Original Research Article

ASSESSMENT OF PHYSICOCHEMICAL AND BACTERIOLOGICAL PARAMETERS OF BOREHOLE AND HAND DUG WELL WATER IN MICHIKA AND ENVIRONS, ADAMAWA STATE, NIGERIA.

Abstract

Physicochemical and Bacteriological Parameters of Borehole and Hand dug well water of Michika town in Michika Local Government Area of Adamawa State, Nigeria and environs were assessed to determine their suitability or otherwise for drinking and domestic purposes. Ten (10) water samples, five each from boreholes and hand-dug wells, from five selected areas in Michika town, were collected during the months of January and February 2018. The water samples which are extensively used for drinking and other domestic purposes, were randomly collected and the results were compared with WHO and NAFDAC standards guidelines for drinking water. These samples were analyzedfor their physicochemical characteristics (pH, temperature, electrical conductivity, TDS, Turbidity, hardness), heavy metals, *Escherichia coli* (E-*coli*) and coliform counts. The results of the investigation revealed that the physicochemical and bacteriological parameters falls within the maximum permissible limits of NAFDAC and WHO guidelines for drinking water. The physicochemical concentrations were higher in borehole water than in hand dug well water; Lead and Cadmium were not detected in all the samples. All the water samples were free from feacal contamination except in Barikin Dlaka hand dug well which contained 0.05 ± 0.001 MPN/100ml total coliform count which is below the WHO/NAFDAC maximum permissible levels. The suitability of water for domestic and drinking purposes indicated that the water samples were within the standards prescribed for potable water. However, there is need for routine checks to ascertain the suitability or otherwise of these water sources so as to forestall outbreak of water born diseases.

Keywords: Physiochemical, Bacteriological, Borehole, Hand dug well, Michika and Environs.

Introduction

Water is one of the most indispensable resources and is the elixir of life. It constitutes about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water. [1]It acts as a media for both chemical and biochemical reactions and also serves as an internal and external medium for several organisms [1]. Additionally, basic functions of a society require water for cleaning, for public health consumption, for industrial processes and cooling and for electricity generation [1]. Studiesdone by John [2] emphasized that groundwater plays an important role in supplying water to many of the global population for use in agriculture, drinking water, and industrial purposes. Physical and/or economic water scarcity occurs on all of the populated continents, with some parts of the world facing a genuine water crisis [3]. Water quality problems are both natural and anthropogenic in nature, with emerging contaminants playing an increasing role. Groundwater quantity and quality problems constitute a major set of challenges facing the world during this century [4].

Ground water constitutes about 20% of freshwater 5 . The value of groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply for drinking water [5]. However, ground water resources are under a serious threat due to growing interest in mechanized agricultural practices, increasing population density and rapid urbanization as well as domestic and industrial usage. Ground water provisions are sometimes unsustainable because of poor water productivity of wells, drying of wells after prolonged drought and sometimes due to poor water quality [6].

Contaminated water resources have important implications on health and environment [7]. The importance of water quality in human health has recently attracted a great deal of interest. In developing world, 80% of all diseases are directly related to poor drinking water and unsanitary conditions [8]. Ground water quality can be affected by varied pollution sources, Hamilton and Helsel, [9] stated that a connection between agricultural and ground water pollution is well established. According to Chandio [10], applications of Nitrogen-Phosphorus-Potassium fertilizer (NPK) have been increasing in Pakistan over the last few decades. As a result, high concentration of NO_3-N has been reported to be common in ground water sources in the world [11,12].

Water quality is the physical, chemical and biological characteristics of water. It is the measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose. Water quality is determined by the concentration of physical, chemical and biological contaminants. Water is never 100% pure as it carries traces of other substances, which bestow physical, chemical and biological characteristics [13].

The natural water analysis for physical, chemical, biological properties including trace elements contents are very important for public health studies. Safe drinking water is defined by

World Health Organization as that water having acceptable quality in terms of physical, chemical and bacteriological parameters [14].

