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GROUNDWATER QUALITY ASSESSMENT FOR DRINKING WATER USING WATER QUALITY INDEX (WQI): A CASE STUDY OF NGURU, YOBE STATE, NIGERIA

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Abstract

Despite the importance of groundwater, its quality assessment has received little attention and effort to use hydrochemistry data to solve a particular problem is either little or non-existent. This study, therefore, assesses the groundwater quality and its suitability for drinking in Nguru town, Nguru LGA, Yobe State using WQI. The study was carried out using laboratory techniques to determine the level of concentration of parameters such as pH, colour, total hardness, conductivity, calcium, magnesium, chlorides, sulphate, sodium, turbidity, copper, manganese, zinc, lead and iron in boreholes across the Nguru metropolis, which consists of four wards namely; Hausari, Bulabulin, Sabon Gari and Nglewa-Tsoho Nguru Wards. Water samples were collected from eight sampling points across the four urban wards. The collected samples were analysed using the standard method in Yobe State University, Damaturu. The student's t-test was used to compare the level of concentration of physicochemical parameters with the WHO and NSDWQ standards for drinking water. The result shows the level of concentration of parameters among the four Wards are within the acceptable drinking water standard using WHO 2010 standards and Nigeria standards for drinking water respectively except for Bulabulin ward and Nglewa-Tsoho Nguru Ward whereby lead and iron are higher than the permissible limit for both the WHO and NSDWQ. Consequently, the water quality index(WQI) analysis reveals that water samples analyzed from borehole among the four sampled wards are unsuitable for human consumption because it exceeds 100 with exception of the Sabon Gari ward which falls within excellent water quality (2.21). Thus, only water sampled in Sabon Gari is fit for human consumption without treatment. As such, the study suggests periodical testing and treatment of water.

Keywords: Groundwater, Physicochemical, Turbidity, Total hardness, Drinking, WQI

Introduction

People on the globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to the increased human population, industrialization, use of fertilizers and human activities, water is highly polluted with different harmful contaminants. The quality of drinking water must be checked at regular intervals because due to the use of contaminated drinking water, the human population suffers from varied water-borne diseases. Hence, the availability of good quality water is an indispensable feature for preventing diseases and improving quality of life (Usman, 2015 as cited in Mukhtar, 2018).

Groundwater is a vital resource especially in arid and semi-arid areas since surface water is not available throughout the year for various purposes. Due to the meagre surface water resources, most of the requirements for irrigation, industry and domestic purposes are being met from groundwater. It is therefore essential to ensure the availability of groundwater throughout the year. Sufficient groundwater with high quality is required to meet increasing domestic, agricultural, and industrial needs (Mukhtar, 2018).

Worldwide, the stress on freshwater resources is increasing due to population growth and rapid industrialization. Groundwater contamination has become one of the most serious problems in the world in the last decades. Groundwater quality depends on the quality of recharged water, atmospheric precipitation, inland surface water, and sub-surface geochemical processes. Temporal changes in the origin and constitution of the recharged water, hydrologic and human factors may cause periodic changes in groundwater quality (Butu, 2002).

According to World Health Organization (2010), about 80% of all diseases in human beings are caused by water. Once the groundwater 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 groundwater and to devise ways and means to protect it (Duda et al., 2000).

Though many works have been done on the water quality, there is a need to have a water quality index (WQI) and an update on the quality of the water being consumed by the masses in the study area, this will create a consciousness for a need to treat water to ensure healthy living. Water has an important and undeniable influence on human health. In its pure state water helps the circulation of nutrients around the body whereas on the other hand, when water is impure it circulates disease pathogens through the body system.

Water Quality Index (WQI) is one of the most effective tools to communicate information on the quality of groundwater to concerned citizens and policymakers. The water quality index (WQI) provides a single number that expresses the overall water quality at a certain location and time based on several water quality parameters. The objective of WQI is to turn complex water quality data into information that is understandable and usable by the public. The index result represents the level of water quality in a given water basin, such as a lake, river, stream or aquifer. WQI is calculated from the point of view of the suitability of groundwater for human consumption. The objective of the present work is to discuss the suitability of groundwater for drinking purposes based on computed water quality index values.

