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Bacteriological Quality of Boreholes And Wells in Bokkos, Plateau State Nigeria

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Abstract: *Access to safe drinking water is scarce in most developing countries. As a result most communities depend on underground water sources such as well and boreholes. The aim of this research was to analyze the bacteriological quality of water used in Ndar and Butura communities in Bokkos, Plateau State. Thirty water samples from 15 wells and 15 boreholes were analyzed using standard water evaluation techniques. The physicochemical analysis of the water samples reveals that most of the water samples were colourless, odourless and tasteless, contain no particle with a pH range of 6.5 to 8.4. This is within the acceptable standard limit of 6.5 -8.5for drinking water. The most probable number (MPN)/ 100ml of both the wells and boreholes ranged from 12 -24/100ml. This value exceed the Zero total coliform per 100ml of water stipulated by EPA. All the water samples contain coliform bacteria namely Klebsiella pneumonia, Enterobacter aerogenes, Citrobacter freundii and Escherichia coli. Pathogenic strains of Salmonella typhi, Staphylococcus aureus and Pseudomonas aeruginosa were also isolated. Poor hygiene, and sanitation, proximity of sewage tanks to the water source may account for the poor quality of the water sources. The presence these coliform bacteria and the pathogenic bacteria is an indication that the water samples are contaminated. None of the water sample analyzed in this research is fit for drinking. Regular quality control and analyses of the water samples shoud be conducted to ascertain the fitness of the water.*

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I. Introduction

Water is the most important elements for all forms of life. Access to quality drinking water is important to the health and continued existence of the people (Nwosu and Oguoke, 2004; WHO, 2004; Olajuyigbe *et al.*, 2010; Omole and Ndambuki, 2014). More than 1.1 billion people have no access to safe drinking water and about 5 million people die of water related diseases annually with about 500 death cases daily (Duse *et al.*,2003; CDC, 2014; WHO, 2004; Azizullah, 2011).

Water quality and safe water supply constitute a major challenge in developing countries because majority of the communities have no access to pipe water supply. In Nigeria only about 30% of the population have access to safe drinking water and an estimated 63 million people do not have access to safe drinking water (WHO/UNICEF, 2014). Hence most of the water available for use are obtained from other sources. Most communities depend solely on ground water sources including wells, borehole and water vendors for water supply (WHO, 2004; Abiola, 2010, Olukanni *et al*., 2014). These water sources are prone to natural and man manmade pollution (Figueras and Borregas, 2010). .

Bacteria, Viruses and protozoans and fungi are the major pathogens that pollute ground water (U.S EPA, 2010; Krauss and Gribler, 2011; Pandey *et al*., 2014;). Groundwater contamination with bacteria can result from poor agricultural practices, well conditions, proximity of pollutants to the water sources, poor hygiene and sanitation , condition of sewage disposal systems and septic tanks, overloaded sewage treatment plant and soil topography (Adetunji *et al.*, 2011; Nabeela *et al.*, 2014). Coliforms and *Esherichia coli* have been used to assess the microbial quality of water over the years. The presence of fecal coliforms and E. coli is an indicator for water contamination with human or animal wastes (Horan, 2003; Farooq *et al*., 2008). This research was aimed at investigating the bacteriological quality of ground water in Mbar and Batura community in , Bokkos, Plateau State

II. Methods

Sources of Water sample Collection And Processing

The water analyzed was obtained from wells and boreholes in and around the Mbar. The wells were categorized into open (wells without cover) and closed (wells with cover). Important information such as the

year of the excavations of boreholes and wells, location of boreholes and wells, proximity to source of contaminations such as pit latrines, septic tanks, refuse dumps, suck –away and information regarding the depth and the casting status of boreholes and wells sampled was sought and recorded

Thirty water samples from 15 different wells and 15 boreholes were collected into sterile water bottles. For the borehole, the water was allowed to pump out for about 2-3 minutes before collection. The water was collected into sterile bottle by the application of pressure. The well water was collected using the method described by Pesewu *et al.,* (2015). A rope was tied to a sterile sample bottle and a heavy piece of metal was attached as a weight. The bottle cap was aseptically removed and the bottle was lowered into the well to collect the water. The bottle was raised out of d well when no air bubble observed and the cap was carefully replaced. The bottle was labeled accordingly. The samples were transported to the Microbiological Laboratory of Plateau State University.

