Original article

Distribution of *E. coli* and Total Coliform in Drinking Water Supply System in Khartoum Locality

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Abstract

A total of 53 treated water samples were collected from the treatment plant and distribution system in Khartoum Locality, to assess the microbial quality by investigating the total coliform count, the prevalence of *Escherichia coli*, and to detect the association between *E. coli* prevalence and the residual chlorine, during the period from September 2014 to October 2015. The total coliform count indicated a very high percentage of 81.1% distributed as **(**11.6 %**),** (23.3%) and (65.1%) in the treatment plant, storage pipes, and consumers' taps respectively. The overall prevalence of *E. coli* was (52.8%). Distribution of *E. coli* in the treatment plant, storage pipes, and consumers' taps showed 10.7%, 21.4% and 67.9% respectively. Moreover, the highest occurrence of *E. coli* was detected during the rainy season (50%). The consumers' taps water showed the highest contamination with *E. coli* (67.9%). Association of the occurrence of *E. coli* with residual chlorine was highly significant (P< 0.001). This work indicated that the bacteriological quality of drinking water in Khartoum Locality needs more consideration.

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Introduction

World Health Organization defines water supply surveillance as keeping a careful watch at all times, from the public health point of view, over the safety and acceptability of drinking water supplies. It involves two complementary activities: Sanitary inspection and water quality analysis. Health education is required to explain the relationship between health, water, sanitation and hygiene.

In piped water distribution systems, a sanitary inspection will often not detect problems occurring during distribution, e.g. pipes buried underground might be damaged, allowing for pollution. Analysis is also used to check the effectiveness of disinfection processes. Most of the mortality and morbidity associated with water-related disease in developing countries is due directly or indirectly to infectious agents (Cheesbrough, 2006).

Coliform organisms are the suitable microbial indicator of drinking-water quality because they are easy to detect and enumerate in water. They are regarded as belonging to the genera *Escherichia*, *Citrobacter*, *Enterobacter*, and *Klebsiella* (WHO, 1997).

Microbial quality of drinking-water includes testing for *Escherichia coli* which provides conclusive evidence of recent fecal pollution and should not be present in drinking-water. *Escherichia coli* is a member of the family *Enterobacteriaceae* (Edberg *et al*., 2000). *Escherichia coli* is widely distributed in the gastro-intestine tract of humans, pests, ruminants, non-ruminants and wild animals, where it is known to live as commensal. *Escherichia coli* has been isolated from humans, farm animals, wild animals, milk, water and environmental samples some of which have been responsible for food borne illnesses and deaths (Adzitey *et al*., 2015).

E. coli is the fecal indicator of choice used in WHO Guidelines for Drinking-water Quality, and several countries include this organism in their regulations as the primary indicator of fecal pollution. Although it has long been known that *E. coli* can cause disease in humans, the bacteria naturally occur in the lower part of the gut of warm-blooded animals (Figueras and Borrego, 2010).

Chlorine can be easily monitored and controlled as a drinking-water disinfectant, and frequent monitoring is recommended wherever chlorination is practiced (WHO, 2006). The use of reactive chemical agents such as chlorine is essential and very commonly involves the destruction of microbial pathogens. Residual disinfection is used to provide a partial safeguard against low-level contamination within the distribution system (WHO, 2006). Chlorine leaves a disinfectant residual that assists in preventing recontamination during distribution, transport, and household storage of water. The absence of a chlorine residual in the distribution system may, in certain circumstances, indicate the possibility of post-treatment contamination (WHO, 2006).

The presence of microorganisms does not necessarily indicate that drinking water poses a health risk. The important consideration is the kind of microorganisms that are present. This work has been carried out with the following objectives:

a) To detect the presence of *Escherichia coli* in drinking water of Khartoum Locality. b) To investigate the total coliform count in collected samples. c) To determine the association between *E. coli* presence and residual chlorine concentration.

