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ASSESSMENT OF HEAVY METAL CONCENTRATION IN DRINKING WATER (A CASE STUDY OF GASHUA TOWN, BADE LOCAL GOVERNMENT AREA YOBE STATE, NIGERIA)

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Abstract

The contamination of water is directly related to the degree of contamination of our environment Assessment of Heavy Metals concentration in drinking water quality in Gashua town, Bade LGA, Yobe State was carried out using laboratory techniques to determine the level of concentration of parameters such as Cadmium, Cobalt, Copper, Iron, Manganese, Mercury and Nickel in boreholes across the Gashua metropolis consisting of six wards namely; Katuzu, Lawan Fannami, Lawan Musa, Sabon Gari, Sarkin Hausawa and Zango Wards. Water samples were collected from eighteen sampling point across the six urban wards. The collected samples were analyzed using standard method in Yobe State University Damaturu. Analysis of Variance ANOVA was used to determine the physicochemical variation between the six wards. Student's t-test was also used to compare the heavy metals concentration and the acceptable drinking standard using USEPA. The results shows that there is no significant variation in the heavy metal concentration variation between the six wards. In addition, the result of the student t-test shows that all the parameters are within the acceptable drinking limit with that of USEPA. Thus, the null hypothesis is accepted. Although some wards samples were not suitable for drinking because of the excess accumulation of some of the heavy metals that can cause renal failure or kidney stones. Thus, it is recommended that the water should be treated before consumption.

Key Words: Groundwater, Heavy metals, Cadmium, Copper, Bore holes, USEPA

1.1 Introduction

Freshwater is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world, and as world population continues to rise at an unprecedented rate, many more areas are expected to experience this imbalance in the near future (Usman, 2015).

According to World Health Organization, about 80% of all the diseases in human beings are caused by water. Once the water is contaminated, its quality cannot be restored by stopping the pollutants from the source. Therefore, it becomes very important to regularly monitor the quality of water and to device ways and means to protect it (Mishra and Patel, 2001). In the last 20 years, many people have suffered from diseases that led to serious studies to find out the relationship between drinking water and chronic diseases. The chemistry of drinking water has been cited as an important factor in many diseases. A strong relationship between contaminated drinking water with heavy metals such as Pb, Cd, Cu, Mo, Ni, Cr and chronic diseases such as renal failure, kidney stones, liver cirrhosis, hair loss, and chronic anaemia etc. has continue to be a threat to the population of Gashua, Bade LGA, Yobe state (Mukhtar, 2018).

The World Health Organization (WHO) International Standards for drinking water have been among one of the most widely recognized and utilized WHO publications. International water quality standards started in 1958 when WHO published its first International drinking water standard (Goodman, 1980). Nevertheless, quite before then several standards were published in the United State, they include United States Public Health (1914, 1925, 1946) drinking water standards. On the contrary, the UK had none until the development of the 1958's WHO standard and subsequently in 1961 WHO aimed at providing upgraded standards to industrialized countries in Europe, besides the international standards. In 1975, the European Economic Community published its first drinking water standards for its member countries and the UK inclusive (Goodman, 1980). From there onward several other publications come from time to time, they include the revised editions of the WHO standards such as WHO (1993 and 2005) and Environmental Protection Agency (2003) standard among others.

UNESCO (1983) and EPA (2003) classified the chemical and physical characteristics of water into four namely organoleptic-those rapidly observable by any untrained observer and pose little or no health threat also included are natural physio- chemical parameter: normal characteristics with no health significant but indicate evidence of stability of water undesirable parameter-those directly harmful in high concentration and toxic parameters-those with adverse toxic effect to man. The WHO standards follow these classifications also. Shaw, (1993) classified the parameters into inorganic, organic, aesthetic and microbiological parameters.

Scholars in different part of Nigeria have carried out different researches. For instance (Iguisi *et al* 1999, Dim *et al*,2000, Butu 2002), on quality of groundwater, surface water, and pipe borne water, in Zaria where some pollutants were found to be above the international permissible limit for water meant for domestic and agricultural uses (Ibrahim, 2011). No study has try to assess the heavy metal concentration in drinking water in Gashua thus creating a research gap in which this study intends to fill.