Bacteriological parameters, especially *Escherichia coli* (E.*coli*) and total coliforms have been used to determine the general quality of drinking water Worldwide [15]. The E. *coli* in particular has been found to be the most specific indicator of faecal contamination in drinking-water [16]. E. *coli* is an actual bacterium that causes gastroenteritis in humans, and is abundant in human and animal feces (up to 1,000,000,000 E. *coli's* per gram of fresh feces). The presence of E. *coli* in water always indicates potentially dangerous contamination requiring immediate attention [17]. Its presence indicates contamination of water with faecal waste that may contain other harmful or disease causing organisms, including bacteria, viruses, or parasites [18]. WHO recommends that no faecal coliform should be present in 100 ml of drinking water? The main origins of pollution of boreholes are industrial, domestic and agricultural sources and can be accidental or continuous [19. Domestic pollution may involve seepage from broken septic tanks, pit latrines, cesspools and privies [19]. WHO, [20] recommends that boreholes should be located at least 30m away from latrines and 17meters from septic tanks.

For some time now, there is either sporadic or no supply of pipe-borne water in Michika. Hence, people in Michika largely depend on boreholes and hand dug wells water for drinking and other domestic purposes. Drinking water should be of high purity, as the magnitude of demand for water is fast approaching the availability supply [21]. Groundwater is being increasingly used for drinking without the knowledge of the level of its purity. With the fast increase in population, there is high need for efficient conservation and usage of water especially boreholes and hand dug wells for healthy and sustainable development [22]. However, water pollution often endangers and negates the benefit of these water resources [21]. This study ascertained the suitability for consumption of boreholes and hand dug wells water of Michika town in Adamawa State, Nigeria.

Materials and Methods

Study area:

Michika is a town in Michika Local Government Area, being one of the 21 Local Governments Areas of Adamawa State situated in the North Eastern part of Nigeria. Michika lies between latitude $10° 36^1$N- $10° 40^1$N and longitude $13^0 21^1$E [23]. It shares common boundaries with Madagali Local Government Area to the North, Lassa (Borno State) to the West, Republic of Cameroon to the East and to the South are Mubi North and Mubi South Local Government Areas. It has a land area of about 142,199Km^2. It has total population of 155, 238 according to 2006 population Census. It has two seasons, dry and rainy seasons, the dry season lasts for a minimum of five months (November to March), while the rainy season spans seven months from April to October. The mean annual rainfall in Michika ranges from 900-1050mm [24].

