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Original article

STUDY OF THE PHYSICO - CHEMICAL PARAMETERS OF SELECTED BOREHOLES WITHIN IBRAHIM BADAMASI BABANGIDA UNIVERSITY MAIN CAMPUS, LAPAI, NIGER STATE, NIGERIA

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ABSTRACT

This study assessed fifteen (15) physico - chemical parameters of selected boreholes (7) within Ibrahim Badamasi Babangida University main campus, Lapai, Niger State, Nigeria between May 2019 and August 2019. There were fluctuations in these parameters with marked observed differences in conductivity, total dissolved solids and nitrate. Variations of these parameters, which differ significantly ($p<0.05$) in the boreholes with exception of temperature and pH, showed that turbidity and colour were highest at B4 (IBBU Central mosque), while conductivity, total dissolved solids, total hardness, alkalinity, calcium, magnesium, chloride and carbon (IV) oxide were highest in B7 (IBBU University hostel). Similarly also, dissolved oxygen was highest at borehole B2 (IBB University garden) while phosphate and nitrate in B1 (IBBU farm). There were significant differences ($p<0.05$) in monthly: temperature with highest in May and lowest in July, pH with highest in May and lowest in August, conductivity with highest in August and lowest in July, calcium, magnesium and chloride all had highest in August and lowest in May. The boreholes water are slightly hard and alkaline. Turbidity of B2 (IBBU Biological garden) and B4 (IBBU central mosque) were above the set limit of Nigerian Drinking Water Quality Standard, dissolved oxygen was above the set limit by World Health Organization, colour of water except for boreholes B3 (IBBU twin lecture theatre), B5 (IBBU administrative block) and B7 (IBBU hostel) were above the set limits of NDWQS and WHO. Continuous monitoring of water quality of these boreholes should be carried out, similar study need to be done for the remaining months, water from boreholes B1 (IBBU farm), B2 (IBBU Biological garden), B4 (IBBU central mosque) and B6 (IBBU staff quarters) should be treated before consumption and there is need for microbial analysis of water from these boreholes.

Keywords:- Boreholes, conductivity, total dissolved solids, total hardness, alkalinity

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INTRODUCTION

Water is said to be the source of life on earth, whether as ground or surface water. Globally, safe drinking or portable water is one of the fundamental requirements for good health. It is indeed according to [1] an essential component of life on earth. It is needed on a daily basis for human activities, such as cooking, washing, drinking as well as industrial activities [2]. Therefore, the quality of water is very important in order to ensure that it is portable or safe for drinking [3].

Drinking water that is of good quality has great importance due to the fact that man's continued existence on this earth depends solely on water availability and accessibility. The quality of water depends on the chemical, physical and biological characteristics, which is expected to conform to specified standards or limits. Therefore, water is subjected to several purification processes for the purpose of consumption and this will depend on the extent or level of contamination.

The physical and chemical characteristics of water are characterized by the geo - chemical, pollution, climatic as well as the geomorphological conditions of their basins. This result in the variations of water quality, which is mainly caused by changes in the concentrations of these water characteristics flowing into another water body. These variations could result from natural activity, such as erosion, or man - made / anthropogenic activity such as farming.

In Nigeria, like other developing countries, access to quality and portable drinking water is very important. The quality and quantity of drinking water is deteriorating in the country, which is as a result of bad sanitation such as direct discharge of untreated sewage, inadequate water treatment plants and water distribution management [4]. This has therefore become a serious issue of concern in most developing countries. [5] reported that contaminated water has caused serious health concerns especially in developing countries where 80% of all diseases and 30% deaths were related to drinking water.

Borehole has been identified as an important source of water supply for human use. There are several of these boreholes on main campus of Ibrahim Badamasi Babangida University, Lapai, Niger State used by students, staff as well as the surrounding community. There are several activities, which include indiscriminate disposal of domestic wastes, frequent visits by animals and washing of clothes around these boreholes and this could contaminate the water. However, there is dearth of information on their water quality with regards to physico - chemical status. These could pose health risks as the safety of this water used for drinking as well as for other domestic purposes is not known.

