EFFECTS OF 'DISINFECTANT A' ON THE PHYSICOCHEMICAL AND BACTERIOLOGICAL QUALITY OF SOME WELL WATER

SULE, I. O., ODEBISI-OMOKANYE, M. B.,
GAMBARI-AMBALI, R. O., & OKEWALE T.A.
Department of Microbiology, Faculty of Life Sciences,
University of Ilorin, PMB 1515 Ilorin, Nigeria
E-mail: suleism@gmail.com; Phone No: +234-805-666-3764

Abstract
Majority of the population in semi-urban and urban areas of Nigeria depend on wells as their source of water. The rate of water-borne diseases are on the increase, therefore, this study was carried out to examine the effects of 'disinfectant A' on bacteriological and physicochemical quality of some well water samples in Ilorin metropolis, Kwara, Nigeria. The disinfection of the well water was done by adding 0.5ml of the disinfectant to 100ml of each of the water sample and was allowed to stand for a contact time of 30 minutes. Both disinfected and undisinfected water samples were analyzed comparatively. The pH, chloride, total hardness, and suspended solids of the water samples prior to disinfection ranged from 6.71 - 7.49, 4.05 - 19.9mg/l, 56 - 295mg/l, and 0.001 - 0.022g/100ml respectively. Similarly, the values of the physicochemical properties of the water samples after disinfection ranged from 7.02 - 7.62, 4.76 - 25.9mg/l, 70 - 290mg/l, and 0.002 - 0.09g/100ml respectively. The total bacterial count ranged from 1.0 x 10^2 - 4.2 x 10^4 cfu/ml for the untreated water samples and 0 - 7.0 x 10^2 cfu/ml for the treated well water samples. The total coliform count ranged from 0 - 2.7 x 10^3 cfu/ml for the untreated water samples and 0 - 2.0 x 10^2 cfu/ml for the treated well water samples. There was no faecal coliform isolated in all the water samples. Comparatively, the addition of 'disinfectant A' to the water samples led to increase in the pH, chloride content and total hardness of the water but there was decreased in bacterial load. Therefore, the use of 'disinfectant A' should be encouraged especially in communities where pipe borne water is not available.

Keywords: bacterial counts, disinfection, physical and chemical properties, well water, reduction

Introduction
It is estimated that 8% of worldwide water use is for household purposes. These include drinking, bathing, cooking, sanitation and gardening. Drinking water is water that is of sufficiently high quality so that it can be consumed or used without risk of immediate or long term harm. Water could be classified as either surface or ground water. Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, and evapotranspiration (Willey *et al.*, 2011).

Groundwater is fresh water that is located in the pore space of soil and rocks. It is water that is flowing within aquifers below the water table. Ground water is the largest single supply of fresh water available for use by humans. A well is an excavation or structure created in the ground by digging, driving, boring, or drilling to access groundwater in underground aquifers. The well water is drawn by a pump, or using containers such as buckets, that are raised mechanically or by hand. Wells can vary greatly in depth, water volume and water quality.

The quality of groundwater is changing as a result of human activities (Trevett *et al.*, 2004). Ground water is less susceptible to bacterial contamination than surface water because the soil and rocks through which groundwater flows, screens out most of the bacteria. Bacteria, however, occasionally find their way into ground water, sometimes in dangerously high concentrations

(Pavlov *et al*., 2004). Freedom from bacterial contamination alone does not mean the water is free for drinking (Adekunle *et al*., 2007).

Many undissolved mineral and organic constituents are present in ground water in various concentrations. Most are harmless or even beneficial; though occurring infrequently, others are harmful, and a few may be highly toxic. The most common dissolved mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate and sulphate. Water typically is not considered desirable for drinking if the quantity of dissolved minerals exceeds 1000mg/l (WHO, 2008).

