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Original Research Article

Gross Alpha and Beta Radioactivity of Water from Gubi Dam Water Treatment Plant Gubi Village, Bauchi

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ABSTRACT

In this research, a total of 25 replicate samples from the study area comprising source water, treated water as well as water from some bore holes around Gubi dam and Gubi water treatment plant were collected for the analysis using Gas-flow Detector Dual Phosphor (counting system) method to determine the gross alpha and beta concentrations. The results showed that the values for the gross alpha and beta measurements were found to be (7.057E-03Bq/ m3), (1.0253E-02 Bq/ m3) and (2.693E-02 Bq/ m3) for samples from the dam, treated water and the borehole respectively. Furthermore, the mean concentrations were also determined to be (4.11E-02Bq/ m3), (3.74E-02Bq/ m3) and (1.0756E-01Bq/ m3). The study revealed that water from Gubi dam whether treated, untreated or ground water around the dam purses no radiological hazards for agricultural and other domestic uses.

1. Introduction

Groundwater can also become contaminated from both natural and anthropogenic sources of pollution. Naturally occurring contaminants are present in the rocks and sediments. As groundwater flows through sediments, metals such as iron and manganese are dissolved and may later be found in high concentrations in the water. Industrial discharges, urban activities, agriculture, groundwater withdrawal, and disposal of waste all can affect groundwater quality. Contaminants from leaking fuel tanks or fuel or toxic chemical spills may enter the groundwater and contaminate the aquifer. Pesticides and fertilizers applied to lawns and crops can accumulate and migrate to the water table (Caralyn *et. al.,* 2018)

Water pollution arises from wastes and sewage disposals into rivers and streams from industries, hospitals and rain-wash out from fertilizers used for farming. Some of these pollutants are radionuclides. Another source of water pollution arises from the secondary particles of cosmic radiation, which release radionuclides into the atmosphere, and these radionuclides, are washed down by rain into surface water bodies. Water sources are equally polluted by naturally occurring radioactive materials (NORM) of the earth's crust (terrestrial radioactivity), which emits alpha, beta and gamma radiations (Longtin, 1988).

Radionuclides both natural and artificial sources may find their way into water body through several ways, some radionuclides that reach either groundwater or surface water will move with the water. Others will be deposited on the surrounding soil or rocks. One important factor affecting their movement is how thoroughly they dissolve in water (solubility). Another factor affecting movement is the ability of the radionuclide to adhere to the surfaces of rocks or soil through which the water flows (Martin and Steven, 1996).

These radionuclides that are found in water include radium, radon, uranium, polonium and few other Isotopes. For instance the US Geological survey recently reported high concentration of radon in well water and Blue Ridge region of the New River watershed located in North Carolina and Virginia respectively. The highest level of concentration in the North Carolina well was 303.14 Bq/m^3 and the lowest found was 12.32 Bq/m^3 (EPA, 2000). This gave a course for concern and the inhabitants were advised to install radon mitigation system, to check radon in air, and radon in water, in their residential houses. Also ^{210}Po has been detected in the water of east central Florida (Belloni *et. al.,* 1995).

In order to give an approximate idea of the radioactivity of water, the gross alpha and gross beta activity are measured. The gross activity does not indicate which radionuclide is responsible for the radioactivity measured. Also the results obtained cannot be used for exact direct dose calculation but it gives only the degree of contamination. Gross radioactivity accounting also cannot measure tritium concentration in water, as water with tritium evaporates and the ruminant may not contain tritium.

A second option is provided for states that choose not to develop enhanced indoor air programmes. Community water systems in such states would be required to reduce radon levels in drinking water to 300 pCi/L. This amount of radon in water contributes about 0.03 pCi/L of radon to the air. Even if a state does not develop an enhanced indoor air programmes, water systems may choose to develop their own local indoor radon programmes. This option would require them to meet a radon standard for drinking water of 4,000 pCi/L, which would enable the reduction of overall risks from exposure to radon from both air and water (Cember, 1996).

2. Methodology

2.1 Samples Collection and Identification

A total of twenty-five (25) replicate samples from the study area which made up of the source water from the dam, the treated water and a borehole water near the dam is well representatively collected for the analysis.

