ARTICLE

SEASONAL VARIATION DETERMINATION OF PHYTOPLANKTON DENSITY IN AQUATIC SYSTEM

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ABSTRACT

Algae might be one of the biggest causes of fresh water problems in Kafr El-Sheikh the governorate, Egypt; where phytoplankton density increases in certain periods of the year for many reasons and negatively affects the quality of fresh water used as resources by drinking water purification plants in terms of changing color, taste and smell. This study aimed to monitor the seasonal variation of fresh water phytoplankton density in front of intakes of three water purification plants located on Nile River in terms of counting and classification of algae as well as treated water phytoplankton density for determination of raw water situation and evaluation of water purification plants efficiency to remove algae. Results of this study showed that phytoplankton density increased in spring and summer seasons more than autumn and winter, while efficiency of algal removal exceeded 90 % for the three tested plants; finally this study provided a classification and an identification of certain types of dominant species of algae found in water

KEY WORDS
Pollution, Diatoms, Green Algae, Blue Green Algae, Efficiency Evaluation

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INTRODUCTION

There is no life without water as water is one of the most essential necessities of life on earth. All countries of the world have turned to the importance of water quality because of its great impact on human health. Production of safe potable water is of great importance in precaution of incidence of many water-born diseases. Phytoplankton in particular species belonging to cyanobacteria (blue-green algae) are very significant because of their impact on the quality of water Because of the secretion of some substances that change the color, taste and smell of water as well as the secretion of some toxins that affect human health and cause diseases, they also have an impact on many environmental factors related to the quality of water as well as they may negatively affect the process of purification itself as algae species belonging to diatoms might cause filters clog because of their silicon frustules. [1].

Aquatic systems all over the world have been affected by the excessive discharge of many types of pollutants, causing phytoplankton blooms and affecting the environmental characteristics of those systems in many ways [2, 3, and 4]. And with the civilization leap in all countries of the world; a specific need have been originated to analyze and follow up the situation of these water resources to determine the adequacy of water purification processes and changes that may arise in certain periods as a result of pollution and monitor these changes for the sake of prediction of crises before their occurrence and work to find solutions to avoid disasters that may occur and affect human health and safety. this perception prompted researchers around the world to carry out many studies and statistical analyses to know about the reasons for increasing of algal density in raw water at certain periods and link between this increase and other various environmental factors to determine the reasons of this increase and follow its impact on the status of water and the process of purification in order to find appropriate solutions [5, 6 and 7].

Water resources pollution is considered one of the most critical problems affecting Nile River in Egypt. Pollution of Nile River has grown in the last few years because of increases in population; several new irrigated agriculture projects which have been increased with the expansion of agricultural plantation causing a huge increase of the quantity of agricultural drainage water discharging into Nile water and other activities along the Nile. As a result the dilution capacity of the Nile River system will diminish at the same time that the growth in industrial capacity is likely to increase the volume of pollutants discharged to the Nile. Other sources of pollution including sewage discharge regarding the increase of population [8].

The phenomenon of algae bloom on the River Nile and its tributaries became common in the last six years. Increased algae bloom negatively affects purification plants which have not been constructed to deal with high density of algae. Increased density of phytoplankton can cause serious problems in purification plant basins considering the accumulation of algae on their walls, frequently clogging of filters, affecting the purification process and increase the dose of coagulant and chlorination which cause financial increases. Consecutive Clogging of filters results in more back-wash water to be used, consuming more power and reducing water supply level to clients. Phytoplankton density increase also affects potable water quality through increasing alkalinity, pH, slightly and turbidity. As well as increasing clients complain from bad smell and odor starting from grassy, spicy, musty, and fishy to septic water [9].

MATERIALS AND METHODS

Sampling Site Description: Water samples were collected seasonally for one year (2016) from Intakes of three water purification plants located on Rosetta branch of Nile River. Water treatment plants are: 1) Mahalet Abo-Ali drinking water purification plant. 2) Fowah drinking water purification plant. 3) Mettobus drinking water purification plant. [Table 1] and [Fig.1] showed the three sites of sampling. Samples were

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taken manually 30 cm under the surface of the water and transferred to Laboratory within an ice-box according to standard methods of water and wastewater [10].

