Commonwealth Journal of Academic Research (CJAR.EU)

Assessment of Physico-Chemical Parameters in Millennium Development Goals (Mdg's) Boreholes in Kuje Area Council, Abuja North Central Nigeria

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Abstract

This study assessed water quality of MDG's boreholes in Kuje Area Council Abuja with a view to determine its suitability for human consumption, to achieve this, the study embarked on physic-chemical characteristics of water samples and comparison of result obtained in above with WHO Drinking Water Standard, in the study area and value obtained were compared with WHO 2011 drinking water guidelines, GPS was employed for reference purpose, Ten, borehole were sampled and analyzed in laboratory using standard method or guidelines procedures suggested by American Public Health Association APHA (1995); Result obtained were computed using statistical analysis of mean, STDE, range, variables and %cv; values were compared with WHO 2011 drinking water guidelines; Result reveal that, PH and alkalinity were high in some sampled boreholes, while Temp, Ec, Thb, Turbidity and Tds are normal for drinking Borehole water in the study area. Further and trial laboratory test can be conducted in the study area at wet and dry season, geophysics survey report is required in any subsequence drilling, water hygiene should be advocated and water treatment is required before human can consume borehole water in the study area.

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INTRODUCTION

Water is an essential element for both human, plants and animals. As an essential element, water must attain some degree of certain requirement called quality or standard to meet up her purpose. Therefore, all the purposes or uses have their quality, for instance in rural and urban cities, people speak of colour and colourless water, odour and odour furious, cool and hot, salty and fresh water, and in a nut shell this water is not good for drinking.

Water resources have proven themselves to be generally resilient, but they are unceasingly vulnerable and threatened. Our growing population need for water, food, raw materials and energy is increasingly competing with nature own demands. For water to sustain already imperiled ecosystems and the services on which we depend. Day after day, we pour millions of tons of untreated sewage and industrial and agricultural wastes into the world water system. Clean water has become scarce and will become even scarcer with the onset of climate change. And the poor countries to suffer first and most from pollution, water shortages and the lack of adequate sanitation Ban (2014). Groundwater provides potable water to an estimated 1.5 billion people worldwide daily and has proved to be the most reliable resources for meeting rural water demand in sub-Saharan African, WHO/UNICEF (2010).

The United Nations millennium development goals (MDGs) include target 7c, to halve the "proportion of the population without sustainable access to safe drinking-water" between 1990 and 2015 UNDP (2003). The joint Monitoring Programmed for Water Supply and Sanitation (JMP) of the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) reports progress towards meeting this goal WHO/UNICEF (2010). The corresponding MDG indicator is the "proportion of households using water from an improved source, and is reported on country basis UNDP (2003). However, data and monitoring mechanisms regarding the safety of water sources at a national scale when the MDG targets *were cast, and remain, scant* Kyle, et al (2012). As such, at the time the MDGs were developed, there were no credible alternative approach to an indicator that allows for the calculation of a percentage figure easily aggregated to the country and global scales and amenable for use as a target given the types of data available, Kyle et al, (2012).

Using this approach, WHO and UNICEF estimate that 5.8 billion people used improved sources in 2010, with 783 million using unimproved water sources WHO/UNICEF (2012). Treating use of an improved source as an indicator for use of safe water is likely to overestimate the population using safe water, since some improved sources may provide water that is microbiologically or chemically contaminated whether at source or by the time it reaches the home and is consumed Godfrey et al (2011); Wright et al (2004). On the other hand, most unimproved sources do not provide safe drinking water, so under-accounting of safe water coverage due to unimproved sources providing sage water is likely to be small Kravitz et al, (1999); Gullemin et al (1999).

In 2010, WHO and UNICEF released data on water quality and sanitary risk (i.e., risk of contamination) associated with improved sources from five countries as part of the Rapid Assessment of Drinking-Water Quality (RADWQ) study which had been undertaken between October 2004 and April 2005, Tadesse et al, (2010); Ince et al, (2010); Properzi; (2010); Aldana; (2010), Aliev et al (2010). The RADWQ study is the only source of nationally-representative drinking water quality data amenable to analysis for microbial contamination disaggregated by water source type kyle, et al (2012).

The growing deficit of good quality water in developing countries, including Nigeria, has spurred the need to utilize other sources of water other than conventional treated waters at maximal risk of microbiological and chemical pollution, Obiri-Danso et al, (2009). These non-

treated water sources are being increasingly used as drinking water yet, testing to see whether the water is of good quality is almost non-existent. Preliminary research on some physicochemical properties of water from these boreholes has been reported, (Turkura et al 2014). Physic-chemical parameter of water includes Temperature, P^H, Turbidity, Total Alkalinity, Electrical Conductivity (CE), Total Hardness, Total Dissolve Solid (Tds) and Nitrate. Previous studies conducted in this area, mainly on comparative determination of rural water quality on surface water, borehole and well water. Abdulkadir (1993). Studies conducted of water have indicated that pure water containing no minerals hardly exists naturally in the environment Ademorati (1996) and Christopherson (2006). Revealed that even freshly precipitated rain water dissolve gases from the atmosphere through which it passes, then it dissolves more or less minute's proportions of everything of which it falls over or through which it flows. Incompatible human activities also have introduced to water bodies (both in surface and underground sources) substances at intensities above threshold level considered safe for such sources, culminating therefore in water quality problems.

Geology of some rocks has shown that the weathering of primary minerals from bedrock and subsequent release in water receiving sources may accumulate at intensities likely to be deleterious to human health Ogbaje, et al (2007). Over the years, the various components of the government have adequately addressed the problem of rural water supply. Recently, the intervention by MDGs is quite commendable as it enhances rural water accessibility for all by the year 2015, though quality of the water was not readily discussed at the formation of this agency, construction of their boreholes are not properly evaluated, and are haphazardly located in some rural areas that can affect the quality of the water. Against these constraints, the study is essentially concerned about an assessment of the physic-chemical parameters from the borehole drilled by MDGs, on health related matters in Kuje area council Abuja North Central Nigeria with a view to assessing their level of suitability for domestic use.

