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Microbiological Studies during the Different Treatments of Drinking Water in Road El-Farag Station

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Abstract

The collected water samples were microbiologically evaluated, the total bacterial count was evaluated at 22°C and 37°C. Total bacterial counts at different seasons of investigations revealed that 37°C obtained higher rate of bacterial counts than at 22°C. Total coliform was also recorded for water samples that obtained directly from the River Nile during all examination periods. There was no *E. coli* contamination found in the final treatment stage and all distribution regions. No fecal streptococci contamination was found in the final treatment stage and all distribution regions. The highest *Salmonella* and *Shigella* counts were recorded for water samples obtained directly from the River Nile during all examination seasons. On the other hand, *Salmonella* and *Shigella* were not detected in all distribution regions. Higher value of turbidity was observed during the summer period followed by the spring in both seasons. During the investigation period pH values ranged between 7.0 to 8.4. The highest pH value was recorded during winter 2017. Whereas, the lowest value was recorded during autumn 2016. The lowest COD values were recorded in summer 2016 and winter 2017. Whereas, the highest COD values were recorded in summer 2017 for water samples that obtained directly from the River Nile during all examination seasons. The highest BOD value (15.2 mg/l) was recorded in winter 2017 for water samples that obtained directly from the River Nile during all examination seasons.

Keywords: Microbiological studies, Drinking water, Road El-Farag station, fecal streptococci, *E. coli* and *Salmonella* sp.

Introduction

Water is fundamental to maintain life, because all organisms are made up mostly by water. Water in general obtained from two natural sources, include surface water such as seas, lakes and rivers **(Annual Drinking Water Quality Report, 2005).** Contaminated water causes problems to health and leads to waterborne diseases which can be prevented by taking measures even at the household level. Providing safe water for human uses is a challenging task. Continued research efforts in this area for more than few decades resulted in many processes/technologies **(Shannon *et al.*, 2008).**

The microbial contaminants include pathogens like bacteria, viruses and parasites such as microscopic protozoa and worms. These living organisms can be spread by human and animal waste knowing or unknowingly some contaminants can be easily identified by assessing color, odor, turbidity and the taste of the water. However, most contaminants cannot be easily detected and require different test to reveal whether water is contaminated or not. Thus, the contaminants may result in unappealing taste or odor and stay as well as health effects **(Sharma and Bhattacharya 2017)**.

Rivers are the most important fresh water resources and the River Nile has played an extremely important role in the civilization, life and history of the Egyptian Nation **(Dimian *et al.*, 2014)**. River Nile is the longest river in the world, located in the north-east of the continent of Africa, and stems specifically from Lake Victoria and ends in the Mediterranean Sea, with a length of 6695 kilometers. The Nile basin covers more than three million kilometers and it passes through 11 countries. The upstream States are Uganda, Ethiopia, Eritrea, Congo, Burundi, Tanzania, Rwanda, Kenya and the down-stream states, South of Sudan, Sudan and Egypt *(***Encyclopedia Britannica, 2017)**.

The present work focused the microbiological and chemical evaluation during the different treatments of drinking water in Road EL-Farag station during 2016 and 2017 seasons. The evaluation was based on the seasonal variation correlations between the microbiological and physicochemical parameters. The spatial and temporal pattern of bacteriological contamination (total count, total coliform, faecal streptococci, *E. coli* and *Salmonella & Shigella*) were investigated.

Moreover, water turbidity, temperature, pH, biological oxygen demand and chemical oxygen demand content were also examined.

Materials and Methods

Materials

Source of sample

This study was carried out on Road El-Farag station, great Cairo, Egypt. Samples were collected during different stages (Nile River, clarification, filtration and the distribution system) during two different seasons (2016 – 2017). Samples from the distribution system were withdrawn from Road El-Farag station, El-Azhar and El-Abasia region respectively.