Several studies have been conducted to investigate the quality of surface and groundwater for irrigation and domestic uses. For example, Bichi and Amatobi (2013) carried out a study on assessment of the quality of water supplied by water vendors to households in Sabon-Gari Area of Kano, Northern Nigeria, which found out that water quality was compromised at the private commercial supply, during hawker's distribution and in the household storage. Mohammed (2013) on quality assessment of potable water in Sabon-Gari, Kano State, compared the quality of some of the most patronized water considered consumable in Sabon Gari area of Kano State with the World Health Organization (WHO, 2002) set a standard which revealed a significant difference in the level of concentration of physicochemical parameters which are not within the WHO standard.

The studies above did not consider the groundwater quality of Nguru town, using the water quality index (WQI), which mainly depend on groundwater as its source of water supply for domestic and irrigation uses. Thus, serves as a research gap that this study intends to fill. To this end, this research assessed the groundwater quality and its suitability for drinking in Nguru town, Nguru LGA, Yobe State using WQI.

Hypothesis

H_0: There is no significant difference in the level of concentration of physicochemical parameters and the acceptable drinking water standards of NSDWQ and WHO.

Material and Methods

The study area

Nguru Local Government Area is located approximately between latitude $12^0 52' 45''$ N to $10^0 21' 09''$ E of the equator with a land area of 916km^2. Karasuwa LGA bound it to the north, to the south is Machina LGA and to the west by Bade LGA about 45km northeast. Nguru is located along Gashua – Kano road. The climate of Nguru is characterized by a 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 ^{0}C but the mean monthly value range between 27^{0}C 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 Nguru 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.

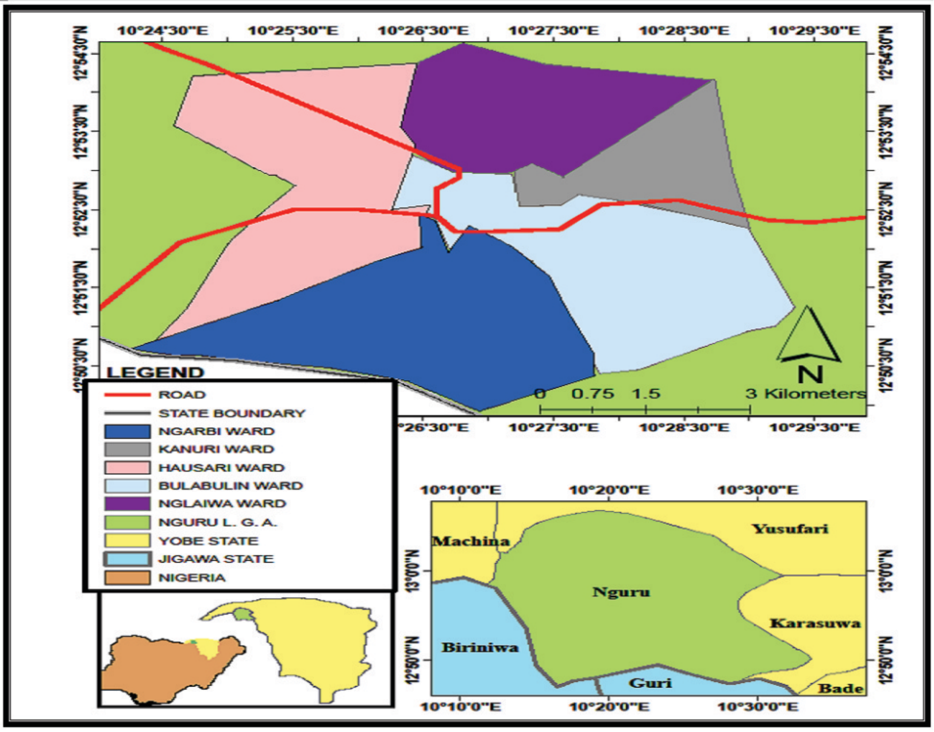

Figure 1: Map of Yobe showing the study Area
Source: Adapted from the Administrative map of Yobe state.

