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Microbial Contamination of Domestic Drinking Water in Khartoum (Sudan)

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Abstract

Background: Public and environmental health protection requires safe drinking water free of pathogenic bacteria. Sources of fecal pollution in potable water resulting from human contamination must be strictly controlled.

Objective: To assess microbial contamination of domestic drinking water in Khartoum, Sudan.

Materials and methods: This was a descriptive study conducted in East Nile region (Khartoum) during the period from June to August (2012). Water specimens were collected from water baked-clay jars (zeers) and water stands (sebeels). The specimens were collected from mosques, public streets, private houses, and schools. Water samples were analyzed using membrane filter technique and cultured on Endo agar media. Consequently, the number of colony-forming units was counted to give the presumptive number of fecal coliforms. *E. coli* isolated were tested by Eijkman test for gas and indole production to identify *E. coli* type I.

Result: A total of 100 water specimens were investigated for bacteriological analysis. They were collected from different areas of East Nile region (Khartoum), namely: Hillat Kuku, Haj Yosuf Extension (squares 9 and 10), Al Shigla, and Eid Babkir. Potable water collected from zeers of private houses was found to be the least contaminated. All sebeels' zeer water samples tested in this study were found to harbor uncountable number of coliform organisms together with *E.coli* type I. All mosques zeer water samples were found not permissible for consumption; except for potable water collected from mosques zeers located in Al Shigla area. As regard schools zeer water, 4 samples (out of 25 tested) were found to harbor *E.coli* type I.

Conclusion: Public streets water stands (sebeels) were the most potable water sources likely to be contaminated by fecal coliforms.

Key words: Microbial contamination, Domestic drinking water, *E.coli* type I

Introduction

Water is essential to sustain life, and without it life becomes impossible. It is an indispensable commodity, which should be easily accessible, adequate in quantity, free of contamination, safe, affordable and available throughout the year in order to sustain life[1].

Availability of water implies sufficient quantity and good quality. Adequate supply of quality water is essential to maintain good public and community health since protection of water resources from contamination is the first priority[2].
Waterborne diseases occur worldwide, and outbreaks caused by the contamination of community water systems have the potential to cause disease in large numbers of consumers. Waterborne outbreaks have economic consequences beyond the cost of health care for affected patients, their families and contacts, and the economic costs of illness and disease, as they also create a lack of confidence in potable water quality and in the water industry in general. In addition to outbreaks caused by contaminated potable water, there are outbreaks caused following the accidental ingestion of recreational waters. Center for Disease Control and Prevention (USA) has maintained a collaborative surveillance system for collecting data pertaining to the occurrence and causes of outbreaks of waterborne disease[3].
Bacteria are the most widely distributed life forms. Pathogenic bacteria range in length from approximately 0.4 to 14 micrometer and 0.2 to 1.2 micrometer in width. Bacteria are organisms often composed of single cells shaped like rods, spheres or spiral structures. Common agents causing waterborne diseases include: *Vibrio, Campylobacter, Salmonella, Shigella and Escherichia.* Coliform bacteria are used for monitoring the bacteriological safety of water supplies on the basis of the realization that the presence of coliform bacteria in water is an indicator of potential human fecal contamination and therefore the possible presence of enteric pathogens. Unsafe or inadequate water, sanitation, and hygiene cause approximately 3.1 per cent of all deaths worldwide. Infectious diseases such as waterborne diseases especially by coliform bacteria are the number one killer of children under five years old and more people die from unsafe water annually than from all forms of violence, including war[4].
In India there are reports stating that, unsafe water causes 4 billion cases of diarrhea in each year, and results in 2.2 million deaths, mostly of children under 5 years. The single largest cause of ill-health and death among children is diarrhea, which kills nearly half a million children each year[5].
The WHO reported that infectious diseases caused by pathogenic bacteria are the most common and wide spread health risk associated with drinking water. It is those a gents that affect millions of people worldwide leading to high mortality and morbidity rates, particularly in vulnerable groups such as the very young, old and immune-compromised persons[4].
The Sudanese commonly keep their drinking water in jars made of baked-clay called zeers. Sebeels are public, street-side water stands which may consist of one, two, or up to six zeers. Water from sebeel is normally served by one cup which is dipped into the zeer whenever one wants to drink. There are many sebeels in Khartoum, at least one sebeel in every street, mosque, school, hospital, and market place. These sebeels serve a large sector of the population of Khartoum. The hygienic fitness of the sebeel or zeer has been questioned. The little research carried out to date concerned itself specifically with disease transmission and was confined to zeers found in private homes[6].
This study dealt with the microbiology of sebeels' water stands located in mosques, public streets, and schools as well as zeers' water located in private houses. The aim of the study was to estimate the number of fecal coliforms and to assess the quality of water in these water sources.