Physicochemical Parameters of the Water

A 20ml volume of each water sample in a beaker were examined under bright light for cloudiness, colour and presence of particles. The presence of odour in the different water samples was detected when brought close to the nose. The tongue was used to taste a small quantity of the water samples with instant use of taste free distil water to rinse the tongue. The pH of each water sample was measured and recorded using a portable digital pH meter (Muazu *et al*., 2012)

Bacteriological Analysis

Water samples were analyzed using Most Probable Number (MPN) technique as described by APHA (2005). Presumptive coliform test was carried out using sterile MacConkey broth containing inverted Durham tubes. The first set of the three tubes had sterile 10ml double strength lactose broth and the second and third sets had 10ml single strength Mac conkey broth. The three sets of the tubes were inoculated with 10, 1 and 0.1 ml of water samples using sterile pipettes.The tubes were properly closed and shaken for uniform distribution of sample in the medium. The tubes were incubated at 37^{O}C for 24-48 hours and examined for acid and gas production. Acid production was determined by colour change of the broth from reddish purple to yellow and gas production was checked for by entrapment of gas in the Durham tube. Confirmed test was carried out by transferring a loopful of culture from a positive tube from presumptive test into a tube of Brilliant Green Lactose Bile Broth with Durham tubes. The tubes were incubated at 37^{O}C for 24-48h hours for total coliform and observed for gas production. The most probable number (MPN) of coliforms was determined from the Probability table.

Completed test was carried out by streaking a loopful of broth from positive tube onto Eosine Methylene Blue agar plates for pure colonies. The plates were incubated at 37^{O}C for 24 - 48 hours.

Biochemical Analysis

Identification of the bacterial isolates was carried out as described in Berge's manual of bacteriology. Gram staining, motility test, catalase, indole, citrate utilization, urease, Tripple sugar iron Agar test were carried out on the isolates..

III. Results And Discussion

Out of the 15 wells analyzed, 7 (46.7%) were casted, 6(40%) were closed to source of contamination, and 6(40%) had a cover over them. The oldest well was dug in 2007 and the newest was dug in 2018. For the borehole water analyzed, 7(46.7%) were close to source of contamination (Table1 and Table 2)

Table 3 shows the physicochemical parameter of the water samples analyzed by standard procedures. All the water samples analyzed were colorless, tasteless and odorless. W4, W5 and B17 of the water samples contained visible particles. The pH of well water ranged from 5.72-8.90 and that of borehole water ranged from 5.10 -8.40. Four wells (W5, W6, W7 and W9) and five bore holes (B16, B17, B22, B25 and B27) have pH range that is not within the standard limit of 6.5-8.5 specified by WHO (2004). The coliform count using the most probable number from the positive presumptive test of the multiple tube fermentation carried out on the various water samples is shown in Table 4. The MPN value for the well water ranged from 12/100ml to 24/100ml while that of the bore hole ranged from 18.1/100ml to 24/100ml. High coliform count were also observed in other part of the country where ground water was microbiologically analyzed (Anyawu and Okoli, 2012; Eboh *et al*., 2017; Obioma *et al*., 2017). The high coliform count using the MPN technique does not conform to the Zero total coliform per 100ml of water (EPA, 2002).

The coliforms present in the water samples analyzed include *Klebsiella pneumonia, Enterobacter aerogenes, Citrobacter freundi,* and *Escherichia coli* (Table 5). *Escherichia coli* had the highest occurrence in both well and borehole with a percentage occurrence of 30.6 and 21.7% respectively (Table 6). Other pathogens isolated include *Salmonella typhi, Staphyloccocus aureus, Pseudomonas aeruginosa, Proteus vulgaris*. Similar

isolates were also obtained by Bello *et al*(2013) in Ijebu- ode South western Nigeria who isolated coliforms and *Staphylococcus aureus, Salmonella spp, Aerobacter aerogenes, Pseudomonas aeruginosa and , Proteus spp;* Tula *et al* (2013) in Mubi Metropolis, Adamawa also isolated *Proteus vulgaris* and *Salmonella spp* in addition to the coliforms. *Acinetobacter spp, Micrococcus spp,* and *Streptococcus spp* isolated by Eboh *et al* (2017) in Delta State from wells and Boreholes were not isolated in this studies.

The term "coliform" first coined by Blachstein in 1883 are Gram negative non spore forming aerobic or facultative anaerobic rods that belong to the family Enterobacteriaceae. They are well recognized for their ability to ferment lactose with gas and acid production. The presence of coliform and *Escherichia coli* may not cause any health problems but they are indicators of water contamination by pathogens such as bacteria, viruses and protozoa (WHO, 2002; Turtuello, 2003; Azizulah, 2011; Odonkor and Ampofo, 2013). *Staphylococcus aureus* is a gram-positive aerobic bacterium known for its enterotoxin production. It is a normal flora of the skin and mucous membrane but is also pathogenic. It is the leading cause of skin and soft tissue infection, osteomyelitis, pneumonia, endocarditis and device related infections (Barlette and Hulten, 2010;Otto, 2014; Koboyashi *et al*., 2015). *Pseudomonas aeruginosa* is a gram –negative, non-motile, non-fermenting opportunistic pathogen commonly found in the soil and surfaces in aqueous environment and have been implicated in respiratory tract infection in patience with cystic fibrosis, urinary tract infection, hospital acquired pneumonia in immune compromised individuals, skin and soft tissue infection, bacteria keratitis in patience with pre-existing ocular disease (Gellatly and Hancock, 2013; Alhazmi, 2015, Streeter and Katouli, 2016). *Proteus vulgaris* is a gram negative urease positive bacterium with swamming motility belonging to the family Enterobacteriaceae. They are part of the human intestinal floral but are also opportunistic pathogens that causes urinary tracts infection, wound, eyes skin, nose and throat infections(Mohammed *et al*., 2016). *Salmonella typhi* is a gram negative non spore forming facultative anaerobic rod that causes typhoid fever in humans (House *et al*, 2001; Tiwari *et al*., 2017).

