Determination Of Some Physicochemical Parameters And Selected Heavy Metals In Borehole Water Samples From Wawa Town, In Borgu Local Government Area Of Niger State, Nigeria.

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Abstract: Some physicochemical parameters and heavy metals were investigated in water samples collected from selected boreholes in Wawa town for the purpose of ascertaining the water quality of the boreholes for drinking and other domestic purposes. Four selected boreholes were sampled three times each. The physicochemical parameters investigated are as follows; temperature, pH, electrical conductivity, alkalinity, turbidity, total dissolved solids and total hardness using standard methods. And from the results, the physicochemical parameters had mean values of 32.35±0.92 ºC, 7.06±0.18, 217.42±72.60 µS/cm, 140.25±23.00 mg/L, 0.94±0.23 NTU, 130.90±49.05 mg/L and 246.25±25.97 mg/L respectively. The results obtained were compared with the WHO [1] and NSDWQ [2] standards for drinking water and it was observed that majority of the physicochemical parameters had values which were within the maximum permissible limits. However, the total hardness of all the sampled boreholes were above the permissible limit set by NSDWQ (150 mg/L) but lower than the permissible limit set by WHO (500 mg/L). The heavy metals investigated are zinc, cadmium, iron, copper and lead. The heavy metals listed had mean values of 0.165±0.095 mg/L, 0.001±0.0004 mg/L, 0.715±0.09 mg/L, 0.145±0.02 mg/L and 0.008±0.0007 mg/L respectively. The results obtained revealed that the values for zinc, cadmium, copper and lead were below the maximum permitted levels set by WHO (5 mg/L, 0.003 mg/L, 2 mg/L and 0.01 mg/L) and NSDWQ (3mg/L, 0.003mg/L, 1 mg/L and 0.01mg/L) respectively. The values obtained for iron in all of the water samples were also below the acceptable limit for groundwater set by WHO (3 mg/L) but above the permissible limit for drinking water by NSDWQ (0.3 mg/L). As such, the borehole water is of good quality for human consumption and other domestic uses. However, treatment is recommended to reduce or remove the lead and cadmium concentrations in the boreholes.

Keywords: Borehole, Heavy metals, Physicochemical parameters, Water samples, Wawa Town.

I. INTRODUCTION

Water is the most abundant substance on the earth's surface that is essential for the survival of all known forms of life. Next to air we breathe, water is humankind most important substance [3]. It is always the vital commodity for humans, used for drinking, cooking, agriculture, transport and recreation, among other purposes. Nevertheless, most important is the fact that water is a major constituent of all living matter, comprising up to two-thirds of the human body. In addition, water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances, industrial cooling and transportation. It also serves as a receptor of industrial waste, domestic waste and wastewater resulting from other uses of water [4], as well as playing significant roles in the growing, development and establishment of cities and communities [5], hence man rely on water for proper existence.

Clean drinking water is now recognized as a fundamental right of human beings but over a billion people lack access to safe potable water supply globally and out of this number, around 6–8 million people die each year due to water related diseases and disasters and more than 300 million people living in rural area of sub-Saharan Africa are being affected [6]. In Nigeria, due to the inability of the various levels of government to provide water for its citizens, there has arisen private boreholes indiscriminately drilled by individuals, corporate organizations and even government agencies in their different homes, and office environments [7, 8] to curb the menace of inadequate water supply. The alternative sources of water supply provided is uncontrolled and therefore produces negative implications on the groundwater and surface water which negates the principle of sustainable development and its goals [9].

Rural settlements in Nigeria are characterized by lack of portable water supply. This situation makes dwellers depend on stream, lakes, shadow dug wells etc. However, it is known that water resources in rural areas of Nigeria are prone to pollution either by low level of hygiene manifested by the inhabitants or by agricultural and local industrial activities of the inhabitants [10]. These rural areas are most often neglected by government as they lack basic infrastructure like potable water, health facilities, access roads, sanitation facilities and even electricity. The near absence of these facilities exposes the dwellers to a variety of health-related risks. Contamination of water resources unarguably stands prominent among the many ills plaguing the rural settlements in developing countries [11].