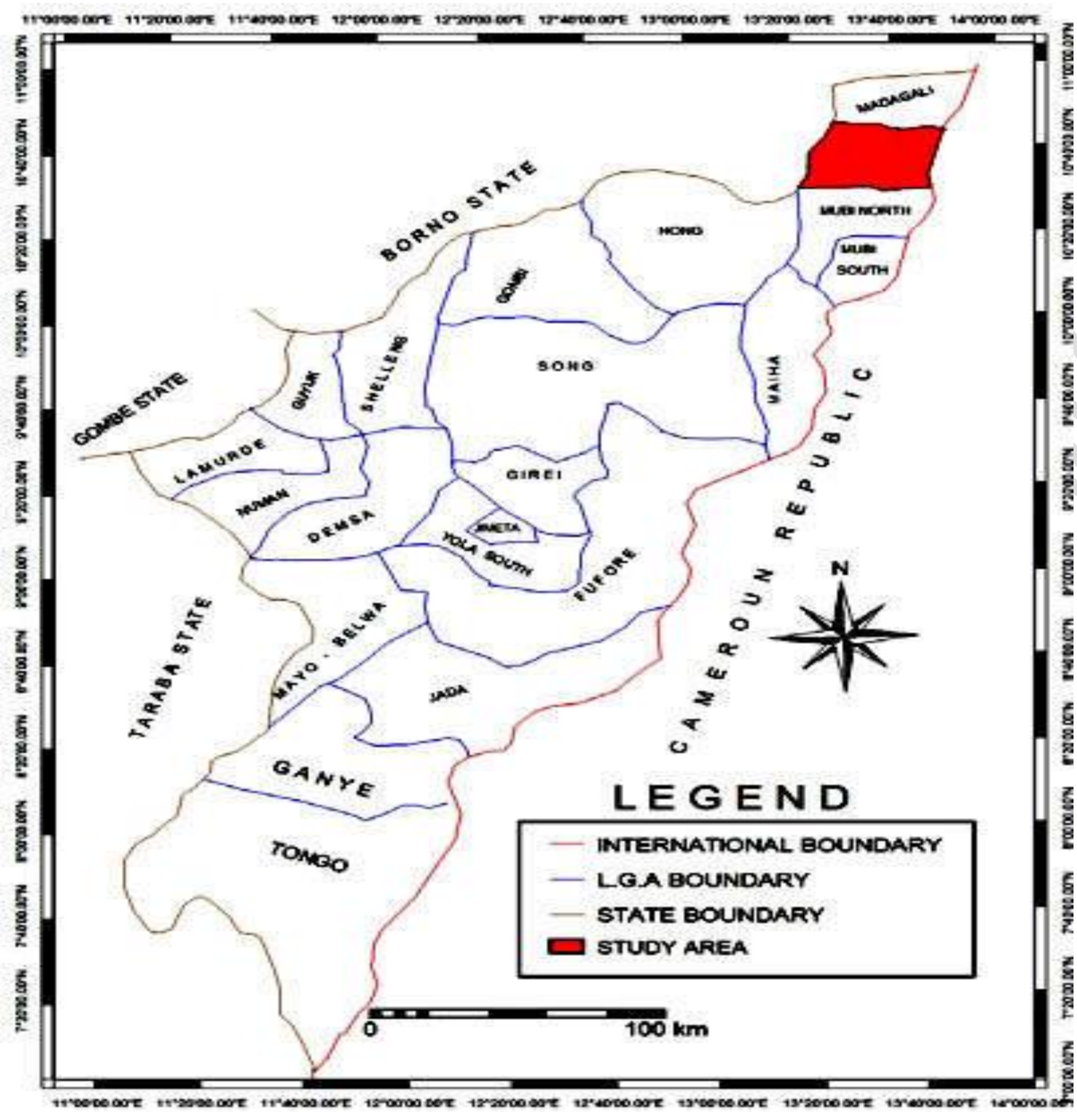
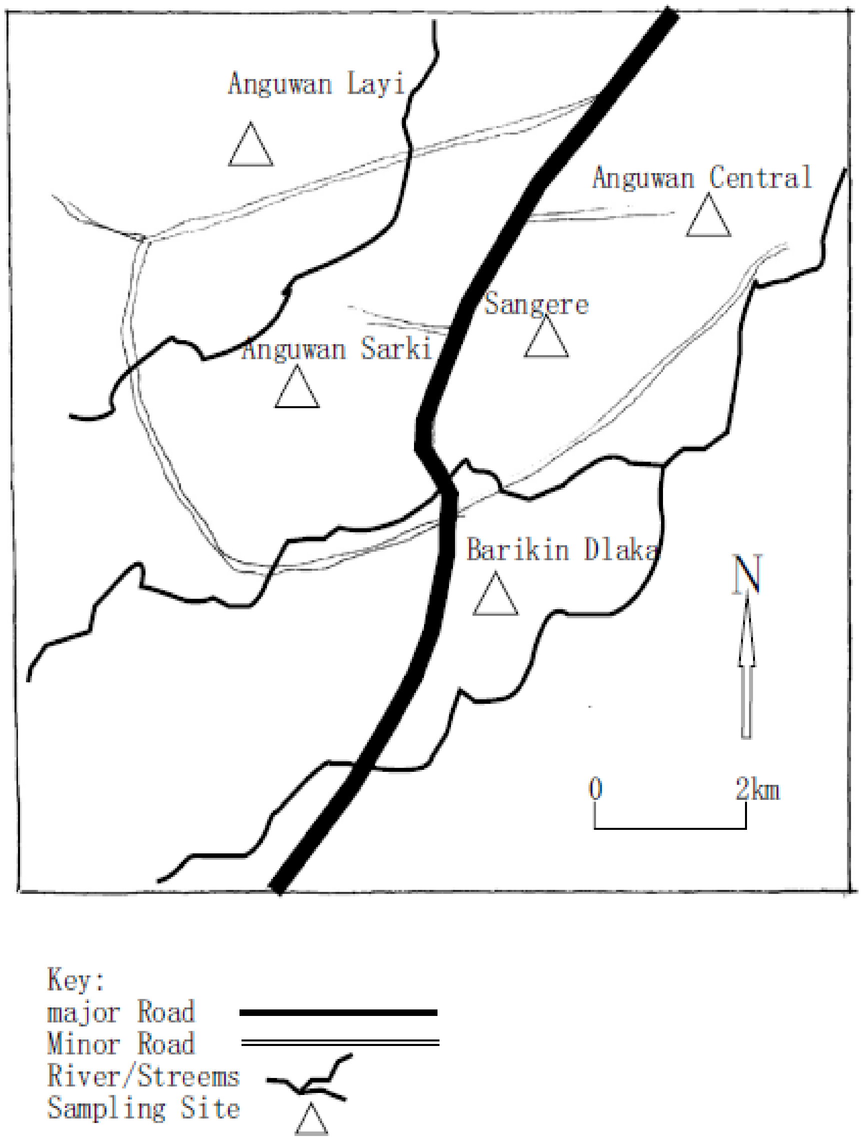


