BACTERIOLOGICAL AND PHYSICOCHEMICAL QUALITY OF WATER SUPPLY TO SOME RESTAURANTS IN UNIVERSITY OF ILORIN, NIGERIA

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Abstract
The water supply to some public restaurants within University of Ilorin, Permanent Site were assessed for their physicochemical and bacteriological qualities. Water samples were collected directly from the taps and the reservoirs. The bacteriological parameters assessed were the aerobic bacterial, total coliform and faecal coliform counts while the physiochemical parameters included pH, free residual chlorine, total solids, and hardness of water. The results of the physiochemical parameters were as follows: pH 6.34 to 7.03; free residual chlorine 1.04 to 1.16 mg/l; total solids 450 to 1020 mg/l; and total hardness 108 to 148 mg/l. The aerobic bacterial counts ranged from 1.0 x 10^1 to 1.8 x 10^3cfu/ml. The total coliforms per 100ml of the water ranged from 15 to 1100 most probable number (MPN) while the faecal coliforms ranged from 2 to 100 cfu/ml. The bacterial species isolated from the water samples were Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus, Corynebacterium sp., Enterobacter aerogenes and Escherichia coli. Some of these bacterial isolates are of public health concern. The sanitary conditions of the vicinity of the water sources at each restaurant were evaluated in order to identify the possible sources of contamination and the necessary control measures to be adopted.

Keywords: Bacteriological, Physiochemical, Water supply, Restaurants

Introduction

Water is essential for the survival of all known forms of life on Earth (Hughes & Koplan, 2005). Access to drinking water has improved steadily and substantially over the last decades in all parts of the world (Bjorn, 2001). Water can be divided into different types according to occurrence: surface water, ground water, mineral water, and fresh water. Approximately 70% of fresh water is used for agriculture (Baroni *et al.*, 2007).

Water is a tasteless, colourless, odourless liquid at normal temperature and pressure. Water is considered to be neutral with a pH of 7. The hardness of water affects its pH (De Zuane, 1997). Water fit for human consumption is called potable water. It is estimated that 15% of worldwide water is used for drinking, bathing, cooking, washing and agricultural purposes. Basic household water requirements have been estimated around 50 litres per person per day (Island Press, 2009).

Humans require water that does not contain impurities. Common impurities include metal salts and /or harmful bacteria such as *Escherichia coli*, *Enterobacter* sp., *Salmonella* sp., *Streptococcus* sp., *Klebsiella* sp., *Shigella* sp., and *Vibrio* sp., this occur through construction operation and maintenance of water distribution channels which provide ample opportunities for microbial contamination (Anguiar *et al.*, 2000). Pipe joints, valves, elbows, tees and other fittings may provide stagnant areas where bacteria can attach and colonize (Le Chevallier *et al.*, 1996). According to UNESCO (2006) more than 2.2 million people died in the year 2000 due to water borne diseases.

Coliforms are found in large numbers in human faeces and their presence in a water sample is an indication of faecal pollution. High load of coliforms usually signify that further measures such as chlorination or boiling are required before consumption to ensure safety. In compliance to the international water supply and sanitation laws, developing countries have made special efforts to increase the availability of potable water to the populace (Musa *et al.*, 1999).

This research was carried out to check the water quality at the restaurants. The use of unwholesome or contaminated water at the restaurants for activities such as cooking, drinking and washing of cutlery could pose health problems to the consumers.

The objectives of this study were to determine the pH, residual chlorine, hardness and total solids as well as the aerobic bacterial count, total and faecal coliform counts of water supplies to restaurants at the University of Ilorin. The possible sources of contamination were also noted.

Materials and Methods

Collection of samples: Water sample (500ml) was collected from each public restaurant within University of Ilorin permanent site using sterile conical flask. The water samples were collected from these restaurants since they were close to the students' hostels. The samples were collected from the tap according to Standard Methods (American Public Health Association, 1998).

