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Original Research Paper

Physical and Microbiological Quality of Drinking Water Sources in Gwafan Community, Plateau State, Nigeria

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Access to safe drinking water remains a target for many developing countries with an ever expanding population. This study aimed to identify drinking water sources in a community of Jos North and determine certain physical and microbiological quality. A total of 3 boreholes and 65 wells were identified in the community. Physical parameters showed that 19 water sources had low pH values and 63 of the wells had higher turbidity values. Color and odor were not detectable in any of the samples. Coliforms were detected in 2 boreholes and 30 of the wells examined. Organisms that were isolated included *Citrobacter sp*., *Enterobacter sp*., *Escherichia sp*., *Klebsiella sp*., and *Serratia sp*. Disinfection of drinking water was recommended to the members of this community.

Keywords: Drinking water, sources, physical quality, microbiological quality, Plateau.

INTRODUCTION

Water quality is a growing concern throughout the developing world. Drinking water sources are under increasing threat from contamination by natural and man-made influences with detrimental consequences on the health of individuals, families, communities and the nation at large. [1] The pollution of drinking water is responsible for a large number of morbidity and mortality from water borne diseases like typhoid, cholera, dysentery, and hepatitis as well as many protozoal and helminthic infestations. It is estimated that under 5 mortality rate in Nigeria due to diarrheal diseases is 13.5%. [2] Over the last decades, access to potable drinking water has been achieved in almost every part of the world. However, safe drinking water still remains inaccessible to about one billion people, and adequate sanitation is not accessible to over 2.5 billion people. [2] It is estimated that 41% of 160 million Nigerians do not have access to potable water supply, with rural areas having a higher proportion than those of the urban areas. [3]

The reports by Water Supply and Sanitation Baseline Study (WSSBS) and the UNICEF/WHO Joint Monitoring Program (JMP) have shown that Nigerian water supply has not kept pace with meeting the Millennium Development Goal (MDG) target of 75% coverage for safe drinking water. [4] This is however not unconnected to several challenges faced in providing potable drinking water to all communities which could be attributed to increased population density and urbanization, industrialization, inadequate and inequitable distribution of adequate surface and ground water supply and the global threat of climate change. [5] When potable water is not sufficient in adequate quantity and quality for household consumption, people would be compelled to use contaminated water from less hygienic sources with resultant water related diseases and outbreaks. Major sources of water supply within Jos Metropolis and the environs are mainly tap water (piped into dwellings or public tap); borehole; ground water from protected and unprotected wells and springs; surface water from rivers, lakes and streams; rainwater and within the last decade- bottled water. Well water is mainly used by a majority of the populace within Jos metropolis and environs but its quality for household consumption is still left to be desired. [6]

The primary goal of this research is to assess the suitability of the water for drinking and other domestic purposes by assessing the physical and microbiological quality of drinking water sources in Gwafan community, Lamingo ward of Jos, Plateau State.

METHODS AND MATERIALS

The study was conducted in Gwafan community, Lamingo Ward of Jos North Local Government Area (LGA) of Plateau State. The semi-urban community with an estimated population of 130,000 is located about 6 km east of the Jos municipal area, the capital of the State. [7] The community's population is continuously rising due to the relocation of the Jos University

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Teaching Hospital to the permanent site situated within the ward. Gwafan is located between latitude 80° 24´N and longitude 80° 32´ and 100° 38´ east. The altitude ranges from 1,300 metres to a peak of 1,709 metres above sea level. The temperature of the area ranges from 17 - 35°C yearly, with the highest temperature experienced in the month of March. The mean annual rainfall ranges from 131cm to 146cm. [8]

The dominant native tribe residing here is the Afizere. Other tribes native to the area are the Anaguta and Berom. The predominant religion is Christianity. Subsistence farming/ nomadic agriculture, hunting and trading are the main occupation of the populace. Facilities around the area included privately owned nursery/primary schools, a primary health care facility, a theological college and a tertiary health care facility. A descriptive cross-sectional study was carried out to assess the quality of water sources. There were a total of 733 households in the community. Their water sources were identified by inquiring from each household where water was obtained for drinking and household use. A total of sixty eight (68) different water sources were identified; three (3) boreholes and sixty five (65) wells. Samples were taken from all water sources used by the community. They were collected using sterilized 1 litre plastic containers, kept in a cold box, transported to the laboratory and stored in the refrigerator and analysis for microbiological examination was done within 9 hours of collection. Physical parameters of temperature and pH of the samples were measured on site using potable thermometer and electrode respectively. Turbidity and color were analyzed using the absorptiometric and the alpha-platinum-cobalt standard methods respectively. Odor was detected with the use of human sensory organ.

Microbial analysis of the sample involved the use of the Agar plate count method for coliform count. The samples were incubated at temperatures of 22 - 37 °C degrees centigrade in eosin methylene-blue agar for 48 hours. All data generated was processed using the statistical software EPI info version 3.5.4 (2008). Quantitative data are presented using mean and standard deviation, while qualitative data are presented using frequency tables. Permission for the study was sought and obtained from the ward and village heads of Gwafan who also assisted in mobilizing the community for the survey.