2.2 Sample Preparation

2.2.1 Apparatus/Equipment/Materials/Reagents–Requirement

The material used includes; Gas-flow Detector Dual Phosphssor (counting system), Beakers (100-1500)ml, Graduated Measuring Cylinder, Ceramic Petri-dishes, Planchets, Spatulas, stirring rod, needle with syringe, cotton wool, detergent, hot plates, Infrared radiator, Analytical weighing Balance, Glass desiccator, Vinyl acetate, acetone and distilled or deionized water.

2.2.2 Procedure

a. All apparatus- beakers, petri-dishes, planchets, spatulas, stirring rods, and syringes were washed and rinsed properly with distilled water and acetone respectively
b. A little quantity of the sample were used to rinse the beakers twice to ensure that cross contamination is avoided.
c. 1000ml of the sample were measured and transfer into the beaker and place on the hotplate.
d. The hotplate was then switch on from the mains supply and the temperature were regulated below 100^{o}C to prevent the water sample from boiling in order to achieved the required residue.
e. When the sample volume substantially reduced to about 50ml, it was then transferred to an empty weighed petri-dish.
f. The petri-dish with its content were placed on the hot plate or under the infrared radiator for surface evaporation and drying to obtain the require residue.
g. The weight of the petri-dish and the residue were measured again.
h. The weight of the residue obtained from 1000ml of the sample evaporated were obtained by subtracting the weight of empty dish from the weight of the residue and the dish.
i. The weight of residue require for measurement must be 77mg (0.077g) but if the weight exceeds this value according to literature only the 77mg of the residue should be used for analysis.
j. The residue i.e. 77mg (0.077g) were transferred into a sterilized planchette and weighed on the analytical balance.
k. The volume of sample that produce 0.077g was calculated using the expression below:

$$0.77g \; x \; Vr = WrV \qquad (1)$$

Where: V_r = Volume that produce the residue
W_r = Weight of the residue
V = Volume that will give 0.077g

If the weight of the residue is less than 0.077g after evaporation and drying, more of the samples must be evaporated until 0.077g was achieved. Then the volume that gives 0.077g can be calculated from the given expression above.

For samples with residue greater than or equal to 0.077g, the efficiency of the sample was 100%.

For samples with residue less than 0.077g, the sample efficiency can be calculated from

$$sample \;\; efficiency = \frac{weight \; of \; residue}{0.077g} \; x \; 100\% \qquad (2)$$

NOTE: The residue were properly dried to ensure accurate residual weight measurement and also to ensure efficient detection by the system (detector). Therefore hydroscopic residues were stored in a desiccator during preparation.
The residue were spread uniformly on the planchet surface and few drops of the vinyl acetate was added this act as an adhesive to the residue on the planchette.
The planchette with the residue were mounted on the proportional counter for measurement to obtain the alpha and beta count rates.
The sample efficiency, volume that produce 0.077g residue, calibration factors and other constants were used to convert the counts obtained into activity concentration.

2.2.3 Interference

a) Moisture absorbed by the sample residue interfere and obstructs counting and self-absorption characteristics.
b) Non-uniformity of the sample residue in counting planchet interferes with the accuracy and precision of the method.
c) Sample density on the planchet area were not more than $10mg/cm^2$ for gross alpha and not more than $20mg/cm^2$ for gross beta.
d) When counting alpha and beta particle activity by a gas-flow Detector counting system, counting at the alpha plateau discriminates against beta particle activity, whereas counting at the beta plateau is sensitive to alpha particle activity present in the sample. This latter effect were determined and compensated for during the calibration of the specific instrument being used.

3. Results and Discussion

3.1 Results

The results obtained using the procedures outlined in *2.2*.2 to *2.2*.3 of the twenty five (25) samples, for the analysis of the Gross alpha and beta measurement of the radioactivity activity in water, ten (10) samples are located at various points within the dam, ten (10) samples of the treated water from the treatment plant and five (5) samples from a borehole near the dam in Gubi village of Bauchi are presented respectively in the table and charts below in which the activity is plotted against the sample ID.

Table 1 Result for the alpha and beta activities of the Dam water samples taken at various point.

