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Bacterial Distribution and Physico-Chemical Studies on Drinking Water from Different Sites in Zagazig City (El-Sharkia Governorate)

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Abstract

Water quality assessment of drinking water has been studied in Zagazig city, El-Sharkia Governorate, Egypt between Summer 2015 to Autumn 2016. Water samples were collected from 7 sites during the four seasons. These sites are raw water (Bahr Mowees), Prechlorinated Water and Postchlorinated Water from Zagazig drinking water treatment plant and 4 drinking water sites which are (Zuhur District, Zagazig university Area, El-Janine street Area, Farouk Street Area). The obtained results clearly indicated that the physical and chemical results agreed with the WHO limit and standard limits for drinking water in Egypt, in Zagazig except alkalinity and residual chlorine. This study indicated the Total viable bacterial counts (T.V.B) on nutrient agar medium, total coliform (T.C.F) and feacal coliform (F.C.F) on endo agar base medium at different sites in Zagazig city through four seasons expressed as colony forming unit (CFU)/100 ml sample of each group using membrane filter technique. In this study the bacterial isolates were isolated from all sites during different seasons in Zagazig city and purified. It is reported that untreated water sources were more heavily contaminated with both total and faecal coliforms than treated water sources.

Keywords: *Physical, Chemical, Bacterial parameters, water, Zagazig city, El-Sharkia Governorate.*

Introduction

Water is the lifeblood of all living things on Earth **(International Association of Hydrology (IAH, 2001)**. Safe drinking-water should not pose any significant risk to health over the course of a lifetime of consumption, including differential sensitivities that occur between life stages **(WHO, 2006)**. Egypt has faced severe water shortages for the past few years. Increased population leads to increased water demand and rapid economic growth leads to ecosystem degradation **(Ibrahim *et al.*, 2018)**.

Egypt covers approximately 1 million square kilometers; however, today 95% of the country is desert. With an estimated population of 95 million people, the country accounts for the one-fourth of the recent Arabic world's population. More than 90% of Egypt's population lives along the Nile River and the Nile Delta in the north of the country accounts for only 10% of the total area **(Abdel-Ghaffar *et al.*, 2019)**.

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, a length of 6695 kilometers, and covers the Nile basin more than three million kilometers **(Encyclopedia Britannica, 2017).** The Nile in Egypt divides into two tributaries, the first being the Rosetta tributary in Lower Egypt, on the western boundary of the delta before the river empties into the Mediterranean Sea. The second is the Damietta branch to the east (**Salvini *et al.*, 2015).** It also has four Rayahs (Canals) namely ElNassery, El-Behery, El-Menofy and El-Toufeky **(Abdel-Aziz, 2005).** Bahr Mowees is branched from El-Toufeky and entered Zagazig city, El-Sharkia Governorate as shown in (Figure 1).The Nile River in Egypt provides an important source of drinking water for communities and has important fisheries value. Anthropogenic activities including agricultural runoff, industrial and municipal wastes can affect the water quality of the Nile. The pollutants enter into the Nile system by direct discharges or surface runoff. Things got worse as the budget for water from the Nile to Egypt dwindled and the construction of the Ethiopian Renaissance Dam was completed. In order to improve the water quality of the Nile, it is necessary to deal with the different wastes that are discharged directly into the water of the Nile or seep into the drains, which cause a lot of pollution to the river **(Abdel-Satar *et al.*, 2017).**

The physical, chemical, or biological aspects of a water sample will generally comply with water quality guidelines or requirements to assess the consistency of the water for human use. Some processing procedures should pay attention to some disturbance parameters. Seasonal water quality monitoring is also seen as a good practice for evaluating plants and processes for water treatment **(Elamary *et al.*, 2022).** Water has unique chemical properties due to its polarity and hydrogen bonds, so it is capable of dissolving, absorbing, adsorbing or suspending many different compounds **(WHO, 2007).**

Numerous studies have clearly shown, Improving the microbiological quality of on-site domestic water, or improving point-of-use treatment and safe storage in containers, reduces diarrhea and other water-borne diseases in communities and households in several countries **(Ouma and Gerba, 2011)**.

In addition to contributions from human activities, water-rock interactions also control water chemistry. Agricultural, industrial and municipal wastewater is a major cause of water pollution and should be treated before discharge into the Nile as shown in (Figures 2 and 3). Water sources and drinking water should be continuously monitored to prevent associated human waterborne diseases **(Abdelhafiz *et al.*, 2021)**.

Water usually comes from two main natural sources; surface water such as freshwater lakes, rivers, streams, etc. and ground water such as borehole water and well water (**McMurry and Fay, 2004 , Mendie, 2005**).The world faces enormous challenges in meeting the growing demand for clean water as available fresh water supplies are drying up due to (i) prolonged drought, (ii) population growth, (iii) stricter health regulations and (iv) competing demands from various users **(USEPA, 1998a and 1999b ; BRSNL, 2003)**.

