Determination of Coliforms in Different Sources of Drinking Water in Gwagwalada, Abuja

Amaeze Ngozi Jacinta [1*], Irekeola Ahmad Adebayo [2]

[1.] Department of Biological Sciences, University of Abuja, Abuja-Nigeria.
[2.] Education Advising Center, PAS, US Embassy, Garki, Abuja-Nigeria.
ngoziamaeze@yahoo.com.sg, profahmad007@yahoo.com

Abstract: Faecal contamination of drinking water consumed within Gwagwalada was investigated. A total of 60 drinking water samples were collected from Dagiri, kutunku and Phase one areas of Gwagwalada between July – August 2011. The survey revealed that inhabitants of these areas source for drinking water from tap, well, packaged water and borehole. The drinking water samples were examined using the multiple tube fermentation method. Out of the 60 samples collected, 11 (18.3%) were contaminated with either one or more than one type of organisms. Organisms isolated include *E. coli* (71.4%), *Klebsiella pneumoniae* (14.3%) and *Enterobacter aerogenes* (14.3%). Of all the contaminated water samples, well water was found to be the most contaminated (i.e. 73%). The statistical analysis (ANOVA) employed revealed that the mean coliform count per 100ml of well water was significantly ($P < 0.05$) higher than tap, borehole, and packaged water in each of the three locations. Contrary to well, borehole samples were devoid of coliforms in every 100ml.
[Amaeze Ngozi Jacinta, Irekeola Ahmad Adebayo. **Determination of Coliforms in Different Sources of Drinking Water in Gwagwalada, Abuja.** *Rep Opinion* 2015;7(1):1-6]. (ISSN: 1553-9873). http://www.sciencepub.net/report. 1

Key words: drinking water; coliform; multiple tube fermentation technique; WHO; Abuja

1. Introduction

Water has always been an important and life-sustaining drink to humans, and is essential to the survival of all organisms (Greenhalgh, 2001). Despite this, most people in all parts of the world still do not have access to potable water, and they suffer gastrointestinal illness such as Cholera from contaminated water (Bergquist and Pogosian, 2000). Diarrhoea is more prevalent in the developing world, due in large part, to the lack of safe drinking water, sanitation and hygiene, as well as poorer overall health and nutritional status (UNICEF and WHO, 2009). Many of the organisms that cause serious diseases such as Cholera, Amoebiasis, Dysentery and Shigellosis can be traced directly to polluted drinking water. According to rough estimate, more than 15 million deaths worldwide result annually from waterborne infections (Atlas and Bertha, 1997).

Although water can contain unwanted chemicals (from natural sources and agricultural activities), the greatest risk to human health is from faecal contamination of water supplies. Serious ill health can be caused by water becoming contaminated from faeces being passed or washed into rivers, streams or pools or being allowed to seep into wells or bore holes. The most important aspect of analysis is therefore to determine whether faecal contamination is present (Monica, 2000).

Drinking water from underground source (e.g. wells) can be consumed safely, but surface water from most lakes and rivers must be treated (Ingraham and Ingraham, 2004). It is rare to locate a water source that does not need treatment before consumption. The general rule is that water must be treated to remove potentially harmful microbes and to improve its clarity, odour and taste (Alcamo, 2003). The three processes used by cities to purify raw water to a potable level that ensures the delivery of microbiologically acceptable water to consumers are sedimentation, filtration and chlorination (Bergquist and Pogosian, 2000). Up to 99.5% of microorganisms and fine particles can be removed by sedimentation followed by filtration (Bergquist and Pogosian, 2000).

Other techniques, such as filtration, chemical disinfection and exposure to ultraviolet radiation (including solar UV) have been demonstrated in an array of randomized control trials to significantly reduce levels of water-borne diseases among users in low-income countries (Classen *et al.,* 2007), but this suffer the same problem as boiling methods.