The major source of drinking water for the inhabitants of Wawa town in Borgu Local Government Area of Niger state is the untreated groundwater obtained from recently drilled boreholes across the entire study area by non-governmental agencies and individuals. Hence, quality assessment of these borehole water samples has become necessary to provide firsthand information on their quality to ascertain their suitability as drinking water.

II. MATERIALS AND METHODS

In the preparation of reagents, it was ensured that chemicals of analytical grade and distilled water were used in order to avoid unnecessary contamination. Glassware were washed thoroughly with detergent, rinsed properly with distilled water, immersed in 25% nitric acid and finally rinsed with distilled water and dried in an oven before use. The condition of all the equipment used were inspected in order to make sure equipment is safe for use and that all systems are working properly. They were also calibrated according to manufacturer's specifications.

2.1 Study Area

Wawa is a town located in Borgu local government area of Niger state, Nigeria. Its geographical coordinates are 9º 54' 8" North, 4º 25' 9" East, with postal code 912105. It shares its boundaries with Kainji and with Kaiama in Kwara state. Wawa town has an area of 19km^2 and a population of 23, 438 at the 2006 census. The people of Wawa are predominantly farmers that engage in commercial crops and animal production. The major source of their water in recent time is the groundwater in the form of boreholes which are being drilled across the entire study area mostly as non-governmental agency projects and in some cases by individuals.

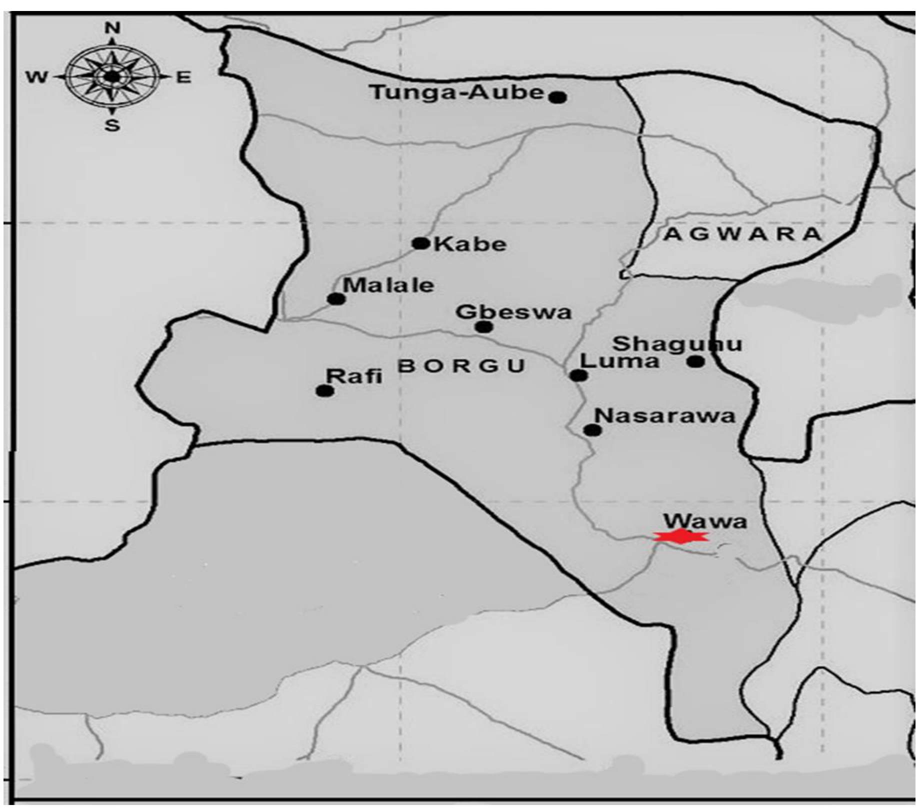

Figure 1: Map of Borgu L.G.A. Showing the Major Towns Including Wawa (the study area).