Fig 1: Map of Adamawa State showing the sampling areas



Fig> 2 Map of Michika Township showing the sampling sites

Sample Collection

A total of ten (10) water samples, five each from boreholes and hand dug wells water were randomly collected from Michika town. The water samples were collected from Anguwan Central, Anguwan Layi, Anguwan Sarki, Barikin Dlaka and Sangere, the samples were collected from boreholes and hand dug wells which are extensively used for drinking and other domestic purposes, the samples were collected during the dry seasonduring the months of January and February, 2018. The water samples were collected using previously cleaned 1liter polyethene bottles. The bottles were first washed with detergent and rinsed with distilled water and then rinsed with the water to be sampled and filled to the brim with it and covered immediately. The cover of the containers were sealed with masking tape to avoid any form of contamination and labeled. The water samples were preserved with trioxonitrate (V) acid [25].

The water samples for bacteriological analysis were collected in sterilized high density polypropylene bottles covered with aluminum foils [26]. The water samples were transported to the laboratory in insulated containers with ice, stored in a refrigerator at a temperature of 4^{0}C, and analyzed within 24 hour of collection [27]. Some parameters such as pH and temperature were analyzed on sites of sample collection. The bacteriological tests were undertaken within 6 hours after collection to avoid the growth or death of microorganisms in the sample [14].

Physico-Chemical Analysis

pH and temperature were measured immediately at the points of sample collection. The pH was measured using Jenway 3505 pH meter. The water temperature was measured using a mercury thermometer graduated up to 110 ^{0}C. Turbidity was measured by Nephelo-turbidity meter (systronic type No 131). Total Dissolved Solid (TDS) and Electrical Conductivity were determined using multipurpose JENWAY portable combined TDS/Conductivity meter (4510 model) the probe portion of the equipment was inserted into the water samples about 1cm depth and the reading was display and recorded [28].

Determination of Heavy metals

The method described by Tsafe et al., [29] was adopted. Magnesium, calcium Potassium and sodium were determined using Flame Photometer (Sherwood Scientific 410 Model, (UK) and heavy metals concentrations were determined using Atomic Absorption Spectrophotometer (Buck Scientific 210 model, (Scotland). The water sample was aspirated into the instrument after all the necessary set up and standardization procedures. Atomic vapour was produced as the sample drop on the acetylene flame, a beam of monochromatic light with a wavelength at which only the element of interest was absorbed, passes through the flame. The atom of the element in flame absorbed some amount of light which corresponded to its concentration. This was detected on the display unit read as the absorbance. A calibration curve of each element was plotted using the absorbance of the standard against their corresponding concentrations and it was used to determine the concentration of the elements in the samples.

Bacteriological Analysis

Total heterotrophic bacteria in the water samples were obtained using the pour plate method. The enumeration and isolation of coliform bacteria was by the use of the membrane filtration technique and growth on MacConkey agar [30,31. The presence of *Escherichia coli* in the water samples was assessed by growth and colour reaction on Eosin Methylene blue (EMB) agar, together with standard biochemical reactions as described in APHA [32].

Results and Discussion

The results of the physicochemical parameters of boreholes and hand dug wells water samples were presented in Table 1 and Table 2. In this study the values of pH in Tables 1 and 2 ranged from 6.8 ± 0.36 to 8.0 ± 0.41 for borehole water, and 6.5± 0.11 to 7.8± 0.41 for hand dug well water. This result indicated the neutral and alkaline nature of both the hand dug well water and borehole water respectively. The highest pH 8.0± 0.41 was recorded in Sangere borehole water, while the lowestpH 6.5± 0.11 was recorded in Anguwan Layi hand dug wells, and all these values were within the accepted limits prescribed, for various uses of water, including drinking water supplies [14]. The WHO set a pH guideline value of between 6.5 and 8.5 as generally considered satisfactory for drinking water. The values were however in agreement with a similar study done on ground water in Bauchi by Chindo et al.[37] . pH is the most important parameter that serves as an index for pollution and also measures the hydrogen ion concentration (H^+) and negative hydroxide ion (OH^-) in water [20]. Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. Low pH water is likely to be corrosive. Alkalinity and calcium management also contribute to the stability of water and control its aggressiveness to pipes and appliances [33].

