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AN ASSESSMENT OF GROSS BETA RADIOACTIVITY CONCENTRATION IN UNDERGROUND WATER IN NASSARAWA TOWN OF NASARAWA STATE, NIGERIA

Ahmed S. Abdullahi[1], John S. Mathew[1] and Chifu E. Ndikilar[2]
[1] Department of Physics, Nasarawa State University, P.M.B 1022, Keffi, Nigeria
[2] Department of Physics, Federal University Dutse, P.M.B 7156, Dutse, Nigeria.

Abstract- Beta radioactivity in underground water (wells and boreholes) collected in some selected areas of Nassarawa town was investigated. The gross beta content of the selected wells and boreholes was measured and the activity concentrations were determined using ISO 9696 and 9697 respectively. Results obtained shows that the concentration of beta activity is relatively high in well water than boreholes compared with the maximum contaminant limit showing that well water in these areas is not safe for human consumption.

Keywords: Activity, Contaminant limit, Effective dose, Gross beta.

I. INTRODUCTION

Naturally occurring radioactive materials (NORM) are found almost everywhere and is inherent in many geologic materials, consequently it is encountered during geological related activities. NORM encountered in hydrocarbon exploration and production operations originate in subsurface formations that may contain radioactive materials such as Uranium and thorium and their daughter products, Ra-226 and Ra-228. In gas processing activities, NORM generally occurs as radon gas in the natural gas stream (Ajayi *et al.*, 2009; Mokobia *et al.*, 2006). Radioactive tracers are also used in evaluating the effectiveness of well cementing and underground water and crude oil flow direction for the purpose of correlation (Ajayi *et al.*, 2009). In some cases, various amounts of radioisotopes are injected with the secondary recovery flooding fluids to facilitate flow. In Nigeria and other countries, many studies have been carried out on the radioactivity matrices (Tchokossa, 2006 Ajayi *et al.*, 2009, Diad *et al.*, 2008, Al-Masri and Suman, (2003); Isinkaye and Shitta, 2010 and Fatima *et al*., 2008). It has been noted that radiation is part of the natural environment and it is estimated that approximately 80% of all human exposure comes from naturally occurring radioactive materials. Mineral exploration and production activities have the potential to increase the risk of radiation exposure to the environment and humans by concentrating the quantities of naturally occurring radiation beyond normal background levels. EPA, (2005) on environments, health and safety online stated that the more radiation dose a person receives, the greater the chance of developing cancer, leukemia, eye cataracts, Erithemia, hematological depression and incidence of chromosome aberrations. This may not appear until many years after the radiation dose is received (typically, 10-40 years). Water has been an essential necessity of life. It is a major constituent of the human body and the environment. It is used for various purposes ranging from agriculture to industrial power generation and domestic consumption etc. In this research work, twelve (12) samples of water (wells holes and well water) were collected to ascertain their beta activity concentrations in Nassarawa town.

II. MATERIALS AND METHOD

Sample Collection and Preparation

The materials used for this experiment are as follows, Scintillation defecator system, Drying Oven, Drying Lamp, Gas dedicator, Glass ware, Analytical balance, Electric hot plate, Infrareds, Ceramic dishes, Planchet, Spatula, and weighing balance. The operation voltage (v), channel/detector efficiencies, background value for the gas filled detector (count per meter) is as reported in Onoja (2004).

The drinking water samples were collected in different parts of Nassarawa town and obtained from wells and boreholes located in Nassarawa town, Nasarawa State. The method applied to this sampling is the stratified random sampling technique. The map is grid into six (6) locations, two samples were obtained from each location: one from well source and the other from boreholes source which gives a total of twelve (12) samples. The sampling procedure is in accordance with international standard organization (ISO-5667-3).

Evaporation was done using hot plates without stirring in open beakers. It took an average of 24hrs to complete the evaporation of a 1litre of the water sample. When the sample is almost dried up (about 50ml), It is then transferred to the

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ceramic dish (which is sterilized to avoid cross contamination) and the dish is placed under an infrared radiator of about 65°C until it is completely dried and weighed to obtain the weight of the residue then a little quantity (about 0.077g) of the residue is transfer in to a sterilized planchette using a spatula and the weighing balance. The residue is then uniformly spread on the planchette to obtain a uniform surface area of the sample for effective detection of the activities of the samples. Sterilizations were done using acetone to avoid contamination of any form.

