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Bacteriological and physico-chemical analysis of drinking water quality in Omugwa, Rivers State, South-South, Nigeria

Wokem V C*, Nwabueze P E
Department of Microbiology, Faculty of Science, University of Port Harcourt, P.M.B 5323, Port Harcourt, Nigeria

Abstract
The bacteriological and physicochemical analysis of drinking water quality was carried out in Omugwa Community, Rivers State, Nigeria to determine the level of contamination. The sources of water examined were borehole water and well water samples. Water samples were collected from five boreholes and wells from different locations using sterile universal glass bottles. The results of physicochemical analysis revealed that the pH of the borehole and well water samples ranged (6.0 – 6.7) and temperature (24 – 27^{O}C), biochemical oxygen demand (BOD) of well water (WW) samples ranged (13.85 – 16.37ppm). Chemical Oxygen Demand (COD) for WW (163.53 192.42ppm) BW (120.28 – 153.10ppm), electrical conductivity ranged WW (31.67 – 43.23us/cm) and bw (240.39 – 278.46us/cm), nitrate content, WW (16.25 – 18.53mg/l) and BW (12.18 – 14.82 mg/l), total dissolved solid (TDS) and total suspended solids (TSS) for WW ranged TDS (149.52 – 172.48ppm) TSS (118.33 – 135.28ppm) while for BW, TDS (72.37- 93.61ppm) TSS (65.92 – 74.45ppm) respectively. Bacteriological analysis of WW samples showed' total viable bacterial (TVB) average counts ranging between 9.8 x 10^{-6} – 1.5 x 10^{7}cfu/ml while that of BW ranged between (1.5x10^{1} – 2.6x10^{7}cfu/ml). The well-water and borehole water samples were positive for Total Coliform (TC) and faecal coliform (FC) tests of most probable number (MPN) indicating that the water samples were contaminated with total faecal coliforms. Isolation and identification tests showed that the WW samples had percentage occurrence of bacteria genera as follows; *Escherichia coli* (32%), *Staphylococcus*, *Enterobacter*, *Proteus* and *Bacillus* species (17%) each. That of the BW samples were *Bacillus* sp (25%), *Klebsiella* (17%), *Staphylococcus*, *Escherichia coli*, *Proteus*, *Salmonella*, *Pseudomona* and *Shigella* species (8.3%) respectively. The study has revealed that some of the physico-chemical characteristics and bacteriological results obtained from the drinking water sources, had values beyond the maximum tolerable limits recommended by WHO. The water samples should be subjected to treatment processes to improve the water quality to be used as potable water sources for the community.

Keywords: borehole water, well water, physicochemical, bacteriological total coliform, faecal coliform

Introduction

Water is absolutely essential to life of all living organisms, from the simplest plants and microorganism to the most complex living system animals and humans. It is significant due to its unique chemical and physical properties. Water is required or involved in most of the biochemical reactions that take place in metabolism and growth of living cells (Camp, *et al.*, 2009). Water plays a vital role in the proper functioning of earth's ecosystems. Water is used by man for various purposes which include drinking, transportation, industrial and domestic use, irrigation in agriculture, recreation among others (Shitu *et al.*, 2008) [18]. Ground water provides potable water to an estimated 1.5billion people world wide daily and has proved to be the most reliable source for meeting rural water demand. During passage through the ground, ground water dissolves mineral rocks, collect suspended particulate matter, particularly those from organic sources as well as pathogenic microorganism from faecal matters. Water that is of good drinking quality is important to human physiology and well being and these depends so much on it availability (Ajayi and Adejumo, 2011) [4]. Heavy metals such as; zinc, manganese, nickel and copper act as micro-nutrients of low concentrations, by when they exceed the required level, they become toxic. Trace minerals, total suspended solids are also agents of water contamination. Water pollution can result due to chemicals from natural resources, industrial and agricultural activities as well as faecal contamination of water supplies. The faecal contamination arise from run-off into rivers, stream, pools or being allowed to seep into wells or boreholes. Most human diseases such as cholera, gastroenteritise, typhoid, paratyphoid, amoebiases, Samonellosis, shigelloses and diphtheria are known to be water bone disease (Ewington *et al.*, 2001). These water-borne diseases are capable of lading to outbreak of disease impacting the whole community if not seriously checked. The fastest ways to prevent outbreak of such diseases and to determine the potability of water sources is to carry out bacteriological analysis of water to confirm if the water supply source have been faecally contaminated. This include to determine the microbial load, if the microbial load is not within the acceptable limit, the water sources should be condemned immediately by the appropriate authority (Fair *et al.*, 2000; Ajayi and Adejumo, 2011) [4]. Faecal coliforms (thermotolerant coliform organism or *Escherichia coli*) are the most appropriate of faecal pollution, as they are referred to as indicator organisms.

