

Assessment of Watercare Efficacy on Treatment of Water for Human Consumption in Makurdi Metropolis Nigeria

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Abstract

Assessment of the efficacy of Water-Care in the treatment of water to safe health level was carried out on water samples from different water sources within six populated communities of Makurdi Metropolis. Thirty six (36) water samples were collected and treated with WaterCare based on the product manufacturer's instructions. Treated water stored for 30 minutes and 24 hours were tested for coliforms using Multiple Tube Fermentation technique. Analysis of variance (ANOVA) was used with the Tukey Honestly Significant Difference (HSD) for multiple comparisons of the data variables. Most probable Number (MPN) of coliforms /100mL of sampled water ranged from 43 to >1,100cfu/100ml. Mean MPN of treated water for 30 minutes and 24 hours interval was 37.7 ± 33.0 cfu/100ml and 16.17 ± 14.8 cfu/100ml respectively. Improved/deep sources such as boreholes show 3cfu/100ml and 0cfu/100ml respectively for 30 minutes and 24 hours treatment while unimproved/shallow sources such as wells show ≤ 120 cfu/100ml and ≤ 53 cfu/100ml respectively for 30 minutes and 24 hour interval. A significant difference between treated samples and the untreated was observed ($F = 6.321$, $P = 0.005$). Tukey multiple comparison test revealed that MPN index/100ml in the water samples was significantly lower ($P = 0.015$, $P = 0.009$) after treating for 30 minutes and 24 hour time interval respectively as compared to untreated water. But there was no significant difference between the 30 minute and 24 hour time interval ($P = 0.970$). The study found that, drinking water sources in Makurdi Township were heavily contaminated, and that 30 minutes and 24 hours' time interval was not a sufficient time for total elimination of bacteria contaminants after treatment with WaterCare. Future research should ascertain the actual treatment time for inactivation of all bacteria in water treated with WaterCare.

Keywords: Assessment, Watercare, MPN index, Water, Makurdi

Introduction

Water, the universal solvent, is one of the world's most valuable resources, and a basic necessity of life for both plants and animals (Mile *et al.*, 2012). The human body is known to be made up of about 70% water (Tebutt, 1998). However, un-availability of a clean and reliable water supply for drinking, cooking, washing and even bathing have been reported world over (Aper and Agbeshi, 2011).

Globally, about 783 million people do not have access to clean and safe drinking water. Majority of them are reportedly poor and live in remote rural areas or urban slums (UNICEF, 2014). Ten countries (China, India, Nigeria, Ethiopia, Indonesia, Democratic Republic of Congo, Bangladesh, United Republic of Tanzania, Kenya and Pakistan) houses almost 2/3 of the global population without access to improved drinking water source (UNICEF & WHO, 2010). The projections of the Millennium Development Goal (MDG, 2012) for Oceania and Sub-Saharan Africa shows that 605 million people will still be living without improved drinking water source in 2015 because these regions are not on track to meet the MDG drinking water target.

According to WHO, (2007) diseases related to drinking water contamination represent a major burden of human health. The availability of reliable and clean water for drinking is one of the most important determinants of a healthy life. Unfortunately, in resource poor settings, water often comes from unsafe sources and carries deadly pathogens which could be agents of diarrhea, cholera, typhoid etc (Parsons and Jefferson, 2006; PATH, 2010). Consequently unsafe drinking water and sanitation infrastructure are linked to an estimated 4 billion cases of diarrhea and 1.87 million deaths per year especially among children less than 5 years of age in developing countries (Blanton *et al.*, 2007; Lantangne *et al.*, 2011; Ami, 2011)

Nigeria, with two great Rivers (Benue River and Niger River) running across the country down to the Atlantic Ocean is faced with a serious portable drinking water problem. Statistics show that 63.2 million Nigerians lack access to safe water, and over 112 million people do not have access to adequate sanitation. Hence, about 97, 000 children (mostly under - 5) reportedly die every year from diarrhea caused

by unsafe drinking water and poor sanitation (UN, 2014).

