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Comparison between different water-treatment works in El-Menofeyia province, Egypt

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ABSTRACT

This study was carried out during a period extending between March 2016 and February 2017. The aim of this work is to make a comparison between certain physico-chemical and biological parameters at three different water plants in El-Menofeyia province, Egypt. According to data of the physico-chemical parameters, the treated water at these treatment plants proved a remarkable enhancement as compared with raw one mainly with the values of TDS, Conductivity, Turbidity, Total alkalinity, Phosphates, Nitrates and Ammonia. Regarding biotic component, it was proved that both Total and Fecal coliform beside protozoans disappeared more or less completely at the end of the water treatment process in the present study. On the other hand, the protozoan organisms showed that the total protozons, sarcodines and ciliates' numerical densities achieved the highest densities during June 2016 in Meligue and Dalaton influent water, while those of Shobra-bass occurred on March for ciliates, October-November for flagellates and August for sarcodines. From the practical and statistical point of views, it could be possible to conclude that the direct filtration treatment process (Meligue) was the most effective method to obtain better potable water followed by the river-bank filtration (Dalaton) then the compact water treatment plant at Shobra-bass.

Key words : Water-treatment plants, physico-chemical parameters, protozoa, total and fecal coliform bacteria, El-Menofeyia province, Egypt.

INTRODUCTION

River Nile is considered as the main Egyptian water sources for the domestic, industrial and irrigation uses. The rapid increase in population and urbanization is a big challenge to the country in facing water scarcity (El Gammal, 2008). One of the most important factors of water pollution is the microbial contaminations; especially with pathogenic microorganisms. Pathogens are typically responsible for waterborne diseases **(**Karaboze *et al.,* 2003). Bacteriological water analysis is a method of analyzing water to estimate the numbers of bacteria present and find the sort of bacteria that contaminated the water source (Sabae and Rabeh, 2007). Twenty percent of the world's population lacks safe drinking water, and nearly half the world population lacks adequate sanitation. In addition, water contamination also leads to the increase in parameters like biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), and salinity and thus deteriorates the water quality and make it unfit for drinking and other purposes. Consequently, potable water should be colorless, tasteless, odorless and free from any micro-organisms. This processes involves removing the contaminants using physical processes such as settling and filtration, chemical processes such as disinfection and coagulation and biological processes such as rapid and slow sand filtration (Galal, 1989).

Measuring of certain physico-chemical parameters of water is very important to investigate both water quality and ecological variations of the water body (WHO, 1996). Chlorine is widely used as a disinfectant at water treatment plants, but its concentrations did not kill some protozoan organisms and their cysts (Wallis *et al.,* 1996; Liberti *et al.,* 2002).

Conventional water treatment plant has a series of treatment processes such as coagulation, flocculation and clarification through sedimentation, filtration and disinfection. Direct filtration is considered as a conventional plant without clarifiers.

Compact water treatment plant is a type of treatment which is carried out through coagulation (via coagulant alum), filtration in a closed container with sandy media in the ground of the filter and disinfection through chlorine.

River Bank Filtration is the infiltration of surface water, mostly from a river system into a groundwater system induced by water abstraction close to the surface water as a river bank. As the water flows through the soil, it is filtered and its quality hence is improved (Sharma and Amy, 2009; Huelshoff *et al.*, 2009). Bank Filtration has been used for over 100 years in Europe and is now gaining interest and application globally as an effective process for reducing organic and particulate loads to drinking water treatment systems (Schmidt *et al*., 2003).

The microbiological quality of water and the effectiveness of treatment are based on fecal contamination indicators. Ciliated protozoans, together with bacteria, algae colorless flagellates, small metazoans such as rotifers, crustaceans and nematodes, constitute the characteristic plankton community of freshwater ecosystems and play an important role in its trophic structure (APHA; 1992 and Sola *et al*.; 1996). Also, ciliates play a significant role in decomposition process and nutrient recycling (Madoni and Zangrossi, 2005; Senler and Yildiz, 2004). Changes in species diversity and structure are a reliable and generally useful means for assessing the biological effects of pollution (Velho *et al*., 2005; Madoni and Zangrossi, 2005; Chen *et al*., 2008). The tolerance of ciliates to ammonia is necessary in the toxicological studies of aquatic ecosystems (Xu *et al*., 2004).