Well water contamination results from poor sanitary conditions surrounding the well. The wells may be without covers or not properly protected, which lead to run-off water from the surrounding getting into the well. The bucket and rope used to draw the water could be left in muddy ground and split-water could seep back into the well taking with it surface contaminants. The absence of concrete slab around the well with appropriate cover could be an opening for contaminants (Ajayi and Adejumo, 2011) [4].

Availability of potable water in the rural areas of the Niger Delta is major problem. The rural dwellers depend on wells, streams and rivers. High income earners in the rural settlements depend on boreholes for drinking water. In the urban and sub-urban cities, individuals depend surely on borehole water sources for their water supply, since there are no more water treatment facilities even in the urban cities. Some vendors supply borehole water in plastic jericans to individual homes for domestic purposes. The low income class citizens in some cases are allowed to fetch from the boreholes within the neighbourhood in the morning and evening to be stored in various containers. Through these processes, the water becomes contaminated and thereby gives way to contamination.

Several studies have been carried out on the physicochemical and bacteriological qualities of borehole and well water sources in different communities of the Niger Delta region of Nigeria. This study aims at the analysis of bacteriological and physicochemical quality of well and borehole water sources in Omugwa in Ikwerre Local Government Area of Rivers State, South – South, Nigeria.

Materials and Methods

Study Area

The study was carried out in Omugwa town in Ikwerre Local Government Area of Rivers State, South-South, Nigeria. Omugwa Town is located about 8km from Port Harcourt city the state capital and host the Port Harcourt International Air Port, Adokie Amesimaka stadium and hotels. It is a part of the New Greater Port Harcourt City plan under development. The influx of new duellers as a result of increased economic activities and the indigens has placed, the community under pressure of need for potable water. The inhabitants depend on borehole and well water for domestic and drinking water sources. The low income earners in the rural area depend on well water, few borehole do exist. The study covered four (4) different communities namely; Omulo, Omuagubia, Mgbagu and Omuketu of Omuawa Town. In each case, proximity to refuse dump, suckaway pit (septic), palm oil mill and farm land and domestic activities were measured.

Sample Collection

A total of ten (10) water samples were collected from two water sources; borehole water five (5) and well water five (5). The borehole water samples were aseptically collected into sterile sampling bottles from each sampling site by allowing the water to run-off first, the sampling bottles were rinsed with the borehole water from the tap outlet then allowed to be filled and cooked.

Well water samples were collected by means of a strong rope tied to the neck of each sterile sample bottle and gently low and into the well. The opened bottle was allowed to sink below the water and was pulled up after observing that there were no bubbles. The bottle was gently pulled out of the well without allowing it to touch the sides of the well in both samples, the water was reduced to avoid filling to the brim of the sampling bottles, caps were carefully re-capped, labelled properly and transported in ice pack to the Microbiology Research Laboratory of University of Port Harcourt for microbiological and physicochemical analysis.

Reagents and Media

All the reagents employed in this study were of analytical grade and were products of Sigma chemical company St. Louis Missori, USA and BDH chemical, Ltd, Poole, England. All microbiological media used were products of oxoid and Difco Laboratory, England. Nutrient Agar (NA), MacConkey's agar (MaCA), Manitol Salt Agar (MSA) and Salmonella-Shigella Agar (SSA). All glass are used were sterilized in hot are oven at 160^0C for 1h (Umeaku, *et al.*, 2019).

Physicochemical Analysis

Physicochemical parameters such as pH, temperature and turbidity were measured *in-situ* using standard instruments. pH and turbidity were measured using Wagtech International pH and turbidity meters (Wag-WT3020, Halma Plc Company), temperature was determined using mecury-bulb theremometer at the point of collection. Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Nitrate and Conductivity were determined in the Laboratory using standard methods adapted from APHA (2005) [5].

Bacteriological Analysis

Serial dilution: A tenfold serial dilution was carried out for all the 10 water samples from their representative stock samples. One millilitre of each water sample was aseptically transferred into 10 flask test tube containing 9ml sterile peptone water (10^{-1}) using a sterile pipette. From the first test tube, one milimeter was aseptically transferred to the test tube labelled 10^{-2} using separate sterile pipette, this was repeated up to dilution 10^{-5}.