In 2000, the United Nations established Millennium Development Goal 7, Target C, which was aimed to reduce by one half the proportion of the world's population without access to safe water and sanitation by 2015 (Robert and Chienjo, 2013) that same year, with the technical support from the U.S. Centre for Disease Control and Prevention (CDC), Population Service International (PSI) (a social marketing non-governmental organization that sells affordable health products in developing countries through wholesale and retail commercial networks) developed a chlorine-based water treatment solution or Safe Water System (SWS) and was marketed under the brand name WaterGuard (a liquid chlorine water treatment product consisting of 1.25% sodium hypochlorite solution in a standard 150mL bottle with a cap that enables appropriate dosing for a 20 litre container) to enable venerable families to treat their water at home with a safe easy-to-use and cost effective product. This was in pursuant to the WHO & UNICEF call for approaches to provide safe drinking water to ensure better health among a poor population (Kwak *et al.*, 2010).

In Nigeria, members of the public were advised by medical experts through WHO to use WaterGuard to treat and purify their drinking water to prevent the spread of typhoid fever (Champion Newspaper, 2013). In line with this, Center for Disease Control and Prevention (CDC), Society for Family Health (SFH) a PSI local affiliate, and United States Agency for International Development (USAID) target a nationwide distribution of WaterGuard product to parents of under-5 children. On November 2004, PSI launched the product branded WaterGuard and in the first month, 55000 bottles were sold (CDC, 2008).

WaterGuard or WaterCare as is commonly seen today is sold in pharmacies and medical stores in Nigeria including Makurdi Metropolis where only about 25-30% of the population of over 297, 398 people are served by a crumbling water network (Wikipedia, 2012; Apeh and Ekenta, 2012). The operational efficiency of water supply in Makurdi Metropolis is unacceptably low or in total lack.

The State capital is currently unable to meet the existing demand for safe water by its inhabitants. This puts increasing pressure on women's work, health and wellbeing and children education, given that the principal burden of searching for a clean water to fetch continues to be borne by women and girls. Most inhabitants fetch raw water from the Benue polluted River (Apeh and Ekanta, 2012) and highly contaminated wells (Mile *et al.*, 2012) for consumption while a few access manual/motorized boreholes. In view of the need to improve water and sanitation conditions in Makurdi Metropolis and reduce the risk of diseases relating to contaminated water, Household Water Treatment and safe Storage (HWTS) appears to be the choice for the inhabitants.

To assure a safe drinking water, inhabitants are compelled to assume the responsibility of treating water at home either by boiling, sieving or employing chemicals without taking into cognizance the desired dose and treatment time required for complete inactivation of microbes. Thus the study questions the reliability of WaterCare to ascertain the microbial water quality for human consumption. In line with the above question, the study therefore sought to investigate the treatment effectiveness of WaterCare on water sources used for cooking, drinking and other domestic purposes.

Materials and Methods

Study Area

Makurdi is a local government and headquarters of Benue State, Nigeria, and is located in the Benue valley. It lies between longitude 8° 32" and 9° 00" East and latitude 7° 44" and 8° 00" North. The town is bisected into the North and South banks by River Benue, which is the second largest River in Nigeria. Makurdi metropolitan city is poorly drained, low-lying and susceptible to flood during the rainy season. A lot of water collects in pools before it slowly drains into the soil. This serves as breeding grounds for disease vectors like mosquitoes and flies especially in the high density areas of the town (Wadata, Wurukum, Logo I&II, Akpehe, North bank, and Ankpa quarters)

Study Design

Cross sectional study design was adopted for the study.

Sample Collection

Water samples were collected from different water sources used as sources of domestic water within six (6) densely populated zones (Wadata, Wurukum, Logo1, North bank, Fiidi and Apir) of the Metropolis; two water sources per location were thus selected making a total of twelve (12) sources. Each water source was visited 3 times for sample collection. Inhabitants in each sampling point were interviewed to know if they use the water source for food preparation and drinking before collection was made. Raw water samples were collected into sterile 750ml freshly blown water bottles (supplied by Oracle Business limited) and taken to Biological Sciences laboratory of Benue State University Makurdi analysis.

