Global Scientific JOURNALS

GSJ: Volume 8, Issue 5, May 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

COMPARATIVE STUDY OF DRINKING WATER SOURCES IN MAKURDI BENUE STATE NIGERIA

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KeyWords
Coliform, contamination, bacteria, *Enterobacter spp*, most probable number, Water,

ABSTRACT

Water samples were collected from boreholes, hand dug wells, tap and the river side from four different locations within Makurdi Metropolis and were analyzed to compare their bacterial load using their coliform content. The most probable number method was used for the analysis of the water sources. A total heterotrophic count of bacteria was also conducted to confirm the coliform number gotten from using the MPN method. The results obtained from the most probable number method show a high level of colifom presence in all the water samples examined which is an indication of faecal contamination. The highest number of organism isolated from each of the sample *was Escherichia coli*, the others include *Enterobacter aerogens* and *Klebsiella pneumonia* which are also enteric bacteria, and suggest faecal. The average coliform count for well water samples was 546MPN/100ml, 416 MPN/100ml for boreholes and tap water and river water with 266MPN/100ml. the results show gross contamination especially the most trusted water source, pipe-borne water; it points to lack of proper sanitation practice adopted by the people in these area of study and negligence on the part of the government to ensure potable water for her people.

Introduction

Water is seen as one of the most important element for all forms of life. It is indispensable in the maintenance of life on earth. It is also essential for the composition and renewal of cells. But human activities are continuing to pollute water sources resulting in provoking water related diseases (WHO, 2008).
About 73% of the earth's surface is covered by water and more than 97% of all the water occurs in the ocean. The lakes, rivers, ponds, streams, ice and groundwater comprise the rest. Water serves as a major constituent of the human body for physiological and chemical processes and thus essential for health and life. Its availability and consumption is very vital for man's survival and sustainability (Sobsey, 2002). However, according to the World health organization and UNICEF, over one billion people worldwide do not have access to safe, drinkable water and about 40% of the world population lacks basic sanitation (WHO/UNICEF, 2014). Good health is dependent upon a clean, potable (drinkable) water supply. This means the water must be free of pathogens, dissolved toxins, and disagreeable turbidity, odour, colour, and taste (Cowan, 2012) giving a basis to the need for such water supplies for human consumption.

From observation, there are four major sources of drinking water in Makurdi town. They include pipe borne water, well water, and boreholes which are all groundwater and River which is considered as surface water (Jacquelyn, 2008). According to Ince et. al., (2010) out of 714,560 households in Benue State, 6.8% have access to piped water, 6.1% to boreholes, 29.7% to protected dug wells, 2.6% to tankers and vendors, that is 45.3% have access to improved water supply. 47.6% have access to ponds, streams, rainwater, and 7.2% to unprotected dug well making a total of 54.8% that have access to unimproved water supply.
A survey conducted by the Federal Ministry of water resources in 2008 show that about 80% of residents in Nigeria lacked access to improved drinking water (Ezenwaji *et al*., 2014) and the little water available for human consumption is gradually shrinking as a result of pollution from agriculture, industry and other human activities which is degrading the water quality in many rivers, lakes, streams, and even groundwater sources that most people depend on (Galadima *et al*., 2011). It is now universally acknowledged by water and medical experts that the greatest risk associated with the ingestion of water is the microbial risk due to water contamination by human and/or animal faeces (WHO, 2004).

The importance of good drinking water became so expedient that in 2005, the National Council on Water Resources (NCWR) recognized the need to urgently establish acceptable Nigerian Standard for Drinking Quality. This is because it was observed that the 'Nigerian Industrial Standard for Potable water' developed by Standard Organization of Nigeria (SON) and the "National Guidelines and Standards for water Quality in Nigeria" developed by federal Ministry of Environment did not receive a wide acceptance by all stakeholders in the country. (SON, 2007)
According to Talaro (2011) only in remote, undeveloped or high mountain areas is this water used in its natural form. In most cities, it must be treated before it is supplied to consumers. Furthermore, water supplies such as deep wells that are relatively clean and free of contaminants require less treatment whereas shallow well water could be highly contaminated with bacteria pathogens amongst others (Mile *et al*., 2012).

Materials and Methods

Study area

Makurdi is the capital city of Benue state in north central Nigeria. The town is divided by River Benue which traverses the town into Makurdi North and South banks. The southern part of the town is made up of several Wards, including Central ward, Ankpa ward, Wadata ward, High level, Wurukum, New G.R.A. The north area of the town is commonly called north bank. Makurdi town which started as a small river port in 1920 has grown to a population of 297,393 people (NPC, 2006).

