IMPACT OF URBANISATION ON GROUND WATER QUALITY IN GOMBE LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

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ABSTRACT

The study examined how urbanisation affects groundwater quality in Gombe Local Government Area, Gombe State, Nigeria. Eleven water samples were collected and analysed using standard methods to assess their physico-chemical properties and compare them to WHO threshold limits. The parameters evaluated include pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), salinity, turbidity, nitrate, sulphate, chloride, fluoride, total hardness, sodium, iron, manganese, arsenic, chromium, and lead. The laboratory analysis results indicated that the majority of physio-chemical parameters in the samples met WHO permissible limits, except for chloride and turbidity values in some samples, which exceeded the thresholds. Analysis of variance and simple correlation show that one-third of the boreholes sampled exhibited strong acidic characteristics, while two-thirds of the sampled water displayed basic characteristics. All the samples showed high levels of dissolved chloride ions. Based on the study findings, the water samples in the study area were deemed suitable for human consumption due to their good quality. Efforts were made to integrate possible sources of observed phenomena from past studies, which clearly demonstrated that urbanisation, population growth, and urban activities contribute to groundwater pollution threats. The study recommended treating the water extracted on-site before supply and consumption to prevent contamination of groundwater supplies in the study area and ensure consistent water quality.

Keywords: groundwater, pollution, urbanisation, environment, WHO, physico-chemical properties, water quality, Nigeria.

1. INTRODUCTION

Rapid urbanisation brings with it many problems as it places huge demands on land, water, housing, transport, health, education, etc. Freshwater is essential for life, and humans have always worked to find and use it. Water is vital for life and, in its natural state, is free from pollution. But when man tampers with the water body, it loses its natural conditions. Groundwater has become an essential resource over the past few decades due to the increase in its usage for drinking, irrigation, and industrial uses (Kanagalakshmi and Nagan, 2013). The quality of groundwater is equally important as the quantity (Asadi et al. 2007). Development significantly harms water resources and quality. Conversion of agriculture, forest, grass, and wetlands to urban areas usually comes with a vast increase in impervious surface, which can alter the natural hydrologic conditions (Tang et al., 2005).

African cities have a long history of water supply from surface and groundwater sources. However, due to the deteriorating quality and quantity of surface water through increased urbanisation and industrialisation and the high cost of developing new dams, urban groundwater is viewed as a better option (Adelana et al., 2008). This advantage notwithstanding, urbanisation has important overall implications for freshwater use and waste management, specifically for the development, protection, and management of sub-surface water in an urban environment (Eni et al., 2011).

Several studies by Adelana et al. (2003, 2004, and 2005) on the groundwater quality of the southeastern parts of Lagos from 1999–2001 on the impact of urbanisation found that of the water samples analysed, concentrations of sulphate, nitrate, and chloride at an objectionable proportion were noted in all the wells. Nitrate, in particular, was noted to be very high and is linked with anthropogenic activities. Groundwater in Lagos is easily polluted because it is shallow and has loose, permeable sand and gravel. In a similar study, Eni et al. (2011) assessed the impact of urbanisation on the sub-surface water of Calabar town and found the water to be acidic, with nitrate and faucal coliform having very high concentrations in the wells. Results of multiple regression show faucal coliform, pH, and chlorine have a positive relationship with urbanisation.

The acute water shortage forced many people to drink untreated water obtained from surface and underground sources thereby exposing them to hazardous chemicals and infectious agents. This has made many researchers to focus their attention towards evaluation of physicochemical and microbial characteristics of water supplies (Kamar et al., 2011; Yerima et al., 2008; Akansha et al., 2010; Okonkwo and Okorie, 2011; Ahmed, Haruna and Abubakar, 2013). Gombe Local Government, the administrative capital of Gombe State provides a good study of the situation. Prior to 1996 when it was made the capital of the state, Gombe Local Government was a provincial town with a modest population. This has however changed today due to urbanization. And, the major source of drinking water to people living in the Gombe Local Government is processed water from DadinKowa Dam. Although the state government has made a lot of effort to ensure steady supply of this vital resource to the citizenry, but the quantity available to the people at any given time is far from being adequate. This is because the state's Water Board has no installed capacity to meet the city's water demand, as unfortunately, the city's development has long outstripped its distribution network. Epileptic power supplies and other supply problems that militate against water production to design schedules have also been described as impediments. This has led to a situation in which many people resolved to` drill their own boreholes or revert to the traditional hand dug wells that were used before the construction of the DadinKowa water treatment plant (Ahmed, Haruna and Abubakar, 2013).