Treatment for Raw water Samples

In the laboratory, 10mL of waterGuard solution required to treat 20 liters of raw water was calculated to give its equivalent (0.375mL or 375uL) to treat 750mL of raw water. The treated water was allowed to stand for 30minutes (standard treatment time before consumption as prescribed by the manufacturer of the product) and 24 hours. Raw water samples were used as control.

Determination of coliforms

Presumptive Test

A nine (9) tube assay method of the most probable number (MPN) technique for 3 sets of 10ml, 1ml and 0.1m aliquots of water sample was adopted with MacConkey broth (Titan Biotech Ltd, India) as the media (Ibe and Okpleny, 2005). Durham tubes were inserted in all tubes, and aliquot of 10mL broth was pipette into each of the tubes and sterilized in the autoclave at a temperature of 121°C for 15minutes at 15 pounds per square inch (psi). After autoclaving, a 10ml, 1ml and 0.1ml water sample was pipette in the respective sets of tubes and incubated at 35°C for 24-48 hours for coliform determination. A yellow colour change from the normal neutral red colour of MacConkey broth culture indicates acid production while displacement of the broth in the

inverted Durham tube suggest entrapment of the gas produced. Thus tubes with acid and gas production were considered as positive results.

Confirmed Test

Confirmed test was carried out by inoculating a loopful of culture from each positive tube on Eosin Methylene Blue (EMB) (Titan Biotech Ltd, India) agar plates using a wire loop. Inoculated plates were incubated at 35°C for 24-48 hours to examine growth. Characteristic green metallic sheen colonies were presumed to be *E. coli* an indication of faecal contamination.

MPN test Interpretation

Readings of MPN results followed exactly those described at 95% confidence level for MPN procedure for 3 tubes in the 18th edition of Standard Method for the Examination of Water and Wastewater (APHA, 1992).

Data Analysis

Analysis of variance (ANOVA) was used with the Tukey Honestly Significant Difference (HSD) for multiple comparison tests using Statistical Package for Social Science (SPSS) version 21.

Results

The MPN test performed for water analysis repeatedly demonstrate that the main drinking water sources (River, Wells, and Boreholes) in Makurdi Township were contaminated. Total bacteria index/100ml of all the water sources sampled within the metropolis ranged from 43- >1,100cfu/100ml (Table 1). Samples treated with WaterCare, tested negative for *E. coli* with exception of highly turbid water sources such as Well1 & River (Table 2). However, other coliforms organisms were found in all the water samples after treatment indicating incomplete inactivation of microbes (Plate 3). The mean value of microbes in treated water at 30 minutes was (37.7±33.0cfu/100ml) and 24 hour interval was (16.17±14.8cfu/100ml) (Figure 1). WaterCare was more effective on deep water sources such as boreholes (3cfu/100ml and 0cfu/100ml) respectively for 30 minutes and 24hour treatment time interval but was less effective in treating shallow water sources such as wells (≤ 120 cfu/100ml and ≤ 53 cfu/100ml) respectively for 30 minutes and 24hour treatment time interval (Table 2). Water sources from Wadata area of the metropolis had the highest microbial load followed by Logo1 but the least number of coliform was recorded in samples from Apir community (Figure2).



Plate 2: Coliforms colonies grown on EMB agar plates.



Plate 1: Water Care .

