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Indices of drinking water quality in four centers Qalyubia at Governorate, Egypt

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Abstract

This study was carried at out four main centers in Qalyubia Governorate, Egypt namely Benha, Kafr Shukr, Toukh and Qalyub before and after treatment process of drinking water. Each of the four main sites included subsites along the distribution system namely Benha (Mit Asem and Benha), Kafr Shukr (Isnit and Kafr Shukr), Toukh (Toukh, Al Deir and Qaha), Qalyub (Qalama and Qalyub). Physical and bacteriological examinations were carried out in both main and subsites during winter and summer 2017-2016. Turbidity and pH values were ranged between (1.16-2.60) NTU and (7.27-7.87) during two seasons after treatment process, respectively. Additionally, lower values of electric conductivity (EC) and Total hardness (T.H.) were recorded after treatment than and before, the lowest values were observed in Qalyub and Benha during summer, respectively. Moreover, total solids (dissolved TDS and suspended TSS) values were in permissible limits and indicate the efficiency of treatment process. Respecting the changes in total bacterial counts in all main subsites under study, higher counts bacteria were observed in samples incubated 37℃ than 22℃ with highest count in Qalyub and Toukh, respectively. While Salmonella and fecal streptococci counts were reduced with considerable numbers after treatment than before and most of subsites didn't record any counts of Salmonella during winter. The most prevalence bacteria were isolated and testing of their susceptibility agains antibiotics and found one of them was multiple antibiotics resistant which finally identified by 16sDNA genev sequencing as Salmonella enterica. Various chlorine concentrations found to be efficient against S. enterica 7.0 ppm was the best with save residual chlorine concentration.

Keywords: drinking water, bacteriological, physical, treatment process, chlorination, antibiotic susceptibility.

Introduction

Availability of a safe and clean water source is one of the most important foundations for establishing healthy communities, and then reconstruction and development **(El-Kowrany *et al*., 2016)**. Water quality is a matter of global concern, based which water is classified into drinking water, water used in agriculture, or water used in industry **(Sargaonkar and Deshpande, 2003)**. Water in nature is not pure enough to make it drinkable because it acquires pollutants from the surrounding environment, so the right balance in the sensory, chemical, physical and bacteriological qualities of water makes it drinkable **(Hassanein *et al*., 2011)**. the other hand, drinking water is a major source of microbial pathogens, especially those transmitted through the digestive system due to its wastewater discharge, which causes the death o many people annually (Alarousy et al., 2018). The better-known waterborne bacteria of concern are *Salmonella* spp., *E. coli and* Streptococci besides many opportunistic bacteria **(Ashbolt, 2004)**. It is easy purify water and eliminate all microbial pathogens by chlorination, but the most serious problem is the re-contamination of treated water during its transportation within water distribution systems (DWDSs) **(Ashbolt, 2015)**. Generally, water is susceptible of contamination with microorganisms, among them the presence of *E. coli* and *Enterobacter* sp. in water is a likely indicator of the presence of pathogenic organisms such as *Salmonella* spp. **(Onyango *et al*., 2018).**

Qalyubia is one of the ten Nile Delta governorates that contains eight centers and included many cities and villages. Its main water resources are the surface water, of which the river Nile is the most important one **(EWQS, 2007).** Generally, the river Nile in Egypt is considered the lifeline, which represents the main source of fresh water necessary for most the water requirements, but it is exposed many sources of pollution that represent a real threat to obtaining a healthy safe water source **(Ali *et al*., 2014).**

Hence, this study was designed to assess the suitability and drinking water for human use in four centers in Qalyubia Governorate via physical and bacteriological examination of samples before and after treatment during two seasons (winter and summer). Moreover, isolate the most abundant pathogens, then estimate their antibiotics-susceptibility and finally, identify evaluate chlorination process against these pathogens.

Materials methods

This study was carried out to assess drinking water in four centers at Qalyubia Government, Egypt (latitude 30.3541° north and longitude 31.201° east) during summer winter (2016 - 2017).

Source of water samples

Drinking water samples were gathered from four main sites (before and after treatment) namely Benha, Kafr Shukr, Toukh and Qalyub included nine sub-sites (after treatment) from distribution net namely Mit Asem, Benha, Isnit, Kafr Shukr, Toumkh, Al Deir, Qaha, Qalama, Qalyub **(Fig. 1)**.