Ordinarily, inspection can check the proximity of a water supply to sources of pollution, e.g. latrines or refuse collection point (WHO, 2011). However, in piped water distribution systems, a sanitary inspection will often not detect problems occurring during distribution, e.g. pipes buried underground might be damaged, allowing pollution. Therefore, microbial analysis is used to check the effectiveness of disinfection processes. It is also a useful way of keeping communities interested in their water supplies and justifying request to health authorities for improvements in water quality (WHO, 2011).

Faecal coliforms are the most appropriate indicators of faecal pollution (Monica, 2000). The coliform group consists of several genera of bacteria in the family Enterobacteriaceae. These bacteria include *E.coli, Enterobacter aerogenes* and *Klebsiella pneumoniae* (Willey *et al.*, 2008). Coliforms are facultatively anaerobic, Gram-negative, non-sporing, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35^{o}C. Members of the coliform groups especially *E. coli* is a normal inhabitant of the intestinal tract of humans and other warm blooded animals and thus regarded as the faecal type of coliform (Atlas and Bertha, 1997). The large number of *E. coli* present in the gut of humans and other warm-blooded animals and the fact that they are not generally present in the environments supports their continued use as the most sensitive indicator of faecal pollution available (Edberg *et al.,* 2000; Okpokwasik and Akujobi, 1996).

In Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) is the parastatal under the Federal Ministry of Health, charged with the responsibility for the regulation and control of imported and locally processed foods and water products (Omotayo and Denloye, 2002). To ensure strict adherence to international standards, NAFDAC's regulation for bottled and sachet-packed water in Nigeria has been put at the standards established by the World Health Organization (WHO). According to these standards, potable water for human consumption must be free of microbial indicators of faecal contamination, and coliform count per 100 ml of drinking water must be zero (World Health Organization, 1997; Pierre, 1999).

The microbial examination of the quality of drinking water drunk in some areas of Gwagwalada was therefore conducted in this study with respect to faecal contamination.

2. Materials and Method

2.1 Sample collection

A total of 60 different drinking water samples were collected randomly from different homes within the sampling areas. 3 water samples were collected from each of the three areas on weekly basis, and a total of 20 samples each were collected after 7 weeks. The 60 water samples collected comprised water from borehole, tap, packaged water, and well.

Samples were collected during the day between 8am and 12pm in July and August 2011. The samples were gently and aseptically collected into sterile bottles and labelled appropriately as described by Monica (2000) and Mackie and McCartney (1989). The temperature of the samples was taken and the level of turbidity was physically assessed.

2.2 Microbiological Analysis of the Water Sample

The multiple tube fermentation test technique was employed and the most probable number (MPN) was used to enumerate coliforms present in the water sample.

2.2.1 Presumptive Test

This was carried out as described by Willey *et al.* (2008). In this, 15 test tubes containing inverted Durham tubes and 10ml of sterile lactose broth were arranged in 3 rows (5 tubes each). The first row contained the double-strength broth. Aseptically, 10ml of the drinking water sample was transferred to the first row of 5 tubes, 1ml to the second row of 5 tubes, and 0.1ml to the third row of 5 tubes.

After inoculation, the tubes were gently shaken to mix contents, and then incubated at 35^{o}C for 24 hours. At the end of 24 hours incubation period, the tubes were examined for evidence of gas production in the inverted Durham tubes. Negative tubes were re-incubated for another 24 hours after which the tubes were then observed again and the result consequently taken.

From the presumptive test, the MPN was determined by comparing with probability table.

2.2.2 Confirmed Test

Confirmed test for the major representative of the coliform group, *E. coli* was done by inoculating EMB plates with materials from positive (tube containing gas) presumptive tubes as described by Pelczar *et al*. (1993). The plates were then incubated at 37^{o}C for 24 hours.

