BACTERIOLOGICAL ASSESSMENT OF TREATED PIPED WATER IN PARTS OF ILORIN METROPOLIS

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Abstract The bacteriological quality of treated piped water in distribution system in Ilorin metropolis was assessed. The pH, suspended solid and microbiological characteristics (heterotrophic bacteria count and coliform count) of treated water collected from thirty different locations within the metropolis were determined. The samples were slightly acidic (pH 5.16 to 6.53); the suspended solid content was low (3-OxlO"[4] to 6.5xl0"[3] mg/ml) but the bacterial counts were high (l.OxlO[4] to 2.25xl0[5] cfu/ml); the coliform count varied between 0 and 19cfu/ml. In all 11 bacterial species were encountered; *Bacillus subtilis Enterobacter aerogenes Micrococcus luteus* were the predominant organisms. Each samples contained between 3 and 7 bacterial species. The results suggest that the treated water sometimes fall below the WHO bacteriological standard required of drinking water. Post-treatment contamination especially, breach of distribution network's integrity is suspected. The study highlights the need for regular surveillance of the water distribution system.

Key words: distribution network, drinking water, contamination, surveillance

INTRODUCTION

Water is very important in life for proper functioning of the human body; its importance is underlined by the assertion that: safe drinking water is the birthright of all humankind – as much a birthright as clean air (Lenton *et al.*, 2005). However, it can and does transmit disease in countries in all continents – from the poorest to the wealthiest. The most predominant waterborne disease, diarrhoea, has an estimated annual incidence of 4.6 billion episodes and causes 2.2 million deaths every year (WHO, 2010). The majority of the world's population, especially in most parts of Africa and Asia, does not have access to safe drinking water. As much as 6 million children dies daily as result of waterborne diseases linked to scarcity of safe drinking water or sanitation (TWAS, 2002).

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Diseases related to contamination of drinking-water constitute a major burden on human health. Safe water provide significant benefits to health, therefore there is need for interventions to improve the quality of drinking-water (WHO, 2004).

One of the targets of Millennium Development Goal (MDG) 7 is to reduce by half the proportion of people without sustainable access to safe drinking-water and basic sanitation. This will require tackling both the quantity (access, scarcity) and quality (safety) dimensions of drinking-water provision. For most communities, the most secure source of safe drinking water is pipe-borne water from municipal water treatment plants. However, contamination can, and does occur due to breach of the integrity of the distribution pipes; regrowth of injured bacteria in the distribution system and bacteria surviving the disinfection process (LeChevallier *et al.*, 1996). The quality of drinking-water is a powerful environmental determinant of health. The

quality of drinking-water varies throughout distribution system and its management has been a key pillar of primary prevention for over one-and-a-half centuries and it continues to be the foundation for the prevention and control of waterborne diseases (WHO, 2010).

The primary aim of the Guidelines for drinking-water quality is the protection of public health. They are intended to be used as a basis for the development of national standard that will ensure the safety of drinking-water supplies through the elimination, or reduction to a minimum concentration, of constituents of water that are known to be hazardous to health. As part of the broad goal of protecting human health; it is recommended that the quality of drinking water should be assessed to determine whether the final quality of water delivered to the consumer routinely meet established health-based targets (WHO. 2004). Water is essential to sustain life, and a satisfactory supply must be made available to consumers. Every effort should be made to achieve a drinking-water quality as high as practicable (WHO, 1997).

In most urban cities, the supply of water is through piped distribution system connected to storage unit within or outside the water treatment facilities. Sometimes, and perhaps often, there are breaches in the integrity of pipes in the distribution system leading to ingress of contaminants; including organic matter (WHO, 2007). This has the potential of introducing organisms into the water and enhancing survival of organisms in the water by serving as shield for them or consuming the residual chlorine (LeChevallier et al., 1996). Monitoring the quality of drinking water within distribution systems helps to define and identify quality problems (USEPA, 2002). It involves a continuous assessment and overview of the supply, safety and acceptability of drinking water from network and storage unit (WHO, 2004). In this paper, we present the result of surveillance of the quality of water in the distribution systems connected to two water treatment facilities in Ilorin metropolis: Agba dam and Asa dam. The quality was assessed based on bacteriological criteria: total bacterial count and presence or absence of coliform bacteria.

MATERIALS AND METHODS

Samples of treated piped water were collected at thirty locations within Ilorin, Nigeria (8°28'N 4°38'E). The sampling locations were spread across the metropolis (Figure 1). Samples were collected from tap into disinfected 2L containers as described by WHO (2006). The samples were collected in triplicates and kept in ice chest and immediately taken to the laboratory for analysis. Sampling was done monthly for five months. The pH and suspended solid contents were determined as described by APHA (1992). The populations of heterotrophic bacteria were determined by plating 1ml of the appropriate tenfold dilution on Nutrient agar using the pour plate technique (APHA, 1992). The plates were prepared in duplicates and incubated at 37°C for 24 hours. The coliform counts of the water samples were determined by MPN technique (WHO, 1997). Colonies that developed were purified by subculturing on sterile Nutrient agar plates; the isolates were characterized based on colonial and cellular morphology as well as biochemical characteristics. The isolates were identified using reference text (Holt *et al.*, 1994; Barrow and Feltham1995; Brown 2007).