This study is therefore very crucial at the moment because of the rapid increase in the number of the boreholes constituting a substantial source of drinking water for public consumption in

Gombe Local Government. The level of nitrates in some part of the Metropolis that are built in reclaimed dumpsites could be high. The consumers are however not aware of such concern as they do not know, rather do not really care for since the groundwater appears clean and clear to their eyes. Worse still, many of these boreholes were constructed without due consideration to the locations of pit latrines and waste dumping sites, which could make the water more susceptible to chemical and microbial contaminants through leaching and percolation, respectively. All these, really cast heavy doubt in the minds environmental scientists and managers on the safety of the already constructed borehole water for public consumption.

Furthermore, the significance of this study lies in the fact that it would be beneficial to, Local, State, Country, and National Governments as it is a base line data for further studies on policy intervention formulation and implementation, monitoring and evaluation in issues of water quality and managements. The aim of this study was to assess the impact of urbanisation on quality of water obtained from boreholes in Gombe Local Government, Gombe State, Nigeria with a view to determining it suitability for drinking and other domestic uses. Hence, the specific objectives of the study are to: identify the physicochemical properties of groundwater of the study area, examine the quality relationship between the ground water sources in different location of the urban area, and compare the quality of ground water consumed in the study area with the WHO.

2. MATERIALS AND METHODS

2.1 STUDY AREA

Gombe metropolis refers to the entire Gombe Local Government Area and other sub urban areas in other Local Government Areas of Gombe State. It is located between Latitudes 10°15'00"N, 10°19'30" and Longitude 11°07'15" and 110°13'30". It is situated in the center of the state and shares common boundary with Akko Local Government Area in the South and West, YalmatuDeba to the East and Kwami to the North. It has a land area of 52km^2 (Rebecca, Idoma and Comfort 2022). These include JauroAbare, Jauro Kuna, Arawa, Kagarawal, Kundulum, Malan Inna, Barunde Bye-pass etc. Gombe has a tropical wet and dry climate or savanna climate. The city averages a yearly temperature of 30.54 °C (86.97 °F), which is 1.08% warmer than the country as a whole. Gombe has 96.26 wet days (26.37% of the time) and receives approximately 66.84 millimeters (2.63 inches) of rain annually (Gombe, NG Climate Zone, Monthly Weather Averages and Historical Data, 2022). The population of the study area as at 2006 was 266, 844 people (National population commission, 2006). The vegetation of the study area can be described as Sudan savannah with open grassland and shrubs which dries up during the dry season. The natural vegetation has been greatly affected and modified over most of the areas by human activities such as overgrazing, bush burning, construction and agriculture. The predominant tree species consist of Afzillia Africana, parkaibigiobosa, Adamsoniadigitata and tamarindusindica, instead of continuous grass cover, the vegetation has been cleared in places for farm and building (Mbaya, 2017).

