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Research Article

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Analysis and Assessment of Gross Alpha and Beta in Drinking Water of Some Selected Areas of Gashua, Yobe State, Nigeria

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Abstract

Water is an essential substance for human existence and his environment but water sources are often polluted by human activities and some natural phenomena which arises from waste and sewage disposal into rivers and streams. This study intends to assess the gross alpha and beta in Gashua, Yobe state, Nigeria using the protean MPC-2000-DP Proportional counter. The results revealed that, for the gross alpha, the activities concentration varied from 0.091 ± 0.0058 to 1.990 ± 0.1010 mSv/yr with an average of 0.574 ± 0.0308 mSv/yr, while for the gross beta, the values varied from 0.55 ± 0.014 to 9.47 ± 0.240 mSv/yr with an average of 2.91 ± 0.068 mSv/yr. Also, for the alpha, the CED values for the adult varied from 0.146 ± 0.009 to 3.196 ± 0.162 mSv/yr with an average of 0.922 ± 0.049 mSv/yr, the CED values for the children varied from 0.073 ± 0.006 to 1.598 ± 0.081 mSv/yr with an average of 0.461 ± 0.025 mSv/yr and the CED values for the infants varied from 0.037 ± 0.002 to 0.799 ± 0.041 mSv/yr with an average of 0.231 ± 0.012 mSv/yr. For the beta, the CED values for the adult varied from 0.883 ± 0.022 to 15.21 ± 0.385 mSv/yr with an average of 4.667 ± 0.110 mSv/yr, the CED values for the children varied from 0.442 ± 0.011 to 7.604 ± 0.193 mSv/yr with an average of 2.334 ± 0.055 mSv/yr and the CED values for the infants varied from 0.221 ± 0.006 to 3.802 ± 0.096 mSv/yr with an average of 1.167 ± 0.027 mSv/yr. Based on the findings presented, most of these values are found to be above the World Health Organization recommended limit of 1 Bq/l except for few points. It is therefore assumed that the aggressive gross alpha activity might be attributed to uranium and radium and its alpha daughters which are contained in some of agro chemicals such as fertilizers while enhancement of gross beta activity in the area may be due to the increase in potassium concentration. agricultural fertilizers product contained various trace of elements such as Uranium and Thorium decay series members and 40K. It is therefore concluded that the water in the area under investigation is not a safe water for drinking, for this reason, it strongly recommended that there should be public health law, to safeguard the lives of the inhabitants, seasonal study of the radioactivity of ground water in the mentioned areas should be conducted to check whether the radio activity is affected by season and there is also need to extend these research in the entire Gashua town so as to have a comprehensive study of the entire ground water in the town.

Keywords: Gross Alpha, Gross Beta, Committed Effective Dose, Activity, Concentration.

Introduction

Water is an essential substance to man animals and all that surround them. It has been in existence since from the origin of the universe itself. Water forms greater percentage of men and animal's blood and tissue [1]. However, water sources are constantly polluted by some human activities and natural phenomena, thus adversely affecting the quality of water, water pollution arises from wastes and sewage disposals into rivers and streams from industries, hospitals and rain washout from fertilizers used for farming. Some of these pollutants are radionuclides [2]. Another source of water pollution arises from secondary particles of cosmic radiation which release radionuclides into the atmosphere, and these radionuclides, are washed down by rain into ground and surface water bodies. Water sources are equally polluted by naturally occurring radioactive materials (NORM) of the earth crust (terrestrial radioactivity), which emits alpha, beta particles and gamma radiations. These materials normally element of Uranium and Thorium series are more concentrated in deep ground water then in surface water. They contaminate the water body directly with their radionuclide products, and directly, through the Radon and Thoron gaseous

product s which can solidify and attached themselves as aerosols to the air particles and are washed down by rain into the water bodies [3]. Furthermore, flowing water encounters shelves, sedimentary rocks, igneous rock s and phosphate rocks all of which are radioactive (Sanchi and Honey Man 1989). All these contribute to the level of radioactivity in water [4].

Radioactivity in drinking water is an easy means of man's internal contamination with radionuclides [5]. The most important natural radionuclide in drinking water are Tritium, Potassium, Radium, Radon and their progeny which are also alpha, beta emitters and gamma radiation [6]. Hence it is needful to determine the specific activities of radionuclides present in drinking water and also the concentration of alpha and beta in drinking water [7].