Counting and Identification of algal count: A volume of 10 ml of each sample of raw and treated water was centrifuged for 10 min at 4000 rpm by Centrifuge, the supernatant was discarded, and then the pellet was dissolved in 1 ml of saline water, which was transferred to Sedgwick–rafter counting chamber that was covered by a slide cover. Algae were counted using inverted microscope fitted with colour video camera attached to a TV monitor. The count was carried out using the TV monitor; Diatoms, green algae, blue green algae and total algal count were recorded for each sample as showed by [10].

Table 1: Representing the sites of sampling and their coordinates

Site of Sampling	Latitude	Longitude
Mahalet Abo Ali Purification plant	31° 6'7.92"N	30°41'53.57"E
Fowah Purification plant	31°12'16.24"N	30°34'12.69"E
Mettobus Purification plant	31°16'56.68"N	30°31'28.43"E

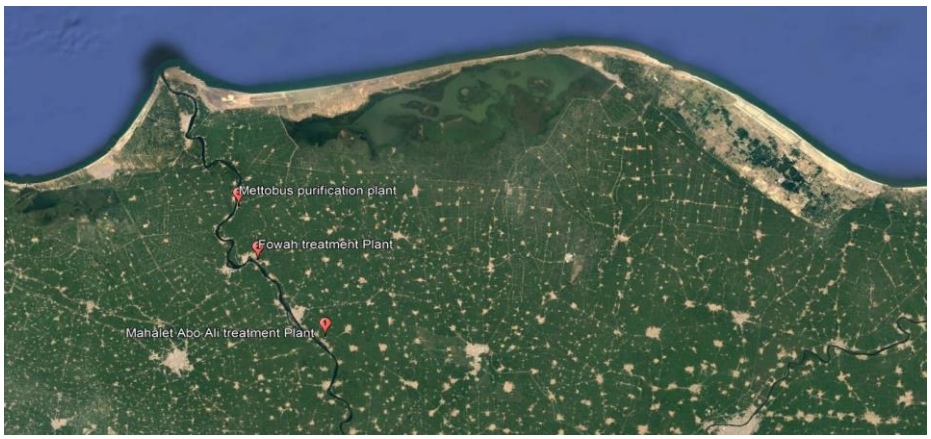

Fig. 1: Representing the three sampling sites and their locations on Rosetta Branch of Nile River.

RESULTS

This study monitored seasonal variations of algae densities in raw and treated water collected from three water purification plants in Kafr El-Sheikh Governorate which their intakes are located on Rosetta Branch of Nile River. Samples were investigated for the presence and count of Diatoms, Green Algae, Blue Green Algae and Total Algal Count around four seasons of one year (2016). This study also tried to evaluate the performance of algal removal of the tested purification plants.

Results of this study indicated that Total Algal count, Diatoms, Green Algae and Blue Green Algae increased in summer and autumn rather than winter and spring seasons with regard to Mahlet Abo Ali water purification plant. The highest Total Algal count (10860 org. /ml.) was recorded in summer 2016. The lowest Total Algal Count (7200 org. /ml.) was recorded in spring 2016 with regard to raw water samples. With reference to treated water samples; results revealed great removal ratio along the four seasons, The lowest value (650 org. /ml.) was recorded in winter 2016 while the highest value was recorded (840 org. /ml.) in summer 2016. [Table 2]and [Fig. 2] represented counts of Diatoms, Green and Blue Green algae including the Total Algal Count of raw and treated water samples of Mahlet Abo Ali water purification plant. Concerning efficiency evaluation of Algae removal of Mahlet Abo Ali water purification plant; results showed similar pattern over the four seasons. Removal rate was recorded 90.4 %, 90.2 %, 92.2 % and 91.8 % in winter, spring, summer and autumn 2016 respectively. The highest removal rate was recorded in summer 2016.

