MICROBIAL QUALITY OF DRINKING WATER IN DAR ES SALAAM AND USE OF WATERGUARD® AS DISINFECTANT

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Summary

Water borne diseases are alarmingly high in urban areas like Dar es Salaam. Hence the importance of chlorine-based water disinfectant solutions such as Waterguard® that consists of 0.75% sodium hypochlorite. Waterguard® has been in the market in Dar es Salaam for about 4 years. Despite this, prevalence of waterborne diseases like cholera, dysentery and typhoid are still high. The aim of this study was to investigate the effectiveness of Waterguard® in disinfecting drinking water, and determine the level of fecal coliform contamination of water from four sources viz. taps, streams, shallow wells and deep wells located within Dar es Salaam city. The investigation on the efficacy of the agent was carried out in water samples collected in the city during a 4-month period.

Sixty-four water samples were randomly collected and analyzed by the Most Probable Number (MPN) technique based on coliform counts for both untreated and treated water samples. Negative (distilled water) and positive (distilled water contaminated with feces) controls were also included. Results show that three out of the four water sources were heavily contaminated with the exception of deep wells. But appropriate use of Waterguard® reduces the level of microbial contamination significantly. In this study the assayed Waterguard® was found to be 100% efficacious in treating the samples to a level within the WHO safety standards, hence is fit for disinfecting water for human use.

Keywords: Drinking water quality, Coliform Contamination, Waterguard.

Introduction

The World Health Organization (WHO) has estimated that up to 80% of all the sickness and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. Approximately three out of five persons in developing countries do not have access to safe drinking water, and only about one in four have some kind of sanitary facility.[1] A group of microorganisms called coliform bacteria particularly *Escherichia coli*, is used as an indicator of the possibility of water to contain disease-causing microorganisms possibly as a result of fecal contamination.[2]

Coliforms are a `found in soils, plants and animals, though some are intestinal obligate bacteria so that their presence in water indicates recent contamination of water by feces [3]. The presence of fecal coliforms in drinking water is evidence that human or animal waste has been or is present. This may be a cause for concern because many diseases can be spread through fecal transmission. The presence of some fecal material in lakes, ponds and rivers is to be expected as part of the environment in which we live. However, the presence of any fecal coliform in drinking water is a warning sign that action should be taken. Coliforms in drinking or swimming water will not necessarily make person ill. However, the presence of these organisms implies that other pathogens may also be present. Health symptoms related to drinking or swallowing water contaminated with coliforms generally range from no ill effects to gastrointestinal distress. Four common waterborne diseases viz. cholera, dysentery, typhoid and giardiasis all cause intestinal illness.[2] But bathing should pose no risk, although reasonable care should be taken to ensure that children do not swallow water by sucking on washcloths or sponges.

Chlorine is the water-disinfectant of choice, which is normally added to drinking water to destroy pathogenic microorganisms.[4] It can be applied as chlorine gas, sodium hypochlorite (bleach) like Waterguard® solution and dry calcium hypochlorite. Waterguard® is a water-treating agent that consists of 0.75% sodium hypochlorite, which has been used in many households for treating drinking water for about 4 years. It acts by oxidation and chlorination of various proteins in microorganisms. Germicidal action of hypochlorous acid (HOCl) which is its active form is enhanced at a slightly acidic medium, whereby its optimum activity is at pH5. At this pH, HOCl chlorinates proteins with the subsequent oxidation of sulfydryl groups in several enzymes.[5]

Chlorine-based disinfectants have a potent germicide action against myriad of pathogens found in drinking water, and reduce many disagreeable tastes and odors from decaying vegetation. They also eliminate slime bacteria, molds and algae that commonly grow in water supply reservoirs, on the walls of water mains and in storage tanks[6,7]. Therefore, this study intended to assess the antimicrobial effectiveness of Waterguard® against coliforms that are commonly found in water in the city.

Material and Methods

Aseptic Collection of the samples

Samples from the taps were collected aseptically by first cleaning the outside nozzle of the tap and then was turned on completely allowing water waste for 1 minute. This permitted the nozzle to be flushed and discharge any stagnant water in the pipe. The tap was then sterilized by igniting a piece of cotton wool soaked in methylated spirit held close to the nozzle until the tap was unbearable hot. Then the tap was left to cool by running water for few seconds. A sterile bottle was employed for collecting the sample and the cap was replaced, and the sample was labeled.