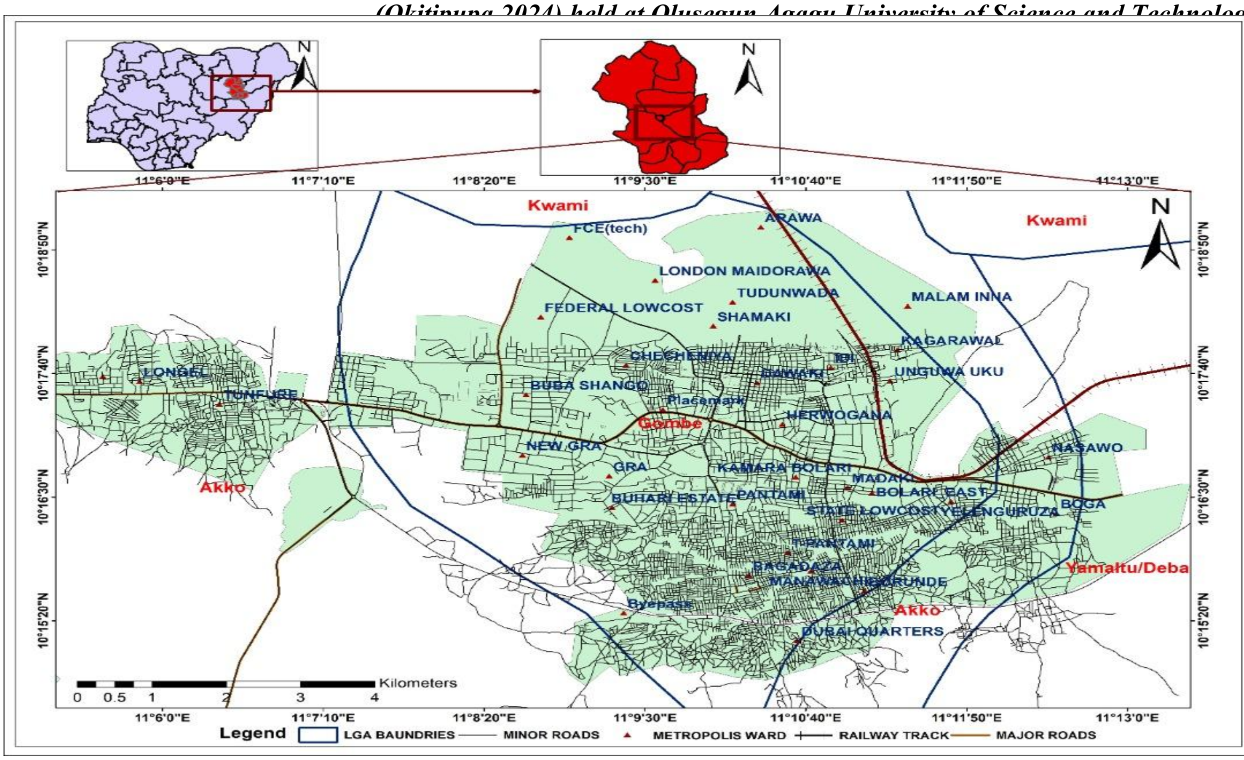

Figure 1: Map of the Study Area

Source: G.I.S and Remote Sensing Lab. (2023)

2.2 METHODOLOGY

Water samples were collected from eleven different points within the study area and were analyzed for their physico-chemical properties using standard methods and compare their standards with WHO threshold limits. The parameters evaluated include: pH, Temp, EC, TDS, Salinity, Turbidity, Nitrate, Sulphate, Chloride, Fluoride, Total Hardness, sodium, iron, manganese, arsenic, chromium and lead.

2.3 SAMPLING PROCEDURE

Multi stage sampling techniques was adopted. Firstly, purposive sampling was used to select only functional water sources in Dawaki, Jekadafari, kumbiya, Bajoga, Shamaki, Pantami, Nasarawo, Herwagana, Ajiya, Bolari-East and Bolari-West. Secondly, systematic random sampling technique was used; where the various sources was listed alphabetically and serially numbered. Thereafter, every first and last water source was selected to give a total of 11 water samples from the study area for investigation. Water was sampled from Boreholes in each of the eleven selected areas using sterile sample containers. Thus all the sample containers were kept in ice blocks and taken to laboratory for analysis, at each sampling point the coordinate was taken using global positioning system (GPS) which help in plotting the map of the study area.

2.4 LABORATORY ANALYSIS

Water samples were analysed at the Department of Biochemistry Laboratory, Faculty of Science, Gombe State University. The physic-chemical parameters were determined using the standard method given by WHO guidelines (2006).