A key issue with water for humans is sanitation. More than 4 million people have died from disease following exposure to microorganisms, and most cases caused by contamination of water with microorganisms. However, to obtain safe drinking water, it is necessary to get a pathogen free drinking water **(Manafi, 2011)**.As such, the Nile has a dominant influence on the country's economic, cultural, public health, social and political aspects **(Mahrous, 1997 ; Rabeh, 2007).** The Nile provides approximately 98% of Egypt's water supply **(Saad and Goma, 1994)**. The Nile provides 96% of Egypt's water **(Barnes, 2012)**. Pollution in the Nile system (mainstream of the Nile, drains and canals) has increased over the past few decades due to population growth **(Barnes, 2012).**The main purpose of the present work is to find out the physico-chemical and bacteriological characteristics of drinking water samples from the municipality of Zagazig, El-Sharkia governorate.

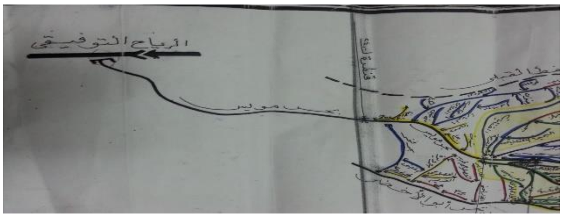

Fig. (1): Bahr Mowees is branched from El-Toufeky and entered Zagazig city, El-Sharkia Governorate.

Fig. (2 and 3): Contamination of Bahr Mowees in Zagazig city.

Materials and Methods*Collection of water samples*

Water samples were collected from 7 sites during the four seasons. These sites are raw water (Bahr Mowees), Prechlorinated Water and Postchlorinated Water from Zagazig Drinking Water Treatment Plant (ZDWTP) as shown in (Figure 4) and 4 drinking water sites which are (Zuhur District, Zagazig university Area, El-Janine street Area, Farouk Street Area) in Zagazig City, El-Sharkia Governorate. All water samples were collected in 1000 ml sterilized bottles according to American Public Health association **(APHA, 2005)** and collected from Summer 2015 to Autumn 2016.

Physicochemical characteristics

Different physical properties were measured by using standard technical methodologies. List of measured physical parameters includes, temperature, (pH), turbidity, electrical conductivity (EC), total dissolved solids (TDS). Chemical parameters are chloride (Cl-), total alkalinity, total hardness, magnesium hardness, calcium hardness and residual chlorine. Both parameters were determined according to **(APHA, 2005)**.Bacterial methods

Fig. (4): Bahr Mowees (Raw water) and Zagazig Drinking Water Treatment Plant (Prechlorinated and postchlorinated water)in Zagazig city.

Water samples were analyzed for the determination of classical bacterial indicators of pollution, water samples were separately collected in clean, dry autoclavable polypropylene containers. Samples were transferred immediately to the laboratory in the ice box and analyzed. All the bacteriological tests and the consequently used culture media were performed according to recommended methods in the standard methods for examination of drinking water and raw water **(APHA, 2005)**.Isolation of different bacteria:

The method membrane filter (M.F) is based on the filtration of known volume of water sample through a membrane filter consists of a cellulose compound with uniform pore diameter of 0.45 micron, the bacteria are remained on the surface of filter paper for (clarified, filtrate stages and tap water) as shown in (Figure 5). When the membrane containing the bacteria is incubated in a sterile container at appropriate temperature with a selective media, colonies of coliform are counted directly **(WHO, 2004 and Gautam, 2014).**

Fig. (5): Membrane filter technique.

*Enumeration of total viable bacterial count (TVBC) using pour plate method*TVBC was carried out according to **APHA (2005)**. Nutrient agar medium was poured into the petri dishes and left to solidify. The inverted Petri dishes were incubated at 37°C for 24 h and. Negative control plates were also incubated. After the incubation periods, all dishes were counted with colony counter (Cook Electoromics LTD.) and recorded as colony forming unit (CFU/ml).

*Enumeration of total coliform*According to **APHA (2005)** m-Endo agar media was used for detection and enumeration of total coliforms. The filtered sample size was depending on the expected bacterial density. The sterile cellulose nitrate membrane filter (Whatman®, 47mm diameter, 0.45µm pore size) was placed over a sterilized porous plate receptacle using sterile forceps, then place sterilized matched funnel unit over receptacle and lock it in place. The sample was filtered through the membrane filter, unlock and remove funnel, immediately remove membrane filter with sterile forceps and place it on m-Endo agar LES with a rolling motion to avoid entrapment of air, invert dish and incubate for 22 to 24 hr at 35 ± 0.5ºC. The typical coliforms colony has a pink to dark-red color with a metallic surface sheen. Pink, blue, white or colorless colonies lacking sheen were considered non-coliforms. The membrane filters with 20 to 80 coliforms colonies and not more than 200 colonies of all types per membrane was calculated as colony forming unit (CFU/100 ml).