RESULTS

A total of 68 water sources were sampled of which 65 (95.6%) were wells and 3 (4.4%) were boreholes. Water was obtained from one of the boreholes through a hand held pump while the other 2 were from taps connected to the boreholes. Most of the wells (53.8%) were located outside the household premises while thirty (46.2%) wells were located within. (Table 1) Six (9.2%) wells were located less than 30 meters from a potential source of contamination. All the wells (100%) had covers and about half (50.8%) had concrete aprons constructed around them. Most (75.4%) of the wells had no attached permanent fetcher.

Table 1: Characteristics of the wells

Characteristics	Frequency	%
Location of well		
Within household compound	30	46.2
Outside household premises	35	53.8
Presence of a cover		
Yes	65	100.0
No	0	0.0
Presence of a potential source of contamination (<30m)		
Yes	6	9.2
No	59	90.8
Concrete apron		
Present	33	50.8
Absent	32	49.2
Presence of an attached fetcher		
Yes	16	24.6
No	49	75.4

The entire water samples were colorless and odorless. The mean temperature range of well water sources was 21.7 ± 1.9 °C while that of the boreholes was 21.3 ± 2.9 °C. The mean pH for wells was 6.7 ± 0.6 while for the boreholes, it was 6.2 ± 0.3. The majority of the wells (72.3%) had pH values within normal range. Seventeen (26.2%) had values less than the acceptable standard while a well had a pH value above 8.5. Only one of the three boreholes sampled had a pH value within the normal range while the other two had pH values below 6.5. All the boreholes sampled had an acceptable turbidity of not more than 5.0 NTU. Most of the wells (96.9%) however had turbidity above the acceptable limit with a mean turbidity measurement of 12.9 ± 5.6 NTU. (Table 2)

Table 2: Physical properties of water samples

Source	Parameter	Measurement	Frequency	%
Borehole	**pH**	< 6.5	2	66.7
		Within 6.5 – 8.5	1	33.3
		> 8.5	0	0.0
	Turbidity	≤ 5	3	100.0
	(NTU)	> 5	0	0.0
	Color	≤ 15	3	100.0
	(TCU)	> 15	0	0.0
	Presence of odor	Yes	0	0.0
		No	3	100.0
Well	**pH**	< 6.5	17	26.2
		Within 6.5 – 8.5	47	72.3
		> 8.5	1	0.5
	Turbidity	≤ 5	2	3.1
	(NTU)	> 5	63	96.9
	Color	≤ 15	65	100.0
	(TCU)	> 15	0	0.0
	Presence of odor	Yes	0	0.0
		No	65	100.0

Only one (33.3%) of the boreholes as against 35 (53.8%) of sampled wells met the recommended criteria of the coliform count of zero per 100ml of water, 14 (21.5%) wells had values of 1-10 coliforms / 100ml and 16 (24.6%) wells had values as greater than 10 coliform/ 100ml. Microbiological analysis indicated the presence of coliforms. (Tables 3 and 4) The mean total coliform counts were 30.7 ± 35.8 and 30.3 ± 149.0 cfu/100ml in the boreholes and wells respectively. Bacterial isolates obtained included *Citrobacter sp*., *Enterobacter sp*., *Escherichia sp*., *Klebsiella sp.,* and *Serratia sp*.

Table 3: Microbial quality of sources

Source	Parameter	Measurement	Frequency	%
Borehole	**Coliform count (cfu/100ml)**	0	1	33.3
		1-10	0	0.0
		> 10	2	66.7
Well		0	35	53.8
		1-10	14	21.5
		> 10	16	24.6

Table 4: Microbial isolates from water samples with confirmed presence of coliforms

Bacteria specie	Source of water	
	Borehole (%) N=2	**Well water (%) N = 30**
A - *Citrobacter spp.*	1 (50.0)	6 (20.0)
B - *Enterobacter spp.*	1 (50.0)	3 (10.0)
C - *Escherichia spp.*	1 (50.0)	6 (20.0)
D - *Klebsiella spp.*	1 (50.0)	6 (20.0)
E - *Serratia spp.*	1 (50.0)	2 (6.6)

DISCUSSION

The main sources of water found in this community were wells and boreholes. There was a total absence of piped tap water. Studies conducted in Kwara State and Ijebu – North area of Ondo State of Nigeria reported similar findings. [9, 10] The latter study indicated that only three percent (3%) of the people have access to clean and safe pipe-borne water while the remaining 97% relied on streams, rain water, wells and springs for their domestic uses. [10,11] The provision of safe pipe-borne water has proved a challenge to the government of the country and this in the face of an ever increasing population such as the community under study. This may in future put pressure on existing water resources and highlights the need for proper water management in this community.