The aim of this study is to assess the Heavy Metals concentration in Drinking water of Gashua town, Bade LGA, Yobe State. The aim was achieved through the specific objectives; to determine the level of concentration of the Heavy metals, and compare their level of concentrations with the acceptable drinking water quality standard according to United States Environmental Protection Agency (USEPA).

2. Materials and Method

2.1The Study Area.

Gashua is located between latitude 12^0 52’ 05 N and 12^0 87’11 N and longitude 11^0 57’26 E and 11^0 02’47 E. The community came under Bade local government area. Gashu’a has an area of 3,336 square kilometer and population of 88,014m as at (2006 census). Gashu’a lies in plain region that covered by savannah, which support the cultivation of crops such as millet, groundnut, guinea corn, and rearing of animals that support the life of people. (Oladimeji 2001). The climate of Gashua is characterize by having high amount of temperature and low annual rainfall toward the north region. The rainfall ranges between 400 mm and 800 mm with an annual mean of 750 mm.

The mean annual temperature is about 39^0c but the mean monthly value range between 27^0c in the coolest month of December to January and 32^0 C in the hottest month of April to May. The major river that flows in Gashua and the adjoining area is the River Komadugu yobe. The Hadajia jamaare River Basin is part of the vast Lake Chad drainage Basin and consists of three main tributaries. The water table is usually 0-15m below the drainage line. (Kimmage K.2012)

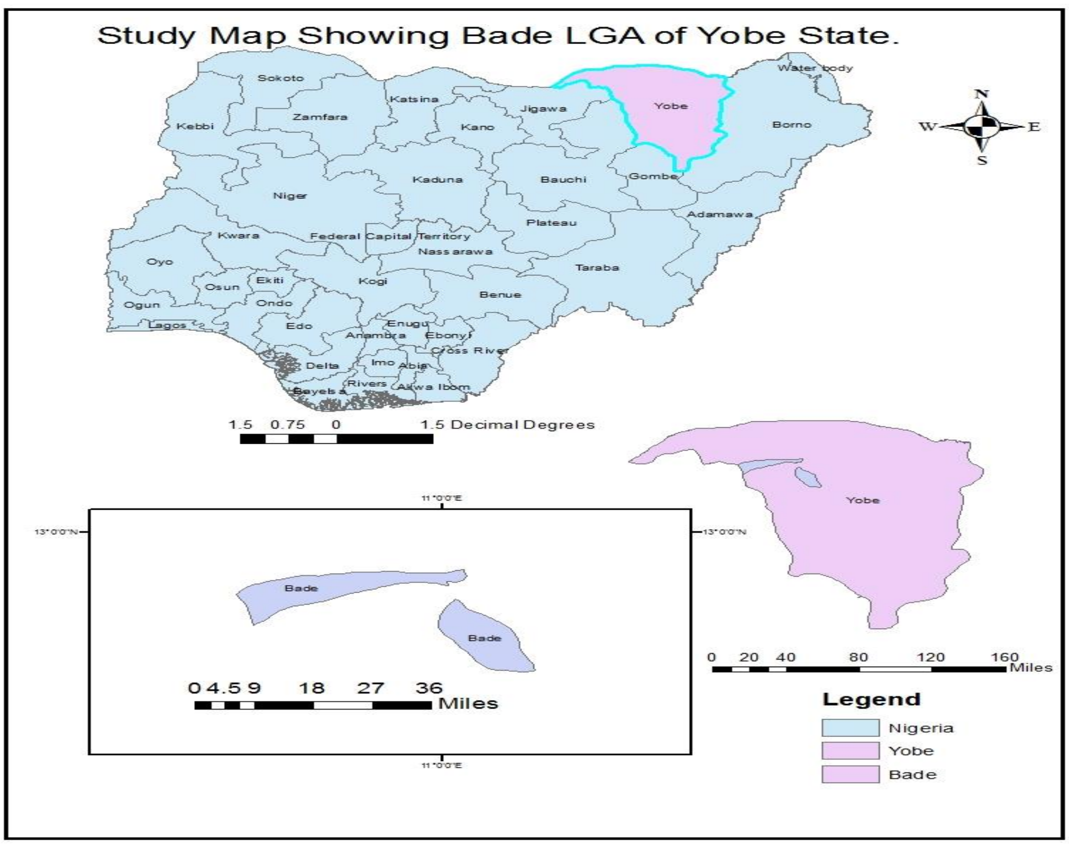

Fig 1: Study Area

Source: Department of Geography, GIS unit, Federal University, Gashua (2021)