Enumeration of fecal coliform m-Endo agar media was used for the detection and enumeration of fecal coliforms in all water samples using membrane filter technique **(APHA, 2005).** Feacal Coliform colonies showing dark red colour or green with metallic sheen were counted as F.C.F on endo agar base medium after incubation at 44-45°C for 24 h was counted as fecal coliforms (CFU/100 ml).

Results

Physical analysis

The data obtained for physical analysis of water samples collected from 7 sites of El-Zagazig city, El-Sharkia governorate, Egypt during four seasons (2015-2016). The obtained data were presented in table (1).

1- Temperature – (^{0}C)

Table (1) showed that the slight remarkable variation in temperature was recorded in all studied sites through four seasons. High temperatures were 23.8^{0}C, 24.7^{0}C, 21.2^{0}C and 20.3^{0}C in spring, summer, autumn and winter (2015-2016) respectively. The low temperatures in the same sequence of the previous seasons were 21.9^{0}C, 22.2^{0}C, 19.3^{0}C and 18.7^{0}C . It is important to notice that the effect of temperature in the water was lesser than that of the air.

2- Hydrogen ion concentration (pH)

Data of pH during four seasons were represented in table (1). The highest value of pH was 7.84 which recorded in winter followed by 7.8, 7.78 and 7.69 in spring, summer and autumn respectively. The lowest value of pH was 6.87 which recorded in autumn 2016 followed by 6.9, 7.2 and 7.3 in winter, summer and spring.

3- Turbidity – Nephelometric Turbidity Unit (NTU)

Table (1) clearly showed that the range of turbidity is between 2.8 to 16.8 NTU at site 1 in spring and summer respectively. At sites 3, 4, 5, 6 and 7 the high reduction of turbidity was recorded at four seasons.

4- Electric conductivity (E.C) – (ds/m)

Table (1) demonstrated that the measured values of E.C in autumn in all studied sites were between 414 ds/m and 451 ds/m. In spring the lowest range was 322 ds/m at site 7 and the highest range was 403 ds/m at site 2. At site 2 the lowest values were 328 ds/m and 359 ds/m in summer and winter respectively. At site 6 the highest value was 458 ds/m in winter. The highest value was 754 ds/m at site 7 in summer. It is important to notice that this also was the highest value in all studied sites at the four seasons.

5- Total dissolved salts (T.D.S) – (mg/l)

Table (1) showed that the value of T.D.S was 482.5 mg/l at site 7 in summer. The value of T.D.S was 209.9 mg/l at site 2 in summer also. The value of T.D.S was ranging from 206 mg/l and 293.76 mg/l in all studied sites in winter, spring and autumn.

Table (1):Physical parameters as Temperature-(ºC), (pH), Turbidity-(NTU), (E.C)-(ds/m) and (T.D.S)-(mg/l) of water samples collected from 7 sites of El- Zagazig city, El-Sharkia governorate, Egypt during the four seasons (2015- 2016)

Season	**Physical ** parameters**	**Samples * collected**						
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Summer 2015	Temperature	24.7	24.1	23.9	23.4	23.5	23.5	22.2
	pH	7.7	7.2	7.29	7.65	7.7	7.72	7.78
	Turbidity	16.5	9.3	0.34	0.47	0.25	0.28	0.24
	E.C	339	328	355	381	370	366	754
	T.D.S	216.9	209.9	227.2	243.8	236.8	234.2	482.5
Winter 2015/2016	Temperature	18.8	18.7	18.9	20.3	20.1	19.5	19.7
	pH	7.84	7.24	7.54	7.30	7.20	6.9	7.1
	Turbidity	16.8	10.2	0.34	0.81	0.82	0.98	0.63
	E.C	364	359	383	442	450	458	453
	T.D.S	232.9	229.7	248	282.8	288	293.1	289.9
Spring 2016	Temperature	23.8	22.9	22.6	21.9	22	22.8	22.5
	pH	7.6	7.8	7.5	7.3	7.4	7.5	7.3
	Turbidity	2.8	2.1	0.5	0.39	0.4	0.5	0.5
	E.C	383	403	329	341	334	330	322
	T.D.S	245.1	257.9	210.5	218.2	213.7	211.2	206
Autumn 2016	Temperature	19.5	19.6	19.7	21.2	21	19.3	20.8
	pH	7.69	7.15	7.1	7.4	7.5	6.87	7.51
	Turbidity	5.39	3.64	0.549	0.19	0.78	0.94	0.539
	E.C	451	414	451	446	445	445	451
	T.D.S	293.76	264.96	288.64	285.44	284.8	284.8	288.64

* 1=Bahr Mowees; 2=Prechlorinated Water; 3=Postchlorinated Water; 4=Zuhur District; 5=Zagazig University Area; 6=El-Janine StreetArea; 7=Farouk Street Area

** E.C= Electric Conductivity-(ds/m); T.D.S=Total Dissolved Salts-(mg/l)

Chemical analysis

The data obtained for chemical analysis of water samples collected from 7 sites of El-Zagazig city, El-Sharkia governorate during four seasons (2015-2016). The obtained data were presented in table (2).