Methods

The primary source of data required for this study comprises data collected directly from boreholes and open wells within the study area. Only the wards located within the town were used because of their population density. The four wards sampled were Hausari, Bulabulin, Sabon Gari and Nglewa-Tsoho Nguru wards. Eight (8) water samples were collected from the four wards and 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 analysis. The collected water samples were analyzed using standard procedures. Elements to be determined are: pH, Colour, Total Hardness, Conductivity, Calcium, Magnesium, Chlorides, Sulphate, Sodium, Turbidity, Copper, Manganese, Zinc, Lead and Iron

The level of concentration of each parameter was compared with the WHO and NSDWQ standards. In addition, the Student's test was used to compare the concentration of each element and the WHO and NSDWQ.

Water Quality Index

Water quality assessment using WQI was computed to reduce a large amount of water quality data to a single numerical value. Once the WQI scores were known, it was then compared against a scale to determine how healthy the water is for different Wards that make up the Metropolis.

$$WQI = (WnQn)/\sum Sn*100$$

Where $wi = 1/sn$

$$Qn = Vi - Vo/Sn - Vo$$

Results and Discussion

Level of concentration of physicochemical parameters

Table 1 presented in this section shows the summarized laboratory results of water quality from the study area. The mean of each quality parameter was calculated for borehole water for each ward that constitutes the study area.

From Table 1.1, the mean concentration for pH showed higher values in Sabon Gari, Hausari and Nglewa-Tsoho Nguru wards while a lower value in Bulabulin ward respectively. Sabon Gari, Hausari and Bulabulin wards show similar values for the colour parameter but a lower value in Nglewa-Tsoho Nguru ward. The concentration for total hardness higher values in Bulabulin, Hausari and Nglewa-Tsoho Nguru wards, while Sabon Gari recorded lower value. Conductivity concentration showed higher values in Bulabulin and Hausari wards

Table 1: Mean Concentration of Physicochemical Parameters for Boreholes Water

Physicochemical Parameters	Hausari ward	Bulabulin ward	Sabon Gari ward	Nglewa-Tsoho Nguru
PH	7.34	6.71	7.52	7.29
Colour (tcu)	5.00	5.00	5.00	3.75
Total hardness (mg/l)	74.25	87.68	4.32	12.23
Conductivity (µS/cm)	400.95	530.00	4.59	7.58
Calcium (mg/l)	3.75	13.43	4.29	4.78
Magnesium (mg/l)	14.98	15.73	0.69	1.00
Chlorides (mg/l)	19.28	72.18	0.55	0.86
Sulphate (mg/l)	3.19	7.63	1.34	2.18
Sodium (mg/l)	16.01	12.72	0.59	5.38
Turbidity (ntu)	3.48	2.70	0.30	12.96
Copper (mg/l)	1.18	0.27	0.02	0.36
Manganese (mg/l)	0.92	0.02	0.02	0.05
Zinc (mg/l)	1.91	1.46	0.15	0.26
Lead (mg/l)	0.01	0.03	0.00	0.02
Iron (mg/l)	3.26	2.17	0.04	0.45

Source: Laboratory Analysis, 2021

Table 2: Difference in the level of concentration of parameters and acceptable drinking water standard