Radioactivity is defined as the spontaneous emission or transmission of energy in the form of wave or particle through space, or through a material medium [8]. It is makes up of different forms among which are the particle radiation which include alpha and beta particles radiations and neutron radiation [9]. Alpha particles are helium 4 nuclei made up of two protons and neutrons [10]. They interact with matter strongly due to their charges and combined mass with low penetrating power such that they cannot penetrate the outer layer of the skin. But alpha radiation is dangerous when alpha emitting particles are ingested or inhaled (breathed or swallowed) [11].

However, Beta radiation is divided into two categories, Beta-minus (β^-) and Beta-plus (β^+). Beta minus (β^-) radiation consist of an energetic electron, it is more penetrating than alpha radiation, But less than gamma radiation. Beta radiation from radioactive isotope can be stopped with a few centimeters of plastic or a few millimeters of metal [12].

Beta-plus (β^+) radiation is the emission of positrons which are the anti-matter form of electron, when the positron slows it's speed similar to that of electron in the material the positron will annihilate the electron to produce two gamma photons of energy 511kev, in the process [13]. These gamma photons are of high energy they are also ionizing radiation [14].

Gashua is one of the largest towns in Yobe state with a population of about 139,782 [15]. More so, the people depend mainly on borehole and river water as their major sources of water for domestic and farming activities. However, these water sources can be polluted by various activities going on around and near the water sources such as refuse dumping, agrochemicals and domestic activities [16]. These activities are alpha (α) and beta (β) emitters which are threat to the health of human, animals and plant when consume through ingestion or inhalation [17].

Materials and Method

Materials

The following are the materials used for this study:

1. 2litre Plastic Container
2. 20ml Disposable Hypodermic Syringe
3. Diluted Nitric Acid
4. Hot Plate for Evaporation
5. 500ml Beakers
6. Vinyl Acetate
7. GPS (Global positioning system)
8. Planechatte (0.3m in diameter 0.002 thicknesses)
9. Evaporating Dish
10. Spatula, Forceps
11. Cotton Wool
12. Acetone Desiccator
13. Analytical Weighing Balance.

Method

Method of Sample Collection

Samples were collected at various point within the town using GPS (Global positioning system) to record the exact position of the samples sites during the period of dry season. (Global positioning system) to record the exact position of the samples sites. Samples were collected in two litter plastic containers with a tight cover, containers used were washed carefully three times with the water sample at site to be sure that samples collected are representative of the bulk.

Method of Sample Preparation and Analysis

The samples collected at the time of collection were acidified with 20ml of dilute Nitric acid to preserve the water from biological growth and chemicals at the surface of the container and then transferred to the laboratory.

In the laboratory about 500ml of the water sample was measured in a beaker and evaporated slowly using hot plate at a temperature range of 50 °c to 60 °c till the required level this is then transferred to a petridish to obtain the actual dried residue.

Method of Sample Analysis

About 0.077g of the residue is then transferred to aplanchette using spatula, vinyl acetate is added to have even spread of the residue on the planechette, the planechette is then kept for cooling before transferred to counting room were protean MPC-2000-DP a convenient and versatile "bench top" alpha/beta radiation counter was used to analyzed the level of alpha/beta activities in the samples.

Method of Data Analysis

Count Rate

Equation 1 and 2 were used according to [18] to calculate the concentration C in Becquerel per liter (Bq/l) for alpha and beta activities respectively in the water samples. Eequation 2 represent the specific activity of 4 K in KCL.

$$C = \frac{R_n \times A_s \times M \times 1.02}{R_b - R_o \times 1000 \times V} \quad (1)$$

$$C = \frac{R_n \times A_s \times 14.4 \times M \times 1.02}{R_b - R_o \times 1000 \times V} \quad (2)$$

Where R_n is the count rate per second corrected for background count.

Thus, $R_n = R_b - R_o$ (3)

R_b is the observed sample count rete in count per second, R_o is the background count rate in count per second, A s is the specific activity of the alpha standard, V is the volume of the sample evaporated in liter and M is the mass of the residue in (mg) from volume and 1.02 is included to correct for 20ml of Nitric acid added per 2litre as a sterilizer [19].

Estimation of Annual Committed Effective Dose

The annual committed effective dose to an individual due to ingestion of natural radioactive material from all the water samples is estimated using the following equation as pointed out by [20].

CED = A x IW x DCF (4)

Where

A = Sample activity concentration (Bq/l), IW = Water intake. The quantity of water taken by each age group in a year are given below according to [21].

IW for teenage/adults (>12, yrs) is 730 litres per year, IW for children (1 – 12yrs) is 365 per year and IW for infants ( ) is 182.5 litres per year

DCF = Dose conversion factor (mSv/Bq). Dose conversion factor used to calculate the internal radiation exposure by ingestion of radionulcides of radiological significance in drinking water for members of the public is 2.2 x 10-3 mSv/Bq as reported by [22, 23].