2.2.3 Completed Test

The completed test was also carried out as described by Pelczar *et al*. (1993). Lactose broth tube and a nutrient agar slant were inoculated with organisms from the EMB plate. Both the broth tube and agar slant were incubated at 37^{o}C for 24 hours. The broth tubes were then observed for gas production and Gram stain was done for organisms on the nutrient agar slant.

Biochemical analysis done on the isolated organisms included Indole, Methyl Red and Voges Proskauer, and Citrate test.

3. Statistical Analysis

Using the SPSS software (version 16), the coliform counts obtained from the analysis of samples from the three locations were compared using ANOVA at 5% level of significance.

4. Result

4.1 Site observation

Generally, the commonest source of drinking water in the areas is borehole, which amounts to about half of the water source and tap with the least as shown on Table 1.

Table 1: Source, number and percentage of water samples collected from Dagiri, Kutunku and Phase 1 areas of Gwagwalada.

S/N	Source	Dagiri		Kutunku		Phase 1		Total	
		No of samples	%	No of samples	%	No of samples	%	No of samples	%
1	Bore hole	14	70	10	50	6	30	30	50
2	Pure water	3	15	4	20	6	30	13	21.67
3	Well	3	15	5	25	2	10	10	16.67
4	Tap	-	-	1	5	6	30	7	11.67
	Total	20	100	20	100	20	100	60	100

In areas where well water is consumed, the wells are usually properly sited away from sewage or pits and are properly covered except for three homes (two at kutunku, one at Dagiri) where the wells were not properly covered. Containers for drawing water are of tins, plastic cans, leather or rubber tubes which are in most cases kept unprotected.

The water drunk in all the homes do not undergo further treatment (e.g. boiling etc.) before consumption.

4.2 Temperature, Turbidity and Coliform Count

The temperature of the water samples ranged between 27.0°C and 29.0°C. This suggests an ideal condition for mesophilic bacteria proliferation.

Turbidity which was physically assessed revealed well water as the most turbid (i.e. less clearer). Ordinarily, well water is not expected to be turbid since sand serves as a filter for underground water. The turbidity of the well water may be due to the action of heavy rainfall and strong wind which transfers organic matters and particles to wells that are not properly protected.

Tables 2, 3 and 4 show the results of the temperature, turbidity, coliform count, and organism identified in water samples collected from Dagiri, Kutunku & Phase One respectively.

Water samples were collected from four sources; tap water (n=7), borehole (n=30), packaged water (n=13) and well water (n=10). All the water samples were clear, except 10% (n=6) and coliforms were grown from 11 samples.

The result shows that eleven (18.3%) samples (4 each from Dagiri and Kutunku and 3 from Phase 1) were contaminated with one or more than one type of organisms. *E. coli* was the commonest cause of contamination, about 73% which indicates that the samples were faecally contaminated and hence unsafe for human consumption.

Table 2: Source, Temperature, Turbidity, MPN Result and Organism Identified In Water Samples Collected From Dagiri

Sample	Source	Temp. °C	Turbidity	No of +ve tubes after 48 h 10ml-1ml-0.1ml	Coliform Count (MPN/100mL)	Organism identified
1	B.H	28.0	CL	0-0-0	< 2	-
2	B.H	28.0	CL	0-0-0	< 2	-
3	Well	28.5	CL	1-0-1	4	*E.coli*
4	B.H	28.0	CL	0-0-0	< 2	-
5	B.H	28.0	CL	0-0-0	< 2	-
6	B.H	28.5	CL	0-0-0	< 2	-
7	B.H	28.0	CL	0-0-0	< 2	-
8	B.H	28.5	CL	0-0-0	< 2	-
9	Well	28.0	ST	4-0-0	13	*E.coli*
10	B.H	28.0	CL	0-0-0	< 2	-
11	P. W	27.5	CL	0-0-0	< 2	-
12	P.W	28.0	CL	0-0-0	< 2	-
13	B.H	28.5	CL	0-0-0	< 2	-
14	B.H	28.5	CL	0-0-0	< 2	-
15	Well	28.0	ST	1-3-0	6	*E.coli*
16	B.H	28.0	CL	0-0-0	< 2	-
17	B.H	28.0	CL	0-0-0	< 2	-
18	B.H	28.0	CL	0-0-0	< 2	-
19	P.W	27.5	CL	0-0-0	< 2	-
20	B.H	28.5	CL	0-2-0	4	*E.a / K.b*

