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Assessment of Heavy Metals and Radioactivity Concentration in Drinking Water Collected From Local Wells and Boreholes of Dutse Town, North West, Nigeria

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Abstract The study examined the heavy metals and radioactivity concentration of drinking water in 24 sample locations collected from Dutse town. The samples were divided into groups namely: Borehole and well water samples. It was first analyzed for heavy metals using Atomic Absorption Spectrometer (ASS). The mean concentration computed for borehole water samples were 0.006, 0.04, 0.03, 3.419, 0.029, 0.399, 1.867 and 0.089 mg/l for Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively and the mean computed for well water samples were 0.001, 0.041, 0.0002, 0.597, 0.002, 0.097, 2.632 and 0.002 mg/l for Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively. The samples were later study for gross alpha and radioactivity using MPC-2000, a low background alpha and beta detector. The mean activity for gross alpha and beta were 0.085 and 18.60 Bq/l respectively for borehole water samples and 0.329 and 508 Bq/l for well water samples respectively. An attempt was made to determine the correlation between gross alpha and beta activity, which yielded fairly good correlation of 0.72 for well water samples and poor correlation of 0.23 for borehole water samples. The correlations were improved when an outlier was removed from each correlation plot. This suggested that the outlier had unduly weight in the correlation. The results obtained were also compared with other previous works. This study reveals that some areas exceeded the maximum recommended level set by WHO and NSDWQ for safe drinking water especially the samples collected from wells for radioactivity and those collected from boreholes for heavy metals. Therefore, the sampled locations were contaminated with both heavy metals and radioactivity. We recommend that the water should be treated for both heavy metals and radioactivity before consumption.

Keywords: *heavy metal, gross alpha, gross beta, borehole, well, drinking water, Dutse town*

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1. Introduction

1.1. Heavy Metals Poisoning

Heavy metals poisoning can be defined as the excess accumulation of heavy metals into the soft tissues of the body [1]. Toxic metals are usually present in industrial, municipal and urban runoff, which can be harmful to humans and other organisms. Increased concentration of heavy metals are associated with urbanization and industrialization particularly heavy metals in our drinking water supplies. The dangerous chemicals released in our environment, accumulate in the soil and sediments of our drinking water bodies. More than 50 elements are categorized as heavy metals, but only 17 out of 50 elements are considered to be very toxic and relatively accessible. Heavy metals poisoning depends on the type of metal, its biological role and the type of organisms that are exposed to it. It is also recorded that it has serious effect on aquatic flora and fauna which makes it possible to enter the food chain and eventually affect the human health as well. The common heavy metals poisoning in drinking water include lead, iron, copper, zinc, chromium and so on. They are only useful to human body when in small amount but toxic when in large doses. In this section and next two sections most of our discussion will be drawn from [2].

Heavy metals like copper are significant trace element but indicate toxicity if in excess amounts in drinking water but cadmium is extremely toxic even in low concentrations and will bio-accumulate in organisms and ecosystems as it has long biological half-life in the human body, ranging from 10 to 33years. A long term exposure to Cadmium also causes renal damage. So cadmium is considered as one of the primary pollutants from monitoring in most countries and international organizations.

The contamination of water is directly related to the water pollution. There is need to continuously assess the quality of ground and surface water sources. The known fatal effects of heavy metal toxicity in drinking water include damaged or reduced mental and central nervous function and lower energy level. They also cause irregularity in blood composition, and badly affect vital organs such as kidneys and liver. The long term exposure to these metals result in physical, muscular, neurological degenerative processes that cause Alzheimer's disease (brain disorder), Parkinson's disease (degenerative disease of the brain), muscular dystrophy (progressive skeletal muscle weakness), multiple sclerosis (a nervous system disease that affects brain and spinal cord). Also, lead is one of the most common heavy metals in drinking water, if occurs more than its permissible limit triggers general metabolic poison and enzyme inhibitor. Lead has the ability to replace calcium in bone to form sites for long term replacements. Drinking water is obtained from a variety of sources like wells, rivers, lakes, reservoirs, ponds etc. These various sources of water pose the greatest risk to human health due to contamination of the sources .Water pollutants mainly consists of heavy metals, microorganisms , fertilizers and thousands of toxic organic compounds. Heavy metals in water occur only in trace levels but are more toxic to the human body. Keeping in view the hazardous nature of heavy metals contamination in water, it became necessary to study the concentration of heavy metals in our drinking water and highlight the danger if the concentration exceeds the maximum level as recommended by World Health Organization (WHO) and other international organization such as USEPA, EPA and so on.