Results Presentation and Discussion

Result Presentation

Table 1: Result of Gross Alpha and Beta Activities in Bq/l

S/No	Sample ID	Gross Alpha (Bq/l)	Gross Beta (Bq/l)
1.	A. Loko	0.091 ± 0.0058	0.55 ± 0.014
2.	G. Zango	0.510 ± 0.0340	2.48 ± 0.056
3.	L. Zango	1.990 ± 0.1010	9.47 ± 0.240
4.	Katuzu	0.150 ± 0.0064	1.31 ± 0.016
5.	FUGA	0.130 ± 0.0066	0.72 ± 0.016
	Mean	**0.574 ± 0.0308**	**2.91 ± 0.068**

The analyzed results for both gross alpha and gross beta in the water samples are presented in Table 1.

For the gross alpha presented in Table 1, the values varied from 0.091 ± 0.0058 to 1.990 ± 0.1010 mSv/yr with an average of 0.574 ± 0.0308 mSv/yr, while for the gross beta, the values varied from 0.55 ± 0.014 to 9.47 ± 0.240 mSv/yr with an average of 2.91 ± 0.068 mSv/yr.

Table 2: Result of Committed Annual Effective Dose for Alpha in mSv/yr

Sample ID	CED Adults (α) (mSv/yr)	CED Child (α) (mSv/yr)	CED Infant (α) (mSv/yr)
A. Loko	0.146 ± 0.009	0.073 ± 0.006	0.037 ± 0.002
G.Zango	0.819 ± 0.055	0.410 ± 0.027	0.205 ± 0.014
L. Zango	3.196 ± 0.162	1.598 ± 0.081	0.799 ± 0.041
Katuzu	0.241 ± 0.010	0.120 ± 0.005	0.060 ± 0.003
FUGA	0.209 ± 0.011	0.104 ± 0.005	0.052 ± 0.003
Mean	**0.922 ± 0.049**	**0.461 ± 0.025**	**0.231 ± 0.012**

The calculated CED values for alpha in the water samples are presented in Table 2.

For the alpha as presented in Table 2, the CED values for the adult varied from 0.146 ± 0.009 to 3.196 ± 0.162 mSv/yr with an average of 0.922 ± 0.049 mSv/yr, the CED values for the children varied from 0.073 ± 0.006 to 1.598 ± 0.081 mSv/yr with an average of 0.461 ± 0.025 mSv/yr and the CED values for the infants varied from 0.037 ± 0.002 to 0.799 ± 0.041 mSv/yr with an average of 0.231 ± 0.012 mSv/yr.

Table 3: Result of Committed Annual Effective Dose for Beta in mSv/yr

Sample ID	CED Adults (β) (mSv/yr)	CED Child (β) (mSv/yr)	CED Infant (β) (mSv/yr)
A. Loko	0.883 ± 0.022	0.442 ± 0.011	0.221 ± 0.006
G.Zango	3.983 ± 0.090	1.991 ± 0.045	0.996 ± 0.022
L. Zango	15.21 ± 0.385	7.604 ± 0.193	3.802 ± 0.096
Katuzu	2.104 ± 0.026	1.052 ± 0.013	0.526 ± 0.006
FUGA	1.156 ± 0.026	0.578 ± 0.013	0.290 ± 0.006
Mean	**4.667 ± 0.110**	**2.334 ± 0.055**	**1.167 ± 0.027**

The calculated CED values for beta in the water samples are presented in Table 3.

For the beta as in Table 3, the CED values for the adult varied from 0.883 ± 0.022 to 15.21 ± 0.385 mSv/yr with an average of 4.667 ± 0.110 mSv/yr, the CED values for the children varied from 0.442 ± 0.011 to 7.604 ± 0.193 mSv/yr with an average of 2.334 ± 0.055 mSv/yr and the CED values for the infants varied from 0.221 ± 0.006 to 3.802 ± 0.096 mSv/yr with an average of 1.167 ± 0.027 mSv/yr.

Comparison of Results

The results presented in table 1, 2 and 3 were used to plot charts in order to compare of our result with literature.