The WHO/UNICEF Joint Monitoring Program for Water and Sanitation regards that a “protected dug well is a dug well that is protected from runoff water by a well lining or casing that is raised above ground level and a platform that diverts spilled water away from the well. A protected dug well is also covered, so that bird droppings and animals cannot fall into the well.” [11] If any of these characteristics are absent, the well is regarded as being “unprotected”. Based on this classification, 49.2% of the wells in this community will be regarded as unprotected. In addition, nearness to potential sources of contamination has been shown to further reduce the quality of wells as was seen in 6 of the wells in this study. [12, 13] This situation puts members of this community at risk of diseases such as typhoid, cholera, Hepatitis A, guinea worm and diarrheal diseases as has been seen in other studies. [14]

Temperature

Temperature tends to affect other physical parameters of water. It affects color and turbidity because it affects coagulation. It also increases odor as increasing temperature increases vapor pressure of trace volatiles. The growth rate of microorganisms is also positively associated with temperature. [15] Ground water is known to have stable temperatures as was seen in this study where the temperature range was between 18 – 24 °C. At this level, odors are less detectable the growth of micro-organisms is reduced in the wells. The lower temperatures also means the water will be more palatable to consumers who may drink to quench thirst and not consider that there might be contamination.

Color

In this study, no water sample had color values beyond the recommended. This was despite the high level of turbidity. This may be explained by the phenomenon of “apparent color” and “true color”. The former is color measured in water that contains suspended matter while the latter is measured in water samples from which particulate matter has been removed by centrifugation, [15] true color being substantially less than apparent color. Color may result from the presence of organic substances, metals such as iron, manganese and copper and certain industrial wastes such as those from the textile industries. The absence of color indicates that such contaminants may not be present in the water sources in this community, especially with the lack of mines and industries in this locality.

Odor

Odor is detected by stimulation of the olfactory nerves and is closely related to taste. Good quality water should not have objectionable smells. Consumers may easily detect water contamination through the presence of odors. It may indicate the presence of decaying organic matter, pesticide poisoning and in some cases the presence of disinfectants that have been used for treatment. None of the samples were detected to have objectionable odors and this again may allow the presumption by the community that the water is free of contaminants which in this study was shown not to be so from the microbiological analysis.

pH

The pH parameter is the standard measure of how acidic or alkaline a solution is. It is measured on a scale from 0 – 14. According to WHO and SON standards, the safe pH range of water is between 6.5- 8.5. Low pH values can alter the taste of water; corrode pipes and household water storage appliances. In this study 2 (66.7%) of the boreholes and 17 (26.2%) of the wells had values below the value of 6.5 recommended by

WHO and SON. This finding is similar to a study in Jos that assessed the quality of wells and found 17 (47.5%) of the wells assessed had pH values less than 6.5. [6] Another study in Jos attributed the findings of lowered pH in wells to the acidifying of rain water in the environment which is reducing ground water pH. [16] Low pH values may corrode common household metals and increase the chemical toxicity of drinking water especially if metal containers are used for storage. One of the wells was found to have a pH above the recommended 8.5. Alkalinity has been demonstrated to cause eye irritation, exacerbation of skin disorders, swelling of hair fibers and gastrointestinal irritations in sensitive people. [17] However, these disorders cannot be confirmed in this community as it is beyond the scope of this study.

Turbidity

Turbidity measurements indicate the level of materials that are suspended in the water. It therefore expresses the light scattering and absorbing properties of water caused by the presence of particles such as clay, silt, colloids and micro-organisms. [18] Turbidity promotes microbial proliferation and encourages formation of complexes that affect the chemical quality of water. Most of the wells in this study were found to have turbidity levels above the acceptable value of 5 NTU. Studies across Nigeria have demonstrated that this finding is common. [19,20,21] Since the use of wells as a drinking water source is so common in the country, there is a need to encourage communities to use flocculants in the treatment of groundwater which will clarify the water and further discourage the growth of microbes.

Microbiological quality

A good proportion of both the boreholes and wells had the presence of coliforms. Water obtained from boreholes is perceived to be purer than those obtained from wells in this environment. This study showed that 2 out of the 3 boreholes had high coliform counts. This finding has repeatedly been demonstrated in studies conducted in various parts of Nigeria.[22 – 27] Similarly, almost half of the wells demonstrated microbial contamination which is also a consistent finding in many studies conducted in the country. [28, 32] Many of these studies attribute this situation to the poor state of environmental sanitation and poorly built wells. However, when wells are properly protected this contributes to lower microbial contamination as was seen by a study done in another local government area of Plateau State. [33] This finding shows that the community is at risk of waterborne diseases and possibly epidemics. The bacterial isolates *Citrobacter sp*., *Enterobacter sp*., *Escherichia sp*., *Klebsiella sp*., and *Serratia sp*., are also similar findings to the ones seen in the earlier mentioned studies. They are all faecal organisms and indicate that the ground water in this area is being contaminated with faecal waste possibly from poor sanitary practices and poor sitting and construction of the wells and boreholes.

CONCLUSION AND RECOMMENDATIONS

In Gwafan community about half of the wells were found to be unprotected. Most of the wells had high turbidity levels, while low pH was seen in some of the wells. Some of the wells and boreholes were also contaminated with coliforms. Based on these findings the community should disinfect these water sources before consumption. Technical assistance from government agencies responsible for water resources management is required in the provision of hygienic wells and future planning of water sources for this expanding community to ensure sustainability.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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