Turbidity values varied from 1.00 ± 0.01 to 2.00 ± 1.02 NTU for borehole water and 1.00± 0.01 to 2.00 ± 0.01 NTU for hand dug well water respectively, all the values analysed were very low but were all within the permissible limit for drinking water WHO, [14] (5NUT). The result of this finding was also in agreement with the report of Chindo et al.[37] and Maitera et al.[34]. Turbidity may be defined as the measure of clarity of water, high turbidity may indicate the presence of disease causing organisms such as bacteria, viruses and parasite that causes symptoms like nausea, cramps, diarrhea and headaches [34]. It is also caused by the presence of suspended insoluble materials such as clay and silt particles, discharges of sewage or industrial wastes, or the presence of large numbers of micro-organisms mainly occurring in surface water, which makes them objectionable for almost all uses [35]. Excessive turbidity protects microorganisms from effects of disinfectants and stimulates the growth of bacteria in water [33].

The values of the Electrical conductivity in the present investigation ranged from 612± 2.71 to 701± 1.98 µs/cm for borehole water and 480±2.61 to 711±0.00 µs/cm for hand dug well water samples. The highest concentration 711±0.00 µs/cm was recorded in Sangere borehole and lowest concentration 480±2.61 µs/cm was found in Anguwan layi hand dug wells which are considered below the guideline set by NAFDAC[36], (1000 µs/cm) and were considered safe for drinking and other domestic purposes. The values recorded in this study were high compared to similar study by Odiba et al. [31].. Electrical conductivity is a quantitative measure of the ability of water to pass electric current. This ability depends largely on the quantity of dissolved salts present in any water sample [37]. In dilute form conductivity is approximately proportional to dissolved solids (DS) content. Monitoring of conductivity can thus usefully indicate variations in salt concentration in water, but for water quality control, various limitations abound. Thus, organic compounds do not ionize greatly in aqueous solutions; therefore organic pollutants would not be monitored by conductivity measurement [13].

Total Dissolved Solid is given as a number expressing the concentration of filterable solids present in water. Water with high concentration of dissolved solid present has poor taste and may induce unfavorable psychological reaction in the consumer [37]. For this reason, a limit of 500mg/l of dissolved solids is desirable for potable waters. This includes settle able and non-settle able solids [13]. In this investigation, the value of Total Dissolved Solid recorded 101 ± 0.11 to 311±1.67 mg/l for borehole water and 191±1.14 to 301±4.28 mg/l for hand dug well water. Sangere and Anguwan central borehole water had the highest and lowest concentrations (311±1.67 mg/l and 101±0.11 mg/l) respectively. A limit of 500 mg/l has been recommended as desirable and 1500 mg/l as maximum permissible limit for drinking water (WHO). However, all the values obtainedwere within the recommended limit of 500mg/l. In natural water Total dissolved solid (TDS) consist mainly of inorganic salts such as carbonates, chloride, sulphate, phosphate, nitrate, magnesium, calcium, sodium, iron and small amount of organic matter and dissolved gases [38].

The values of temperature presented in tables 1 and 2 varied from sample to sample. The temperature of the study area ranged from 28±1.00 – 33±0.00^{0}C for borehole water and 26±0.52

– 29±0.20^{0}C for hand dug well water, with the lowest temperature 26±0.52^{0}C recorded in Anguwan central hand dug well, and highest temperature 33±0.00^{0}C found in Sangere borehole water. The result of this investigation was higher compared to reports from Chindo et al.[37] and Odiba et al [31]. These temperatures are considered desirable as they fall within the permissible limit. It has been suggested that solar radiation, clear atmosphere and low water level increases the temperature of water body [14]. The temperature of water to a large extent determines the degree of microbial activity. Water temperature could be raised as a result of both natural volcanic activities and industrial discharges [39]. Normally, water with lower temperature is palatable [14,40,41]. High water temperature enhances the growth of microorganisms and may increase taste, odour, and colour problems of drinking water [20,42].Temperature also affects the concentration of dissolved oxygen and can influence the activity of bacteria in water bodies [43].