S/N	SAMPLING LOCATION	CODE
1.	Central Primary School, Wawa.	BH A
2.	Basic Health Centre, Wawa.	BH B
3.	Saidu Abubakar Memorial Central Mosque, Wawa.	BH C
4.	Customs Barracks, Wawa.	BH D

Table1: Sampling Locations and their Code

2.2. Sampling

2.2.1 Sample Collection and Preservation

Four samples of borehole water (coded BH A - BH D) were collected from different locations across the entire study area in triplicate. The water was allowed to run for a few minutes before collection in order to obtain a uniform flow rate [12]. Three water samples were collected from each borehole at intervals of four hours, between the hours of 8.00 am to 4.00 pm. The samples were collected in new and cleaned polyethylene plastic bottles. The samples were covered in black polyethylene bags to prevent growth of algae and stored in a Haier thermocool chest freezer at a temperature below 4°C, to prevent growth of microorganisms. Some parameters like pH, electrical conductivity and temperature were determined immediately during each sampling period due to their low stability while the remaining parameters were determined in the laboratory [13]. The samples were preserved by acidifying with 2 mL concentrated nitric acid so as to prevent metal adsorption onto the inner surface of the container [14]. Samples were collected between 7^{th} -10^{th} April, 2021.

2.3 Methodology

2.3.1 Temperature and pH

An ATC digital pen-type portable temperature/pH meter [(model PH-009 (III)] was used to measure temperature and pH *in situ*. The meter was switched on and standardized with a buffer solution. The meter was then immediately introduced into the water sample and measurement was taken after a stable reading was observed. The probe was then rinsed with distilled water before taken another measurement. The probe was also recalibrated after ten runs [15].

2.3.2 Electrical Conductivity (EC)

The electrical conductivity of the water samples was measured with a conductivity meter (model DA-1) *in situ*. The meter was switched on and 0.01 mol/dm^3 solution of potassium chloride was used to standardize the probe. The probe was thoroughly rinsed with distilled water and then immersed directly into water sample and each measurement was taken. The probe was thoroughly rinsed with distilled water after each measurement [16].

2.3.3 Alkalinity

Alkalinity was determined by taking 100 mL of the sample, followed by the addition of 2 drops of phenolphthalein indicator. A color change was observed followed by titration with 0.1M HCl until the color changed from pink to colorless [13]. Calculation;

$$\text{Alkalinity in mg } (CaCO_3)/L = \frac{A \times M \times 50{,}000}{Volume\ of\ sample}$$

Where: A= Volume of acid used., N= Molarity of standard acid

2.3.4 Turbidity

The turbidity of the water samples was measured using a digital turbidimeter (2100AN HACH model). The meter was standardized with a distilled water, and then 10 mL of water sample was placed in the sample cell in the turbidimeter. The turbidity reading of each sample was then recorded [17].

2.3.5 Total Dissolved Solids (TDS)

The total dissolved solid was determined using a conductivity meter, the programme menu of the conductivity meter was switched to total dissolved solid, 100 mL of the water sample was measured into a beaker and the probe was introduced into the sample. The results of total dissolved solids were displayed and recorded [13].

2.3.6 Total Hardness (TH)

The EDTA titration method was used in determining the total hardness of the samples. The sample was shaken thoroughly. Out of the sample collected, 25 mL was taken and diluted with 50 mL of distilled water and transferred quantitatively into a clean 250 mL Erlenmeyer flask. Then 2 mL of buffer solution (NH_4Cl –NH_4OH) was added, followed by two drops of Erichrome Black indicator and the sample titrated with 0.01M EDTA solution that had been standardized using the standard calcium solution. The formation of blue color indicated the end point, titre value was recorded [17]. Calculation;

$$\text{Total hardness in mg } (CaCO_3)/L = \frac{A \times B\ X\ 100}{Volume\ of\ sample}$$

Where: A= Volume of EDTA used for titration, B= Molarity of the EDTA titrant.