STUDY AREA

Kuje area council of Abuja has an area land size of 1,644km^2 and population of 97,233, NPC, (2006). Its geographical location is between Lat $8^0 15' 0''N$, Long. $7^0 0' 0''E$; $8^0 05' 0''E$, $7^0 05' 0''E$; $8^0 10' 0''N$, $7^0 35' 0''E$ and $8^0 35' 0''N$, $7^0 25' 0''E$ respectively. It is bounded by Abuja Municipal Area Council in the northeast, at the South-east Toto LGA Nasarawa State, at the South-West - Abaji Area Council and at the West – is the permanent site of Abuja University, Gwagwalada Area Council. The region lies on gentle undulating terrain interlaced by reverine depression. It rises from 250m in the valley of River Usuma in the North-West of the Kuje Township to the top of the sharp slope in the North-East. Generally, the region is a plain with a gentle undulating land. The topography dotted with isolate hills of ancient igneous intrusion. However, the major development in them existing towns and villages of Kuje take place on the low plain. The soils of the site are deep well drained, having low moderate credibility run off potential. The textures are typically loamy, sandy and clay loamy especially on the Ike-gurara, Ubo and Rubochi plains FCDA (1987). Indeed, in terms of soil and land characteristics Kuje has most fertile soil and the best agricultural land of the plain of Federal Capital Territory Abuja.

Climate is one of the major determinants of the habitability of any region. This study is based on the available climatic data of FCT sub region FCDA, (1987).

The bi-seasoned weather condition of this sub-region allows for wet, rainy period as well as hot dry harmattan period through the year. Within these two seasons is the fluctuation in temperature, relative humidity, rainfall, daily sunshine and wind/speed/direction. The

southwesterly winds blowing from Atlantic Ocean introduces the wet/rainy season to the Federal Capital Territory (FCT) sub-region in March/April. This season persist till October/November. Within this period, there is tendency of frequent cloud formation which yields more rainfall and reduces the mean duration of daily sunshine. This period is characterized by excessive heat, low humidity and minimum monthly rainfall FCDA (1987) with temperature been relatively warm during the year. Temperature ranges from 28^0c-34^0c are regarded as maximum recorded between February and April, while 18^0c is the minimum recorded temperature between the months of November and January.
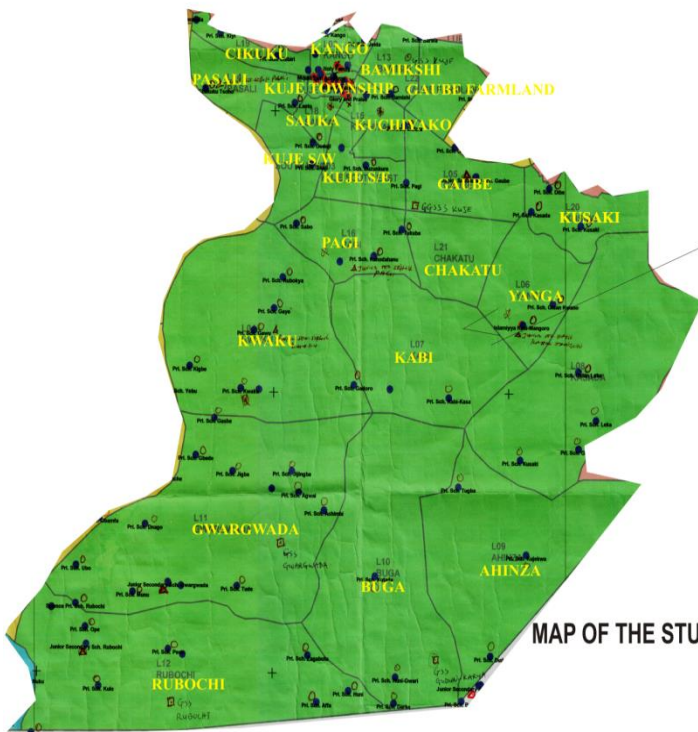
LOCATION MAP OF THE STUDY AREA
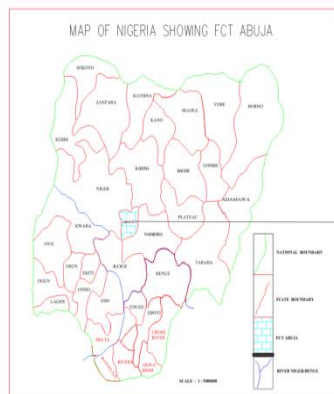
MAP OF NIGERIA SHOWING FCT

MAP OF FCT SHOWING KUJE AREA COUNCIL

MAP OF KUJE AREA COUNCIL SHOWING STUDY AREA

MAP OF THE STUDY AREA

Sources: FCDA 2014

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The major characteristics of the vegetation type in Kuje Area are generally park savannah, which is typically a community with a discontinuous canopy of shrubs and grass layers. The tress stratum is less dense than that of savannah woodland FCDA (1987).

Structurally, the park savannah include thick tall grass layer consisting of Andopogon and hyparrhenia species and shrubs layers in which termainanahga piliostigma, ammonia, naueka and bombax are most common FCDA (1987). Shrubs savannah vegetation occurs on flatter plains and undulating terrain. It comprises, primarily of shrub vegetation, with grass layer and a few scattered emergent trees. However, human activities in the area play an important role of removal of plants cover.

The Usuma river valley in the area is characterized by riverine complexes vegetation, and along the stream valley bottom, there are patches of rain forest savannah woodland which occur in isolated areas, and on steeper slopes. This consists of canopy of the tolerance species with thin shrubs and herbs.

The major rivers in Kuje are Usuma and Ushe River. Apart from the two major rivers, which flow almost throughout the year. There are numerous streams that are seasonal. This is responsible for fertility of the region. The entire Kuje group of villages lies within the fertile watershed of Zango kuku hill range which covers between 1600 and 2800 above sea level. The major ethnic groups are the Gbagyi, Gwaris Gade, Bassa, Ebira-Koto and a few others like Hausas and Tivs that migrated to the area. Being an area council headquarters has some civil servants and a few socio-cultural centers, development area, rural market prison service, council secretariat, local education secretariat, clubs, general hospital, clinics and others.

METHODOLOGY

The methods used in conducting this study concerns Site location through reconnaissance survey, sample selection, boreholes water selection, sample collection, sample analyses, and method of determination of various parameter selected. Data used for the study were obtained through primary and secondary. Primary through field work.

Reconnaissance survey was conducted through physical visit to the study area in order to be familiar with the study area; this visit was guided by a Base map of the study area. See Figure 2.

Field Method.

This involved identification of existing boreholes drilled by MDGs from 2000 to date in the study area, to enable the researchers determines the number to be sampled. The random sampling technique was employed in sampling. This was done to avoid duplication in the choice of the sampled boreholes water in the study area.

The study area has 56 number of borehole spread all over, not all were functioning. The study area was stratified into ten political wards according to INE, (2011) political division of the area council representation into ward councilship. One borehole was selected for sampling in each political ward. Kuje central, Gaube, Chibiri, Kwaku, Kabi, Rubochi, Gwargwada, Gudu-Karya, Yenche and kuje-kwa ward. Reason for Ten borehole selection, was to give a wider coverage in the study area.

Geographical coordinate were collected at each sample point of the borehole using Global Positioning System, (Figure. 3 and Table 1).