Hardness may be defined as the concentration of all multivalent metallic cations in solution. The principal ions causing hardness in natural water are calcium and magnesium. Others, which may be present though in much smaller quantities, are iron, manganese, strontium and aluminum [44]. Ground water is much prone to hardness due to high concentration of calcium and magnesium ions. An elevated hardness, however, makes water unsuitable for domestic and industrial use [13]. The values of hardness of water samples recorded for borehole water in this study area ranged from 30±0.01 – 50±0.16 mg/l and 20±0.11 – 35±0.01 mg/l for hand dug well water. The highest concentration 50±0.16 mg/l was recorded in Sangere borehole and lowest concentration 20 ± 0.11 mg/l was found in Anguwa layi hand dug well. The values are below the guidelines set by WHO and NAFDAC, of (150mg/l and100mg/l). Hardness of water do not have any health implications but might affect the taste of water as well as influence its lathering ability when used for washing [13].

The results of the heavy metals and essential elements as presented in tables 3 and 4 indicated that the concentration of iron recorded for all the water samples ranged from 0.10± 0.01- 0.20± 0.01 mg/l and 0.10± 0.10- 0.20 ± 0.11 mg/l for boreholes and hand dug wells respectively. The desirable limits and maximum permissible limits of iron in drinking water are 0.3mg/l and 1.0mg/l respectively according to WHO. The entire water sample analyzed had their iron concentration very low but falls within the desirable limits for drinking water. The result was in agreement with a similar study done by Shittu et al. [45] and Alexander et al. [38]. Iron in drinking water may be present as geological sources, industrial waste and domestic discharges and also from mining products [45]. Excess amount of iron, (more than 10.00mg/kg) causes rapid increase in respiration, pulse rate, coagulation of blood vessels and hypertension [36].

Copper is essential to humans, the daily adult requirement has been estimated at 2.0mg/l. Copper salts are used in water treatment to control biological growths in reservoir and distribution pipes and to catalyze the oxidation of manganese [44]. Copper is also an essential nutrient that the body requires in very small amounts. However, drinking water containing very high levels of copper can cause nausea, vomiting and diarrhoea, and can damage the liver and kidneys [20]. The stipulated Cu level in drinking water according to the WHO, [20] is 1.0 mg/l. The concentration of copper recorded in this study ranged from (0.01± 0.50 to 0.30 ± 0.10 mg/l) and (0.10 ± 0.03 to 0.20 ± 0.75 mg/l) for borehole and hand dug well water respectively. Highest concentration was recorded in Barkin dlaka borehole (0.3±0.10 mg/l) and lowest concentration was found in Anguwan layi borehole, (0.01±0.50 mg/l). All the samples in this study falls within the WHO and NAFDAC maximumlimit of 1.0mg/l. However, copper was not detected in Anguwan central borehole water. The value of Cu recorded in this study was lower compared to report given by Chindo et al.[31],

The Fluoride concentration in the ground water analysed varied from 0.10±0.01 to 0.50± 0.01 mg/l and 0.01±0.01 to 0.30± 0.50 mg/l for borehole water and hand dug well water respectively. The recorded values in all the water samples studied were very low compared to the WHO and NAFDAC standards set for drinking water (1.00 to 1.50mg/l). However, when fluoride is present in drinking water at concentrations much above the guideline value of 1.5mg/l, long term use can result in the development of dental fluorosis or at its worst bone fluorosis [41,46].

Calcium concentration in all the water samples investigated varied from (0.10± 0.20- 0.20± 0.18 mg/l) and (0.10 ±0.20- 0.20± 0.01 mg/l), for borehole and dug well water respectively. According to WHO and NAFDAC the desirable standard unit for calcium specified is 75mg/l. Distribution of calcium in all the water samples analysed had very low concentrations. Its low concentration in drinking water may cause defective teeth and rickets. Calcium is essential for nervous system, cardiac function and coagulation of blood [20].

In this investigation the concentration of magnesium recorded in all the water samples analysed was very low compared to the WHO and NAFDAC maximum permissible standard limits for drinking water 30mg/l. The average concentration of magnesium recorded in all the water samples analysed was (0.01±0.03 mg/l) for both the hand dug well and borehole water respectively.