In water treatment plants, it is generally accepted that the feeding of ciliates on bacteria improve the treatment process, resulting in a lower organic load in the output water. Due to their biodegradation potential some attempts have been made to use ciliates specifically in environmental biotechnology (Pauli *et al*., 2001; Spellman; 2003). Therefore, this study aims to compare between certain physico-chemical and biological parameters at three different water plants in El-Menofeyia province, Egypt. These plants apply different water treatment methods as mentioned previously.

MATERIALS AND METHODS

Water samples were collected using sterilized one liter polypropylene containers at 30 cm below water surface from inlets of three different water treatment plants; Meligue, Shobra-bass and El- Dalaton. The former plant is a direct filtration water treatment plant; the second one is a compact water t plant, while the latter one is a well that located next to the River Nile (Bank Filtration). Water samples were collected during a period extending from March 2016 to February 2017 and were analyzed physico-chemically using APHA (2005) method.

Total coliform (Tc) and fecal coliform (Fc) bacteria were used as indicators for pollution in all water samples. Total and fecal coliform bacteria were investigated and counted using membrane filter technique method according to APHA (1998) and EPA (2005).

Protozoan sedimentation was carried out as mentioned by Galal *et al.* (2008), while their identification was performed using Patterson and Hedley (1996) in laboratories of Zoo. Dept., Faculty of Science, El-Menofeyia University. Statistical analyses were performed using Minitab statistical package.

RESULTS

According to the present physico-chemical data of the three examined water-treatment plants, it appears that the treated water (effluent) of these water works exhibited a remarkable enhancement as compared with the raw one (influent) mainly in TDS, Conductivity, Turbidity, temperature, total alkalinity, phosphates, nitrates and ammonia. The latter three parameters beside the turbidity showed the highest efficiencies at Meligue effluent water as compared to those of the other two plants. Simultaneously, it was proved that most of the physico-chemical parameters of Meligue treated water have more satisfied values than those of Dalaton and Shobra-bass water–treatments' plants, respectively. Regarding the treated water, it was found that TDS, conductivity, total alkalinity, total hardness, turbidity, iron, manganese, phosphates, nitrates and ammonia of Shobra-bass were mostly higher in their values as compared with those of the other two water plants particularly during spring as could be seen in Figures (1 and 2).Taking Coliform bacteria (Total and Fecal types) in our consideration, it was proved that the influent water samples of these water works have varying contamination levels (22700 TC -10600 FC/100 ml monthly). The highest densities of these bacteria were recorded during August 2016 and the lowest ones occurred on February 2017. The highest numbers of Total Coliform were detected at Shobra-bass followed by those of Meligue and then those belonging to El-Dalaton plants, while those of Fecal Coliform illustrated maximal densities at Meligue, then Shobrabass followed by El-Dalaton (Table (2). The treated water (effluent) illustrated completely nill for both types of bacteria (<1/100 ml) apart from very few total coliform values at Shobra-bass compact water-treatment work.

Data of the protozoan organisms indicated the presence of two genera of sarcodines, seven mastigophoreans and 13 of ciliates at Meligue influent (raw) water, while those of Shobra-bass and Dalaton achieved 2, 13, 27 and 2, 13 and 16 genera, respectively as could be seen in Table (1). The total protozoan organisms at Shobrabass influent water showed higher numerical densities than those of Meligue and Dalaton plants. On the other hand, influent total protozoa of Dalaton water plant exceeds those of Meligue during a period extending only from March to September 2016, while those in-between November and January behaved in an opposite manner. It is worthy to mention that ciliates showed the highest numerical densities followed by flagellates and then sarcodines. The maximal and minimal monthly numerical densities varied between 69 and 29 10^3 /L during June and January, respectively at Meligue influent water, 183 and 52 10^3 /L on March and January at Shobra-bass, 84 and 11 on June and January at El-Dalaton. Considering flagellates, their respective values were 33 and 2 on August and Novmber, 33 and 20 on October and February and 43 and 9 10^3 /L during March and February at Meligue, Shobra-bass and El-Dalaton, respectively. Regarding sarcodines, the upper and the lower numerical densities were 4 and 1; 5 and 1; 3 and 0 10^3 /L at Meligue, Shobra-bass and El- Dalaton inflow water, respectively.