1.2. Radioactivity in Water

Radioactivity in water is relatively easy to measure. Given the appropriate equipment and radio-analytical expertise, the interpretation of the significance of the measured radioactivity to the domestic water user is beset with uncertainties and imponderables, especially when it comes to evaluating the actual risk to the consumer. Water is a necessity to man and his environment; it has existed throughout the history of the earth crust or even before the existence of man. Man uses water for the following activities: irrigation, power generation and domestic activity. There are two natural sources of water: rain and ground waters. It is found in rivers, wells, lakes and streams. The activities of human and natural phenomena constantly pollute the sources of water and affect water quality. Water pollution arises as a result of waste and sewage disposal into the environment and rivers by industries, hospitals and use of materials such as fertilizers by farmers. These disposed materials often contain radio nuclides [3]. In developing countries like Nigeria, lack of safe drinking water is one of the serious threats to the human health as a result of that, rivers, streams, well and borehole waters are often used as alternative to the scarce pipe-borne water for drinking and domestic activities without any treatment [4].

Water bodies are also polluted from Naturally Occurring Radioactive Materials (NORM) that emits alpha, beta and gamma radiation. These usually have elements in the uranium and thorium series whose radioactivity bring about an appreciable airborne particulate activity and contribute to the radioactivity of rain and ground waters. It also affects drinking water from deep wells which are expected to have a higher concentration of radioactive elements compared to surface water. Furthermore, man-made alpha emitters, such as plutonium and americium could be transported into springs or wells there upon extending the activity level of the water [3].

There is a great concern for the quality of drinking water as it is critical to overall socio-economic development of any society and involves individuals, groups, government and non-governmental organizations. Since the public utilities are simply unable to cope with the demand for qualitative water, alternative source (s) of water must be devised. Consequently, the frustrated citizen of Dutse town in north-western Nigeria seek realistic solutions by digging local wells and boreholes as well as other water sources that are clean, clear, odorless, apparently pure and safe to drinking. Available statistics show that urban centers are better off than the rural areas in terms of access to safe drinking water sources. This is so perhaps where large population resides, as a result of that most of the national and international aids are directed to these centers. Moreover, the conditions are just as dreadful in the cities as in rural localities, since there is no boundary between the rural and cities centers. To justify the situation evidently, UNICEF in 2010 joint monitoring program for water supply and sanitation, reported that only 58% of Nigerian population has access to improved drinking water supply and only 32% have sanitation coverage. This translates into about 64 millions of Nigerians without access to improved drinking water and over 100 million people do not have access to improved sanitation, all out a total population of about 150 million [11].

The critical water shortage forced people of Dutse to drink untreated water obtained from surface and underground sources, thus, exposing themselves to hazardous chemicals and infectious agents. This has drawn the attention of many researchers to examine the radioactivity, physicochemical and microbial characteristics of water sources [11].

This work examined the level of heavy metals and radioactivity concentration in water drawn from local hand-dug wells and boreholes used for drinking and other domestic activity. The study will be significant to the communities around the sampled locations and the government in its effort to provide safe drinking water to masses.

2. Materials and Method

2.1. Counting Equipment

The gross alpha and beta counting equipment used in this work is MPC-2000, a Low Background alpha and beta counter. The equipment is a gasless proportional counter with ultra-thin window. The sample was placed in a planchet and later placed in a sample carrier. The carrier was then placed on the sample drawer and closed for the purpose of gross alpha and beta counting. The counting was done automatically according to the selected count mode when the appropriate sample parameters were entered [5]. The second equipment used for determination of some trace heavy metals is Atomic Absorption spectroscopy (AAS).

2.2. Sampling

a). Sampling Frame

The area under study is Dutse metropolis and this investigation is limited to underground water sources in local boreholes and wells used by people for drinking, domestic activities, irrigation and animal husbandry. The method adopted for the sampling is stratified random sampling [4].

b). Sampling Procedure

The sampling procedure involves the following: The sample container was rinsed three times with the water being collected, to minimize contamination from the original content of the sample container. Two samples were collected per sampling point which makes the total 48 samples from 24 different sampling points. Air space of about 1% in the container of water collected was left for each sample to give room for thermal expansion. There was marked on each container indicating two liters of volume corresponding to the air gap. 20 ml of diluted nitric acid was added to the sample immediately after collection to reduce the pH and to minimize precipitation and absorption on container walls. The samples were tightly covered with container cover and masking tape and kept in the laboratory for analyses.