3.0 RESULTS AND DISCUSSION

3.1 WATER QUALITY ANALYSIS RESULTS

The results of the water quality analysis carried out on the water samples from boreholes in different locations of the study area are presented in Tables 1, 2, and 3. The results revealed that the level of physical and chemical properties of drinking water from boreholes in Gombe Local Government Area was within the acceptable standard level for WHO permissible limits for drinking water. Thus, the drinking water in the study area was relatively safe for drinking.

The pH is a measure of the hydrogen ion concentration in water, which indicates acidity or alkalinity. Drinking water with a pH between 6.5 and 8.5 is typically safe for consumption. Therefore, acidic water tends to be corrosive to plumbing, particularly if the pH value is below 6. Alkalinity tends to have a bitter or salty taste. The lowest acidity level (pH) in the study area is 6.54 in Dawaki Ward (Table 1). While the highest 8.20 in Bajoga Ward with an average 7.5. In the study area, the concentration of hydrogen ions (pH) ranges from 6.54 to 7.5. This indicates that all the water samples analysed have concentrations within the acceptable range of 7 to 8.5, as set by the WHO. This is in line with the findings of (Olasehinde et al, 2015 and Jackson et al, 2019). The water sample temperatures ranged from 22.50 to 26.00 °C, exceeding the WHO guideline's acceptable range of 12–25 °C. Thus, temperatures above this level are considered to be too warm to be aesthetically pleasing (Oliver and Fidler, 2001).The conductivity levels for the water samples (Table 1) ranged from 527.50 to 1347.00 µs/cm, with a mean of 798.18 ± 228.47. Therefore, both the minimum and the maximum recorded were not within the WHO acceptable limit. Hence, they are not safe.

Total dissolved solids (TDS) generally reflect the amount of mineral content that is dissolved in the water, and this controls its suitability for use. Generally, high concentrations of total dissolved solids may cause adverse taste effects and intestinal irritation in humans, and prolonged intake of water with higher total dissolved solids can cause kidney stones and heart disease. High-mineralised water may also deteriorate domestic plumbing and appliances. The total dissolved solids observed in the study area range from 263 mg/L to 674 mg/L (Table 1), with a mean value of 359 mg/L. The highest value recorded was in Shamaki Ward, and the lowest was in Pantami Ward. The WHO's most desirable limit is 500 mg/L. The Shamaki Ward falls above the limit (TDS < 674 mg/L); therefore, it is not safe for consumption in terms of domestic use. High TDS in an area may be due to the influence of anthropogenic sources such as domestic sewage, solid waste dumping, agricultural activities, and rock water interaction.

The turbidity levels for the water samples (Table 1) ranged from 1.5 to 3.84, with a mean of 2.456 ± 0.920. The minimum and maximum values recorded are not within the acceptable WHO (1.00 mg/L) permissible limits for drinking water. This means that the borehole water samples from all the study sites are not suitable for human consumption, as their turbidity values exceeded the maximum allowable limit recommended by international drinking water regulatory authorities. Excessive turbidity in drinking water, apart from being aesthetically unappealing, may also present a health threat by providing food and shelter to pathogens. This is in line with the findings of (Ahmed, Haruna and Abubakar, 2013). Nitrate, the main form of nitrogen, is a colourless, odourless, and tasteless polyatomic ion. All living systems need nitrogen for the production of complex organic molecules, such as proteins, nucleic acids, vitamins, hormones, and enzymes (Mensinga et al. 2003). The nitrate levels for the water samples (Table 2) ranged from 5.41 to 45.75, with a mean of 19.667 ± 13.646. The minimum and maximum values recorded are within the acceptable WHO permissible limits for drinking water (50 mg/L) and therefore could have no hazardous effects for people in the area.

