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Bacteriological Pollution of Rural Groundwater of Benue State, Nigeria

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Abstract

Pollution indicator bacteria were used in assessing the microbial quality of rural groundwater of Benue State.Water samples were collected from 26 rural community boreholes in the months of February and October for the dry and wet seasons respectively. The analyses was done according to standard methods of examination of water using multiple tube fermentation and most probable number(MPN) techniques in the determination of total coliform and faecal coliforms.The results was reported based on WHO drinking water guidelines. The results of analyses show all the boreholes have total coliform counts in varied concentrations for the wet and dry seasons.Coliform count ranged between $0.4x10^1$ and $1.7x10^1$(4-170) for wet season as against $0.4x10^2$(2-140) for dry season.Faecal coliform (Escherichia coli) of health implication were noted in 6(23%) of the boreholes and 4(15%) of the boreholes for wet and dry seasons. The presence of coliform bacteria in these boreholes may attributed to the sanitary environment of the boreholes as open defecation is common in the rural areas and poor construction and maintenance of the waterpoints.Discinfection, community protection of the boreholes and control of water polluting activities should be encouraged to safeguard the quality of drinking water for rural population. There is need for rural water developers to ensure that the bacteriological safety of groundwater harnessed by taking necessary precautions at the construction, finishing and maintenance stages of boreholes as contamination can occur at any stage. Local communities should be involved in all stages of development projects that affect their welfare.

Keywords
Bacteria, coliform, groundwater, wet and dry seasons.

Introduction

Groundwater pollution has become a major subject of public concern the world over. Although groundwater within aquifers is generally of good microbial quality, it can become contaminated if protective measures at wells, boreholes or springs are not well maintained. The control of microbiological quality of water remains the highest priority of WHO because of the potentially devastating consequences of water borne infectious disease (MacDonald et al,2005).For rural water supplies ,treatment of water is rarely possible, so emphasis is on adequate protection measures so that the quality of water provided at the pump remains good. It has been estimated that consumption of untreated contaminated groundwater, faulty well construction, and improper well location are the primary causes of waterborne outbreak(Craun and McCabe,1973; Lamka,

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Lechevallier and Seildler, 1980).With respect to microbial quality, the guideline and standard specify a complete absence of indicator organism such as E-Coli,enterococci or therm-tolerent coliform, and this remains the dominant concern in provision of safe drinking water(MacDonald et al,2005).The microbiological quality of drinking water has been implicated in the spread of infectious and parasitic diseases such as cholera, typhoid, dysentery, hepatitis, giardiasis, guinea worm and schistosomiasis in the tropics (Bradley,2003).The presence of coliforms in a high proportion in water samples is a good indicator of water contamination and the presence of E-Coli is an enteric pathogen responsible for gastroenteritis in human(Robbin-Brown,1987). According to Reiff et al(1996) the worldwide interest in the quality of drinking water stems from the documented association between contaminated water and diarrheal diseases. Faecal contamination combined with failure to adequately treat water has resulted in many waterborne diseases (Bridgman et al, 1995; US CDCP, 1994)

Several studies have shown bacteriological pollution of rural groundwater in different parts of the world. In rural Trinidad, Welch et al (2000) found that of the 167 households water tested, total coliform were detected in 132 (79.0%) faecal coliform in 102 (61.1%) and Escherichia coli in 111 (66.5%) samples and concluded that the water was not fit for drinking. In similar studies, Mackintosh and Colvin(2004) noted that overall scheme dependent on groundwater in rural western and eastern Cape South Africa failed microbial drinking water criteria.WaterAid(2005) in sanitary risks assessment noted that all the boreholes and hand dug wells sampled failed bacteriological criteria in rural Zambia and in rural Malawi, all the shallow wells examined were heavily polluted with both total and faecal coliforms(Prichard et al,2008). In rural province of South Africa where the poorest people rely on groundwater, out of the 29 boreholes sampled 20 (77%) had detectable Escherichia coli which was attributed to lack of protection of the boreholes and indiscriminate grazing of livestock up to well head (Kelly,2007).