Enumeration of Total Viable Bacteria (TVB)

Total viable bacterial counts were enumerated by inoculating 0.1ml aliquot of each appropriate dilutions (10^{-4} and 10^{-5}) of water samples in triplicates on solid agar plates (NA, MAC, MSA) by the spread plate method (APHA, 2005, Opeuraocha, 2010) [5] plates were incubated at 37^0C for 48h. The mean counts of the bacterial counts were expressed in cfu/ml.

Total Coliform and Faecal Coliform Counts

For total coliform and faecal coliform counts, the most probable number (MPN) method was employed using multiple fermentation tubes (APHA, 2005; Adetunde *et al*, 2011) [5, 3]. Presumptive test was carried out by incubating samples in lactose broth tubes at 370C for 24h. Ten millilitres (10ml) of the double strength broth (MacConley) was poured into first set of three tubes and 9.9ml of the single strength broth was poured into the second set and third tubes respectively. Inverted Durham's tubes were placed in the bottles containing the media to indicate gas production sterilized by autoclaving was carried out at 121^0C for 15mins at 15psi. The bottles were arranged in three sets of 50ml, 10ml and 1ml and each had 5 bottles. The three sets of test tube were inoculated with 10ml of diluted water sample for 10ml of double strength broth tube, 0.1ml of diluted sample were inoculated into 9.9ml single strength broth tube and 1ml of dilated sample was inoculated into 9ml single strength broth tube. The tubes were incubated at 39^0C for 48h in accordance with standard

methods (APHA, 2005) [5]. Positive tubes producing acid and gas were used to estimate the presumptive Most Probable Number (MPN). The confirmed test for total coliform was determined by plating a loopful of positive MacConkey's broth on Eosine Methylene Blue (EMB) agar and incubated at 37^0C for 24h while the faecal coliform was determined by transferring a loopful of broth from positive tube to brilliant green lactose bile (BGLB) broth and incubated at 44.5^0C for 24 - 48h and the tubes were observed for gas formation. Completed test for faecal coliform was carried out by plating a loopful of broth from a positive brilliant green lactose bile (BGLB) broth tube unto EMB agar plate. The plates were incubated at 44.5^0C for 48h and observed for a dark red colour with metallic green sheen. The colonies on each plate were counted.

Characterization and Identification of Bacterial Isolates

Colonies were randomly picked from countable NA and MacConkey agar plates and inoculated into 5ml nutrient broth tubes. Incubation was at 37^0C for 24h. Colonies were purified by sub-culturing repeatedly on NA plates by streaking and incubated at 28 ± 2^0C for 24h. Discrete colonies were further sub-cultured on NA slants in Bijou bottles as pure culture and stored in the refrigerator at 4^0C. Identification was based on standard microbiological methods, which included Gram's reaction, cultural and microscopic morphology, use of selective media and biochemical characteristics with reference to determination schemes of Bergey and Holt (1994), Gregersenn (1978), Cheesbrough (2006) [8] suspected non-lactose fermenting bacterial colonies were further characterized by inoculating onto *Salomenalla-Shigella* agar incubated at 37^0C for 48h for detection of *Salmonella* and *Shigella* species.

Results

Microbial load of borehole and well water samples. The mean table viable bacterial (TVB) counts for well water and borehole water samples are shown in Table 1. The TVB count ranged ($6.7x10^7$ – $1.6x10^8$cfu/ml), while that of the borehole water samples ranged ($1.5x10^7$ – $2.6x10^7$cfu/ml). The highest bacterial load was recorded in well-water (WW) located 20m away to a palm oil mill factory while for borehole water, the highest was in borehole 5 (BHWS) ($2.6x10^7$cfu/ml) located 5m away to the kitchen. For total coliform (TC) and faecal coliform (FC) counts of MPN for well-water and borehole water samples, well-water (WW1) had the highest TC and FC counts of 180, while well water 3 (WW3) had the least TC counts of (33) and FC counts respectively (Table 2). Table 3 shows the borehole-water samples with borehole water 5 (BHW5) and BHW2 having the highest TC and FC counts of 20 while as BHW1 had the least value of 14 for the two coliform test (counts) respectively. A total of 24 aerobic mesophilic bacteria were isolated and characterized to genera level. In the well-water and borehole water samples. The isolates were found to be dominated by *E. coli* (34%), *Enterobacter, Proteus, Bacillus* and *Staphylococcus* 17% each respectively in the well water samples. In the borehole water samples, the dominants were, *Bacillus* sp (25%), *Klebsiella* sp (17%) while *Staphylococcus aereus, E. coli, Shigella* spp, *Pseudomonas* sp, *Salemonela* sp, *Proteus* sp and *Enterobacter* sp were 8.3% each respectively. Despite high counts of *Enterobacteriacea* and coliforms in some of the water samples, the species of *Salmonella* and *Shigalla* were not found in the well water samples, but were implicated in the borehole water samples.