Human life according to [6] depends on water, its proper utilization as well as management. Therefore, it is pertinent to know the status of water from these boreholes within the school premises. This study tends to ascertain the quality of some boreholes water available to Ibrahim Badamasi Babangida Lapai students on main campus. This will go a long way in providing information on the current status of the boreholes water, thereby serving as guide to protect this valuable resource.

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MATERIALS AND METHODS

Study area

The study was conducted at the main campus of Ibrahim Badamasi Babangida University, situated at Lapai, Niger State. The metropolis of Lapai is located on Latitude 8°49'N and Longitude and 6°41'E with its Headquarters also at Lapai. It adjoins the Federal Capital Territory (FCT), Abuja. It is about 50 km from Minna, the state capital with a population of 110,127 according to 2006 census with a total area of 3,051 km^2.

Water sample collection

Seven (7) boreholes at different locations within the main campus of the University were chosen and used for this (Table 1). Water samples were collected separately from each borehole using sterile plastic bottles. The choice of plastic containers was because level of contamination to the water from it is low [7].

The plastic containers were capped immediately, labelled accordingly, then placed in coolers, which contained ice and transported to laboratory for further analysis.

Water samples were collected in the morning (8:00am - 10:00am). This was done twice in every month for a period of four months (May 2019 - August 2019).

Table 1: Sampling areas description at Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria

Boreholes	Sampling location/description
B1	Ibrahim Badamasi Babangida University Farm
B2	Ibrahim Badamasi Babangida University Biological garden
B3	Ibrahim Badamasi Babangida University Twin lecture theatre
B4	Ibrahim Badamasi Babangida University Central mosque
B5	Ibrahim Badamasi Babangida University Administrative block
B6	Ibrahim Badamasi Babangida University Staff quarters
B7	Ibrahim Badamasi Babangida University Hostel

Physico-chemical analysis of water samples

The samples of water collected were analyzed for fifteen (15) physico-chemical parameters. These included temperature (^oC), pH, dissolved oxygen (mg/l), colour , turbidity (NTU), conductivity (μ/S/m), nitrate (mg/l), phosphate (mg/l), total dissolved solids (mg/l), hardness (mg/l), alkalinity (mg/l), calcium (mg/l), carbon (IV) oxide, magnesium (mg/l) and chloride (mg/l). These parameters were analyzed at the Niger state Water Board in Minna. Standard methods for water and wastewater examination as described by [8] were used at the laboratory for the analyses.

Comparison of water quality parameters with national and international standards

Physico-chemical parameters measured were compared with National and International standard values for drinking water and domestic purposes.

Statistical analysis

Descriptive statistic was used to compute for means, standard deviations, minimum and maximum values. Analysis of variance (ANOVA) was used to determine significant difference at 95% confidence limit of the data collected. The new Duncan multiple regression test (NDMRT) was used to separate means. Pearson Correlation was carried out to test for any significant relationship between physico-chemical parameters.

Special Package for Social Sciences (SPSS) was used as statistical tool for the analyses.

RESULTS

Table 2 shows mean physico - chemical parameters of boreholes water on Ibrahim Badamasi Babangida main campus, Lapai,

Niger State, Nigeria. Temperature (°C) ranged between 28.00-31.30 with mean 29.60±1.15, pH range from 6.70-7.90 with mean 7.07 ±0.24 while turbidity (NTU) range from 3.00-6.50 with mean 4.94 ±1.03. Conductivity (µ/Scm) range from 51.00-200.00 with mean value of 128.9 ±37.8, dissolved oxygen (mg/l) of range 5.60 - 6.72 of mean 6.48 ± 0.15, colour (TCU) of range 10.00-26.00 of mean 16.57 ±3.69, total dissolved solids of range from 46.00 - 157.00 mg/l with mean 88.73 ±30.12.Total hardness (mg/l) ranged from 18.00 - 56.00 of mean 37.34 ±9.86 and alkalinity (mg/l) range of 10.00-30.60 with mean 22.30 ±5.47.

Calcium (mg/l) had ranged from 2.32 - 13.20 with mean 7.82 ±2.69, magnesium (mg/l) ranged between 1.30- 6.12 with mean 3.86 ±1.62, chloride (mg/l) of range 3.92 - 14.60 of mean 10.00 ±2.26. Carbon (IV) oxide ranged from 1.10 - 5.00 with mean 2.59 ±0.97, phosphate (mg/l) ranged between 0.14 - 5.37 with mean 2.23±1.34 and nitrate (mg/l) with range 0.98 - 26.04 with mean 5.87 ±6.74.

