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Gross Beta Radioactivity in Underground Drinking Water from Permanent Site of Usmanu Danfodiyo University Sokoto Nigeria

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Abstract— *The conditions to measure the gross beta radioactivity in water samples from the permanent site of Usmanu Danfodiyo University Sokoto in Sokoto State Nigeria were established. The gross beta radioactivity of water samples were measured using proportional gas counter. The result show that the gross beta radioactivity in most samples is higher than the maximum contaminant level of 1.0Bq/L set by WHO. The range of the measured activity was found to be between 0.300Bq/L to as high as 78.57Bq/L with a geometric mean of 4.0034Bq/L. The gross beta effective dose was found to be 1.046 mSv/yr.*

Index Terms—Activity, Contaminant limit, Effective dose, Geometric mean, Gross alpha

1 INTRODUCTION

Water is quite an essential necessity of life. It is a major constituent of the human body and his environment. It is used by man for various purposes, ranging from agricultural to industrial, power generation and domestic consumption etc. However, human activities and some natural phenomenon are polluting this water and thus affecting its quality. Some of these human activities include sewage disposing, leaching of fertilizers from the soil, industrial wastes disposals etc. some of these waste disposals often contain radioactive materials which contribute significantly to the background activity of the water bodies[1].

Another form of water pollution is as a result of certain rock types containing radioactive elements referred to as Naturally Occurring Radioactive Materials (NORM). These materials disintegrate and thereby emitting alpha particles, beta particles or gamma radiation. Drinking water sourced from deep wells and boreholes are usually expected to have high concentration of radioactive nuclides. This is because they pass through fractures in bedrocks or within the soil which contains minerals deposits that might have radioactive constituents and thus leaking into the water ways. Radioactivity in drinking water is one of the major ways in which radionuclides from the environment gets into the human body, which might consequently lead to radiation-induced disorderness [2].

There is evidence from both human and animal studies that radiation exposure at low to moderate doses may increase the long term incidence of cancer and that the rate of genetic malformations may be increase by radiation exposure [3]. It is therefore important to determine the amount of radioactivity in drinking water for every area where people live in, so as to guard against its health hazards [4].

Some work has been done on measurement of radioactivity in water in Nigeria. Onoja determined gross alpha and beta activity in well water from Zaria area. The result shows geometric mean value of 75.53Bq/m^3 (or 0.07553Bq/L) for beta activity [5]. Tajudeen did similar work in Gwammaja area of Kano metropolitan city and the result shows a geometric mean value of 0.05Bq/m^3 for beta activity [6]. Habila worked on survey of gross beta radioactivity in wells and boreholes from Jos city .The result shows ranges of beta activity from 0.25 to 9.64 Bq/L, with a Geometric mean of 1.56Bq/L [7]. Avwiri and Agbalagba surveyed gross beta radionulide activity in Okpare-Creek Delta State and reported that mean beta activity was 0.481Bq/L [8].

The maximum contaminant limit of radioactivity allowable in drinking water is 1.850Bq/L set by USEPA [9] and 1.0Bq/L as set by WHO for beta [10]. The geographical/geological formation of an area determines to extent the radionuclide present in water [8].

However Saidu worked on gross beta radioactivity in wells and boreholes water in Sokoto city. The result obtained from proportional counter shows that the beta activity for: **wells** ranges from 0.35 to 49.85 Bq/L with geometric mean of 4.86Bq/L; and that of **boreholes** ranges from 0.71 to 32.69 Bq/L with geometric mean of 3.38Bq/L [10]. These results also show activities above practical screening level. Although Saidu carried out his work

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within Sokoto city but the water samples from Usmanu Danfodiyo University permanent site was not included. This is the reason why it deem necessary to carry out this research for the fact that the major source of drinking water on the campus is underground water.

The campus is located on longitude 13º05'13" to 13º09'45"N and latitude 5º10'15"N to 5º15'05"E. Its geology is consistent with the general geology of the Sokoto basin.

This paper presents beta activity in Bq/L for water from bore holes and wells from Usmanu Danfodiyo University Sokoto Permanent site, based on reference to USEPA maximum contaminant limit of 1.85Bq/L and WHO maximum contaminant limit of 1.0Bq/L [9], [10].

