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Bacteriological Quality of Water in Meet Khamis Drinking Water Plant, Egypt: Detection of Bacterial Pathogens and Contamination Sources

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Authors' contributions

This work was carried out in collaboration between all the authors who read and approved the final manuscript.

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ABSTRACT

This study aims to evaluating the bacteriological quality of water in four areas. Locations under investigation were: (1) The River Nile water at Damietta Branch, which used as source water for Meet Khamis Water Treatment Plant, (2) the sedimentation tank in the treatment plant, (3) the final product of Meek Khamis Water Treatment Plant and (4) samples from the distribution system. Water samples from area 1, 2 and 3 were taken in the period from January 2015 till December 2015. Bacteriological analyses involved total coliforms (TC), faecal coliforms (FC), faecal streptococci (FS) and some pathogenic bacteria. The results showed that total coliforms (TC) ranged from 31667 to 78667 cfu/100 ml, faecal coliform (FC) from 2200 to 8200 cfu/100 ml and finally faecal streptococci (FS) ranged from 1200 to 2867 cfu/100 ml. Densities of these bacterial indicators decreased dramatically from raw water to sedimentation tank and completely disappeared in the treated water. One hundred and thirty-nine bacterial isolates obtained from the previously mentioned locations

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were identified using biochemical reaction tests. This included, the following suggested genera: *Esherichia coli* (25.9%), *Klebsiella* (12.2%), *salmonella* (18.7%), *Citrobacter* (0.72%), *Proteus* (16.5%), *Shigella* (24.5%), *Serratia* (1.4%). The obtained results indicated that, the River Nile water was subjected to sewage pollution; however, Meet Khamis water treatment station had the ability to completely remove it.

Keywords: Bacteriological quality; Damietta branch; Nile River; Meet Khamis; pathogenic bacteria; indicators.

1. INTRODUCTION

Water is the source of the life. In Egypt, the River Nile is the main source of drinking water. Unfortunately, the Nile receives heavy loads of industrial, agricultural and domestic wastes. Drinking water must meet strict criteria and standards to ensure that water supplied to the public is safe and free-from pathogenic microorganisms as well as hazardous compounds [1]. One of the most important factors of water pollution is the microbial contamination; especially with pathogenic microorganisms. Enteric pathogens are typically responsible for waterborne sickness [2]. Contamination of water is a serious environmental problem as it adversely affects the human health and the biodiversity in the aquatic ecosystem [3].

The use of indicator bacteria such as faecal coliforms (FC) and faecal streptococci (FS) for assessment of faecal pollution and possible water quality deterioration in fresh water sources is widely used. The faecal coliforms and faecal streptococci indicate that the water has been contaminated with the faecal material of man or other animals, and water may have been contaminated by pathogens or disease producing bacteria or viruses. The presence of fecal