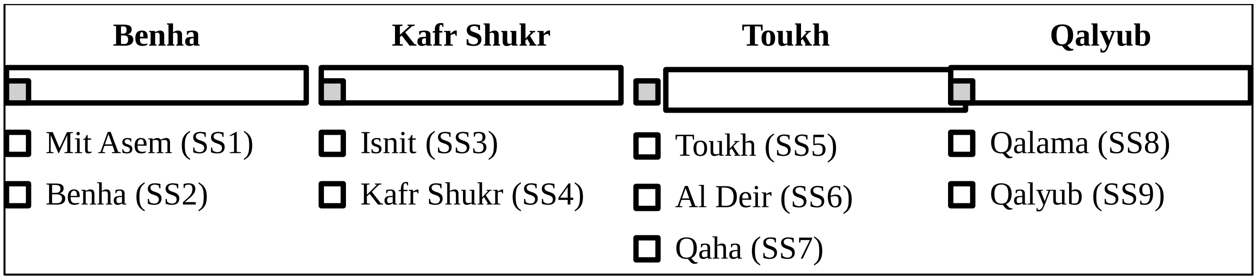

Figure 1. Main sub-sites under study.

Sampling

Samples were collected according to the standard methods of water wastewater examination **(APHA, 2005)** in sterilized plastic bottles (250 ml) and transported in ice box, then kept at 5℃ further for examinations. The microbiological examination was conducted during the first 18 hours from sampling. One ml of sodium thiosulphate solution (10%) was added to 120 ml each sample that represent the chlorinated drinking water (sublocations samples).

- Before treatment samples were collected directly from the river Nile the station inlet 1.0 km from the Nile after removal of suspended matter in main four sites.
- After treatment samples were collected from nine sub-sites belonging to the main sites, within the distribution system in the government.

Examinations

Physical, and microbiological analyses were performed according to the standard methods for examination of water and wastewater suggested by American Public Health Association **(APHA, 2005)**.

In situ parameters (at the same place time 0f sampling)

Turbidity values (NTU) were determined using EPA 180.1 method by nephelometry. pH values were measured using EPA method 9040C pH electrometric measurement. Electric conductivity (E.C.) (µS/cm) was estimated using EPA Method 120.1: Conductance (Specific Conductance, µmhos 25°C) by conductivity meter.

Physical parameters

Total dissolved solids (T.D.S.) and total suspended solids (T.S.S.) were measured together gravimetrically using EPA method 160.1. The water sample was filtered through 2.0 µm filter then evaporated drying in an oven 180ºC finally weighed recorded as mg/L. Total hardness (T.H.) is the sum of cations concentrations, it measured by using EPA method 130.2: Hardness (Titrimetric, EDTA) expressed as mg/L $CaCO_3$.

Microbiological indicators

Collected drinking water samples were subjected microbiological analyses to count total bacteria 22°C 37°C using tryptone glucose yeast agar. Furthermore, fecal streptococci *Salmonella* sp. were detected azide dextrose agar medium and bismuth sulfite agar medium amended with 50 units/ml of mycostatin, respectively. After incubation 37ºC for 24-48 h, colonies showing red to pink color were counted, isolated as fecal streptococci bacteria. While colonies producing diffusible black pigment with or without metallic sheen were counted and isolated as salmonella.

Antibiotics susceptibility test

The recovered colonies on both azide dextrose agar and bismuth sulfite agar media were tested for their susceptibility to various antibiotics namely Ceftazidime, Cefaclor, Gentamicin, Imipenem, Nalidxic acid, Nitrofurantion, Levofloxacin, Cefotaxime, Ampicillin, Cefadroxil, Aztreonam, Clindamycin, Ampicillin, Cefoxitin, Cefamandole, Ceftriaxone, Trimethoprim, Amikacin, Norfloxacin using the standard Kirby-Bauer disk diffusion method **(Bauer *et al*., 1966).** The resulted interpreted according protocols standardized the assay of antibiotic compounds as guided by National Committee for Clinical Laboratory Standards “NCCLS”, then categorized as: R (resistant),and S (sensitive) **(NCCLS, 2007).**

Identification of the most antibiotics-resistant isolate

The most antibiotics-resistant isolate was selected identification by 16SrDNA gene sequencing according **(Khedr *et al*., 2017)**. The resulted sequence was aligned with other identified strains in the Gene bank database using an online BLAST tool determine the similarity score (http://www.blast.ncbi.nlm.nih.gov/Blast). The phylogenetic tree with the more related bacterial strains BLAST NCBI was constructed using the MEGA-X program the neighbor-joining method.

Chlorination

Effect of chlorine concentrations on *Salmonella enterica* was achieved by growing *S. enterica* 37℃ 24h in TSB and then centrifuged 8000xg for 20 min., the formed pellet was washed twice with sterilized distilled water. Then, the pellet was resuspended in 10 ml of sterilized distilled water and directly counted. After that, various chloride concentrations (0.2, 0.3, 0.4, 0.5, 0.6, 0.7 ppm) have been added individually and let for 20 min then the pellets were transferred to TSA incubated at 37℃ to 24h. Finally, the viable cells were counted to estimate the chlorination effect upon the bacterial growth reduction rate as well as the residual chloride after each chloride dose 20 min contact time was carried out by N, N-diethyl-p-phenylenediamine (DPD) titration method.