The results are represented in Figures 1 and 2. Physicochemical characteristics of the well-water and borehole water samples are shown in Tables 4 and 5. The borehole water samples has higher pH values (6.5-7.4) than that values for well-water samples was higher with range of (21.47 – 26.28ppm) than that of borehole-water samples with range (13.85 – 16.37ppm), the maximum mean BOD value of 26.28. The mean temperature was recorded in well water 3, the minimum 13.85ppm was recorded in borehole 4 values of the well-water samples ranged (24.8 – 270C) while that of borehole-water samples were (25-27OC). Mean nitrate concentration (mg/l) values of range (16.25 – 19.46) were recorded for well water samples and that of borehole water samples were (12.18 – 14.82). The maximum nitrate value of 19.46 was recorded in well water (WW2) (Table 4). High conductivity us/cm range of (240.39 – 278.46) were observed in well-water samples while borehole water samples had relatively lower conductivity values range (31.67 – 43.23 us/cm) with the least value, observed in borehole water 4 (BHW4).

The mean COD values recorded in well-water samples were higher range (163.53 – 192.43ppm) than the borehole water samples of range (120.28 – 153.48ppm) were observed in well-water samples with the highest value recorded in well-water sample 4 (ww4). Lower mean TDS values were observed in borehole water samples ranged (72.37 – 93.61ppm). The highest values were observed in borehole water sample 1 (BHW1) while the lowest was in BHW4. Similarly, high TSS values were observed in the Well-water samples ranged (118.33 – 135.28). The highest value was recorded in WW5, while the least value was observed in WW4.

Table 1: Mean Total Viable Bacterial (TVB) counts of well-water and borehole water samples

Sample code	Mean TVB count cfu/ml	Log cfu/ml	Sample code	Mean TVB count cfu/ml	Log cfu/ml
WW1	$1.6x10^8$	8.2	BHW1	$2.1x10^7$	7.3
WW2	$9.5x10^7$	8.0	BHW2	$1.9x10^7$	7.3
WW3	$1.0x10^8$	8.0	BHW3	$1.6x10^7$	7.2
WW4	$9.6x10^7$	8.0	BHW4	$2.5x10^7$	7.4
WW5	$6.7x10^7$	7.8	BHW5	$2.6x10^7$	7.4

WW1 – WW5 = Well Water Samples; BHWI – BHW5 = Borehole water samples

Table 2: Total and Faecal Coliform Counts of Most Probable numbers (MPN) for well-water samples

S/N	Sample code	Total faecal coliform	DS (10ml)	SS (1ml)	SS (0.1)	Confirmed test	Completed test	MPN Index per ml
1	WW1	Total	5	3	3	+	+	180
	WW1	Faecal	5	3	3	+	+	180
2	WW2	Total	5	0	2	+	+	43
	WW2	Faecal	5	0	2	+	+	43
3	WW3	Total	5	1	0	+	+	33
	WW3	Faecal	5	1	0	+	+	33
4	WW4	Total	5	4	1	+	+	170
	WW4	Faecal	5	4	1	+	+	170
5	WW5	Total	5	4	1	+	+	170
	WW5	Faecal	5	4	1	+	+	170

Key: DS – Double Strength; SS = Single Strength; WW1-5= Well water samples

Table 3: Total and Faecal coliform counts of most probable numbers (MPN) for borehole-water samples

S/N	Sample code	Total faecal coliform	DS (10ml)	SS (1ml)	SS (0.1)	Confirmed test	Completed test	MPN Index per ml
1	BHW1	Total	3	1	1	+	+	14
	BHW1	Faecal	3	1	1	+	+	14
2	BHW2	Total	4	1	2	+	+	26
	BHW2	Faecal	4	1	2	+	+	26
3	BHW3	Total	3	2	1	+	+	17
	BHW3	Faecal	3	2	1	+	+	17
4	BHW4	Total	4	1	1	+	+	21
	BHW4	Faecal	4	1	1	+	+	21
5	BHW5	Total	4	2	1	+	+	26
	BHW5	Faecal	4	2	1	+	+	26