Samples from open wells were collected by fixing a sterile bottle to a weighted length of string. The cap from the bottle was removed aseptically, the bottle was lowered into the well and filled with the sample and then it was labeled. Sample from the streams were collected by aseptically removing a bottle cap, the bottle mouth facing upstream. The neck of the bottle was plunged downward

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about 30 cm below the water surface, and it was slightly tilted upward to be completely filled, then the cap was replaced and the bottle was labeled.

Samples from each of the above mentioned water sample sources were divided into two: the first was direct water sample (untreated) directly from the source, and secondly was a Waterguard® treated sample as directed by the manufacturer. These were separately processed as described below. Each sample was collected twice from the same source at a14 day-time interval for statistical purpose, by following the same procedures as outlined above.

Treatment of water samples with Waterguard®

Water sample (20L) previously collected from the tap was thoroughly mixed with 2.5 ml of Waterguard® solution in a sterilized container. The mixture was then left for 30 minutes for the reaction to take place. The same quantity of water samples from the rivers, streams, and wells were also thoroughly mixed with 5 ml of Waterguard® solution and processed as described above. Two different batches of Waterguard® were used in the study (Table 1).

Evaluation of coliform bacteria from the water samples

About 100 ml of each of the Waterguard® -treated and untreated water samples was divided into 10 ml aliquots (5 universal bottles), and the remaining 50 ml in another bottle. Each aliquot was thoroughly mixed with MacConkey (MAC) broth at a ration of 1:1 and then a sterile Durham tube was inserted. For each untreated water sample, additional 5 ml of the water sample was added to each of the 5 universal bottle-mixtures. Positive and negative controls that consisted of distilled water contaminated with feces and distilled water respectively, were also included. The mixture of each bottle was thoroughly mixed by inverting several times, and then they were incubated for 24 hours at 37°C while loosely capped. After 24 hours, a number of bottles in which lactose fermentation occurred and acid as well as gas were produced were recorded. Indole test was also conducted to identify enteric bacteria previously obtained from MAC broth media. A total of 64 water samples were assayed, and the experiment was designed as detailed below (Table 2).

Observation of the specimens on production of acid was based on color changes from purple to yellow, and collection of bubbles in Durham tube in case of gas production. The number of fecal coliforms was determined by referring to the MPN probability tables and expressed as the number of coliforms in 100 ml of the water sample.[7] Consequently, the positive broths (mixtures) were sub-cultured into MAC agar medium and then incubated at 37°C for 24 hours. Examination of colonies and indole test were carried out as previously described.[2]

Data Analysis

Statistical analysis was carried out by comparing the means of the number of coliforms/100 ml of sample, among different water sample sources and localities by the Paired Sample-T-Test (SPSS version 10), and significance level was set at $p<0.001$.

Results

Results obtained from the determination of MPN of fecal coliforms after treatment of the water samples with Waterguard® solution show significantly lower coliforms/100 ml counts compared to the untreated water samples ($p<0.001$). All water samples from the deep wells were coliform negative (Table 3) with exception of the positive control, which also became negative upon treatment with Waterguard®.

All untreated water samples from shallow wells were coliform positive, but only when were treated with Waterguard® the bacterial counts decreased significantly ($p<0.001$) as shown in Table 4. Also all untreated water samples collected from the streams were coliform positive regardless of the locality where the water samples were obtained. But upon treatment with Waterguard® the bacterial counts decreased significantly ($p<0.001$) up to the acceptable levels[1] as depicted in Table 5.

All water samples collected from the taps, that is both treated and untreated samples were statistically not different from the negative controls ($p<0.001$) as shown in Table 6.

Table 1: Two batches of Waterguard® solutions used in the study

Batch No.	Manufacture date	Expiry date	Age of product
614	September 2004	August 2005	7 months
772	January 2005	December 2005	2 months

Table 2: Experimental design for both treated and untreated water samples

Water sample	No. bottles	Volume of broth (ml)	Strength of broth
Treated	1	50	Double
	5	10	Double
Untreated	1	50	Double
	5	10	Double
	5	5	Single

Note: Double strength broth refers to broth made up of twice as much as the normal amount of the powder.