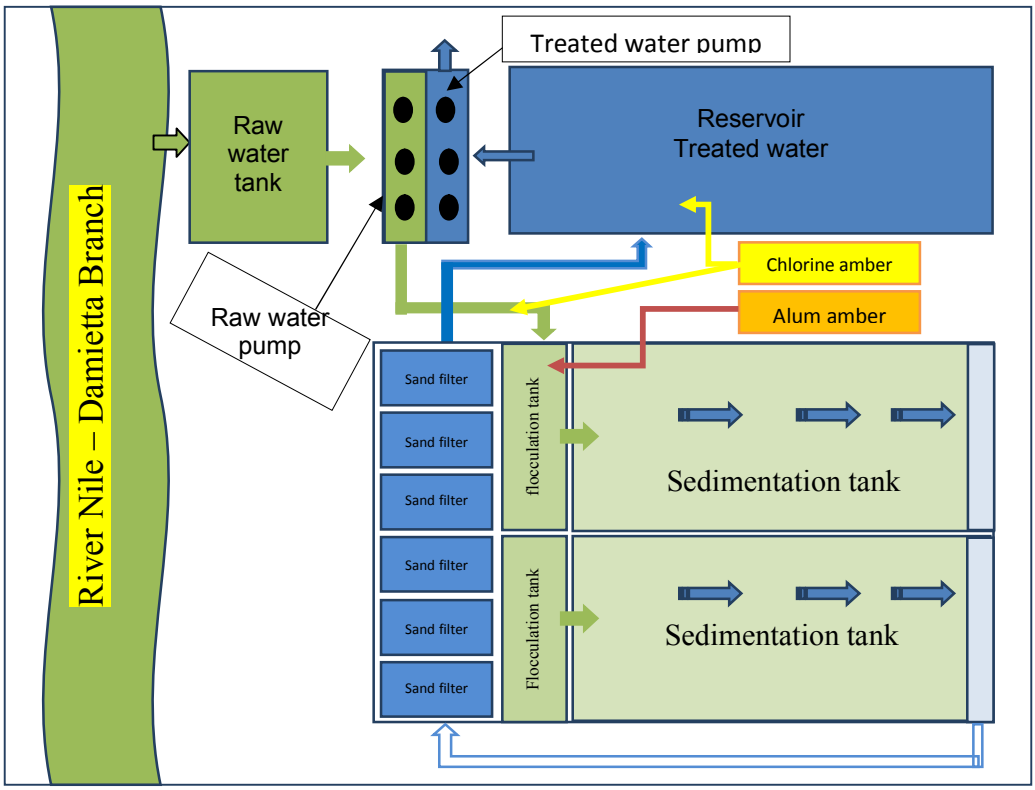

Fig. 1. Design of the Meet Khamis drinking water station

contamination is an indicator that a potential health risk exists for individuals exposed to this water [4].

Pathogens are a serious concern for managers of water resources, because excessive amounts of faecal bacteria in water have been known to indicate risk of pathogen-induced illnesses in humans [5]. The main water related diseases caused by bacteria are cholera, salmonellosis and shigellosis. Most of bacterial pathogens found in wastewater can cause infections of the gastrointestinal tract of warm-blooded animals. They mostly belong to the following genera: *Vibrio, Salmonella, Shigella,* and *E. coli* [6].

Meet Khamis drinking water treatment plant is the biggest water purification station in Dakahliya governorate, Egypt. The treatment plant uses the River Nile as source water. The treatment process in this plant is classical which known as coagulation-flocculation process.

Fig. 1 illustrates the design of Meet Khamis treatment plant.

The objective of this study was to determine the seasonal variations in microbial pollution indicators throughout: (1) Damietta Branch, (2) the sedimentation tank in Meet Khamis treatment plant and (3) final treated water. Additionally, examine the bacterial quality in the distribution system and to identify the pathogenic bacteria.

2. MATERIALS AND METHODS

2.1 Samples' Collection

Samples were collected in clean, sterile, nonreactive borosilicate glass bottle with screw-top closures, 500 ml volume and contained Sodium thiosulfate ($Na_2S_2O_3$). The sample bottles placed in a lightproof insulated box containing ice-packs to ensure rapid cooling and preservation temperature (8°C) during transport to the laboratory [4].

2.2 Study Areas

Water samples were collected monthly during the period between January 2015 and December 2015 from the following spots: River Nile water (Source water of Meet Khamis treatment plant), end of the sedimentation tank in Meet Khamis Plant, and treated water (final product of Meet Khamis Plant).

Additionally, samples from distribution system were collected at three different times a day at 8 am, 4 pm and 12 am for three separate days in the period from 15 to 29 March, 2017. Distribution system samples include: Mansoura university tap water, Mansoura university Reservoirs water (reservoirs found above buildings to store water), El-Baqlia tap water, and El-Baqlia Reservoirs water.

2.3 Bacteriological Examination

The numbers of total coliform, faecal coliform and faecal streptococci were determined using membrane filter (MF) technique. 100 ml sample of treated water were filtered through the membrane (pore diameter, 0.45 µm); while other type of water samples, smaller sample volumes were filtered depending on the expected bacterial density. Upon completion of filtration process, membrane filter was removed using sterile forceps and placed on the selective medium (*LES Endo agar* for total coliform, *m FC agar* for faecal coliform and *m Enterococcus agar* for faecal streptococci). The plates were then incubated at 35°C for 24 hr for total coliforms, at 44°C for 24 hr for faecal coliforms and at 35°C for 48 hr for faecal streptococci [4].

