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Physicochemical Analysis of Borehole and Well Water in Some Selected Areas of Fagge Local Government Area, Kano State

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ABSTRACT

Water is very paramount for survival of all living organism. The quality of water is of great concern for humans since it is directly linked with human health, protection of environment and sustainable development. Increasing population and the problems associated with it has led to the deterioration of surface and groundwater. Groundwater is the major source of drinking water in both rural and urban centres. The aim of this research is to analyze the water quality of borehole and well water sources of some selected areas of Fagge Local Government Area, Kano State. A total of sixteen (16) well and borehole water samples were collected for physicochemical assessment. Parameters such as colour, odor, total hardness, acidity, conductivity, nitrate, sulphate and phosphate were determined using standard methods. The results revealed that both well and borehole water in Fagge LGA generally met WHO standards for pH, and Electrical conductivity (EC). However, well water exhibited higher total dissolved solids (TDS) levels, exceeding the permissible limit of 500 mg/L, while borehole water remained within acceptable levels. Phosphate levels in both water sources exceeded the WHO limit of 10 mg/L. Nitrate concentrations were within safe limits for both water sources. Statistical analysis using student's t-test also showed significant difference in EC and TDS of the borehole and well water. Therefore, borehole water was deemed more suitable for consumption due to lower TDS and phosphate levels compared to well water.

Keywords: Physicochemical Parameters; Borehole water; Well water

INTRODUCTION Water is vital for the survival and growth of all living organisms, making its quality a critical concern for human health, environmental protection, and sustainable development. Increasing population and industrialization have led to the deterioration of both surface and groundwater resources. Groundwater, in particular, is the primary source of drinking water in both urban and rural areas, and its contamination has become a growing issue. Domestic sewage and industrial waste are among the leading causes of groundwater pollution (Dahiya 1999; Saharan 2009). Contaminated water is responsible for numerous cases of waterborne diseases, posing significant health hazards (Desai 1995).

The World Health Organization (WHO) emphasizes that the quality of drinking water is a crucial environmental determinant of health (WHO 2010). Waterborne diseases, particularly in developing countries, account for 80% of all diseases, reflecting the link between poor water quality and public health (Cheesbrough 2006). Managing drinking water quality has been a cornerstone of public health for over a century, forming the foundation for the prevention and control of waterborne diseases (WHO 2010). Contaminated water, whether through microbial or chemical pollutants, poses a global public health threat, leading to diarrhea, chemical intoxications, and other severe health risks (Okonko *et al*. 2009).

A major risk to human health is the contamination of water supplies by fecal matter, which can enter water systems through various pathways, including rivers, streams, and boreholes (Cheesbrough 2006). In developing regions, contamination of borehole water due to nearby domestic wastewater and livestock manure is common, particularly when the protective soil layers are compromised (Obi & Okacha 2007). These contaminants can travel with rainwater into boreholes or seep through well walls, causing the spread of pathogens. The faecal-oral transmission pathway is a significant contributor to the spread of waterborne diseases, especially where infrastructure such as pipes is obsolete or unhygienic handling of household water occurs (WHO, 2010).

The rapid growth in human population, particularly in developing countries, presents significant challenges in ensuring access to safe drinking water (Okonko *et al*. 2009). The high incidence of diarrhea and cholera among children and infants is often attributed to unsafe water and poor hygiene practices (Tortora *et al*. 2002; Oladipo *et al*. 2009). As a result, waterborne diseases account for millions of deaths annually, especially among children, and cause widespread illness (Shittu *et al*. 2008).

In addition to microbial contamination, water can also contain toxic inorganic chemicals, which may have either acute or chronic health effects. Acute effects, such as nausea, lung irritation, and vomiting, can occur, while long-term exposure can lead to chronic conditions such as cancer, organ damage, and neurological disorders (Erah *et al*. 2002). Lead contamination, for example, can interfere with red blood cell chemistry, delay physical and mental development in children, and increase blood pressure in adults (Oladipo *et al*. 2002). Furthermore, excessive levels of nitrites from agricultural fertilizers in rural water supplies can reduce oxygen levels in the blood, leading to serious health risks (Oladipo *et al*. 2002).