Key: B.H= borehole, P.W= packaged water, CL= clear, ST= slightly turbid, *E.a= Enterobacter aerogenes, K.b= Klebsiella pneumonia*

Table 3: Source, Temperature, Turbidity, MPN Result and Organism Identified In Water Samples Collected From Kutunku.

Sample	Source	Temp. ^{o}C	Turbidity	No of +ve tubes after 48 h 10ml-1ml-0.1ml	Coliform Count (MPN/100mL)	Organism Identified
1	Well	28.0	ST	3-1-0	8	*E. coli*
2	B.H	28.5	CL	0-0-0	< 2	-
3	B.H	28.5	CL	0-0-0	< 2	-
4	B.H	28.5	CL	0-0-0	< 2	-
5	B.H	28.5	CL	0-0-0	< 2	-
6	Well	28.5	CL	0-0-0	< 2	-
7	B.H	28.0	CL	0-0-0	< 2	-
8	Well	28.0	CL	0-0-0	< 2	-
9	Well	28.5	CL	3-3-1	17	*E. coli*
10	B.H	28.0	CL	0-0-0	< 2	-
11	P.W	27.5	CL	0-0-0	< 2	-
12	B.H	28.5	CL	0-0-0	< 2	-
13	P.W	27.0	CL	0-0-0	< 2	-
14	B.H	28.0	CL	0-0-0	< 2	-
15	P.W	27.0	CL	0-0-0	< 2	-
16	P.W	27.5	CL	0-0-0	< 2	-
17	B.W	28.0	CL	0-0-0	< 2	-
18	Well	28.5	ST	3-2-1	17	*E. coli*
19	B.H	28.0	ST	0-0-1	< 2	-
20	Tap	29.0	CL	1-1-0	4	*E. coli*

Key: B.H= borehole, P.W= packaged water, CL= clear, ST= slightly turbid

Table 4: Source, Temperature, Turbidity, MPN Result and Organism Identified In Water Samples Collected From Phase One.

Sample	Source	Temp. ^{o}C	Turbidity	No of +ve tubes after 48 h 10ml-1ml-0.1ml	Coliform count (MPN/100mL)	Organism Identified
1	B.H	28.0	CL	0-0-0	< 2	-
2	B.H	28.0	CL	0-0-0	< 2	-
3	Tap	29.0	CL	0-0-0	< 2	-
4	P.W	27.0	CL	0-0-0	< 2	-
5	Tap	29.0	CL	0-0-0	< 2	-
6	Well	28.0	CL	0-3-0	4	*E. coli/E.a/K.p*
7	Tap	28.5	CL	0-0-0	< 2	-
8	B.H	28.0	CL	0-0-0	< 2	-
9	P.W	27.5	CL	0-0-0	< 2	-
10	P.W	27.5	CL	0-0-0	< 2	-
11	Well	28.5	ST	1-0-0	2	*E. coli*
12	Tap	29.0	CL	0-0-0	< 2	-
13	Tap	28.5	CL	0-0-0	< 2	-
14	B.H	28.0	CL	0-0-0	< 2	-
15	P.W	27.0	CL	0-0-0	< 2	-
16	Tap	29.0	CL	0-0-0	< 2	-
17	P.W	27.5	CL	0-1-0	2	*E. coli*
18	P.W	27.0	CL	0-0-0	< 2	-
19	B.H	28.0	CL	0-0-0	< 2	-
20	B.H	28.5	CL	0-0-0	< 2	-