Key: DS – Double Strength; SS = Single Strength; BHW1-5= Borehole water samples

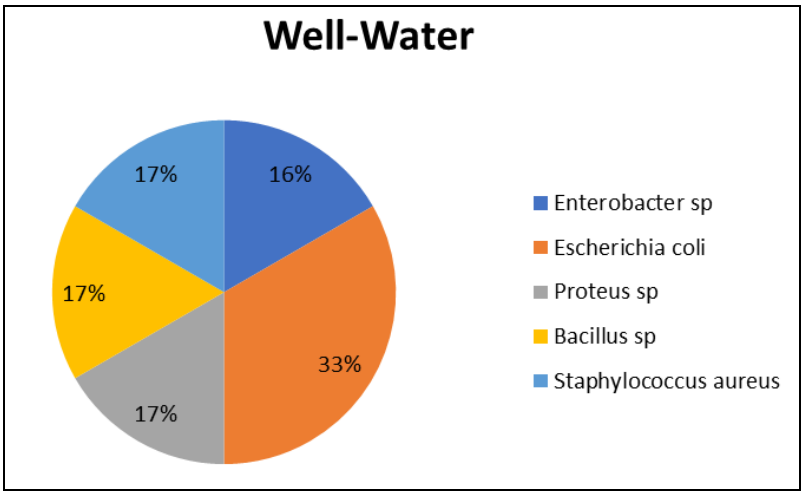

Fig 1: Percentage Occurrence of bacterial isolates in the well water samples

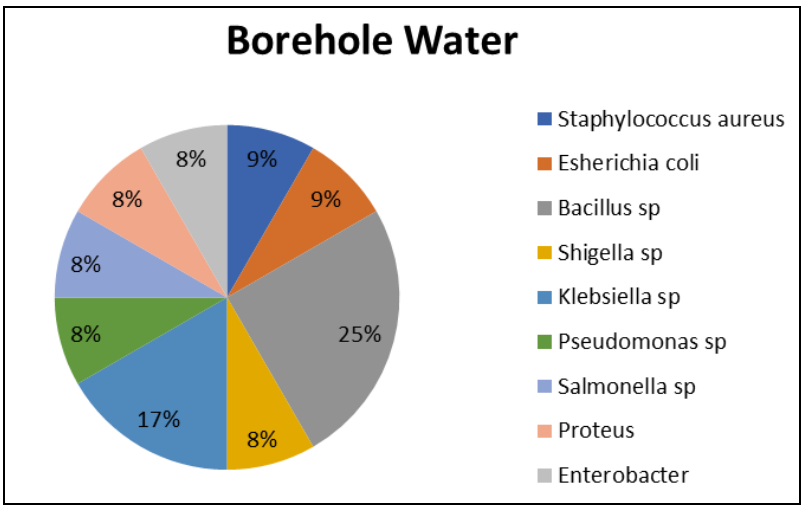

Fig 2: Percentage occurrence of bacterial isolates in the borehole water samples

Table 4: Physicochemical Characteristics of the well-water samples

S/N	Parameters	WW1	WW2	WW3	WW4	WW5	WHO standard
1	pH	6.7	6.0	6.5	6.8	6.5	65-8.5
2	Temperature (^{O}C)	24	27	24	26	24	27-29
3	Conductivity (µS/cm	253.48	271.04	240.39	265.83	278.46	500
4	Nitrate (mg/l)	17.24	19.46	16.25	18.53	16.83	10
5	BOD (ppm)	23.52	24.92	26.28	21.47	22.38	6
6	COD (ppm)	163.53	192.42	175.62	185.03	173.71	250
7	TDS (ppm)	162.74	158.34	149.52	172.48	165.82	500
8	TSS (ppm)	132.10	128.43	135.28	118.33	130.35	210

Key: WW1-WW5 = Well water 1 – well water 5; TDS = Total Dissolved Sold; TSS = Total Suspended Solid; BOD = Biochemical Oxygen Demand; COD = Chemical Oxygen Demand

Table 5: Physicochemical Characteristics of the well-water samples

S/N	Parameters	BHW1	BHW2	BHW3	BHW4	BHW5	WHO standard
1	pH	7.4	6.5	7.3	7.0	7.1	6.5-8.5
2	Temperature (^{O}C)	26	27	27	25	26	27-29
3	Conductivity (uS/cm	43.23	35.38	41.10	31.67	39.72	500
4	Nitrate (mg/l)	13.64	14.82	12.18	14.16	13.24	10
5	BOD (ppm)	15.32	14.18	16.26	13.85	16.37	6
6	COD (ppm)	153.10	132.23	120.46	148.53	120.28	250
7	TDS (ppm)	93.61	76.25	85.43	72.37	82.34	500
8	TSS (ppm)	73.42	71.37	68.22	65.92	74.45	210

Key: BHW1-BHW5 = Borehole water 1 – Borehole water 5; TDS = Total Dissolved Sold; TSS = Total Suspended Solid; BOD = Biochemical Oxygen Demand; COD = Chemical Oxygen Demand

Discussion

The results of the mean bacterial counts, total viable bacteria (TVB), total coliform (TC) and faecal coliform (FC) counts of well and borehole water samples used in this study reveals high microbial loads with all the water samples having TVB counts greater than 7 log cfu/ml, this was in agreement with earlier study carried out by Shamsuddeen *et al.,* (2010) [17]. These high microbial counts indicates high level of pollution of the water samples which could be attributed to human and animal activities surrounding the sites or environments of the water samples. These counts can also be attributed to high organic matter contamination in the water sources. Routes of bacterial species into well-water sources include; run-off, animal wastes deposition and pasture (Rajine and Ibrahim, 2011) [16].