Concerning Fowah water purification plant; Results indicated that Total Algal count, Diatoms and Green Algae densities increased in summer and autumn rather than winter and spring seasons with regard to raw water samples. Except for Blue Green Algae count; results showed that their count increased in summer season followed by winter season. The highest Total Algal count (11450 org. /ml.) was recorded in summer 2016.The lowest Total Algal Count (7850 org. /ml.) was recorded in winter 2016 with regard to raw water samples. With reference to treated water samples; results revealed satisfactory removal ratio all over four seasons, The lowest value (580 org. /ml.) was recorded in spring 2016 while the highest value was recorded (800 org. /ml.) in summer 2016.[Table 2] and [Fig. 3] represented counts of Diatoms, Green and Blue Green algae including the Total Algal Count of raw and treated water samples of Fowah water purification plant. Concerning efficiency evaluation of Algae removal of Fowah water purification plant; results showed similar removal ratio all over the four seasons. Removal rate was recorded 91.8 %, 92.7 %, 93.0 % and 92.8 % in winter, spring, summer and autumn 2016 respectively. The highest removal rate was recorded in summer 2016.

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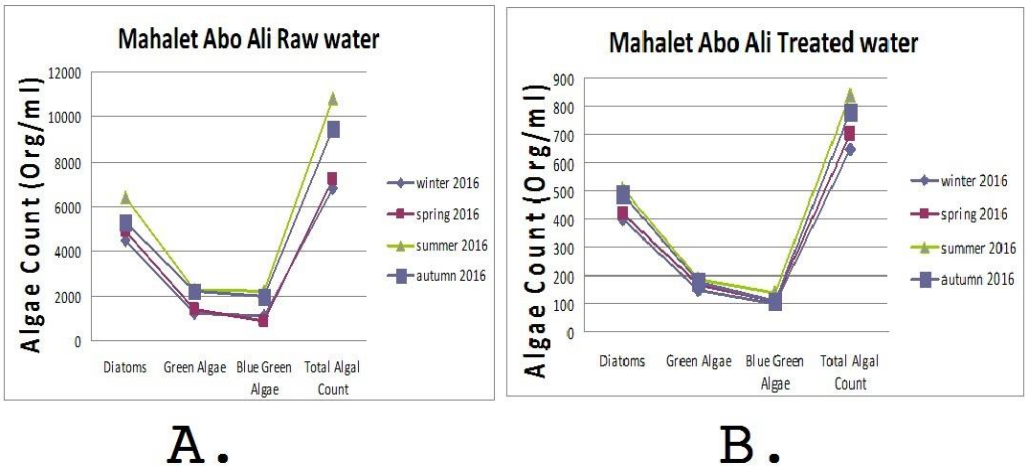
As for Mettobus water purification plant; Results showed that Total Algal count, Diatoms and Green Algae densities increased in summer season rather than any other season concerning raw water samples. The highest value of Blue Green Algae count was recorded in spring season. The highest Total Algal count (11100 org. /ml.) was recorded in summer 2016, while the lowest Total Algal Count (7000 org. /ml.) was recorded in winter 2016 with regard to raw water samples. Concerning treated water samples; results revealed acceptable removal rate around the year, The lowest value (450 org. /ml.) was recorded in winter 2016 while the highest value was recorded (740 org. /ml.) in summer 2016. [Table 2]and [Fig.4] represented counts of Diatoms, Green and Blue Green algae including the Total Algal Count of raw and treated water samples of Mettobus water purification plant. Efficiency evaluation of Algae removal of Mettobus water purification plant showed adequate removal rate around the year which was recorded 93.6 %, 93.9 %, 93.3 % and 93.7 % in winter, spring, summer and autumn 2016 respectively. The highest removal rate was recorded in spring 2016 in this case.

Efficiency evaluation of the three water purification plants under investigation showed satisfactory and accepted capabilities of algae removal over the course of four seasons of 2016 representing the period of study. [Fig.5] indicated the efficiency evaluation of the three plants around the year based on plants capability of algal removal throughout the four seasons of the period of study.