Water sample were collected during dry season, within a month in late Nov - Dec., 2014. The average sampling time was 9am-12noon each day, due to weather condition at this period, in order to minimized physical, chemical changes from the sample water. Due to distance of the samples location of some boreholes, it was necessary to stay overnight, and get the sample early as possible to meet up with sampling time 9am-12noon on each collection day, in order

to minimize any physical and chemical change from the sample water boreholes in the study area.

Plastic bottle produced by coca- Cola Company were use because of the plastic standard. Twelve (12) were purchased with water content, all surface were wash with clean water, liquid detergent clean and sterilized middle size plastic basin container use for washing and rinsing of the plastic bottle treated with distilled water to prevent chemical reaction. Rinse and air dried for ten minute. Plastic Bottle size 150cl.

Table 1. Description of sampling Location site

| Ward	Description	GPS Reading	Geo. Coordinates
Kwaku	Kwaku Health Clinic	N 964119 E 298406	8^0 43 03.34 N 7^0 10 20.94 E
Kabi	Kabi – kasa	N 963393 E 325117	8^0 42 47.53 N 7^0 24 34.70 E
Chibiri	Chibiri	N 984037 E 300059	8^0 53 55.74 N 7^0 10 51.70 E
Gaube	Bamishi	N 981217 E 309844	8^0 52 25.48 N 7^0 16 12.38 E
Kuje central	Ang. Gade pri. Sch.	N 951462 E 305333	8^0 36 16.35 N 7^0 13 49.32 E
Rubochi	Rubochi	N 944801 E 283526	8^0 32 36.11 N 7^0 15 7.34 E
Kujekwa	Kujekwa	N 946770 E 321805	8^0 33 46.00 N 7^0 22 48.66 E
Gwargwada	Gwargwada Health Clinic	N 946175 E 291449	8^0 33 22.12 N 7^0 06 16.15 E
Gudun-karya	Afa	N 937923 E 2303610	8^0 28 42.44 N 7^0 33 0.90 E
Yenche	Yenche Health Clinic	N 954355 E 293298	8^0 37 48.64 N 7^0 07^1 15.29 E
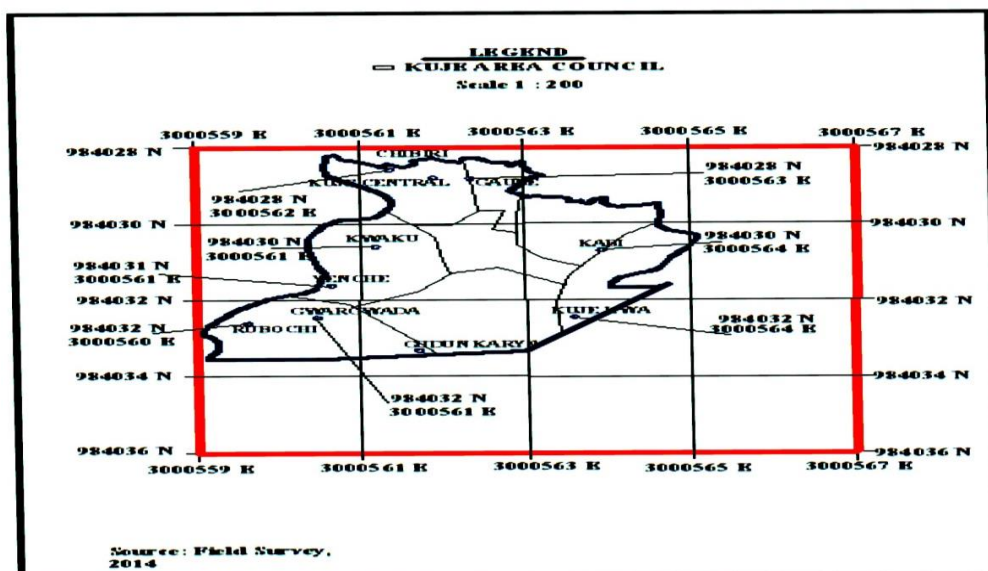
Fig 2: Map of the Study Area Showing Sampling Borehole Water in the Study Area.
Source: Field Survey, 2014

The plastic were opened and water content were pour into a clean plastic basin to re-rinse and air dried for another 10-20 minute, then cork back. Paper tape was sealed round the plastic body, and then labeled, with the following: Temperature, Ec, and pH for field Recording. Features: name of the ward, name of the sample site or location, description of sampling location site see table 2 with a permanent marker pen. Hard copy form design for GPS result title description of sample location site. All plastic were packed in a clean bag.

Cooler-box was made available for samples collection, with ice block for preservation (to prevent some chemical and physical changes), average time for sample collection was 9:00am-12noon to be precise. At the site or collection point geographical co-ordinate of the borehole were obtained with a mobile GPS. First pumping was conducted for 5-10 minutes. To allow the trap air in the borehole to be flush out; washing of the outlet both inner and surface (sanitary and sterilizing), second pumping was to rinse the washing pump inner and outlet surface; sterilizing were through carried out, with a Flame cigarette lighter, at the outlet. Third pumping conducted for 2-3 minutes for cooling. Fourth – sixth (4-6) pumping for rinsing of the 150cl plastic bottle. To allow trap air in the 150clplastic bottle out. The plastic bottles were rinsed three times (3) with sample borehole water. Pumping into 150cl Eva plastic bottle were carried out with field assistant. Temp, Ec and pH were instantly measured determined and recorded at the site. Using mobile thermometer, conductivity meter, and Hanna microprocessor pH meter respectively. The bottle were firmly corked and dropped inside the cooler box with ice block, movement to laboratory for further analysis.

Laboratory Method:

All sample were transported to laboratory, analysis were carried out using Standard methods of suggested by American Public Health Association APHA (1995). Physico-chemical properties at NAFDAC approved standard laboratory, Nasarawa State University, Keffi School of Agriculture laboratory, Lafia Nasarawa State.

Parameter and Laboratory Techniques

Selected parameters, their elements and the method used in determination of various elements in the laboratory

(i)   Physico-chemical Analysis
   a) Temperature
   b) pH
   c) Turbidity
   d) Total alkalinity
   e) Electrical Conductivity (EC)
   f) Total hardness (Th)
   g) Total Dissolve solids (TdS)
   h) Nitrate

Physico-chemical Parameters Determination

   a. Measurement of Temperature

This was carried out in-situ at the site of sample collection using a mobile thermometer, dipped into the borehole sample water, for a while, when stable reading were obtained and recorded.

   b. Determination of Turbidity

This were determined using a standard Hanna H198703 Turbid meter. The samples were poured into the measuring bottle and the surface or the bottle was wiped with silicon oil. The bottle was then inserted into the turbid meter and the reading was obtained.

c. Determination of Alkalinity

50ml of the water sample was pipette into a clean 250ml conical flask. Two drops of methyl red indicator were then added and the solution titrated against a standard 0.01M HCl solution to a pink end-point. (American Society for Testing and Materials, 1982).