The health of millions of people worldwide is negatively impacted by chronic exposure to elevated concentrations of geogenic fluoride in groundwater. Due to health effects including dental mottling and skeletal fluorosis, the World Health Organisation maintains a maximum guideline of 1.5 mg/L in drinking water. Health studies have shown that the addition of fluoride to water supplies at levels above 0.6 mg/L leads to a reduction in tooth decay in growing children and that the optimum beneficial effect occurs around 1.0 mg/L. The fluoride levels for the water samples (Table 2) ranged from 0.00 to 0.06 mg/L, with a mean of 0.0110 mg/L. The minimum and maximum values recorded are within the acceptable WHO permissible limits for drinking water (1.5 mg/L) and therefore have no hazardous effects. Sodium in water does not, by itself, cause odour problems. The World Health Organisation has established a drinking water guideline of 200 mg of sodium/L on the basis of aesthetic considerations (WHO, 2004). The sodium levels for the water samples (Table 3) ranged from 196.28 to 1424.51, with a mean of 604.72 ± 376.97. The maximum value of 1424.51 mg/L recorded at the boreholes in Gombe LGA is not within the acceptable WHO permissible limits for drinking water (200 mg/L), which causes hypertension if taken in excess, while the minimum value of 196.28 mg/L recorded is beyond the WHO permissible limits for drinking water (200 mg/L).

Iron is frequently found in groundwater due to large deposits in the earth's surface; the acceptable limit is 0–0.3 mg/L (WHO, 2010). The iron levels for the water samples (Table 3) ranged from 0.0000 to 0.38 mg/L, with a mean of 0.58 mg/L ± 0.11. The minimum and maximum values recorded are within the acceptable WHO permissible limits for drinking water (0.3 mg/L).Lead is a naturally occurring toxic metal. Its widespread use has caused extensive environmental contamination, human exposure, and health problems in many parts of the world. It is a cumulative toxicant that can affect multiple body systems. Children are particularly vulnerable to the neuro toxic effects of lead (WHO, 2016). The lead levels for the water samples (Table 3) ranged from 0.00 to 0.01 mg/L, with a mean of 0.014 mg/L ± 0.270. The minimum and maximum values recorded are within the acceptable WHO permissible limits for drinking water (0.01 mg/L), and therefore they have no hazardous effects for people in the area.Manganese occurs naturally in many surface water and groundwater sources from the dissolution of manganese oxides, carbonates, and silicates in soil and rock. Anthropogenic activities (industrial discharges, mining, and landfill leaching) can also be sources of manganese contamination of water (Stokes and NRCC, 1988; Kohl and Medlar, 2006; Ljung and Vahter, 2007). The limited level of manganese is 0.1–0.5 (WHO, 2004). The manganese levels for the water samples (Table 3) ranged from 0.00 to 0.71 mg/L, with a mean of 0.17 mg/L ± 0.23. The minimum recorded value is within the acceptable WHO permissible range (0.05 mg/L), while the maximum value is not within the acceptable WHO permissible limits for drinking water (0.05 mg/L).

Arsenic is a natural component of the earth's crust and is widely distributed throughout the environment in the air, water, and land. It is highly toxic in its inorganic form. Arsenic contamination of groundwater is widespread, and there are a number of regions where arsenic contamination of drinking water is significant. An estimated 140 million people in at least 70 countries have been drinking water containing arsenic at levels above the WHO provisional guideline value of 10 µg/L. The arsenic levels (Table 3) ranged from 0.000 to 0.03 mg/L, with a mean of 0.0065 mg/L ± 0.0089. The minimum and maximum values recorded are within the acceptable WHO permissible limits for drinking water (0.3) and therefore could have no hazardous effects for people in the area.The chromium levels for the water samples (Table 3) ranged from 0.00 to 0.06 mg/L, with a mean of 0.010 mg/L ± 0.0196. The minimum value recorded is within the acceptable WHO permissible limit for drinking water, while the maximum value recorded is not within the acceptable WHO permissible limits for drinking water (0.05 mg/L).

In summary, The water samples from boreholes in the study area met WHO permissible limits, indicating safe drinking water quality overall.

