ORIGINAL ARTICLE

Analysis of Bacterial Load in Domestic Water Sources in Ekpoma, Edo State, Nigeria

Jemikalajah, Daniel Johnson

ABSTRACT

Background: Drinking water must be free from harmful microorganisms that can cause serious ill health. Supplies of drinking water may be contaminated with sewage allowed to seep into wells or bore-holes, or faecal matter from man and animals passed into rivers, streams or pools of water.

Objectives: This study was carried out to ascertain the bacteriologic quality of domestic water sources used in Ekpoma, Edo State, Nigeria from February 2016 to June 2017.

Methods: Ten samples each of domestic water sources (sachet water, bore-holes, storage tanks, wells and river) were collected and bacteriological analysis was carried out using the total viable count and multiple tube fermentation technique to determine the most probable number of coliforms/ *E. coli.*

Results: The highest mean total viable count (TVC) of bacterial load of 4.1×10^6 CFU/ml was obtained for river water followed in descending order by 1.5×10^6 CFU/ml, 7.5×10^5 CFU/ml, 3.2×10^5 CFU/ml and 1.9 x 10 CFU/ml for reservoir well, reservoir tank, bore-hole and sachet water sources respectively on nutrient agar. The highest mean total viable count of bacterial load of 4.1×10^3 CFU/ml was recorded for reservoir tank followed by 1.3×10^3 CFU/ml, 3.7×10^2 CFU/ml, 3.6×10^2 CFU/ml and 0.0 CFU/ml for reservoir well, bore-hole, river water and sachet water sources respectively on macConkey agar. The highest mean of most probable number (MPN) for the presumptive total coliform counts of 140 MPN/100ml was observed for river and the lowest 0.4 MPN/100ml for sachet water. Also, the highest mean of most probable number (MPN) for faecal *Escherichia coli* counts of 31 MPN/100ml was obtained for reservoir well and the lowest 0.0 MPN/100ml for sachet water.

Conclusion: This study has shown that there is urgent need for an effective, thorough sanitary condition and proper purification given the bacteriological state of these water bodies in order to maintain good quality water.

Keywords: Analysis, bacterial load, water, Ekpoma, Nigeria.

[1]Department of Medical Microbiology and Parasitology, Delta State University, Abraka, Nigeria

Correspondence:
Jemikalajah, Daniel Johnson
Department of Medical Microbiology and Parasitology,
Delta State University, Abraka, Nigeria
Email: jemikalajahjohnson2007@yahoo.com

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Introduction

The United Nations (UN) set a goal in their Millennium Declaration to reduce the number of people without safe drinking water by half in the year 2015[1]. Safe drinking water for human consumption should be free from pathogens such as bacteria, viruses and protozoan parasites, meet the standard guidelines for taste, odour, appearance and chemical concentrations, and must be available in adequate quantities for domestic purposes[2]. However, inadequate sanitation and persistent faecal contamination of water sources is responsible for a large percentage of people in both developed and developing countries not having access to microbiologically safe drinking water and suffering from diarrhoeal diseases[3]. Diarrhoeal diseases are responsible for approximately 2.5 million deaths annually in developing countries, affecting children younger than five years, especially those in areas devoid of accessible potable water supply and sanitation[4]. Political upheaval, high numbers of refugees in some developing countries, and the global appearances of squatter camps and shanty rural towns, which lack proper sanitation and water connections, have contributed to conditions under which disease-causing microorganisms can replicate and thrive[5]. The people most susceptible to waterborne diseases include young children, the elderly, people suffering from malnutrition, pregnant women, immunocompromised individuals, people suffering from chemical dependencies and persons predisposed to other illnesses like diabetes [6].

In developing countries including –Nigeria (Ekpoma), many people are living in rural communities and have to collect their water some distance away from the household and transport it back in various types of containers[5].

To improve and protect the microbiological quality and to reduce the potential health risk of water to these households, intervention strategies are needed that are easy to use, effective, affordable, functional and sustainable. A variety of physical and chemical treatment methods to improve the microbiological quality of water are available[5]. Detection of each pathogenic microorganism in water is technically difficult, time consuming and expensive and therefore not used for routine water testing procedures[7]. Instead, indicator organisms are routinely used to assess the microbiological quality of water and provide an easy, rapid and reliable indication of the microbiological quality of water supplies[7]. The aim of this study was to establish the bacteriological quality of domestic water source used in Ekpoma.