Total alkalinity (mg/l)=[Vx Mx 100,000]/ ml of sample used

Where V= volume of NaOH used

M= molarity of acid used.

d. Electrical Conductivity (EC)

The Electrical Conductivity were carried out in-situ at the site of sample collection. This was done using a conductivity meter. The probe was dipped into the container of the samples until a stable reading was obtained and recorded.

e. P^H

The pH was carried out in-situ at the site of sample collection using the Hanna microprocessor pH meter. It was standardized with a buffer solution of pH range between 4-9.

f. Total Hardness

25ml of the sample was placed in different clean 250ml conical flasks. To this were added 3ml of ammonium chloride in concentrated ammonia buffer and 2 drops of Eriochrome Black T indicator. This were titrated against 0.01M EDTA solution until there were a colour change from violet to blue.

Calculation:

Hardness in mg/l $CaCO_3$= [V x M x 1000]/ ml of sample used

Where M=Molarity of EDTA Used

V= Volume of EDTA used

g. Total Dissolved Solids (Tds)

A portion of water were filtered out and 10ml of the filtrate were measured into a pre-weighed evaporating dish. Following the procedure for the determination of total solids above, the total dissolved solids content of the water were calculated.

Total dissolved solids (mg/l) = [(W2-W1) mg x 1000]/ml of filtrate used

Where W1 = initial weight of evaporating dish

W2 = Final weight of the dish (evaporating dish + residue).

h. Nitrate (NO$_3$)

A photometric method were used for the determination, NO_3. Analytical water test tablets prescribed for Palintest Photometer 5000 (Wagtech, Thatcham Berkshire, Uk) series were used.

Descriptive statistical analysis were applied in computing physic-chemical, heavy metal microbiological for each sample location. Computed statistical analysis were mean, Range, Standard deviation variable and (%CV) Coefficient of variation.

The laboratory result were compared with the World Health Organization Standard for Drinking Water WHO (2011) and were values are not stated, Standard for Drinking Water for SON/NIS and Canada Health base were employed, to fill in the gap for various permissible limit for drinking water quality in order to identify areas of needs.

Table 3: Physico-chemical parameters obtained across the ten sample borehole water from the study area
Source: Field Survey, 2014

Location	Tem ⁰C	pH	Turbi mg/l	Alkalinity mg/l	EC mg/l	TH mg/l	TDS mg/l	Nitrate
Kwaku	28	6.7	3.5	156	70	56	50	0.05
Kabi kasa	28	6.1	2.7	36	70	60	50	0.05
Chibiri	27	7.0	3.2	120	300	180	200	0.10
Bamshi	28	6.4	3.0	104	170	64	110	0.05
Ang. Gade	28	6.6	2.5	120	320	156	220	0.05
Rubochi	27	6.3	2.8	40	80	60	50	0.05
Kujekwa	27	6.9	3.5	98	180	80	120	0.05
Gwargwada	28	7.0	3.0	140	280	152	190	0.10
Afa	28	7.2	2.5	164	210	96	140	0.06
Yenche	27	6.2	3.6	84	300	140	200	0.05
Mean	29	6.7	3.0	106.2	198	104.4	13.3	0.061

Table 2 World Health Organization WHO, (2011) Guidelines for Drinking Water Quality 2011

Parameter	Symbol Formula	Unit	Guidelines
Temperature	O	Celsius	30 – 32o(ca)
Ph			6.5 – 8.5(fb)
Turbidity		NTU	5
Total Hardness	CaCO3	(mg/l)	500(ᶜ)
Iron	Fe+	(mg/l)	0.300 cunala
Chloride	Cl	(mg/l)	250
Nitrate	No3	(mg/l)	50
Total dissolved solid (tds)		Mg/l	259 – 500(ᶜ)
Zinc	Zn	Mg/l	0.01
Lead	Pb	Mg/l	0.01(a,t)
Elecritical conductivity	Ec	Us/cm	400/500
Sodium	Na+	Mg/l	50
Alkalinity		Mg/l	100
THB	THB	Cfu/ml	100
E.coli	E.Coli	Cfu/100ml	0(e)
Faecal streptococci		Cfu/100ml	0(f)
Total Coliform		Cfu/100ml	0(d)

Source: WHO (2011), SON NIS (2007) AND CANADA (2006)
a. No guideline value proposed for Temperature in world Health Organization (WHO, 2011; value is based on Health Nigeria, 2007; Canada, 2006).
b. No guideline value was proposed for Pʰ in WHO (2011); value were based on WHO (2007).
c. No guidelines value propose for Total hardness by WHO (2011). Value were maximum consumers tolerate stated in WHO (2011).

d. No guideline value propose for Total coliform by WHO (2011), value was based on Health Nigeria (2007).
e. No guideline value were propose for E.coli by WHO (2011) value were based on health Nigeria (2007).
f. No guideline value were propose for faecal streptococcus by WHO (2011). Value were based on Health Nigeria (2007).

ANALYSIS AND RESULTS

The presentation of the physico-chemical characteristics concentration result in the study area, and compared with the WHO (2011) Standard for drinking water. Physico-chemical characteristics concentration of the Boreholes water samples

