GROSS ALPHA AND BETA RADIOACTIVITY IN DRINKING WATER FROM SOME TOWNS IN NORTH-WESTERN NIGERIA

Onoja, R.A. and Akpa, T.C.
Health Physics and Radiation Biophysics SectionCentre for Energy Research and Training, Ahmadu Bello University, Zaria,Nigeria
E-mail: raonoja@yahoo.com

(Submitted:10 July, 2008; Accepted: 10 June, 2008)

Abstract

Thirty-two samples of well water were drawn at random from around Zaria, forty samples comprising of both well (35) and borehole (5) were drawn from locally dug wells and boreholes in Gwamaja area of Kano Metropolitan City. Also, thirty samples of river water were taken along the course of river Kaduna. These samples were analyzed for total alpha and beta radioactivity using a gas filled proportional counter. Results show that samples from Zaria, Kano, and Kaduna have average alpha activity values of 6.35±0.45Bq/m^3, 3.99±0.22 Bq/m^3 and 2.70±0.017 Bq/m^3, respectively. The respective average beta activity values of these places were found to be 75.34±1.55Bq/m^3 50.01 ± 1.01 Bq/m^{3}and 43.9±0.99 Bq/m^3. The overall results show that the alpha and beta activity obtained were below 100Bqm^{-3} for alpha and 1000Bqm-^{3} for beta which are the WHO screening levels of radioactivity in drinking water respectively.

Keywords: *Limit, alpha, beta, radioactivity and water,*

1. Introduction

When a radioisotope enters a body, it accumulates in one or more organs, and it is cleared from the organ at a rate determined by the biological half-life. The retention of the radionuclide in the body can be expressed by the relationship (Cember, 1992):

$$A = A_o e^{-\lambda_E \tau} \qquad (1)$$

Where A is the activity remaining at time after the deposition of activity Q_o and $_E$ is the effective clearance constant. If intake continues, then the accumulation of the isotopes is given by:

$$A = \frac{K}{\lambda_o}(1 - e^{-\lambda_E \tau}) \qquad (2)$$

In this case K is the initial intake activity per unit time (Bq/day). For practical purposes, the limiting values are reached after about 6 half-lifes At this steady state condition, the activity deposited will be equal to the activity eliminated. This defines the maximum concentration of any radionuclide type in drinking water. In this work, the quantity of radioactivity is determined and compared with the estimated limit, Q.

Most research work on water quality in Nigeria have been on determination of elemental concentration measurement only. For instance, Nwugo (2001) determined chlorine, iron, copper and manganese contents in drinking water in Zaria. Odogu (2001) determined heavy metals in "Fadama water". Fluorine in local water supply in Zaria was determined by Isma (1993). Pilot work on this radioactivity measurement in water was done using gas filled proportional counter, available at the Centre for Energy Research and Training, Zaria. Some of the results have been reported in Onoja (2004). Others have been reported as project work Tajudeen (2006) and Nwoke (2006). The aim of this paper is to compare the results obtained in

these works with those obtained in other countries and to determine the usefulness of the work on water quality measurement in Nigeria.

2. Materials and Methods

Gross alpha and beta was measured using EURYSES SYTSEM which is an eight-channel proportional counter using a mixture of argon and carbon dioxide in the ratio of 90:10 respectively. Equipment characterization has been reported by Akpa *et al.* (2004) and the method used was initially reported in Onoja *et al.* (2007) but later modified by taking into consideration ISO (1992a) for alpha analysis and ISO (1992b) for beta analysis. All samples were collected based on procedures described in the ISO standard methods and were preserved at time of collection by adding IN HNO_3 to the sample to bring it to a pH to less than 2. The containers used were polyethylene bottles. The standards used for channel efficiency calibration of the system were plutonium-239 which is an alpha emitter and strontium-90 a beta emitter. For sample efficiencies, uranium nitrate and potassium chloride were respectively used to calibrate for alpha and beta in the samples as described by ISO standards procedures. In the method, 10 ml of concentrated nitric acid was added to 2.5g of calcium sulphate in a 150-ml beaker and stirred. The mixture was further diluted with 100 ml of hot distilled water. Then, 0.02g of uranium nitrate which is equivalent to activity of about 10 Bq was added and the solution was transferred to a 200-ml-weighed porcelain dish and was heated to dryness to obtain the residue which was used as sample standard for counting alpha. For the beta standard, an aliquot of 71 mg of potassium chloride which is equivalent to activity of 1.02 Bq was used for beta standard count rate. These methods of sample efficiency determination differ from the method used in Onoja (2004).

3. Results and Discussion

3.1 Detector parameters for the Various measurements

The physical parameters of measure-ments used to obtain the results are as compared in Table 1. From the table, it could be seen that the lowest efficiency of determination was obtained by Onoja (2004). This is because of changes in the gas supply and time of measure-ment. It is difficult to have exact replication. Also, the results of measure-ment of these parameters show that there had not been appreciable drift of the values over the years. Since the data is usually compared with standard, the final result is not affected by the measured efficiency.