Key: B.H= borehole, P.W= packaged water, CL= clear, ST= slightly turbid, *E.a= Enterobacter aerogenes, K.b= Klebsiella pneumonia*

5. Discussion

The results from the bacteriological analysis of 60 samples obtained from various homes of the sampled areas (Dagiri, Kutunku and Phase 1) showed that; 49 samples (81.7%) were free of coliform bacteria in 100ml, this is in line with the standard value set for potable drinking water recommended by the WHO (1985; 1997) which is a standard used by NAFDAC in Nigeria. This also concurs with the Indian standard IS1622: 1981. According to these standards, potable water for human consumption must be free of microbial indicators of faecal contamination, and coliform count per 100ml of drinking water must be zero. On the other hand, 11 samples (18.3%) had 2-17 MPN/ml of the coliform count and thus are unfit for human consumption.

Furthermore, the 11 samples revealed the growth of *E. coli* and/or other coliform bacteria such as *Enterobacter aerogenes* and *Klebsiella pneumoniae*, and are thus considered unfit for consumption following the guideline of the WHO and the Indian standard IS1622: 1981. The mean coliform count per 100ml of well water was significantly ($P < 0.05$) higher than other sources in each of the locations.

Approximately 73% (n=8) of the contaminated water samples were from well. This is in line with the research conducted by Akinyemi *et al.* (2006), in which all the well water samples were contaminated with one or more bacterial pathogens, including *E.coli*. This could be partly due to the mixture of underground water with sewage as a result of proximity of some of the wells to sewerage systems or pit latrines. However, most of the homes visited sited their wells reasonably away from these sources of contamination except for 3 homes. Contamination of these wells could have also possibly come from the grimy ropes, bucket or rubber tubes used to draw up water from the well. Improper covering of the well may also contribute to contamination as it is exposed to dirt (faecal matter or refuse) from the action of wind, rain or animals.

Borehole, tap, and packaged water had one sample each contaminated. This is in disagreement with the earlier studies conducted by Agbabiaka and Sule (2010), Oparaocha *et al.* (2010) and Kalpana *et al.* (2011) where a larger percentage of the water sample analysed were found to habour coliform such as *E. coli* as compared to this study. This insignificant percentage could have arisen from the distribution channels (in the case of borehole and tap) or from the packaging process (in the case of packaged water). In addition, packaged water may have attained its level of purity owing to the fact that most of the brands consumed are produced either from tap or borehole water which have shown to be relatively free of microbial contaminations.

Borehole remains the most consumed (about 50%) water source in the areas and still have proven to be of high quality; stressing the high level of safe drinking water assessed by the populace of Dagiri, Kutunku and Phase 1. However, all the homes visited consume drinking water directly without any further purification (e.g. boiling, addition of alum etc). This could pose a serious health risk, especially in homes that source their drinking water from wells.

On a general note, all the sampled areas (Dagiri, Kutunku and Phase 1) have approximately equal access to safe drinking water supply even though they are from different sources.

The analysis of 60 water samples sourced from various homes in 3 areas of Gwagwalada shows that, 49 samples (81.67%) are of excellent quality and hence safe for human consumption, while 11 samples (18.33%) are of unsatisfactory quality and as such unfit for consumption. Well water dominated the non-potable water sources. Although some turbid samples were indicative of possible microbial contaminants, some other clear samples were also contaminated. Therefore, the so called 'pure water' as used for pure water may not be pure because a water sample can be colourless, odourless and tasteless and yet be unsafe for consumption due to the presence of microbial contaminants. More public enlightenment should be done, detailing the principles of siting and maintaining wells and other water supplies with the prospect of achieving safe drinking water. Also, regular monitoring of the water sources should be done by agencies concerned in order to safeguard the innocent consumers from possible health risk.