2.2 Methodology

The identification of the sources of water was achieve by carrying out a reconnaissance survey of the study area in order to understand the various sources of potable water supply available within the study area, which were boreholes. The primary source of data used for this study comprises of data collected directly from the field using Hand-held Global Positioning System in order to get the coordinates (Latitudes and Longitude) for each sampled point. It also includes laboratory results for each heavy metal level (Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb), Mercury (Hg) and Nickel (Ni)) which was obtained directly from the collected water samples. Secondary source of data comprise data from published USEPA, while relevant literature were sourced from journals, newspapers, internet, annual reports and textbooks.

Three (3) sample points were randomly selected within each of the ward, while the GPS coordinate for each source point were located. A total of eighteen (18) water samples were collected from the study area. The water samples were stored in 250ml plastic bottles pre-cleaned by washing with non-ionic detergents, rinsed with distilled water. Each sample was labelled and transported to Yobe State University Damaturu for the analysis using standard laboratory techniques.

Objective (i) the identification of the sources of water supply was achieved by non-participatory observation for the various sources of groundwater supply available within the study area. Atomic Absorption Spectroscopy (ASS) was used to determine the level of concentration of the Cadmium (Cd), Cobalt (Co), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb), Mercury (Hg) and Nickel (Ni). Atomic Absorption Spectrometry (AAS) is a method for evaluating the quantities of chemical elements available in an environmental sample such as water, soil, plants and other foodstuffs. This method can be done by measuring the absorbed radiation passing through the samples and the energy of the radiation was initially calibrated for the element of interest using a standard. Lastly, to compare concentration levels of each heavy metals with the acceptable drinking water quality standard (USEPA), t-test at 95 % confidence level was used to test hypothesis for significant difference in the level.

2.2.1 Hypotheses

1: There is no significant difference in the level of concentration for the Heavy Metals and the acceptable drinking water standard of USEPA

3.1 Results and Discussion

3.1.1 Level of concentration of heavy metals

Table 1 presents the summarized laboratory results of water quality from the study area. The mean of each quality parameter was calculated for borehole water for the sampled ward that constitutes the study area.

Table 1: Mean Concentration of heavy metals for Boreholes water in Gashua town

Elements	Katuzu ward	Lawan Musa ward	Lawan Fannami ward	Sabon Gari ward	Sarkin Hausawa ward	Zango ward
Cadmium (cd)	0.003	0.010	0.610	0.005	0.004	0.020
Cobalt (Co)	0.040	0.010	0.020	0.01	0.006	0.00
Copper (Cu)	0.01	1.00	0.59	1.01	0.12	0.05
Iron (Fe)	1.82	0.30	0.91	0.17	0.59	0.35
Lead (Pb)	0.01	0.01	0.03	0.02	0.07	0.04
Manganese (Mn)	0.27	0.00	0.01	0.03	0.01	0.02
Mercury (Hg)	0.000	0.002	0.003	0.000	0.001	0.001
Nickel (Ni)	0.04	0.02	0.12	0.03	0.01	0.00