Table 2: representing seasonal variations of Total Algal Count, Diatoms, Green Algae and Blue Green Algae Counts recorded for raw and treated water samples of Mahalet Abo Ali, Fowah and Mettobus water purification plants

		Raw water				Treated water			
		winter 2016	spring 2016	summer 2016	autumn 2016	winter 2016	spring 2016	summer 2016	autumn 2016
Mahalet Abo Ali water purification plant	Diatoms	4500	4900	6400	5300	400	420	510	490
	Green Algae	1200	1400	2250	2200	150	170	190	180
	Blue Green Algae	1100	900	2210	2000	100	110	140	110
	Total Algal Count	6800	7200	10860	9500	650	700	840	780
Fewwah water purification plant	Diatoms	4900	5700	8000	7850	350	290	420	400
	Green Algae	1650	1400	2000	1700	180	175	190	200
	Blue Green Algae	1300	900	1450	650	110	115	190	130
	Total Algal Count	7850	8000	11450	10200	640	580	800	730
Mettobus water purification plant	Diatoms	4200	4850	7500	6350	280	300	480	430
	Green Algae	1650	1910	2450	1730	120	180	130	140
	Blue Green Algae	1150	1740	1150	1720	50	40	130	50
	Total Algal Count	7000	8500	11100	9800	450	520	740	620



A. B.

Fig.2: Representing Seasonal variation of phytoplankton density in raw and treated water regarding Mahalet Abo Ali water purification plant; where, A. representing raw water and B. representing treated water.

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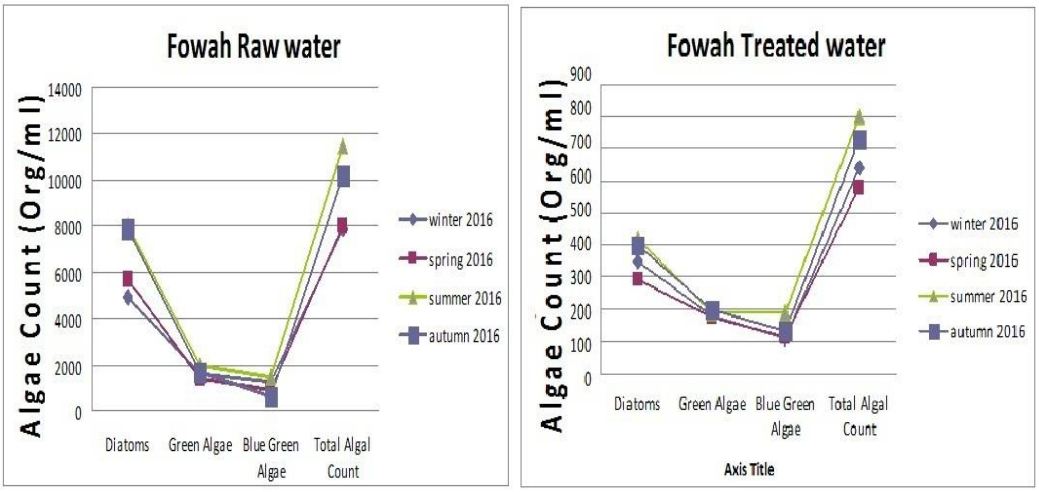
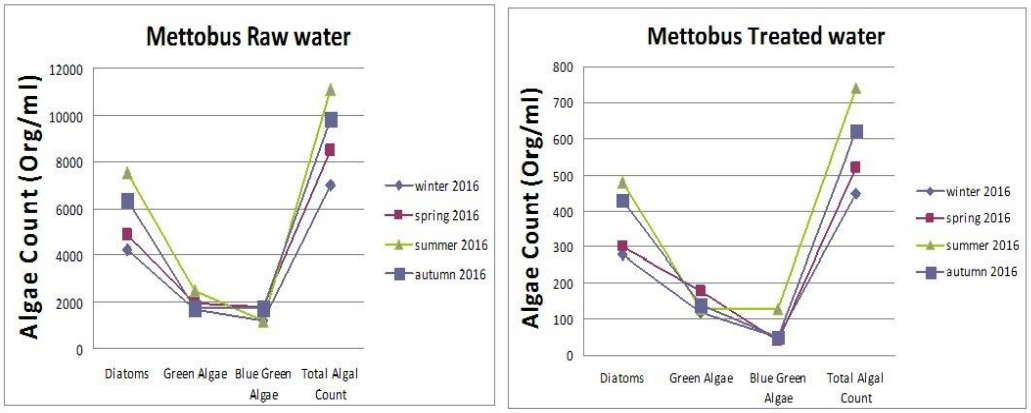


C. D.

Fig.3: Representing Seasonal variation of phytoplankton density in raw and treated water regarding Fowah water purification plant; where, C. representing raw water and D. representing treated water.