Coliform bacteria are the standard used for bacterial quality in drinking water. They are used as indicator of sanitary quality of food and water. The presence of coliform bacteria in drinking water indicates that the water was not properly treated to eliminate pathogens or that sewage or some type of surface water is entering and contaminating the water supply. Along with coliform bacteria, other disease causing organism may be present, and these can cause diseases such as dysentery, typhoid and hepatitis.A well contaminated coliform bacteria requires immediate attention (Kljujev and Raiceevic, 2006)

Groundwater exploitation is generally preferred in rural water supply because of the advantages it has over surface water(MacDonald et al, 2005; Habila,2005).However, the susceptibility of groundwater to pollution from both physical and anthropogenic activities remains a great concern in rural water supply (Edmunds and Smedley,1996; Bresline,2007; Ocheri,2010).

Benue State is predominantly a rural State with over 75% of the population residing in rural areas. The quality and safety of life of these people are in danger as they lack access to improved water supply, efficient health care delivery, good road, power supply etc. Provision of safe water supply to rural communities by governments and non-governmental organization in the State is through borehole systems. Water from some of the boreholes are of doubtful quality due to the presence of colour, odour and taste which are indications of pollution (Ocheri, 2010). Providing water that is not safe bacteriologically is another potential health hazard.According to Adesiyun,Adekeye,and Umoh and Alabi (1983) and Adekeye (1986) rural communities especially in the developing countries are generally at the mercy of service providers as such water of poor quality may be provided for them.Bacteriological examination of water is considered a powerful and foremost tool in order to foreclose the presence of microorganism that might constitute health hazard (Bonde, 1977). The coliform group of organism is used worldwide as indicators of faecal pollution being normally associated with faeces and water. They are characterized broadly by their ability to ferment lactose in culture at 35^0C or 37^0C with the production of both acetaldehyde and gas within 48hours.Hence, this study will attempt to examine the safety of water from rural community boreholes of Benue State.

The Study Area

The study area covers rural communities in the 13 Local Government Areas (LGAs) of Benue State. It lies between Lat.6^0.32N and 8^0.05N, and Long7^0.52E and 10^0.00E.The area shares boundaries with other LGAs Gwer west, Otukpo, and Okpokwu to the west, and Ukum and Kwande to the east. It is bounded in the north by Nasarawa and Taraba States and in the south by Ebonyi and Cross River States(Fig.1). It has a landmass of about 20,732 sq km with a population of 2,195,041(NPC, 2006).The geology of the study area is principally of sedimentary formation with pockets of basement complex. This consists of sandstones, mudstones and limestone that influence both surface and groundwater availability (Kogbe, et al, 1978, Abaa, 2004) .Major rivers that drain the study area are River Benue and its tributary, River Katsina-Ala. Other rivers include Aya, Guma, Konshisha, Logo, Mu, Okpokwu, Obi etc. These rivers constitute traditional sources of drinking water for the rural communities of Benue State. During the dry season water from some of these sources do dry up completely.Consquently, the rural communities are faced with intense water scarcity leading them to source for drinking water from all sorts of places. The implication is that they are exposed to all kind of water related diseases.

Material and Methods

Data for this study were obtained from water samples collected from 26 rural community boreholes across the study area.Two sets of water samples were collected in the months of October and February representing wet and dry seasons. In October, highest rainfall is experienced in the study area and vulnerability to pollution is often expected as water tables will generally rise.Whereas in February, one of the extreme months of dry season when there is general reduction in water table and infiltration contaminants is eliminated hence lesser pollution is expected. .The water samples were analyzed according to standard method of examination of water (APHA-AWWA-WPCF, 1995) and reported in WHO standards for drinking water.

Total coliform and faecal coliform bacteria were determined using multiple tube fermentation and most probable number (MPN) techniques. Media used include nutrient agar for bacteria count, macConkey agar for coliform count. Total coliform organisms were determined at 37oC which enables the detection of small number of coliform organisms (1-10) organism per 100ml.From each dilution it was taken 1ml and added aseptically in order to triplicate tube containing 5ml of macConkey broth. The tubes were then incubated at 37^0 C for 24hours for total coliforms and at 44^0C for faecal coliform. The combined results of all the tubes were statistically interpreted to arrive at the most probable number (MPN) density.