Source: Laboratory Analysis, 2020

From Table 1, the mean concentration for Cadmium (cd) showed higher values in Lawan Fannami, Lawan Musa and Zango wards, while a lower value in Katuzu, Sarkin Hausawa and Sabon Gari wards respectively. The mean concentration for Cobalt (Co) shows that they are within acceptable value with no trace in Zango Ward. Sabon Gari and Lawan Musa have higher values of Copper (Cu) while Katuzu, Lawan Fannami, Sarkin Hausawa and Zango wards have lower values. However, they both fall within the permissible limit. Katuzu and Lawan Fannami have higher value of iron concentration that is higher than the acceptable standard, thus if care is not taken may lead to some diseases which can lead death. Zango, Sarkin Hausawa, Sabon Gari and Lawan Musa have lower values that are within the permissible value. All the six wards have higher value of Lead (Pb) that is higher than the accepted standard using USEPA standard of 0.015. The continuous accumulation of this element may lead to serious health problem such as renal failure and kidney stone. Only Katuzu ward has higher concentration of Manganese (Mn) of 0.27, which is higher than the accepted standard. Zango, Sarkin Hausawa, Sabon Gari and Lawan Fannami have lower values that are within the permissible value with Lawan Musa having no trace of the element. The mean concentration for Mercury (Hg) shows that they are within acceptable value with no trace in Sabon Gari ward while a higher value in Lawan Fannami ward. The mean concentration for Nickel (Ni) shows that they are within acceptable value with no trace in Zango ward.

3.1.2 Hypothesis: Significance of variation in the level of Heavy Metals concentration between the six wards in the study area.

Result of the ANOVA is presented in Table 2

Table 2: ANOVA Results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.329463	5	0.065893	0.478086	0.790519	2.437693
Within Groups	5.788687	42	0.137826			
Total	6.11815	47				

Source: Laboratory Analysis, 2020

The result from Table 2 shows that there is no significant variation in the level of heavy metal concentration between the six wards in the study area. This is because the P-value (0.79) is lower than the table or critical value (2.43), thus the null hypotheses is accepted at 0.05 significant level.

Table 3: Difference in the level of concentration of heavy metals and acceptable USEPA standard for Katuzu Ward

Elements	Katuzu ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.003	0.005	0.000165	No sig. diff
Cobalt (Co)	0.040	0.01		
Copper (Cu)	0.01	1.3		
Iron (Fe)	1.82	0.3		
Lead (Pb)	0.01	0.015		
Manganese (Mn)	0.27	0.05		
Mercury (Hg)	0.000	0.002		
Nickel (Ni)	0.04	0.1		

Source: Laboratory Analysis, 2020

The result from Table 3 shows the level of concentration of parameters in Katuzu Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Iron (1.82) and Lead (0.01). Continuous accumulation of these metals may lead to renal failure or kidney stones. In addition, statistically, the student's t- test was used to test the hypotheses that shows the p-value is lower than the critical value. Consequently,

the comparison between the level of the parameters and the acceptable drinking water standard shows no significant difference. However, it is recommended that the water should be treated before consumption because of the excess of iron and lead present.
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This is similar to the study of Ishaku (2011) who carried out an assessment on groundwater quality for Jimeta Yola area, Northeastern Nigeria and reported that the well water is unfit for human consumption without treatment

Table 4 Difference in the level of concentration of heavy metals and acceptable USEPA standard for Lawan Musa Ward

Elements	Lawan Musa ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.010	0.005	1.56E-10	No sig. diff
Cobalt (Co)	0.010	0.01		
Copper (Cu)	1.00	1.3		
Iron (Fe)	0.30	0.3		
Lead (Pb)	0.01	0.015		
Manganese (Mn)	0.00	0.05		
Mercury (Hg)	0.002	0.002		
Nickel (Ni)	0.02	0.1		

Source: Laboratory Analysis, 2020

The result from Table 4 shows the level of concentration of heavy metals in Lawan Musa Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Cadmium (0.010). In addition, statistically, the student's t- test was used to test the hypotheses, which shows the p-value is lower than the critical value. Consequently, the comparison between the level of the parameters and the acceptable drinking water standard shows no significant difference. However, it is recommended that the water should be treated before consumption because of the excess cadmium present.

Table 5 Difference in the level of concentration of heavy metals and acceptable USEPA standard for Lawan Fannami Ward

Elements	Lawan Fannami ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.610	0.005	3.41E-06	No sig. diff
Cobalt (Co)	0.020	0.01		
Copper (Cu)	0.59	1.3		
Iron (Fe)	0.91	0.3		
Lead (Pb)	0.03	0.015		
Manganese (Mn)	0.01	0.05		
Mercury (Hg)	0.003	0.002		
Nickel (Ni)	0.12	0.1		

Source: Laboratory Analysis, 2020

The result from Table 5 shows the level of concentration of heavy metals in Lawan Fannami Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Cadmium (0.610), Iron (0.91), Lead (0.03) and Nickel. This result is similar to the study of Oko, Aremu, Odoh, Yebpella and Shenge (2014) who reported unsuitable drinking quality for borehole water in Wukari town, Taraba State.