References

1. Agbabiaka TO, Sule IO. Bacteriological Assessment of Selected Borehole Water Samples in Ilorin Metropolis. International Journal of Applied Biological Research 2010; 2(2): 31 – 37.
2. Akinyemi KO, Oyefolu AOB, Salu OB, Adewale OA, Fasure AK. Bacterial Pathogens Associated with Tap and Well Waters in Lagos, Nigeria. East and Central African Journal of Surgery 2006; 11(1): 110-117.
3. Alcamo IE. Microbes and society, an introduction to Microbiology. Jones and Barlett publishers, London 2003: 333-334.
4. Atlas RM, Bertha R. Microbial Ecology - Fundamentals and application. Benjamin/Commings Science Publishing 1997: 01-694.
5. Bergquist LM, Pogosian B. Microbiology Principles and Health Science Application.

W.B. Saunders Company, New York 2000: 482-485.
6. Classen T, Schmidt W, Rabie T, Roberts I, Cairncross S. Interventions to improve water quality for preventing diarrhoea a systematic review and meta-analysis. British Medical Journal 2007; 334(7597): 782.
7. Edberg SC, Rice EW, Karlin RJ, Allen MJ. Escherichia coli: the best biological drinking water indicator for public health protection. Journal of Applied Microbiology 2000; 88: 106-116.
8. Greenhalgh A. Healthy living – water. BBC Health 2001; http://www.bbc.co.uk/health/healthy_living/nutrition/drinks_water.shtml. Retrieved 19-02-2007.
9. Ingraham JL, Ingraham CA. Introduction to Microbiology, A case history approach. 3rd edition. Thomson Books/Cole, Australia 2004: 712-713.
10. Kalpana S, Bagudo AI, Aliero AA. Microbiological Analysis of Sachet Drinking Water Marketed at two Sites in Aliero, Kebbi State, Nigeria. Continental J. Microbiology 2011; 5 (1): 29 – 36.
11. Mackie, McCartney. Examination of water in medical microbiology. Vol. 2. Churchill stone. Medical division, longman group, United Kingdom 1989.
12. Monica C. District Laboratory Practice in Tropical Countries. Part 2. Cambridge University Press, New York. 2000: 38-39; 143-157.
13. Okpokwasik GC, Akujobi TC. Bacteriological indicators of Tropical Water Quality. Environ Toxicol Water Quality 1996; 11: 77-82.
14. Omotayo RK, Denloye SA. The Nigerian Experience on Food Safety Regulations. Conference Room Document Report F.A.O./W.H.O. Global Forum of Food Safety Regulators. NAFDAC Publications, Nigeria 2002: 1-5.
15. Oparaocha ET, Iroegbu OC, Obi RK. Assessment of Quality of Drinking Water Sources in the Federal University of Technology, Owerri, Imo state, Nigeria. Journal of Applied Biosciences 2010; 32: 1964 – 1976.
16. Pelczar MJ, Chan ECS, Krieg NR. Microbiology Concepts and Applications. McGraw-Hill Inc., New York 1993: 681-694; 806-825.
17. Pierre P. Poor Efficacy of Residual Chlorine Disinfectant in Drinking Water to Inactivate Water-Borne Pathogens in Distribution Systems. Canadian J. Microbiol. 1999; 45(8): 709-715.
18. UNICEF, WHO. Diarrhoea – why children are still dying and what can be done 2009.
19. Willey JM, Sherwood LM, Woolverton CJ. Prescott, Harley, and Klein's Microbiology. 7th edition. McGraw-Hill Inc., New York 2008: 1049-1054.
20. World Health Organization. W. H. O. International Standards for Drinking Water. 1985: 10-15.
21. World Health Organization. W.H.O. Guidelines for Drinking Water Quality. Expert Committee on International Standard for Drinking Water, Geneva 27, Switzerland 1997.
22. World Health Organization. Guidelines for drinking-water quality. 4th edition. Geneva 2011: 77-91.

1/10/2015