Materials and methods

This was a quantitative study conducted to detect the microbial contamination in domestic drinking water. It is a descriptive study performed in Khartoum (Sudan). The study was performed during the period from June to August (2012). The Mann-Whitney U test (because of the rejection of normality) and receiver-operator-characteristic curve analyses were performed with SPSS software, version 16.0 (SPSS Inc., Chicago, USA).

Water specimens were collected from water baked-clay jars (zeers) and water stands (sebeels) located in mosques, public streets' sebeels, private houses, and schools. Lids of most zeers were absent and usually one cup was used to serve drinking water from these zeers. The water specimens were collected in 100 ml capacity sterile bottles. Each specimen bottle was immersed, before opening, into the zeer's drinking cup that was filled with water from the zeer, then opened inside the cup and entirely filled, and immediately closed while it was inside the cup in order to prevent any contamination[7].

Specimens were collected between 10:00 AM and 12:00 Noon, and were transported to the laboratory in ice bags within 30 minutes. In the laboratory, the specimens were examined within 6 hours of collection. During specimen collection care was taken not to disturb the water at the bottom of the zeer.

Water analysis was carried out using membrane filter technique. 100 ml of drinking water was filtered through a membrane filter. The membrane with the coliform organisms on it is then cultured on a sterile Endo agar base (Himedia Laboratories PVT. Ltd) which is a sterile selective broth containing lactose and an indicator. The plates were incubated at 37°C for 24 hours. After incubation, the number of colony-forming units was counted to give the presumptive number of fecal coliform per 100 ml in the water sample.

To detect fecal *E. coli,* 100 ml of drinking water were filtered using membrane filter technique. The filter pad was cultured on a sterile Endo agar plate, incubated at 44.5°C for 24 hours. After incubation, the number of red colony-forming units was counted to give the number of *E. coli* per 100 ml in the water sample. *E. coli* isolated was tested by Eijkman test for gas and indole production to identify *E. coli* type I.

Results

A total of 100 water specimens were collected for bacteriological analysis. These specimens were distributed as follows: 25 specimens were collected from mosques' zeers, 25 specimens were collected from public water stands (sebeels), 25 specimens from private houses' zeers, and 25 specimens from schools' zeers. The specimens were collected from different areas of East Nile (Khartoum), namely: Hillat Kuku, Haj Yosuf Extension (squares 9 and 10), Al Shigla, and Eid Babkir.

Furthermore, 15 water samples were investigated in Hillat Kuko area. The largest number (uncountable) of total coliforms colony-forming units was identified in zeer' water of mosques, public water stands (sebeels), and private houses. *E.coli* type I was isolated from zeer' water of

mosques, public water stands (sebeels), and private houses (Table I).
15 water samples were investigated in Haj Yosuf Extension (squares 9) area. The largest number (uncountable) of total coliforms colony-forming units was isolated from zeer' water of mosques, from public water stands (sebeels), and from private houses. *E.coli* type I was detected in zeer' water of mosques and public water stands (sebeels) only (Table I).
Also 15 water samples were investigated in Haj Yosuf Extension (squares 10) area. The largest number (uncountable) of total coliforms colony-forming units was isolated from zeer' water of mosques only. *E.coli* type I was detected in zeer' water of mosques and public water stands (sebeels) and from private houses (Table I).

Table (I): Number of water samples contaminated with uncountable coliforms and *E.coli* Type I in Hillat Kuku, Haj Yosuf (square 9), and Haj Yosuf (square 10)

Water Sources	Hillat Kuku		Haj Yosuf (Square 9)		Haj Yosuf (Square 10)	
	Uncountable coliforms	*E.coli* Type I	Uncountable coliforms	*E.coli* Type I	Uncountable coliforms	*E.coli* Type I
Mosques	2	1	2	1	1	1
Sebeels	2	3	1	2	0	1
Houses	2	0	1	0	0	1

On the other hand, the 15 water samples analyzed in Al Shigla area showed the largest number (uncountable) of total coliforms colony-forming units in zeer water of mosques and public water stands (sebeels) only. *E.coli* type I was found in zeer' water of public water stands (sebeels) only (Table II).
Also 15 water samples were analyzed in Eid Babkir area. The largest number (uncountable) of total coliforms colony-forming units was detected in zeer water of mosques, public water stands (sebeels) and private houses. *E.coli* type I was identified in zeer' water of mosques and public water stands (sebeels) only (Table II).