The well-water sources evaluated in this study are located close to refuse dumps, palm oil mill site and are often not covered, hence the high chances of contamination with faecal matter. The high TVB counts of the borehole water samples (11.5 x 107 – 2.6 x 107cfu/ml) calls for concern. The borehole water samples may be presumably good for drinking, but the storage tanks, distribution pipes as well as the surroundings of the taps, proximity to kitchen, refuse dump and suckaway pits could be vital sources of contamination (WHO, 2014) [20].

The presence of coliform in the water sample was established through the most probable number (MPN) method. All the water samples in this study were positive for faecal coliforms (FC) and the highest observed mean coliform count was 180 MPN index/ml and least 33 MPN index/ml for the well-water samples, while for the borehole water samples, the highest was 26 MPN index/ml and the least was 14 MPN index/ml (Tables 2 and 3). With these results the water samples cannot be certified safe for drinking unless subjected to some level of treatment or purification as recommended by Nigerian Industrial Standard (NIS, 2007) [14]. The water samples did not conform to the zero total coliform 100ml of potable water standard of World Health Organization (WHO, 2017) [21]. FC counts were higher in the well-water samples compared to the borehole water samples. This can be attributed to discharge of run-off water into the wells by surrounding human activities and pome of the wells are not properly covered (Edema, *et al.,* 2001) [9]. According to WHO guidelines, *E. coli* or thermo-tolerant coliform bacteria should not be detectable in any water intended for drinking Cheesbrough, (2006) [8], (WHO, 2017) [21]. Results of this study is in agreement with earlier study which reported detection of coliforms from 75% of unprotected well and spring samples from North-Gonder, Ethiopia (Mengesha, *et al.,* 2004) and the detection of mean TC and FC counts of 9.67 and 0.53 cfu/100ml from tap water sources and from protected wells and protected springs TC counts of 33 and 30.6cfu/100ml, but FC counts of 6 and 3.4cfu/100ml, respectively (Yasin *et al.,* 2015) [24].

The predominant bacterial genera identified in the well water sources from the present study were *E.coli* (34%), while *Enterobacter*, *Proteus*, *Bacillus* and *Staphylococcus aureus* were 17% each respectively. On the other hand, the predominant genera identified from the borehole water sources include; *Bacillus* sp, (25%), *Klebsiella* (17%), *Staphylococcus, E. coli*, *Shigella*, *Pseudomonas* sp, *Proteus* sp and *Enterrobacter* 8.3% respectively. 66.7% of the identified bacterial genera in both well and borehole water sources were Gram negative, non-spore forming bacilli (rods) belonging to the family Enterobacteriaceae. This is in agreement with the reports made in earlier studies (Abed and Alwakeel, 2007; Yasin et al., 2015) [24]. *Bacillus* sp were the second dominant bacterial group (21%) in the current study. *Bacillus* species are known to be pathogenic to humans and animals being responsible for food poisoning (Jay *et al.*, 2005) [12]. The incidence of *Pseudomonas* in the borehole water sample in this study is in agreement with reports made in other studies (Geldreich, 1996) [11]; Chaidez *et al.,* 2008) [7]. The prevalence of *Salmonella* was low (4.2%) from the boreholes water samples. Results of bacterial identification in this study, reveals the absence of

Salmonella and *Shigella* in all the well water samples examined. In a related study, Shittu *et al* (2008) reported absence of *Salmonella* and *Shigella* in all well water samples examined, although stream samples indicated positive. In the present study, as long as the faecal coliform counts are high in all the water samples examined for bacteriological quality and safety, the absence of any *Salmonella* and *Shigella* in all the well water samples cannot quality the water samples examined for bacteriological well water samples safe for drinking.