Sample collection

Ten (10) water samples were collected from the four main areas of the town, they include; Wadata area, Wurukum area, High Level and North Bank areas of Makurdi town. The samples were taken using the random sampling technique, samples from two wells and two boreholes in the north bank area, four wells in High level area, one well and one pipe borne water, one well and one sample was taken from the Wadata river bank in Wadata area.

Total heterotrophic bacteria count (THBC)

Serial dilution of the samples was carried out and 1ml was taken from the 10^{-4} and 10^{-5} dilution factors. These were inoculated into Petri dishes containing molten Nutrient agar using the spread plate method, and the medium was incubated for 24 hours at 37°C. The number of colony per plate and sample was recorded after incubation to calculate the colony forming unit per ml (CFU/ml).

Most Probable Number method

Bacteriological analyses of drinking water sample were done by multiple tube fermentation method (UNICEF, 2002) using Lactose broth.

a. First, each sample collected was distributed into five tubes containing double strength of Lactose broth, another five tubes containing double strength of lactose broth and another five tubes containing single strength of lactose broth. Each tube with an inverted Durham tube for gas detection and was pre-sterilized before inoculation of samples.

b. For the first five tubes, 10ml of the sample was inoculated into it, 1ml for the next five tubes and 0.1ml for the last five tubes.

c. They were incubated in an incubator for 48hours at 37oC.

d. After incubation, the number of tubes in which lactose fermentation with acid and gas production has occurred was counted. By referring to probability tables the MPN of coliform in 100ml water samples were estimated (Scott, 2010).

e. Furthermore, the entire tubes positive for total Coliforms were analyzed by streaking method on Eosin Methylene Blue Agar plates and Mackonkey agar.

f. They were incubated for 24 hours at 37oC

g. After which a completed test was performed by carrying out Gram Staining, Indole test, Oxidase test, Citrate test for confirmation and identification of organisms.

Data analysis

The results gotten from the study were screened for completeness and entered into the statistical package for social sciences (SPSS) version 116.0 (SPSS inc. Chicago IL 606066412). And the analysis for variance (ANOVA) was to compare the mean values for the entire data set.

Results and discussion

The total heterotrophic count calculated by colony forming unit (CFU/ml) is shown in table 1 with an average of 2.7 × 107 CFU/ml for well water samples, 2.5 × 107 CFU/ml for borehole water samples, 2.5 × 10 CFU/ml for tap water sample and 2.8 × 10 CFU/ml for the river water sample. This shows that the difference between them is not statistically significant (p>0.05).

Table 1: Total heterotrophic bacteria count (THBC)

Sample	Dilution factor	Bacterial count	cfu/ml
A	10-5	272	2.7×107
B	10-5	200	2.0×107
C	10-5	276	2.7×107
D	10-5	200	2.0×107
E	10-5	200	2.0×107
F	10-5	198	1.9×107
G	10-5	240	2.4×107
H	10-5	242	2.4×107
I	10-5	250	2.5×107
J	10-5	281	2.8×107

Table 2 shows the result for the presumptive most probable number method with an average of 546MPN/100ml, 900MPN/100ml for bore hole, 1,600 MPN/100ml for pipe borne water and 1,600MPN/ml for river water, indicating gross contamination in all sources investigated with no significant statistical difference.

Table 2: Results for the Presumptive test: Most Probable Number index

Sample name	Combination of positive tubes			MPN index per 100ml
Sample A	5	5	4	1,600
Sample B	4	0	1	17
Sample C	5	5	4	1,600
Sample D	4	1	2	26
Sample E	4	3	1	33
Sample F	3	2	1	17
Sample G	5	5	3	900
Sample H	5	5	5	≥1,600
Sample I	5	5	5	≥1,600
Sample J	5	5	5	≥1,600

Table 3 presents the confirmed and completed test for the Most Probable Number method with the microorganisms suspected and identified from the water sources.

Table 3: Results for confirmed and completed test for Most Probable Number method

Cultural characteristics	Shape	Gram Reaction	Oxidase	Indole	Citrate	Organism
Pink colonies on Mackonkey agar	Rods in chains	Negative	Negative	Negative	Positive	*Klebsiella pneumoniae*
Light pink circular on MacConkey	Rod-shaped colonies	Negative	Negative	Positive	Negative	*Enterobacter aerogens*
Pink colonies in EMBA	Rod-shaped colonies	Negative	Negative	Positive	Negative	*Enterobacter aerogens*
Purple with black centre and green metallic sheen colonies	Rod-shape colonies	Negative	Negative	Negative	Positive	*Escherichia coli*
Pink colonies on Mackonkey agar	Rod shaped colonies	Negative	Negative	Negative	Positive	*Escherichia coli*
Pink circular colonies on MacConkey agar	Cocci in chains	Positive	Negative	Negative	Negative	*Streptococcus faecalis*