Materials and Methods

This study was carried out in Ekpoma. It is the administrative headquarters of Esan West Local Government Area of Edo State which lies between latitude 6.45°-N to 6.75°-N of the Equator and longitude 6.08°-E to 6.13°-E of the Greenwich Meridian with altitude of about 332m above sea level[8]. It is made up of quarters such as Eguare, Iruekpan, Emaudo, Ujoelen, Ihumudumu, Illeh, Uke, Uhiele, Ujemen, Ukpenu, Idua, Ukhur, Egoro, Emehi, Igor and Idumebo[8]. Ekpoma has a current population of 127,718[9], majority of who are civil servants, traders, business men/women, transporters, farmers, teachers/lecturers and students. A university (Ambrose Alli University) is situated in this town. The main sources of water in the locality are rainfall and wells. It has two distinct seasons, wet and dry seasons. The wet season occurs between April and October with peak in August, average rainfall ranging 150cm to 250cm. The dry season occurs between November and March with cold harmattan between December and January, average temperature of about 25°-C[10].

Collection of Samples

Ten samples of each source of domestic water (sachet water, boreholes, storage tanks, wells/under-ground storage and rivers) in Ekpoma and environs were collected aseptically. After collection, the samples were taken to the Diagnostic Laboratory Department of Medical Laboratory Science, Faculty of Basic Medical Sciences, Ambrose Alli University, Ekpoma for analysis.

Analysis of Samples
Water samples were analysed using two methods:

1. Total viable count (Miles and Mizra Method)[11].
2. Multiple Tube Method.

Statistical Analysis
Data obtained from this study was presented as means and percentages.

Results
The bacterial load of 50 water samples was analysed. Ten (10) each from different domestic water sources (sachet water, bore-holes, storage tanks, wells and rivers) was used. The total viable count (TVC) on nutrient agar and macConkey agar, most probable number (MPN) of coliform organisms and *E. coli*, present in the water samples were used to determine the bacteriological quality of the water sample.

Sachet waters sampled had total viable count that range from 1.4x10 to 9.8 x 10^2 (CFU/ml) and 0 to 33 (CFU/ml) on nutrient agar and macConkey agar respectively. Sachet water also had most probable number (MPN) that range from 0 to 2 (MPN/100ml) and 0 (MPN/100ml) of coliform count and *E. coli* count respectively (Table I).

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Escherichia coli* count (MPN/100ml)
Sachet water 1	2.1 x 10^1	Nil	0	0
Sachet water 2	6.6 x 10^1	Nil	1	0
Sachet water 3	1.5 x 10^2	Nil	0	0
Sachet water 4	7.7 x 10^1	Nil	0	0
Sachet water 5	9.8 x 10^2	33	2	0
Sachet water 6	1.6 x 10^2	Nil	0	0
Sachet water 7	1.4 x 10^1	Nil	0	0
Sachet water 8	1.3 x 10^2	Nil	0	0
Sachet water 9	2.4 x 10^2	27	1	0
Sachet water 10	6.8 x 10^1	Nil	0	0
TOTAL	**1.9 x 10^3**	**60**	**4**	**0**

Table 1: Total viable count (TVC) and most probable number (MPN) of sachet water.

Table 2 shows that bore-hole water had total viable count that range from 1.3 x 10^2 to 3.0 x 10^6 (CFU/ml) and 0 to 6.6 x 10 (CFU/ml) on nutrient agar and macConckey agar respectively. Bore-hole water also had most probable number (MPN) that range from 0 to 160 (MPN/100ml) and 0 to 5 (MPN/100ml) of coliform count and *E. coli* count respectively.

Table 2: Total viable count TVC and most probable number (MPN) of bore-hole water.

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Escherichia coli* count (MPN/100ml)
Bore-hole 1	1.6 x 10^3	1.3 x 10^1	20	1
Bore-hole 2	1.8 x 10^4	6.6 x 10^1	18	1
Bore-hole 3	6.6 x 10^3	3.3 x 10^1	7	1
Bore-hole 4	1.3 x 10^2	Nil	0	0
Bore-hole 5	3.5 x 10^4	1.0 x 10^2	20	2
Bore-hole 6	3.0 x 10^6	2.6 x 10^3	160	5
Bore-hole 7	3.3 x 10^2	Nil	1	0
Bore-hole 8	9.8 x 10^2	Nil	0	0
Bore-hole 9	3.3 x 10^4	7.3 x 10^2	7	0
Bore-hole 10	1.6 x 10^5	1.3 x 10^2	18	5
TOTAL	**3.2 x 10^6**	**3.7 x 10^3**	**2.5 x 10^2**	**1.5 x 10**

Reservoir tank water had total viable count that range from 3.3 x 10 to 5.3 x 10^6 (CFU/ml) and 0 to 4.0 x 10^4 (CFU/ml) on nutrient agar and macConkey agar respectively. Reservoir tank water also had most probable number (MPN) that range from 0 to 180+ (MPN/100ml) and 0 to 5 (MPN/100ml) of coliform count and *E. coli* count respectively.