Physico-chemical characteristics

  a. **Temperature**

The temperature obtained in the sampled Borehole water in the study area ranged between 20^0c – 28^0c. The Highest temperature reading values were obtained in the following sample borehole locations with a Temperature reading at 28^0c in six out of Ten, sampled boreholes water locations Kwaku, Kabi Kasa, Bmamishi, Angwar Gade, Gwargwada and Afa, while the least value 27^0c were obtained in four sample Borehole Location namely Chibiri, Rubochi, Kujekwa and Yenche. See Table 5 and figure 3.
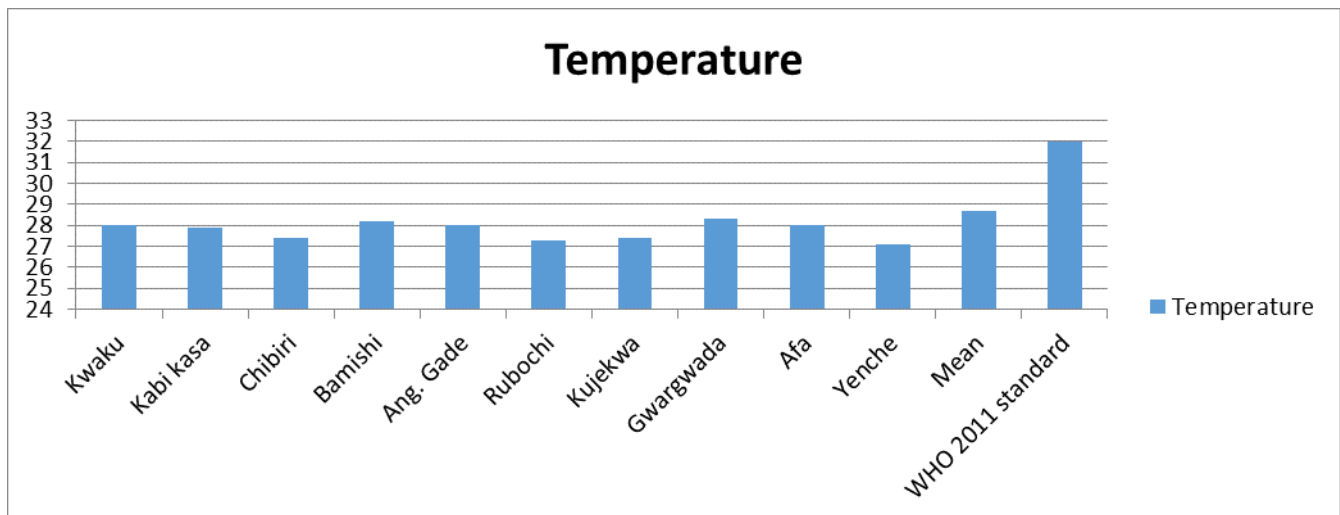
Figure 3: Temperature measurement obtain across the ten sample borehole water from the study area

Source: Field Survey, 2014

b. **pH**

The pH values obtained in the sampled borehole water in the study area ranged between 6.1–7.0. With mean valued 6.6. The highest pH value obtained in the sampled borehole water were found in Afa with valued 7.2. Gwargwada and Chibiri has similar valued of 7.0 respectively while the least valued obtained were in Kabi kasa 6.1, Yenche 6.2 and Rubochi6.3. See Figure 4 and table 3.
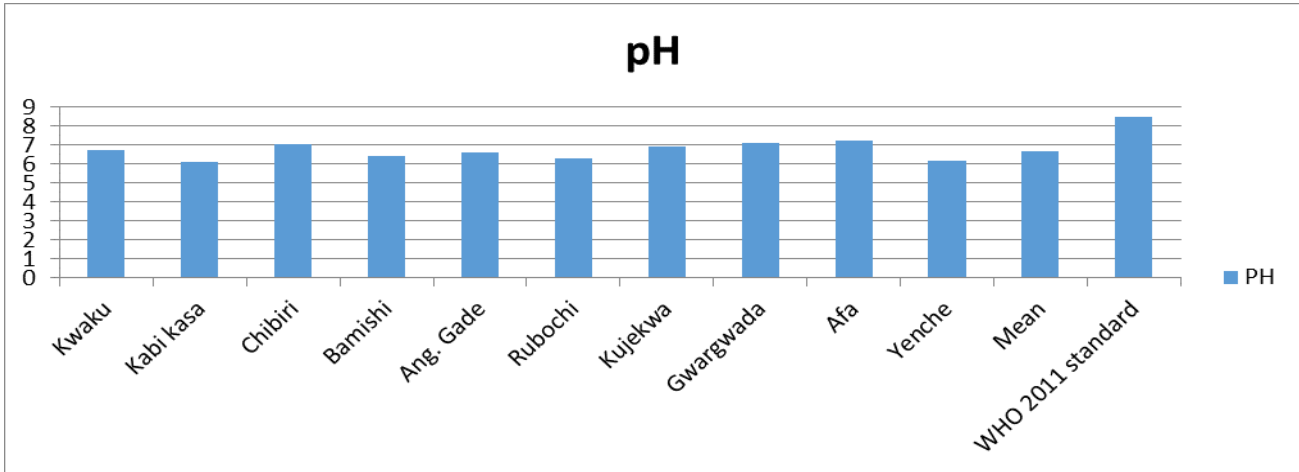

Figure 4: PH reading obtained across the sample borehole water in the study area

Source: Field Survey, 2014

Alkalinity

The value of alkalinity obtained ranged between 36mg/l – 164mg/l. Afa sampled borehole water has the highest valued with 164mg/l, while Kabi-Kasa has the least valued obtained at 36mg/l. Kwaku and Gwargwada also recorded high valued of 156mg/l and 140mg/l respectively. See Figure 5 and Table 3
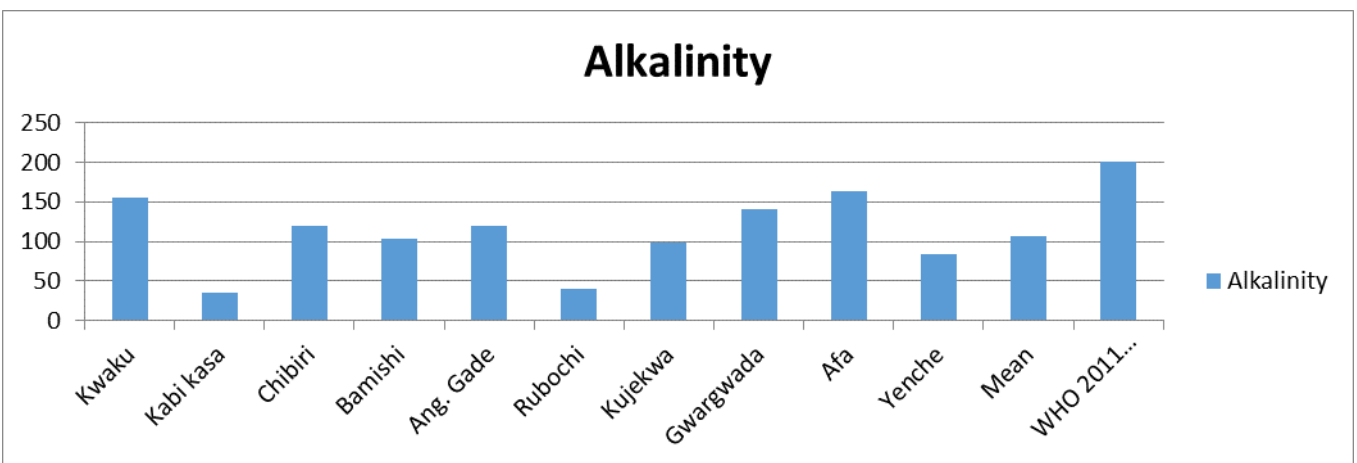
Figure 5 Alkalinity level obtained across the ten sample borehole water from the study area.