Results of physiochemical analysis revealed mean pH value of 6.72 (ranged) between (6.0 and 7.4). The pH values in all the water samples were found within the recommended standards of European Commission and WHO ranges (6.5 to 8.5) for potable water (WHO, 1997) [19]. The pH values recorded in this study are consistent with the studies of Wokem and Udonsi (2003) [23]. Federov *et al* (2001) [10] inferred that a pH of 7.0 play roles in determining both qualitative and quantitative abundance of microflora. Wokem and Lawson-Jack (2014) [22] and Nazina *et al.*, (2002) [13] agrees to this fact that the more available hydrogen ion concentration is in a water body leads to lowering of the pH and this affects the pattern of microbial population. The pH values of the well water samples (6.0 – 6.8) was observed to the relatively lower that of the borehole water (6.5 – 7.4). According to Byamukama *et al.*, (1999), the low pH values observed in the well water samples could be associated with carbon dioxide saturation in the ground water.

Temperature as one of the physicochemical parameter used to evaluate quality of potable water affects many phenomena including the rate of chemical reactions in the water body, amplifications of tastes and colours of water, reduction in solubility of gases and rate of proliferation of microorganism (Olagire and Imeokparia, 2001; Shitu *et al.*, 2008) [18]. The temperature of the well and borehole water samples obtained in this study, ranged mean values of 24 - 27^0C. Temperature recorded from well water samples were slightly lower with minimum temperature of 24^0C than that of borehole water samples having minimum of 25^0C respectively. Most of the recorded water temperatures were within the WHO recommended level (27-29^{O}C) (WHO, 1996). The value of temperature recorded in this study is related with the studies of Bello *et al.,* (2013), who reported temperature values ranging from 20 – 25^0C. The variations in temperature of the water samples may be attributed to sampling locations and exposure time to sunlight.

The electrical conductivity (EC) mean values of the well and borehole water samples ranged were (240.39 – 278.46µS/cm) and (31.67 – 43.23µS/cm) respectively. The higher EC value recorded from well water samples could be due to the corrosion of metals in the wells and exposure of the wells to environmental factors (Abudulahi *et al.*, 2013). All mean EC values of well and borehole water were below WHO recommended value (500µS/cm). Related results were reported from well water samples by Oparaocha *et al.*, 2010, where the EC values ranged (22 – 315µS/cm and by Yasin *et al* (2015) [24], where the mean EC values ranged 46.42 – 336.93µS/cm for protected and unprotected wells and protected/unprotected springs. Electrical conductivity is a parameter that tests for the capability of a solution to conduct electricity based on the principle of migration of ions. It is a criterion for assessing the quality of water samples.

The mean nitrate concentrations of the water samples varied from 16.25 – 19.46mg/l and 12.18 – 14.82mg/l in the well and borehole water samples respectively. These values are above the WHO certified value of 10mg/l. high nitrate levels in drinking water will render the water hazardous to infants as they induce the "blue baby syndrome (Methae-Moglobinaemia) (Raji and Ibrahim, 2011) [16]. Nitrate itself is not a direct toxicant but a health hazard because of its conversion to nitrite which reacts with blood haemoglobin to cause methaemoglobinaemia (Raji and Ibraham, 2011) [16]. High level of nitrate in ground waters, is a cause for suspicion of past sewage pollution or excess level of fertilizer or manure slurries spread on land (Onuh and Isaac, 2009) [15].

The total dissolved solids (TDS) and total suspended Solids (TSS) values of the well water samples were in the range of 149.52 – 172.48ppm and 118.33 – 135.28ppm respectively. That of borehole water samples ranged between 72.37 – 93.61ppm and 65.92 – 74.45ppm respectively.

Conclusion

The bacteriological quality of the water samples analysed in the present study did not meet the WHO standard set for drinking water. Bacteriological analysis revealed microbial populations above the 0 cfu/ml WHO regulations. The most probable number (MPN) tests were positive, indicating the presence of total and faecal coliforms in all the water samples of well ad borehole water in Omuagwa community. The studied water sources could be classified as polluted. Most of the physic-chemical results indicated marginally tolerable quality to WHO standard in respect to pH, temperature, conductivity, COD, TDS and TSS, but poor quality in relation to nitrate and BOD concentrations with values much in excess of the permissible standards of WHO (2017) [21]. High nitrate concentrations in both water well and borehole water samples could cause many health problems including increased starch deposits and haemorrhaging of the spleen. High BOD value above the permissible value recorded in both water samples indicate organic pollution.

With the high dependence on borehole and well water for drinking water in the community, it is therefore highly recommended that awareness development on hygienic handling of well and borehole water be carried out by Regulatory Agencies. The State and Local Government Authority to ensure provision of water treatment facilities for the local communities to improve potable water quality. Some of the physicochemical parameter TDS and TSS value fall within the 500ppm and 210 ppm WHO guide or standard for water analysis, (WHO, 2006), the values suggests that the water samples should still be subjected to purification or treatment before consumption (Onuh and Isaac, 2009) [15].