Sampling

Samples were collected in spring, summer, autumn and winter during two seasons 2016 - 2017 in accordance to the standard method for the examination of water and wastewater **(APHA, 2005)**. Samples were collected in sterilized bottle (250 ml) and transported in ice box. Samples were preserved under cooling condition at 5^{o}C and the microbiological examinations were conducted during 18 hr. from sampling. Samples which representative the chlorinated drinking water were contain 1ml thiosulphate solution (10%) for each 120 ml of the sample

Media used

The following media were used throughout this study: Tryptone Glucose Yeast Agar **(APHA, 1999),** this medium was used for determining total microbial count at 22°C and 37°C. Azide dextrose broth medium **(APHA, 1999),** used for determining faecal streptococci by MPN technique. Mac-Conkey Broth medium **(APHA, 2005),** used for counting coliform bacteria using MPN technique. Eosin Methylene Blue (EMP) agar medium **(APHA, 1999),** used for confirmatory test of coliform as well as counting of *Salmonella* & *Shigella* agar **(APHA, 1999)**.

Methods

Microbiological examination

All water samples used in the present investigation were subjected to bacteriological evaluation and total microbial count at two different temperatures (22°C and 37°C), coliform group {Total coliform (TC), faecal streptococci (FS)}, *E. coli*, *Salmonella* sp., *Shigella* were carried out according to standard method of **(APHA, 2005).**

Physical and chemical examination

Physicochemical analyses were performed according to the standard methods for examination of water and wastewater suggested by American Public Health Association **(APHA, 2005)**. Temperature (ºC) was estimated using thermal thermometer. pH values were determined using portable pH meter with electrode (WTW Model pH 197). Turbidity values were determined using HACH- RATIO/XR-turbidimeter gelex secondary turbidity standards (1800, 180, 18, 1.8 NTU). Chemical oxygen demand COD and BOD were measured gravimetrically according to **Stirling(1985)**.

Results and Discussion

Microbiological analyses Total bacterial count

Water is essential to sustain life and a satisfactory supply must be provided to consumers. An enormous effort should be made to achieve a drinking water quality as high as practicable. Failure to provide adequate protection and effective treatment of drinking water will expose the community to the risk of outbreaks of intestinal and other infectious diseases **(WHO, 1996).** The collected water samples were microbiologically evaluated and the total bacterial counts were detected at 22°C and 37°C. The obtained data were presented in **Tables (1 and 2)**

Table 1. Seasonally changes in total bacterial count at 22°C in various treatment stages in Road El. Farag drinking water station.

Locations	Total counts at 22°C (log CFU/ml)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	2.75	3.54	2.69	2.72	3.80	3.93	3.81	2.72
Clarification stage	ND*	0.24	0.13	ND	0.16	0.31	ND	ND
Filtration stage	ND	0.22	ND	ND	ND	0.18	0.13	ND
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	0.4	0.7	0.5	ND	0.4	0.2	ND	0.1
El-Azhar	ND	0.5	0.6	ND	0.7	0.3	0.5	ND
El-Abasia	ND	0.7	ND	0.5	ND	0.6	ND	0.7

* ND= not detected

The highest bacterial counts were recorded for water samples that obtained directly from the River Nile during all examination periods. Incubation of samples at 37°C resulted in high appearance rate of bacterial counts than incubation at 22°C. Appearance of bacteria in the distribution system indicating high pollution rate that can be explained as over 90% of Cairo's drinking water is drawn from the Nile. The Cairo Water Authority has 16 clean water treatment plants. The finished water goes to storage or pump stations for distribution and at this point, microbial contamination enters the distribution system **(El-Gohary, 1994)**

Moreover, problems in the water distribution system or storage sometimes lead to erratic water supplies and/or contaminants entering the drinking water in several areas **(Saleh *et. al.*, 2001).** Time and temperature of incubation are very significant variables, high temperature incubation (35-37^{O}C) and short incubation time (34-48h) favor the growth of bacteria from animals and human, Low temperature incubation (20-28^{O}C) and longer incubation time (5-7days) favour the growth of water-based bacteria **(Allen *et. al.*, 2004).**

Table 2. Seasonally changes in total bacterial count at 37°C in various treatment stages in Road El. Farag drinking water station.