The study revealed that the concentrations of sodium and potassium recorded in the water quality investigatedwere very low compared to the WHO and NAFDAC (20 mg/l and 30mg/l) for sodium and potassium respectively. Nevertheless, lead and cadmium were not detected in all the water samples.

Bacteriological analysis: The coliform group of bacteria was the principal indicator of suitability of water for domestic uses. The density of coliform group was the criteria for the degree of contamination and had been the basis for bacteriological water quality standard [41]. The results obtained for microbial analysis was presented in tables 5 and 6. The results of the investigation indicated that all the water samples were free from faecal coliforms (faecal contamination). This indicated good quality water and safe for drinking and domestic purposes.

Table 1: Physicochemical Parameters of Borehole water

SAMPLE SITE	pH	Temperature (^{0}C)	Electrical Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)	Hardness ($CaCO_3$) (mg/L)
Anguwan Central	7.3±0.36	28±1.00	630±2.41	101±0.11	ND	40.0±0.62
Anguwan Layi	7.1±0.21	29±0.20	612±2.71	200±2.11	1.00±0.21	30.0±0.01
Anguwan Sarki	6.8±0.36	29±1.02	631±4.11	201±1.11	1.0±0.60	30.0±0.01
Barikin Dlaka	7.1±0.30	32±1.01	628±2.51	203±0.25	1.0±0.01	30.0±0.00
Sangere	8.0±0.41	33±0.00	701±1.98	311±1.67	2.0±1.02	50.0±0.16
Range	6.8±0.36-8.0±0.41	28±1.00-33±0.00	612±2.71-701±1.98	101±0.11-311±1.67	1.00±0.01-2.00±1.02	30±0.01-50±0.16
WHO	6.5-8.5		1000	500	5.00	100

NAFDAC	6.5-8.5	Ambient	1000	500	5.00	150

Results were presented as mean ± standard deviation of five determinations.

Table 2: Physicochemical Parameters of Hand dug well water

SAMPLING SITES	pH	Temperature (^oC)	Electrical Conductivity (µs/cm)	TDS (mg/L)	Turbidity (NTU)	Hardness ($CaCO_3$) (mg/L)
Anguwan Central	7.7±0.32	26±0.67	567±2.67	201±2.13	ND	30.0±0.22
Anguwan Layi	6.8±0.00	26±0.52	480±2.61	191±1.14	1.0±0.01	20.0±0.11
Anguwan Sarki	6.5±0.11	27±0.42	623±1.00	234±3.12	1.0±0.13	25.0±0.00
Barkin Dlaka	7.5±0.31	28±2.18	540±1.12	200±6.11	1.0±0.52	30.0±0.20
Sangere	7.8±0.41	29±0.20	711±0.00	301±4.28	2.0±0.01	35.0±0.01
Range	6.5±0.11-7.8±0.41	26±0.52-29±0.20	480±2.61-711±0.00	191±1.14-301±4.28	1.0±0.01-2.0±0.01	20±0.11-35±0.01
WHO	6.5-8.5		1000	500	5.00	100
NAFDAC	6.5-8.5	Ambient	1000	500	5.00	150

Results were presented as mean ± standard deviation of five determinations.

Table 3: Elemental concentrations for Borehole water (mg/L)

SAMPLE SITES	Zn	Cu	Cd	Pb	Fe	F	Mg	Na	K	Ca
Anguwan Central	0.30±0.04	ND	ND	ND	0.10±0.10	0.20±0.30	0.10±0.01	0.01±0.00	0.10±0.00	0.01±0.00
AnguwanLayi	0.10±0.10	0.01±0.50	Nm	ND	0.10±0.11	0.40±0.33	0.02±0.00	0.10±0.02	0.10±0.22	0.10±0.20
AnguwanSarki	0.09±0.03	0.10±0.00	ND	ND	ND	0.20±0.00	0.10±0.12	0.10±0.03	0.10±0.10	0.01±0.00
BarkinDlaka	0.20±0.01	0.30±0.10	ND	ND	ND	0.10±0.01	0.01±0.00	0.10±0.01	0.10±0.10	0.20±0.00
Sangere	0.40±0.00	0.02±0.17	ND	ND	0.10±0.11	0.50±0.01	0.02±0.01	0.01±0.00	0.10±0.30	0.20±0.00
Range	0.09±0.03 -0.4±0.00	0.01±0.50- 0.3±0.10	-	-	0.10±0.10- 0.10±0.11	0.10±0.01- 0.5±0.01	0.01±0.02- 0.01±0.02	0.1±0.01- 0.10±0.03	0.10±0.00- 0.1±0.3	0.1±0.2- 0.2±0.18
WHO	50	1.0	0.003	0.01	0.30	1.5	50	20	100	75
NAFDAC	50	1.0	0.003	0.01	0.3	1.0	30	20	100	75

Results were presented as mean ± standard deviation of five determinations.