DISCUSSION

It is obvious in the present study that some of the parameters showed high values in municipal pipes and distribution system which could be referred to damage, leakage and rusting of its pipes. Temperature is considered as a very significant factor influencing various activities of the microorganisms (Galal *et al.*, 2011; Gopalkrushna, 2011). It has a positive significant correlation with turbidity in both conventional and direct filtration water plants (Galal, *et al.*; 2014). Turbidity is one of the daily monitoring parameters in water treatment that affects other water characters such as health, physical and disinfection aspects (Mazloomi *et al.*,2009). It is the most widely used particle measurements in water treatment process that include coagulation, sedimentation and filtration (WHO, 2009).Hydrogen ion concentration is considered as a controlling factor affecting dissolved oxygen and total alkalinity. Its values in the present study ranged between 7.6-7.9 at the different stages of these water plants and the highest levels were recorded during summer and winter which is parallel to those of Elawa and Mahdi (1988).

The present data illustrated higher pH values on summer as compared to those of winter and other seasons which could be referred to the decomposition of the organic matter which is confirmed with the findings of Birhanu (2007). The total dissolved salts (TDS**)** achieved the maximum values on winter in all water samples of the water treatment plants which is in agreement with those of Elawa and Mahdi (1988) and opposite to those of Elewa and Authman (1991). Simultaneously, TDS values showed high positive correlation with the electrical conductivity which is confirmed with data obtained by Galal *et al.* (2014). Decreasing of conductivity may be attributed to the precipitation of calcium carbonate which is mainly caused by algal depletion and secondarily by higher temperatures.

According to the present data, it was proved that total alkalinity (carbonate and bicarbonate), total hardness (Calcium and Magnesium) which affects toxicity of the pollutants and chloride ions (sewage pollution indicator) achieved their highest levels mostly during winter and autumn, while the lowest ones were obtained mainly on summer and spring exactly as those obtained by Helal, (1981), Elewa and Authman, (1991) and Bergmann, (2009).

The seasonal levels of iron concentrations in the present investigation did not exceed 0.07 mg/L which is parallel to those of Galal (2014). The presence of iron and manganese at different water treatment stages and at the drinking water distributing system could be referred to the using of ferric coagulants as well as using steel pipes which is confirmed by Thompson *et al.* (2009).

Ammonia in water samples of the present study is an indicator of bacterial, sewage and animal waste pollution. Ammonia is occasionally found in potable water samples and distribution system (less than 0.4 mg/L) where chlorine is used as a residual disinfectant (WHO, 2009) keeping in mind that Shobra-bass water treatment plant has no clarification. It was found that the seasonal values of ammonia showed a minimum concentration on spring and a maximum level during summer in both Meligue and Dalaton water plants, while those of Shobra-bass were achieved on winter and autumn, respectively.

Nitrates can reach both surface and ground water as a consequence of agricultural activity and also from waste water disposal product from human. The seasonal nitrate concentrations of the present study exceeded the international permissible limits. This could be due to variations in pollution levels in the municipal pipes of water treatment plant and the connected pipes for consumers.

Phosphates are very important elements for phytoplankton growth. It stimulates the activity of nitrogen fixing bacteria and increasing the nitrifying activity of the soil (Authman, 1991). The present phosphate levels exceed those of the Environmental Protection Agency limits (0.1 mg) which could be an indication of sewage contamination which is a serious environmental problem as it adversely affects the human health and the biodiversity in the aquatic ecosystem (APHA, 2005). Drinking water must meet specific criteria to ensure that water supply to the public is safe and free from any pathogenic microorganisms as well as hazardous compounds (WHO, 2009).

The total and fecal coliforms were not detected in treated, filtrated and potable water samples which could be attributed to the effectiveness of the disinfection process which is concomitant with pathogenic bacteria (WHO, 1993). Raw water of the present study was contaminated with fecal material of different origin. The positive results of coliform bacteria in treated water of certain stages in treatment plants might indicate the presence of bio-film in the distribution system. Protozoan organisms were detected throughout the year mainly at the three water treatment plants with highest densities among other plankton and they were mostly absent from filtered and treated water which could be attributed to the effect of adding chlorine and coagulant alum mainly at Meligue and Shubra-bass water plants.