Statical analysis

Analysis variation or dispersion values set was carried out by standard deviation (SD) using CoStat version 6.400 (CoHort software, Monterey, CA, 93940, USA). Mean values among treatments were presented as the mean values ± SD. A low standard deviation indicates that the values tend be close the mean (also called the expected value) the set, while a high standard deviation indicates that the values are spread out over a wider range.

Results discussion

Physical examination

Turbidity pH values

Turbidity is the measure of fine suspended matter in water, mostly caused by colloidal particles such as clay, silt, living and non-living of organisms. course, it is possible to estimate turbidity or transparency variable degrees depending 0n location, efficiency of distribution system, hence the turbidity was estimated before and after treatment as shown in **Table (1)**. Results indicated that high turbidity values were recorded in water samples before treatment (main sites), and this was realistic and logic. Furthermore, treatment process caused reduction in water turbidity in all sub-sites under study. Generally, turbidity was higher during summer than winter in most main sites, this trend was reversible to results by **Abdel-Satar *et al*. (2017)** who reported that transparency values were lower (turbidity was higher) during winter. Additionally, Qaha (SS7) of all nine sub-sites was the most turbid site during winter followed by kafr Shukr, while during summer it was observed that Kafr Shukr was the most turbid site. Although Toukh considered from the more turbid main sites, but after treatment it observed among the least turbid sites, this due the efficiency treatment process in this plant.

Table 1. Turbidity and pH in drinking water during winter and summer seasons before and after treatment in various locations.

Main sites	Sub sites	Turbidity (NTU)				pH			
		Winter		Summer		Winter		Summer	
		Before	After	Before	After	Before	After	Before	After
Benha	SS1	11.35±0.78	1.36±0.03	12.05±0.35	1.36±0.03	7.95±0.21	7.79±0.07	8.48±0.07	7.34±0.05
	SS2		1.30±0.04		1.30±0.04		7.87±0.04		7.51±0.03
Kafr Shukr	SS3	10.55±0.21	1.33±0.58	10.70±0.28	1.33±0.58	7.75±0.21	7.32±0.20	7.55±0.35	7.38±0.08
	SS4		1.81±0.04		1.81±0.04		7.50±0.16		7.44±0.18
Toukh	SS5		1.23±0.15		1.20±0.34		7.57±0.06		7.33±0.12
	SS6	10.55±0.35	1.43±0.15	11.55±0.35	1.70±0.20	7.95±0.21	7.41±0.02	8.45±0.07	7.27±0.12
	SS7		2.60±0.43		1.13±0.30		7.27±0.16		7.35±0.06
Qalyub	SS8	10.85±0.07	1.30±0.02	10.70±0.28	1.16±0.11	7.70±0.28	7.52±0.04	7.65±0.21	7.42±0.04
	SS9		1.43±0.15		1.28±0.05		7.62±0.06		7.50±0.04

Regarding the effect of treatment process on pH, data presented in **Table (1)** indicated that pH values in main sites ranged between (7.70-7.95)and (7.55-8.48) during winter and summer, respectively. Whereas, in subsites the pH values ranged between (7.27-7.79) adn (7.27-7.7.51) during winter and summer, respectively. Generally, the treatment process reduced the pH values in all subsites and the highest value was recorded in

Benha (SS2) during both winter and summer whereas, the lowest value (pH 7.27) was recorded in both Al Deir (SS7) and Qaha (SS6) during winter and summer, respectively. Additionally, results showed that the two main sites Benha and Toukh recorded higher pH values compared to other main sites during two seasons. In this respect, **Soliman *et al*. (2018)** reported that pH values of eight locations along Rosetta branch water, River Nile were ranged between 7.16-7.98 during four seasons. While, **El Gammal and El Shazely (2008)** reported that pH values of 24 sites along the Nile from Aswan to Cairo ranged between (7.3-8.5) during winter and between (7.6-8.3) during spring. While, during summer and autumn pH values were ranged between (7.7-8.6) and (7.7-9.0), respectively. Also, **Ezzat *et al*. (2012)** showed that pH values water samples collected from Rosetta branch in summer and winter seasons were ranged from 7.45 7.9. Moreover, **Abdel-Satar *et al*. (2017)** said that pH in the Nile River was generally on the alkaline side.