2.3.7 Digestion of Water samples for Heavy Metals Analysis

This involved transferring 100 mL of the water sample into a 250 mL beaker, followed by the addition of 5 mL concentrated HNO_3. The mixture was heated on a hot plate and allowed to evaporate to about 20 mL. The beaker was allowed to cool and another 5 mL of concentrated HNO_3 was added and heated to evaporate again. The mixture was cooled, filtered and transferred to a pre cleaned 100 mL plastic bottle. It was then diluted to the mark with distilled water. A blank was also digested with the same procedure, as stated above [18]. The solution was used for heavy metal analysis using the Microwave Plasma Atomic Emission Spectrophotometer (MP-AES) 4210 model at Centre for Dryland Agriculture (CDA), Bayero University Kano.

III. RESULTS AND DISCUSSION

3.1 Results

Results are expressed as mean ± SD of the three replicate analyses as follows.

Samples	Temp. (°C)	pH	EC (μS/cm)	Alkalinity(mg/L)	Turbidity (NTU)	TDS (mg/L)	TH (mg/L)
BH A	32.10±3.04	6.90±0.03	320.00±5.57	153.58±3.71	0.76±0.01	205.49±3.60	233.25±3.46
BH B	33.83±4.36	7.35±0.07	216.67±7.02	159.42±1.42	0.85±0.01	104.47±4.15	225.03±1.59
BH C	32.17±1.86	7.03±0.03	114.67±3.51	101.17±2.43	1.33±0.01	73.65±1.83	290.69±2.60
BH D	31.30±2.10	6.95±0.09	218.33±7.64	146.83±1.62	0.83±0.01	139.97±5.23	236.03±2.33

Table 2: Mean and Standard Deviation Values for the Physicochemical Parameters Analyzed in the Water Samples

Samples	Zinc (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Copper (mg/L)	Lead (mg/L)
BH A	0.11±0.01	0.001±0.0003	0.73±0.04	0.16±0.01	0.008±0
BH B	0.16±0.07	0.001±0.0001	0.58±0.02	0.12±0.02	0.008±0.0001
BH C	0.32±0.2	0.002±0.0002	0.71±0.13	0.17±0.03	0.009±0.0001
BH D	0.07±0.03	0.001±0.0002	0.84±0.13	0.13±0.02	0.007±0.0001

Table 3: Mean and Standard Deviation Values for the Heavy Metals Analyzed in the Water Samples

3.2 Discussion

This study determined some physicochemical parameters and some heavy metals of water in selected boreholes in Wawa town, in Borgu local government area of Niger state, Nigeria. All of the parameters analyzed were all detected.

The high temperature obtained from the samples could be attributed to the time and season of sample collection which was throughout the whole day and during the dry season. The temperature of drinking water is often not a major concern to consumers especially in terms of the quality. The quality of water with respect to temperature is usually left to the individual's taste and preference. [19] reported high value of temperature which was attributed to the environmental temperature as well as other climatic conditions prevailing in the study area at the time of sample collection. Higher water temperature increases chemical reactions in the aquifer such as weathering of rocks which leads to the release of the chemical contaminants in water and decreases the level of dissolved oxygen in aquatic level.

The results obtained for the pH level of the water samples were within the acceptable limit of WHO and NSDWQ standard of 6.5 – 8.5. However, [20] recorded pH values ranging from 6.20 to 7.88 and concluded that pH is generally not considered to have a direct impact on humans. However long-term intake of acidic water can lead to mineral deficiencies. Because virtually all groundwater come from precipitation that soaks into the soil and passes down to the aquifer, low pH could be an indication of acidic rain.

The measurement conducted for the electrical conductivity of the water samples indicates that all examined water samples had values which did not exceed the permissible limit of WHO (1000 µS/cm) and NSDWQ (1000 µS/cm) for drinking water and as such, have no potential health risk to the consumers.

From the analyzed results, the alkalinity level of all the samples was within the permissible limit of WHO (500 mg/L) for drinking water. However, [13], reported that the alkalinity value in water provides an idea of natural mineral salts present in the water. The main species that contribute to alkalinity includes bicarbonates, hydroxides, phosphates and borates.