2.3. Sample Preparation

The specified volume of each sample was poured into a beaker and evaporated on a hot plate to 50 ml volume and then transferred to a clean dry planchet. The samples were evaporated to dryness on hot plate. The residues were transferred onto to a clean, dry and previously weighed planchet and the difference between the mass of empty planchet and that of the empty planchet plus residue gives the mass of the residue. The residues were uniformly spread on the planchet by dropping a few drops of ethanol. The residues were allowed to dry and then covered with Mylar film ready for counting.

$$\mathrm{SE} = \frac{(w_2 - w_1) - (w_3 - w_1)}{w_2 - w_1} \times 100\% \qquad (1)$$

Where SE = Sample Efficiency, w_1= weight of empty planchet, w_2 = weight of planchet plus residues obtained after evaporation and w_3 = weight of empty planchet – weight of residue.

The sample preparation for determination of heavy metals in the water were prepared according to the samples preparation procedure developed for the analysis using Atomic Absorption Spectroscopy at the general laboratory, department of chemistry, Ahmadu Bello University (ABU), Zaria.

2.4. Counting and Analysis

The counting equipment is automated. The protocol involves entering preset time, counting voltage and number of counting cycles. Also, the counter characteristics (efficiency and background) volume of sample used and sampling efficiency specified [6]. The calculation formulae for count rate activity and other parameters for a given sample are shown below:

a) Count Rate

$$R(\alpha,\beta) = \frac{Raw(\alpha,\beta)Count}{Count\,Time} \qquad (2)$$

In all modes except mode alpha then beta:

b) Activity (A)

$$A(\alpha,\beta) = \frac{R(\alpha,\beta) - B\square\alpha\ \ \beta}{SE \times CE \times V} \times \frac{1}{60} \qquad (3)$$

Where A is the activity, B is the background, R is the rate, SE is the sample efficiency, CE is the channel efficiency and V is the equivalent volume of water evaporated.

The statistical precision is calculated for the channel, on each measurement and it depends only on the preset count whose value is declared indirectly. Assume N measurements are made during a time T, the average is given by $\bar{m} = \frac{\sum mi}{N}$ and the standard deviation (σ) is given by

$$\sigma = \sqrt{\left[\frac{R_s}{t_s} + \frac{R_b}{t_b}\right]} \qquad (4)$$

R_s = Sample counting rate
R_b= Background counting rate
t_s= Sample counting time
t_b = Background counting time

$$\mathrm{CR} = 1.96\sigma \qquad (5)$$

Where CR = Counting Error

c) Statistical Analysis

In order to analyze the activity measured, statistical techniques employed are estimation of the central tendencies and deviations, correlation analysis and histograms. The correlation coefficient (r) is given by the expression below [7]:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right]\left[n\sum y^2 - (\sum y)^2\right]}} \qquad (6)$$

And the geometric mean (GM) is given by as:

$$\mathrm{GM} = \sqrt[n]{(x_1, x_2, \ldots, x_n)}. \qquad (7)$$

All statistical analyses were carried out using the Microsoft Excel.

3. Results and Discussion

In this section, the water samples drawn from boreholes and local hand-dug wells were studied and analyzed for heavy metals and radioactivity concentration using Microsoft excel and some simple statistical tools.

3.1. Measured Heavy Elements for Borehole and Well Water Samples

Figure 1 shows the plot of measured heavy elements of borehole water samples from Dutse, Jigawa state. The concentrations were continuously varied across the sample locations. The maximum concentration obtained at Fatara hovers around 23.256 mg/l (Iron). It could be realized that the Iron concentration was not reflected in the plot, it was removed due to its larger magnitude compared to other elements in the plot. The chart was further explained using Table 1, Table 2 and Table 3 below.

