Science World Journal Vol 13(No 3) 2018
www.scienceworldjournal.org
ISSN 1597-6343
Published by Faculty of Science, Kaduna State University.

Full Length Research Article

ASSESSMENT OF PHYSICOCHEMICAL AND MICROBIOLOGICAL QUALITY OF BOREHOLE WATER IN DUTSE METROPOLITAN JIGAWA STATE, NIGERIA

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ABSTRACT
The health risks associated with individual borehole water quality consumed is not well known for a developing nation like Nigeria. Spatial distribution of physico-chemical and microbiological parameters were assessed from Dutse metropolitan in Jigawa state of Nigeria. Water samples were collected from four boreholes A, B, C & D and analyzed in the Dry season (on 22nd February, 2016). Atomic absorption spectroscopy and standard microbiology methods were used to determine the chemical and microbiological quality of sampled water. The results showed that physico-chemical parameters; pH ranged from (6.5-7.5). Others all in (mg/L); TDS varied from (150 – 440); NO_3-N ranged from (1.0 – 3.0), $CaCO_3$ (1.0 - 3.2), Mn (0.01 - 0.1), and F- ranged from (0.0-0.4). Micro-biological parameters; Total plate bacteria (cfu/100ml) ranged from (5.8x10 – 2.6x10). F.C and E.coli values recorded (Nil). Sample A boreholes produced slightly more acidic water than sample B boreholes. However, the entire sample tends towards Neutral. TDS, NO_3-N, $CaCO_3$, Mn and F- values were all far below the NSDWQ and WHO standards of drinking water. However, Values for TPB recorded were below the NSDWQ and WHO while the E.coli and FC values are in agreement with NSDWQ and WHO requirement Value. It is therefore recommended to conduct survey of borehole sites prior to drilling to prevent areas of potential hazard to groundwater.

Keywords: Boreholes, Physico-chemical, Water, Microbiological quality, Groundwater

INTRODUCTION
Water is the precious resource that qualifies the planet earth to be habitat of the biosphere. Water covers 71% of the earth surface and it is vital for all known forms of life. It is transparent fluid which forms the world's streams, lakes, oceans and rain, and is the major constituent of the fluids of organisms. As a chemical compound (chemical formula: H_20) it contains one oxygen and two hydrogen atoms that are connected by covalent bonds.
Boreholes and wells are groundwater types that form an integral part of water supply systems in rural and urban areas especially in Nigeria, and therefore are indispensable because of inadequate public water supply systems (Pickering and Owen, 1994; MacDonald *et al.,* 2005; Calow *et al.,* 2011). Over one billion people lack access to clean safe water worldwide, up to 300 million rural people in Sub Sahara Africa have no access to safe water supplies and this is on the rise (NAS, 2009).
The only realistic option for meeting rural water demands is through groundwater exploitation (MacDonald *et al*., 2005). A large population of the world especially in sub-Sahara Africa depends on groundwater as their main source of domestic water (Sha, 2004; Calow *et al*, 2011), this is because it is accessible anywhere, less capital intensive to develop and maintain and is less susceptible to pollution and seasonal fluctuation, naturally has good quality (Bresline, 2007).
Nigeria has greater challenges when it comes to groundwater development and management. The management of the resource is lagging behind the pace of development, and often, very little control is exercised in its exploitation. The current groundwater resources development and supply status is unacceptably low and needs a major transformation (Nwankwoala, 2011). The dry region of Nigeria depends mostly on ground water, its abstraction account for 20% of the total water usage. Currently demands for groundwater usage have been increasing due to population growth and diminishing opportunities to economically develop surface water supplies (Akpoveta *et al,* 2011). Dutse as the state capital of Jigawa, there is an increasing efforts to supply portable water by the state through harnessing both the surface and ground sources. Consequently, as the state capital there rise in the demand of water for domestic, industrial, and agricultural developments and this requires the need for sinking of more boreholes. The digging of more boreholes in the state capital brings the need to monitor the issue of water quality that remains a major contender of its supposed existence in abundance essentially its quality is as equally important as its quantity.
The quality of water is of vital concern for mankind since it is directly linked with human welfare. According to Ranjana (2010), the quality of public health depends to a greater extent the quality of groundwater. Though groundwater quality is believed to be quite good compared to surface water, its quality is the sum of natural geology of the environment and anthropogenic influences such as Withdrawal, land use change, and solid waste dumping (Chapman, 1996).Water quality parameters reflect the level of contamination in water resources and show whether water is suitable for human consumption.
Physico-chemical and micro-biological parameters of water indicate the safety of portable water (MacDonald et al., 2009) and their analysis is important for public Health and pollution studies (Kot et al, 2003). The acceptability aspect of drinking water to consumers is subjective and can be influenced by different constituents.