1- Chlorides - (mg/l)

Table (2) demonstrated that the slight flactuation was observed in the studied sites at three seasons only (winter 2015/2016, spring 2016 and autumn 2016). High difference was observed in chlorides in summer 2015.The highest value was 70.6 mg/l at site 7 while the lowest value was 17.2 mg/l at site 1 in summer 2015.2- Alkalinity - (mg/l)

The most important compounds in water that determine the alkalinity include carbonate $(CO_3)^{-2}$ and bicarbonate $(HCO_3)^{-1}$ ions.

The obtained results in table (2) showed a slight flactuation at sites 2, 3, 4, 5 and 6 at all seasons. At site 1 the alkalinity was 240 mg/l, 171.6 mg/l, 158 mg/l and 136 mg/l in spring 2016, autumn 2016, winter 2015/2016 and summer 2015 respectively. The highest value of alkalinity was 244 mg/l which recorded at site 7 only in summer 2015 then decreased to 144 mg/l, 135 mg/l and 130 mg/l in autumn 2016, winter 2015/2016 and spring 2016 respectively.

3- Total hardness (T.H) – (mg/l)

Table (2) showed that the same pattern of alkalinity was recorded at sites 2, 3, 4, 5 and 6 in all seasons. Total hardness was 200 mg/l in spring 2016 at site 1, 156 mg/l at both winter 2015/2016 and autumn 2016 and decreased to 133 mg/l in summer 2015. At site 7 the value of total hardness was 179.6 mg/l in summer 2015, 162 mg/l in autumn 2016, 142 mg/l in winter 2015/2106 then the lowest value 120 mg/l was recorded in spring 2016. There is a relation between the total hardness with magnesium and calcium hardness as the following:Total hardness = Magnesium hardness + Calcium hardness

4- Magnesium hardness (Mg hardness) – (mg/l)

Table (2) showed that the highest values of Mg hardness were 82 mg/l, 80.8 mg/l, 80 mg/l and 60 mg/l in autumn 2016 at site 3, summer 2015 at site 7, winter 2015/2016 at site 1 and spring

2016 at site 1 respectively. The lowest values of Mg hardness were 26.6 mg/l in summer 2015 at site 5, 30 mg/l at both winter 2015/2016 and spring 2016 at site 3 and 41 mg/l in autumn 2016 at site 4 .

5- Calcium hardness (Ca hardness) – (mg/l)

Table (2) showed that in spring 2016 in general the highest value of Ca hardness was 140 mg/l at site 1 and in all seasons. The lowest value of Ca hardness was 70 mg/l at site 7. The slight flactuation was recorded in summer 2015 and winter 2015/2016 (98.8 to 74 mg/l) and (96 to 68 mg/l) respectively. In autumn 2016 the highest value of Ca hardness was 124 mg/l at site 4 and the lowest value was 80 mg/l at site 1.

6- Free radical chlorine (F.R.Cl^-) – (mg/l): (Residual chlorine)

Table (2) showed that the F.R.Cl^- was not detected (measured) at site 1 in all seasons. The highest values of F.R.Cl^- were 3.5 mg/l, 3.1 mg/l, 3 mg/l and 2.5 mg/l in autumn 2016, winter 2015/2016, spring 2016 at site 7 and summer 2015 at sites 3, 4 and 5 respectively. The lowest values of F.R.Cl^- were 0.4 mg/l at both summer 2015 and spring 2016 at sites 7 and 2 respectively. This is followed by 1.6 mg/l and 1.8 mg/l at site 2 at both autumn 2016 and winter 2015/2016 respectively.

Table (2):Chemical parameters as Chlorides-(mg/l), Alkalinity-(mg/l), (T.H)-(mg/l), (Mg hardness)-(mg/l), (Ca hardness)-(mg/l) and Residual chlorine-(mg/l) of water samples collected from 7 sites of El- Zagazig city, El-Sharkia governorate, Egypt during the four seasons (2015- 2016)