E. F.

Fig. 4: Representing Seasonal variation of phytoplankton density in raw and treated water regarding Mettobus water purification plant; where, E. representing raw water and F. representing treated water.

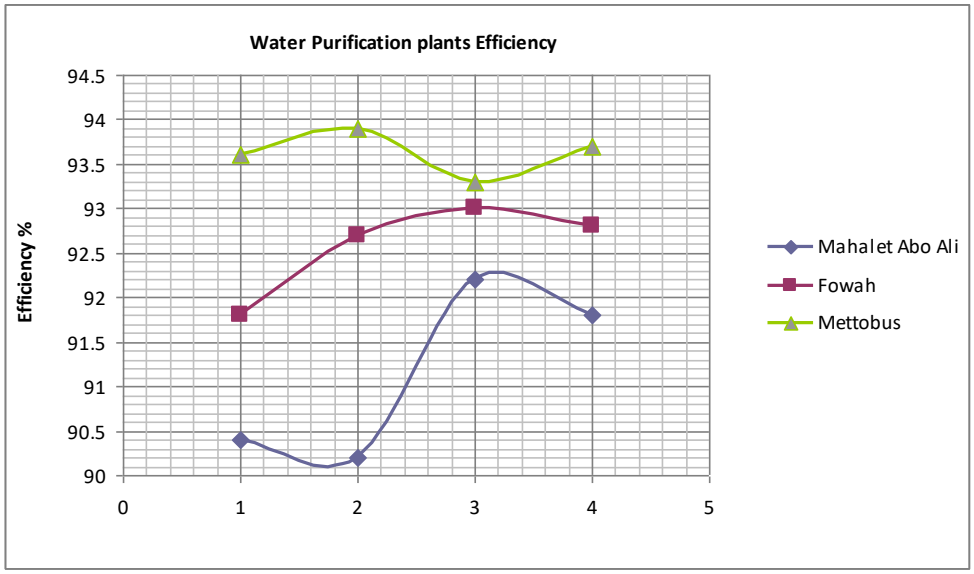


Fig.5: Representing Efficiency evaluation of the three tested water purification plants around the four seasons

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Algae are known as a distinct group of plant-like organisms which exist in different environments. They are photo-autotrophic cells containing chlorophyll; those cells are characterized by simple reproductive structures, and their tissue is not differentiated into true roots, stems or leaves. They vary in shape from unicellular to complex multi-cellular organisms. Some are complex in growth similar to vascular plants. Algae are found everywhere (air, soil and water) and can cause detrimental problems in water purification plants and drinking water supplies. Their growth is increased in stagnant waters with exposure to sunlight and temperatures. With regard to purification process of drinking water; Algae can cause formation of such a layer of growth on water surface and on basins walls; they can hinder filtration process through filter clogging and increase chlorine demand [11].

Types of Algae: Algal growth occurs in three substantial styles: Planktonic, Filamentous and Macrophytic. Planktonic algae are unicellular single cells floating freely in water. Excessive growth of algae is called "bloom"; when occur, it can change water color to green, brown, yellowish, red or gray. Filamentous species are called thread algae; they occur as floating green threads. They are found attached to rocks and aquatic plants. Macrophytic algal species look like vascular plants with regard to appearance [14].