Physicochemical analyses: The pH of the water sample was determined using Pyecam pH meter (model 29 mk) as described by American Society for Test and Measurements (1985). The free residual chlorine was determined by argentiometric titration as reported by British Pharmacopeia (1993). In addition, the total hardness and total solid contents of the samples were determined as described by De Zuane (1997); Hammer and Hammer, (2003).

Bacteriological analyses: The aerobic bacterial count was determined using standard Methods as described by American Public Health Association (1998). Pour plate technique was used with nutrient agar as the medium of choice for the enumeration of viable bacterial count.

The total coliforms count was determined using most probable number (MPN) method with MacConkey broth as the medium for cultivation (Fawole & Oso, 1988). Simlarly, faecal coliform count was done using eosin methylene blue agar medium and spread plate technique as described by Salle (1973).

Sanitary survey: A Survey of all surroundings and conditions that may affect the quality of the water supply at each restaurant was undertaken using some of the parameters given by WHO (2008) and Palomi *et al.* (2001). The sanitary score of each restaurant in percent was obtained by dividing the number of ''yes'' scores by total number of parameters assessed and multiplying the result by 100 (Sule *et al.*, 2011).

Identification of bacterial isolates: This was determined based on the colonial, cellular and biochemical characteristics of the pure culture of each bacterial isolate (Fawole & Oso, 1988). The biochemical tests carried out included catalase, oxidase, coagulase, indole, methyl red, citrate, voges proskauer, starch hydrolysis, lactose fermentation, and oxidative-fermentation.

Statistical analysis: The data obtained were analysed using SPSS 15.0 for their mean, range, percentage, standard deviation, and one way analysis of variance was determined using Duncan's multiple range test (SPSS, 2010).

Results

The pH values of water samples from the restaurants ranged from 6.34 to 7.03 while the free residual chlorine ranged between 1.04 to 1.16 mg/l. The total hardness had minimum and maximum values of 108 and 148mg/l respectively. Similarly, the total solid contents had a range of 450 to 1020 mg/l (Table1).

The aerobic bacterial count of the water samples ranged between1.0 x 10^1 to 1.8 x 10^3 cful/ml. The total coliform count ranged between 15 to 1100 coliform /100ml of water while the faecal coliform count ranged between 0.0 x 10^1 to 1.0 x 10^2 cfu/ml (Table 2).

Based on the colonial morphology, cellular and biochemical characteristics the following bacterial species were identified: *Bacillus subtilis*, *Staphylococcus aureus*, *Micrococcus luteus*, *Corynebacterium* sp., *Enterobacter aerogenes* and *Escherichia coli* (Table 3). The occurrence of diverse bacterial species in the water samples were as presented in (Table 4) while the sanitary survey and sanitary scores of the restaurants were as presented in (Table 5). The sanitary score ranged from 60 to 90% for the different restaurants.

Table 1: Physicochemical qualities of the water samples from different restaurants

Water samples	pH *	Free residual chlorine (mg/l)*	Total solids (mg/l)*	Total hardness (mg/l)*
A	6.70^{c} ± 0.03	1.14^{de} ±0.10	590^{b} ±20	132^{bc} ±11
B	7.03^{f}± 0.03	1.11^{cd} ±0.10	980^{f} ±20	148^{c} ±8
C	6.84^{e}±0.04	1.14^{de} ±0.02	450^{a} ±25	124^{ab} ±10
D	6.77^{d} ±0.02	1.04^{a} ±0.02	630^{bc} ±30	108^{a} ±8
E	6.78^{d} ±0.03	1.11^{cd}±0.03	800^{e} ±50	116^{ab} ±6
F	6.75^{d} ±0.02	1.11^{cd}±0.02	670^{cd} ±20	128^{b} ±8
G	6.34^{a} ±0.03	1.16^{e} ±0.01	720^{d} ±30	132^{bc} ±12
H	6.36^{ab} ±0.02	1.05^{ab} ±0.02	830^{e} ±25	120^{ab} ±10
I	6.4^{b} ±0.01	1.08^{bc} ±0.02	1020^{f} ±50	116^{ab} ±10