Sample ID	Longitude	Latitude	Alpha Concentration (Bq/m^3)	±Error	Beta Concentration (Bq/m^3)	±Error
S1	10°24'29.39"N	9°51'11.04"E	BDL	BDL	2.29E-02	3.31E-03
S2	10°24'42.39"N	9°51'10.34"E	BDL	BDL	1.74E-02	4.34E-03
S3	10°24'52.13"N	9°51'02.87"E	2.12E-02	1.56E-03	8.54E-02	3.85E-03
S4	10°25'13.41"N	9°50'52.71"E	2.58E-02	1.24E-03	6.34E-02	3.05E-03
S5	10°25'23.69"N	9°51'14.78"E	2.03E-02	1.16E-03	7.43E-02	2.86E-03
S6	10°25'53.27"N	9°51'46.20"E	3.10E-02	1.140-03	4.68E-02	4.44E-03
S7	10°25'49.34"N	9°52'10.97"E	4.68E-02	1.59E-03	8.51E-02	3.48E-03
S8	10°25'15.39"N	9°52'40.03"E	5.86E-02	1.02E-03	5.04E-03	2.30E-03
S9	10°24'44.47"N	9°51'59.29"E	1.17E-02	1.10E-03	7.43E-03	2.39E-03
S10	10°24'24.50"N	9°51'09.85"E	8.12E-03	7.60E-04	3.45E-03	1.87E-03

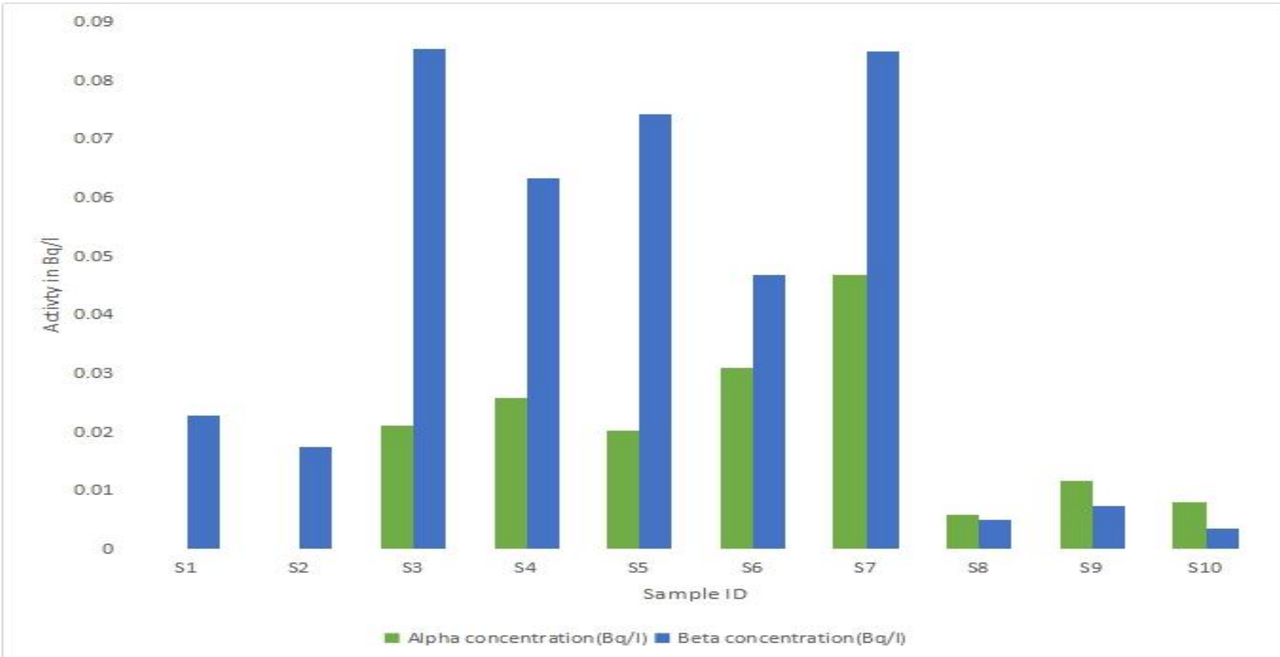

Fig.1. Alpha and Beta activity concentration in samples of the dam water.

From fig.1. Above, it could be seen that the distribution of alpha activities is only slightly higher in S3, S4, S5 and S7. This means that most of the points are of elevated activity, with some having quite moderate activity and some extremely low activity. Also beta activity is moderate at S3, S4, S5, S6 and S7, and extremely low at S1 and S2.