In aquatic environments, ciliates are considered as mediators of energy transfer from pico- and nano-plankton levels to higher trophic ones in the functioning microbial loop (Dolan and Coats, 1990; Sime-Ngando *et al.*, 1995; Jiang *et al.*, 2013). It is becoming increasingly recognized that there are several advantages in using ciliated protozoan for the assessment of water quality due to their short life cycles, their semipermeable membranes and their reacting more rapidly to the environmental changes than other eukaryotic organisms. Furthermore, many forms can inhabit environments that are unsuitable to metazoan organisms (Cairns *et al*., 1972; Franco *et al.*, 1998; Corliss 2002; Madoni and Braghiroli, 2007; Jiang *et al*., 2007). Other investigations have revealed that some dominant species are significantly correlated with concentrations of nutrients (Jiang *et al.*, 2011). Thus, it is possible to conclude that some ciliates could respond predictably to different environmental conditions.

The relations between biotic and abiotic components could be examined via simple and multiple regression analyses by applying Minitab statistical package and the significant relationships could be seen in Table (3). By applying stepwise regression analysis, it was proved that Meligue water plant was the most efficient one in producing potable water followed by El-Dalaton and then Shobra-bass plant.

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Table (1). Protozoan genera at three different water-treatment works in El-Menoufeyia Province.

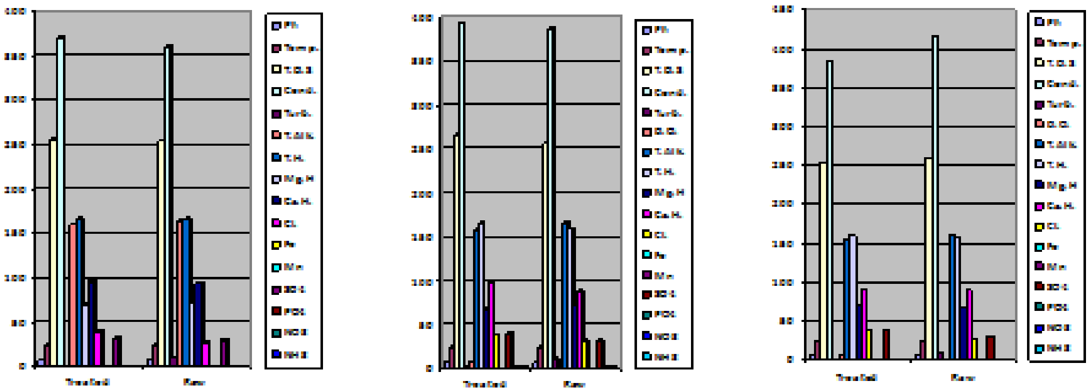
Table (1).	Meligue	Shubrabass		Dalaton	
Sarcodina	*Nuclearia* *Arcella*	*Amoeba* *Arcella*		*Amoeba* *Arcella*	
Mastigophora	*Euglena* *Cryptomonas* *Peranema* *Peridinium* *Ceratium* *Astasia* *Chlorogonium*	*Peridinium* *Peranema* *Euglena* *Cryptomonas* *Ceratium* *Synura* *Heteronema* *Eudorina*	*Carteria* *Actionmonas* *Chlorogonium* *Uroglena* *Trachelius*	*Eudorina* *Heteronema* *Uroglena* *Carteria* *Actionmonas* *Euglena*	*Chlorogonium* *Cryptomonas* *Uroglena* *Peranema* *Ceratium* *Actionmonas* *Synura*
Ciliophora	*Halteria* *Aspidisca* *Colpoda* *Euplotes* *Tetrahymena* *Paramecium* *Tachysoma* *Cyclidium* *Childonella* *Colpidium* *Vorticella* *Anisonema* *Centophyxis*	*Colpidium* *Acineta* *Colpoda* *Homalozoon* *Climacostmum* *Stentor* *Vorticella* *Lacrymaria* *Chlamydodon* *Glaucoma* *Cyclidium* *Strobilidium* *Tachysom*	*Frontonia* *Acanthocystis* *Coleps* *Tetrahymen* *Chilodenlla* *Euplotes* *Aspidisca* *Dileptus* *Halteria* *Phascolodon* *Podophyra* *Tpkokphyra* *Paramecium* *Nassula*	*Litonous* *Halteria* *Podophyra* *Aspidisca* *Nassula* *Tetrahymena* *Vorticella* *Tokophyra*	*Homalozoon* *Colpidium* *Paramecium* *Coleps* *Stentor* *Strobilidium* *Dileptus* *Glaucoma*
Total Protozoa	**22**	**42**		**31**	

Table (2). Monthly numerical densities of Total (T) and Fecal (F) Coliforms /100 ml at Different water treatment works in El-Menofeyia Province, Egypt.