Majority of the organisms isolated are of faecal origin indicating possible human and animal waste contamination(EPA, 2003; WHO,2004) The proximity of some of the water source to septic tanks and laterines,, poor hygiene and sanitation could be a route of water contamination. In addition The result of this research reveals that the water sources in Nbar and Butura in Bokkos local Government area of Plateau State are not fit for human consumption

TABLE 1: GENERAL INFORMATION ON THE WELL WATER

Source	DEPTH(M)	CASTING STATUS	Proximity to source of contamination	Cover	Year of excavation
W1	12.50	Casted	Far	Absent	2013
W2	13.00	Casted	Far	Absent	2011
W3	12.50	Not casted	Close	Absent	2007
W4	11.70	Not casted	Close	Present	2009
W5	12.50	Not casted	Far	Present	2010
W6	11.20	Not casted	Close	Present	2017
W7	9.30	Casted	Close	Absent	2018
W8	8.40	Casted	Far	Absent	2016
W9	10.70	Not casted	Far	Present	2015
W10	13.01	Not casted	Far	Absent	2018
W11	10.70	Casted	Far	Present	2014
W12	11.20	Not casted	Far	Absent	2016
W13	13.50	Not casted	Far	Absent	2017
W14	11.00	Casted	Close	Absent	2015
W15	12.10	Casted	Close	Present	2014

TABLE 2: GENERAL INFORMATION ON THE BORE HOLE

BOREHOLE SOURCE	PROXIMITY TO SOURCE OF CONTAMINATION	YEAR OF EXCAVATION
B1	Far	2007
B2	Far	2014
B3	Far	2014
B4	Close	2013
B5	Close	2016
B6	Far	2008
B7	Far	2010
B8	Far	2011
B9	Close	2013
B10	Close	2015
B11	Close	2017
B12	Far	2016
B13	Far	2016

B14	Close	2014
B15	Close	2017

TABLE 3: PHYSICO-CHEMICAL PARAMETERS OF THE WATER SAMPLES FROM MBAR AND BUTURA BOKKOS PLATEAU STATE, NIGERIA

S/N	SOURCE	COLOUR	ODOUR	TASTE	TURBIDITY	PH
1	W1	Colourless	Odourless	Tasteless	NVP	6.96
2	W2	Colourless	odourless	Tasteless	NVP	6.98
3	W3	Colourless	odourless	Tasteless	NVP	7.03
4	W4	Colourless	Odourless	Tasteless	NVP	??
5	W5	Colourless	odourless	Tasteless	VP	5.97
6	W6	Colourless	odourless	Tasteless	NVP	5.72
7	W7	Colourless	odourless	Tasteless	NVP	7.33
8	W8	Colourless	odourless	Tasteless	NVP	6.30
9	W9	Colourless	odourless	Tasteless	NVP	5.77
10	W10	Colourless	Odourless	Tasteless	NVP	7.27
11	W11	Colourless	Odourless	Tasteless	NVP	7.1
12	W12	Colourless	Odourless	Tasteless	NVP	8.7
13	W13	Colourless	Odouless	Tasteless	NVP	8.9
14	W14	Colourless	Odourless	Tasteless	NVP	7.0
15	B15	Colourless	Odourless	Tasteless	NVP	6.7
16	B16	Colourless	Odourless	Tasteless	NVP	5.82
17	B17	Colourless	Odourless	Tasteless	VP	5.10
18	B18	Colourless	Odourless	Tasteless	NVP	7.90
19	B19	Colourless	Odourless	Tasteless	NVP	8.40
20	B20	Colourless	Odourless	Tasteless	NVP	7.80
21	B21	Colourless	Odourless	Tasteless	NVP	7.72
22	B22	Colourless	Odourless	Tasteless	NVP	5.71
23	B23	Colourless	Odourless	Tasteless	NVP	7.44
24	B24	Colourless	Odourless	Tasteless	NVP	6.98
25	B25	Colourless	Odourless	Tasteless	NVP	6.39
26	B26	Colourless	Odourless	Tasteless	NVP	6.81
27	B27	Colourless	Odourless	Tasteless	NVP	6.01
28	B28	Colourless	Odourless	Tasteless	NVP	6.50
29	B29	Colourless	Odourless	Tasteless	NVP	7.1
30	B30	Colourless	Odourless	Tasteless	NVP	7.2
	Standard Limit	Colourless	Odourless	Tasteless	NVP	6.5-8.5