The need for regular monitoring and analysis of water quality is therefore essential to address both chemical and microbial contaminants and ensure the safety of drinking water, especially in areas with high population growth and industrial activity (WHO 1999; Nath 2001).

MATERIALS AND METHOD

Study site

The study was conducted in Fagge Local Government Area of Kano state, which is situated in Northern Nigeria, within the greater Kano state;12^0 0^1 21^{11} N,8^0 31^1 44^{11} E it has an area of 20 km^2 and a population of 13,06,860 at the 2006 census.

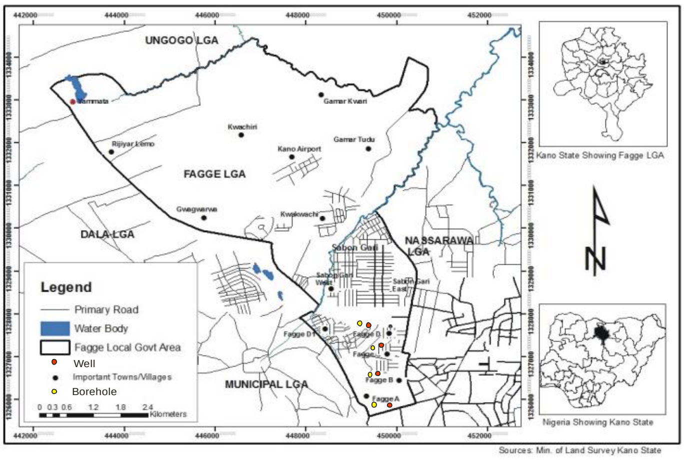

Fig1: Map of the Study Area Showing Sampling Site

Sample Collection

A total of sixteen wells and boreholes were randomly selected from different geographical location in Fagge local government area for determination of physico chemical parameters. Samples were collected for three weeks. As recommended by Cheesbrough, the sample bottles were rinsed with the sample water before filling them. The bottles were held at the bottom while filling to avoid contamination of water from the hand. The samples were labelled with code names before going to the laboratory for analysis (Cheesbrough 2006).

Determination of Physico-chemical Parameters

Physicochemical analysis involves visual assessment of the external features of the water samples, which include; odour, colour, turbidity and presence of floating particles, or extraneous materials). Indicators such as total hardness, acidity, conductivity, presence of minerals (such as nitrate, sulphate, and phosphates) were assessed using appropriate methods as described by Bennet and David (1974).

pH

The pH was measured in situ using a pH meter JENWAY 3071, model pH 82 (degree of accuracy 0.01) equipped with a temperature probe. The pH meter was initially calibrated by dipping the electrode into a buffer solution of known pH (pH 4) and the asymmetric potential control of the instrument altered until the meter reads the known pH value of the buffer solution. The standard electrode after rinsing with distilled/deionised water was then immersed in a second buffer solution (pH 9) and the instrument adjusted to read the pH value of this buffer solution. With the pH meter calibrated, it was immersed in the water sample, allowed to stabilize and the pH value read from the instrument. The beaker and the electrode were washed in between samples with deionised water in order to prevent contamination by other samples. Duplicate pH values were taken.

Temperature

The measurement of the temperature of the water was taken from the site. The temperature was recorded by dipping the mercury-in glass thermometer electrode in to the sample for about 30seconds as described by Bennet and David (1974).

Electrical Conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts (Kaur 1999). The EC was measured using a high-powered microcomputer conductivity meter JENWAY 40710 model HI 9032withadegreeof accuracy of 0.01. The instrument was initially calibrated using standard solution ofconductivities500µs/cm and 1500 µs/cm. Duplicate values were taken and units were in micro siemens per centimetre.

Total Dissolved Solids (TDS)

TDS was determined using a JENWAY 40710, model HI 9032 (0.01 degree of accuracy) (MAKE/MODEL). One hundred millilitres of the sample was poured into a 250 ml beaker and the probe was then immersed into the sample and the value read on the digital screen. (Bertram and Balance 1996).

Dissolved Oxygen

The DO of the sample was measured using dissolved oxygen meter (JENWAY 40710) by dipping the probe into the sample as described by Betram and balance (1996).