The most important quality assessment of water is the microbial quality which is determined by microbial load. Some microorganisms are known to be microbial indicators of water quality. The term "total coliforms" refers to a large group of Gram-negative, rod-shaped bacteria that share several characteristics. The group include thermotolerant coliforms and bacteria of faecal origin, as well as some bacteria that may be isolated from environmental sources. World Health Organization (WHO) Guidelines, and most national drinking water standards, take the presence of *Escherichia coli* or thermotolerant coliforms as an indication of recent faecal pollution from human or warm-blooded animals.

Worldwide, about 1.2 billion people lack access to safe drinking water, and twice that may lack adequate sanitation (WHO, 2008). As a result, the World Health Organization estimated that 3.4 million people, mostly children, die every year from water-related diseases. Well-known pathogens such as *E. coli* are easily controlled with chlorination, but can cause deadly outbreaks under conditions of inadequate or no disinfection. Even where water treatment is widely practiced, constant vigilance is required to guard against waterborne disease outbreaks (Curtis *et al*., 2000; Craun *et al*., 2002).

Water treatment involves two types of processes: physical removal of solids (mainly mineral and organic particulate matter) and chemical disinfection (killing/inactivating microorganisms). Treatment practices vary from system to system, but there are four generally accepted basic techniques which are coagulation, sedimentation, filtration, and disinfection (Willey *et al.,* 2011).
In households, hypochlorite is used frequently for the purification and disinfection of the water. When hypochlorite is added to water, hypochlorous acid is formed which ionizes into hydrochloric acid and oxygen (Mwambete and Manyanga, 2006). The oxygen atom is a very strong oxidizing agent. The pH of water determines how much hypochlorous acid is formed. Sodium hypochlorite is effective against bacteria, viruses and fungi. Sodium hypochlorite can easily be stored and transported, its dosage is simple, and it produces residual disinfectant.
Many people depend on well water as their source of potable water and is a common practice these days for people to disinfect water from wells to tackle microbial contaminants. Hence, this research was conducted to determine the effect of a commercial 'disinfectant A' on the bacteriological and physicochemical characteristics of well water samples.

Materials and Methods

Collection and treatment of the water samples

A total of 10 well water samples were collected according to APHA (1998). One hundred millilitre of the collected water samples was measured into each of the two 250ml capacity conical flasks. Aliquots of 0.5ml of the 'disinfectant A'was added to one of the water sample in the conical flask and left for 30 minutes contact time. Nothing was added to the well water sample in the second conical flask and termed as control. Thereafter, the undisinfected and disinfected water samples were analyzed comparatively.

Determination of physicochemical characteristics

The pH of the water sample was determined using a standardized pH meter (Fawole and Oso, 2007). The chloride content of the water was determined by titrating 100ml of the water sample with 0.1N $AgNO_3$. Two millilitre of 5% Potassium Chromate was added as an indicator and the titration was done until the initial yellow colour changed to faint pink. The titre value obtained was multiplied by 3.55 in order to obtain the chloride content in mg/l (Sule *et al.*, 2014).

The total hardness was determined by placing 100ml of the water sample in a 250ml conical flask and 5 drops each of ammonia and erichrome black-T (an indicator) were added. This was then titrated with EDTA until there was a colour change from purple to light blue. The titre value of the 0.1N EDTA multiplied by 100 gives the total hardness in mg/l (De Zuane, 1997).

The suspended solid content was determined by drying a Whatman filter paper at 105^oC for an hour and weighed it as W_1. The water sample was shook and filtered with the weighed filter paper. The filter paper was left folded and dried again at the same temperature and duration. It was reweighed and recorded as W_2. The loss in weight represents the suspended solid content in g/100ml (APHA, 1998).

Bacteriological analysis

The water samples were serially diluted up to 10^{-3}. Pour plate technique was used to determine the bacterial count using nutrient agar. The total coliform and faecal coliform counts were determined using spread plate method while the media used were MacConkey agar and eosin methylene blue agar respectively (Fawole and Oso, 2007).

Statistical analysis

The mean value of the bacteriological and physicochemical parameters obtained were tested using students' T-test in order to determine if there is significant difference between the undisinfected and disinfected well water samples (SPSS, 2010).

