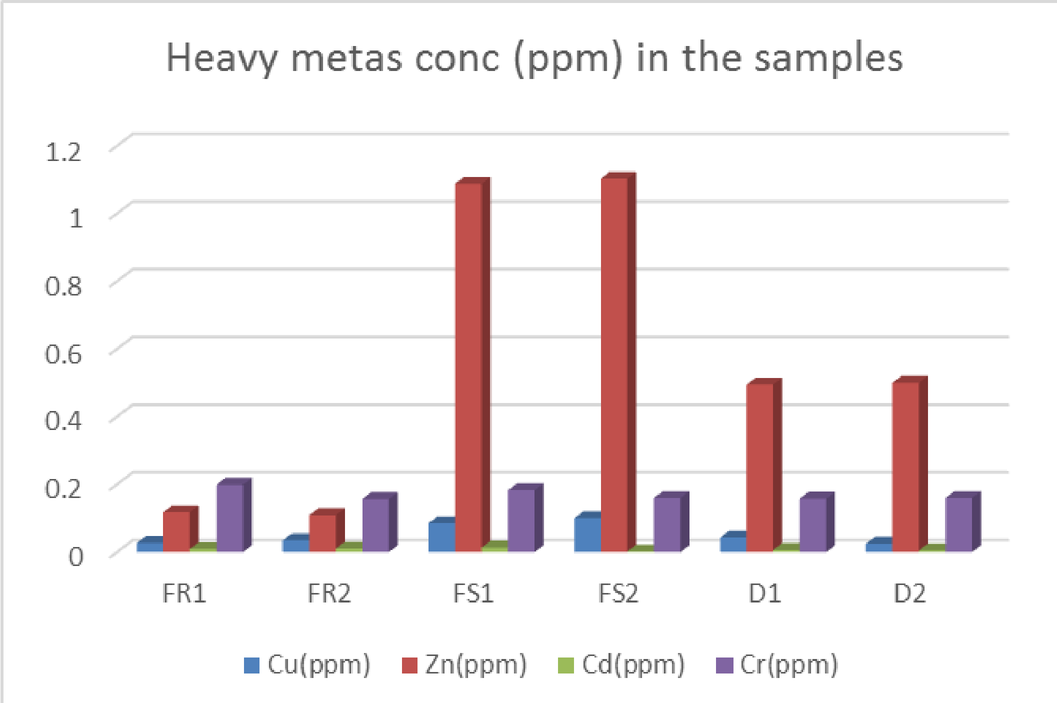

Figure 1 Total concentrations of five metals in different points (ppm)

From the figure above it can see clearly that Zn recorded the highest value in most of the samples followed by Cr and Cu, while Cd showed lowest concentration.

Table 2 Correlation of heavy metals measured in this work

	Pb (ppm)	Cu (ppm)	Zn (ppm)	Cd (ppm)	Cr (ppm)
Pb(ppm)	1				
Cu (ppm)		1			
Zn (ppm)	_	**0.909435**	1		
Cd (ppm)	_	-0.12944	-0.18654	1	
Cr (ppm)	_	-0.06291	-0.10657	0.525642	1

There is a strong and positive relationship between Cu and Zn, while there is no any relationship among the rest of the metals.

Human Health Risk Assessment

Levels of the selected metals in water via ingestion route from Ajiwa Dam are summarized in table 3, while the Hazard Quotient through ingestion of Cr and Cd were also presented in figure 2 and 3 respectively.

Table 3 Summary of health risk assessment for the selected metals in water samples from Ajiwa Dam through ingestion pathway.

Element	$RfD_{ingestion}$ (µg/Kg)	$Exp_{ingestion}$	$HQ_{ingestion}$	CDI	$CR_{ingestion}$
Zn	300	1.9130E-08	6.3750E-11	1.7878E-07	ND
Cu	40	1.7652E-09	6.4131E-11	1.65E-08	ND
Cr	3	5.254E-08	0.001751	5.3271E-08	1.0508E-10
Cd	0.5	2.3249E-09	4.0787E-05	2.3571E-09	3.8112E-13
Pb	1.4	ND	ND	ND	ND
$\Sigma HI_{ingestion}$			1.792E-03		