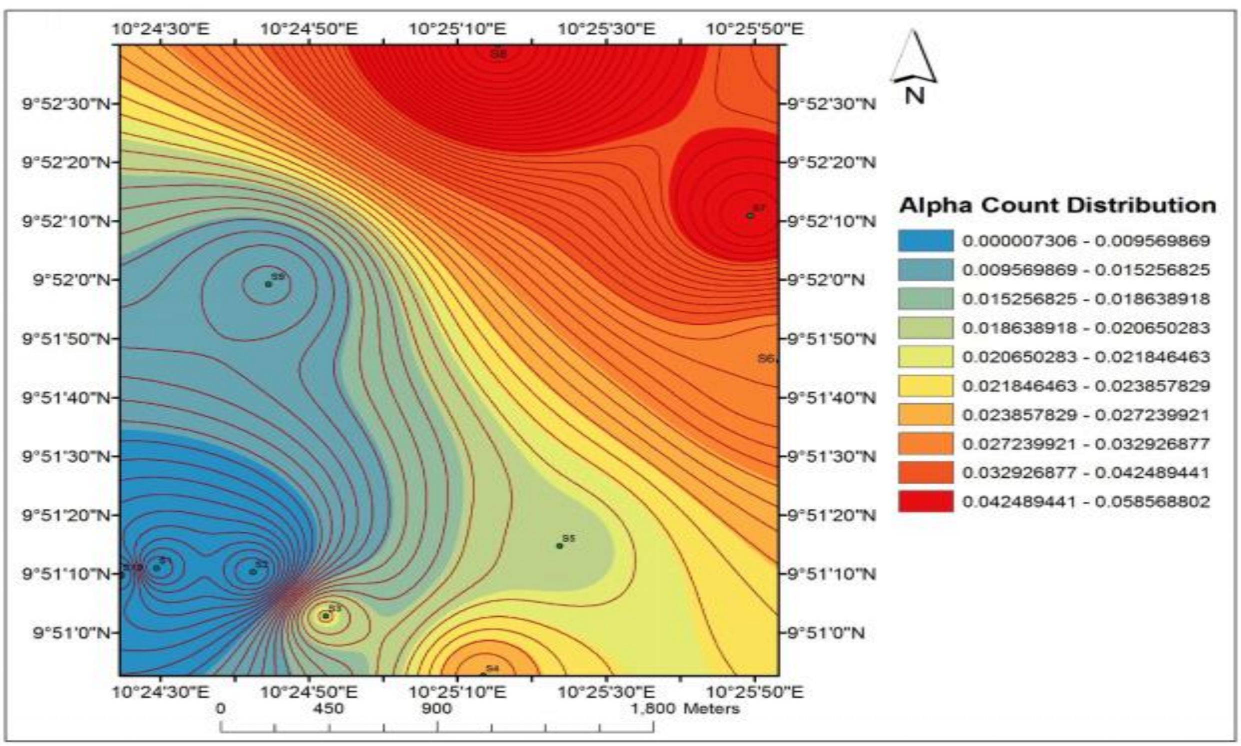

Fig. 2. Contour distribution pattern of Alpha activity of samples collected at the dam