B= Bore hole, W= well water,
NVP= No visible particle

TABLE 4: COLIFORM COUNT USING THE MOST PROBABLE NUMBER (MPN)

	3X1Oml	3X1ml	3X0.1ml	MPN/100ml
W1	3	3	2	24
W2	2	2	3	17
W3	3	1	1	14
W4	3	1	2	17
W5	3	2	2	20
W6	2	2	3	17
W7	3	2	1	17
W8	1	2	3	12
W9	3	1	3	20
W10	3	2	3	24
W11	3	1	2	17
W12	3	2	3	24
W13	3	1	2	17
W14	3	2	2	20
W15	1	2	3	12
B1	3	1	2	17
B2	2	3	3	20
B3	2	3	1	14
B4	3	2	1	17
B5	3	2	1	17
B6	3	1	3	20
B7	3	1	2	17
B8	2	2	1	12
B9	3	2	1	17
B10	3	1	2	17
B11	2	1	1	9.2
B12	3	1	2	17
B13	1	1	2	8.1
B14	3	2	1	17

B15	2	2	1	12

TABLE 5: BIOCHEMICAL CHARACTERISTICS OF ISOLATES

Isolate	Gram staining	Catalas	Urease	Citrate	Motility	Indole	TSIA(B/S/G/H_2S	Organism
DOT I	Gram negative rods	+	-	-	+	+	Y,Y, +, -	*Escherichia coli*
DOT 2	Gram negative rods	-	+	+	-	-	Y,Y,+,-	*Klebsiella pneumonia*
DOT 3	Gram positive rods	+	+	-	+	+	Y,R,+,+	*Proteus vulgaris*
DOT 4	Gram negative rods	+	-	+	+	-	Y,R,-, -	*Salmonella typhi*
DOT 5	Gram negative rods	+	-	+	+	-	Y,Y, +, -	*Citrobacter spp*
DOT 6	Gram negative rods	+	-	+	+	-	Y,Y,+,-	*Enterobacter aerogenes*
DOT 7	Gram negative rods	-	-	+	+	-	R,R,-,-	*Pseudomonas aeruginosa*
DOT 8	Gram positive cocci	+	+	+	-	-	Y,Y,-,-	*Staphyloccocus aureus*

KEY : - = negative, + = positive, Y= Yellow, R= Red,

TABLE 6: PERCENTAGE OF OCCURRENCE OF ORGANISM FROM THE WATER SAMPLES

S/N	Samples	Organism	frequency	% of occurrence
1	Borehole	*Escherichia coli*	10	21.7
2	Borehole	*Salmonella typhi*	6	13.0
3	Borehole	*Klebsiella pneumonia*	7	15.2
4	Borehole	*Proteus vulgaricus*	5	10.9
5	Borehole	*Staphylococcus aureus*	4	8.7
6	Borehole	*Citrobacter freundii*	5	10.9
7	Borehole	*Enterobacter aerogenes*	4	8.7
8	Borehole	*Pseudomonas aeruginosa*	5	10.9
1	Well	*Escherichia coli*	11	30.6
2	Well	*Salmonella typhi*	5	13.9
3	Well	*Klebsiella pneumonia*	4	11.1
4	Well	*Enterobcter aerogenes*	6	16.7
5	Well	*Proteus vulgaricus*	2	5.6
6	Well	*Staphylococcus aureus*	3	8.6
7	Well	*Citrobacter aerogenes*	3	8.3
8	Well	*Pseudomonas aeaeruginosa*	2	5.6

IV. Conclusion

The availability of safe portable water is a global challenge particularly in developing nations . Most people will continue to depend on ground water which may be polluted with human, agricultural, animal and industrial waste. The bacteriological quality of well and Borehole water in Ndar and Butura reveals that the water did not meet WHO and EPA standard for drinking water. The presence of pathogens in this water source can result in water borne diseases. It is highly important that Government should direct the right agencies to take drastic steps in the provision of pipe borne water for the populace. The residence in these areas should be properly educated on personal hygiene, sanitation and the healthy construction and location of wells and Boreholes meters away from contamination point. Microbiological and physicochemical analysis of these water samples should be carried out on regular basis by NAFDAC to check for contamination and act accordingly to prevent disease out break.

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