Biochemical Oxygen Demand (BOD)

The BOD is a measure of the amount of oxygen required by micro-organisms to decompose the organic matter in water sample under a specific set of conditions. BOD is also the amount of oxygen expressed in milligram/litre, required for the decomposition of organic matter in a given water sample by aerobic bacterial action. Untreated water sample to be analysed was stored in a dark cupboard at room temperature for 5 days as described by Akpata *et al*. (1987).

When the biochemical oxygen demand (BOD_5) was due for determination, 2ml each of Winkler's reagent and manganese chloride was added into 100ml of the samples and was titrated against sodium thiosulphide solution ($Na_2S_2O_3$) to end point using starch and methyl orange as indicators. Hence the difference between the earlier determined oxygen concentration at (0) day and after 5 days was calculated using the following expression:

$$\text{DO} = \frac{ml\ of\ titrant\ X\ N\ X\ 1000}{Sample\ volume\ in\ ml}$$

Therefore, $DO_5 = DO_1 - DO_5$

where N = normality of sodium thiosulphate.

Determination of phosphate

The procedure was carried out as follows: the stored program number 490 was entered to the computerized spectrophotometer. The wavelength was dialled and rotated to 890nm; 10ml of cell riser was initially inserted into the compartment. A 3- phosphate powder pillow was added to the 10ml of the sample and swirled to mix the solution formed a blue colour which indicated the presence of sulphate (USEPA, 1986).

Determination of nitrate

The procedure employed was called cadmium reduction method (powder pillows or Accuvacampuls). The stored program number 355 was entered, and the wavelength was dialled and rotated to 500nm. 25ml of the sample filled in to the sample, one milligram of nitrate reagent powder pillow was added to the cell and shaken vigorously, after 5-minute reaction the timer beeps and amber colour was developed which indicates the presence of nitrate/nitrogen. Another sample cell was filed with 25ml of sample and inserted simultaneously; the timer beeped again and displayed the result (USEPA 1978).

Determination of sulphate

The procedure employed for determination of sulphate was called sulfaver 4 method (powder pillows or Accu vac ampuls). The stored program number 680 was entered, and the wavelength was dialled and rotated to about 450nm. 25ml of the sample was filled-in to the sample cell; one sulfaver 4 sulphate reagent powder pillow was added to the cell and shaken vigorously. After five minutes, the reaction produced a white turbidity which developed indicate the presence of sulphate. Another sample cell was filled with 25ml of the sample and inserted for five minutes, and then the timer beeped. A prepared sample was placed into the sample cell, the light shield was closed and pressed, and the result was displayed and recorded (USEPA, 1978).

Statistical analysis

Student's t-test was use to compare values of physicochemical parameters of the bore-hole and well water using Microsoft excel

RESULTS AND DISCUSSION

Table1: Mean Values of Physicochemical Parameters of Borehole and Well Water in Fagge area, Kano

Parameters	**Fagge WW**	**Fagge BHW**	**WHO standard**
pH	6.80±0.46	7.04±0.42	6.5 – 8.5
DO_2(mg/L)	4.51±0.47	4.39±0.35	10
BOD (mg/L)	2.19±0.48	2.02±0.30	10
EC(µs/cm)	137.83±27.16 *	40.82±11.08*	1000
TDS (mg/L)	426.33±290.5 *	309.07±107.05*	500
$N0_3^{2-}$ (mg/L)	31.04±18.47	22.58±6.93	50
$S0_4^{2-}$ (mg/L)	23.36±3.79	21.53±1.62	100
$P0_3^{2-}$ (mg/L)	57.29±10.24	54.83±14.29	10

*Shows a significant difference at 5% level of significance

Water quality analysis at three (3) different locations in Fagge Local Government was performed and different chemical parameters were measured. The results obtained were shown in the table below. The mean values with standard deviations for the study locations were summarized in the Table.

The result of the physicochemical analysis of the water showed that the pH of the well water samples ranges from 6.56 – 6.96 and that of borehole ranges from6.73-7.50 and complied with the standard requirements as recommended by WHO, NAFDAC and NSDWQ. Even though, pH has no direct effect on the human health, its indirect action on physiological process cannot be over-emphasized (NSDWQ, 2007).