Material and methods

Sampling design and strategy

A total number of 53 treated samples of drinking water were collected from the taps of Bahri treatment plant, El-Sahafah storage pipes, and consumers' taps from different sites of the network in Khartoum locality included El-Deum, El-Sahafah, El Reyad, El- Taif, Elmamoura, Arkaweet, and Gabra. Water from each tap was collected as described by Gillet *et al*. (2009) by using sterile glass bottles (250 ml), transported in ice boxes to the Microbiological Laboratory of Environmental Sciences Department, Al-Neelain University for microbial analysis during the period from September 2014 to October 2015. Also, other samples were collected in plastic bottles for residual chlorine measuring

Microbiological analysis

Total coliform count

Most Probable Number (MPN) technique was used for total coliform count as described by Rompre *et al* (2002). An amount of 10 ml from water samples was added to each of five tubes containing 10 ml of double-fold MacConkey broth with Durham tubes. Samples were incubated at 37°C for 24 hours. Fermentation with acid and gas was observed and recorded, then confirmed with brilliant green lactose bile broth where a formation of gas within 48 hours considered positive.

Isolation of *E. coli:*

A loop-full from the incubated fermented brilliant green lactose bile broth was streaked directly onto Eosin Methylene Blue Agar (EMB) and incubated at 37°C for 24 hours; metallic green colonies were sub cultured on nutrient agar plates and incubated at 37°C for 24 hours. The purified colonies were streaked onto nutrient agar slants and incubated at 37°C for 24 hours.

Identification of *E. coli:*

Isolates were identified by using Gram's staining, detection of motility, oxidase test, Indole test, methyl-red test, Voges-Proskauer test, citrate utilization test, urea hydrolysis, and sugars fermentation as described by Cheesbrough (2006).

Residual chlorine investigation:

Residual chlorine was measured in the field immediately after collection by chlorine comparator apparatus

Results and Discussion

The present study showed that 81. 0 % of samples were positive for the total coliform by using the MPN method (Figure 1).

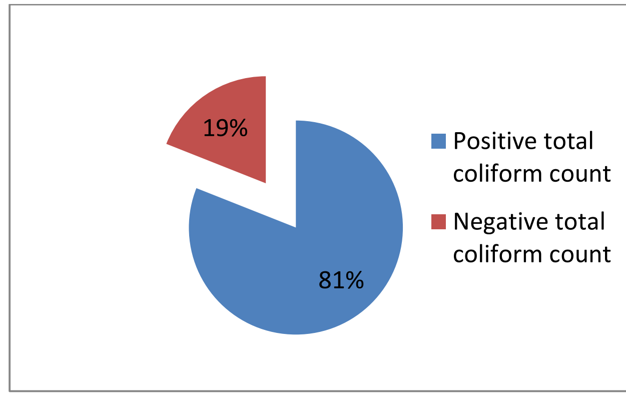

Figure 1. The percentage of total coliform count in water samples of Khartoum Locality.

This percentage is higher compared to El-Amin *et al*. (2010) who mentioned that 62% and 29 % of samples were contaminated with total coliform and fecal coliforms in Wad–Medani and Khartoum samples, respectively, and Rahman *et al*. (2015) who revealed that 70% of samples were positive for total coliform count from primary schools water in Bangladesh, and Malhotra *et al*. (2015) reported that 1.6 % was found to be suspicious after multiple tube fermentation tests for coliforms from samples collected in India.

However, this result is lower compare to Elfadil and Muzdalifa, (2014) who reported 100% contamination with a total coliform count in treated tap water samples collected from Khartoum metropolitan city. Shittu *et al*. (2008) in Nigeria who revealed that none of the samples complied with bacteriological standards as total coliform counts generally exceeded 1,600 MPN/ml., Abera *et al*. (2011) reported that twenty four water samples with no regular treatment had shown 87.5% have presumptive bacteria count MPN above the permissible limits for drinking water. Distribution of total coliform according to the treatment plant, storage pipes, and consumers' taps was 11.6 %, 23.3% and 65.1% , respectively (Figure 2).