RESULTS

The samples were generally slightly acidic with the pH varying between 5.16 and 6.53. The suspended solid content was generally low; it varied between 3.0×10^4 and 6.5×10^3 mg/ml. The population of heterotrophic bacteria in the samples was generally high: 1.0×10^4 to 2.25×10^5 cfu/ml; the coliform count varied between 0 and 19cfu/ml (Table 1). A total of 11 bacterial species were encountered which included *Bacillus subtilis, Citrobacter freundii,*

Escherichia coli, Enterobacter aerogenes, Klebsiella oxytoca, Micrococcus luteus, Pseudomonas aeruginosa, Proteus vulgaris, Salmonella typosa, Serrastia marcescens and *Shigella flexneri. Micrococcus luteus* was the most prevalent (found in 96.67% of samples examined) while *E. coli* was found in only one sample. Each sample contained at least three bacterial species, however none contained all the bacteria encountered.

DISCUSSION

The physicochemical characteristics of the water samples (Table 1) show that the pH was largely within the pH range recommended for effective chlorine disinfection of water (WHO, 2005). The total suspended solid contents suggest the presence of particulates which can react with the chlorine used in disinfection. The chlorine is either consumed or less effective combined forms of chlorine are produced (WHO, 1997). This can cause reduction in amount of residual chlorine in the water within the distribution line leading to loss of the protection intended to be provided by the residual chlorine. WHO (2006) recommends that a free residual chlorine concentration of at least 0.5 mg/litre after a contact time of at least 30 min is present at the delivery point. Also injured bacteria that may escape into the distribution line may be able to repair, resuscitate and survive in the absence of disinfectant.

The populations of heterotrophic bacteria in the samples were higher than 100cfu/ml. The high population of heterotrophic bacteria suggest failure of disinfection and or recontamination of the treated water, as distance from the treatment plant increased. It also suggests the presence of bacterial nutrient in the water (WHO, 2004). The presence of *Klebsiella* and *Enterobacter* suggests contact with faecal material. The presence of *Bacillus subtilis* and *Micrococcus luteus,* which are common soil organisms suggest ingress of soil into the distribution network. It can thus be assumed that the water in the distribution system was contaminated; probably through burst pipes and failing connections. Contamination of water in distribution system implies that many of those who have access to water are exposed to contaminated water. This portends grave risk to public health; and could easily promote wide spread dissemination of infectious diseases.

Lack of safe water perpetuates a cycle whereby poor populations become further disadvantaged, and poverty becomes entrenched (WHO, 2007). Treating and safely storing water in these homes would clearly accelerate progress towards meeting the MDG Target 10. Intervention at household level is imperative for those faced with problem of contamination of water either during transportation or distribution. The use of effective technologies for household water treatment and storage have direct beneficial effects in the form of reducing infectious diseases and also contributing to greater productivity and other benefits associated with improved health. Simple techniques for treating water at home and storing it in safe containers could save a huge number of lives each year (WHO 2007). Household or Point of use (POU) interventions such as: boiling, filtering, solar disinfection, coagulation-flocculation, chemical disinfection with germicidal agents (primarily chlorine) and use of plants e.g *Moringa oleifera;* can dramatically improve the microbial quality of household water and reduce the attendant risks of diarrhoeal and other waterborne diseases and death (WHO 2008).

This study demonstrates that water supplied trough piped network in Ilorin metropolis sometimes fall short of the WHO recommended bacteriological standard for drinking water. Breach of the distribution network appears to be responsible for the presence of undesirable organisms in the water. It highlights the need for surveillance to identify point where the distribution networks have been breached. Also surveillance of the distribution network should be made regular as recommended

WHO (2011). In the short term, point of e (POU) interventions such as boiling and sing with chlorine based chemical (water guard) is recommended to guarantee safety of the water.