Conductivity of 49.66 – 399.33 µs/cm has been observed in the well water sample collected and 27.33 – 48.66µs/cm were observed for borehole water. Although there is no disease or disorder associated with conductivity of drinking water (NSDWQ, 2007). Low conductivity of 27.33µs/cm was also observed in borehole water collected from site C, (BHW), this showed that all the samples have conductivity within the permissible limit of 1000µs/cm (WHO, 2007). Higher conductivity of tenindicates elevated levels of dissolved salts (such as calcium, magnesium, sodium, and chloride), which may contribute to hardness or salinity. Though minerals like calcium and magnesium are essential for health, excessive levels may reduce water palatability and damage pipes and appliances through scaling (WHO 2011). Also, total dissolved solids (TSD) of the water samples range from 42.33 – 579.00mg/l for well water and that of borehole water showed a range of 265.66 – 393.33mg/L. This showed that the TDS of the well water has exceeded the standard recommended by WHO, NAFDAC and NSDWQ (500 mg/l). High TDS can affect the taste of water, making it **salty, bitter**, or**metallic**. While this may not pose a direct health risk, itcanreduce water consumption due to poor taste, particularly in sensitive populations like children or the elderly. (WHO 2017).

The Dissolved Oxygen for the well water ranges from 4.16 – 4.73mg/L while that of the borehole water ranges from 4.00 – 4.83mg/L and these values are below the permissible limits by WHO (2007). And these findings are consistent with the findings of Jadeja and Thakur (2006) who studied the quality of groundwater in the industrial area of Dharmapur in Porbandar city of Gujarat by examining various physico-chemical and bacteriological characteristics. The Biochemical Oxygen Demand for the well water ranges from 2.00 – 2.30mg/L and that of borehole water ranges from 1.14 – 2.66mg/L which is below the recommended limit of WHO (2007). Low BOD lead to anaerobic conditions which often increase the solubility of heavy metals like iron, manganese, and lead from sediments into the water, posing health risks to humans and aquatic organisms. These metals can affect taste, color, and the safety of water for drinking (Chapman 1996).

The results showed that phosphate levels range from 48.15 – 71.83mg/L for the well water and ranges of 36.64 – 62.00mg/L were observed for borehole water. All these values are above the permissible limit of 10mg/L (WHO 2007). The increased levels of phosphate have been due to the precipitation which eroded the land containing fertilizer, However, these values exceeded the permissible limits of 10mg/L (WHO 2007). Elevated phosphate concentrations, typically above **0.1 mg/L** for freshwater bodies, can lead to significant issues for both ecosystems and human health (USEPA 1986). Similar results were reported by Kotaiah and Reddy (2004) in their study on canals located in Kurnool district.
The result of Nitrate ion concentration obtained ranges from 26.17 – 35.00mg/L for well water and a range of 16.17 – 28.00mg/L was observed in borehole water. These are within the range of 50mg/L as permitted by WHO (2007) and European Union. Also the sulphate ion concentration obtained ranges from 19.95-25.1mg/L for well water and a range of 36.64 – 62.00mg/L for borehole water. These values were within the permissible limit of 100mg/L as permitted by WHO (2010). This has been due to the accumulation of human and domestic wastes that runs through, e.g detergent, soaps etc. Populated areas show higher concentrations because of activities of laundry men.Consequently, high concentration of sulphate increase acidity of the soil, hardness of the water and eutrophication process (Shahbaz *et al*. 2017). The mean values were below the permissible limit of 100mg/L (WHO, 2007).

From the statistical analysis, only mean values of Electrical Conductivity and the Total dissolved Solid had significant differences (p value <0.05).

CONCLUSION

In conclusion, the borehole water in Fagge Local Government Area isgenerally more suitable for drinking compared to well water, particularly due to lower TDS levels. However, the elevated phosphate levels in both water sources are a causé for concern and require attention to prevent potential ecological and health issues. Regular monitoring and appropriate water treatmentmeasures are recommended to ensure the safety and quality of the drinking water in the area.

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