Table 6 Difference in the level of concentration of heavy metals and acceptable USEPA standard for Sabon Gari Ward

Elements	Sabon Gari ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.005	0.005	1.39E-10	No sig. diff
Cobalt (Co)	0.01	0.01		
Copper (Cu)	1.01	1.3		
Iron (Fe)	0.17	0.3		
Lead (Pb)	0.02	0.015		
Manganese (Mn)	0.03	0.05		
Mercury (Hg)	0.000	0.002		
Nickel (Ni)	0.03	0.1		

Source: Laboratory Analysis, 2020

The result from Table 6 shows the level of concentration of heavy metals in Sabon Gari Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Iron (0.17) and Lead (0.02). This is similar to the study of Ishaku (2011) who carried out an assessment on groundwater quality for Jimeta Yola area, Northeastern Nigeria and reported that the well water is unfit for human consumption without treatment. However, it is recommended that the water should be treated before consumption to reduce the excess Iron and Lead.

Table 7 Difference in the level of concentration of heavy metals and acceptable USEPA standard for Sarkin Hausawa Ward

Elements	Sarkin Hausawa ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.004	0.005	2.79E-06	No sig. diff
Cobalt (Co)	0.006	0.01		
Copper (Cu)	0.12	1.3		
Iron (Fe)	0.59	0.3		
Lead (Pb)	0.07	0.015		
Manganese (Mn)	0.01	0.05		
Mercury (Hg)	0.001	0.002		
Nickel (Ni)	0.01	0.1		

Source: Laboratory Analysis, 2020

The result from 7 shows the level of concentration of heavy metals in Sarkin Hausawa Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Iron (0.59), Lead (0.07) and Manganese (0.01). This result is similar to the study of Oko, Aremu, Odoh, Yebpella and Shenge (2014) who reported unsuitable drinking quality for borehole water in Wukari town, Taraba State

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Table 8 Difference in the level of concentration of heavy metals and acceptable USEPA standard for Zango Ward

Elements	Zango ward	USEPA Standard (1994)	P-value	Remarks
Cadmium (cd)	0.020	0.005	2.42E-06	No sig. diff
Cobalt (Co)	0.00	0.01		
Copper (Cu)	0.05	1.3		
Iron (Fe)	0.35	0.3		
Lead (Pb)	0.04	0.015		
Manganese (Mn)	0.02	0.05		
Mercury (Hg)	0.001	0.002		
Nickel (Ni)	0.00	0.1		

Source: Laboratory Analysis, 2020

The result from Table 8 shows the level of concentration of heavy metals in Zango Ward with the acceptable drinking water standard using USEPA 1994 standard. Each of the heavy metals in the ward were between the permissible limit with the exception of Cadmium (0.020), Lead (0.04) and Iron (0.35). In addition, statistically, the student's t- test was used to test the hypotheses, which shows the p-value is lower than the critical value. Consequently, the comparison between the level of the parameters and the acceptable drinking water standard shows no significant difference.

4.1 Conclusion

Therefore, the study reveals that there is no significant variation in the heavy metals variation between the six wards. In addition, the result of the student t-test shows that all the parameters are within the acceptable drinking limit with that of USEPA and except for iron, lead and cadium, which are slightly higher than the acceptable limit. The continuous accumulation of these metals if not properly controlled may lead to serious health impact leading to renal failure and so on.

5.1 Recommendation

Based on the findings, the following recommendations were suggested;

1. All contaminated sources be subjected to further treatments so as to reduce drastically, the concentration of these identified heavy metals which are capable of posing adverse threat to health of the society.
2. Individuals are advised to take responsibility of their well-being by testing their drinking water sources periodically and treatment of water before it can be used for drinking and other domestic purposes.
3. There should be proper orientation and re-orientation of all communities within the metropolis by government and non-governmental organizations on the impacts of indiscriminate waste discharge on water quality, health and environment, proper siting of wells and boreholes in residential areas, treatment and maintaining of existing water supply facilities.

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