ble 1. Physicochemical and bacteriological characteristics of the water samples

Sample	Characteristics			
	pH	TSS (mg/l)	TBC (cfu/ml)	TCC MPN/100ml)
WS 01	5.76 ± 0.03	3.50 ± 0.15	6.50×10^1	3
WS 02	6.01± 0.03	1.90± 0.03	6.10×10^1	8
WS 03	6.50± 0.03	2.20± 0.03	8.50×10^1	4
WS 04	5.16± 0.03	5.20± 0.03	9.35×10^1	19
WS 05	6.53± 0.03	6.10± 0.03	6.10×10^1	0
WS 06	6.23± 0.03	3.10± 0.03	8.50×10^1	0
WS 07	5.79± 0.03	1.00± 0.03	1.96×10^2	2
WS 08	6.33± 0.03	51.00± 0.03	2.00×10^2	3
WS 09	6.19± 0.03	5.10± 0.03	2.05×10^2	16
WS 10	6.20± 0.03	2.90± 0.03	1.10×10^2	19
WS 11	5.57± 0.03	30.00± 0.03	2.02×10^2	9
WS 12	5.84± 0.03	1.20± 0.03	1.00×10^1	1
WS 13	6.00± 0.03	90.00± 0.03	1.10×10^2	0
WS 14	6.06± 0.03	3.50± 0.03	9.20×10^1	14
WS 15	6.08± 0.03	6.50± 0.03	9.00×10^1	4
WS 16	6.03± 0.03	6.10± 0.03	1.35×10^2	1
WS 17	6.13± 0.03	5.10± 0.03	2.30×10^2	0
WS 18	6.13± 0.03	4.30± 0.03	5.30×10^1	0
WS 19	5.21± 0.03	1.90± 0.03	1.30×10^2	0
WS 20	5.95± 0.03	2.10± 0.03	3.90×10^1	9
WS 21	5.24± 0.03	6.00± 0.03	4.90×10^1	4
WS 22	5.47± 0.03	80.00± 0.03	5.80×10^1	8
WS 23	5.99± 0.03	30.00± 0.03	9.40×10^1	0
WS 24	6.10± 0.03	30.00± 0.03	2.50×10^2	0
WS 25	5.61± 0.03	30.00± 0.03	4.70×10^1	8
WS 26	5.82± 0.03	1.20± 0.03	5.10×10^1	6
WS 27	5.95± 0.03	1.50± 0.03	1.30×10^2	4
WS 28	5.80± 0.03	3.10± 0.03	1.20×10^2	3
WS 29	6.00± 0.03	3.00± 0.03	1.25×10^2	4
WS 30	6.00± 0.03	80.00± 0.03	5.20×10^1	0

Values are means of five samples

TSS: Total suspended solid; TBC: Total bacterial count; TCC: Total coliform count

Table 2 Occurrence of bacterial isolates in sampling locations

Isolate	Number of Location where organism is present	
	Number	Percentage (%)
Bacillus subtilis	25	83.33
Citrobacter freundii	4	13.33
Enterobacter aerogenes	28	93.33
Escherichia coli	1	3.33
Klebsiella oxytoca	7	23.33
Micrococcus luteus	29	96.67
Pseudomonas aeruginosa	24	80.00
Proteus vulgaris	23	76.67
Salmonella typosa	6	20.00
Serrastia marcescens	4	13.33
Shigella flexneri	8	26.67

Figure 1. Locations within Ilorin metropolis from which samples were collected.

A: Olorunsogo area. B: Oja Oba area C: Gambari area D: Fate area E: Tipper garage area
F: Challenge area G: Asa Dam area H: Pipeline area I: Oke Odo Area
J: University of Ilorin Permanent site area

REFERENCES

American Public Health Association: APHA (1992). Water Pollution methods for the Examination of Water and Waste water. 18th ed. Washington D. C. p.1437.

Barrow, G. I. and Feltham, R K. A. (1995). Cowan and Steel's manual for identification of Medical Bacteria. 3rd ed. Cambridge University Press.

Brown, A. E. (2007) Benson's Microbiological Applications, 10th ed. Laboratory Manual in General Microbiology. McGraw Hill Higher Education New York. Pp. 251- 293

Holt, J. G., Krieg N.R., Sneath, P.H.A. Staley, J.T. and Williams, S.T. (1994). Bergey's Manual of Determinative Bacteriology. 9th ed. Williams and Wilkins. Baltimore.

LeChevalier, M. W., Welchi, N.J. and Smith, D.B. (1996). Full Scale studies of factors related to coliform regrowth in drinking water. *Journal of Applied and Environmental Microbiology*, 62(7): 2201- 2211.

Third World Academy of Sciences TWAS (2002) Safe Drinking Water: The need, the problem, solutions and an action plan. Report of the Third World Academy of Sciences. Third World Academy of Sciences, Trieste, Italy.

UNESCO (2006) Water a shared responsibility. The United Nations World Water Development Report 2. UN-water/wwap/2006/3 http://www.unesco.org/ water/ wwap

United States Environmental Protection Agency- USEPA (2002) Finished water storage facilities. http://www.epa.gov/safewater

World Health Organization: WHO (1997). Surveillance and control of community supplies. Guideline for drinking water quality. 2nd ed. WHO. Geneva, Switzerland

World Health Organization: WHO (2002) Managing Water in the Home: Accelerated Health Gains from Improved Water Supply. WHO. Geneva, Switzerland

World Health Organization: WHO (2004). World Health Organization guidelines for drinking water quality. 3rd ed. 1, Recommendation. Geneva, Switzerland.

World Health Organization: WHO (2006). Guidelines for drinking-water quality [electronic resource] incorporating first addendum. Vol. 1, Recommendations. – 3rd. Geneva, Switzerland.

World Health Organization: WHO (2007) Combating Waterborne disease at the household level. Geneva, Switzerland.

World Health Organization: WHO (2008) http://www.who.int/household_water/ research/technologies_intro/en/print.html.

World Health Organization: WHO (2010). Water for Health. WHO Guidelines for Drinking water quality. World water Day 2010. World Health Organization, Geneva, Switzerland.

World Health Organization: WHO (2011). Guidelines for Drinking water quality. 4th ed. World Health Organization, Geneva, Switzerland.