Locations	Total counts at 37°C (log CFU/ml)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	3.88	4.97	3.79	3.76	4.94	5.18	4.96	3.98
Clarification stage	ND	0.5	0.5	ND	0.6	0.9	ND	0.3
Filtration stage	0.6	0.5	ND	ND	0.3	0.4	ND	ND
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	ND	0.1	0.2	ND	0.1	0.3	0.2	0.1
El-Azhar	ND	0.1	ND	0.1	ND	0.1	ND	0.2
El-Abasia	0.2	ND	0.2	ND	ND	0.3	0.2	ND

* ND= not detected

In both tables (1&2), total bacterial count ranged between 2.7 to 3.8 cfu/100 ml at 22ºC and 3.8 to 4.9 cfu/100 ml respectively at the entrance of Rod EL-Farag station (River Nile resource). Such counts were strongly declined or not detected during the different treatments. **Osman *et. al.*, (2011)** found that the highest average log count of Nile water at 37°C reached 6.4 cfu/100 mL in EL-Giza district, followed by Helwan, Shubbra EL-Khema and lastly Embaba being 5.8, 5.63 and 6.4 cfu /100 mL, respectively. On other hand, the highest average log count of Nile water at 22°C reached 6.2 cfu/100 mL in both Helwan and EL-Giza region, while Shubbra EL-Khema and Embaba region recorded lower count, being 5.42 and 2.9 cfu /100mL, respectively. **EL-Taweel** and **Shaban, (2003)** reported that the log total bacterial count of Nile water ranged from 4.1 to 7.4 cfu/100 mL at 22°C, while it reached from 4.1 to 7.3 cfu/100 mL at 37°C.

Total coliform (TC) count

The coliform group is probably the earliest water pollution indicator to detect faecal pollution and prevalence of pathogenic bacteria in water and wastewater **(APHA, 2005)**. Coliform group includes multiple bacterial genera such as *Escherichia, Klebsiella, Enterobacter and Citrobacter*. Data presented in **Table (3)** clearly indicated that, the highest total coliform counts were recorded for water samples that obtained directly from the River Nile during all examination periods.

Table 3. Seasonally changes in total coliform (TC) in various treatment stages in Road El. Farag drinking water station**.**

Locations	Total coliform (log CFU/ml)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	2.10	2.54	2.14	2.14	2.23	2.38	2.04	2.27
Clarification stage	ND	0.13	ND	ND	0.6	0.5	ND	ND
Filtration stage	0.5	0.4	ND	ND	0.4	0.3	0.6	0.4
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	ND	ND	ND	ND	ND	ND	ND	ND
El-Azhar	ND	ND	ND	ND	ND	0.1	ND	ND
El-Abasia	ND	ND	ND	ND	0.2	ND	ND	ND

* ND= not detected

In this respect total coliform was absolutely absent near Rod EL Farag station (ND). But in some cases of summer 2017 (0.1 cfu/100 ml) was appeared, in EL-Azher region or 0.2 cfu/100 ml in EL-Abasia region. Such TC counts could be indicated as a pollution for water system from the walls of the old pipes which provide ideal surface for microbial colonization and biofilm formed causing a number of problems for the water companies **(Charmain *et al.*, 2003)**. In addition, despite effective treatment of drinking water, microbes can enter water utility distribution system and biofilm formation may account for the persistence of microbes in the distribution system **(Marciano-Cabral, 2010).** Additionally, microorganism can also enter distribution network during installation, repair or replacement of infrastructure and by net ingress under dynamic or another depressurization event **(Besner *et al.*, 2011).**

Also, obtained data indicated high coliform counts in summer than the other seasons which can be attributed to the high atmospheric temperature. The obtained results are in harmony with **Silva *et* al., (2008)** they found that, microbiological characteristics of tap water was as following: heterotrophic plate count 500 CPU, total coliforms 0, fecal coliforms 0, *E. coli* 0, *Staphylococcus* spp. 0, *Pseudomonas aeruginosa* 0, fecal streptococci 0 and no sulfite-reducing clostridia were detected.