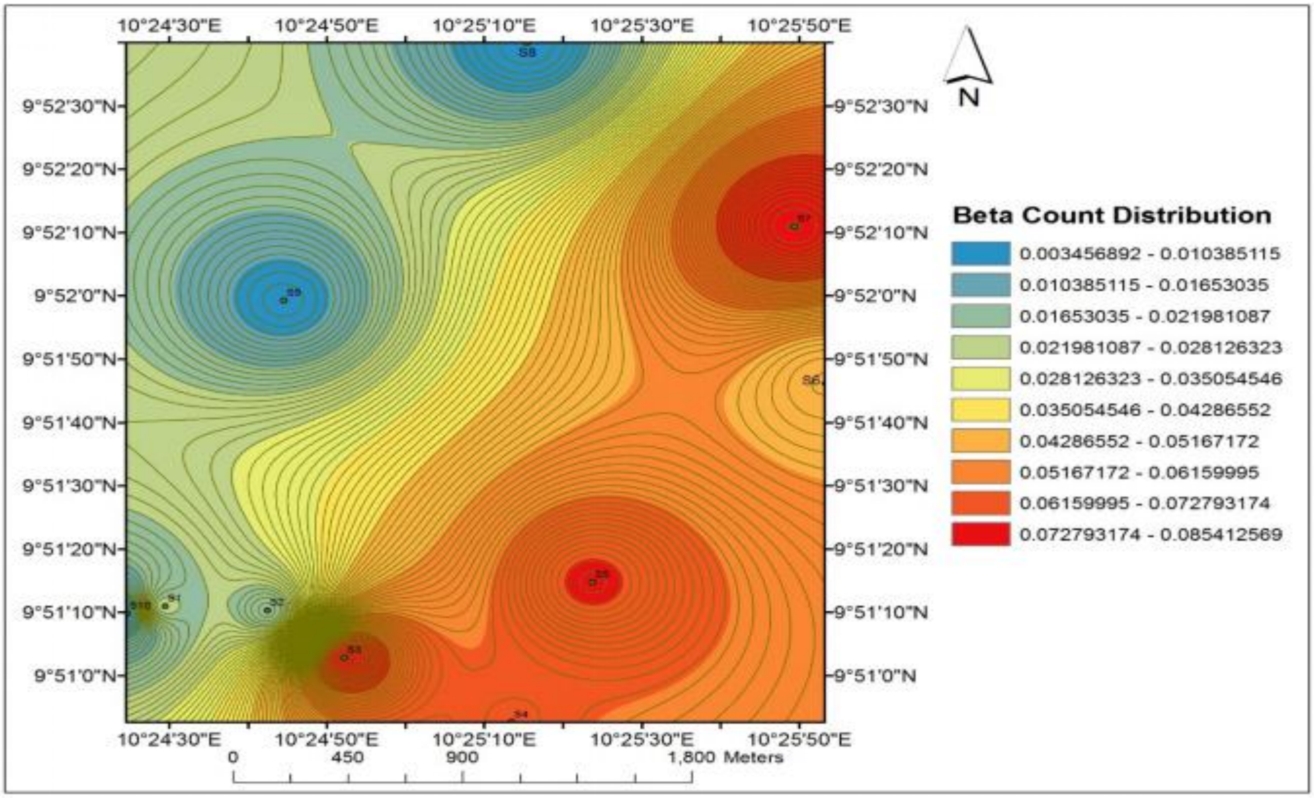

Fig. 3. Contour distribution pattern of Beta activity of samples collected at the dam

Table 2 Result for the alpha and beta activities of the treated water samples taken at one point

Sample ID	Longitude	Latitude	Alpha Concentration (Bq/m^3)	±Error	Beta Concentration (Bq/m^3)	±Error
A1	10°24'47.74''N	9°51'41.49''E	BDL	BDL	1.54E-02	1.63E-03
A2	10°24'47.74''N	9°51'41.49''E	6.65E-03	7.48E-04	1.03E-02	1.70E-03
A3	10°24'47.74''N	9°51'41.49''E	2.78E-03	1.85E-04	1.48E-02	4.80E-03
A4	10°24'47.74''N	9°51'41.49''E	1.37E-03	8.81E-04	2.46E-02	1.98E-03
A5	10°24'47.74''N	9°51'41.49''E	9.60E-03	9.80E-04	1.54E-02	2.22E-03
A6	10°24'47.74''N	9°51'41.49''E	1.85E-03	9.92E-04	1.26E-02	2.07E-03
A7	10°24'47.74''N	9°51'41.49''E	1.42E-03	1.19E-04	5.04E-02	2.89E-03
A8	10°24'47.74''N	9°51'41.49''E	BDL	BDL	8.70E-02	2.17E-03
A9	10°24'47.74''N	9°51'41.49''E	4.60E-03	8.00E-04	1.53E-02	1.90E-03
A10	10°24'47.74''N	9°51'41.49''E	7.55E-03	9.86E-04	8.71E-02	2.76E-03