Table 2: Mean physico - chemical parameters of borehole water on Ibrahim Badamasi Babangida main campus, Lapai, Niger State, Nigeria

Parameter	Minimum	Maximum	Mean ± SD
Temperature (°C)	28.00	31.30	29.60 ± 1.15
pH	6.70	7.90	7.07 ± 0.24
Turbidity (NTU)	3.00	6.50	4.94 ± 1.03
Conductivity (µ/Scm)	51.00	200.00	128.90 ± 37.80
Dissolved Oxygen (mg/l)	5.60	6.72	6.48 ± 0.15
Colour (TCU)	10.00	26.00	16.57 ± 3.69
Total Dissolved Solids (mg/l)	46.00	157.00	88.73 ± 30.12
Total Hardness (mg/l)	18.00	56.00	37.34 ± 9.86
Alkalinity (mg/l)	10.00	30.60	22.30 ± 5.47
Calcium (mg/l)	2.32	13.20	7.82 ± 2.69
Magnesium (mg/l)	1.30	6.12	3.86 ± 1.26
Chloride (mg/l)	3.92	14.60	10.00 ± 2.26
Carbon (IV) Oxide	1.10	5.00	2.59 ± 0.97
Phosphate (mg/l)	0.14	5.37	2.23 ± 1.34
Nitrate (mg/l)	0.98	26.04	5.87 ± 6.74

Mean physico - chemical parameters of the various boreholes water sampled from Ibrahim Badamasi Babangida University main campus, Lapai, Niger State in Table 3 showed variations during the period of study. However, these variations of temperature amongst the boreholes were statistically not significant (PS>0.05).

Temperature (°C) was highest at borehole B2 (29.70) and lowest in B6 (29.55). pH was highest in B3 (7.16) and lowest in B6 (6.91). The variations were also statistically not significant (P>0.05) Turbidity (NTU) was significantly highest (P<0.05) in B4 (6.31) and B2 compared to other locations and the lowest at B5 (3.39). Conductivity (mg/l) was highest in B7 (173.88) and lowest in B3 (81.13). Conductivity at B6 and B1 were significantly higher (P<0.05) than other locations. Dissolved oxygen (mg/l) was highest in B2 (6.59) and lowest in B4 (6.30). B2, B1 and B6 were significantly higher (P<0.05) than the other locations. Colour (TCU) was significantly highest in B4 (22.90) and lowest in B5 (12.06). Total dissolved solids (mg/l) was highest in B7 (126.25) and lowest in B5 (12.06). TDS inB6 and B7 were significantly higher (P<0.05) than the other locations. Total hardness

(mg/l) was highest in B7 (46.75) and lowest in B3 (20.38). Hardness in B1 and B7 were statistically the same but differ from those of other locations ($P<0.05$)

Alkalinity (mg/l) was highest inB7 (28.64) and lowest in B3 (14.00). Calcium (mg/l) was highest in B7 (10.99) and lowest in B3 (4.71). Alkalinity in B6 and B7 were statistically the same, however, these 2 boreholes were significantly higher than the other locations. Magnesium (mg/l) was highest in B7 (5.18) and lowest in B3 (2.52). Chloride was highest in B7 (11.75) and lowest in B3 (6.61). Carbon (IV) oxide was highest in B7 (4.14) and the lowest in B3 (1.46). Phosphate (mg/l) was highest in B1 (4.83) and lowest in B3 (0.86) while Nitrate was highest in B1 (16.50) and lowest in B3 (1.17).