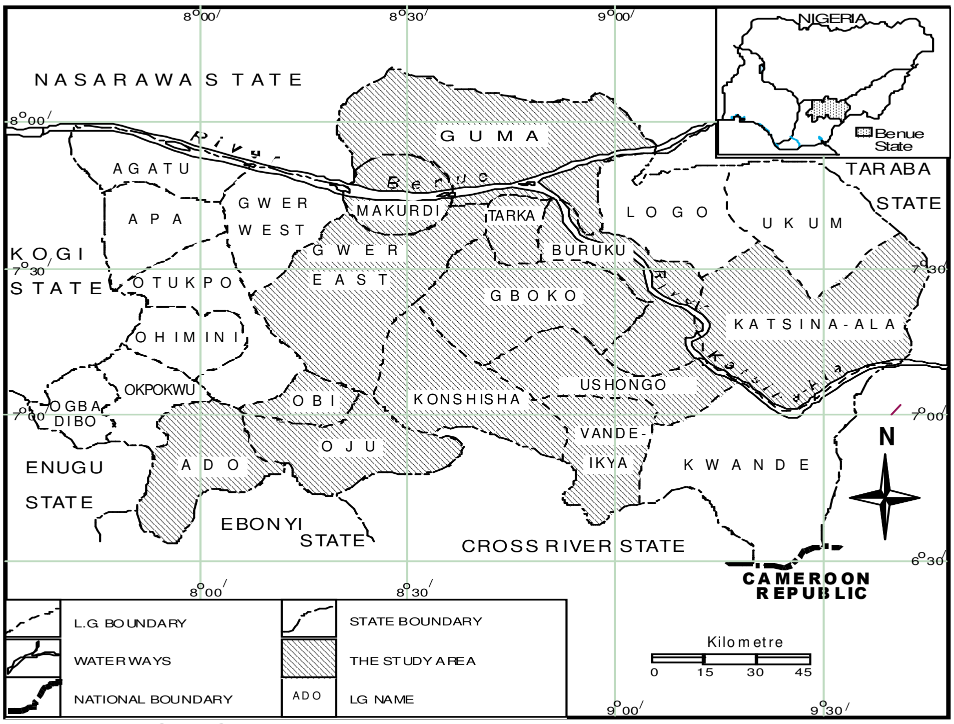

Fig.1 - Benue State Showing the study Area
Source: Benue State Ministry of Lands and Survey