Table 3: Comparison between treated and untreated water samples from deep wells

Place of collection (n= 4 for each locality)	No. of coliforms/100 ml sample	
	Untreated	Treated
Upanga (Ilala)	0	0
Tandika (Temeke)	0	0
Hananasif (Kinondoni)	0	0
Kijichi (Temeke)	0	0
Positive control	180+	2
Negative control	0	0

Key: 180+ implies more than 180 coliforms/100 ml of water sample and the same applies for the subsequent tables.

Table 4: Comparison between treated and untreated water samples from shallow wells

Place of collection (n= 4 for each locality)	No. of coliforms/100 ml sample		Indole test
	ntreated	Treated	
Msewe (Kinondoni)	180+	1	Positive
Hananasif (Kinondoni)	180+	0	Positive
Tandika (Temeke)	180+	0	Positive
Bungoni (Ilala)	180+	1	Positive
Positive control	180+	3	Positive
Negative control	0	0	Negative

Table 5: Comparison between treated and untreated water samples from streams

Place of collection (n= 4 for each locality)	No. of coliforms/100 ml sample		Indole test
	Untreated	Treated	
Golani (UB-Kinondoni)	180+	0	Positive
Sinza/Uzuri (Kinondoni)	180+	3	Positive
UDSM (Kinondoni)	180+	1	Positive
Temeke (KTM-Textile)	180+	1	Positive
Positive control	180+	0	Positive
Negative control	0	0	Negative

Table 6: Comparison between treated and untreated water samples from taps

Place of collection (n= 4 for each locality)	No. of coliforms/100 ml sample		Indole test
	Untreated	Treated	
MUCHS Hostel (Ilala)	3	0	Negative
Mkwajuni (Kinondoni)	4	0	Positive
Vijana (Kinondoni)	1	0	Negative
Sokota (Temeke)	3	0	Positive
Positive control	180+	0	Positive
Negative control	0	0	Negative

Discussion

The results from untreated water samples revealed high levels of fecal coliforms contamination in the streams and shallow wells and hence possibility of containing pathogens that are transmitted through feces. While the results obtained from Waterguard® treated samples show that the agent is efficacious in disinfecting the coliforms found in water.

According to WHO guidelines for qualities of drinking water, the analyzed untreated water samples from shallow wells and streams can be categorized as class D (grossly contaminated), which suggests a need for an alternative source of water.[1] Also results obtained from this study show that water from deep wells is free from fecal coliform contamination. This could be due to fact that deep wells are more than 50 meter deep; thus water contamination becomes very rare. Besides, soil acts as a filter trapping the bacteria from the surface water. In addition to that, most underground water contains salts and ions that make the environment inhabitable for microorganisms.[8] Water from taps contains a small amount of coliforms (< 5 coliforms/ 100 ml), which is within the WHO acceptable range. The presence of coliforms in tap water samples, though within an acceptable range, could be due to leakage of water pipes, or insufficient disinfection at the main source.

On the other hand water from streams and shallow wells was grossly contaminated with fecal coliforms, hence it is not recommended for drinking as per the WHO safety standards.[1] This could be attributed to poor city planning, as a consequence most of the water from steams come into contact with sewerage, and the undesirable habits of people to take bath or defecate in the streams. Moreover, overcrowding of the slums with general poor infrastructure and lack of adequate health education for the public might have attributed to construction of shallow wells near sewerage tanks. This could result into contamination of water with coliforms. But also the vessels used in fetching water from the streams and wells might had been contaminated with feces. Consequently, it is not uncommon to find that stream and shallow wells are highly contaminated with feces. Hence the intention of this study was to assess the antimicrobial effectiveness of Waterguard® against coliforms found in water used by the public. In conclusion, the study findings have shown that Waterguard® is a very efficacious water disinfectant, since it reduces the coliform counts down to acceptable levels in accordance with the WHO water safety standards. Moreover, it is strongly recommended that water should be used very cautiously, particularly water from shallow wells and streams when it is intended for oral uses (drinking or gaggles), because it has been found to be heavily contaminated with coliform bacteria.

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