References

1. Abed KF, Aliwkeed SS. Mineral and microbial contents of bottled and tape water in Riyadh, Saudi Arabia, Middle East. Journal of Science Res,2007:2:151-156.
2. Abudullahi BT, Ahmed SB, Mohammed SA. Bacteriological and physicochemical properties of borehole water in Niger State Polytechnic, Zunge ru

campus. Indian Journal of Science Research,2013:4(1):1-6.
3. Adetunde LA, Glover RKL. Evaluation of bacteriological quality of drinking water used by selected secondary school in Navrongo in Kassena-Nankana District of upper East region of Ghana. Prime Journal of Microbiological Res,2011:1:47-51.
4. Ajayi AO, Adejumo TO. Microbiological assessment and some physicochemical properties of water sources in Akungba-Akoko, Nigeria. Journal of Toxicology and Environmental Health Sciences,2011:3:342-346.
5. American Public Health Associated (APHA). Standard method of examination of water and waste water, 20th Edition. American Public Health Association Inc., New York, 2005.
6. Bello OO, Osho A, Bello TK. Microbial quality and antibiotic susceptibility profiles of bacteria isolates from boreholes water used by some schools in Ijbu-Ode, South-Western, Nigeria. School Academic Journal of Biological Science,2013:1(1):4-13.
7. Chaidez C, Solo M, Martinez C, Keswick B. Drinking water microbiological survey of the North-Western state of Sinaloa, Mexico. J. Water Health,2008:6(1):125-129.
8. Cheesbrough M. District Laboratory Practice in Tropical Countries. Part 2, (2nd edition), London, Cambridge University Press, 2006, 143-180.
9. Edema MO, Omenue MM, Fapetu OM. Microbiology and physicochemical analysis of different sources of drinking water in Abeokuta, Nigeria. Nigeria Journal of Microbiology,2001:15(1):57-61.
10. Federov AY, Volchenko EV, Korzhenevich VL, Singirtsev LN, Krestyaninov VY. A polysubstrate strain that degrades wastewater components of phenol production. J. Applied Biochem. Microbiol,2001:29:532-536.
11. Geldreich EE. Characterizing microbial quality supply in distribution systems. Boca Ration CRC Press Inc, 1996, 236.
12. Jay JM, Loessner MJ, Golden DA. Modern Food Microbiology. 11th ed. New York, Springer, 2005, 236.
13. Nazina TN, Grigoryan AA, Xus Y, Sokolova DS, Novikova EV, Yourova TP, *et al*. Phylogenetic diversity of aerobic saprophytic bacteria isolated from the dragging oil field. Microbiology,2002:71:91-97.
14. Nigeria Industrial Standard (NIS). Nigerian Standard for drinking water quality. NIS, 2007, 554.
15. Onuh JO, Isaac VU. Physicochemical and microbiological quality of water sources from some major towns in Igana land. Nigerian Food Journal,2009:27(22):66.
16. Raji MIO, Ibrahim YKE. Prevalence of water borne infections in North West Nigeria. Retrospective study. Journal of Public Health and Epidemiology,2011:3(8):382-385.
17. Shamsuddeen U, Bukar A, Usman AD, Kabir MH, Abdulmalik SA. Bacteriological quality of water used for ice making in some part of Kano metropolis, Nigeria. Bayero Journal of Pure and Applied Science,2010:3:199-201.
18. Shitu OB, Olaitan JO, Amusa TC. Physicochemical and bacteriological analysis of water used for drinking and swimming purposes in Abeokuta. Nigeria. African Journal of Biomedical Research,2008:2:238-290.
19. WHO. Guidelines for drinking-water quality, surveillance and control of community supplies Switzerland. World Health Organization, Geneva, 1997.
20. WHO. Water safety in distribution systems Geneva. World Health Organization, 2014.
21. WHO. Guidelines for drinking water-quality. Fourth edition, incorporation the first addendum, Geneva; World Health Organization, 2017.
22. Wokem GN, Lawson-Jack T. Microbiological quality of domestic water sources in Abonnema Community. Journal of Aquatic Science,2014:29(2B):391-400.
23. Wokem GN, Udonsi JK. Physicochemical properties of pound water in relation to zooplanktonic organisms of the ponds of Oso-Adda in Afrikpo, Ebonyi State, Nigeria, Glob. J. Env. Sc,2003:2(2):82-87.
24. Yasin M, Katema T, Bacha K. Physico-chemical and bacteriological quality of drinking water of different sources, Jimma Zone, South West Ethiopa. Biomed. Central Res. Notes,2015:8:541-554.