Table 1: Mean MPN counts of Raw water and Treated water for 30minute & 24hours with WaterCare product

Water source	Source depth(M)	Chemical dosage (375uL)	Treatment Time		Control MPN/100ml
			30Minutes MPN/100ml	24Hours MPN/100ml	
W1	2.9	2	75	11	>1,100
W2	2.7	1	23	14	210
W3	3.2	1	39	15	120
W4	2.8	1	35	14	75
W5	3.3	1	36	14	210
W6	7.4	1	42	27	93
W7	6.2	1	34	26	160
BH1	-	1	39	20	460
BH2	-	1	3	0	64
BH3	-	1	3	0	64
BH4	-	1	3.6	0	43
RV	-	2	120	53	>1,100

W = well, BH = borehole, RV= River

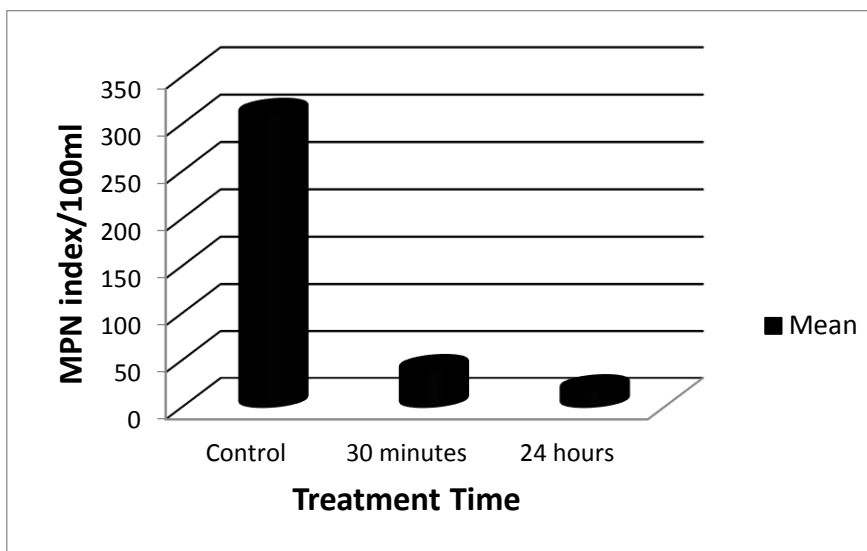


Figure 1: Mean MPN index/100ml with respect to treatment time.

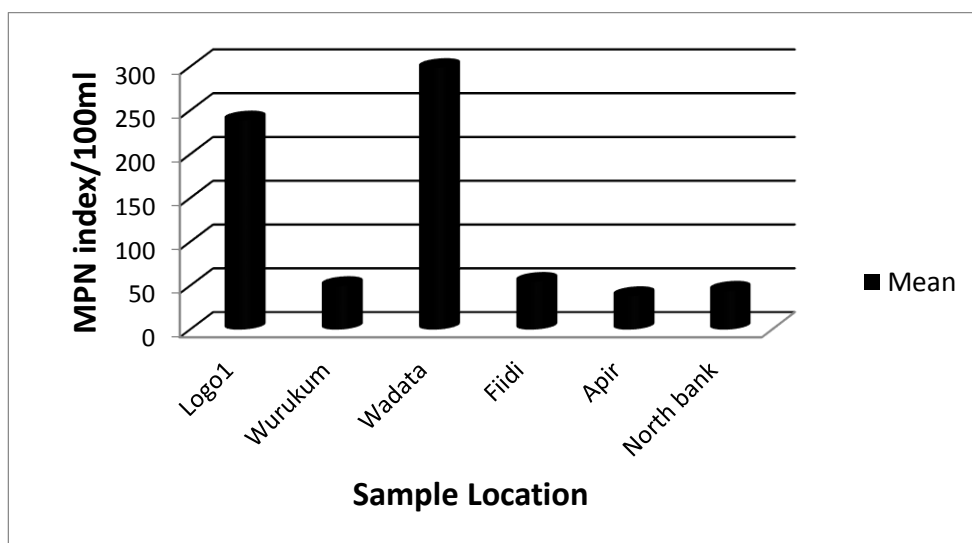


Figure 2: Mean MPN index/100ml with respect to sample location.