Table 3: Mean physico - chemical parameters of water from the selected boreholes of Ibrahim Badamasi Babangida main campus, Lapai, Niger State, Nigeria

Parameters	B1	B2	B3	B4	B5	B6	B7
Temperature (°C)	29.56±1.26^{a}	29.70±1.22^{a}	29.59±1.24^{a}	29.59±1.70^{a}	29.60±1.17^{a}	29.55±1.23^{a}	29.63±1.25^{a}
pH	7.13±0.32^{a}	7.09±0.17^{a}	7.16±0.15^{a}	7.14±0.26^{a}	7.05±0.35^{a}	6.91±0.11^{a}	7.00±0.19^{a}
Turbidity (NTU)	4.40±0.33^{c}	6.21±0.18^{a}	4.19±0.39^{c}	6.31±0.16^{a}	3.39±0.42^{d}	5.10±0.31^{b}	5.01±0.10^{b}
Conductivity (µS/cm)	114.75±19.08^{b}	112.63±16.77^{b}	81.13±13.20^{c}	121.38±20.29^{b}	129.25±25.69^{b}	169.00±31.42^{a}	173.88±31.55^{a}
Dissolved Oxygen (mg/l)	6.51±0.07^{ab}	6.59±0.08^{a}	6.42±0.11^{b}	6.39±0.09^{b}	6.53±0.07^{b}	6.50±0.03^{ab}	6.42±0.33^{b}
Colour (TCU)	15.40±1.48^{d}	19.89±1.55^{b}	14.35± .05^{d}	22.90±1.98^{a}	12.06±1.02^{e}	16.66±1.53^{c}	14.70±0.97^{d}
Total Dissolved Solids (mg/l)	78.13±9.06^{b}	76.63±5.71^{b}	54.88±7.24^{c}	79.75±14.17^{b}	22.06±1.02^{b}	121.88±30.13^{a}	126.25±30.52^{a}
Total Hardness (mg/l)	44.75±8.19^{a}	28.98±2.03^{d}	20.38±3.68^{e}	40.50±4.21^{c}	36.5±2.45^{c}	43.50±4.17^{b}	46.75±3.11^{a}
Alkalinity (mg/l)	22.50±2.27^{cd}	22.18±4.76^{d}	14.00±3.12^{f}	16.90±0.97^{e}	24.88±1.46^{bc}	27.00±1.58^{ab}	28.64±1.18^{a}
Calcium (mg/l)	9.26±2.37^{a}	6.55±2.04^{c}	4.71±2.11^{c}	7.07±2.08^{b}	6.90±1.48^{b}	9.27±1.57^{a}	10.99±1.74^{a}
Magnesium (mg/l)	4.80±0.61^{a}	3.08±0.82^{b}	2.52±0.81^{b}	3.29±1.07^{b}	3.47±0.64^{b}	4.66±1.10^{a}	5.18±1.01^{a}
Chloride (mg/l)	10.44±1.33^{ab}	10.60±2.54^{ab}	6.61±2.84^{c}	9.56±0.92^{b}	10.35±0.87^{ab}	10.70±1.30^{ab}	11.75±1.58^{a}
Carbon (IV) Oxide	2.79±0.72^{c}	1.73±0.66^{f}	1.46±0.36^{f}	2.15±0.13^{de}	2.54±0.33^{cd}	3.30±0.36^{b}	4.14±0.39^{a}
Phosphate (mg/l)	4.83±0.47^{a}	1.43±0.18^{c}	0.86±0.60^{dc}	1.47±0.21^{c}	2.05±0.60^{c}	2.03±0.46^{c}	2.91±1.02^{b}
Nitrate (mg/l)	16.50±8.06^{a}	9.70±7.51^{b}	1.17±0.20^{d}	1.55±0.55^{d}	2.83±0.57^{d}	2.43±0.41^{d}	6.89±4.06^{bc}

Values on rows with same superscript did not show significant difference ($P<0.05$)

B1 = Ibrahim Badamasi BabangidaUniversity Farm; **B2** = Ibrahim Badamasi Babangida University Garden; **B3** = Ibrahim Badamasi Babangida University Twin lecture theatre; **B4** = Ibrahim Badamasi Babangida University Central mosque;**B5** = Ibrahim Badamasi Babangida University Administrative block;**B6** = Ibrahim Badamasi Babangida University Staff quarters;**B7**= Ibrahim Badamasi Babangida University Hostel

Table 4 shows the mean monthly physico - chemical parameters of water from all the boreholes sampled from Ibrahim Badamasi University main campus, Lapai, Niger State. There were fluctuations in these parameters across the months during the period of study.