PHYSIOCHEMICAL PROPERTIES OF WATER IN THE STUDY AREA

Table 1 Physical Analysis of Water Samples Obtained from Gombe LGA Wards

Samples	Physical Parameters					
	pH	Temp. (^{0}C)	E.C (µS/cm)	TDS (mg/L)	Salinity (%)	Turbidity (NTU)
Ajiya	7.75	26.00	765.00	383.50	1.15	3.33
Bajaga	8.20	24.50	821.00	414.50	1.28	2.31
Bolari East	7.56	25.50	602.50	296.50	0.70	1.97
Bolari West	7.93	23.60	905.00	460.00	1.54	3.84
Dawaki	6.54	22.50	684.00	340.00	0.80	1.30
Herwagana	7.27	24.30	895.50	448.50	1.47	3.70
Jekadafari	7.21	25.50	893.50	454.50	1.32	2.32
K/Kumbiya	7.83	22.50	795.00	396.00	0.89	1.54
Nasarawo	7.30	24.50	544.00	273.00	0.64	1.84
Pantami	7.48	22.50	527.50	263.00	0.61	1.54
Shamaki	7.39	23.50	1349.00	674.00	1.92	3.32

Source: Author's Fieldwork 2023

Table 2 Chemical Analysis of Water Samples Obtained from Gombe LGA Wards

Samples	Chemical Parameters (mg/L)				
	Nitrate	Sulphate	Chloride	Fluoride	Total hardness
Ajiya	38.58	23.40	753.00	0.00	245.00
Bajaga	45.71	6.51	813.00	0.00	261.00
Bolari East	30.07	18.88	355.00	0.00	124.00
Bolari West	16.88	13.61	854.00	0.00	318.00
Dawaki	8.16	55.61	379.00	0.00	142.00
Herwagana	12.36	18.91	846.00	0.063	359.00
Jekadafari	7.75	32.89	795.00	0.048	285.00
K/Kumbiya	25.36	17.30	428.00	0.00	140.00
Nasarawo	5.41	27.91	352.00	0.01	135.00
Pantami	18.44	32.65	346.00	0.00	128.00
Shamaki	7.62	23.54	1642.00	0.00	482.00

Source: Author's Fieldwork 2023

Table 3: **Elemental Analysis of Water Samples Obtained from Gombe LGA Wards**

Samples Location	Concentrations (mg/L)					
	Sodium (Na)	Iron (Fe)	Manganese (Mn)	Arsenic (As)	Chromium (Cr)	Lead (Pb)
Ajiya	684.40	0.0219	0.0371	0.0000	0.0000	0.0000
Bajaga	752.71	0.0137	0.0565	0.0000	0.0000	0.0000
Bolari East	275.12	0.0017	0.0000	0.0000	0.0000	0.0000
Bolari West	843.97	0.0116	0.0224	0.0186	0.0000	0.0000
Dawaki	296.44	0.0035	0.0177	0.0000	0.0000	0.0000
Herwagana	815.75	0.0347	0.7069	0.0253	0.0626	0.0075
Jekadafari	794.34	0.0254	0.2185	0.0067	0.0176	0.0000
K/Kumbiya	343.74	0.0528	0.0414	0.0000	0.0044	0.0000
Nasarawo	224.65	0.0165	0.1843	0.0126	0.0000	0.0023
Pantami	196.28	0.0731	0.0585	0.0000	0.0000	0.0000
Shamaki	1424.51	0.3827	0.5224	0.0085	0.0265	0.0058

Source: Author's Fieldwork 2023

4.1 QUALITY RELATIONSHIP BETWEEN THE GROUNDWATER SOURCES IN DIFFERENT LOCATION

Looking at the values of water quality parameters studied in the eleven locations during the period of the study was observed to be similar in nature of distribution (figure 2). Even though the data presented in figure 2 seems to have a normal distribution, ANOVA was employed to examine whether the physical and chemical properties of groundwater sampled in different location of the study area varies or not. The ANOVA test result was Presented table 5.

Table 5: ANOVA for Relationship Between groundwater sources in different location

Elements	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	13530751.901	16	845671.994	38.688	.000
Within Groups	3716025.068	170	21858.971		
Total	17246776.969	186			

Source: Author's Fieldwork 2023

The result in table 5 shows P value is 0.00 which is less than the alpha level 0.05 hencewe reject the Ho and accept the $H_I$which means the quality of groundwater sources indifferent location of the study area varies.