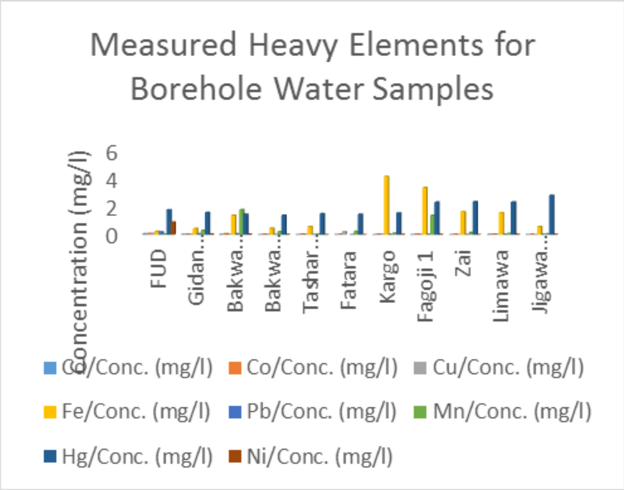

Figure 1. Plot of Measured Heavy Elements of Borehole Water Samples for Dutse Town

Table 1. The maximum admissible limit set by different national and international organizations for safe drinking water [8,9,10]

	Concentration of Heavy metals in mg/l							
	Cd	Co	Cu	Pb	Fe	Mn	Hg	Ni
NSDWQ	0.003	NM	1.0	0.01	0.3	0.2	0.001	0.02
NAFDAC	0.0	NM	NM	0.0	NM	NM	0.0	NM
USEPA	0.005	0.1	1.3	0.015	0.3	0.05	0.002	0.1
WHO	0.003	NM	2.0	0.01	0.3	0.4	0.001	0.07

NM: Not mention.

Table 1. shows the maximum contamination level (MCL) of some heavy metals in drinking water set by different organizations such as Nigerian Standards for Drinking Water Quality (NSDWQ), National Agency for Food and Drug Administration and Control (NAFDAC), United States Environmental Protection Agency (USEPA) and World Health Organization (WHO). The heavy elements in the Table 1 above were the elements of concern in this study.

Table 2. Locations with concentration above Maximum Contamination Level (AMCL) and below Maximum Contamination Level (BMCL) for borehole water samples

Heavy Elements for Borehole Water Samples								
Sample Locations	Cd	Co	Cu	Fe	Pb	Mn	Hg	Ni
FUD	+	NM	-	-	+	-	+	+
Gidan Dubu Yadi	+	NM	-	+	+	-	+	-
Bakwato 1	-	NM	-	+	+	+	+	-
Bakwato 2	-	NM	-	+	-	-	+	-
Tashar Danwake	-	NM	-	+	-	-	+	-
Fatara	-	NM	-	+	-	-	+	-
Kargo	-	NM	-	+	-	-	+	-
Fagoji 1	-	NM	-	+	-	+	+	-
Zai	-	NM	-	+	-	-	+	-
Limawa	-	NM	-	+	-	-	+	-
Jigawar Tsada	-	NM	-	+	-	-	+	-

NM: Not Mention in the guidelines set by most of the organizations
(+): Above the maximum permissible limit
(-): Below the maximum permissible limit

Table 2 shows the heavy elements and corresponding locations for borehole water samples. The table was used to identify the areas with concentration above and below the maximum recommended level denoted by (+) and (-) respectively. The concentration of cadmium in all the sample locations was almost below the maximum contamination level set by NSDWQ and WHO except for FUD and Gidan dubu yadi with 0.056 and 0.01 mg/l respectively. The guidelines for Cobalt was not mentioned in either NSDWQ or WHO. The copper concentration for all samples was below the guidelines set by NSDWQ and WHO respectively. The iron concentration exceeded the guidelines for almost all the sample locations except for FUD with 0.228 mg/l. Lead concentration was high at FUD, Gidan dubu yadi and Bakwato 1 estimated at 0.194, 0.062 and 0.053 mg/l respectively. Manganese concentration was high at Bakwato 1 and Fagoji 1 amounting to 1.787 and 1.388 mg/l respectively. The mercury concentration was extremely high for all the sample locations, and exceeded all the guidelines set by national and international organizations including WHO and NSDWQ. Finally, Nickel concentration was high at FUD and low for all other sample locations.

Table 3. Range and mean values of measured heavy elements for borehole water samples

Borehole Water Samples		
Heavy Metals	Range (mg/l)	Mean (mg/l)
Cd	0-0.056	0.006
Co	0.027-0.077	0.04
Cu	0-0.193	0.033
Fe	0.228-23.256	3.419
Pb	0-0.194	0.029
Mn	0.035-1.787	0.399
Hg	1.38-2.806	1.867
Ni	0-0.03	0.089

Table 3 shows the range and mean values for each measured heavy elements collected from borehole. The arithmetic mean computed indicated that almost all the values exceeded the maximum recommended level set by WHO and NSDWQ except for Co and Cu which indicated low concentration.