Temperature (°C) was significantly highest in May (30.61 ± 0.49) and lowest in July (28.540.51) ($P<0.05$)). The pH of the boreholes water was significantly highest in May (7.24± 0.27) and June (7.13± 0.28) and lowest in August (6.93± 0.13). Turbidity (NTU) was highest in August (5.10±0.96) and lowest in June (4.8438.58) but not statistically significant in all the locations. Conductivity was highest in August (138.64±34.87) and significantly lowest in July (108.21±43.64) ($P<0.05$).

Dissolved oxygen (mg/l) was highest in May (6.53± 0.09) and lowest in June (6.43± 0.25), but non-significant difference. Colour was highest in May (17.13± 4.42) and lowest was August (15.93±3.15) but not significant. Total dissolved solids (mg/l) was highest in June (97.07± 35.71) while the lowest was July (79.14±34.23) but not significantly different, .Total hardness (mg/l) was highest in August (40.56±9.83) and lowest in May (33.15 ± 7.39) but not statistically significant in all the locations. Nitrate (mg/l) was highest in August (8.81±0.47) and lowest in May (3.40±0.43) but not statistically significant in all the locations , In the case of phosphate (mg/l) the month of August was the highest (8.81±0.47) and the lowest was May (3.40±0.43) but not statistically significant in all the locations.

Calcium (mg/l) was also significantly highest in August (9.63±1.89) and July (9.08±2.22) and lowest in May (5.70± 1.93). Magnesium (4.49±0.81 mg/l) was significantly highest in August and July (4.40±1.04) compared to other locations. Chloride (11.49±1.59 mg/l), carbon (IV) oxide (2.84±0.79).

Table 4: Monthly mean physico - chemical parameters of boreholes water on Ibrahim Badamasi Babangida main campus, Lapai, Niger State, Nigeria

Parameter	May	June	July	August
Temperature (°C)	30.61 ± 0.49^{a}	29.66 ± 0.47^{b}	28.54±0.51^{c}	29.59±1.61^{b}
pH	7.24 ± 0.27^{a}	7.13 ± 0.28^{ab}	6.98±0.11^{bc}	6.93±0.13^{c}
Turbidity (NTU)	4.95 ± 1.22^{a}	4.84 ± 1.08^{a}	4.89±0.94^{a}	5.10±0.96^{a}
Conductivity (µ/S cm)	131.29 ± 28.14^{ab}	137.29 ± 38.58^{ab}	108.21±43.64^{b}	138.64±34.87^{a}
Dissolved Oxygen (mg/l)	6.53 ± 0.09^{a}	6.43 ± 0.25^{a}	6.46±0.07^{a}	6.50±0.12^{a}
Colour	17.13 ± 4.42^{a}	16.85 ± 4.12^{a}	16.36±3.18^{a}	15.93±3.15^{a}
Total Dissolved Solids (mg/l)	91.64 ± 22.32^{a}	97.07 ± 35.71^{a}	79.14±34.23^{a}	87.07±26.57^{a}
Total Hardness (mg/l)	33.15 ± 7.39^{a}	36.78 ± 10.22^{a}	38.86±11.09^{a}	40.56±9.83^{a}
Alkalinity (mg/l)	21.08 ± 6.17^{a}	21.25 ± 6.07^{a}	22.93±4.63^{a}	23.94±4.96^{a}
Calcium (mg/l)	5.70 ± 1.93^{b}	6.87 ± 2.73^{b}	9.08±2.22^{a}	9.63±1.89^{a}
Magnesium (mg/l)	2.98 ± 0.81^{c}	3.56 ± 1.63^{bc}	4.40±1.04^{ab}	4.49±0.81^{a}
Chloride (mg/l)	8.62 ± 2.23^{b}	9.11 ± 2.51^{b}	10.78±1.38^{a}	11.49±1.59^{a}
Carbon (IV) Oxide	2.25 ± 0.97^{a}	2.47 ± 1.11^{a}	2.77±0.96^{a}	2.84±0.79^{a}
Phosphate (mg/l)	1.88 ± 1.56^{a}	1.95 ± 1.44^{a}	2.43±1.15^{a}	2.64±1.16^{a}
Nitrate (mg/l)	2.76 ± 1.16^{a}	5.24 ± 5.86^{a}	7.34±7.64^{a}	8.12±8.89^{a}