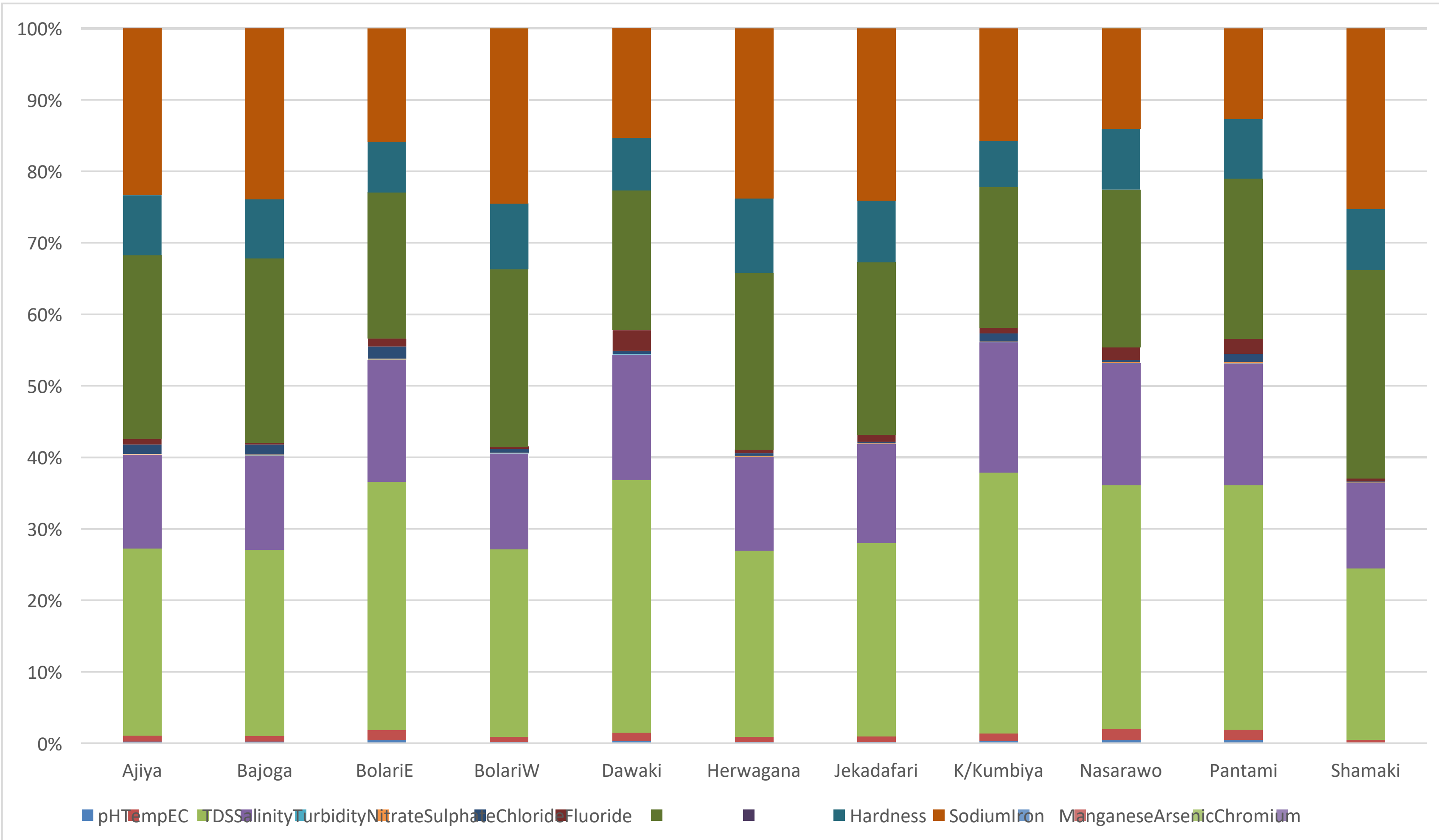

Figure 2: Relationship between the groundwater sources in different location

Source: Author's Fieldwork 2023

4.2 MEAN QUALITY RELATIONSHIP BETWEEN GROUNDWATER OF STUDY AREA AND THE WHOSTANDARD.

In order to established the relationship between the quality of groundwater consumed in the study area with the WHO standard for drinking water, the maximum, minimum, mean and standard deviation of values of all the parameters investigated in all the eleven wards within the study area was calculated and the result were used to compared with the WHO as presented in Table 6.