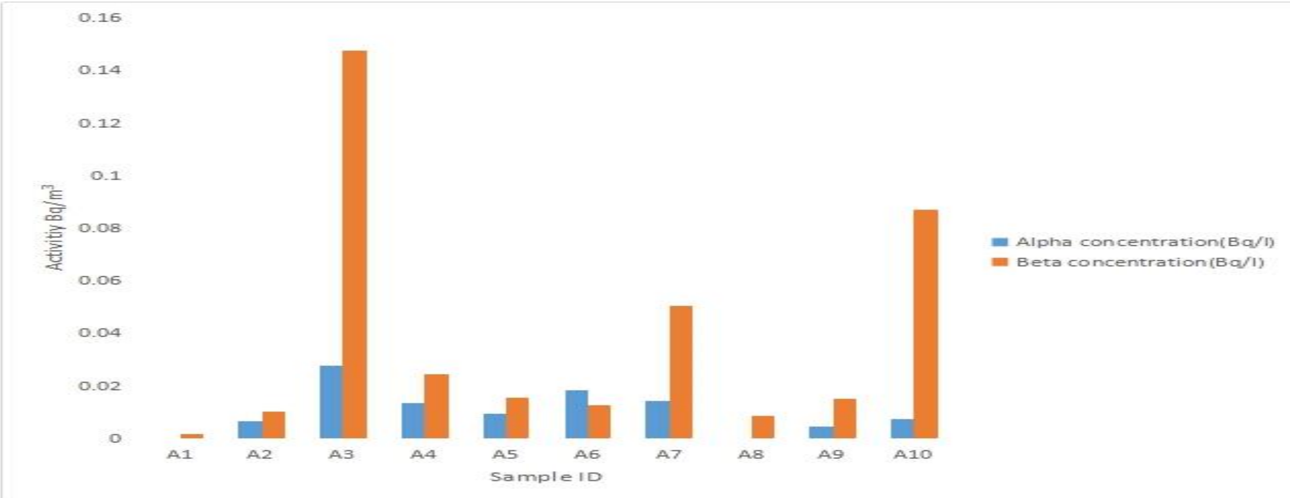

Fig.4. Alpha and Beta activity concentration in samples of the treated water.

From fig.4 above, it could be seen that the distribution of alpha activities is only slightly higher in A3, A4, A6 and A7. This means that most of the points are of elevated activity, with some having quite moderate activity and some extremely low activity such as those in A1 and A8.

Table 3 Result for the alpha and beta activities of the borehole water samples taken at various point.

Sample ID	Longitude	Latitude	Alpha Concentration (Bq/m^3)	±Error	Beta Concentration (Bq/m^3)	±Error
S11	10°24'46.66"N	9°50'41.26"E	BDL	BDL	BDL	BDL
S12	10°24'46.39"N	9°50'41.55"E	BDL	BDL	BDL	BDL
S13	10°24'46.35"N	9°50'42.66"E	3.04E-03	4.23E-02	4.23E-02	6.17E-03
S14	10°24'48.64"N	9°50'42.64"E	3.12E-03	1.52E-02	1.52E-02	6.95E-03
S15	10°24'45.26"N	9°50'40.88"E	E1.285E-01	4.80E-01	4.80E-01	9.72E-03