Values on columns with same superscript did not show significant difference ($P<0.05$)

Water regardless of the source need to have a set standard for usage. These standards are determine on the basis of the physical, chemical as biological characteristics of the water both at national and international levels. The safe limits for water according to Nigerian Standard for Drinking Water (NDWQS) and WHO (World Health Organization) for temperature are 40^{o}C and ambient respectively. The mean value for this study is lower, which falls within the acceptable limit. The mean pH of this study fall within the accepted limits of 6.5 - 9.0 and 6.5 - 8.5 for NDWQS and WHO respectively. Turbidity of the study was below the safe limit of 5.0 and 5.0 - 25 of NDWQS and WHO, likewise conductivity being below the limits of 1000 set standards. Dissolved oxygen of this study also falls within the safe limits of $\geq$ 6 of WHO. The limit of colour set by these organizations are 6 and 16 TCU, which are lower than the findings of this study. Total dissolved solids and total hardness of this study were all below the set limits of 500 and 1000 mg/l and 80 - 120 mg/l respectively for drinking water. Mean calcium (mg/l) and magnesium (mg/l) values of this study were also below 200 and 150 safe limits of [9] respectively.

DISCUSSION

Physico - chemical parameters are very important in determining the quality of water and safety of water for domestic and other purposes. The mean temperature of boreholes at IBB main campus was higher than 26^{o}C and 28^{o}C reported by [10], in the physico - chemical assessment of water quality in selected borehole in Anyigba town, Kogi State, Nigeria. This could be due to differences of location of boreholes and season. Hydrogen ion concentration, which is also known as pH determines acidity or alkalinity of water. The water from these boreholes were all neutral. This is higher than that of [11] where pH values of 6.1, 6.0 and 5.7 were reported for some boreholes water. This could be due to difference of bicarbonate and carbonate of alkali and alkaline earth metals.

Turbidity measures the loss of transparency of water and even other solutions. The mean value for this study is higher than 0.77 NTU and 0.98 NTU reported by [12], in the Physicochemical and bacteriological analyses of drinking water from wash boreholes in Maiduguri Metropolis, Borno State, Nigeria. This may be due to the presence of high colloidal solids in the boreholes water, which gives cloudy appearance hence reduces transparency. Conductivity measure the ability of water to conduct electric current or electricity. The mean value recorded in this study was less than 445.83µs/cm and 466.92µs/cm reported by [13], in the physico-chemical assessment of borehole and well water used in Akungba - Akoko, Ondo State, Nigeria.. Since this is influenced by the presence of dissolved salts, it could be the reason for such observation. Dissolved Oxygen (DO) is the quantity of oxygen present in water. The mean value for this study was higher than 5.1 mg/l and 0.49 mg/l reported by [10], in the physico - chemical assessment of water quality in selected borehole in Anyigba town, Kogi State, Nigeria. This could be due to the activities of microbes in the environment, in IBB University environment. Colour apart from portraying clarity of water also help to determine the fitness of water for consumption. The mean value reported in this study was higher than 3.70 and 7.40 TCU reported by [14]. This implies that the water of the boreholes are not colourless. This could be due to the season, level of water percolation and other human activities around these boreholes. Total

dissolved solids is responsible for hardness, odour, taste, colour and turbid nature of water. The mean value of this study was higher than 5.90 and 30.53 reported by [14], in the physico - chemical assessment of borehole waters in Ovim, Isiukwuato Local Government Area, Abia State, Nigeria, but less than 223.3 mg/l and 236.0 mg/l reported by [13], in the physico-chemical analysis of borehole and well water used in Akungba - Akoko, Ondo State, Nigeria. This could be due to the differences in level of pollution and soluble materials present in these boreholes. Hardness in water is determine by the presence of carbonate, hydroxides and bicarbonate. The mean value for this study was less than 18 mg/l and 34 mg/l reported by [10], in the physico - chemical assessment of water quality in selected borehole in Anyigba town, Kogi State, Nigeria. Likewise alkalinity mean value for this study was lower than 60 mg/l reported by [11]. This could be due to differences in the concentrations of carbonate, hydroxides and bicarbonate present in these water.