Algal problems in water: Algal densities increase when nutrients increased within surface waters and when water is stagnant or has a high temperature leading to rapid growth of algae; called Algal blooms. Such thing has caused serious problems regarding water purification processes for many years. If raw water used as resources for drinking water purification process contains algal blooms, clogging of filters can occur and odors may arise in treated water. Algal blooms may cause toxins to be released in water; such toxins might be secreted by the cyanobacteria species of algae as known as blue-green algae which can cause also a bad odor to water, scum layer on the surface and may cause a risk to human health. If increased in density, Green algae may change water color to green. Therefore algal problems are mostly undesired and algae monitoring and control is very important [12, 13 and 14].

Algae Growth Conditions: Excessive algae growth will affect other forms of aquatic plant life, and can block sunlight necessary for their adequate growth. Excessive blooms of planktonic algae can also cause taste and odor problems in drinking water. Filamentous algae and macrophytic algae often form dense growths which would have a negative effect regarding fishing, swimming, and other recreational uses. Total coverage of water surface can restrict sunlight penetration and limit the production of oxygen and food items necessary for growth of aquatic habitat [14].

Changes in Phytoplankton Density: Considering the increase in total phytoplankton number was mainly attributed to diatoms which represents around 60 % of total algal counts of Nile water of Mahalet Abo Ali water purification plant, about 75 % of total algal counts of Nile water of Fewwah water purification plant and between 60 -65 % of total algal counts of Nile water of Mettobus water purification plant. Highest numbers of Diatoms were recorded in summer season indicating the effect of temperature which supports the growth of these species; similar results were given by [9 and 11]. Green algae restricted their growth to the summer season and comprise about 20% of total algal counts of raw water of the three tested sites; that agrees with Sinada et al. [15], which causes odor and taste in purified water. The high count of green algae in this season might refer to clarity of water (low turbidity) that transmit the light and the suitable temperature of the summer. Also the green algae prefer the minimal nutrients that agree with Nour Aldeen et al. [16]. Some kind of green algae can develop in summer period (high temperature) with high pH value close to that reported by Sinada et al. [15]. The alkalinity was reached the high values and so the pH that agree with NourAldeen et al. [16]. Fortunately, blue-green algae rarely grew to significant numbers during the investigated period. Blue-green algae had its maximum density in summer season with 10 – 20 % of total algal counts of raw water of Mahalet Abo Ali and Mettobus water purification plants and 6 – 12 % with regard to raw water of Fewwah water purification plant; such findings were given by [11]. Generally, the presence of high proportion of diatoms in Nile water algae indicated that, water purification plants will expect to expose frequent taste and odor problems and reduction in filter runs; however the tested treated water of the three plants had expressed a very well efficiency of the plants in algal removal process, the efficiency of the three purification plants were recorded over 90 % through out the four seasons of the year [11].

Dominant Species of Algae: There were 13 species of Diatoms had been found during the period of study as shown in [Table 3]. Findings of this study illustrated that the most dominant species of diatoms were *Syndra sp.*, *Melosira sp.*, *Diatoma sp.*, *Stephanodiscus sp.* and *Cyclotella sp.*; concerning chlorophyta, they were the second group of abundance all over the four seasons. Results of this study showed that there were 13 species of green algae which were identified and proved to be existed in raw water of the three sampling sites around the four seasons. The most dominant species were *Scendesmus sp.*, *Pediastrum sp., Actinastrium sp.* and *Kirchnella sp., and* concerning cyanophyta, their numbers were relatively lower than other groups, and results of this study indicated the existence of five species during four seasons as shown in [Table 3]. Results of this study indicated that the most dominant species were *Chrocooccus sp., Merismopodia sp.* and *Oscillatoria sp.*

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Table 3: Variations in cell number (org/L) of the recorded phytoplankton species of raw water sites all over the year