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MATERIALS AND METHODS

Study Area

Dutse is the state capital of Jigawa state in Nigeria. Its geographic coordinates are Latitudes $11^0$40'20 '' to $11^0$44'31.17''N and Longitudes $9^0$19 ''40 '' to $9^0$23''13.49''E. Its altitude ranges from 431 to 527m above sea level. The terrain of Dutse consists of mainly flat plateau with medium mountains. River Hadejia flows across the state to meet the various water needs of the people. The climate is tropical and the annual rainfall varies from 700 to 1300mm of rainfall and it has two seasons, dry and wet. The average daily temperatures vary between 25^{o}Cand 35^{o}C.

Sample Site Selection

A simple random sampling was used to select the four (4) boreholes in the study area based on the availability of boreholes in the area. The location for each of the four boreholes selected with their geographic coordinates was given in the table1 below. The boreholes were designated using alphabet A, B, C and D respectively. However, for the purpose of this research the sample taken from these sites was taking to Soil and Water Laboratory in Farm Centre Kano under the Kano state ministry of environment for analysis and generation of data.

Table1: Location of the four Sample Points

S/N	Sample ID	Latitude	Longitude	Sampling Requirement
1	A	11^0 43' 24.17''N	009^0 21' 52.00'' E	Water quality
2	B	11^0 40' 42.64''N	009^0 20' 11.94'' E	Water quality
3	C	11^0 43' 31.6''N	009^0 20' 11.90'' E	Water quality
4	D	11^0 43' 3.30''N	009^0 21' 47.63'' E	Water quality