Results

Physicochemical analysis of the well water samples

The pH, chloride, total hardness and suspended solid content of the undisinfected water from the wells ranged from 6.71 - 7.49, 4.05 - 19.9mg/l, 56 - 295mg/l, and 0.001-0.022g/100ml respectively while the corresponding values for the disinfected water from the wells were 7.02 - 7.62, 4.76 - 25.9mg/l, 70 - 290mg/l, and 0.002 - 0.09g/100ml respectively (Table 1).

Bacteriological analysis of the well water samples

The bacterial load of the well water samples ranged from 1.0×10^2 – 4.2×10^4cfu/ml for the undisinfected water samples and 0 - 7.0×10^2 cfu/ml for the disinfected well water samples. The total coliform count ranged from 0 - 2.7×10^3cfu/ml for the undisinfected water samples and 0 - 2.0×10^2 cfu/ml for the disinfected well water. The faecal coliform count was zero in both undisinfected and disinfected well water samples (Table 2).

Table 1: Physicochemical characteristics of undisinfected and disinfected well water samples

Sampling points	pH		Chloride content (mg/l)		Total hardness (mg/l)		Suspended Solids (g/100ml) $\times 10^{-3}$	
	BD	AD	BD	AD	BD	AD	BD	AD
W1	$6.81^a \pm 0.02$	$7.56^b \pm 0.03$	$6.46^a \pm 0.02$	$7.28^b \pm 0.04$	$77^a \pm 5$	$115^b \pm 6$	$2^a \pm 0$	$9^b \pm 1$
W2	6.71^a	7.02^b	19.9^a	25.9^b	$295^a \pm 9$	$290^a \pm 8$	$9^a \pm 2$	$8^a \pm 1$

	±0.03	±0.02	±0.03	±0.07				
W3	6.79^{a} ±0.02	7.07^{b} ±0.04	10.3^{a} ±0.05	10.7^{b} ±0.06	148 ^{a}±3	152^{b}±6	1^{a}±0	2^{a}±0
W4	7.20^{a} ±0.01	7.62^{b} ±0.02	6.25^{a} ±0.04	6.53^{b} ±0.04	56^{a}±3	70^{b}±4	2^{a}±0	2^{a}±0
W5	7.22^{a} ±0.02	7.43^{b} ±0.02	4.05^{a} ±0.03	4.76^{b} ±0.04	105^{a}±5	112^{b}±5	2^{a}±0	2^{a}±0
W6	7.33^{a} ±0.02	7.40^{b} ±0.03	9.59^{a} ±0.02	10.9^{b} ±0.02	155^{a}±5	166^{b}±6	22^{a}±2	36^{b}±3
W7	7.36^{a} ±0.02	7.43^{b} ±0.02	15.2^{a} ±0.04	15.6^{b} ±0.05	180^{a}±6	198^{b}±10	3^{a}±0	4^{a}±1
W8	7.27^{a} ±0.02	7.31^{b} ±0.03	5.43^{a} ±0.03	6.04^{b} ±0.04	56^{a}±3	70^{b}±5	10^{a}±1	18^{b}±2
W9	7.49^{a} ±0.04	7.65^{b} ±0.02	7.3^{a} ±0.03	8.45^{b} ±0.03	134^{a}±4	150^{b}±5	8^{a}±1	4^{b}±1
W10	7.19^{a} ±0.02	7.23^{b} ±0.02	4.90^{a} ±0.02	5.18^{b} ±0.02	76^{a}±3	92^{b}±5	2^{a}±0	2^{a}±0

Values are means of 3 replicate ± standard deviation

Mean values followed by different alphabets for the same parameter are significantly different at 95% confidence level using T- test statistical analysis

Key: BD= Undisinfected water (control); AD= disinfected water; W(1 - 10) = Well water samples

Table 2: Total heterotrophic counts of the undisinfected and disinfected well water samples