Species	Mahalet Abo Ali water purification plant				Fewwah water purification plant				Mettobus water purification plant			
	winter	spring	summer	autumn	winter	spring	summer	autumn	winter	spring	summer	autumn
Diatom count	**4500**	**4900**	**6400**	**5300**	**4900**	**5700**	**8000**	**7850**	**4200**	**4850**	**7500**	**6350**
Asterionella sp.	375	420	580	564	399	538	624	590	305	365	550	530
Cyclotella sp.	455	390	450	365	357	387	670	649	450	478	752	654
Stephanodiscus sp.	480	240	654	458	368	488	825	792	320	350	558	418
Diatoma sp.	450	366	500	365	348	400	601	568	478	480	601	450
Nitzchia sp.	600	510	535	412	298	405	587	567	416	478	560	355
Melosira sp.	175	350	398	318	351	378	599	566	300	315	470	440
Syndra sp.	212	322	520	420	398	348	650	687	218	387	610	589
Cocconies sp.	165	220	400	388	427	454	501	497	388	401	580	560
Navicula sp.	420	512	687	550	569	597	487	565	208	351	690	516
Amophora sp.	365	385	485	410	378	466	509	488	165	284	517	380
Surirella sp.	223	294	330	290	354	394	635	621	388	270	400	408
Gyrosigma sp.	314	237	365	362	287	395	677	662	314	320	602	490
Fragilaria sp.	266	654	496	398	366	450	635	598	250	371	610	560
Green algae count	**1200**	**1400**	**2250**	**2200**	**1650**	**1400**	**2000**	**1700**	**1650**	**1910**	**2450**	**1730**
Crucigenia sp.	91	115	185	165	131	107	140	110	149	171	208	140
Selanastrum sp.	108	118	252	218	125	120	165	140	138	164	187	154
Scendesmus sp.	85	93	191	180	106	101	187	114	125	148	192	130
Pediastrium sp.	170	182	250	231	190	174	180	185	136	166	188	174
Tetraedron sp.	101	120	170	184	150	135	165	172	143	158	210	168
Oocyst sp.	74	85	135	143	132	91	137	124	115	124	194	121
Botryococcus sp.	77	90	156	162	114	96	176	161	104	140	200	104
Straurastrum sp.	66	84	145	162	95	90	148	143	106	120	150	103
Actinastrium sp.	80	92	167	154	126	84	190	91	110	176	151	93
Kirchnella sp.	75	81	90	92	96	76	102	80	107	152	172	141
Coelastrum sp.	45	75	94	87	87	69	94	84	90	104	130	97
Ankistrodesmus sp.	60	74	97	108	85	71	86	99	93	100	188	83
Microactinum sp.	98	105	185	174	120	90	118	87	129	107	120	115
Anthophysis sp.	70	86	133	140	93	96	112	110	105	80	160	107
Blue green count	**1100**	**900**	**2210**	**2000**	**1300**	**900**	**1450**	**650**	**1150**	**1740**	**1150**	**1720**
Chrococcus sp.	222	210	580	558	261	220	320	109	275	377	184	353
Oscillatoria sp.	280	190	531	497	269	201	291	115	254	391	299	352
Microsystis sp.	87	100	296	188	284	161	271	130	180	305	193	345
Merismopodia sp.	270	214	393	371	276	168	322	157	231	287	256	384
Ulothrix sp.	241	186	410	386	210	150	246	139	210	380	218	286

CONCLUSION

Drinking water purification plants in Kafr El-Sheikh Governorate are affected by the excessive discharge of many types of pollutants through the resources of surfaces water used as sources for drinking water purification; causing many problems with regard to the performance of the purification plants and the health of consumers. Algae might be one of the biggest problems of fresh water in Kafr El-Sheikh governorate, Egypt. This study monitored the seasonal variation of fresh and treated water phytoplankton density of three water purification plants located on Nile River in Kafr El-Sheikh governorate and showed that phytoplankton density increased in spring and summer seasons more than autumn and winter seasons; while efficiency of algal removal process exceeded 90 % for the three tested plants. The study also accentuated the most dominant species of algae which might be found in raw water of the area of study. This study recommends the continuous follow-up of counting, classification and identification of algae with regard to the resources of fresh water for early detection of problems and proper preparation in order to avoid such troubles at the technical and operational levels of purification plants to avoid the risks resulting from increased numbers of algae or the emergence of new species which may cause dangerous dilemmas to maintain the health of citizens and the integrity of purification process.

CONFLICT OF INTEREST
There is no conflict of interest.

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None

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