Season	**Chemical ** parameters**	**Samples * collected**						
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Summer 2015	Chlorides	17.2	19.1	20.8	24.8	25.9	25.2	70.6
	Alkalinity	136	127	116	119	122	118.2	244
	T.H	133	125	114	126.2	105.2	128.2	179.6
	Mg hardness	45	43	36	50.8	26.6	54.2	80.8
	Ca hardness	88	82	78	75.4	78.6	74	98.8
	Residual Cl^-	0.0	1.9	2.5	2.5	2.5	2.2	0.4
Winter 2015/2016	Chlorides	31	33.2	35	39.8	39.4	38	42
	Alkalinity	158	157	156	141	143	138	135
	T.H	156	142	126	149	138	151	142
	Mg hardness	80	74	30	69	66	65	67
	Ca hardness	76	68	96	80	72	86	75
	Residual Cl^-	0.0	1.8	2.6	2.6	2.5	2.8	3.1
Spring 2016	Chlorides	34.6	37	40	49	50	40	30
	Alkalinity	240	190	140	127	130	140	130
	T.H	200	168	120	150	130	140	120
	Mg hardness	60	55	30	38	50	40	50
	Ca hardness	140	113	90	112	80	100	70
	Residual Cl^-	0.0	0.4	0.6	0.5	0.5	2.5	3
Autumn 2016	Chlorides	39.9	41.7	43.4	42.7	42.6	41.9	45.2
	Alkalinity	171.6	163	146.4	160	162	146.2	144
	T.H	156	149.6	166	165	154.2	173.2	162
	Mg hardness	76	59.6	82	41	68.2	76	74
	Ca hardness	80	90	84	124	86	97.2	88
	Residual Cl^-	0.0	1.6	2.8	2.8	3	2.3	3.5

* 1=Bahr Mowees; 2=Prechlorinated Water; 3=Postchlorinated Water; 4=Zuhur District; 5=Zagazig University Area; 6=El-Janine StreetArea; 7=Farouk Street Area

** T.H=Total Hardness-(mg/l); Mg hardness= Magnesium Hardness-(mg/l); Ca hardness= Calcium Hardness-(mg/l); Residual Cl^-= Residual chlorine-(mg/l)

Bacterial analysis

Detection and estimation of the isolated groups of bacteria T.V.B, T.C.F and F.C.F by using different selective media from the studied sites in Zagazig city were shown in tables (12,13,14 and 15).

1- **T.V.B** : Total of viable bacteria developed in the form of colonies were counted as T.V.B on nutrient agar medium.

2- **T.C.F** : Total Coliform colonies showing pink to dark red colour were counted as T.C.F on endo agar base medium as shown in (Figure 6).

3- **F.C.F** / ***E.coli*** : Feacal Coliform colonies showing dark red colour or green with metallic sheen were counted as F.C.F on endo agar base medium as shown in (Figure 7).

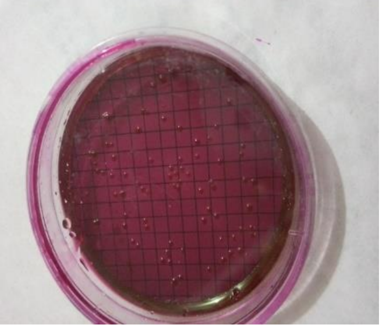

Fig. (6):Total coliform on endo agar base medium

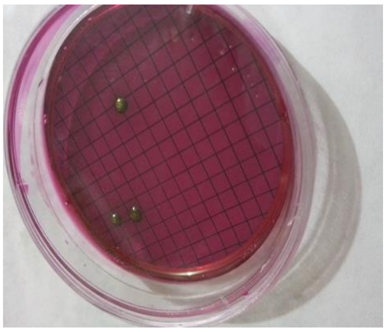

Fig. (7): Feacal coliform on endo agar base medium .

Table (3): Total viable bacterial counts (T.V.B) on nutrient agar, total coliform (T.C.F) and feacal coliform (F.C.F) on endo agar base medium at different sites in Zagazig city through ***Summer* 2015** as amean of counts of June, July and August 2015, ***Winter 2015 / 2016*** as amean of counts of December 2015, January 2016 and February 2016, ***Spring 2016*** as amean of counts of March, April and May 2016 and ***Autumn* 2016** as amean of counts of September, October and November 2016 expressed as CFU/100 ml sample of each group using membrane filter technique as shown in materials and methods.

Season	**Media**	**Bacterial Group ****	**Total viable bacterial count and total bacterial count (CFU/100 ml) in samples * collected**						
			(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Summer 2015	Nutrient agar	T.V.B	824 +3 —	700 +2 —	179 +1 —	180 +2 —	161 +1 —	312 +4 —	290 +3 —
	Endo agarbase	T.C.F	180 +3 —	160 +2 —	50 +1 —	70 +1 —	80 +2 —	120 +1 —	110 +2 —
	Endo agar base	F.C.F	70 +3 —	6 +2 —	3 +1 —	3 +1 —	3 +1 —	3 +1 —	3 +1 —
Winter 2015 / 2016	Nutrient agar	T.V.B	2000 +7 —	100 +4 —	144 +3 —	20 +2 —	138 +2 —	142 +1 —	292 +5 —
	Endo agar base	T.C.F	1440 +6 —	146 +2 —	6 +1 —	2 +1 —	46 +2 —	108 +3 —	134 +2 —
	Endo agar base	F.C.F	1080 +8 —	180 +3 —	0.0	0.0	10 +2 —	2 +1 —	174 +3 —
Spring 2016	Nutrient agar	T.V.B	944 +7 —	94 +2 —	4 +1 —	8 +2 —	48 +3 —	30 +7 —	197 +7 —
	Endo agar base	T.C.F	712 +8 —	3 +1 —	0.0	2 +0.5 —	16 +1 —	4 +1 —	168 +6 —
	Endo agar base	F.C.F	680 +4 —	0.0	0.0	2 +0.5 —	8 +1 —	0.0	102 +3 —
Autumn 2016	Nutrient agar	T.V.B	818 +15 —	60 +3 —	5 +1 —	8 +2 —	30 +5 —	30 +3 —	140 +2 —
	Endo agar base	T.C.F	710 +5 —	4 +1 —	0.0	3 +1 —	15 +2 —	12 +3 —	138 +10 —
	Endo agar base	F.C.F	512 +7 —	2 +1 —	0.0	3 +1 —	7 +1 —	0.0	100 +2 —