Sampling Sites	Bacterial count x 10^2 (cfu/ml)		Total coliform x 10^1 (cfu/ml)		Faecal coliform (cfu/ml)	
	BD	AD	BD	AD	BD	AD
W1	57^{a}±4.0	6.0^{b}±1.0	30^{a}±3.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W2	1.0^{a}±0.0	0^{b}±0.0	21^{a}±2.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W3	1.8^{a}±0.0	0^{b}±0.0	10^{a}±1.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W4	1.0^{a}±0.0	0^{b}±0.0	10^{a}±1.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W5	420^{a}±10.0	2.0^{b}±0.0	270^{a}±10.	20^{b}±1.0	0^{a}±0.0	0^{a}±0.0
W6	27^{a}±3.0	3.0^{b}±0.0	20^{a}±2.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W7	60^{a}±4.0	2.0^{b}±0.0	20^{a}±2.0	0^{b}±0.0	0^{a}±0.0	0^{a}±0.0
W8	27^{a}±2.0	7.0^{b}±1.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0
W9	6.0^{a}±1.0	1.0^{b}±0.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0
W10	6.0^{a}±1.0	1.0^{b}±0.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0	0^{a}±0.0

Values are means of 3 replicate ± standard deviation

Mean values followed by different alphabets for the same parameter are significantly different at 95% confidence level using T- test statistical analysis

Key: BD= Undisinfected water (control); AD = disinfected water; W(1 - 10) = Well water samples

Discussion

This study shows that the well water samples varied in their physicochemical and bacteriological quality. This could be as a result of the location of the wells, human usage, condition of the well (covered or uncovered, ringed or unringed etc), sanitation and other environmental factors.
The pH values of the well water samples analyzed in this study were all in conformity with the WHO standard of 6.5 - 8.5 (NIS, 2007; WHO, 2008). pH plays an important role in the growth and survival of bacteria. Bacteria generally grow well at pH between 6.0 - 8.0 and more at neutral pH. With increasing pH levels, there is also a progressive decrease in the effectiveness of chlorine disinfection processes (De Zuane, 1997). In this study, it was observed that the pH of the well water samples increased on addition of the disinfectant, but still within the acceptable limit.

Generally, the higher the chlorine content, the lower the bacterial load of the water (Dada *et al.*, 1990). This explains why water from well 2 with a chloride content of 19.9mg/l had the lowest bacterial count of 1.0 x 10^2 cfu/ml and water from well 5 with the lowest chlorine content of 4.05mg/l has the highest bacterial count of 4.2 x 10^4 cfu/ml. The total hardness of water is expressed in terms of the amount of calcium and magnesium salts. Water is considered soft if it contains 0-60 mg/l of hardness, moderately hard from 61-120 mg/l, hard between 121-180 mg/l, and very hard if more than 180 mg/l (De Zuane, 1997). Very hard water is not desirable for many domestic use. In this study only water from wells 4, and 8 are considered soft before disinfection while others were hard water either before or after disinfection. Total suspended solids or turbidity is the material in water that affects the transparency or light scattering ability of the water. Generally, the higher the suspended solid content, the higher the organic matter content, and hence the higher the bacterial load (Dada *et al.*, 1990). The total viable bacterial count of the water showed that all the well water samples, with the exception of water from wells 2 and 4, are not in conformity with the WHO standard of drinking water which allowed 100cfu/ml (NIS, 2007). The physicochemical characteristics of the water from the wells may have effect on the bacterial load of the water. The addition of the disinfectant to the well water samples led to a drastic reduction in their bacterial load. Presence of coliform in water may or may not be due to faecal contamination. The WHO guideline for total coliform states that no coliform should be detected in 100ml of water samples (Osunide and Enuezie, 1999; EPA, 2002; WHO, 2008). In this study, all the water samples with the exception of water from well 5 had zero total coliform count on addition of the disinfectant. No faecal coliform i.e. *E.coli* was isolated from any of the well water samples either before or after disinfection.