Electric conductivity (EC) Total hardness (T.H)

Regarding the changes in electric conductivity (EC) as a good indicator of pollution in water, results indicated that EC in all sites before treatment exceed after treatment with considerable values which clearly indicated that water treatment reduced its content of pollutants which already caused reduction in EC values **(Table 2)**. Additionally, EC values were higher during winter than summer in all main sites except in Toukh. After treatment, EC recorded the highest values in Qaha (SS7) and Toukh (SS5) during winter and summer, respectively with confirms the inefficiency of the treatment process in Toukh.on the other hand, the two sub-sites belonging to Qalyub (Qalama and Qalyub) recorded the lowest EC values during summer, while both subsites belonging Benha (Benha and Mit Asem) recorded the lowest EC values after treatment during winter.

Table 2. Electric conductivity (EC) and total hardness (T.H.) changes in drinking water during winter and summer seasons before and after treatment in various locations.

Main sites	Sub sites	Electric conductivity (µS/cm)				T.H. (mg/L)			
		Winter		Summer		Winter		Summer	
		Before	After	Before	After	Before	After	Before	After
Benha	SS1	455.5±0.70	367.7±2.52	450.0±8.48	348.7±6.42	152.5±7.77	137.7±2.52	143.0±9.9	101.3±32.3
	SS2		351.7±3.51		335.7±6.50		141.7±3.06		102.7±18.8
Kafr Shukr	SS3	455.0±9.89	390.0±3.51	448.5±19.09	314.7±9.01	159.5±2.12	137.7±2.52	145.0±4.2	109.7±14.3
	SS4		396.0±3.00		308.0±7.21		132.7±2.52		113.7±14.9
Toukh	SS5	432.0±22.6	395.0±9.64	434.5±4.95	378.0±4.36	153.5±10.63	136.7±2.03	144.5±4.9	132.0±12.5
	SS6		403.7±13.2		323.0±4.58		138.0±2.00		116.0±5.13
	SS7		413.7±14.2		374.3±5.50		137.3±3.05		123.7±9.86
Qalyub	SS8	437.0±38.2	391.7±4.04	387.0±7.07	304.3±28.1	142.0±14.14	138.0±6.00	146.0±4.2	129.3±11.5
	SS9		373.3±6.11		301.3±35.4		132.7±3.06		119.3±6.11

Total hardness (T.H) is a test overall water quality, values near 150 mg/L are generally ideal for human, while water less than 150 mg/L are considered soft water and values greater than 200 mg/L are considered hard water. In this concern, the relation between treatment process and total hardness content in water was shown in **Table (2)**. Results indicated that T.H. values in main sites before treatment were ranged between (159.5-142.0) (146.0-143.0) during winter and summer, respectively. While in subsites the T.H. values were ranged between (141.7-132.7) (101.3-132.0) during winter and summer, respectively. Moreover, T.H. values were lower during summer than winter in both cases before and after treatment process. In general, water in all sites under study before or after treatment was fit human consumption.

TDS and TSS

As TDS to refers anything present in water and cause water impurity, results in **Table (3)** showed the relation between TDS treatment process. Generally, TDS values in good quality water range from 0 600 mg/L while TDS over 1200 mg/L indicates water impurities. In this concern, results indicated that TDS values before or after treatment process during winter were within the safe permissible limits while in summer the TDS values in main sites exceed the permissible limits with small values. The highest TDS values in water before treatment were recorded in Toukh followed by Kafr Shukr, this trend was true during both seasons (winter summer). The highest TDS values in subsites were recorded in Toukh (SS5) and Qaha during winter and summer, respectively. While, the lowest values during two seasons were recorded in both Benha subsites (Benha and Mit Asem) by 247.7 mg/L. This trend of results refers to the efficiency of treatment process in the Benha plant compared to other plants under study.

Table 3. Total dissolved solids (TDS) and total suspended solids (TSS) in drinking water during summer and winter seasons before and after treatment in various locations.

Main sites	Sub sites	TDS (mg/L)				TSS (mg/L)			
		Winter		Summer		Winter		Summer	
		Before	After	Before	After	Before	After	Before	After
Benha	SS1	424.0±25.5	247.7±2.0	547.5±41.7	247.7±2.5	<1.0	ND	<1.0	ND
	SS2		247.7±2.5		247.7±2.5		ND		ND
Kafr Shukr	SS3	446.0±25.5	272.3±3.5	621.5±12.0	272.±3.51	<1.0	ND	<1.0	ND
	SS4		263.3±3.5		263.3±3.5		ND		ND
Toukh	SS5		392.3±4.5		276.7±11.5		ND		ND
	SS6	453.0±55.2	260.7±5.0	630.0±16.9	283.3±11.5	<1.0	ND	<1.0	ND
	SS7		281.3±3.5		290.0±5.3		ND		ND
Qalyub	SS8	436.5±30.4	262.7±5.0	578.0±49.5	273.0±8.3	<1.0	ND	<1.0	ND
	SS9		262.3±4.5		274.0±12.2		ND		ND

Since the World Health Organization has set a provisional guideline for a TSS value of 10 µg/L in good drinking water, the results in **Table (3)** indicated that water in four main sites under study recorded less than 1.0 mg/L equivalent (1000 µg/L), while after treatment, no TSS values were recorded, which indicates the quality of the treatment process in all the plants under study and the suitability of their water for human consumption.