Discussion

The test performed for the different water sources show evidently clear that the main drinking water sources (River, Wells, and Boreholes) in Makurdi Township were heavily contaminated, this pose a high disease risk for consumers. When contaminated water samples were treated with WaterCare at different treatment time interval, the test most often was negative for *E.coli* except with highly turbid water sources (plate 2) but total coliforms were always found in the water samples (plate 3) indicating no complete inactivation of microbes. The observation of this study agrees with the report of Robert and Chienjo (2013) where they found that WaterGuard “rebranded to WaterCare in Nigeria” was ineffective on turbid waters. Total coliforms found in treated water which should be coliform-free may indicate treatment ineffectiveness or loss of disinfectant break through. Analysis of variance test (ANOVA) showed that there was a statistical significant difference between water samples treated with WaterCare and the untreated water samples at different time intervals ($F_{2,33} = 6.321$, $P = 0.005$). Tukey honestly significant difference (HSD) multiple comparison test revealed that MPN index/100ml in the water samples was statistically significantly lower after treating the water with WaterCare for 30 minutes ($P = 0.015$) and 24 hour time interval ($P = 0.009$). There was no statistical significant difference between the 30 minute and 24 hour time interval ($P = 0.970$).

However, the mean value of treated water at 30 minutes and 24hour interval does not comply with the WHO (0cfu/100mL) standard for drinking water quality for treated water (WHO, 2010) and the (10cfu/100ml) Nigerian standard for drinking water quality (NSDWQ) for total coliform and (0cfu/100ml) for thermotolerant and *E.coli* (NIS, 2007). The results of this study disagrees with the findings of Mwambete and Manyanga in Tanzania (Mwambete and Manyanga, 2006) where they reported that WaterGuard “rebranded to WaterCare in Nigeria” was 100% efficacious in treating water to a level within the WHO safety

standards. This study reveals that WaterCare was more effective when used to treat improved and deep water sources such as boreholes but was less effective in treating unimproved and shallow water sources such as wells. The efficiency of the product on improved and deep water sources could be attributed to lesser concentration of microbes with dept since percolation of microbes is been affected by the soil profile also to the fact that borehole sources are completely covered thereby reducing the proximity of microbial contamination. The finding is consistent with a UNICEF report where WaterGuard “rebranded to WaterCare in Nigeria” was found to perform better when used to treat improved and deep water sources (UNICEF, 2012). This study shows that disinfection with WaterCare (A chlorine based product) is not instantaneous; time is required in-order to inactivate dangerous microbes present in a water sample. Some observers (Linda *et al.*, 1988; EPA, 1999; OSU, 2011) have noted that the efficiency of inactivation of microbes by chlorine is affected by a number of factors including, contact time and the reaction of chlorine with the water. The specified 30 minutes time interval was not a sufficient amount of time for total inactivation of microbes in water samples, this suggest the persistent nature of some disease causing microorganism that have longer life span in aqueous medium. The findings contradict another study elsewhere where the authors stated that 30 minutes was a sufficient amount of time for complete treatment despite the depth and turbidity of surface waters (Temitope *et al.*, 2011). One study established that time taken for different types of microbes to be killed vary widely with the dosage of chlorine applied to a water sample (Linda *et al.*, 1988).

Another factor may be that chlorine readily combines with chemicals in water, microorganisms, small animals and algae materials; these components could use up chlorine and comprise the chlorine demand of the treatment system. The dosage and time lag of reaction of chlorine in water is of great importance for total bacteria elimination. It is

imperative to note that a longer contact time between chlorine and microorganisms in water can result in an effective disinfection process. The result of this study is contrary to expectations and belief of consumers since WaterCare technology has been shown to be ineffective on turbid and grossly contaminated water samples in the present study.

Conclusion

The study found that, drinking water sources in Makurdi metropolis were grossly contaminated, also the 30 minutes time interval was not a sufficient time for total elimination of bacteria in contaminated turbid waters.

Recommendations

Further research should be conducted to ascertain the actual treatment time and dosage that could inactivate all bacterial in contaminated water treated with WaterCare.

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