Source: Field Survey, 2014.

c. **Total Hardness (CaCO$_3$)**

The Total Hardness obtained ranged between 56mg/l – 180mg/l. The highest valued were obtained Chibiri 180mg/l sampled borehole water, while the least valued obtained kwaku 56mg/l. High valued were also obtained in sampled borehole water in Angwar Gade 156mg/l, Gwargwada 152mg/l and Yenche 104mg/l. Low valued were also obtained in Kabi Kasa and Rubochi with similar value 60mg/l , and Bamishi 64mg/l. see Figure 8 and Table 3.
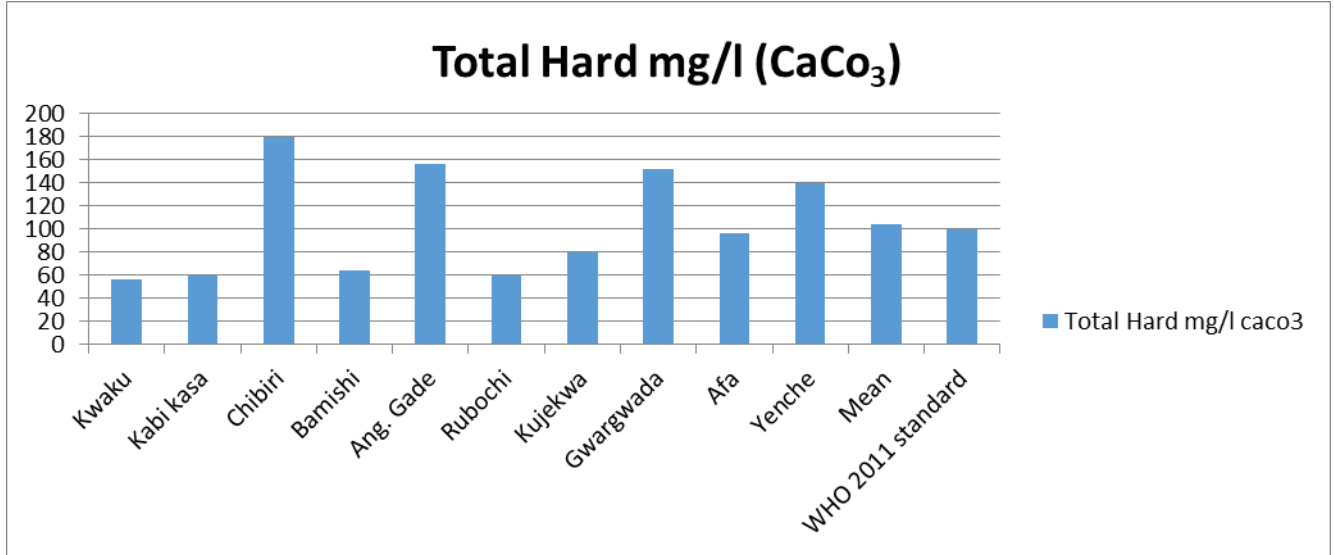

Figure 8: Total Hardness obtained across the ten sample borehole water from the study area.

Source: Field Survey, 2014

d. **Turbidity**

The Turbidity valued obtained ranged between 2.5 – 3.6NTU. The high valued were obtained in Yenche 3.6NTU sampled borehole water, while the least valued were obtained in two sampled borehole water, Angwar Gade and Afa at 2.5NTU. High valued were also obtained in Kwaku and Kujekwa with similar valued of 3.5NTU, and Bamishi and Gwargwada has similar valued of 3.0NTU, and low value were also obtained in Kabi-Kasa 2.7NTU and Rubochi 2.8NTU. See Figure 9 and Table 3.
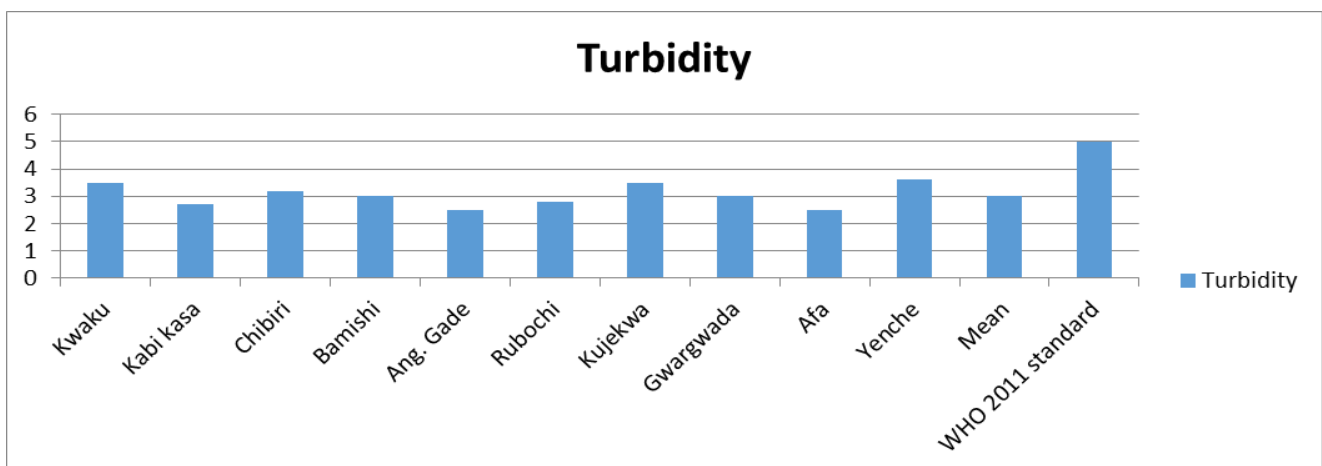

Figure 9: Turbidity obtained across the ten sample borehole water from the study area

Source: Field Survey, 2014

e. Total Dissolved Solids (Tds)