Microbiological examination

Regarding the correlations between the microbiological examination and treatment process efficiency, the collected water samples were microbiologically examined for its content of total bacterial counts at 22°Cand 37°C, fecal streptococci, and *Salmonella* sp. the obtained data were shown in **Tables (4 5)**.

Total bacterial counts

Generally, results indicated that the incubation of water samples at 37°C resulted in high growth count of bacteria than incubation at 22°C as similarly observed by **(Taha, 2019)**. Results also indicated that higher bacterial count was recorded in main sites before treatment compared to subsites after treatment, Toukh and Qalyub recorded higher bacterial counts at 22 37°C during both winter and summer **(Table 4)**.

Table 4. Total bacterial count (TBC) (log CFU/ml) at 22℃ and 37℃ in drinking water during summer and winter seasons before and after treatment in various locations.

Main sites	Sub sites	22℃				37℃			
		Winter		Summer		Winter		Summer	
		Before	After	Before	After	Before	After	Before	After
Benha	SS1	4.02±0.01	3.17±0.12	4.1±0.02	3.39±0.13	33.7±0.02	3.34±0.06	53.8±0.02	3.26±0.11
	SS2		3.05±0.14		3.73±0.07		3.43±9.06		3.67±0.04
Kafr Shukr	SS3	3.99±0.02	3.95±0.02	4.2±0.01	3.47±0.11	36.7±0.03	3.70±0.03	63.9±0.02	3.21±0.10
	SS4		2.26±0.24		3.64±0.10		2.23±0.40		3.10±0.05
Toukh	SS5		2.93±0.10		2.71±0.24	67.5±6.36	2.81±0.13	69.5±10.6	2.52±0.07
	SS6	18.0±8.49	2.49±0.10	11.5±4.9	2.16±0.28		2.46±0.15		2.26±0.24
	SS7		3.11±0.13		3.70±0.07		2.62±0.15		3.67±0.05
Qalyub	SS8	14.0±15.56	3.25±0.16	9.0±4.24	3.89±0.06	92.0±5.66	3.13±0.08	69.0±7.07	3.61±0.05
	SS9		3.12±0.34		3.87±0.07		2.79±0.20		3.59±0.05

While the lowest bacterial counts grown at 22℃ were observed in Kafr Shukr and Benha during winter and summer, respectively and vice versa in case of bacteria grown at 37℃. In case subsites, Kafr Shukr and Al Deir recorded the lowest bacterial count during winter and summer when samples were incubated at 22℃ and 37°C. The appearance of bacteria at high rate in drinking water refer to problems in the water distribution system or storage which led to contaminants entering the drinking water in several areas **(Saleh *et al*., 2001).** As well as, time and temperature of incubation are very significant variables, the incubation temperature lie in range of 35 to 37℃ is very preferable for growth bacteria that originated from animals and human while, low incubation temperature (20-28℃) favor the growth of water-based bacteria **(Allen *et al*., 2004).**

Salmonella fecal Streptococci counts

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).** In this regard, results in **Table (5)** indicated that treatment process reduced both *Salmonella* and fecal Streptococci counts in all subsites under study. It was observed that among the nine subsites under study, five sites appear free of *Salmonella* during winter while the same sites recorded moderate counts during summer which indicate that the high temperature during summer was for suitable bacterial growth especially human-borne pathogens. Similar results were observed by **Taha (2019)** who didn't record any *Salmonella* counts in three target distribution regions during four seasons. the other hand, only two subsites Mit Asem (SS1) and Isnit (SS3) observed free of fecal Streptococci during winter, while Benha (SS2) and Kafr Shukr (SS4) did not record any fecal streptococci during the summer. Additionally, Qalyub (SS9) recorded high *Salmonella* and fecal Streptococci counts during both winter summer which refer to an inadequate treatment process in Qalyub plant.

Table 5. *Salmonella* sp. and fecal Streptococci counts (log CFU/ml) in drinking water during summer and winter seasons before and after treatment in various locations.