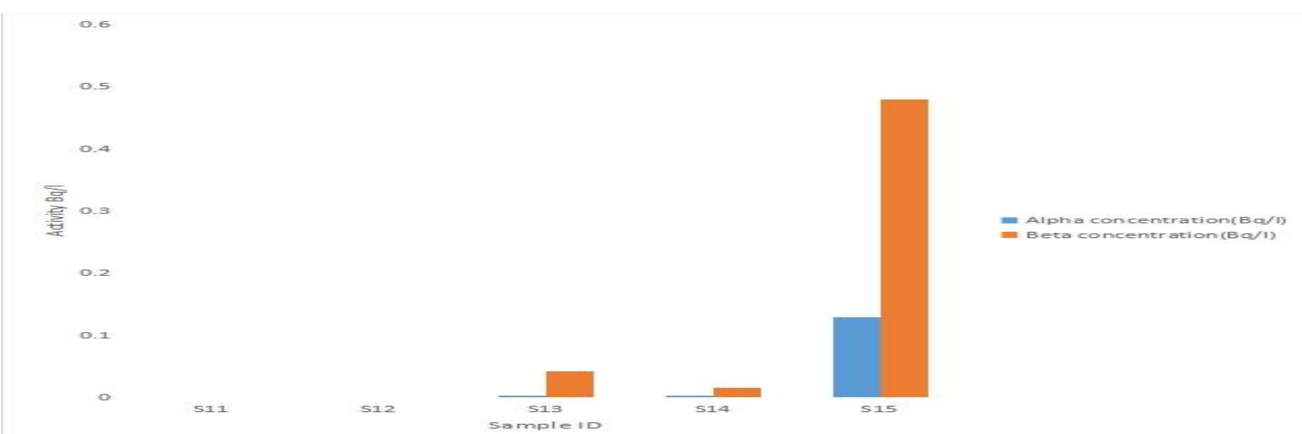

Fig.5. Alpha and Beta activity concentration in all samples of the boreholes water.

From figure 13 above, it could be seen that the distribution of alpha activities is only slightly higher in S15 only. This means that S15 point is of elevated activity, with some having quite moderate activity and some extremely low activity At S11 and S12.