Table 6: Descriptive Statistics of quality of groundwater of the Study Area

	N	Minimum	Maximum	Mean	Std. Dev	**WHO**
pH	11	6.54	8.20	7.4964	.44282	**6.5-8.5**
Temp	11	22.50	26.00	24.0818	1.27186	**12-25°C**
EC	11	527.50	1347.00	798.1818	228.47443	**400**
TDS	11	263.00	674.00	400.3182	115.63137	**500-1000**
Salinity	11	.61	1.92	1.1200	.42750	**0.5**
Turbidity	11	1.30	3.84	2.4555	.92969	**0.1**
Nitrate	11	5.41	45.71	19.6673	13.64572	**50**
Sulphate	11	6.51	55.61	24.6555	12.94235	**250**
Chloride	11	346.00	1642.00	687.5455	387.00940	**250**
Fluoride	11	.00	.06	.0110	.02245	**1.5**
Hardness	11	124.00	482.00	238.0909	117.42611	**500**
Sodium	11	196.28	1424.51	604.7191	376.97417	**200**
Iron	11	.00	.38	.0580	.10981	**0.3**
Manganese	11	.00	.71	.1696	.23421	**0.1-0.5**
Arsenic	11	.00	.03	.0065	.00891	**0.03**
Chromium	11	.00	.06	.0101	.01957	**0.05**
Lead	11	.00	.01	.0014	.00270	**0.01**
Valid N (listwise)	11					

Source: Author's Fieldwork 2023

4.3 STUDENT T-TEST RESULT

The research hypothesis result for the significant mean difference between the quality of groundwater consumed in study area and the WHO standard for drinking water was tested using Paired-Sample Test and the results is presented in Table 7.

Table7: Paired Samples Test for the Groundwater and WHO Standard

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	d. Error Mean	Confidence Interval of the Difference Lower	Upper			
Pair1	Groundwater–WHO	7.18227	249.10345	60.41646	-120.89490	135.25944	.119	16	.907

Source: Author's Field work 2023

Calculated value of t(0.119) shown in Table 7 is less than the critical value of t(2.12) at 0.05 significance level and degree of freedom 16; hence, the Ho is accepted which means there is no significant mean difference between the quality of groundwater consumed in study area and the WHO standard for drinking water. This implies that the groundwater in the study area is within the acceptable WHO permissible limits for drinking water.

Conclusion

The result of the present study revealed that quite a number of the water quality parameters investigated fall within the acceptable limits set by the world health organization (WHO). However, the water obtained from the boreholes if use for drinking purpose could bring about some health problems. This is because the water from all the 11 wards contained high levels of turbidity and chloride above the limits recommended by the (WHO) for drinking water. The continuous use of water from these boreholes in Gombe Local Government could, therefore, lead to outbreak of especially gastroenteritis diseases. The public should be properly educated on the dangers associated with drinking turbid water. They should be enlightened on the need to allow debris and other particles to settle down at the bottom of the water container before use. The community should be encourage to adopt the use of simple water purification technology such as the use of local plant *Moringa olifera* (Mangale *et al*, 2012; Ahmed, Haruna and Abubakar, 2013) which speed up sedimentation of particle in the water before drinking. Anthropogenic activities in the study area through urbanization have impacted on the groundwater resources through the pollution load seen. Illegal waste dumps and leachate, waste water emission and poor sanitary practices could be attributed to the problem which changes the groundwater chemistry and it could be summarized that urbanization remains a threat to water resources. As Nnodu (2008), summarized that high population in urban areas with the point and non-point sources of water pollution intensifies the pollution level of water resources for various uses. Since inhabitants depend heavily on groundwater for drinking, there is a greater tendency that most of the chronic diseases and ailments people suffer presently could be as a result of high intake of polluted water. Therefore, there is need for frequent and constant monitoring of ground water resources.

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