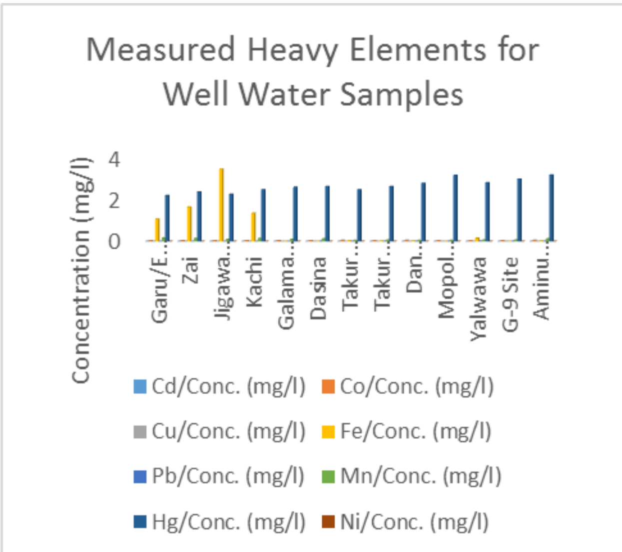

Figure 2. Plot of Measured Heavy Elements of Well Water Samples for Dutse Town

Figure 2 shows the plot of measured heavy elements of well water samples for Dutse town, Jigawa state. The maximum heavy element recorded at Jigawa sarki was 3.428 mg/l, followed by mercury concentration for all the sample locations. The plot was further explained by the Table 4 and Table 5 below.

Table 4. Locations with concentration above Maximum Contamination Level (AMCL) and below Maximum Contamination Level (BMCL) for well water samples

Heavy Elements for Well Water Samples								
Sample Locations	Cd	Co	Cu	Fe	Pb	Mn	Hg	Ni
Garu/Emir palace	-	NM	-	+	-	-	+	-
Fagoji 2	-	NM	-	-	-	+	+	-
Jigawa Sarki	-	NM	-	+	-	-	+	-
Kachi	-	NM	-	+	-	-	+	-
Galamawa	-	NM	-	-	-	-	+	-
Dasina	-	NM	-	-	-	-	+	-
Takur Adua	-	NM	-	-	-	-	+	-
Takur Site	-	NM	-	-	-	-	+	-
Dan Masara	-	NM	-	-	-	-	+	-
Mopol Base	-	NM	-	-	-	-	+	-
Yalwawa	-	NM	-	-	+	-	+	-
G-9 Site	-	NM	-	-	-	-	+	-
Aminu Kano Way	-	NM	-	-	-	-	+	-

Table 4 shows the heavy elements and corresponding locations for well water samples. The table was used to identify the areas with concentration above and below the maximum recommended level denoted by (+) and (-) respectively. The concentration obtained for cadmium, cobalt, copper and nickel was below the maximum permissible limit as shown in the Table 1 above. The iron concentration was high at Garu/Emir palace, Jigawa sarki and Kachi hovering around 1.057, 3.428 and 1.34 mg/l respectively. The Lead concentration was high at Yalwawa estimated at 0.021 mg/l and all other areas were below the guidelines recommended by WHO and NSDWQ respectively. The measured concentration of Manganese at Fagoji 2 of value 1.033 mg/l was higher than the maximum permissible limit. Finally, the concentration measured for mercury was extremely higher than the recommended level set by any national and international organizations including WHO and NSDWQ.

Table 5. Range and mean values of measured heavy elements for well water samples

Well Water Samples		
Heavy Metals	Range	Mean
Cd	0-0.003	0.001
Co	0.033-0.048	0.041
Cu	0-0.003	0.0002
Fe	0-3.428	0.597
Pb	0-0.021	0.002
Mn	0.057-0.175	0.097
Hg	2.179-3.148	2.632
Ni	0-0.006	0.002

Table 5 shows the range and mean values for each measured heavy elements collected from well. The arithmetic mean computed shows that almost all the values were below the maximum recommended level set by WHO and NSDWQ respectively except for Iron and Mercury which indicated highest concentration.

3.2. Measured Activity for Well and Borehole Water Samples

The measured activity for the samples collected from borehole and local dug well were discussed. It was observed that the arithmetic mean of alpha activity were 0.09 and 0.33 Bq/l for borehole and well water samples respectively and that of beta activity were 18.6 and 508 Bq/l for borehole and well water samples respectively.