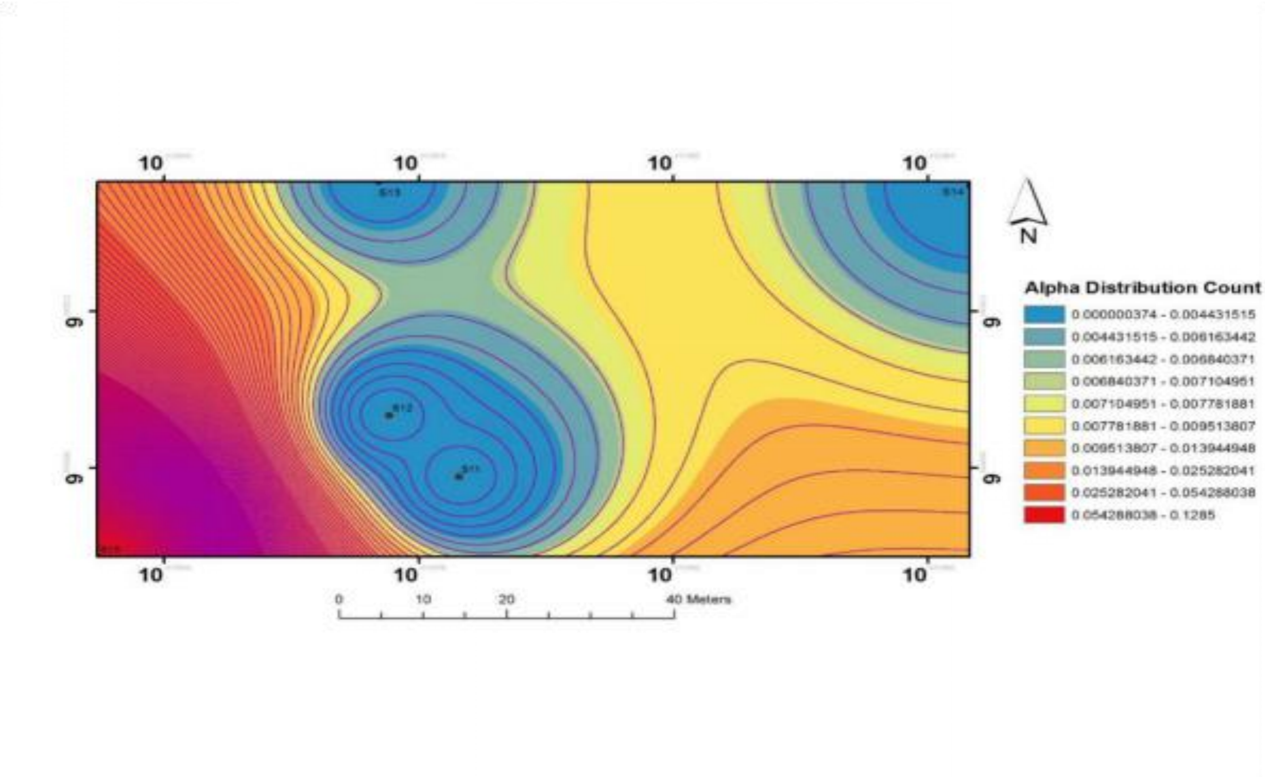

Fig.6. Contour distribution pattern of Alpha activity for the boreholes samples

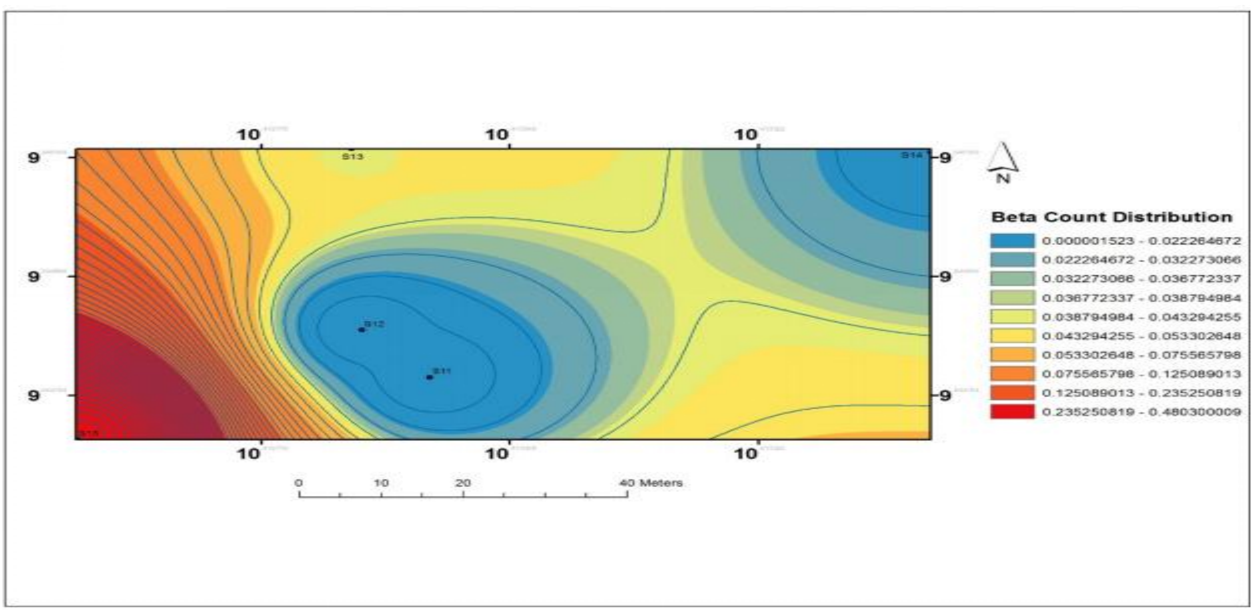

Fig.7. Contour distribution pattern of Beta activity for the boreholes samples

3.2 Discussions

The results obtained show that the gross alpha and beta activity in the samples vary between BDL-8.121E-03 Bq/m^3 and 2.291E-02 -3.448E-02 Bq/m^3 for the dam source, BDL-7.547E-03Bq/m^3 and1.544E-03-8.714E02Bq/m^3 for the treated water and BDL-1.285E-01Bq/m^3 and BDL-4.803E-01Bq/m^3 for the borehole water respectively. These results indicates the safety of the water in the area for drinking and other domestic use since the activity are far below the World Health Organization (W H O) standard of 100 Bq/m^3 and 1000 Bq/m^3 for alpha and beta respectively.

4. Conclusion

The gross alpha and gross beta activity measured from the water samples showed average alpha activity of (7.057E-03Bq/m^3) in the dam, (1.0253E-02 Bq/m^3) in the treated water and (2.693E-02 Bq/m^3) and in the borehole water. The average beta activity is 4.11E-02Bq/m^3, 3.74E-02Bq/m^3 and 1.0756E-01Bq/m^3 for the dam, treated and the borehole water samples respectively. In comparison the alpha activity is highest in the borehole water sample. And also the beta activity is highest in the borehole water samples. It can be concluded that the comparatively high alpha and beta activity in the borehole water samples may be due to some anthropogenic activities that might have taken place in the past. In general the alpha and beta activity in the three samples are far below the WHO limits. The alpha and beta activity in the water along the three samples collected are just background radioactivity. Therefore water from Gubi dam weather treated, untreated or ground water purses no radiological hazards to the inhabitants of Bauchi.

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