Recommendations

It is recommended that good hygiene should be employed in the use of well water. Wells should not be constructed in the flood plain. Well covers should be replaced immediately upon any physical damage. It is also advisable to chlorinate the well water upon construction and when it has been opened for a long time. The quality of the well can also be improved by lining the well, fitting a pump, and ensuring that the area is kept clean and free from stagnant water and animals. The well water should not be assumed to be clean and pure by physical examination alone, bacteriological as well as physicochemical analysis of the water should also be done at least twice a year.

Conclusion

It can be concluded from this study that the 'disinfectant A' disinfectant has helped to reduce the bacterial load of the well water samples and its use is encouraged.

Acknowledgements

The authors acknowledge the cooperation received from the households from which the well water samples were collected.

References

Adekunle, I. M, Adetunji, M. T., Gbadebo, A. M., & Banjoko, O. B. (2007). Assessment of groundwater quality in a typical rural settlement in South West, Nigeria*. International Journal of Environmental Research and Public Health,* 4(4), 307 - 318.

APHA (1998). *Standard methods for the examination of water and wastewater*, 20th edition. Washington DC: American Public Health Association.

Craun, G. F., Nwachuku, N., Calderon, R. L., & Craun, M. F. (2002). Outbreaks in drinking-water systems, 1991-1998. *Journal of Environmental Health*, 65,16 - 25.

Curtis, V., Cairncross, S. & Yonli, R. (2000). Domestic hygiene and diarrhea: Pinpointing the problem. *Tropical Medicine and International Health,* 5(1), 22 - 32.

Dada, O. O., Okuofu, C. A. & Yusuf, Z. (1990). The relationship between residual chlorine and bacteriological quality of tap water in the water distribution system of Zaria, Nigeria, *Savannah,* 10(2), 95 - 101.

De Zuane, J. (1997). *Maintaining potability: Handbook of drinking water quality*. 2nd edition, John Wiley and sons Inc., NewYork. Pp. 478 – 480.

EPA (2002). *US environmental protection agency: Safe drinking water act amendment.* http://www.epa.gov/safe water/mcl. Html.

Fawole, M. O. & Oso, B. A. (2007). *Laboratory manual of microbiology*. Spectrum books limited, Ibadan, 123 pp.

Mwambete, K. D. & Manyanga, V. (2006). Microbial quality of drinking water treatment in Dares Salaam and use of waterguard as disinfectant. *Tanzania Medical Journal,* 21(1), 22 - 24.

NIS (2007). *Nigerian standard for drinking water quality.* ICS 13.060.20. Approved by standard organization of Nigeria (SON) governing council, Lagos and Abuja, Nigeria.http://www.unicef/ng_publication_Nigerian_Standard_for_Drinking_Water_Quality.pdf

Osunide, M. I. & Enuezie, N. R. (1999). Bacteriological analysis of groundwater. *Nigerian Journal of Microbiology*, 13, 47 - 54.

Pavlov D., de Wet C. M. E., W. O. K., Grabow, & M. M. Ehlers (2004). Potentially pathogenic features of heterotrophic plate count bacteria isolated from treated and untreated drinking water*. International Journal of Food Microbiol*ogy, 92, 275 - 287.

SPSS (2010). *Statistical package for social scientists 15.0 for window evaluation.* www.spss.com

Sule, I. O., Agbabiaka, T. O., Saliu, B. K., Arekemase, M. O., & Adeoye, O. B. (2014). Comparative bacteriological assessment of input and output water from tanker trucks. *Ilorin Journal of Science,* 1(1),171 – 178.

Trevett, A. F., Carter, R. C. & Tyrell, S. F. (2004). Water quality deterioration: A study of household drinking-water quality in rural Honduras. *International Journal of Environmental Health Research,* 14, 273 - 283.

Willey, J. M., Sherwood L. M., and Woolverton, C. J. (2011). *Prescott microbiology.* 8th edition, McGraw-Hill company, New York. 1070pp.

World Health Organisation (WHO) (2008). *Guidelines for drinking water quality, 3rd edition.* Incorporating the first and second addenda, volume 1, Recommendations (http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en).