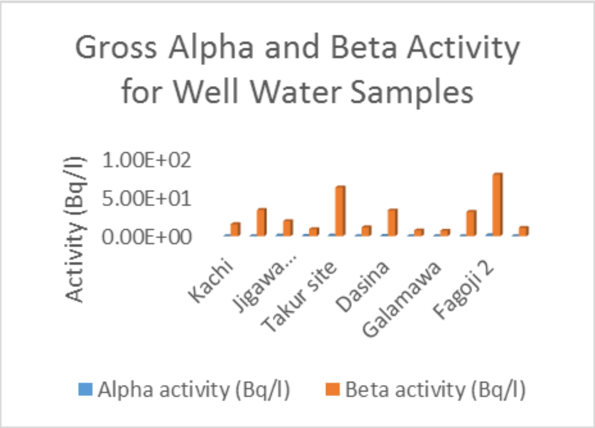

Figure 3. Plot of Gross Alpha and Beta Radioactivity of Well Water Samples for Dutse Town

Figure 3 shows the chart of gross alpha and beta radioactivity of well water samples for Dutse town. It was observed that Jigawa sarki, Mopol base, Takur site, Dasina and Fagoji 2 had values of 0.834, 0.55, 0.884, 0.551 and 1.08 Bq/l respectively exceeding the maximum contamination level set by WHO of 0.5 Bq/l for alpha activity in drinking water. The maximum and minimum values recorded were 1.081 and 0.003 Bq/l respectively.

It was further observed that the measured beta activity for all sample locations were above the guidelines recommended by WHO of 1.0 Bq/l. The maximum and minimum activity observed were obtained and they gave 6284.5 and 6.826 Bq/l respectively. The high values of beta activity might be due to the nature of the sample locations and geological activities in the environment.

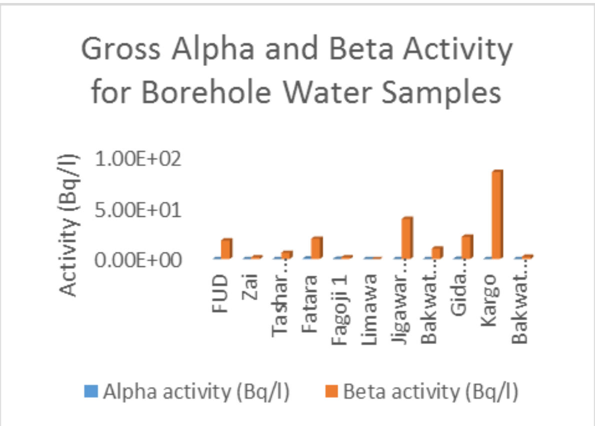

Figure 4. Plot of Gross Alpha and Beta Radioactivity of Borehole Water Samples for Dutse Town

Figure 4 shows the chart of gross alpha and beta radioactivity of borehole water samples of Dutse town, Jigawa State. The observed alpha activity of all the sampling areas was below the maximum contamination level set by WHO of 0.5 Bq/l. The observed beta activity of all the sampling locations was above the guidelines recommended by WHO of 1.0 Bq/l. The maximum activity reported for both alpha and beta were 0.485 and 84.677 Bq/l respectively and the minimum activity recorded was Below Detection Limit (BDL). The alpha activity recorded in borehole water samples were lower than the activity recorded in the well water samples. The difference might be from the absorption of radionuclides by the wall of the pipes unlike that of wells which was fetched directly from its source.

3.3. Relationship between Gross Alpha and Beta Activity

A study was made to examine the correlation between gross alpha and beta activity for borehole and well water samples respectively collected from Dutse town, Jigawa State, Nigeria.

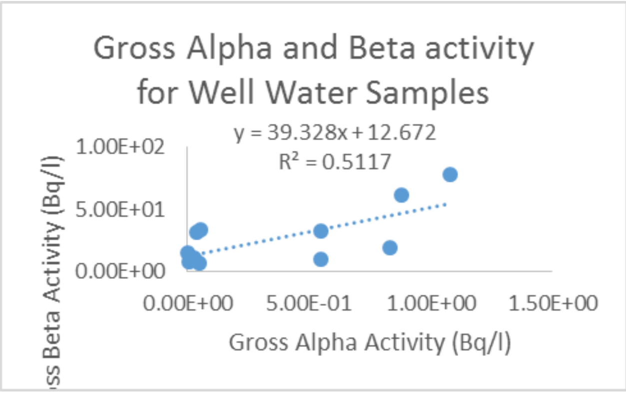

Figure 5. Correlation between Gross Alpha and Beta Activity of Well Water Samples

Figure 5 shows the correlation between measured alpha and beta activity of well water samples of Dutse town. The following were computed: coefficient of determination (R) of 0.51, Pearson regression coefficient (r) of 0.72, gradient of 39.33 and intercept of 12.67. The result showed a fairly good correlation. The correlation was improved by removing only one point which was considered to be an outlier that had significantly reduced the correlation.