ND: not detected

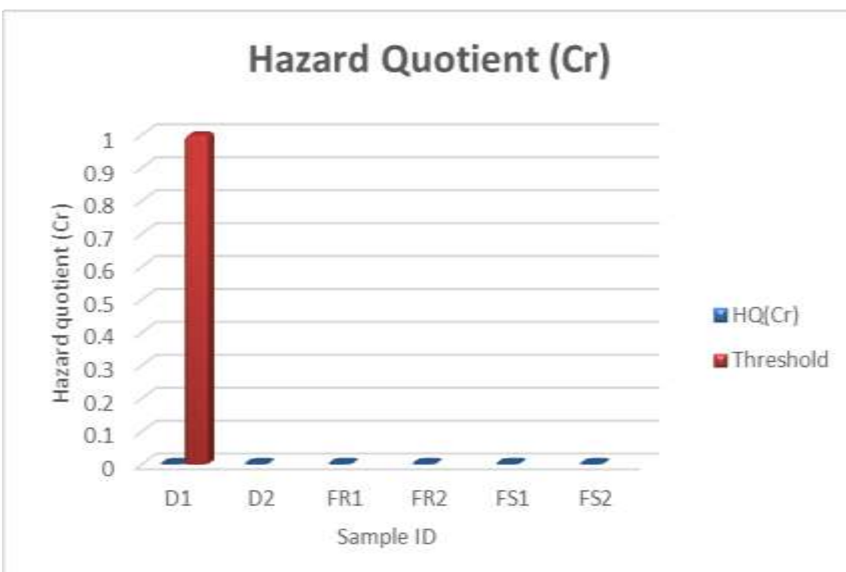

Figure 2 Hazard Quotient through ingestion of (Cr)

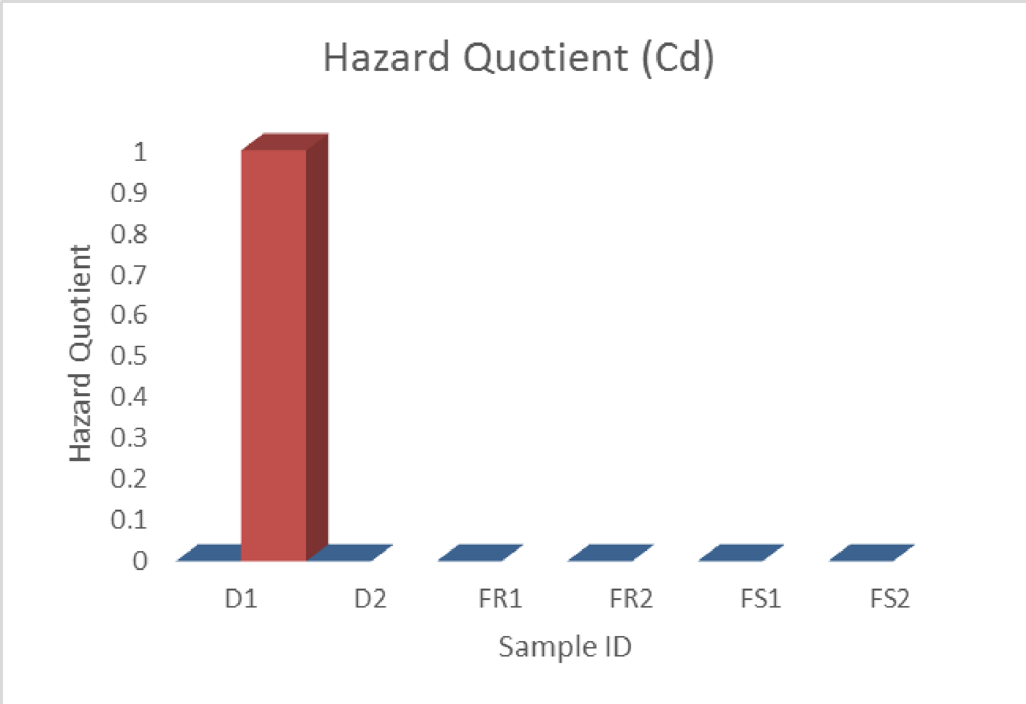

Figure 3. Hazard Quotient through ingestion of (Cd)

The levels of Exp_{ing} observed in order: Cr>Cd respectively, while Cu, Pb and Zn were not detected. These results suggest that Cr and Cd were the main contributors to the human environmental area.

In the present study the levels of HQ_{ing} for the metals were smaller than unity (table3), which indicates that these metals could pose minimum hazard to local residents (Wu B., et al., 2009).