Main sites	Sub sites	*Salmonella* sp.				fecal Streptococci			
		Winter		Summer		Winter		Summer	
		Before	After	Before	After	Before	After	Before	After
Benha	SS1	2.62±1.33	Nil	2.88±1.66	Nil	3.77±1.33	Nil	2.79±0.2	1.80±0.2
	SS2		Nil		1.87±0.1		1.87±0.2		Nil
Kafr Shukr	SS3	2.80±0.17	1.80±0.2	2.69±0.21	1.87±0.1	3.80±0.17	Nil	3.28±0.1	1.93±0.1
	SS4		Nil		1.93±0.1		2.00±0.0		Nil
Toukh	SS5		1.73±0.2		1.43±0.1		1.80±0.2		1.87±0.1
	SS6	2.66±0.71	Nil	2.44±0.66	1.50±0.1	4.50±0.71	1.87±0.1	3.80±1.6	1.87±0.1
	SS7		1.63±0.1		1.33±0.2		1.87±0.1		1.93±0.1
Qalyub	SS8	2.44±1.15	Nil	2.50±0.71	1.93±0.1	3.65±0.28	2.92±0.2	3.50±0.7	1.87±0.1
	SS9		1.87±0.1		1.87±0.1		2.40±0.2		2.16±0.3

Similar results by **Ezzat *et al*. (2014)** were confirmed the obtained results and reported that fecal streptococci counts in Rosetta branch were ranged between (0.8-1.1)10^5 CFU/100 ml. Furthermore, **Abo-State *et al*. (2014)** found that the fecal streptococci count in eleven sites Rosetta branch ranged between (10 -7.0 x10^4 CFU/ml) during four seasons. Generally, sites in Rosetta branch exceeding 1000 CFU/100 ml were reported out of international standard limits **(Abdo, 2013).** Also, **Soliman *et al*. (2018)** observed lower higher numbers of fecal streptococci in eight locations along Rosetta branch during winter and summer, respectively.

Isolation and antibiotic susceptibility test of the most prevalence pathogens in sites under study

The recovered colonies on both azide dextrose agar and bismuth sulfite agar media were isolated, purified and then tested for their susceptibility to 19 antibiotics **(Table 6)**. Data indicated that colony (1) which recovered on azide dextrose agar was resistant to only four antibiotics sensitive to others. the other hand, colony (2) which recovered on bismuth sulfite agar medium appear its sensitivity to only two antibiotics and resistant 17 ones. Hence, colony (2) was selected for identification as the most antibiotics-resistant isolate.

Table 6. Antibiotics susceptibility of two Gram-positive and Gram-negative bacteria isolated from drinking water treatment plant

	Ceftazidime	Cefaclor	Gentamicin	Imipenem	Nalidxic acid	Nitrofurantion	Levofloxacin	Cefotaxime	Ampicillin (1)	Cefadroxil	Aztreonam	Clindamycin	Ampicillin (2)	Cefoxitin	Cefamandole	Ceftriaxone	Trimethoprim	Amikacin	Norfloxacin
Isolate (1)	R	R	S	S	S	S	S	R	S	S	S	S	S	R	S	S	S	S	S
Isolate (2)	R	R	R	R	R	R	R	R	S	R	R	R	R	S	R	R	R	R	R

R: resistant ; S: sensitive ((Diameter of inhibition > 7 mm)

Isolate (1): recovered on azide dextrose agar medium; Isolate (2) recovered on bismuth sulfite agar medium

Similar results were recorded by **Abdo (2013)** who tested the antibiotic susceptibility of *Salmonella choleraesuis* isolated from Ismailia canal water, Egypt and found that this strain was resistant against 13 antibiotics. The overuse and abuse of antibiotics, whether in humans or animals, is one of the main factors responsible for the spread of multi-antibiotic-resistant bacteria throughout the world, which is considered a public health threat **(Gootz, 2010).** Moreover, **Heikal (2000)** recorded a gradual increase in the incidence of antibiotic resistant bacteria along the river Nile. Additionally, **Lateef (2004)** found a wide presence antibiotic resistant bacteria at Rosetta Nile branch. The relatively high level of resistance to antimicrobial agents reflects misuse and abuse these agents in the environment.

Identification of the most resistant bacteria to antibiotics

The selected isolate was identified by 16rDNA gene sequence analysis through BLAST. The FASTA homology demonstrated high similarity the of 16S rDNA gene sequence with more than 99% *Salmonella enterica* strain FDAARGOS_711 and *Salmonella enterica* strain FDAARGOS_718 **(Table 7 and Fig. 2)**. The phylogenetic tree with the more related bacterial strains on BLAST of NCBI was constructed using the MEGA-X program and the neighbor-joining method to ascertain their taxonomic positions. Finally, the results were confirmed by the phylogenetic position of the obtained isolates.