3.2 Measured activity level in the drinking water from study areas

The activity values obtained for the gross alpha and beta measurements made by various researchers are reported in Table 2.

Table 1: Detector parameters in the determination of activities

Physical Parameters	Onoja (2004)		Nwoke (2006)		Tajudeen (2006)	
	α	β	α	β	α	B
Background Activity (Bq)	0.01	0.08	0.007	0.03	0.009	0.03
Efficiency (%)	32.25±0.12	18.19±0.46	35.32±0.05	53.58±0.01	35.78±0.35	53.70±0.35
Detection Limit (Bq)	0.61±0.04	3.11±0.29	0.008±0.001	0.050±0.002	0.33±0.05	0.76±0.15

Table 2: Values of measured activities

Area of study		Alpha activity	Beta activity	Source of water	Author
Zaria		6.35±0.45	75.34±1.53	Wells	Onoja (2004)
Gwamaja Kano		3.99±0.22	50.00±78	Wells and boreholes	Tajudeen (2006)
Kaduna	Farming area	0.03±0.20	58.50±00	Surface river	Nwoke (2006)
	Residential area	0.03±0.10	41.10±00		
	Industrial area	0.03±0.30	32.10±00		

The results of the deep underground water measurements show the same magnitude for both alpha and beta with the one of Gwamaja Kano having lower activity for both alpha and beta. The reason for this is not immediately known but is suspected that method of sample preparation and analysis using ISO (1992a) for alpha and ISO (1992b) for beta may be responsible. The work of Nwoke (2006) shows that, the alpha activity in Kaduna River is much less than that obtained for well and borehole water in this part of the world. This is expected, since the source of most of alpha activity is primordial. On the other hand, the decreasing values from upstream shows that there is dilution of the elements responsible for the beta activity and that the industries situated along the river course are not contributing radioactivity to the water body.

3.3 Distribution of activity in the study area

The frequency distribution of the results using class marks from 1 to 10 is described in the equation

$$f(x) = ae^{-0.5\left(\frac{ln\left(\frac{x}{c}\right)}{b}\right)^2}$$

x = data (location)
f(x) = activity
[Parameters]
a = constant (amplitude= $\frac{1}{x\sigma\sqrt{2\pi}}$)
b = standard deviation = $\sqrt{2}\sigma$
c = population mean = $e^{-\mu^2}$
This is a log normal distribution where a, b and c are fitting constants.
The distribution for alpha activity in the three study areas is given in Fig 1
For all the studies the alpha activity distributions are log-normal and skewed to the left with the fitting constants:a (Maximum peak) = 20.37±6.15, b (FWHM) = 0.31±0.07 and c = 1.45±0.04.

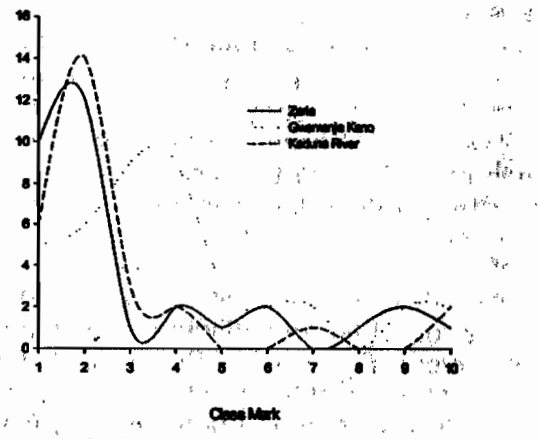

Fig. 1: Alpha activity distributions (frequencies)

For Zaria data; a = 8.47±1.32, b = 0.67±0.11 and c = 2.36±0.32 for Gwamaja data and a = 16.54±1.69, b = 0.35±0.03 and c = 1.63±0.05 for the Kaduna river data. The patterns of the distribution appear to be the same (heavily skewed to lower values) except that the Gwamaja data seem to be more evenly distributed.

The beta activity distributions are shown in Fig.2 and follow the same trend as pha for all the study areas.