Physicochemical Parameters	Hausari ward	Bulabulin ward	Sabon Gari ward	Nglewa-Tsoho Nguru	WHO Standard (2010)	NSDWQ Standard (2007)
PH	7.34	6.71	7.52	7.29	6.5-8.5	8.5
Colour (tcu)	5.00	5.00	5.00	3.75	15	15
Total hardness (mg/l)	74.25	87.68	4.32	12.23	500	150
Conductivity (µS/cm)	400.95	530.00	4.59	7.58	1400	1000
Calcium (mg/l)	3.75	13.43	4.29	4.78	75	NA
Magnesium (mg/l)	14.98	15.73	0.69	1.00	50	0.20
Chlorides (mg/l)	19.28	72.18	0.55	0.86	250	250
Sulphate (mg/l)	3.19	7.63	1.34	2.18	250	100
Sodium (mg/l)	16.01	12.72	0.59	5.38	50	200
Turbidity (ntu)	3.48	2.70	0.30	12.96	5.0	5.0
Copper (mg/l)	1.18	0.27	0.02	0.36	2.0	1.0
Manganese (mg/l)	0.92	0.02	0.02	0.05	0.1	0.2
Zinc (mg/l)	1.91	1.46	0.15	0.26	3.0	3.0
Lead (mg/l)	0.01	0.03	0.00	0.02	0.01	0.01
Iron (mg/l)	3.26	2.17	0.04	0.45	0.3	0.3

Source: Laboratory Analysis, 2021

respectively while Nglewa-Tsoho Nguru and Sabon Gari recorded lower values. The concentration for turbidity showed a much higher value in Nglewa-Tsoho Nguru ward compared to the other three wards, which have lower values. Lead concentration showed considerably lower values across the Wards while no trace was recorded for Sabon Gari Ward.

The result from Table 2 shows the level of concentration of parameters in Hausari Ward with the acceptable drinking water standard using WHO 2010 standard and Nigeria standard for drinking water respectively. Each of the parameters in the ward was between the permissible limit for both the WHO and NSDWQ. In addition, the result shows the level of concentration of parameters in Bulabulin Ward with the acceptable drinking water standard using the WHO 2010 standard. Each of the parameters in the ward was between the permissible limit for both the WHO and NSDWQ except for iron and lead.

Furthermore, the result also shows the level of concentration of each parameter in Sabon Gari and Nglewa-Tsoho Nguru Wards. Each of the parameters in Sabon Gari Ward was between the permissible limit but for Nglewa-Tsoho Nguru Ward the parameters were within the permissible limit except iron and lead, which were slightly higher than the permissible limit.

Table 3: Water Quality Index for Nguru Metropolis

Water Quality Index Level	Water Quality Status	Kano Metropolis	WQI for Borehole
0-25	Excellent water quality	Hausari ward	199.73
25-50	Good water quality	Bulabulin ward	284.87
51-75	Poor water quality	Sabon Gari ward	2.21
76-100	Very poor water quality	Nglewa-Tsoho Nguru Ward	183.81
>100	Unsuitable for drinking		

Source: Laboratory Analysis, 2021

The WQI for a borehole in the four wards that make up Nguru town shows that the WQI values are greater than 100 except the Sabon Gari ward (2.21). This result for borehole water is in contrast with the study of Olowe, Oluyege and Famurewa (2016) who reported poor water quality ratings for borehole water WQI 54.16 but in agreement with the study of Oko et al. (2014) who reported unsuitable for drinking ratings for borehole water having WQI of 136 in Wukari Town, Taraba State. Therefore we can conclude that the water quality for the three wards sampled was unfit for human consumption without treatment.

Conclusion

Assessment of physicochemical parameters of water quality and its suitability for drinking in Nguru town, Nguru LGA, Yobe State using WQI. The result shows the level of concentration of parameters among the four Wards are within the acceptable drinking water standard using WHO 2010 standard and Nigeria standard for drinking water respectively with the exception of Bulabulin ward and Nglewa-Tsoho Nguru Ward respectively whereby lead and iron are higher than the permissible limit for both the WHO and NSDWQ.

The water quality index analysis reveals that water samples analyzed from borehole among the four sampled wards are unsuitable for human consumption because its exceed 100 with exception of Sabon Gari ward which fall within excellent water quality (2.21). Thus, only water sampled in Sabon Gari is fit for human consumption without treatment.

Recommendations

Based on the findings, the following recommendations were suggested;

1. Subject all contaminated sources to further treatments by the government agencies to reduce drastically, the concentration of these identified physicochemical parameters that 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 they 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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