Gross Beta Counting

The gross beta counting equipment used in this work is a Eurisys System Low Background Multiple (eight) Channel 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. 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 was calculated using (1) and (2) respectively (ISO, 1992).

$$C = \frac{R_b - R_o}{R_s - R_o} \, x \, a_o \frac{m}{1000} \, x \, \frac{1.020}{V}$$

In general, the sample activity concentration C in Becquerels Per Seconds, is calculated as follows;

$$C = R_n \, x \, \frac{1}{\varepsilon_s} \, x \, \frac{1}{V_p}$$

where;

C is the alpha activity, in becquerels per liter, R_n is the sample count rate per second, ε_s is the fractional efficiency of counting of the sepcified radioactive standard, V_p is the volume of sample, in litres equivalent to the mass of solid on the planchet.
Thus,

$$R_n = R_b - R_o$$

where;

R_b is the observed sample count rate in pulses per second $(R_b S^{-1})$, R_o is the background planchet count rate in pulse per second $(R_o S^{-1})$,
and

$$\varepsilon_s = \frac{R_s - R_o}{01A \, x \, a_s} \, x \, 1000$$

where;

R_s is the observed standard count rate in pulse per second $(R_s S^{-1})$, A is the area of the planchette, in square millimetters, 0.1A is the mass of standard solids, in milligrams on the planchette (mg), a_s is the specific activity of the standard solids, in Becquerels per gram (Bq/g).

and

$$V_p - \frac{V}{m} \, x \, 0.1A$$

V is the volume of sample in litres, m is the mass in milligrams of ignited residue from volume V. Thus the general equation (2) becomes;

$$C = \bar{R_b} - R_o \, x \, \frac{0.1A}{(R_s - R_o) \, x \, 1000} \, x \, \frac{m}{V \, x \, 0.1A} \quad (1)$$

$$C = \frac{R_b - R_o}{R_s - R_o} \, x \frac{a_s}{1000} \, x \, \frac{m}{V} \quad (2)$$

III. RESULTS AND ANALYSIS

The counting equipment (gas fill detector) is automated. Results are displaced as raw count, count rate, activity and standard deviation. Acquisition was made in beta mode. The selection of mode of counting was arbitrary. The calculation formula for gross beta radioactivity is discovered in equation (1) - (6). The results for the gross beta radioactivity concentrations for the water samples are reported in Table 1.

$$- \qquad (3)$$

Table 1: Sample Location and Activity Concentration for Gross Beta Activity

SAMPLE LABELING	LOCATION	GEOGRAPHICAL COORDINATES	BETA ACTIVITY CONCENTRATION (BQ/L)
NS 01**	Taimen	N08^{0}51.544 E007^{0}52.72	0.087 ± 0.037
NS 02*	Tudun Mallam	N08^{0}51.647 E007^{0}52.221	1.840 ± 0.017
NS 03**	General Hospital	N08^{0}51.394 E007^{0}53.568	0.060 ± 0.025
NS 04*	Angwan Tudun	N08^{0}51.793 E007^{0}54.163	7.620 ± 0.033
NS 05**	Nas. Poly.	N08^{0}50.620 E007^{0}52.368	0.780 ± 0.014
NS 06*	Motor Garage	N08^{0}50.316 E007^{0}52.252	5.875 ± 0.021
NS 07**	Gss Nas.	N08^{0}50.452 E007^{0}54.492	0.754 ± 0.031
NS 08*	Court Premises	N08^{0}50.926 E007^{0}54.163	1.160 ± 0.040
NS 09*	Zango	N08^{0}50.108 E007^{0}52.314	2.700 ± 0.320
NS 10**	Toto Road	N08^{0}50.056 E007^{0}51.670	0.775 ± 0.100
NS 11**	Government College	N08^{0}50.777 E007^{0}53.207	0.963 ± 0.037
NS 12*	Football Field	N08^{0}50.073 E007^{0}50.312	6.890 ± 0.093

c

*** Well water sources**
**** Borehole water sources**

From table 1 above, results show that the activity of beta concentration ranges from 0.020 ± 0.025 to 7.620 ± 0.033 Bq/l obtained from the various locations within the reference point of study. It shows that the highest beta radioactivity concentration is observed in well water samples. The distribution of the activities of beta concentration is represented as a pie chart in the fig. 1.

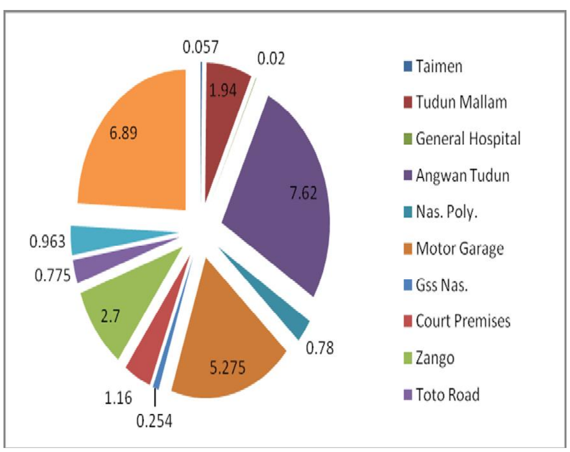

Fig. 1: A Pie Chart Plot Showing the Percentage Distribution of Beta Activity Concentration

Fig. 1 shows that, six (6) samples of boreholes obtained from Nas. Poly, Toto Road, G/Hospital, GSS Nassarawa, Taimen, Govt. college have a beta activity concentration of less than one occupying a total percentage of 9% from the chart and six (6) of the well samples obtained from football field, Motor Garage, Angwan tudun, Zango, Tudun mallam and Court premises occupies a total percentage of 24%, 19%, 27%, 9%, 7% and 4% respectively. The high percentage in well water samples could be attributed to the high rate of beta activity in those areas as at that period.