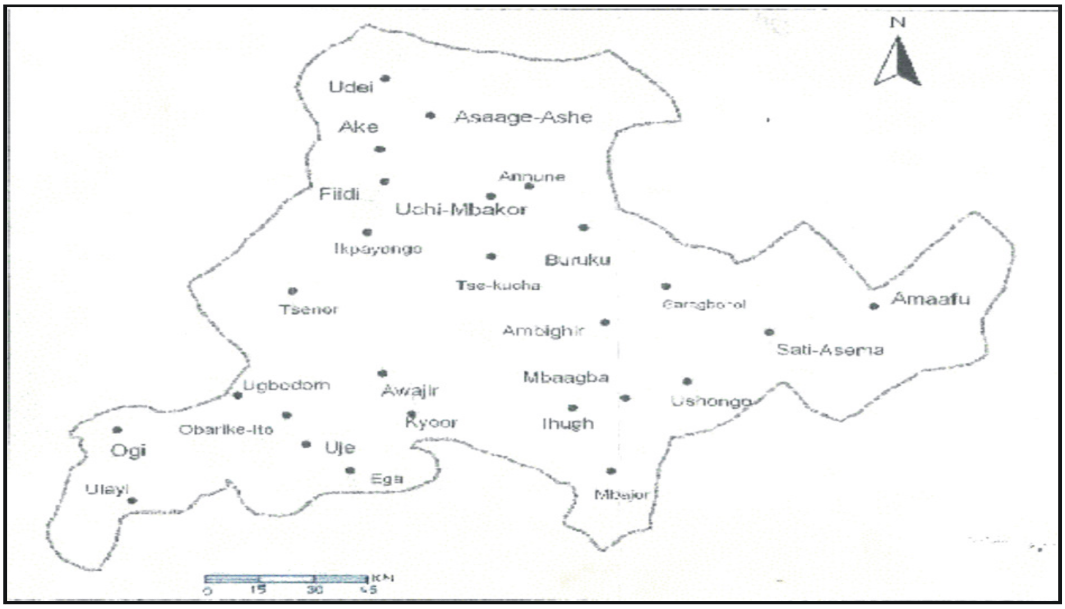

Figure 2. Location of Rural Communities Bore holes in in Benue state

Results and Discussion

Table 1 and Figure 2 show the location of the boreholes and their characteristics in terms of depth, static water level and yield. These characteristics have the capacity of influencing the release, transmission and dilution of contaminant in groundwater. For instance, shallow wells are more prone to pollution from infiltrating run off and bacteriological contamination than deep wells.Offodile (2000) noted that most bacteria and other biological contaminants are removed during percolation of water into the aquifer, but the degree of removal depends on permeability. Hence, coliform bacteria can be found in shallow wells with high water tables or wells very close to sewage tanks, pit latrines and other sources of pollution with which it maintains hydrologic contact. But in deep well-protected boreholes, harmful group of bacteria can be introduced during drilling. The boreholes in the study area has a mean depth of 35.9m; static water level 5.65m, and yield 89.89m^2 .This implies water table is generally high and therefore prone to bacteriological pollution.

From Table 2 all the boreholes examined have coliform count bacteria in varied concentrations both for the wet and dry seasons. For wet season,coliform bacteria ranged between $0.4x10^1$ and $1.7x10^1$(4-170) and 0.2x101 and $0.2x10^1$ and $0.4x10^2$ (2-140)for the dry season. Faecal coliform (Escherichia coli) of health implication is found in BH 11,BH12, BH 14,BH17,BH23 and 24 for the wet season as against that of the dry season as noted in BH11,BH17 and BH 24.Total coliform counts were generally higher in the wet season than in the dry season. This is consistent with the findings of Bowell et al (1996).

The presence of these bacteria may not be unconnected with the general high water table in the study area making them highly susceptible to overland pollution arising from organic and inorganic materials. The presence of Escherichia coli originating from human and animal wastes in 6(23%) of the boreholes especially in the rainy season is a reflection of open defecation a common practice in rural areas. With rainfall, these wastes are washed down to pollute groundwater sources. Indiscriminate animal grazing was also noted in our study area.

The entry of these bacteria into groundwater may be traced to improper drilling and flushing of the boreholes at the construction stage. Since they are thermo-tolerant bacteria they can survive under very difficult biological conditions.

The study has not shown any clear relationship between bacteriological loads and well depth, static water level and yield. For instance BH17 with the highest total Coliform count of $1.7x10^2$ has a depth of 34m, static water level 5m and yield of 80m^2 .Whereas BH 21 with the depth of 18m, static

Table 1: Borehole characteristics

Community	Code	Depth(m)	Static Water level(m)	Yield(m^2)
Ikpayongo	BH1	47	4	180
Tsenor	BH2	40	13.2	62
Awajir	BH3	37	5	85
Kyoor	BH4	34	6.8	98
Ega	BH5	33	6.1	36
Uje	BH6	24	1.72	36
Obarike-Ito	BH7	22.5	6	200
Ugbodom	BH8	32.5	6.8	142
Ogi	BH9	39	1.72	150
Ulayi	BH10	30	2.3	208
Asaage-Ashe	BH11	41.5	2.3	36
Udei	BH12	33.5	5	180
Fiidi	BH13	29	1.78	72
Ake	BH14	38	3	40
Uchi-Mbakor	BH15	33	6.6	30
Annune	BH16	65	6	45
Ambighir	BH17	34	5	80
Tse Kucha	BH18	52	2.2	0.4
Garagbohol	BH19	54	5.2	100
Buruku	BH20	26	6.5	38
Sati-Asema	BH21	18	11.5	1.22
Amaafu	BH22	28	5.4	120
Mbaagba	BH23	45	5.2	140
Ushongo	BH24	30	6.3	102
Ihugh	BH25	41	6.4	100
Mbajor	BH26	27	6.2	42
	Mean	35.9	5.63	89.87
	STD	10.33	2.8	59.27