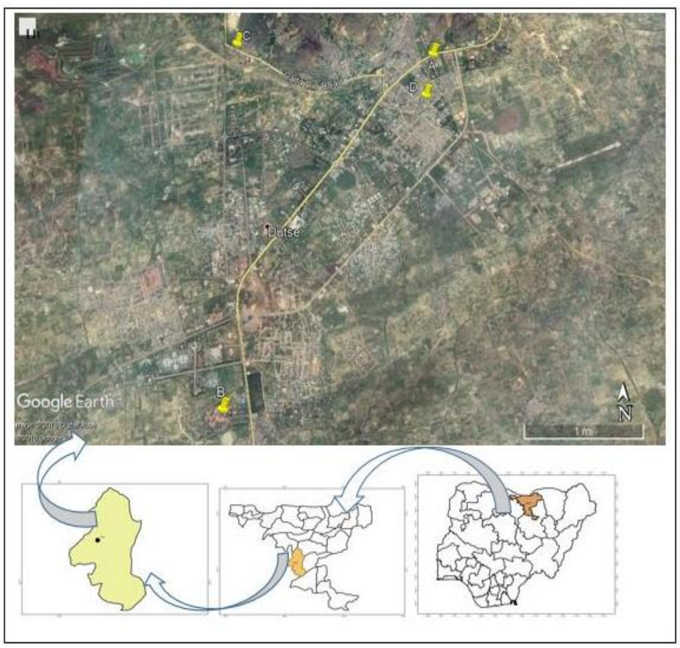

Figure1: Study Area showing sampling points

Collection and Preparation of Samples

Each of the borehole tap was disinfected with Sodium Hypochlorite (NaOCl) and neutralized with Sodium Thiosulphate ($Na_2S_2O_3$) to eliminate any contamination due to anthropogenic activity or any external natural occurrence. Glass water bottles (250mls) was also sterilized by addition of Sodium Thiosulphate (0.1ml). The borehole was flushed for about 3 minutes to remove any externally induced contamination and then the boreholes will then pump to fill the water bottles leaving an air space of 2.5cm to create space for oxygen such that organisms do not die before testing in the laboratory. The bottles was marked for identification using the labels for each borehole. The bottles was then transported to the laboratory in an insulated box to prevent external factors like high temperatures from changing some of the water parameters. Analysis commenced within 12hrs of sampling.

Determination of the physico-chemical and microbiological parameters of borehole water

Physical parameters such as conductivity, turbidity, pH and temperature were measured in the field using; cyber scan 500 conductivity meter, portable turbidity meter (TB200-IR-10), pH meter (Model 300408.1) which was calibrated using two buffer solutions, pH 4 and pH 7, and Mercury thermometer, respectively. Atomic absorption spectroscopy was used to measure the concentration of cations such as iron, cadmium, lead, arsenic, calcium and magnesium and anions such as chlorides, fluorides, nitrates, sulphates and phosphates. Membrane filtration method was used in the determination of total coliforms and E. coli (bacterial indicator for faecal contamination) as described by United States Environmental Protection Agency (2009).

RESULTS

The physico-chemical parameters analyzed included pH, TDS, Nitrates (NO3-N), Calcium hardness as Calcium Carbonate (CaCO3), Fluorides, chlorides, copper, zinc and Manganese while the micro-biological parameters included Total plate Bacteria, Coliform (TC) and Faecal Coliform (FC). Table 2 to 5 presents the values obtained from parameters analyzed for each sample alongside the maximum permitted levels for every parameter provided by Standard of Nigeria for drinking water quality.

It is clearly shown from the comparison table that the values of both physical parameters such as turbidity, color, conductivity, and inorganic constituent such as fluorides, chlorides, nitrate, copper, calcium, manganese, magnesium, hardness and sulphate are below the maximum permitted levels provided by the standard of Nigeria for drinking water quality while all the pH values obtained (6.5, 7.5, 7.2 and 7.1) from the sample (A, B, C and D respectively) are within the recommend range of 6.5 to 8.5 of the standard of Nigeria for drinking water quality. However, it is also shown that all the borehole water contain Nil values of micro biological parameters such as coli forms and E.coli, this clearly indicate the absent of these parameters in the samples and the made them to be within the limit of recommended value of standard of Nigerian drinking water quality. Hence, the absence of these parameters in the samples shows that the sample may likely contain no any associated health impact and other related diseases.

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Table 2: Comparison of Samples with Nigerian Standards for Drinking Water Quality (NSDWQ).