Table 7. Query coverage for the selected isolate PCR product sequence that identified via 16S rDNA as *Salmonella enterica strain* and the most related strains

Description	**Scientific Name**	**Max Score**	**Total Score**	**Query Cover**	**Per. Identification**	**Accession**
Salmonella enterica strain FDAARGOS_711 chromosome	*Salmonella enterica*	1349	9427	100%	99.86%	CP055130.1
Salmonella enterica strain FDAARGOS_718 chromosome	*Salmonella enterica*	1349	9394	100%	99.86%	CP054901.1
Salmonella enterica strain FDAARGOS_717 chromosome	*Salmonella enterica*	1349	9342	100%	99.86%	CP054897.1
Salmonella sp. strain Enteritidis_S85_04530 16S ribosomal RNA gene, partial sequence	*Salmonella sp.*	1349	1349	100%	99.86%	MT621365.1
Salmonella sp. strain Enteritidis_S78_04484 16S ribosomal RNA gene, partial sequence	*Salmonella sp.*	1349	1349	100%	99.86%	MT621358.1

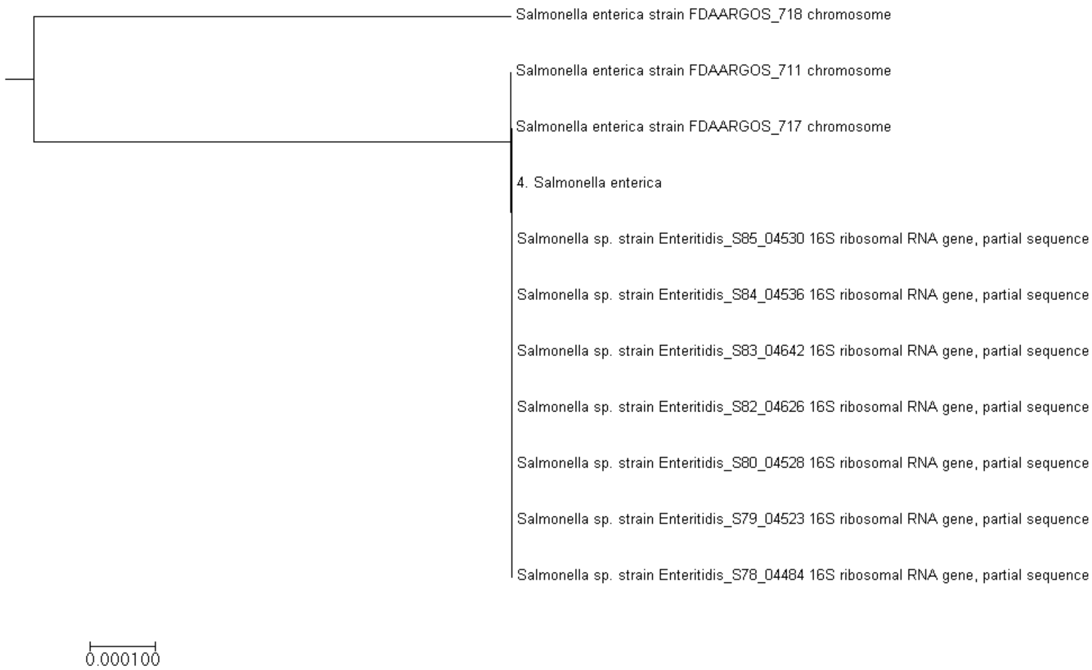

Figure 2. Phylogenetic tree of the recovered isolate with the more related bacterial strains on BLAST of NCBI.

Among the enteric pathogens, *Salmonella* spp. can be divided into two distinct groups: the typhoidal (*S. typhi and S. paratyphi*) and non-typhoidal (the remaining species and serovars). *Salmonella* spp. are relatively sensitive disinfection. Many researchers concluded the overview of local water situation indicated that the detection of the abovementioned pathogen in water samples that were withdrawn from of the distribution system explained as inefficiency the treatment process **(Ezzat *et al*., 2012).** Overuse and sometimes misuse of antibiotics in human and veterinary medicine are major promoters for the development and spread of multi-resistant bacteria worldwide **(Gootz, 2010)**.

Chlorination of water is a process of which chlorine was added water in any chlorine compounds form. This method is used to kill bacteria, viruses and other water-borne microbes especially cholera, dysentery, and typhoid **(WHO, 2011)**.

In this experiment, six concentrations and chlorine as sodium hypochlorite namely 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 ppm were applied to select the most suitable one reduction bacterial counts residual chloride in water. Results in **Table (8)** indicated that the reduction of *S. enterica* count was gradually increased with the increasing chlorine concentration. No bacterial colonies were detected 0.7 ppm.

Chlorination residual chlorine

Table 8. Effect of chloride concentrations (ppm) on *Salmonella* sp. after 24 h of incubation.

Chloride (ppm)	Bacterial count ($x10^3$)	Residual chloride (ppm)
Control *	289	--
0.2	191	< 0.1
0.3	98	< 0.1
0.4	19	0.1
0.5	2	0.3
0.6	1	0.5
0.7	Nil	0.6

* without chloride , Nil: No growth

According to the antibiotic susceptibility test result, the identified Salmonella enterica strain was resistant to a wide range of them, confirming the previous findings 0f **Okeke and Edelman (2001)** that the high prevalence of antibiotic-resistant bacteria in aquatic environments has become a global problem requires significant international attention. Additionally, **Lateef (2004)** recorded wide distribution of antibiotic resistant bacteria in Egyptian Nile which reflect the misuse abuse of these antibiotics in the environment.