E. Coli count

E.coli strains are a natural and essential part of the bacterial flora in the gut of humans and animals. Most *E. coli* strains are non-pathogenic and reside harmless in the colon. However, certain serotypes play a role in intestinal and extra-intestinal diseases such as urinary tract infections **(Gordon and FitzGibbon, 1999)**. Currently, coliforms and *E. coli* are of great importance among bacterial indicators used in water quality definition and health risk **(Giannoulis *et al*., 2005)**. The results presented in **Table (4)** clearly show high pollution rate with *E. coli* in the River Nile as well as clarification and filtration stages.

Table 4. Seasonally changes in *E. coli* count in various treatment stages in Road El. Farag drinking water station**.**

Locations	*E. coli* count (log CFU/ml)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	1.73	2.74	1.30	2.10	2.23	2.50	2.11	2.14
Clarification stage	ND	0.3	ND	ND	0.2	0.4	ND	ND
Filtration stage	0.1	0.3	0.4	ND	ND	0.3	ND	ND
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	ND	ND	ND	ND	ND	ND	ND	ND
El-Azhar	ND	ND	ND	ND	ND	ND	ND	ND
El-Abasia	ND	ND	ND	ND	ND	ND	ND	ND

[*] ND= not detected

Obtained data also indicated high *E. coli* count in the supplier source (River Nile) in summer than the other seasons which can be attributed to the high atmospheric temperature. Moreover, there were no *E. coli* contamination found in the distribution system (Road EL-Farag, EL-Azhar and EL-Abasia).

Fecal streptococci count

The use of indicator bacteria such as faecal streptococci for assessment of faecal pollution and possible water quality deterioration in fresh water sources is widely used **(Sabae and Rabeh, 2007).** The faecal streptococcus group consists of a number of species of the genus *Streptococcus*, such as *S. faecalis*, *S. faceium*, *S.bovis*, *S. equines*, *S. avium* and *S. gallinarum* that are normally found in faeces and gut of warm-blooded animals. Unlike the coliform bacteria, they are Gram-positive and also tend to live longer in water than faecal coliforms **(Manafi, 1999)**.

Table 5. Seasonally changes in faecal streptococci (FC) count in various treatment stages in Road El. Farag drinking water station.

Locations	Fecal Streptococci count (log CFU/ml)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	0.76	1.10	0.2	0.4	ND	0.3	0.2	0.3
Clarification stage	ND	0.02	ND	ND	ND	ND	ND	ND
Filtration stage	ND	ND	ND	ND	ND	ND	ND	ND
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	ND	ND	ND	ND	ND	ND	ND	ND
El-Azhar	ND	ND	ND	ND	ND	ND	ND	ND
El-Abasia	ND	ND	ND	ND	ND	ND	ND	ND

[*] ND= not detected

Data presented in **Table (5)** indicated that no fecal streptococci contamination was found in the filtration stage, final treatment stage and all the distribution regions. Fecal streptococci counts were recorded for water samples that obtained directly from the River Nile during all examination periods.

Obtained data also indicated high faecal counts of streptococci in summer than the other seasons. This finding agrees with **Ezzat *et al*. (2012)** who found that faecal streptococci counts in the river Nile (Rosetta branch) ranged between (8-11)*10^4 CFU/100 ml. Also, **Abo-State *et al*. (2014)** revealed that 99% of 116 faecal streptococci samples collected from 11 locations at the river Nile ranged between (1.0*10^1 - 7.0*10^4 CFU/ml) during the year seasons of their study.