*values are means of three replicates ± standard deviation

Values in the same column with different superscripts are significantly different at p<0.05
A – I indicates water from different restaurants

Table 2: Bacteriological counts of the water samples from different restaurants

Water samples	Bacterial count (cfu/ml)*	Total coliforms (MPN / 100ml of water)	Faecal coliform (cfu/ml)*
A	12^{a}±2.0	43^{a}	0^{a}±0.0
B	700^{c}±20	1100^{c}	2^{a}±1.0
C	10^{a}±2.0	43^{a}	0^{a} ±0.0
D	24^{a}±4.0	75^{ab}	0^{a} ±0.0
E	35^{a}±3.0	210^{b}	0^{a} ±0.0
F	22^{a}±3.0	15^{a}	0^{a} ±0.0
G	680^{c}±15.0	93^{ab}	0^{a} ±0.0
H	460^{b}±20.0	1100^{c}	100^{a} ±10.0
I	1800^{d}±50.0	210^{b}	0^{a} ±0.0

*values are means of three replicates ± standard deviation

Values in the same column with different superscripts are significantly different at p<0.05
A – I indicates water from different restaurants.

Table 3: Characterization and identification of bacterial isolates

ial	col	ial	sh	ar	ele	s	La	Ox	St	Cit	Co	Ca	Me	Vo	In	Ox ida	Probable identity

						Cell's shape	Cells' arrangement	Spore staining												
I	Cr	Ci	Tl	F	-	R	Ch	-	+	-	-	+	-	+	-	+	-	Fe	*Enterobacter aerogenes*
II	Y	Ci	Tl	Co	+	C	Cl	-	+	-	+	-	+	+	+	+	-	Fe	*Staphylococcu aureus*
III	Cr	Ci	Tl	r	+	R	S	+	-	-	+	+	-	+	+	+	-	Ox	*Bacillus subtili*
IV	Y	Ci	Tl	F	+	C	S	-	+	+	+	-	-	+	-	-	-	Ox	*Micrococcus luteus*
V	W	Ci	Tl	F	+	R	S	-	-	-	+	+	-	+	-	-	-	Fe	*Corynebacteriu*
VI	Cr	Ci	Tl	r	-	R	S	-	+	-	+	-	-	+	+	-	+	Fe	*Escherichia coli*

Key: Cr = cream; Y= yellow; W = white; Ci = circular; R = rod; Tl = translucent; ; F, = flat; Co = convex; r = raised; S = Single; Ch = chain; Cl = cluster; Fe = Fermentative; Ox = Oxidative; - = negative reaction; + = positive reaction

Table 4: Occurrence of bacterial isolates in water samples from different restaurants

S/N	Bacterial isolates	Sampling points								
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
I	*Bacillus subtilis*	-	+	-	+	+	-	+	+	+
II	*Staphylococcus aureus*	-	+	-	-	+	+	-	-	+
III	*Micrococcus luteus*	-	+	-	-	+	+	+	+	+
IV	*Corynebacterium* sp.	-	-	-	-	-	-	+	-	-
V	*Enterobacter aerogenes*	-	-	-	-	-	+	-	-	-
VI	*Escherichia coli*	-	+	-	-	-	-	-	+	-

Key: +, isolated; - , not isolated; A – I, water from different restaurants

Table 5: Sanitary appraisal of water from different restaurants

Water samples	Sanitary parameters										Sanitary score (%)
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	
A	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	90
B	Y	Y	Y	Y	Y	Y	Y	N	N	Y	80
C	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	90
D	N	Y	N	Y	Y	Y	Y	Y	N	Y	70
E	N	N	N	Y	Y	Y	Y	Y	N	Y	60
F	Y	Y	Y	Y	Y	N	Y	Y	N	Y	80
G	N	N	Y	Y	N	Y	N	Y	Y	Y	60
H	Y	Y	N	Y	N	Y	Y	Y	Y	Y	80
I	Y	Y	Y	Y	N	Y	Y	N	Y	Y	80