Water can be classified on the basis of hardness as soft (0 - 17.1 mg/l), slightly hard (17.1 - 60 mg/l), moderately hard (60 - 120 mg/l), hard (120 - 180 mg/l) and very hard (180 and over). The value for this study classify water from the boreholes as slightly hard.

Calcium, magnesium and chloride contents in water are also important in determining water quality. The mean values of calcium, magnesium and chloride in this study is less than 99.15 mg/l, 169.44 mg/l and 14.42 mg/l respectively as reported by [11] and the 92.5 mg/l and 92.5 mg/l for calcium and chloride as reported by [10]. This is the reason for slightly hard nature of water from the boreholes because their concentration determine the hardness of water. Phosphate and nitrate are also very important element in determining the status of water. The mean values of these parameters in this study is higher than 1.10 mg/l of phosphate and 2.33 mg/l of nitrate reported by [14].

The highest temperature in May and lowest in July could be due to differences of rainfall, which could cause variations of temperature from the ambient. The pH, which decreases across months with highest pH recorded in May and lowest in August might be due to the rains, which cause increase in water level. Increased in dissolved solids or ions in water as a result of the flood could be the cause of highest conductivity recorded in August and lowest in July. Calcium, which increases across the months, with highest concentration recorded in August and lowest in May and likewise magnesium and chloride, which follow the same trend may be due to increase in dissolved solids resulting from increase water level and mixing.

The temperature and conductivity of the boreholes water were all below the WHO safe limit, which implies that these parameters are adequate for drinking water. Likewise total dissolved solids, total hardness, alkalinity, calcium, magnesium, chloride, phosphate and nitrate of the boreholes were below the set limits. The pH of these boreholes water regardless of the location on the campus falls within the safe limit ranges of WHO and NDWQS for drinking water. However, the turbidity of B2 (Biological garden) and B4 (Central mosque) were above 5 NTU set limit by NDWQS. This implies that the water from these boreholes are turbid. Dissolved Oxygen was greater than 6 mg/l as recommended by WHO. The colour of water in these boreholes with the exception of B3 (Twin lecture theatre), B5 (Administrative block) and B7 (Hostel)

were above the set limits 15 and 6 TCU of NDWQS and WHO respectively for water quality. This implies that water from the remaining boreholes are not clear or colourless.

Boreholes are common source of water and their suitability for human use depends on the concentrations of the dissolved properties. Water with low dissolved oxygen has an unpleasant smell whereas those with high dissolved oxygen are good for drinking. Since the DO of these boreholes are greater than 6, it implies that this parameter is adequate. Water that is too hard is not good for drinking as well as for other domestic purposes. The boreholes water are slightly hard and alkaline, hence adequate for consumption or usage. Likewise other parameters measured apart from turbidity and colour.

Turbidity and colour are also important factors in determining the fitness of water for consumption. The water from boreholes B1 (Farm), B2 (Biological garden), B4 (Central mosque) and B6 (Staff quarters) are turbid because the values recorded were above the acceptable limits. The colour of water from Boreholes B1 (Farm), B2 (Garden), B4 (Central mosque) and B6 (Staff quarters) were not colourless because of dissolved solids resulting from frequent or continuous usage. This means that the water might not be fit for direct consumption as this period.

CONCLUSION

High fluctuation levels were recorded in conductivity, total dissolved oxygen and nitrates. There were significant differences ($P<0.05$) in dissolved oxygen, calcium, magnesium, chloride, phosphate, nitrate, colour, total dissolved solids, conductivity, turbidity, hardness, alkalinity and carbon (IV) oxide.

Monthly fluctuations of physico - chemical parameters, which showed significant difference ($P<0.05$) in temperature, pH, conductivity, calcium, magnesium and chloride were observed.

Water from these boreholes are slightly hard based on classification of water hardness.

Turbidity in boreholes B2 (Biological garden), and B4 (Central mosque),colour in boreholes B1 (Farm), B2 (Biological garden), B4 (Central mosque) and B6 (Staff quarters) were above the set limits of NDWQS and WHO for water quality.

RECOMMNEDATIONS

Continuous monitoring of water quality from these boreholes need to be done. Similar study should be done for the remaining months to have baseline information for the whole year. Water from boreholes B1, B2, B4 and B6 need to be treated before consumption. There is also need for microbial analysis of water from these boreholes.

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