Bacterial densities were calculated using the following equation [4]:

$$\text{Number of colonies } /100\ ml = \frac{\text{colonies counted } \times 100}{\text{ml sample filtered}} = \text{No. CFU}/100\text{ ml}$$

2.4 Isolation and Purification of Gram Negative Bacteria

The bacterial colonies found on filter surface were streaked onto R2A agar for isolation of pure colonies. After that, the isolates were subjected to gram staining and its morphological features were studied using bright field and phase contrast microscope [4].

2.5 Identification of Some Gram-Negative Pathogens

The isolated colonies were identified using some biochemical tests such as motility, catalase, oxidase, lactose fermentation, indole production, sugar iron agar and urease test [4,7,8].

3. RESULTS AND DISCUSSION

3.1 Bacteriological Properties of Meet Khamis Station System

The total coliforms (TC), faecal coliforms (FC) and faecal streptococci (FS) were high in raw water samples than sedimentation tank water. While the treated water showed no growth of the bacterial indicators. Total coliforms (TC) varied from 31667 to 78667 cfu/100 ml, faecal coliform (FC) ranged from 2200 to 8200 cfu/100 ml and faecal streptococci (FS) varied from 1200 to 2867 cfu/100 ml (Table 1).

High bacterial densities shown in raw water were resulted from Omar Bek drain, which considered one of the main and longest drains in El-Gharbia governorate that discharges its wastes directly into Damietta branch [9-11].

3.2 Bacteriological Properties of Distribution System

Neither faecal streptococcus nor faecal coliform were detected in the distribution system samples (Table 2). However, in few cases, total coliform bacteria were shown in water samples from El-Baqlia reservoir.

Because total coliforms are found ubiquitously in the environment, their presence doesn't always mean evidence of contamination by human feces. It could be an indication of contamination with soil or plant material, which wouldn't indicate any harm to humans. Therefore, total coliform is thought to be a process indicator that demonstrates the efficacy of a process, such as chlorine disinfection [4,12,13].

3.3 Isolation and Identification of Gram-Negative Bacteria

In the present study, 139 isolates were obtained from all sampling sites are listed in Table 3. Number of isolates collected from the raw water (Meet Khamis water treatment plant inlet) were 33 which identified as following: *Escherichia coli* represent (11 species), *Klebsiella* (4 species), *Salmonella* (5 species), *Citrobacter* (1 sp.), *Proteus* (4 sp.), *Shigella* (6 sp.) and *Serratia* (2 sp.). This indicated that the raw water of Damietta Branch is subjected to sewage pollution [9,10].

Also, number of isolates showed up in the sedimentation tank water samples which identified as following: Nine species of *Escherichia coli*, two species of *Klebsiella*, eight species of *Salmonella*, six species of *Proteus* and finally five species of *Shigella.* These results indicated that the sedimentation tank had reduced the number of the bacteria, but water still needs further treatment with sand filtration and chlorination [9,10,14,15].

Although, the heavy loads of bacterial densities that found in raw water, Meet Khamis treatment plant was able to produce water free from any of the bacterial indicators which indicate the efficiency of the treatment process in the plant. This is in agreement with the study occurred on Meet-Fris drinking water station [9].

Table 1. Monthly variation of total coliforms (TC), faecal coliforms (FC) and faecal streptococcus (FS) of raw water, sedimentation tank and treated water in Meet Khamis water treatment station

Month	Raw water (cfu/100 ml)			Sedimentation tank (cfu/100 ml)			Treated water (cfu/100 ml)		
	TC	FC	FS	TC	FC	FS	TC	FC	FS
1	32000	3800	2300	1	0	0	0	0	0
2	36667	4067	2067	2	1	0	0	0	0
3	31667	2200	1200	5	0	0	0	0	0
4	36667	3667	2300	1	0	0	0	0	0
5	41667	4000	2300	12	0	0	0	0	0
6	43000	6500	3300	11	1	0	0	0	0
7	65000	6000	2867	4	0	0	0	0	0
8	78667	8200	3700	10	0	0	0	0	0
9	75000	6600	3167	5	0	0	0	0	0
10	56667	5367	2500	9	0	0	0	0	0
11	47000	4733	2000	2	0	0	0	0	0
12	32000	4233	1600	1	0	0	0	0	0