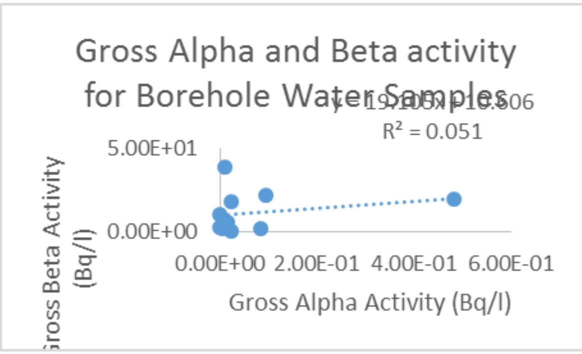

Figure 6. Correlation between Gross Alpha and Beta Activity of Borehole Water Samples

Figure 5 shows the correlation between measured alpha and beta activity of borehole water samples of Dutse town. The following were computed: coefficient of determination (R) of 0.05, Pearson correlation coefficient (r) of 0.23, gradient of 19.11 and intercept of 10.61 respectively. A single point was also removed to improve the correlation as was done for well water samples but yet very poor correlation was obtained.

3.4. Comparison of Results Obtained with Other Studies

The results obtained for heavy metals analysis and radioactivity concentration in the water samples collected from Dutse town were compared with other works in different locations.

Table 6. Comparison of measured heavy elements in dutse town with other places [9,11,12,13,14]

Concentration (mg/l)						
Heavy Metals	Gombe	India	Ethiopia	Pakistan	Egypt	Dutse
Cd	-	0.002	0.017	0.067	0.019	0.003
Co	-	-	0.018	-	-	0.041
Cu	0.02	-	BDL			
Fe	0.62		-	1.676	0.804	1.824
Pb	-	0.003	-	0.351	-	-
Mn	0.12	-	-	-	0.244	0.273
Hg	-	-	-	-	-	2.283
Ni	-	0.003	-	0.004	-	0.043

Table 6 shows the comparison between the measured heavy metals in Dutse town with those of other places such as Gombe-Nigeria, India, Ethiopia, Pakistan and Egypt. It was observed that the cadmium measured in Dutse was greater than that of India and less than the one measured in Ethiopia, Paskistan and Egypt. The measured cobalt in Dutse was greater than the one measured in Ethiopia. The measured copper was less than those of Gombe, Pakistan and Egypt. The iron concentration in Dutse was greater than those of all the other locations in comparison. The lead concentration in Dutse was greater than the concentration measured in India and less than the one measured in Pakistan and Egypt. The concentration measured for manganese in Dutse was greater than those of Egypt and Gombe. The nickel concentration in Dutse was greater than the ones measured in Pakistan and India. Finally, the measured mercury concentration in Dutse was extremely high and exceeded all the guidelines recommended by national and international organizations including WHO and NSDWQ.

Table 7. Comparison of measured activity in dutse with other locations [4,15,16,17,18,19]

Locations	Alpha (Bq/l)			
	Min	Max	GM	Mean
Gombe	0.001	0.063	0.01	-
Kano	0.0005	0.022	-	0.006
Sokoto	0.01	6	0.26	-
Bayelsa	-	-	-	4.02
Turkey	0.08	0.38	-	0.192
Zaria	0.035	0.01	-	0.015
Dutse	0.003	1.08	0.006	0.229
Location	Beta (Bq/l)			
	Min	Max	GM	Mean
Gombe	0.132	3.828	0.526	-
Kano	0.008	0.345	-	0.048
Sokoto	-	-	-	-
Bayelsa	-	-	-	54.23
Turkey	0.12	3.47	-	0.579
Zaria	0.06	0.91	-	0.33
Dutse	0.008	6284.5	13.48	283

Table 7 shows the comparison between the measured gross alpha and beta activity in Dutse town with other places including Gombe, Kano, Sokoto, Bayelsa, Turkey, and Zaria. It was observed that the minimum alpha activity measured in Dutse was greater than the ones in Gombe and Kano but less than those of all the other locations in comparison. The maximum alpha activity measured in Dutse was less than the one measured in Sokoto but greater than those of all the other locations in comparison. The geometric mean computed for the measured alpha activity in Dutse was less than the ones computed in Gombe and Sokoto. Similarly, the arithmetic mean computed for the measured alpha activity in Dutse was less than the one computed in Bayelsa but greater than the ones computed in Kano, Turkey and Zaria respectively.