The results from this study show a high level of coliform count in the well water samples though as high as that present in the samples form the other water sources. This could be because out the wells analyzed, four (4) were protected while 2 were unprotected, 17 MPN/100ml, 26 MPN/100ml, 33 MPN/100ml for the wells protected and 1,600 MPN/100ml for the unprotected wells. The table for the presumptive test shows that the total coliform index for 100ml of water obtained from hand dug wells ranges from 17 – above 1,600 MPN/100ml and it is consistent with the findings of Tse and Adamu (2012) as they observed from the bacteriological analysis of hand dug wells in Makurdi, noting a high concentration of coliform in all the well samples they examined. Other studies carried out by Yerima *et al*., (2008) and Danmo *et al*., (2013) in Bama and Konduga towns in Bornu state noted same.

One of the major reason for this result could be traced to the proximity of pit latrines to the wells which were mostly shallow, this is confirmed in a study conducted by Kimani and Ngindu (2007) in Kenya that the severe contamination of well water is largely due to the close distance of wells and pit latrines. Olukanni *et al*., (2014) agreed that the commonest cause of pollution is attributed to close proximity of latrine to wells and the unhygienic usage of the wells

The results obtained in this study agree with other studies carried out in the study area (Ocheri and Atu, 2011; Tse and Adamu, 2012) and have shown evidence of bacteriological pollution especially coliform and feacal coliform bacteria linked to human wastes (Okponya, 2012; Eneji *et al*., 2012).

The results from a study in Makurdi also agree with that of the researchers above as it reveals that all wells analyzed were contaminated with an average of 3.9 × 10 5CFU/ml and 3.5 × 105 CFU/ml in wet and dry seasons respectively (Mile et al.,2013). They concluded that the presence of bacteria in well samples could be attributed to closeness of these wells to septic tanks and sucker wells in Makurdi.

Escherichia coli was isolated from the borehole water samples and other organisms like Enterobacter aerogenes and Klebsiella sp., consistent with the findings of (Eniola et al., 2007) from the boreholes. The presence of Klebsiella sp., and Enterobacter aerogenes in some of the borehole water samples are unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is need for caution when using these contaminated borehole water sources for any purposes.

The table 3 revealed that the average total coliform count obtained from boreholes was between 900MPN/100. Obiri-Danso et al., (2002) noticed that there are seasonal variations between the results obtained in the rainy seasons and dry seasons. With 3 boreholes analyzed, there was a total count between 3 × 105 and 3.5×107 close to the count from boreholes in this study which was during the dry season, ranging from 2.0 ×104 to 2.2 ×107.

The results here indicate that drinking water in piped systems is highly vulnerable to bacterial contamination. This contamination may be due to leakage in pipes, cross contamination with waste water, poorly constructed well head, short distance between water supply network and sewage the supply lines, construction of septic tanks near with tubes wells and drinking water supply lines, run-off, infiltration of waste water, direct deposition of waste water through leakages are some of the major problems.

This result could also be traced to the location of the piped-borne water server which was in a crowded compound and passes through a rusted pipe which allows the entrance of Coliforms of the soil origin or the proximity of a pit latrine for faecal Coliforms.

Chia *et al*., (2014) in Makurdi, agreed as their findings show that leaks sprout all over when water is pumped from the existing water treatment plant, which has a capacity of just 6,000 cubic meters per day. When the Water Board is not pumping water, the contaminated pool of water at the leakage points may flow back into the pipes and may be pumped into households when pumping activity resumes. Also, during the rainy seasons for instance, water contaminated by faeces deposited in open spaces is washed into the pipes through these leakages. Thus contaminated water may be distributed into households when pumping activity is resumed.

That of the river water is ≥1,600MPN/100ml and 2.8×107 bacterial count; this result could be due to the accumulation of waste including animal faces by the river bank. Though the water is pumped from a little into the river away from the banks, the faeces and other contaminants can gradually seep into the area for human drinking and domestic uses.

(Amadi, 2010) in his study on River water in Makurdi found out that river waters can be generally unhygienic and not safe for human consumption. Due to improper sanitation practices around the river area and dumping off of refuse and faecal waste.

Conclusion

This research work compared the major primary source of drinking water available to the general public in Makurdi metropolis to assess which was safest for drinking and domestic purposes. It was discovered that none of the water samples met the standard for drinking water established by World Health organization (WHO), therefore not suitable for consumption. And could lead to serious health water related issues so now, water should be properly treated by individuals before consumption using the safest means of water purification without attracting more harm.

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