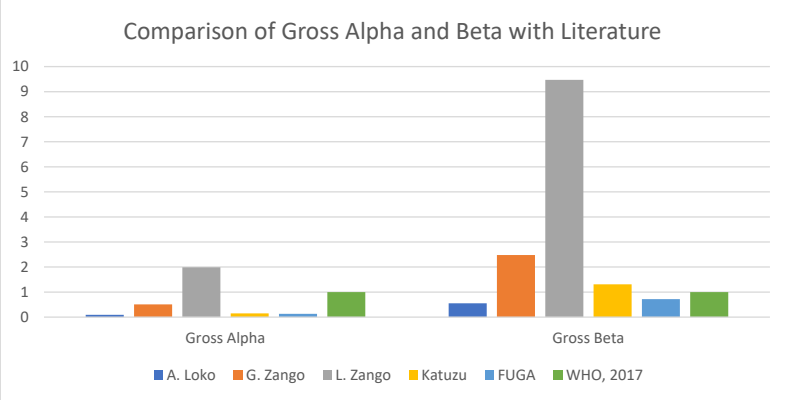

Figure 1: Comparison of Gross Alpha and Beta with World Health Organization

Based on the chart presented in Figure 1, the values for the gross alpha for all the investigated areas are found to be lower than the World Health Organization recommended limit of 1 Bq/l except that of L. Zango which is found to be lower. On the other hand, the values of the gross beta in all areas under investigation are found to be above the World Health Organization recommended limit of 1 Bq/l except that of A. Loko and FUGA which are found to be higher.

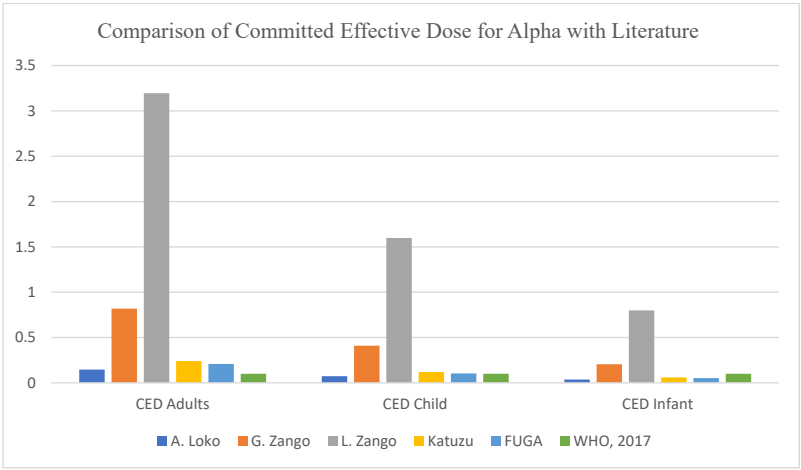

Figure 2: Comparison of Committed Annual Effective Dose for Alpha with World Health Organization

Based on the chart presented in Figure 2, the values for the alpha committed annual effective dose in adults for all the investigated areas are found to be above the World Health Organization recommended limit of 0.1 mSv/yr. In contrary, the values for the alpha committed annual effective dose in children for Katuzu and FUGA are found to be slightly above to the World Health Organization recommended limit of 0.1 mSv/yr, while G. Zango and L. Zango are much greater than the limit and A. Loko found to be lower. On the other hand, the values of the alpha committed annual effective dose in infant in all areas under investigation are found to be lower than the World Health Organization recommended limit of 0.1 mSv/yr except that of G. Zango and L. Zango which are found to be higher.

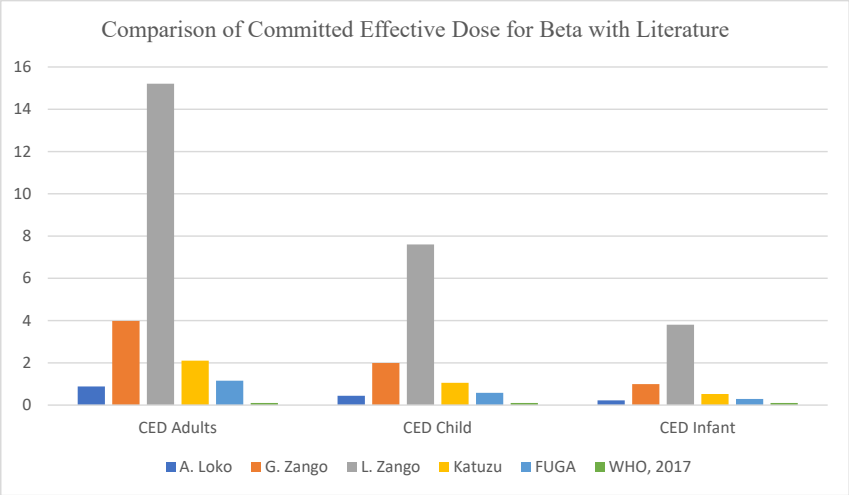

Figure 3: Comparison of Committed Annual Effective Dose for Beta with World Health Organization

Based on the chart presented in Figure 3, the values for the beta committed annual effective dose in adults for all the investigated areas are found to be above the World Health Organization recommended limit of 0.1 mSv/yr. In much the same manner, the values for the beta committed annual effective dose in children for all areas under investigation are found to be above to the World Health Organization recommended limit of 0.1 mSv/yr. On the other hand, the values of the beta committed annual effective dose in infant in all areas under investigation are found also to be higher than the World Health Organization recommended limit of 0.1 mSv/yr.