The Total Dissolved Solids obtained in the study area ranged between 50mg/l – 220mg/l. The highest valued obtained in the sampled borehole water were Angwar Gade 220mg/l, Chibiri and Yenche has similar valued recorded as 200mg/l each, Gwargwada 190mg/l, Afa 140mg/l, while the least valued were obtained in three sample borehole water location Kwaku, Kabi Kasa, and Rubochi 50mg/l; each, and low valued were also obtained in Bamishi 110mg/l and Kujekwa 120mg/l. See Figure 10 and Table 3.
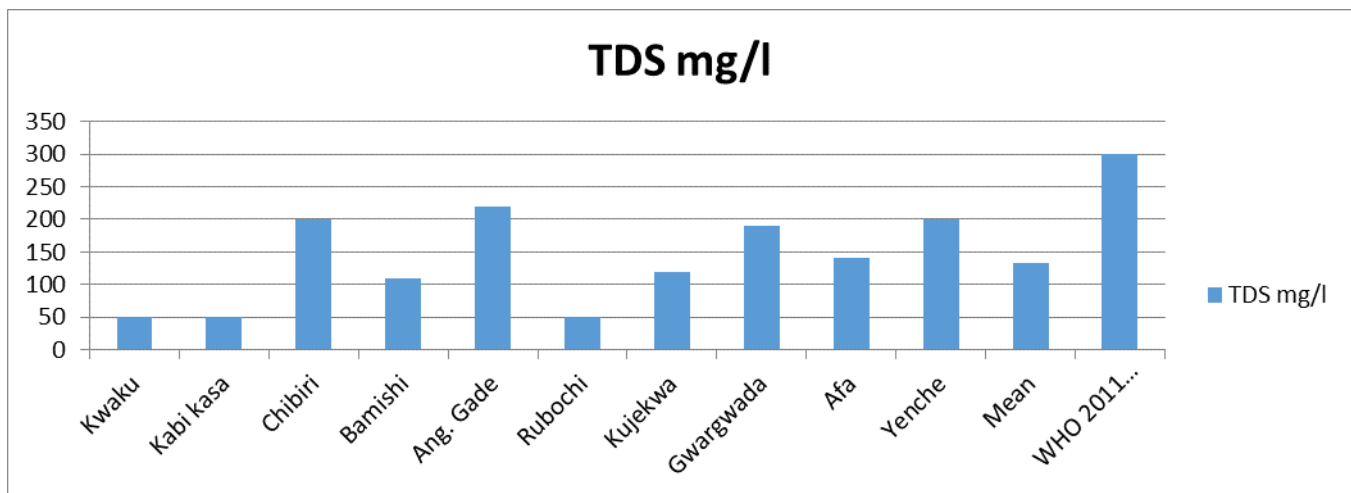
Figure 10: TDS level obtained across the ten sample borehole water from the study area
Source: Field Survey, 2014

f. Electrical Conductivity (Ec)

The valued obtained for Electrical conductivity (EC) in the sampled borehole water in the study area were ranged between 70-320µs/cm. The highest valued obtained Angwar Gade 320µs/cm, Chibiri and Yenche has similar valued of 320µs/cm, Gwargwada 280µs/cm and Afa 210µs/cm, while the least valued were obtained in two location with similar valued Kwaku and Kabi-Kasa 70µs/cm each. Rubochi 80µs/cm, Bamishi 170µs/cm and Kujekwa 80µs/cm. See figure 11 and Table 3.

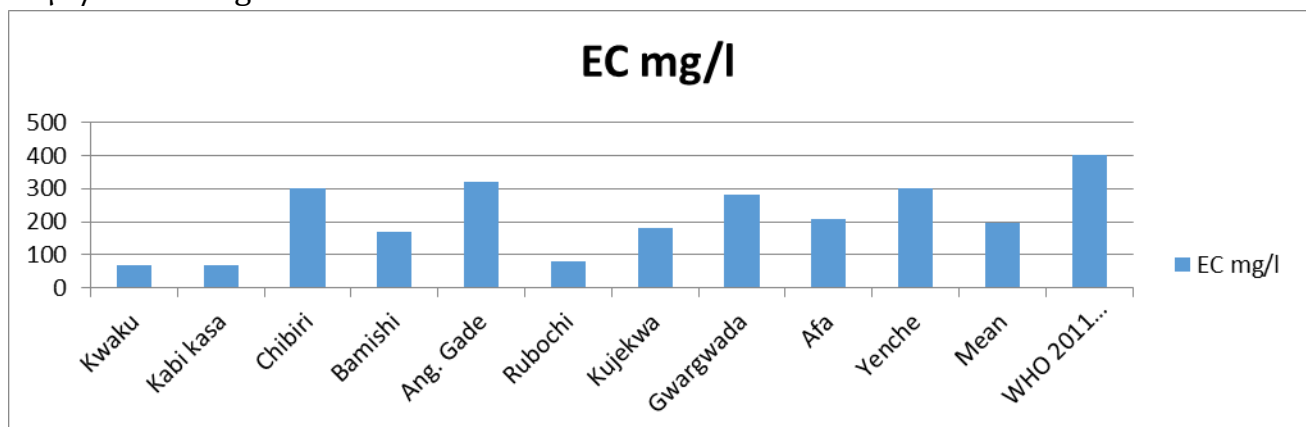**Fig 11: EC level obtained across the ten sample borehole water from the study area**
Source: Field Survey, 2014

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g. Nitrate (Na^{+3})

The Nitrate valued obtained for sampled borehole water in the study area ranged between 0.05-0.10mg/l. The highest valued of nitrate concentration in the sampled borehole water were obtained in two location Chibiri and Gwargwada 0.1mg/l each, while the least valued were obtained in Afa 0.06mg/l and seven sampled borehole water has similar valued, Kwaku 0.05mg/l, Kabi-Kasa 0.05mg/l, Bamishi 0.05mg/l,

Angwar Gade 0.05mg/l, Rubochi 0.05mg/l Kujekwa 0.05mg/l and Yenche 0.05mg/l. See Figure 12 and Table 3.
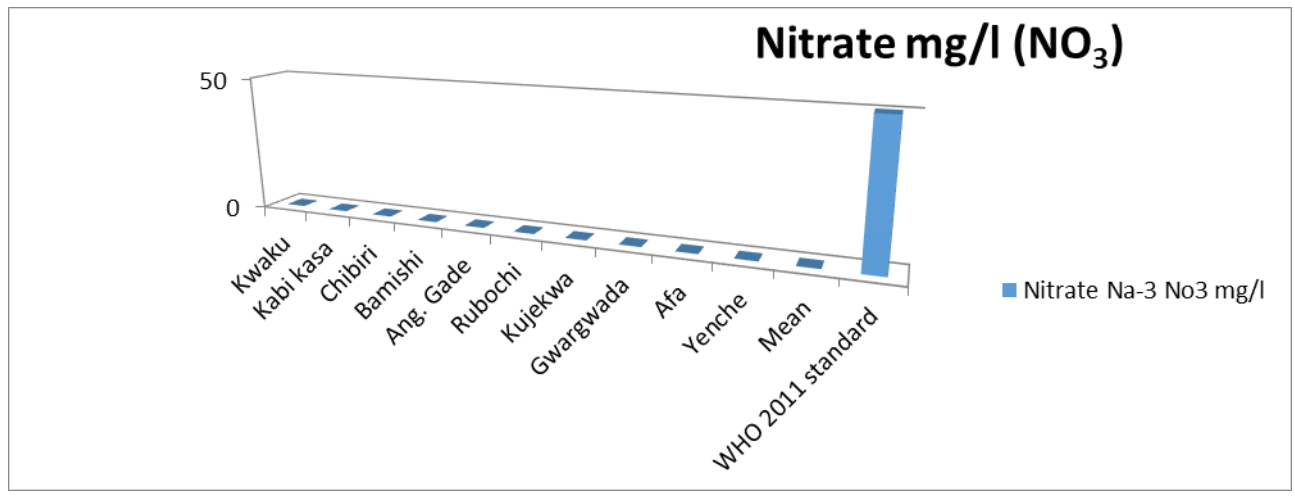