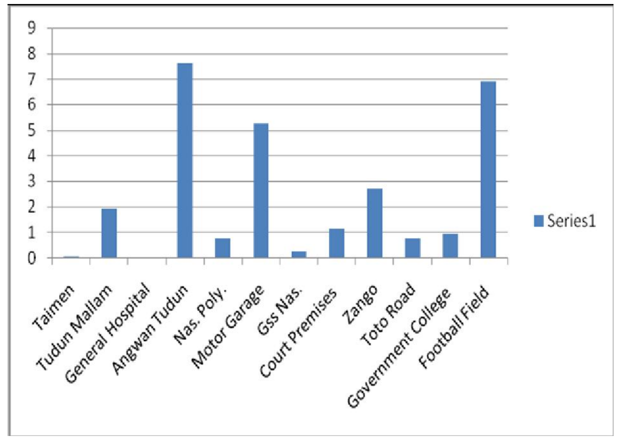

Fig. 2: A Bar Chart Plot Showing the Level at which each Percentage of the Activity Occupying

In fig. 2 is a bar chart showing the level of beta activity concentration from all the samples obtained. Six (6) of the samples (well water) obtained from football field, motor garage, Angwan tudun, Zango, Tudun mallam, Court premises occupied high level in the chart as indicated by the bar, their high level is due to their high rate of beta activity concentration in those areas, as such does not satisfy the recommended contaminant limit of 1.0Bq/L. The low level bar is showing the activity concentration of samples with low rate of beta activity obtained from Nas. Poly., Toto road, General Hospital, Gss Nass., Taimen and Govt. College which satisfy the recommended contaminant limit of 1.0Bq/L as recommended by WHO.

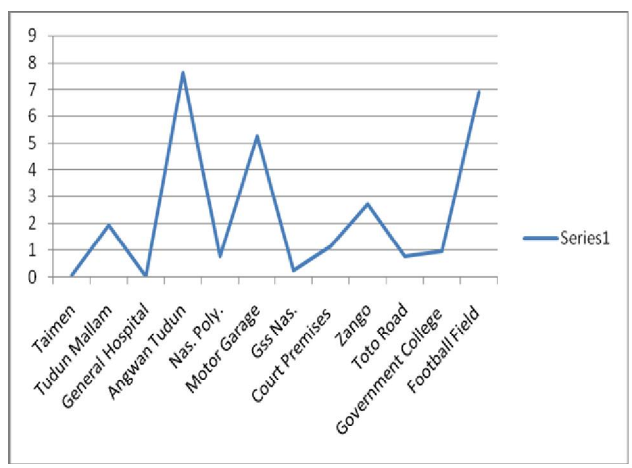

Fig. 3: A Line Chart Showing the Variation of the Beta Activity Concentration in Respect to the Recommended Contaminant Limit.

From the line chart shown in fig. 3 above, results show that all the six (6) samples obtained from boreholes located in Nas. Poly., General Hospital, Gss Nass., Taimen, Govt. college and Toto Road satisfy the recommended contaminant limit of 1.0Bq/L which are occupying a level < 1 in the line chart above and as such are recommended for human consumption. Only one out of the six (6) samples obtained from well sources (Court Premises) satisfy the recommended value while all the remaining five (5) of the samples obtained from football field, motor garage, Angwan Tudun, Zango and Tudun mallam occupy high level as such does not satisfy the recommended contaminant limit of 1.0Bq/L. It is also obvious that the gross beta radioactivity concentration in the well water samples is very high compared to borehole water samples.

From the analysis above, we can deduce that the beta radioactivity concentration in the water taken from Nas. Poly, Court premises, Toto road and Govt. college locations shows that it is safe for human consumption since it is in accordance with the maximum acceptable concentration. Samples taken from Taimen, Gen. Hospital, Gss Nass. are slightly higher than the recommended contaminant limit, therefore not safe for human consumption.

Results also show that it will be highly dangerous to consume well water from Angwan Tudun, Zango and football field axis due to the high level of the beta radioactivity concentration at this period of the year.

From the results obtained, 7 samples out of the twelve (12) representing 13% for beta activity satisfy the recommended contaminant limit and other remaining samples fall out of range recommended by International Standard Organization (ISO) recommended acceptable value.

Comparing the average value mean value 2.3695Bq/L of beta activity obtained in this work with 0.07553Bq/L obtained in Zaria by Onoja, (2004); 0.00005Bq/L in Kano by Tajudeen, (2006) ; and 1.56Bq/L in Jos by Habila (2008); shows that the gross beta activity in Nassarawa Town 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.

IV. CONCLUSION

Since many samples from the bore holes meet the recommended value of 1Bq/L for beta activity, and all samples from wells do not meet specification as recommendations by WHO and ISO, there is therefore need for;

(i) Further screening of radioactivity concentration from wells that are used for drinking because continue usage may pose serious health side effects like cancer, skin diseases etc to the public users.
(ii) It is necessary to survey other drinking water sources especially tap and stored water
(iii) Repeat of this research work should also be carried out both during raining and dry season so as to survey the gross beta activity in the water and to also find out more about the variations of radio nuclides in the water.

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