ND= Not Detected

Table 4: Elemental concentrations for Hand dug well water (mg/L).

SAMPLE SITES	**Zn**	**Cu**	**Cd**	**Pb**	**Fe**	**F**	**Mg**	**Na**	**K**	**Ca**
Anguwan Central	0.10±0.01	0.10±0.01	**ND**	**ND**	**ND**	0.20±0.71	0.01±0.10	0.01±0.00	0.10±0.13	0.10±0.00
Anguwan Layi	0.20±0.10	0.20±0.01	**ND**	**ND**	**ND**	0.20±0.63	0.01±0.01	0.10±0.00	0.10±1.00	0.20±0.14
Anguwan Sarki	0.09±0.41	0.10±0.03	**ND**	**ND**	0.10±0.20	**ND**	0.01±0.00	0.01±0.00	0.10±1.12	0.20±0.00
Barkin Dlaka	0.30±0.11	0.20±0.75	**ND**	**ND**	0.10±0.53	0.12±0.02	0.01±0.00	0.01±0.00	0.21±0.10	0.20±0.18
Sangere	0.41±0.00	0.02±0.61	**ND**	**ND**	0.20±0.01	0.30±0.50	0.01±0.13	0.20±0.21	0.20±0.03	0.22±0.00
Range	0.09±0.03-0.4±0.00	0.01±0.00 -0.2±0.75	-	-	0.10±0.10-0.20±0.11	0.10±0.01 -0.5±0.01	0.01±0.00 - 0.01±0.02	0.01±0.00 - 0.10±0.03	0.10±0.00 -0.1±0.3	0.1±0.2-0.2±0.00
WHO	5.00	1.0	0.003	0.01	0.3	1.5	50	20	100	75
NAFDAC	5.00	1.0	0.003	0.01	0.3	1.0	30	20	100	75

Results were presented as mean ± standard deviation of five determinations

ND= Not Detected

Table 5: Bacteriological Parameters for Hand dug well water

SAMPLE SITES	Total Coliform count (TPC) (MPN/100M/))	E. *Coli* (TPC) (MPN/100ml))
Anguwan Central	ND	ND
Anguwan Layi	ND	ND
Anguwan Sarki	ND	ND
Barkin Dlaka	0.05±0.001	ND
Sangere	ND	ND

ND= Not Detected

TPC = Total coliform count

MPN= Most probable number of coliform

Table 6: Bacteriological Parameters of Borehole water

Sample Sites	Total Coliform count (TPC) (MPN/100 ml)	E. Coli (TPC) (MPN/100ml)
Anguwan Central	ND	ND
AnguwanLayi	ND	ND
AnguwanSarki	ND	ND
BarkinDlaka	ND	ND
Sangere	ND	ND

ND= Not Detected

Conclusion

From the results of this investigation, the concentrations of the physicochemical and bacteriological parameters studied were all within the standard desirable limits for drinking water quality recommended by WHO and NAFDAC; except that the physicochemical concentrations are higher in borehole water samples than hand dug well water; the levels of trace and heavy metals investigated were all below the WHO guidelines levels. All the water samples were free from feacal contamination except Barikin Dlaka hand dug well which contained 0.05±0.001 MPN/100ml total coliform count which was below the WHO/NAFDAC maximum permissible levels. From this study it was concluded that the ground water of Michika town in Michika Local Government Area of Adamawa State, Nigeria is generally, suitable for drinking and domestic purposes. The suitability of water for domestic and drinking purposes indicates that water samples were within the standards prescribed for potable waters. However, there is need for routine checks to ascertain the suitability or otherwise of these water sources so as to forestall outbreak of water born diseases, as human activities are regularly changing the concentrations of these water quality parameters.

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