Salmonella and *Shigella* count

Data presented in **Table (6)** clearly show that the highest *Salmonella* and *Shigella* counts were recorded for water samples that obtained directly from the River Nile during all examination seasons. Moreover, *Salmonella* and *Shigella* were not detected in all distribution regions and the final treatment stage.

Table 6. Seasonally changes in *Salmonella* and *Shigella* count in various treatment stages in Road El. Farag drinking water station.

Locations	***Salmonella* and *Shigella* count (log CFU/ml)**							
	2016				**2017**			
	Spring	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**
The source (River Nile)	0.4	0.6	0.2	0.1	0.2	0.3	0.2	0.3
Clarification stage	ND	0.2	ND	ND	ND	0.1	ND	ND
Filtration stage	0.12	ND	ND	ND	ND	ND	0.2	ND
Final treatment	ND	ND	ND	ND	ND	ND	ND	ND
Distribution regions								
Road El-Farag	ND	ND	ND	ND	ND	ND	ND	ND
El-Azhar	ND	ND	ND	ND	ND	ND	ND	ND
El-Abasia	ND	ND	ND	ND	ND	ND	ND	ND

* ND= not detected

The obtained results are in accordance with **Ali *et al*. (2015),** in which they reported that pathogenic bacteria (*Salmonella* sp., *Shigella* sp. and *E. coli*) were detected in water samples of both sites in River Nile; after and before El-Sail drain with higher values in site II than site I.

Physicochemical analyses Determination of water turbidity

Turbidity is now seen as a key for water pollution, but it also often used as a surrogate variable for suspended solids concentration. Indeed, in most cases; suspended solids are regarded as the primary indicator of pollution **(Akan and Houghtalen, 2003)**. Turbidity is the measure of fine suspended matter in water, mostly caused by colloidal particles such as clay, silt, living and non-living organisms.

In this respect, results in **Table (7)** clearly indicated that the highest value of turbidity was observed during summer followed by the spring in both seasons. Whereas, the lowest value was recorded in autumn for water samples that obtained directly from the River Nile during all examination seasons.

Table 7. Seasonally changes in turbidity (NTU) in various treatment stages in Road El. Farag drinking water station**.**

Locations	**Turbidity (NTU)**							
	2016				**2017**			
	Spring	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**
The source (River Nile)	11.8	12.3	9.3	11.7	11.5	13.2	9.0	10.5
Clarification stage	0.22	0.31	0.42	0.25	0.54	0.65	0.72	0.25
Filtration stage	0.48	0.41	0.41	0.42	0.44	0.40	0.44	0.38
Final treatment	0.46	0.37	0.45	0.44	0.42	0.42	0.44	0.48
Distribution regions								
Road El-Farag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Azhar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Abasia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Moreover, no turbidity was recorded during the all examined distribution system. These results were reversible to results obtained by **Abdel-Satar *et al*. (2017)** who reported that transparency values were lower (turbidity was higher) during winter.

Determination of water temperature

The changes of water temperature may depend on the variations in meteorological conditions, air temperature, latent heat of evaporation and different sampling times and seasons **(Abdel-Satar, 2005;**

Mahmoud *et al*., 2008; Saad *et a1*., 2011 and Ahmed, 2012).

Seasonally changing in water temperature were recorded in **Table (8)**. Values were ranged between 17.0 - 32.1ºC and the highest temperature (32.1ºC) was recorded during summer 2016. Moreover, lower temperatures were recorded during winter followed by spring in all locations.