* 1=Bahr Mowees; 2=Prechlorinated Water; 3=Postchlorinated Water; 4=Zuhur District; 5=Zagazig University Area; 6=El-Janine StreetArea; 7=Farouk Street Area

**T.V.B= Total Viable Bacterial Count; T.C.F=Total Coliform; F.C.F=Feacal Coliform

In Summer 2015:

Table (3) showed that the highest count of T.V.B on nutrient agar medium was 824 CFU/100 ml in Bahr Mowees water (raw water) at site 1, then decreased to 700 CFU/100 ml in supernatant water (prechlorinated water) at site 2 (after sedimentation process). At sites 3,4,5,6 and 7 in postchlorinated water (treated water) the count of T.V.B was 179, 180, 161, 312 and 290 CFU/100 ml respectively.

The same pattern of existance of T.V.B was observed in the count of T.C.F. The count of T.C.F on endo agar base medium was 180 and 160 CFU/100 ml at sites 1 (Bahr Mowees water) and (supernatant water) at site 2 respectively. The count of T.C.F was 50, 70, 80, 120 and 110 CFU/100 ml at sites 3, 4, 5, 6 and 7 treated water respectively.

The count of F.C.F on endo agar base medium was 70 and 6 CFU/100 ml at site 1 (raw water) and site 2 (supernatant water) after precipitation process respectively. At sites 3, 4, 5, 6 and 7 treated water the count of F.C.F was 3 CFU/100 ml of each mentioned site.

In Winter 2015 / 2016:

Table (3) showed that the count of T.V.B on nutrient agar medium in raw water (Bahr Mowees water) was 2000 CFU/100 ml at site 1. At site 2 precipitation stage (supernatant water) the count of T.V.B was 100 CFU/100 ml. At postchlorinated water (treated water) sites 3, 4, 5, 6 and 7 the count of T.V.B was 144, 20, 138, 142 and 292 CFU/100 ml respectively.Total coliform (T.C.F.) count on endo agar base medium was 1440 CFU/100 ml in raw water (Bahr Mowees) at site 1 and decreased to 146 CFU/100 ml in supernatant water (after precipitation stage) at site 2. In treated water (postchlorinated water) the count of T.C.F. was 6, 2, 46, 108 and 134 CFU/100 ml at sites 3, 4, 5, 6 and 7 respectively.

The count of F.C.F on endo agar base medium in raw water site 1 was 1080 CFU/100 ml then decreased to 180 CFU/100 ml in supernatant water at site 2. F.C.F was not recorded at site 3 and site 4 (postchlorinated water). The count of F.C.F was 10, 2 and 174 CFU/100 ml at sites 5, 6 and 7 respectively.**In Spring 2016:**

Table (3) showed that the highest count of T.V.B on nutrient agar medium was 944 CFU/100 ml in Bahr Mowees water (raw water) at site 1, then decreased to 94 CFU/100 ml in supernatant water (prechlorinated water) at site 2. At sites 3, 4, 5, 6 and 7 treated water (postchlorinated water) the count of T.V.B was 4, 8, 48, 30 and 197 CFU/100 ml respectively.

The same pattern of existance of T.V.B was observed in the count of T.C.F. The count of T.C.F on endo agar base medium was 712 and 3 CFU/100 ml at site 1 (Bahr Mowees water) and (supernatant water) at site 2 respectively. In treated water (postchlorinated water) at site 3 the T.C.F was not recorded but at sites 4, 5, 6 and 7 the count of T.C.F was 2, 16, 4 and 168 CFU/100 ml respectively.

The count of F.C.F on endo agar base medium was 680 CFU/100 ml at site 1 (Bahr Mowees water). At site 2 after precipitation process, the supernatant water F.C.F was not recorded. At sites 4, 5 and 7 treated water (postchlorinated water) the count of F.C.F was 2, 8 and 102 CFU/100 ml respectively. F.C.F was not recorded at sites 3 and 6 treated water.