Key: I**,** Water does not accumulate near the tap stand; II, Tap did not show any evidence of leakage; III, No observable point of leakage of the water pipe; IV, Is the sampling point not in a close vicinity to septic tank? ; V, Is the sampling point not in a close vicinity to open dirty gutter? ; VI, Is the sampling point not in a close vicinity to refuse dump? ; VII, Does the tap nozzle as lock? ; VIII, No storage of water in reservoir tank prior to use; IX, The surrounding does not have vegetation or tall trees; X, The plinth of the tap not cracked or eroded; Y, Yes; N, No

Discussion

The maintenance of residual chlorine level up to 1mg/l is intended to provide a safeguard against possible microbial contaminations along the distribution network. The residual chlorine levels of all the water samples collected from the restaurants ranged from 1.05 – 1.16 mg/l which indicated adequate chlorination. Alanc *et al*. (2000) reported that chlorine disinfection level of 0.5 – 2.0 mg/l are commonly in use because of high rate of contamination. The pH values 6.34 – 7.03 values were in conformity with the WHO guideline for drinking water quality which recommends pH values of less than 8.0 for effective disinfection with chlorine (Twort *et al*., 2000; WHO, 2008).

The total hardness level of the water samples with a range of 108 – 148 mg/l can be said to be moderately hard. The purpose of total solid contents evaluation is to determine all the suspended and dissolved matters in water. This should not be more than 500mg/l (De Zuane, 1997). However, a range of 450 – 1020 mg/l was obtained in this investigation. The high level of total solids from some of these sampling points are indications of leakages or broken pipes. Values up to 1000 mg/l of total solids have been encountered in drinking water (Le Chevallier *et al*., 1996).

The total bacterial count of 10 – 1800 cfu/ml was obtained from the water samples. Fifty six percent of the water samples conformed in terms of total bacterial count of less than or equal to 100 cfu/ml. Twenty two percent of the water samples had faecal coliform. WHO (2008) reported that there must be absent of faecal coliform in water in the distribution system. All the water samples had varying ranges of total coliforms (15 – 1100 coliform per 100ml of the water sample). This means that there was contamination along the pipes conveying the water to the different restaurants. The two restaurants (B and H) with faecal coliforms also had the highest total coliform counts. Igunnugbemi *et al*. (2004) reported that over 95% of water samples from University of Ilorin hostel were positive for coliforms while just less than 5% of these were positive for faecal coliforms. Sanitary surveillance revealed the possible sources of contaminations as leaking pipes, proximity of sampling points to gutter and temporary storage of water in reservoir. Lloyd and Bartram (1991); Palomi *et al*. (2001); WHO (2008) suggested that sanitary surveys should be conducted with sufficient frequency for their use in interpreting changes in the quality of drinking water as determined in physical, microbial and chemical monitoring.

A total of six bacterial species were isolated. These were *Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus, Corynebacterium* sp.*, Enterobacter aerogenes* and *E. coli*. The bacterial species isolated from the restaurants ranged from the normal commensals such as *Bacillus* spp. to faecal and non feacal coliforms some of which may be pathogenic. This suggests that efforts need to be made to prevent contamination along the pipes and at the restaurants. Le Chevallier *et al*. (1996) reported the occurrence of coliforms in drinking water with free residual chlorine. In a similar study, Sule *et al*. (2011) reported that only 10% of water stored exteriorly in storage tanks at some homes at Tanke in Ilorin, Kwara, Nigeria were devoid of coliform.

Conclusion

It can be concluded from this study that some of the water samples from the restaurants were not potable in terms of the bacteriological qualities. The isolation of *E. coli* in some of the water samples indicated faecal contamination. The sanitary survey conducted at each restaurant revealed other possible sources of contamination.

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