Table 8. Seasonally changes in temperature (°C) in various treatment stages in Road El. Farag drinking water station**.**

Locations	Temperature (°C)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	20.0	26.8	19.0	17.0	22.5	26.8	19.0	18.0
Clarification stage	21.3	29.3	21.3	19.2	23.2	25.4	19.5	19.6
Filtration stage	22.5	32.1	22.3	18.5	24.5	28.4	27.4	21.9
Final treatment	25.0	27.5	20.1	17.8	24.6	27.8	22.8	22.4
Distribution regions								
Road El-Farag	17.5	23.1	22.4	21.3	18.4	29.3	21.3	22.5
El-Azhar	19.4	29.5	19.4	29.4	23.6	29.4	22.6	21.3
El-Abasia	22.6	24.1	18.3	19.4	21.2	27.2	19.4	22.3

These results were in harmony with **El- Gammal and El-Shazely (2008)** who recorded that the temperature along Rosetta branch ranged from 20 to 30ºC at various seasons. In addition, **Ezzat *et al.* (2012)** reported that temperature changes ranged from 25.5°C to 27.7°C in drains outlets and between 25°C to 28.3°C along Rosetta branch sites during summer 2010 and winter 2011. Moreover, temperature change depends mainly on the climatic conditions. Similarly, results by **Abdel-Satar *et al.* (2017)** showed that temperature ranged between 17.8 to 18.9ºC during winter and between 18.7 to 27.9 ºC during spring. While, during summer and autumn the temperature ranged between 24.5 to 30.7ºC and 20.5 to 26.8ºC, respectively.

Determination of the pH

Regarding the seasonally changes of pH data presented in **Table (9)** indicated that pH values ranged between 7.0 to 8.4. The highest value was recorded during winter 2017. Whereas, the lowest value was recorded during autumn 2016. In this respect, **El-Gammal and El-Shazely (2008)** reported that pH values of 24 sites along the Nile from Aswan to Cairo ranged between 7.3 to 8.5 during winter and between 7.6to 8.3 during spring. While, during summer and autumn pH values were ranged between 7.7 to 8.6 and 7.7 to 9.0, respectively.

Table 9. Seasonally changes in pH in various treatment stages in Road El. Farag drinking water station.

Locations	pH							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	8.2	8.2	8.0	8.2	8.3	8.3	8.2	8.4
Clarification stage	7.2	7.3	7.3	7.2	7.5	7.4	7.2	7.5
Filtration stage	7.3	7.3	7.6	7.5	7.3	7.1	7.2	7.2
Final treatment	7.35	7.3	7.0	7.5	7.3	7.4	7.1	7.1
Distribution regions								
Road El-Farag	7.1	7.4	7.0	7.2	7.1	7.3	7.5	7.1
El-Azhar	7.2	7.4	7.4	7.2	7.5	7.6	7.2	7.1
El-Abasia	7.4	7.3	7.3	7.5	7.4	7.3	7.5	7.5

Also, **Ezzat *et al.* (2012)** showed that pH values water samples collected from the River Nile in summer and winter seasons were ranged from 7.45 to 7.9. Moreover, **Abdel-Satar *et al.* (2017)** reported that pH in the Nile River was generally on the alkaline side.

Determination of the COD

Chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxidant. COD is a reliable parameter for guiding the extent of pollution in water **(Pejman *et a1*., 2009 and Garg *et a1*., 2010).**

Data presented in **Table (10)** indicated that the lowest values were recorded in summer 2016 and winter 2017. Whereas, the highest values were recorded in summer 2017 for water samples that obtained directly from the River Nile during all examination seasons. Moreover, no COD values were recorded during the all examined distribution system.

Table 10. Seasonally changes in COD in various treatment stages in Road El.Farag drinking water station**.**

Locations	COD (mg/l)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	17.3	14.8	15.2	18.3	20.3	25.6	17.4	15.3
Clarification stage	3.50	2.60	3.10	2.60	4.20	5.20	3.60	2.50
Filtration stage	2.70	1.80	1.30	2.10	2.30	1.90	2.40	3.50
Final treatment	1.80	2.30	1.70	2.50	1.70	2.10	2.50	1.30
Distribution regions								
Road El-Farag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Azhar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Abasia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Determination of the BOD

Biochemical oxygen demand (BOD) measurement involves determining the amount of dissolved oxygen required by bacteria to decompose organic matter in water through aerobic biochemical action, thus its determination constitutes a tool for organic pollution evaluation in water **(Chapman, 1992)**.