Month	Dalaton				Shobrabass				Meligue			
	Raw		Treated		Raw		Treat		Raw		Treat	
	T	F	T	F	T	F	T	F	T	F	T	F
March$_{2016}$	16500	6500	< 1	<1	18200	7100	17	< 1	18800	8400	< 1	< 1
April	17700	7000	< 1	<1	18700	7400	< 1	< 1	15700	8100	< 1	< 1
May	16500	5500	< 1	<1	15100	6300	14	< 1	12200	7300	< 1	< 1
June	20000	8900	< 1	<1	16100	7100	22	< 1	16700	8100	14	< 1
July	16500	6600	< 1	<1	19800	8700	< 1	< 1	20400	9700	< 1	< 1
Aug.	22500	9000	< 1	<1	22700	9600	< 1	< 1	23200	10600	< 1	< 1
Sept.	11200	4000	< 1	<1	11700	4400	< 1	< 1	12300	5400	< 1	< 1
Octb.	11200	3800	< 1	<1	12500	5300	15	< 1	13300	6300	< 1	< 1
Nov.	10000	3500	< 1	<1	13200	5700	< 1	< 1	14100	6700	< 1	< 1
Dec.	8800	4600	< 1	<1	11500	5600	< 1	< 1	12200	6600	< 1	< 1
Jan$_{2017}$	8000	2000	< 1	<1	9600	3300	8	< 1	10600	4300	< 1	< 1
Feb.$_{2017}$	8800	1000	< 1	<1	8500	1200	< 1	< 1	9500	2200	< 1	< 1

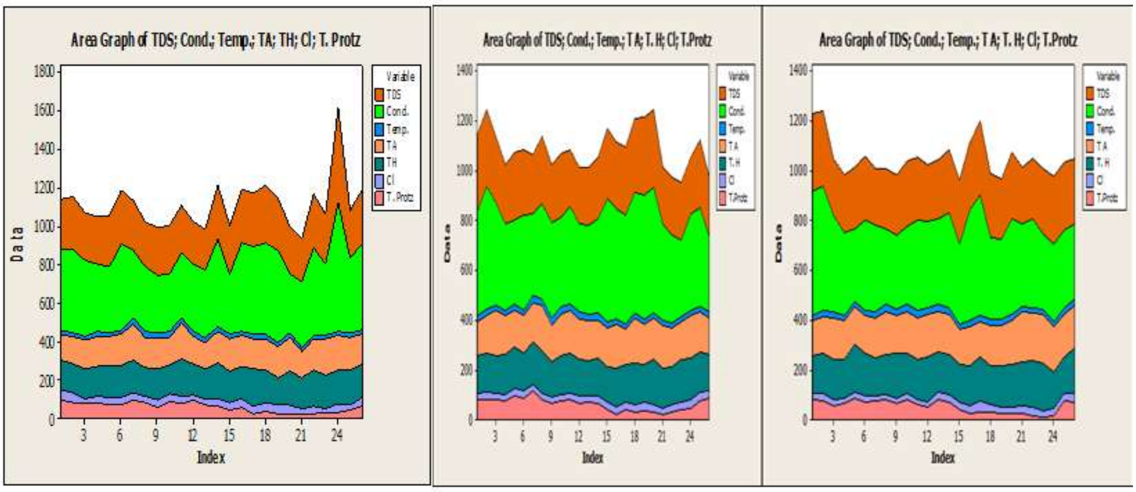
Table (3). Summary of the statistically significant relationships of biotic and abiotic parameters in three water treatment works in El-Menofeyia Province.