Figure 12: Nitrate level obtained across the ten sample borehole water from the study area.
Source: Field Survey 2014

Quality of the Borehole Water Samples.
Comparison of the Physico-chemical characteristics with WHO 2011 Standard for Drinking Water

1. Temperature

The Temperature of the sampled borehole water obtained with mean valued 28^{0}c$\pm$ 0.42^{0}c. While WHO 2011 Standard for Drinking Water permissible limit for Temperature limit valued ranged 30^{0}c-32^{0}c. All sampled borehole water in the study area fall within the WHO 2011 permissible limit for Standard Drinking Water, therefore all sampled borehole water in the study area are safe for human consumption. According to Okoye and Okoye (2008). Cool water area generally more potable for drinking purpose, because high water temperature enhance the growth of micro-organism and hence taste, odour, colour and corrosion problem may increase.

2. pH

The pH of the sampled borehole water obtained has a mean valued of 6.6 $\pm$ 0.40 while WHO 2011 Standard for Drinking Water gave her permissible limit ranged between 6.5-8.5 which proof that all sampled borehole water fall within the ranged of WHO (2011) Standard for Drinking Water. WHO (2011) pH in water is an indication of the hydrogen's (H+) and negative hydroxide (ions)(OH) in water to indicate whether the water is acidic or alkaline. Therefore the sampled boreholes water are safe for human consumption in the study area.

3. Alkalinity

The Alkalinity valued obtained in sampled borehole water has a mean, valued of 106±43.7mg/l. Stipulated by WHO 2011 Standard for Drinking Water permissible limit 100mg/l. Kabi-Kasa 36mg/l, Rubochi 40mg/l, Kujekwa 98mg/l and Yenche 84mg/l fall within the permissible limit of standard for Drinking water of WHO (2011), which accounted for 40% of the sampled borehole water, while Afa 164mg/l, with highest valued, same Kwaku 156mg/l, Gwargwada 140mg/l, Chibiri and Angwar Gade has similar valued 120mg/l each, and Bamishi 104mg/l that accounted for 60% for sampled borehole water in the study area are above the WHO (2011) Standard for Drinking Water. Therefore are not safe for human consumption.

4. Total Hardness

The Total Hardness mean valued obtained 104 ± 47.7 mg/l. The WHO 2011 Standard for Drinking Water permissible limit is 500mg/l. Therefore it has shown that all the sampled borehole water are within the WHO (2011) permissible limit 500mg/l WHO (2011) Hardness in water is mainly a natural occurrence indicating that there is a lot of Calcium, Magnesium, Carbonate, Hydrogen-Carbonate and Sulphate ions present in water. Hardness will cause soap sum and use of excess soap to achieved cleaning. The highest valued obtained in Chibiri 180mg/l while the least obtained valued Kwaku 56mg/l.

5. Turbidity

The Turbidity mean valued obtained 3± 0.4NTU. The WHO 2011 Standard for Drinking Water permissible limit in turbidity 5NTU (Nephelometer Turbidity Unit). The result proof that 100% of the sampled borehole water are within the allowable unit of WHO (2011), and this simply implies that sampled borehole water are safe for human consumption. According to EPA (2012) Treatment technique at no time can turbidity go above 5 NTU. The highest valued obtained Yenche 3.6NTU, while the least valued obtained in the location Angwar Gade and Afa at 2.5NTU each.

6. Total Dissolved Solid (TDS)

The Total Dissolved Solid (tds) mean valued obtained 133± 67.7mg/l. While WHO 2011 Standard for Drinking Water permissible limit 250 – 500mg/l. This results obtained proof that 100% sampled borehole water in the study area are within the allowable limit Standard for Drinking Water. Therefore the sample boreholes water are safe for human consumption in the study area. Total Dissolved Solid (Tds) is an indicator to determine the general chemical quality of water. All the water fall within class of freash using Gorell (1958) classification of ground water as reported by Davis and De Wes (1966).

7. Electrical Conductivity (EC)

The Electrical Conductivity (EC) mean valued obtained 198± 100μs/cm. WHO 2011 Standard for Drinking Water stipulated the permissible limit to 500μs/cm. The result has shown that 100% of the borehole water are safe for human consumption of Electrical Conductivity intake in sampled borehole water. All valued obtained in the sampled borehole water were below the allowable limit, but not above 500μs/cm.

8. Nitrate

The concentration of nitrate mean value obtained were 0.1± 0.0mg/l. the value obtained were generally within the acceptable limit valued of WHO 2011 Standard for Drinking Water. The WHO 2011 Standard for Drinking Water is 50mg/l. All the sampled borehole in the study area are safe for human consumption.

CONCLUSIONS AND RECOMMENDATIONS

The groundwater in Kuje area council and environs are free of acids as indicated, that 100% sample of the boreholes water analyzed proof that all the selected physico-chemical

characteristics are within the WHO 2011 Standard for Drinking Water quality permissible limit for Temperature, Electrical Conductivity (EC), Total Dissolved Solids (Tds). Turbidity, Nitrate, Total Hardness, pH, Alkalinity when compared with WHO 2011 Standard for Drinking Water quality in the study area. This can be accounted to geological formation and anthropogenic activities which has health implication that can result in damage or reduced mental and central nevours functions, lower energy level and damage to blood composition (hypertension) lungs, kidneys, liver and other vital organs, WHO (2011).

Conclusively, all sampled borehole water in the study area are safe for human consumption except Zinc, Iron and Lead content that required treatment or caring before human consumption which are heavy metals. The recommendation are majority of the people living in this area depend on water supply from the stream, hand dug wells, rivers and boreholes for agriculture, construction and domestic purpose, there is need to alert the Area Council Authority in the area of dangerous trend, so that an alternative arrangement or provision can be made to provide potable domestic water for the resident in the study area. All boreholes water in this area should be given appropriate treatment before human consumption, Further study on the quality of the borehole can be carried out in wet season, Local Government and private owned borehole in the study area should be further investigated, Further study on deep should be carried out in the study area, The findings should not be seen as merely academic exercise, stakeholder should invest on this area as well.

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