Similar comparisons were made for beta activity: the minimum beta activity measured in Dutse was equal to the one measured in Kano but greater than those of all the other locations in comparison. The maximum beta activity measured in Dutse town was greater than the ones of all the locations in comparison. Further comparisons were made for geometric and arithmetic mean computed in Dutse with other locations. The geometric mean computed for the alpha activity in Dutse was greater than the one computed all the ones computed in Gombe and Sokoto. The arithmetic mean computed for the measured alpha activity in Dutse was less than the one computed in Bayelsa and greater than the ones of all the other locations. The geometric mean computed for measured beta activity in Dutse was greater than the one computed in Gombe. The arithmetic mean computed for beta activity in Dutse was greater than those of all the other locations. In general, it could be seen that the results obtained in Dutse town, Nigeria, were in agreement with other studies carried out in different locations within and outside the country.

4. Conclusion

The heavy metals data were obtained using Atomic Absorption Spectrometer stationed at general laboratory Ahmadu Bello University, Zaria, Nigeria while the gross alpha and gross beta activity data was generated using MPC-2000, a Low Background alpha and beta counter stationed at Center for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Nigeria. The major aim of this study was to evaluate the quality of drinking water by measuring the level of heavy metals and radioactivity concentration in Dutse town, Jigawa State. A total of 48 drinking water samples were collected from 24 different sampling sites. Emphasis was given to the densely populated areas in the region. The samples were studied and analyzed for Heavy metals and radioactivity concentration. The analyzed heavy metals were Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively. The results for borehole water samples showed that the concentration ranges from 0.0 to 0.06, 0.027 to 0.08, 0.0 to 0.19, 0.23 to 23.26, 0.0 to 0.19, 0.04 to 1.79, 1.38 to 2.81 and 0 to 0.03 for Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively. The average concentration of each heavy metal was also computed, the concentration Iron (Fe), Lead (Pb), Cadmium (Cd), Mercury (Hg) and Nickel (Ni), exceeded the maximum recommended level set by World Health Organization (WHO) and Nigerian Standards for Drinking Water Quality (NSDWQ). The results for well water samples showed that the concentration ranges from 0 to 0.003, 0.033 to 0.048, 0 to 0.003, 0 to 3.428, 0 to 0.021, 0.057 to 0.175, 2.179 to 3.148 and 0 to 0.006 mg/l for Cd, Co, Cu, Fe, Pb, Mn, Hg and Ni respectively. The arithmetic mean of each heavy element was also computed. The concentrations of Iron (Fe), Manganese (Mn) and Mercury (Hg) exceeded the maximum contamination level set by WHO and NSDWQ for safe drinking water. The presence of the heavy metals above the maximum contamination levels in the study area would be from the sources such as transportation, dirty water, industrial activities, atmospheric deposition and geological impact.

The gross alpha and beta radioactivity concentration were also examined. The results for borehole water samples showed that almost all the sampling sites indicated low activity for gross alpha and very high activity were obtained for gross beta. The gross alpha and beta activity ranged from BDL to 0.49 and BDL to 84.68 Bq/l respectively for borehole water samples and for the well water samples, it ranges from 0.003 to 1.08 and 6.826 to 6284.5 Bq/l respectively. The arithmetic mean of gross alpha and beta for borehole and well water samples were also computed. The result obtained was compared with other locations within and outside Nigeria. A study was carried out to examine the correlation between gross alpha and beta activity for borehole and well water samples respectively, the correlation coefficient obtained indicated poor correlation for borehole water samples and fairly good correlation was obtained for well water samples. The correlation was improved by removing an outlier which was considered to have weighed the function unduly to significantly reduce the correlation.

It was also observed that the study area was covered with rocks mostly sedimentary type and sand which was believed to have affected both the heavy metals and radioactivity concentration in the sample locations especially, the well water samples. The reason of having lower activity in the borehole water samples was due to the absorption of some part of the radiation by the wall of the pipes and higher concentration of heavy metals in the borehole water samples may due to old age water supply infrastructure. Therefore, it is recommended that further studies to investigate the level of radioactivity, radionuclides and heavy metals concentration in these locations need to be carried out.

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