W.T. Plants	Parameter	B	df	F	P
Meligue	T. Protz Vs Cond	-0.21	1,25	7.38	0.012
	Vs Temp	3.49	1,25	4.87	0.037
	Vs Chlorine	-2.55	1,25	4.01	0.053
	Vs Rotifers	4.54	1,25	7.28	0.013
	Vs T.Coliform	2.62	1, 25	4.92	0.036
	T. Coliform Vs Temp.	0.81	1,25	14.34	0.001
	T. Coliform Vs Cl	-0.51	1,25	7.36	0.021
	T. Coliform Vs Temp. & Cl	$b_{1 = 0.67}$ $b_{2= -0.31}$	2,25	9.39	0.001
Shobrabass	T. protz. Vs Cond.	-0.12	1,23	4.26	0.050
	Vs Temp	4.13	1,23	8.12	0.009
	Vs Cond & Temp	b1= -0.06 b2= 3.37	2,23	4.56	0.023
	Vs T.Colif	3.39	1,25	12.69	0.002
	Vs F.Colif	4.59	1,25	5.32	0.030
	Vs T & F. Colf	b_1= 6.17 b_2 = -5.77	2,25	7.69	0.003
	T.Colf Vs TDS,Temp& TA	b1= -0.11 b2= 0.02 b3= -0.12	3,25	3.04	0.050
	T.Colf Vs Cl	-0.5	1,25	14.99	0.001
	F.Colf Vs TDS	-0.02	1,25	4.21	0.05
	F.Colf Vs Cond.	-0.012	1,25	6.5	0.018
	F.ColfVs Temp.	0.38	1,25	9.75	0.003
	F.Colf Vs TDS, Cond & TA	b1= -0.07 b2= 0.02 b3= -0.07	3,25	5.56	0.005
El-Dalaton	T.protz . Vs Temp	4.38	1,25	8.73	0.007
	Vs T. Alkl	-0.79	1,25	7.77	0.01
	Vs Temp &T.Alkal	b1= 3.48 b2= -0.6	2,25	7.66	0.003
	Vs T.Colif	3.39	1,25	12.69	0.002
	Vs F.Colif	4.59	1,25	5.32	0.030
	Vs T. &F.Colif	b1 = 6.17 b2 = - 5.8	2,25	7.69	0.003
	Tc Vs TDS, Cond, Cl, Temp,Tur, T.Alk, T.H .		7,25	6.53	0.001
	Tc Vs Temp, T.Alk, Cl, T.protz		4,25	10.01	<0.001
	F.Colf Vs Temp	0.47	1,25	13.37	0.001
	Vs T.Alk	-0.59	1,25	4.54	0.044
	F.Colf Vs Cl	-0.22	1,25	8.78	0.007
	F.Colf Vs Temp, T.Alk,Cl		3,25	10.18	<0.001
	F.Colf Vs Temp, T.Alk, Cl &T.Protz		4,25	10.01	<0.001



El-Dalaton WTW　　Shobra-bass WTW　　Meligue WTW

Figure (1) Physico-chemical parameters of Raw and Treated water at three different water treatment works in El-Menofeyia Province.



Shobra-bass　　Meligue　　El-Dalaton

Fig. (2). Time series graph of different parameters in three water treatment works in El-Menofeyia Province, Egypt.

Comparison between different water-treatment works in El-Menofeyia province, Egypt

مقارنة بين محطات مختلفة لمعالجة مياه الشرب فى محافظة المنوفيـــة بمصر.

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المستخلص

أجريت هذه الدراسة للمقارنة بين الخواص الطبيعية والكيميائية والحيوية للماء الخام الداخل والمعالج لثلاث محطات (مليج للترشيح المباشر – شبرا باص للترشيح بدون مروقات - الدالاتون للترشيح باستخدام بئر بجوار النهر) وذلك لتنقية المياه بطرق مختلفة بمحافظة المنوفية فى الفترة من مارس 2016 وحتى فبراير 2017 . ولقد أوضحت هذه الدراسة أن المياه المعالجة والناتجة من المحطات الثلاث تتمتع بخواص أفضل من النواحى الطبيعية والكيميائية والحيوية بالمقارنة بصفات المياه غير المعالجة قبل دخول تلك المحطات الثلاث ، ولكن بدرجات متفاوتة اعتماداً على طرق المعالجة المستخدمة بهذه المحطات كما يتضح من النتائج المرفقة. ولقد ثبت عملياً وإحصائياً أن معالجة المياه بطريقة الترشيح المباشر بمحطة مليج تكون هى الأكثر كفاءة تليها المعالجة لمياه البئر المجاور للنهر فى منطقة الدالاتون وتأتى فى النهاية الطريقة المستخدمة فى محطة المياه بدون مروقات فى شبرا باص.