Hence, the use of water disinfectants is very important step in water treatment process, the most important traditional disinfectants are halogens, the most prevalent of which is chlorine **(CDC, 2020).** Chlorine as an oxidizing agent kills microorganisms in water via the oxidation of organic molecules as well as its hydrolysis product (hypochlorous acid) which un-charged therefore easily penetrate the negatively charged surface of pathogens **(Calderon, 2000).** Moreover, it is able to disintegrate the lipids that compose the cell wall and react with intracellular enzymes proteins, making them nonfunctional finally the microorganisms die. Also, results in **Table (8)** also showed that the residual chloride was increased with the increasing of the applied chloride concentration, this was realistic and logic result. The residual chlorine was ranged between (< 0.1 0.6 ppm) this lies in the permissible limits which considered the residual chlorine levels up 4.0 mg/L or 4.0 ppm are safe in drinking water, besides this level, no harmful health effects can be occur.

Conclusion

From the obtained results this study, it can be concluded that the treatment process drinking water in four centers at Qalyubia governorate was sufficient water is drinkable regarding the physical and bacteriological examinations. Furthermore, Salmonella and fecal streptococci are of the most abundant bacterial groups found in water before treatment which indicates that the surface water supply in Qalyuia is affected with the sewage drainage, but after treatment these bacteria found in the permissible limits which indicates that the water is safe for human use. Additionally, *Salmonella enterica* found be more susceptible wide range of antibiotics, but generally, the chlorine concentration used disinfect drinking water is sufficient kill pathogenic bacteria.

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مؤشرات جودة مياه الشرب في أربعة مراكز بمحافظة القليوبية ، مصر

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أجريت هذه الدراسة في أربعة مراكز رئيسية بمحافظة القليوبية بمصر وهي بنها وكفر شكر وطوخ وقليوب قبل وبعد عملية معالجة مياه الشرب. تضمن كل موقع من المواقع الأربعة الرئيسية مواقع فرعية على طول نظام التوزيع وهي بنها (ميت عاصم وبنها) وكفر شكر (إيسنيت وكفر شكر) وطوخ (طوخ والدير وقها) وقليوب (قلما وقليوب). تم إجراء الإختبارات الفيزيائية والبكتريولوجية في كل من المواقع الرئيسية والفرعية خلال الشتاء والصيف 2016–2017 وتراوحت قيم العكارة ودرجة الحموضة بين NTU (1.16–2.60) و (7.27–7.87) خلال الموسمين بعد عملية المعالجة على التوالي. بالإضافة إلى ذلك ، تم تسجيل قيم أقل للتوصيل الكهربائي (EC) والصلابة الكلية (T.H) بعد المعالجة عن ذي قبل، ولوحظت أقل القيم في قليوب وبنها خلال فصل الصيف على التوالي. علاوة على ذلك ، كانت قيم المواد الصلبة الكلية (المواد الصلبة الذائبة TDS و TSS المعلقة) في الحدود المسموح بها وبالتالى تشير إلى كفاءة عملية المعالجة. على الجانب الأخر ومع مراعاة التغيرات في التعداد البكتيري الكلي في جميع المواقع الرئيسية والفرعية قيد الدراسة، لوحظ وجود أعداد أعلى من البكتريا في العينات المحضنة عند 37°م عن 22°م مع أعلى تعداد في قليوب وطوخ على التوالي. بينما انخفض تعداد السالمونيلا والمكورات العقدية البرازية بأعداد كبيرة بعد العلاج أكثر من ذي قبل، ولم تسجل معظم المواقع الفرعية أي تعداد للسالمونيلا خلال فصل الشتاء. تلى ذلك عزل البكتيريا الأكثر انتشارًا واختبار مقاومتها للمضادات الحيوية ووجدت أن إحداها كانت مقاومة لعدد كبير من المضادات الحيوية المستخدمة والتي تم تعريفها على أنها *Salmonella enterica* ، ووجد أن تركيزات الكلور المختلفة فعالة ضد *S. enterica* وأن نركيز 7.0 جزء في المليون كانت الأفضل من حيث خفض تعدادا البكتريا وفى نفس الوقت تركيز الكلور المتبقي كان فى الحدود المسموحة والآمنة.

الكلمات الدالة: مياه الشرب ، البكتريولوجية، الفيزيائية ، عملية المعالجة ، الكلورة ، الحساسية للمضادات الحيوية.