SN	Parameters	Units	Sample A	Sample B	Sample C	Sample D	Standard	Comment
1.	Color		Clear Colorless	Colorless	Color	Clear Colorless	Colorless	Within Limit
2.	Taste		Taste Present	Tasteless	Taste Present	Tasteless	Unobjectionable	Unobjectionable
3.	Odour		Odourless	Odourless	Odour	Odourless	Unobjectionable	Unobjectionable
4.	Temperature	^0C	29.5	30.4	30.2	29.7	Ambient	
5.	Turbidity	NTU	0	0	0	0	5	Below Limit
6.	Conductivity	Us/cm	2.14.2	572.8	628.5	500	1000	Below Limit
7.	pH		6.5	7.5	7.2	7.1	6.5- 8.5	Within Limit
8.	Total Dissolve solids	Mg/L	150	401	440	350	500	Below Limit
9.	Chloride	Mg/L	2.1	2.3	4.1	3.2	100	Below Limit
10	Fluoride	Mg/L	0.4	0.3	0.0	0	50	Below Limit
11	Zinc		0	2.1	0.0	1	5	
12	Copper	Mg/L	**0**	0	0.0	0	0.1	Below Limit
13	Calcium	Mg/L	1.4	1.5	0.0	0	NS	Below Limit
14	Nitrate	Mg/L	3	3		2	10	Below Limit
15	Manganese	Mg/L	0.1	0.1	1	0.03	0.56	Below Limit
16	Magnesium	Mg/L	1.7	1.7	0.05	1.0	2	Below Limit
17	Hardness	Mg/L	3.2	3.2	1.0	1.2	100	Below Limit
18	Sulphate	Mg/L	11	11	3.1	5.0	100	Below Limit
19	Total Plate bacteria	Cfu/Ml	5.8x10	5.8x10	4.8x10	2.6x10	100	Below Limit
20	Coliform	Cfu/Ml	Nil	Nil	Nil	Nil	Nil	Within Limit
21	E.Coli	Cfu/Ml	Nil	Nil	Nil	Nil	Nil	Within Limit

Comparison with WHO Recommended Values

The analytical results was also compared with the World Health Organisation (WHO) standard values for drinking water quality through the following figures and table

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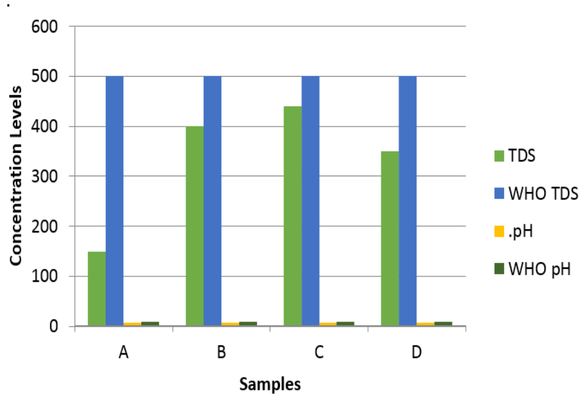

Figure 2: Comparison Graph for Chemical Parameter with WHO Recommended Value

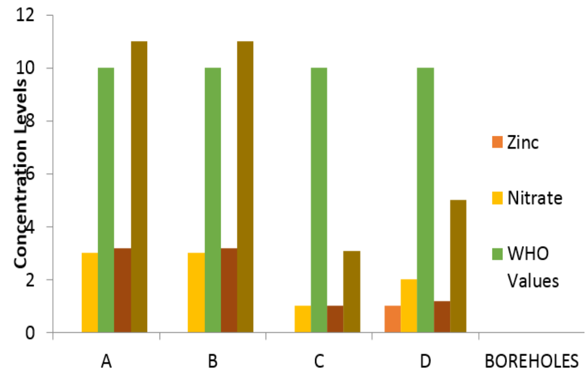

Figure 3: Comparison Graph for Chemical Parameter with Who Recommended Value

Table 3: Comparison of Micro Biological Parameters from Boreholes Samples A, B, C & D with WHO Recommended Value

S/N	Parameters	Sample A	Sample B	Sample C	Sample D	WHO Standard
1.	Total Plate Bacteria cfu/ml	5.8x10	5.8x10	4.8x10	2.6x10	100
2.	Coliforms cfu/ml	Nil	Nil	Nil	Nil	Nil
3.	E. Coli cfu/ml	Nil	Nil	Nil	Nil	Nil

DISCUSSION

The result of physicochemical analysis of water show that the pH of the water samples from sample A, B, C and D, comply with Nigerian standards for drinking water quality guidelines values. Their values are within than the range limits of the pH (6.5 – 8.5) recommended by SON, WHO, NAFDAC and NSDWQ. Even though pH has no direct effect on human health, its indirect action on physiological process cannot be over emphasized (Adekunle et al., 2007; NSDWQ, 2007).