2 MATERIALS AND METHOD

2.1 Sample Collection and Preparation

The method applied to this sampling is the stratified random sampling technique. The mapped area was gridded into 63 of 1000m×1000m each. Each grid according to the scale has an area of 1.0 square kilometer. A total of 20 habitated grids were outlined, one sample was collected from each. However 6 of the samples were lost as a result of 2010 flooding disaster of the Kwalkwalawa River and only 14 were finally analyzed .The samples were prepared and analyzed at the Center for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. The sample efficiency, background measurements and plateau test were carried out using standard methods [11],[12].

The sample efficiency, η_s is given by [12]:

$$\eta_s = \frac{(W_{B+S} - W_B)}{0.077} \times 100\% \quad (1)$$

Where: $\mathbf{W_B}$ is the weight of empty planchet,

$\mathbf{W_{B+S}}$ is the weight of planchet plus sample after evaporation,

0.077 A (mg) is the expected mass of the residue in the planchette.

2.2 Gross Beta Counting

The gross beta counting equipment used in this work is a Eurisys System Low Background Multiple (eight) Channel Alpha and Beta detector. The equipment is a gas flow proportional counter with 450µg/cm^3 and thick window of diameter 60mm. It allows simultaneous counting on eight 300mm or 55mm diameter samples. Alpha (α) and beta (β) activity measurement on compound sources can be selective, sequential or simultaneous. The procedure involves entering the present time, number of cycles and the operational voltage. Also the count characteristics (channel efficiency, and background count rate), volume of sample used and sample efficiency were entered.

For gross beta counting selective measurement was adopted. High voltage of 1700V was used, and samples were counted for 5 cycles of 2700 sec per cycle. The Beta Count Rate, β_{CR} and Beta Activity, β_A were calculated using (2) and (3) respectively [12].

$$\beta_{CR} = \frac{\text{Raw}(\beta)\text{Count}}{\text{Count Time}} \quad (2)$$

$$\beta_A = \frac{\text{Rate}(\beta) - \text{Bgd}(\beta)}{\text{Sample Efficiency} \times \text{Chanel Efficiency} \times \text{volume}} \quad (3)$$

The beta activity is expressed as Activity Concentration, C in Becquerel per liter (Bq/L) using the formula [13]:

$$C = \frac{R_b - R_o}{R_s - R_o} \times \frac{14.4m}{1000V} \times 1.020 \quad (4)$$

Where:

$\mathbf{R_b}$ is observed sample count rate (S^{-1}),

$\mathbf{R_s}$ is observed standard count rate (S^{-1}),

$\mathbf{R_o}$ is background count rate (S^{-1}),

V is volume of sample in liters,

m is mass in milligrams of ignited residue from volume V,

$\frac{14.4}{1000}$represent the specific activity of ^{40}K in KCl.

The factor 1.020 was included in the final equation to correct for the 20ml of the Nitric acid added to the sample as a stabilizer.

3. RESULTS AND DISCUSSION

Preliminary results of the detector characterization for beta particles in the beta only mode are as shown in table 1.

Table 1: Beta Background, Channel efficiency and Channel Detection Limit

Channel No	Beta Back-ground Values (cpm)	Channel Efficiency %	Detection Limit
1	0.966	46.47	0.345
2	0.366	35.39	0.391
3*	0	0	0
4	0.482	38.79	0.34
5	0.423	40.66	0.335
6	0.302	42.94	0.259
7*	0	0	0
8	0.338	34.88	0.288
Average	0.48	39.86	0.326

* Channels 3 and 7 are faulty and not included

The results for the gross beta radioactivity concentrations for the water samples are reported in table 2. The errors quoted in the

table represent the standard deviation from repetition of measurements.