The turbidity values recorded in all the boreholes sampled were below the WHO and NSDWQ maximum permissible limit of 5 NTU and therefore do not have any potential health risk to the consumers. Generally, borehole water usually has low turbidity value since surface water that percolate as groundwater would have undergone natural filtration through the soil as it percolates into the aquifer. Although, [20] reported turbidity of 6.12-60 NTU in groundwater and suggested that the source of the high turbidity is most likely due to those generated as water moves through the loose soils of the area into the groundwater supply, as well as a high likelihood of mud and silt being washed into the groundwater.

From the analyzed results, all the borehole water samples recorded total dissolved solids values within the acceptable limit of WHO and NSDWQ standard for drinking water. These results are in agreement with a study conducted by [21] in India. However, [22] deduced that high level of total dissolved solids in groundwater may be due to dissolution of weathered materials from rock formation.

The hardness levels of the water samples were also analyzed and presented in Table 2. [23] classified water in terms of softness and hardness (in mg/L) as follows: 0-60 soft, 60 – 120 moderately soft, and 121 – 180 moderately hard and above 180 is hard. Considering this classification, it can be deduced that almost all the water samples analyzed are hard, but safe for drinking and other domestic purposes. However, the hardness could be removed by simple boiling, addition of chemicals e.g. washing soda, sodium hydroxide, and ion exchange method.

Research has recorded approximately 0.05 g/kg of zinc to be present naturally in the earth crust [24]. From the analyzed samples, the maximum and minimum zinc levels were 0.32 mg/L (BH C) and 0.07 mg/L (BH D) (Table 3). All examined samples revealed zinc concentration below the permissible standard values of 3 and 5 mg/L set by the [2] and the [1] respectively. This could be associated to the fact that the zinc in its natural mineral form (sphalerite) does not dissolve into underground water bodies via leaching in all examined locations [25].

The presence of cadmium in groundwater occurs via leaching when in contact with soil contaminated with discharges from mining, paints, electroplating, petrochemical, plastics and fertilizer industries [26]. All of the cadmium concentrations detected in the water samples were below the permissible value (0.003 mg/L) specified by the WHO and NSDWQ and this could be attributed to galvanized steel pipe corrosion used in conveying water from the ground level to surface level as reported by [27] or leaching of soil which has been contaminated with discharges from plastics and fertilizers into the underground water. Epidemiological studies have shown that long-term exposure to cadmium could cause kidney damage, lung cancer, high blood pressure and bone defects. However, excess cadmium can be removed or reduced from drinking water with a sodium form cation exchanger, reverse osmosis or electrodialysis.

All of the borehole water samples analyzed had iron concentration below the [1] and [2] maximum permissible limit. The concentration of iron detected in all the samples may be due to the presence of iron bearing minerals in the rocks as they interact with the underground water as well as the pipes used in the construction of the boreholes, as suggested by [28].

Copper was detected in all of the water samples but none was at a level above the permissible limits of [1] and [2]. The copper detected in the water samples may have been derived from rock weathering or corrosion of brass and copper piping [30]. However, when excess copper is present in water (above the permissible level), gastrointestinal disorder occurs after a long period of exposure [29].

Of all heavy metals, lead is the most significant due to its toxic and harmful instinct even at very small concentrations [31]. It can accumulate in body tissue posing threat to human health. From the examined samples at different locations, lead concentrations of all samples were below the permissible value of 0.01 mg/L set by the [1] and [2]. The presence of lead in water beyond the permissible level could result in hypertension, interference with Vitamin D and calcium metabolism, brain development hindrance in fetus and young children, damage to tissues and organs in humans and many more. Water softener, activated carbon filtration and distillation are some means of removing or reducing lead from drinking water.

IV. CONCLUSION

This study assessed the physicochemical parameters and heavy metals content of some borehole water samples collected from Wawa town, in Borgu local government area of Niger state, Nigeria. The study revealed that majority of the physicochemical parameters are within the WHO and NSDWQ permissible limits for drinking water. All of the heavy metals contents were also within the permitted level set by WHO and NSDWQ.

However, frequent monitoring of these water sources is recommended over time as high potential health hazards may occur among the inhabitants of the study area due to the consumption of the water especially in the cases of lead if they are used for drinking and other domestic purposes without treatment and bioaccumulate beyond the tolerable concentrations in the body.

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