Table 2: Results of Bacteriological Analyses of Groundwater for the Wet and Dry Seasons

	WET SEASON		DRY SEASON	
	Counts MPN 100 ML	F. COL MPN	COUNTS MPN 100 ML	F. COLI MPN 100 L
BH1	$0.7x10^{1}$	N/D	$0.6x10^{1}$	N/D
BH2	$0.9x10^{1}$	N/D	$0.6x10^{1}$	N/D
BH3	$0.6x10^{1}$	N/D	$0.4x10^{1}$	N/D
BH4	$0.6x10^{1}$	N/D	$0.7x10^{1}$	N/D
BH5	$0.9x10^{1}$	N/D	$0.9x10^{1}$	N/D
BH6	$1.4x10^{1}$	N/D	$1.7x10^{1}$	N/D
BH7	$0.4x10^{1}$	N/D	$0.8x10^{1}$	N/D
BH8	$0.4x10^{1}$	N/D	$0.6x10^{1}$	N/D
BH9	$0.9x10^{1}$	N/D	$0.8x10^{1}$	N/D
BH10	$0.7x10^{1}$	N/D	$0.9x10^{1}$	N/D
BH11	$1.4x10^{2}$	$0.2x10^{1}$	$1.1x10^{2}$	$0.2x10^{1}$
BH12	$0.9x10^{1}$	$0.2x10^{1}$	$0.9x10^{1}$	$0.2x10^{1}$
BH13	$0.6x10^{1}$	N/D	$0.4x10^{1}$	N/D
BH14	$0.9x10^{1}$	N/D	$0.7x10^{1}$	$0.2x10^{1}$
BH15	$0.8x10^{1}$	N/D	$0.4x10^{1}$	N/D
BH16	$0.6x10^{1}$	N/D	$0.4x10^{1}$	N/D
BH17	$1.7x10^{2}$	$0.2x10^{2}$	$0.4x10^{2}$	$0.2x10^{1}$
BH18	$0.9x10^{1}$	N/D	$0.4x10^{1}$	N/D
BH19	$0.8x10^{1}$	N/D	$0.8x10^{1}$	N/D
BH20	$0.9x10^{1}$	N/D	$0.9x10^{1}$	N/D
BH21	$0.4x10^{2}$	N/D	$0.6x10^{1}$	N/D
BH22	$0.9x10^{1}$	N/D	$0.6x10^{1}$	N/D
BH23	$1.4x10^{2}$	$0.2x10^{1}$	$0.8x10^{1}$	$0.2x10^{1}$
BH24	$1.7x10^{2}$	$0.4x10^{1}$	$1.4x10^{2}$	$0.4x10^{1}$
BH25	$0.4x10^{2}$	N/D	$0.4x10^{1}$	N/D
BH26	$0.4x10^{1}$	N/D	$0.2x10^{1}$	N/D

Source: Author's Fieldwork, 2010

N/D Not detected

water level 0f 11.5m and yield of 1.22m2 has total Coliform of $0.4x10^2$ in the wet season.

Conclusion

This study has shown that bacteriological safety of boreholes for rural water supply is in question. All the boreholes examined show the presence of coliform counts and faecal coliform in their varied concentrations among the seasons. The bacteriological loadings in groundwater were noted to be higher in the wet season. Possible causes of bacteriological pollution groundwater in the study area include sanitary environment of the boreholes and improper construction and maintenance of the boreholes. To counter the bacteriological risks in groundwater, there should sanitary surveillance, all land use polluting activities such as open defecation by humans and indiscriminate grazing by animals should be restricted. There is the need for rural developers to ensure the bacteriological safety of groundwater exploited by taking precautionary measures at the construction stage especially in site selection, drilling and materials used in boreholes construction and their maintenance. Rural communities that are beneficiary of these schemes should be involved in all stages of project as to enable them share in the responsibility of protection and maintenance of the boreholes.

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