Table 2: Sample Location and Activity Concentration Obtained

Sample Labeling	Location	Geographical Coordinates	Elevation (meters)	Activity Concentration (Bq/L)
SK 01	Dan-Jawa Baba	N13.13911° E005.22362°	281	78.570 ± 4.28
SK 02*	Chemistry department	N13.13133° E005.20389°	248	0.300 ±0.58
SK 03	Gidan yunfa	N13.13324° E005.20015°	269	0.610 ± 0.17
SK 04*	Kwalkwalawa	N13.10495° E005.20292°	254	33.080 ± 1.19
SK 05	Gidan Lilli	N13.10344° E005.19062°	267	0.400 ± 2.53
SK 06*	Senior Staff Qrts.	N13.12533° E005.19144°	270	0.735 ± 3.33
SK 07*	Sport complex	N13.12533° E005.19569°	262	17.890 ± 0.72
SK 08	Danjawa Karami	N13.13680° E005.22881°	284	3.386 ±2.37
SK 09	Dundaye	N13.11498° E005.22908°	260	4.909 ± 0.64
SK 10*	Staff School	N13.12440° E005.21250°	282	9.930 ± 3.24
SK 11*	Borehole no. 1 Grid 16	N13.12799° E005.18595°	263	18.050 ± 0.43
SK 12	Sabon Gari	N13.11116° E00531723°	241	1.517 ± 0.57
SK 13*	Makkasi Junction	N13.13557° E005.20153°	270	4.820 ± 2.36
SK 14*	DV Hostel	N13.12212° E005.19838°	269	4.985 ± 2.28

* Represents boreholes sources

Table 1 shows that the background count rate ranges from 0.302 to 0.996 with an arithmetic mean of 0.480cpm. The result of the average efficiency of the different channels of the detector was found to be 39.86%. The limit of detection ranges from 0.259 to 0.391 with an arithmetic mean of 0.326. The overall result of the preliminary investigation indicates low background, good plateau and low detection limit.

Table 2 shows that the activity concentration ranges from 0.300 to 78.570Bq/L with geometric mean of 4.0034Bq/L.

The distribution of the activity is represented as a Histogram in Fig 1.

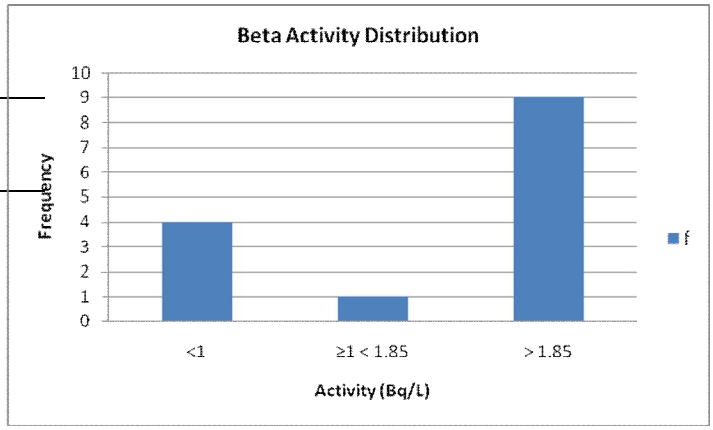

Fig 1: Histogram of Distribution of Beta Activity

From the result obtained, only 4 out of the 14 samples representing 28.57% satisfy the recommended contaminant limit of less than 1.0Bq/L recommended by WHO; and 5 samples representing 32.5% is below the limit of 1.85Bq/L set by USEPA.

Comparing the average value 4.12Bq/L of beta activity obtained in this work with: 0.07553Bq/L obtained in Zaria by Onoja [5]; 0.00005Bq/L in Kano by Tajudeen [6]; and 1.56Bq/L in Jos by Habila [7]; shows that Gross beta activity in Sokoto is relatively higher.

The higher value of Gross beta activity could be as a result of the geological formation of the area whose land is highly invaded with phosphorus, a by-product of phosphate that has potassium-40 which is a beta and gamma emitter whose source is fertilizer used by farmers. Thus regular program of environmental audit and monitoring is here by recommended.

4. CONCLUSION

Since only few samples of water from the bore holes and wells in Usmanu Danfodiyo University permanent site meet the recommendations of WHO and USEPA, majority do not meet the standard. There is therefore need for further screening for radioactivity from the bore holes and wells that are used for drinking because continue to use it may pose serious health side effects to the public users.

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