In Autumn 2016:

Table (3) showed that the count of T.V.B on nutrient agar medium in raw water (Bahr Mowees water) was 818 CFU/100 ml at site 1. At site 2 precipitation stage (supernatant water) the count of T.V.B was 60 CFU/100 ml. At treated water (postchlorinated water) sites 3, 4, 5, 6 and 7 the count of T.V.B was 5, 8, 30, 30 and 140 CFU/100 ml respectively. It is noticed that the count of T.V.B was the same at both sites 5 and 6.

Total coliform (T.C.F.) count on endo agar base medium was 710 CFU/100 ml in raw water (Bahr Mowees water) at site 1.The count was 4 CFU/100 ml in supernatant water at site 2. At treated water sites 4, 5, 6 and 7 the count was 3, 15, 12 and 138 CFU/100 ml respectively. It is important to notice that T.C.F. bacteria was not recorded at site 3.

The count of F.C.F on endo agar base medium in raw water site 1 was 512 CFU/100 ml then decreased to 2 CFU/100 ml in supernatant water at site 2. F.C.F was not recorded in the treated water at site 3 and site 6 but the count of F.C.F was 3, 7 and 100 CFU/100 ml at sites 4, 5 and 7 respectively.

Discussion

Access to safe drinking water is a basic human right. Besides its aesthetic appearance, water intended for human consumption should not contain chemical contaminants and any microorganisms and parasites in such a level that could be harmful to human health. It is clear that quality is the most important and the primary indicator for drinking water safety due to its major public health implications. In this regard, most countries develop their own regulation and standards for drinking water supply by adopting the WHO's International Guidelines for Drinking-water Quality (GDWQ) **(WHO 2021)**.

Water quality testing results are often not available on time, which could manage and prevent the impact of unsafe water. Understanding vulnerability factors related to point-of-use (PoU) microbial water security may help in planning interventions to reduce health vulnerability from unsafe water **(Baidya *et al*., 2018).**

The need for a clean and safe drinking water supply for urban agglomerates has been recognized for over 2000 years **(Nastic, 2022)**.

Waterborne diseases continue to challenge communities in low-income countries.This study will add valuable scientific data for future intervention. Similarly to our results, most physicochemical parameters values were within the acceptable limit values recommended by the WHO. Drinking water systems were likely contaminated with pathogenic bacteria due to poor protection and sanitation practices. Coliforms were significantly high and also significantly varied by water sources **(Sitotaw *et al*., 2021)**.

Correspondingly to our results, **Nogueira *et al*. (2003)** reported that untreated water sources were more heavily contaminated with both total and feacal coliforms than treated water sources.

Similarly to our results, **Omari and Yeboah-Manu (2012)** reported that E.coli (feacal coliform) was detected in surface water samples analyzed.

Similarly to **Elewa and Mahdi (1988)**, the temperature range of this study is between 18.7°C and 24.7°C in winter and summer, respectively.

Several studies have addressed the environmental aspects of the Nile. The pH shows a seasonal variation, varying between 7.5 and 8.2 **(Massoud and Abbas, 1985).** A study of the seasonal variation of the physical and chemical conditions of the Nile shows that the surface water temperature reaches a maximum of 31°C in summer and a minimum of 16°C in winter **(Elewa and Mahdi, 1988).**

Exposure to feacal contamination through drinking water was estimated based on the levels of *E. coli* or thermotolerant coliforms (TTC) in the water source (**Bain *et al.*, 2014)**.

Similarly to our results, It was reported that untreated water sources were more heavily contaminated with both total and feacal coliforms than treated water sources **(Hafez, 2013)**.

Similarly to our results, values of water pH, Electrical conductivity and dissolved organic matter showed suitability of the drinking water for human use according to published permissible limits. All water samples were in the safe zone according to the limits of WHO **(Swelam *et al.*, 2022)**.

Consistent with our results, physicochemical parameters such as temperature, turbidity, pH and residual free chlorine were measured. Presence of total and faecal coliform bacteria was tested using the membrane filtration procedure **(Bekele and Teka, 2022)**.

The obtained results clearly indicated that the physical and chemical results were in agreement with the WHO limits and standard limits for drinking water in Egypt, in Zagazig area except alkalinity and residual chlorine. Mean values of TDS in samples collected at all sites in spring and summer ranged from 206-482.5 mg/L, respectively. Our results agreed with both WHO limit and standard limit for drinking water in Egypt for TDS which is less than 1000 mg/L **(Haydar *et al.*,2009)**.