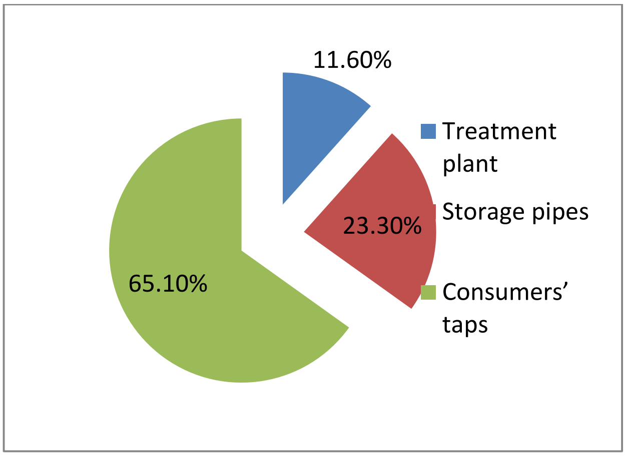

Figure (2). Percentage of positive total coliform count according to different points in Khartoum Locality.

Distribution of the total coliform in this study confirms the fact that total coliform, can be used to measure the effectiveness of treatment and the homogeneity of a distribution system, therefore, high contamination of consumers' taps could be attributed to the absence of residual chlorine (P<0.001) in all samples of consumers' taps.

The present study showed that the overall prevalence of *E. coli* in Khartoum Locality drinking water was 52.8%. This result is higher than that of Yagoub and Ahmed (2009) who revealed 4.5% of water samples in Khartoum State was contaminated by *E. coli*. Momba *et al*. (2008) detected 25.56% from drinking water samples in South Africa, Adzitey *et al*. (2015) who estimated 12% in Nyankpala of Ghana, and Bonyadian *et al*. (2018) who revealed 2.1% in bottled drinking water in Iran, and Rubino *et al*.(2018) who showed negative isolation for *E. coli* in Mexico.

Also, this study showed that the occurrence of *E. coli* during winter season was 35.7% distributed as 7.1% from storage unit and 28.6% from consumers' taps, whereas the treatment unit was negative for *E. coli*. Results also revealed that the prevalence of *E. coli* in summer was 45.0% distributed as 5.0% from the treatment unit, 10.0% from the storage, whereas 30.0% isolated from consumers' taps.

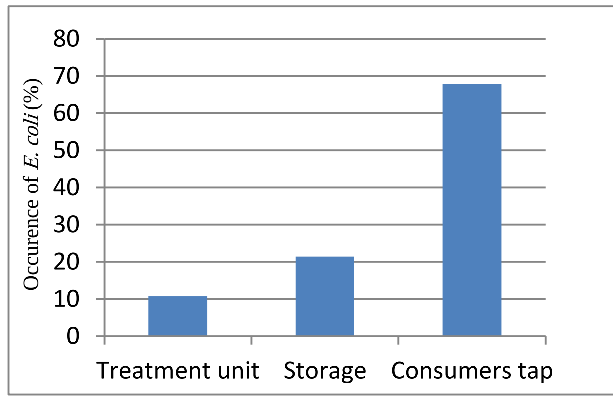

Figure. 3: Occurrence of *Escherichia coli* in drinking water in treatment unit and distribution system.

Also, the results showed that occurrence of *E. coli* in autumn was 73.7% distributed as 10.5% isolated from the treatment unit, 15.8% isolated from the storage, and 47.4% isolated from consumers' taps (Figure 4).

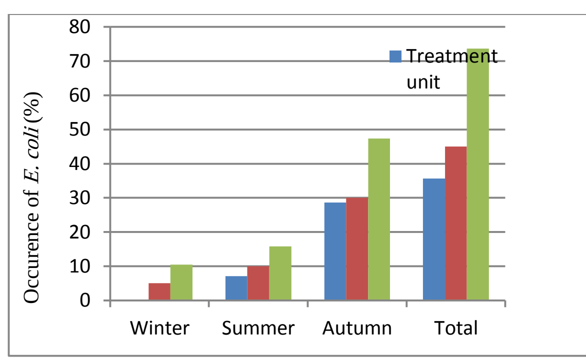

Figure (4): Distribution of *Escherichia coli* in drinking water according to different seasons.