Data presented in **Table (11)** showed that the highest BOD value (15.2 mg/l) was recorded in winter 2017 for water samples that obtained directly from the River Nile during all examination seasons. Moreover, no BOD values were recorded during the all examined distribution system. **Ezzat *et al*. (2012)** reported that BOD in the River Nile were ranged from 5.5-52.0 mg/l. While, **Abdel-Satar *et al*. (2017)** stated that BOD values were ranged between (1.2-8.0 mg/l), (1.8-8.0 mg/l), (1.2-5.9 mg/l) and (1.8-6.5 mg/l) during winter, spring, summer and autumn, respectively.

Table 11. Seasonally changes in BOD in various treatment stages in Road El.Farag drinking water station.

Locations	BOD (mg/l)							
	2016				2017			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
The source (River Nile)	10.2	11.9	13.4	9.40	7.30	12.5	14.7	15.2
Clarification stage	1.30	1.60	0.60	0.80	1.40	1.30	0.40	1.70
Filtration stage	0.60	0.90	0.50	0.50	1.20	1.40	1.20	2.10
Final treatment	0.70	0.30	0.60	0.10	0.30	0.60	0.70	0.50
Distribution regions								
Road El-Farag	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Azhar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El-Abasia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Additionally, **El-Bouraie *et al*. (2011)** indicated that BOD values were ranged between (1.0-130 mg/l), (2.0-110.0 mg/l), (1.0-80.0 mg/l) and (1.0-75.0 mg/l) during winter, autumn, summer and spring, respectively.

Conclusion

Microbiological and physicochemical evaluation of drinking water in Road El-Farag station indicated that, the highest bacterial counts were recorded for water samples that obtained directly from the River Nile during all examination periods. Fecal streptococci, *E. coli, Salmonella* and *Shigella* were not detected in all distribution regions. The highest value of turbidity was observed during summer

Period followed by the spring in both seasons. The highest COD and BOD values were recorded in summer and winter 2017, respectively for water samples that obtained directly from the River Nile during all examination seasons.

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دراسات ميكروبيولوجية خلال المعاملات المختلفة لمياه الشرب بمحطة مياه روض الفرج

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أجريت هذه الدراسة على مياه الشرب في محطة المعالجة بمنطقة روض الفرج .تم أخذ عينات المياه من النيل مباشرة قبل دخولها المحطة وكذلك خلال مراحل المعالجة المختلفة داخل المحطة بالإضافة الي مناطق التوزيع (روض الفرج، العباسية، الأزهر) تم عمل تقييم ميكروبيولوجي وكيميائي لمياه الشرب وأظهرت النتائج أن العدد الكلي للميكروبات وكذلك بكتريا الكوليفورم كان مرتفعا في عينات المياه المأخوذة مباشرة من نهر النيل وذلك في كل فترات الدراسة .أظهر التحليل الميكروبيولوجي لعينات مياه الشرب المأخوذة من مناطق التوزيع (روض الفرج، العباسية، الأزهر) عدم وجود أي تلوث ببكتريا *E. coli*, Fecal streptococci, *Shigella* and *Salmonella* . ظهرت أعلي معدلات للعكارة في مياه النيل خلال فصل الصيف متبوعا بفصل الربيع في كلا الموسمين .تم تسجيل أعلي معدل لل COD و ال BOD في فصلي الصيف و الشتاء للعام 2017 علي التوالي و ذلك لعينات المياه المأخوذة مباشرة من نهر النيل خلال موسمي الدراسة.