The obtained results clearly showed that the chloride values in summer are between 17.2-70.6 mg/L and these results are consistent with the Egyptian and World Health Organization standard limits for drinking water below (250 mg/l) **(Hafez, 2013)**.The obtained results showed that the mean values of hardness in the water samples at all the locations have been cleared that hardness at all sources and house connections were below the WHO guideline value of 500 mg/L (as CaCO3) and ranged between 105.2 to 200 mg/L in summer and spring respectively. As a matter of fact, this guideline value is not proposed on the basis of health. Consumers can tolerate water hardness in excess of 500 mg/L. **(Haydar *et al.*, 2009).**

Bacterial concentrations in water distribution systems are affected by various water parameters including disinfectant residues, availability of biodegradable nutrients, pipe material and roughness, surface area to volume ratio, stagnation, temperature and hydraulic changes **(Carter *et al*., 2000; LeChevallier, 2003; Allen *et al*., 2004 ; Chowdhury, 2012)**.Drinking water must be free from bacterial contamination. Unsimilarly to our results, there was high bacterial counts of TVBC, T.C.F and F.C.F. This may be due to biofilm formation, so water treatment must be improved.

The results of this study showed that networks without any residual chlorine were more likely to be polluted than networks with residual chlorine, so it is better to use chlorine gas which is the chemical of choice in many countries including Pakistan due to its low cost and high effectiveness. It is added to drinking water to disinfect disease-causing microorganisms. Chlorine in drinking water has long been considered an excellent indicator of water quality in distribution networks **(Lienyao *et al* ., 2004)**.

We recommended that proper chlorination of the drinking water system, regular monitoring of the water quality, provision of toilets and waste disposal systems, and intensive health education and sanitation practices for the community should be urgent tasks for concerned bodies **(Sitotaw *et al*., 2021).**

Due to the importance of drinking water quality in distribution networks, this study was carried out to gain a clear understanding of the physical, chemical and microbiological quality of drinking water in distribution networks.

Consistent with our results, the mean values of physicochemical parameters for distribution network drinking water were as follows: turbidity, electrical conductivity, temperature, pH, total hardness, calcium hardness, magnesium hardness, TDS and chloride (**Raeisia *et al*., 2017).**

Conclusion

By analyzing all water samples that were collected from Summer 2015 to Autumn 2016 during the four seasons from 7 sites which were raw water (Bahr Mowees), Prechlorinated Water and Postchlorinated Water from Zagazig Drinking Water Treatment Plant (ZDWTP) and 4 drinking water sites in Zagazig City, El-Sharkia Governorate, the obtained results clearly indicated that the physical and chemical results agreed with the standard limits for drinking water in Egypt, in Zagazig except alkalinity and residual chlorine.

Summing up the results, it can be concluded that the Drinking water in Zagazig is contaminated with bacteria, significant in number and ranging in types. The number of bacteria depends on the water supply system type and technogenic load of the area. Microbiological characteristics of the water indicate the high rate of contamination with bacteria and high no of water borne diseases which mean that the drinking water fails to be safe to drink without preliminary treatment. So water authorities should have to take steps to control coliforms in drinking water in order to prevent population from water borne diseases.

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الملخص العربي

عنوان البحث: دراسات بكتيرية وفيزيائية كيميائية على مياه الشرب من مواقع مختلفة بمدينة الزقازيق (محافظة الشرقية)

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تمت دراسة تقييم جودة مياه الشرب في مدينة الزقازيق بمحافظة الشرقية بمصر بين صيف ٢٠١٥ وخريف ٢٠١٦.تم جمع عينات المياه من ٧ مواقع خلال الفصول الأربعة. هذه المواقع هي المياه الخام (بحر مويس) والمياه سابقة الكلور ومياه ما بعد المعالجة بالكلور من محطة معالجة مياه الشرب بالزقازيق و ٤ مواقع لمياه الشرب وهي (حي الزهور، منطقة جامعة الزقازيق، منطقة شارع الجناين ، منطقة شارع فاروق). أشارت النتائج التي تم الحصول عليها بوضوح إلى أن النتائج الفيزيائية والكيميائية تتفق مع حد منظمة الصحة العالمية والحدود القياسية لمياه الشرب في مصر، في الزقازيق باستثناء القلوية والكلور المتبقي. أشارت هذه الدراسة إلى إجمالي الأعداد البكتيرية القابلة للحياة على الوسط الغذائي النيوترينت آجار ، مجموعة الكوليفورم الكلية ومجموعة الفيكال كوليفورم علي الوسط الغذائي الإندوآجارباز في مواقع مختلفة في مدينة الزقازيق من خلال الفصول الأربعة معبرا عنها بوحدة تكوين المستعمرة لكل ١٠٠ مللي من العينة لكل مجموعة باستخدام تقنية الغشاء المرشح. في هذه الدراسة تم عزل وتنقية العزلات البكتيرية من جميع المواقع خلال الفصول المختلفة في مدينة الزقازيق. وتفيد التقارير بأن مصادر المياه غير المعالجة كانت أكثر تلوثا بكل من مجموعة الكوليفورم الكلية ومجموعة الفيكال كوليفورم من مصادر المياه المعالجة.