This study also revealed that the highest isolation of *E. coli* was recorded during the rainy season, while the lowest isolation was recorded during winter. These results agree with Andaira (2002) who found that there is a clear relationship between season and contamination level and it reaches its peak mostly in autumn (43.50%). This study also revealed that all samples from the consumer taps and storage pipes were absent from residual chlorine (Table 1). however, the treatment unit showed different concentrations of residual chlorine ranged between 0.1 and 0.6 mg/L (Table 1). Chlorine is a potent oxidant which causes the destruction of nucleic acids and cell membranes and it is an attractive option for disinfection due to its ease of handling, low capital cost and production of residual chlorine (Anastasi *et al*., 2013; Chawla *et al*., 2015). Chlorine leaves a disinfectant residual that assists in preventing recontamination during distribution, transport, and household storage of water. The absence of chlorine residual in the distribution system may, in certain circumstances, indicate the possibility of post-treatment contamination (WHO, 2006). Mojisola *et al*, (2017) found that at 0.5 mg/L free chlorine was ineffective in eliminating bacterial isolates. Further treatment at higher concentration of 1.5 mg/l achieved complete inactivation of *E. coli*.

Table 1 : Means different of chemical and physical characteristics of water and MPN through different steps in Khartoum locality

Parameter	Location	N	Mean ± Std. D.	Std. Er.	Min.	Max.	P. value
pH	Treatment unit	11	8.04 ± 0.33	0.10	7.70	8.90	P > 0.05
	Storage	11	7.94 ± 0.22	0.07	7.60	8.20	
	Consumers	31	7.96 ± 0.20	0.04	7.60	8.40	
Turbidity	Treatment unit	11	23.52 ± 23.31	7.03	4.50	80.00	P > 0.05
	Storage	11	18.54 ± 16.42	4.95	1.80	49.00	
	Consumers	31	17.57 ± 17.21	3.09	0.75	59.60	
Temp3rature	Treatment unit	11	27.66 ± 4.92	1.48	21.00	39.50	P < 0.05
	Storage	11	27.47 ± 2.81	0.85	21.00	32.00	
	Consumers	31	28.99 ± 4.11	0.74	13.00	35.00	
Chlorine	Treatment unit	11	0.18 ± 0.20	0.06	0.00	0.60	P < 0.001
	Storage	11	ND	0.00	0.00	0.00	
	Consumers	31	ND	0.00	0.00	0.10	
MPN	Treatment unit	11	7.09 ± 8.83	2.66	0.00	18.00	P < 0. 01
	Storage	11	15.27 ± 6.21	1.87	0.00	18.00	
	Consumers	31	14.87 ± 6.17	1.11	0.00	18.00	

The study also revealed that the physical and chemical characteristics of water sources in all three locations were not fit according to the WHO guidelines (WHO, 2006), (Table.1).

Conclusion:

This study concluded that the drinking water of Khartoum Locality needs more consideration since a highly contamination with total coliform count was detected in 81.0% of water samples with contamination>18 MPN per100ml, moreover, 52.8% of detected water samples was not fit for consumption due to contamination with E. coli. Also, the storage and consumers' taps were found free from residual chlorine and highly significant association between the contamination level and residual chlorine was found (P< 0.001).

The study also revealed that the physical and chemical characteristics of water sources in all three locations do not fit with the WHO guidelines (WHO, 2006)

Recommendations:

This study recommends that

- Testing of source water, water immediately after treatment, water in distribution systems or stored household water should be surveyed.
- Chlorine concentration should be well calculated according to the distance from the treatment station to ensure safety drinking water with especial concern during rainy seasons.
- Chlorine should be added to the storage pipes before the outlet to the distribution system**.**

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