Table 2. Weekly variation of total coliforms, faecal coliforms and faecal streptococcus of Mansoura University tap water and reservoirs, and El-Baqlia tap water from home and reservoirs

		Mansoura University tap water			El-Baqlia tap water from home			Mansoura University Reservoirs water			El-Baqlia Reservoirs water		
		8 am	4 pm	12 am	8 am	4 pm	12 am	8 am	4 pm	12 am	8 am	4 pm	12 am
Total coliform	15/3/2017	0	0	0	0	0	0	0	1	0	4	6	3
	22/3/2017	0	0	0	0	2	0	0	2	0	2	4	0
	29/3/2017	0	0	0	1	1	0	0	0	1	7	3	1
Faecal coliform	15/3/2017	0	0	0	0	0	0	0	0	0	0	0	0
	22/3/2017	0	0	0	0	0	0	0	0	0	0	0	0
	29/3/2017	0	0	0	0	0	0	0	0	0	0	0	0
Faecal streptococcus	15/3/2017	0	0	0	0	0	0	0	0	0	0	0	0
	22/3/2017	0	0	0	0	0	0	0	0	0	0	0	0
	29/3/2017	0	0	0	0	0	0	0	0	0	0	0	0

Table 3. Gram-negative bacteria isolated from Meet Khamis Raw water, Sedimentation Tank water, treated water, Mansoura University taps and reservoirs water, and El-paqlia tap, and reservoir water

Bacteria	Meet Khamis raw water	Sedimentation tank water	Treated water	Mansura University tap water	Mansura UNIVERSITY reservoirs water	El-paqlia tap water	El-paqlia reservoirs water	Total	Percentage
Escherichia coli	11	9	0	0	4	7	5	36	25.9%
Klebsiella	4	2	0	0	8	0	3	17	12.2%
Salmonella	5	8	0	0	0	5	8	26	18.7%
Citrobacter	1	0	0	0	0	0	0	1	0.72%
Proteus	4	6	0	0	0	6	7	23	16.5%
Shigella	6	5	0	0	9	8	6	34	24.5%
Serratia	2	0	0	0	0	0	0	2	1.4%
Total	33	30	0	0	21	26	29	139	

The present investigation on the distribution system reported that, bacteriological water quality of Mansoura University tap water showed the best quality between other examined water samples. This result is due to presence of high concentration of residual chlorine in samples

[9,16]. Mansoura university tap water showed no bacterial growth at all samples. However, Mansoura University Reservoirs water expressed 21 bacterial isolates during the study period (Table 3). Presence of bacteria in reservoirs could be as a result of poor maintenance of reservoirs, high retention time which decrease the concentration of chlorine, as well as introduction of bacteria from outside environment such as insects, dead animals, twigs, algae and/or impurities [12,13,14,15].

Water samples from El-paqlia tap water expressed 26 bacterial isolates during the investigation. Isolates included the following genera: *Escherichia coli* (7 isolates), *Salmonella* (5 isolates), *Proteus* (6 isolates), and *Shigella* (8 isolates). This may be due to absence of the residual chlorine and/or presence of leak in the distribution pipe system [12,13,17,18,19].

4. CONCLUSION

The River Nile at Damietta branch was subjected to a heavy load of microbial contamination but Meet Khamis water treatment plant was successfully able to completely remove it from the produced water. Also, the majority of water samples which collected from Mansoura city and El-Baqlia village networks indicated that water quality remains to be very good. However, a few samples showed poor water quality due to presence of leaks and attacks on the networks which caused the entry of pollutants by back-pressure. Finally, precautions shall be taken to protect reservoirs from contamination by having a hermetically-sealed, opaque lid fitted and by cleaning it periodically using a proper disinfectant.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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