Also total dissolve solid (TSD) of the four borehole water samples A, B, C and D analyzed are below the standard recommended by NSDWQ, WHO, and NAFDAC (500 mg/l). The TDS is the term used to describe the inorganic salt and small amount of organic matter present in solution or water. The principal constituents are usually calcium, magnesium, sodium and potassium cation, carbonate, hydrogen carbonate, chloride, sulphate and nitrate anion (WHO, 1996). The presence of TDS in water may affect its taste (WHO, 1996). It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste (WHO, Bruvold & Ongerth, 1969; Bruvold and Mitchell, 1976).

The turbidity of all water samples used in this study is in agreement with both NWDSQ and WHO standard. Water turbidity is very important because high turbidity is often associated with higher level of disease causing microorganism, such as bacteria and other parasites (Shittu et al., 2008).

The fluoride content of all water samples fell within the standard limit of NSDWQ (1.5 mg/l), likewise the copper content of all the water samples used in this study which is in agreement with NSDWQ standard of 1 mg/l. Although, presence of copper above the standard set by NSDWQ may cause gastrointestinal distress with a shorter term exposure, while a long term exposure may experience liver or kidney damage (EPA, 2012).

All the water samples analyzed in this study have unobjectionable colour which is in agreement with the standard colour of 5 TCU by both NSDWQ , NAFDAC and 6 TCU by WHO (NSDWQ, 2007: WHO, 2001; NAFDAC, 2001). Highest conductivity of 628.5µs/cm was observed in the water sample collected from sample c, which is in agreement with NSDWQ although there is no disease or disorder associated with conductivity of drinking water (NSDWQ, 2007). Iron, chromium and nitrite were not detected in each of the samples.

The total coliform counts of all the four boreholes water samples were Nil, These values indicate the absence which is in agreement with standard requirement of 10 total coliform count per 100 ml for NSDWQ and zero total coliform count per 100 ml for WHO (NSDWQ, 2007: WHO, 2002). A low/Nil total coliform counts vividly indicate that the water from the samples boreholes is not faecally contaminated. This finding is not surprising considering the population and the study area is a new state capital with less number of dump site and mostly the boreholes drilled are located at the required distances from latrines and dump site. Most of the boreholes for this study were drilled and developed recently. Water from old drilled boreholes may lead to deterioration of the water quality, as result of long term usage of boreholes the pipeline may become corroded with random cracks and in most cases clogged with sediment (Onemano & Otun, 2008). This will allow the passage of inorganic metals and bacteria.

The implication of this finding shows the possibility of the absence of pathogens in the analyzed samples. The cause of acute intestinal illness, which are generally considered discomfort to health and could become fatal for some susceptible groups (such as infants, elderly and those who are sick) (Addo et al., 2009; Olowe et al., 2005; NSDWQ, 2007), may not be linked to this selected water sample.

Generally, underground water is often considered as the purest form of water (Shittu et al., 2008), although it's vulnerability to contamination could be due to improper construction, animal waste, proximity to toilet facilities, sewage, refuse dump site and various human activities surrounding it (Bilton, 1994; Shittu et al., 2008). However, no *E. coli* were detected in all the water samples, which indicate that all the water samples are free from recent faecal contamination. The ability to detect faecal contamination in drinking water is necessary, as pathogenic microorganisms from human and animal faeces in drinking water pose the greatest danger to public health.

Conclusion

This study recorded satisfactory laboratory result for physical and chemical parameters, while a zero number of coliform counts, in all the boreholes water samples A, B, C and D analyzed. Thus making the boreholes water from the analyzed samples safe for drinking and require no further treatment. However, Dutse with its overwhelming population require stable sources of water and also there is need for awareness to be created to enlighten the people on the boreholes site selection.

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