Table (II): Number of water samples contaminated with uncountable coliforms and *E.coli* Type I in Al Shigla, and Eid Babkir

Water Sources	Al Shigla		Eid Babkir	
	Uncountable coliforms	*E. coli* Type I	Uncountable coliforms	*E.coli* Type I
Mosques	3	0	2	1
Sebeels	1	2	1	1
Houses	1	0	2	0

Regarding schools of East Nile area, 25 samples of zeer water were investigated. From these, 9 samples showed uncountable total coliforms colony-forming units; and 4 samples showed growth of *E.coli* type I.

Discussion

Continuous microbiological monitoring of drinking water is essential to ensure compliance with quality standards and to protect public health. Total fecal coliforms have traditionally been regarded as indicators of microbial contamination of water. Recent reviews, however, had shown *E.coli* to be the best indicator for assessment of fecal contamination[8].

The most commonly employed method for the detection of total and fecal coliforms in water is the multiple tube fermentation technique. A major limitation of this technique is the length of time (24-96 h) required to complete the test. Membrane filtration techniques have been performed to enumerate total coliforms and *E.coli* in various types of waters[9].

For this reason the membrane filtration technique was employed in our study.

In Sudan occasionally sewage networks contaminate water supplies; and up to a million people are infected by several diseases. Health authorities and international relief agencies in Sudan reported more than 5.000 cases of diseases caused by drinking contaminated water. World Health Organization (WHO) reported 1.1 billion people lacking access to an improved drinking water supply. The WHO also estimated that 94% of diarrheal diseases may be preventable through modifications to the environment, including access to safe water[5].

According to the WHO recommended limits for potable water, the permissible limit should not exceed one coliform colony-forming unit per 100 ml water; and should contain no colony-forming unit of *E.coli* type I per 100 ml water[9].

Applying the WHO recommendations, the potable water of 25 (25%) samples were found not polluted in this study. These samples were considered permissible and acceptable for human consumption. 20 (20%) of these samples were collected from zeer' water of private houses in areas of Haj Yosuf Extension (square 9), Al Shigla, Hillat Kuko, and Eid Babkir areas. The low microbial contamination of private houses' zeers might be due to the daily cleaning, limited usage, and continuous covering of zeers.

Also all public water stands (sebeels) water tested in this study was found to harbor uncountable coliform organisms together with *E.coli* type I, i.e. not acceptable for human consumption. The contamination in public water stands (sebeels) water might be due to the microbial contaminated hands of users specially on dipping handless cups inside zeer' water.

All mosques zeer water was found not permissible for consumption except potable water collected from mosques zeers located in Al Shigla area. These results indicate that the degree of pollution depends on the communal use of zeer water at the site. Water contamination was more noticed in coverless zeers where water gets access to various foreign bodies such as dust, insects, and domestic animals.

As regard schools zeer' water, 4 samples (out of 25 samples tested) were found to harbor *E.coli* type I. This result raised the degree of water contamination of East Nile schools up to 16%.

Unclean school children might contribute to this high degree of contamination.
Hammad and her colleagues[6] performed a microbiological examination of public water stands (sebeels) water in Khartoum by collecting water specimens from houses, public streets, mosques, and schools. They detected 100% coliforms and 69.88% fecal coliforms in the potable water tested. The degree of pollution was clearly much higher in their study than our study. They also found that fecal coliforms count higher for school and public water stands (sebeels) than for mosques and houses. This result was similar to the results of this study.
On the other hand, Abdelmonem and his co-workers[10] studied the microbial quality of drinking water collected from public water stands (sebeels) and private houses zeers in Al Butana region (Sudan). They detected fecal contamination at these two sites as 35% and 17% respectively. Hence their results were higher than those detected in our study.
From this study it may be recommended that health authorities need to minimize the risks of water contamination by daily cleaning, tight covering, routine disinfection, and fixing water tabs underneath each zeer to work as an outlet for drinking water. Public and environmental health in Sudan needs to enforce effective monitoring of potable water and to spread culture of sanitation in the community.
Conclusion: Public water stands (sebeels) were the major potable water source likely to be contaminated by fecal coliforms.

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