Discussion

The gross alpha and beta assessment have been conducted in drinking water of five areas (Angwan Loko, Federal University Gashua, Gabasawan Zango, Katuzu and Lelabawan Zango) of Gashua of Yobe state, Nigeria. For the gross alpha, the values varied from 0.091 ± 0.0058 to 1.990 ± 0.1010 mSv/yr with an average of 0.574 ± 0.0308 mSv/yr, while for the gross beta, the values varied from 0.55 ± 0.014 to 9.47 ± 0.240 mSv/yr with an average of 2.91 ± 0.068 mSv/yr.

Also, for the alpha, the CED values for the adult varied from 0.146 ± 0.009 to 3.196 ± 0.162 mSv/yr with an average of 0.922 ± 0.049 mSv/yr, the CED values for the children varied from 0.073 ± 0.006 to 1.598 ± 0.081 mSv/yr with an average of 0.461 ± 0.025 mSv/yr and the CED values for the infants varied from 0.037 ± 0.002 to 0.799 ± 0.041 mSv/yr with an average of 0.231 ± 0.012 mSv/yr.

For the beta, the CED values for the adult varied from 0.883 ± 0.022 to 15.21 ± 0.385 mSv/yr with an average of 4.667 ± 0.110 mSv/yr, the CED values for the children varied from 0.442 ± 0.011 to 7.604 ± 0.193 mSv/yr with an average of 2.334 ± 0.055 mSv/yr and the CED values for the infants varied from 0.221 ± 0.006 to 3.802 ± 0.096 mSv/yr with an average of 1.167 ± 0.027 mSv/yr.

Based on the findings presented, the values for the gross alpha for all the investigated areas are found to be lower than the World Health Organization recommended limit of 1 Bq/l except that of L. Zango which is found to be lower. On the other hand, the values of the gross beta in all areas under investigation are found to be above the World Health Organization recommended limit of 1 Bq/l except that of A. Loko and FUGA which are found to be higher.

The findings also revealed that the values for the alpha committed annual effective dose in adults for all the investigated areas are found to be above the World Health Organization recommended limit of 0.1 mSv/yr. In contrary, the values for the alpha committed annual effective dose in children for Katuzu and FUGA are found to be slightly above to the World Health Organization recommended limit of 0.1 mSv/yr, while G. Zango and L. Zango are much greater than the limit and A. Loko found to be lower. On the other hand, the values of the alpha committed annual effective dose in infant in all areas under investigation are found to be lower than the World Health Organization recommended limit of 0.1 mSv/yr except that of G. Zango and L. Zango which are found to be higher.

Based on the chart presented in Figure 3, the values for the beta committed annual effective dose in adults for all the investigated areas are found to be above the World Health Organization recommended limit of 0.1 mSv/yr. In much the same manner, the values for the beta committed annual effective dose in children for all areas under investigation are found to be above to the World Health Organization recommended limit of 0.1 mSv/yr. On the other hand, the values of the beta committed annual effective dose in infant in all areas under investigation are found also to be higher than the World Health Organization recommended limit of 0.1 mSv/yr.

Conclusion

Radioactivity in the ground water of Gashua is due to Agricultural practice and the domestic activities within or at the area. It is assumed that the aggressive gross alpha activity in L. Zango might be attributed mainly from uranium and radium and its alpha daughters which are contained in some of agro chemicals such as fertilizers and that of gross beta was mostly due to potassium 40K, 22Ra. Beta daughters and 90Sr.

The enhancement of gross beta activity in the three (G. Zango, L. Zango and Katuru) areas is mainly due to the increase in potassium concentration. agricultural fertilizers product contained various trace of elements such as Uranium and Thorium decay series members and 40K. The use of fertilizers in agricultural areas can increase the concentration of these natural radionuclides in the water. Therefore, the possible sources of gross beta activity are the run off of fertilizers from agricultural practice in these areas. Based on the findings, it is concluded that the water of the area under investigation is not a safe water for drinking, for this reason, it strongly recommended that there should be public health law, to safeguard the lives of the inhabitants, seasonal study of the radioactivity of ground water in the mentioned areas should be conducted to check whether the radio activity is affected by season and there is also need to extend these research in the entire Gashua town so as to have a comprehensive study of the entire ground water in the town.

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