The mean levels of HI_{ing} was found to be 1.792E-03 (table 3). This indicates that there was no cumulative potential of adverse health risk in samples via direct ingestion to the inhabitants of the drinking water, farming and fishing sources (Iqbal J. et al., 2012).

The average CDI value for the selected heavy metals (Zn, Cu, Cr and Cd) were 1.7878E-07, 1.65E-08, 5.3271E-08 and 2.3571E-09 respectively. Therefore CDI indices for heavy metals in the study area were found in order: Zn>Cu>Cr>Cd (table 4.6).

CONCLUSION

It is also concluded from this study that, the heavy metals concentrations were within permissible limits. The health risk assessment indices like HQ_{ing} and CDI were found to be less than unity, indicating that only minimal risk may occur via the ingestion route.

In general the overall non-carcinogenic health risk assessment HI_{ing} is less than unity and considered to be safe ($HI_{ing}<1$).

This study provides preliminary information of different heavy metals status in Ajiwa Dam, which can be used for feature drinking water, farming and fishing quality monitoring and planning elsewhere. It is also concluded from this study that, the heavy metals concentrations were within permissible limits. The health risk assessment indices like HQ_{ing} and CDI were found to be less than unity, indicating that only minimal risk may occur via the ingestion route.

In general the overall non-carcinogenic health risk assessment HI_{ing} is less than unity and considered to be safe ($HI_{ing}<1$).

This study provides preliminary information of different heavy metals status in Ajiwa Dam, which can be used for feature drinking water, farming and fishing quality monitoring and planning elsewhere.

ACKNOWLEDGEMENT

I would like to cordially thank all the members of Centre for Energy Research and Training Zaria, and members of the staff Physics Department, Ahmadu Bello University Zaria for their help.

REFERENCES

DE MIGUEL E., IRIBARREN I. CHACON E., ORDONEZ A., CHARLESWORTH S. Risk-based evaluation of the exposure of children to trace elements in playground in Madrid (Spain). Chemosphere. 66, (3), 505, 2007.

Hall, E.J., and Giacca, A.J. (2006): Radiobiology for the Radiologist. Lippincott Williams & wilkins, Philadelphia, USA.

IQBAL J., SHAH M. H. Health Risk Assessment of Metals in Surface Water from Freshwater Source Lakes, Pakistan. Hum. Ecol. Risk Assess. (doi:10.1080/10807039.2012.716681) 2012.

Martin S,A., Vera Tome, F., Orantos Quintana, R.M., Gomez Escoba; V., &Jurado Vagas, M. (1995). Gamma and Alpha spectrometry for natural radioactive nuclides in the spa water of Extremadura (spain). Jornal of Environmental Radioactivity, 28 (2), 209-220

MUHAMMAD S., HASHMI M. T., KHAN S. Health risk assessment of heavy metals and their source apportionment in drinking water of Kohistan rigion, northern Pakistan. Microchem. J. 98, (2), 334, 2011.

USEPA, Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA-540/R/99/005. Office of Superfund Remediation and Technology Innovation, Washington, DC, USA. 2004.

USEPA. Risk Assessment Guidance for Superfund. Vol. I: Human Health Evaluation Manual (Part A); EPA/540/1-89/002. 1989.

VIERA C., MORAIS S., DELERUE-MATOS, C., OLIVERIRA M. Mercury, cadmium, lead and arsenic levels in three pelagic fish species from the Atlantic Ocean: Intra- and Inter-specific variability and human health risks for consumption. Food Chem. Toxicol. 49, (4), 923, 2011.

WU B., ZHAO D. Y., JIA H. Y., ZHANG Y., ZHANG X. X., CHENG S. P. Preliminary Risk Assessment of Trace Metal Pollution in Surface Water from Yangtze River in Nanjing Section, China. B. Environ. Contam. Tox. 82, (4), 405, 2009.

Wise, S. & Wilken, R.D. (2002): Radon in ground drinking water in south- western Hungary. Prof. 5th Intl.conf. on High levels of Natural Radiation and Radon Areas, Munich. B2:257-259

YU F. C., FANG G. H., RU X. W. Eutrophication, health risks assessment and spatial analysis of water quality in Gucheng Lake, China. Environ. Earht Sci. 59, (8), 1741, 2010.