Table 3: Total viable count (TVC) and most probable number (MPN) of reservoir tank water.

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Escherichia coli* count (MPN/100ml)
Reservoir tank 1	1.6 x 10^4	1.0 x 10^2	14	0
Reservoir tank 2	6.8 x 10^4	2.6 x 10^2	30	1
Reservoir tank 3	5.3 x 10^6	4.0 x 10^4	180+	3
Reservoir tank 4	5.2 x 10^4	3.6 x 10^5	180+	5
Reservoir tank 5	7.1 x 10^3	7.3 x 10^2	35	0
Reservoir tank 6	6.9 x 10^1	Nil	0	0
Reservoir tank 7	2.0 x 10^4	1.6 x 10^3	10	0
Reservoir tank 8	2.0 x 10^6	8.3 x 10^3	180+	3
Reservoir tank 9	1.3 x 10^4	2.4 x 10^1	1	1
Reservoir tank 10	3.3 x 10^1	Nil	0	0
TOTAL	**7.5 x 10^6**	**4.1 x 10^4**	**6.3 x 10^2**	**1.3 x 10**

Table 4 showed that reservoir well water had total viable count that range from 1.0 x 10^4 to 6.3 x 10^6 (CFU/ml) and 6.6 x 10 to 5.0 x 10^3 (CFU/ml) on nutrient agar and macConkey agar respectively.

Reservoir well water also had most probable number (MPN) that range from 10 to 180+ (MPN/ml) and 1 to 180+ (MPN/100ml) of coliform count and *E. coli* count respectively.

Table 4: Total viable count (TVC) and most probable number (MPN) of reservoir well water.

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Escherichia coli* count (MPN/100ml)
Reservoir well 1	1.6×10^4	6.6×10^2	10	5
Reservoir well 2	2.3×10^6	7.6×10^2	180+	40
Reservoir well 3	1.0×10^4	6.6×10^1	20	1
Reservoir well 4	4.6×10^6	4.0×10^2	180+	5
Reservoir well 5	1.0×10^4	1.2×10^2	14	2
Reservoir well 6	6.4×10^5	9.6×10^1	27	5
Reservoir well 7	3.0×10^5	2.6×10^3	90	17
Reservoir well 8	6.3×10^6	5.0×10^3	180+	180+
Reservoir well 9	1.7×10^5	1.0×10^2	17	17
Reservoir well 10	9.3×10^5	3.2×10^3	180+	35
TOTAL	**1.5×10^7**	**1.3×10^4**	**9.0×10^2**	**3.1×10^2**

River water had total viable count that range from 7.4×10^4 to 6.6×10^6 (CFU/ml) and 8.9×10 to 5.6×10^4 (CFU/ml) on nutrient agar and macConkey agar respectively. River water also had most probable number (MPN) that range from 17 to 180+ (MPN/100ml) and 3 to 90 (MPN/100ml) of coliform count and *E. coli* count respectively (Table 5).

Table5: Total viable count (TVC) and most probable number (MPN) of river water.

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Escherichia coli* count (MPN/100ml)
River 1	6.6×10^6	2.7×10^2	160	3
River 2	1.3×10^5	2.3×10^2	17	5
River 3	5.0×10^6	4.3×10^2	180+	3
River 4	4.3×10^6	4.0×10^2	180+	7
River 5	6.0×10^6	5.0×10^2	180+	12
River 6	5.6×10^6	5.4×10^2	180+	40
River 7	3.4×10^5	8.9×10^1	35	8
River 8	7.4×10^4	1.1×10^2	90	14
River 9	6.6×10^6	5.6×10^2	180+	90
River 10	5.9×10^6	5.0×10^2	180+	12
TOTAL	**4.1×10^7**	**3.6×10^3**	**1.4×10^3**	**1.9×10^2**