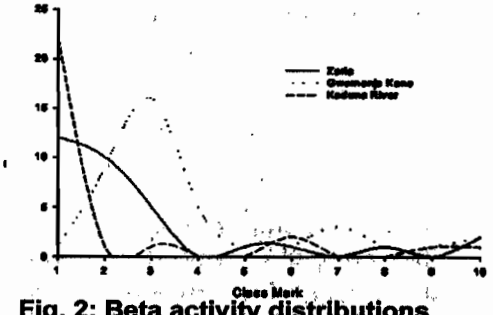

Fig. 2; Beta activity distributions (frequencies)

Comparison of measurement activities with other works

Table 3 shows the results of this work together with those from other parts of the world. The

Table 3: Comparison of activity measured in various works

Location	Measured activity in Bq/m³				Source of data
	Alpha		Beta		
	$\bar{x}$	No of samples	$\bar{x}$	No of samples	
Belgium	13.6	30	175	30	CEC (1982)
Germany	0.0008	371	0.00009	1307	
Netherland	-	+	76	5	
Venezuela	23	25	-	-	Sajo-Bohus, *et al.* (1997)
Zaria*	6.4	32	75.35	32	Onoja (2004)
Kaduna River*	0.3	30	43.67	30	Nwoke (2006)
Gwamaja Kano*	4.0	40	50	40	Tajudeen (2006)

results show very low concentration of radioactivity in water from Germany. This may be because the water was drawn from a surface water body. The values from Belgium and Venezuela are much higher than the values for this work. This shows that the quality of drinking water sources in Nigeria are of high quality with respect to radioactivity content when compared to those of other countries. However the results obtained from different places are far below the contamination limit for radioactivity in water as advised by SEPA (Milvy and Corthern, 1990) which is 550 Bq/m^3 for alpha, 1850 Bq/m^3 for beta; and WHO (2003) limit of 100 Bq/m^3 for alpha and 1000 Bq/m^3 for beta.

Conclusion

There appears to be some differences in values of radioactivity content of drinking water sources from north-western Nigerian towns of Zaria, Kano and of Kaduna River. These differences also appear when compared with results from other countries in Europe and South America. These differences may be due to small variation in the technique and counting parameters or due to geological origin of the water bodies. However, the measured values are consistently lower than the internationally recommended limit of radio activity in water.

References

Akpa, T.C., Mallam, S.P., Ibeanu, I.G.E. and Onoja, R.A. (2004): Chatracterization of Gross Alpha and Beta Proportional Counter in the Centre for Energy Research and Training, Ahmadu Bello University, Zaria. Nig. Journal of Phys. 16(1) 13-18.

CEC (1982): Result of Environmental Radioactivity Measurements in Member State of European Community for air-Deposition-Water-milk in 1980. Commission of European Communities, Luxembourg, 234-235.

Cember H. (1992): Introduction to Health Physics. Elsievier Pub. Ltd. NY.

Isma, M.S. (1993): Fluoride in Local Water Supplies Zaria. Associateship in Civil Engine-ering Project, Ahmadu Bello University Zaria.

ISO (1992a): Water Quality-measurement of Gross alpha Activity in Non-saline water, Thick Sources Method, ISO 9696, Geneva, Switzerland, 13pp.

ISO (1992b): Water Quality-Measurement of Gross Beta Activity in Non-saline water, Thick sources Method, ISO 9697, Geneva, Switzerland, 13pp

Milvy, P. and Corthern, C.R. (1990). Scientific Background for Development of Regulations for Radionuclides in Drinking Water In: (Cothern, C.R. and Rebers, P. eds.) Radon, Radium and Uranium in Drinking Water. Lewis Publishers, Washington D.C. 1-16.

Nwogo, I.M.(2001):. Water Analysis Commercial water Samples Bachelor of Science Thesis, Ahmadu Bello University Zaria.

Nwoke, J.E. (2006): Measurement of gross Alpha and Beta radioactivity in river Kaduna. Unpublished Master of Science Thesis, Ahmadu Bello University Zaria< Nigeira.

Odogu, D.O, (2001): Analysis of Heavy Meeltals in Fadadma Water Soil and Vegetable (Spinach) plant Behind Sabon Gari Market, Sabon Gari Zaria Bachelor of Science Thesis, Ahmadu Bello University Zaria, Nigeria.

Onoja, R.A. (2004): Survey of Gross Alpha and Beta Radioactivity in Well Water from Zaria Area Master of Science Thesis, Ahmadu Bello University Zaria, Nigeira.

Onoja, R.A., Akpa, T.C., Mallam, S.P. and Ibeanu, I.G.E. (2007): Survey of Gross Alpha and Beta Radioactivity in Well Water from Zaria and its Environs Nigerian Journal of Physics 19(1), 39-47.

Sajo-Bohus, I, Gomez, J. Capote, T,

Greaves, E.D. Herrera, O. Salazar, V and Smith, A (1997): Gross Alpha Radioactivity of Drinking Water in Venezuela. **J.** Environ. Radioactivity 3:305-312.

SPSS (2002): Sigma Plot 8. Statistical Package for Social Sciences. SPSS Inc. Chicago.

Tajudeen, H. Y. (2006): Survey of gross Radioactivity in Boreholes and Hand Dug Well-Water from Gwamaja Area of Kano Metropolitan City. Master of Science Thesis, Ahmadu Bello University Zaria, Nigeira.

WHO (2003): Guidelines for Drinking Water Quality WHO, Geneva, Switzerland. 3, Chapter 9.