The mean total viable count (TVC) and most probable number (MPN) of all domestic water sources sampled showed that sachet water, bore-hole, reservoir tank water, reservoir well water and river water had total viable count of 1.9 x 10 (CFU/ml), 3.2 x 10^5 (CFU/ml), 7.5 x 10^5 (CFU/ml), 1.5 x 10^6 (CFU/ml) and 4.1 x 10^6 (CFU/ml) on nutrient agar respectively; and 6.0 (CFU/ml), 3.7 x 10^2 (CFU/ml), 4.1 x 10^3 (CFU/ml), 1.3 x 10^3 (CFU/ml) and 3.6 x 10^2 (CFU/ml) on macConkey agar. The result also revealed most probable number (MPN) total coliform count as 0.4 x 10 (MPN/100ml), 2.5 x 10 (MPN/100ml), 6.3 x 10 (MPN/100ml), 9.0 x 10 (MPN/100ml) and 1.4 x 10^2 (MPN/100ml). And most probable number (MPN) of *Escherichia coli* count of 0.0 (MPN/100ml), 1.5 (MPN/100ml), 1.3 (MPN/100ml), 3.1 x 10^2 (MPN/100ml) and 1.9 x 10 (MPN/100ml) for sachet water, bore-hole, reservoir tank water, reservoir well water and river water respectively.

Table 6: Mean of total viable count (TVC) and most probable number (MPN) of all domestic water sources sampled.

Samples	Total viable on nutrient agar (CFU/ml)	Total viable on macConkey agar (CFU/ml)	MPN of total coliform count (MPN/100ml)	MPN of *Echerichia coli* count (MPN/100ml)
Sachet water	1.9 x 10^1	0.6x10	0.4 x 10	0
Bore-hole	3.2 x 10^5	3.7 x 10^2	2.5 x 10	1.5
Reservoir tank water	7.5 x 10^5	4.1 x 10^3	6.3 x 10	1.3
Reservoir well water	1.5 x 10^6	1.3 x 10^3	9.0 x 10	3.1 x 10
River water	4.1 x 10^6	3.6 x 10^2	1.4 x 10^2	1.9 x 10

Discussion

Water supplies in developing countries are devoid of treatment and the communities have to make use of the most convenient supply. Many of these water supplies are unprotected and susceptible to external contamination from surface run off, windblown debris, human and animal faecal pollution and unsanitary collection[3]. In this study, the TVCs for all the water samples were generally high, exceeding the limit of 1.0 x 10^2 CFU/ml for water as earlier reported by FAO[12].

Previous study by Baxter-Potter and Gilliland[13] on straight river water had shown that when precipitation and stream flows are high, the influence of continuous sources of pollution such as individual sewage treatment plants, industrial and institutional sources and waste water treatment facilities overshadows the driven sources such as feed between run-off and urban storm water which leads to generation of faecal coliform concentrations. Also, illegal dumping of domestic wastes, livestock management, faecal deposit and waste dumps also affect bacterial concentration in run-off.

The findings show that these untreated water samples were grossly contaminated due to the fact that it is open to various objects, uses and gross contamination as well as turbidity which may result from the presence of high levels of organic waste matter. This is contrary to the recommended standard for water which is less than 2 MPN/100ml[12].

The presence of coliform groups in these water samples generally suggest that a certain selection of water may have been contaminated with faeces either of human or animal origin. Other more dangerous microorganisms could be present as suggested by Raymond[14]. This result compared favourably with the report of Banwo[15] and Okonko *et al*[16] which indicates that the presence of bushes and shrubs makes it likely that smaller mammals may have been coming around these water bodies to drink water, thereby passing out faeces into the water.

This study shows that only sachet water is safe for human consumption, thus other sources of domestic water in Ekpoma, Edo State, Nigeria need a serious effort in limiting the numbers of microbial organisms released into the system. The microbial level render these other domestic water sources (bore-holes, storage tanks, wells and rivers) unfit for human consumption though they can be used for other purposes. Water should meet different quality specification depending on the particular uses. Potable and domestic water should be harmless for health of man and other domestic uses[16, 17].

According to WHO (World Health Organisation) and USEPA (United States Environmental Protection Agency) recent news and reports, most tap, boreholes, streams and rivers water in use are not safe for drinking due to heavy industrial and environmental pollution. Toxic chemicals, heavy metals and bacteria in water make people sick while exposing them to long term health condition. It is therefore pertinent that water quality should be controlled to minimize acute problem of water related disease; in addition to effective and thorough sanitary management of these water bodies.

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