ALGAL FLORA AND PHYSICO-CHEMICAL PROPERTIES OF SEWAGE WATER TREATMENT SYSTEM IN EL-GABLE AL-ASFAR, CAIRO
PART 2- BIOLOGICAL PROPERTIES

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Abstract

The present results revealed that phytoplankton communities in the study area were represented mainly by 7 classes namely: Chlorophyceae, Cyanophyceae and Bacillariophyceae as the main groups followed by Euglenophyceae, while Cryptophyceae, Dinophyceae and Xanthophyceae were rarely present. Chlorophyceae was the first dominant group, forming 59.7% of the total phytoplankton community, while Bacillariophyceae was the second dominant group forming 19.3% followed by the third dominant group, the Cyanophyceae forming 15.6% of the total phytoplankton community. The seasonal variations of chlorophyll a and b revealed that ,the maximum chlorophyll a and b values of 251.6 and 70.9 mg/L were recorded in the effluent water during summer respectively, while the minimum one of 26.8 and 2.9 mg/L were recorded in primary sedimentation tank (PST) during autumn and winter respectively. The highest values of gross production (3120 mg C/m^3/h) and net production (1146 mg C/m^3/h) were found in the effluent during summer and spring seasons respectively, while the lowest values 110.9 mg C/m^3/h and 78.6 mg C/m^3/h) were found in the PST during winter season.

Keywords:Wastewater treatment- Phytoplankton community- Biological parameters

Introduction

Pollution is the addition of a substance (whether harmful or harmless) to the environment resulting in a change in the balance or dominance of species and can destroy the natural habitats. The aquatic environment is liable to pollution through several ways but always by agents not prevailing under natural conditions e.g. agricultural wastes, toxic chemical, radionuclide etc... Ibrahim (1989) investigated the standing crop and species composition of the phytoplankton in some polluted and non polluted areas of Manzalah Lake. The samples were collected from eight stations through a period of one year. About 170 taxa were recorded and distributed in the following taxonomic groups: Bacillariophyceae (83), Chlorophyceae (40), Cyanophyceae (29), Euglenophyceae (10), Dinophyceae (7) and Cryptophyceae (1). The results indicated that the phytoplankton was represented by typically eutrophic species. The most dominant species *were Cyclotella meneghiniana*, *Melosira granulata*, *Nitzschia closterium*, *Anabaena* sp., *Microcystis aeruginosa* and *Ankistrodesmus falcatus*. These phytoplankton species reflect the environmental conditions. The effect of treated

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sewage on the quality of water and phytoplankton populations of Lake Manzalah was studied by El-Naggar *et al*. (1997). Marked seasonal and local variations were observed for the physical and chemical characteristics of water. 157 species of algae were identified, 59 Chlorophyta, 37 Bacillariophyta, 30 Cyanophyta, 28 Euglenophyta, one Pyrrhophyta and 2 Cryptophyta. The phytoplankton standing crop was mainly due to the contribution of Bacillariophyta whereas the species composition is dependent mainly on Chlorophyta. Compound eutrophication index indicated that the water nature ranged between eutrophic and hypereutrophic conditions.

Phytoplankton succession and primary productivity relevant to the physico-chemical characters of the wastewater treatment plant in Ataka; Suez, Egypt, depending on stabilization ponds method were studied by Shams El-Din-Nihal (2000). The ponds were typically eutrophic and characterized by high nutrients load resulting in high phytoplankton density. 38 species were recorded belonging to 5 different groups: Chlorophyceae was the first dominant group, followed by Euglenophyceae and Bacillariophyceae as the second dominant groups, while the Cyanophyceae was the third dominant group. The Cryptophyceae was the last group which was scarcely and sporadically distributed. The author found that all the species recorded in this study were pollution tolerant species and considered as eutrophic indicators.

The algal composition and diversity along with physico-chemical characteristics of freshwater pond located in the temple town at Tiruvannamalai, Tamil Nadu, India, were studied by Kumar and Ramakrishnan (2004). A total of 126 algal species including the pollution indicator species were identified. These algal species were distributed over four major divisions: Chlorophyta (30.9%), Euglenophyta (7.1%), Bacillariophyta (25.3%) and Cyanophyta (36.5%). The major pollution indicators species were: *Scenedesmus quadricauda, Ankistrodesmus falcatus, Chlorella vulgaris, Euglena acus, E. minuta, E. proxima Oscillatoria formosa* and *Pediastrum duplex*. The pollution tolerant species were *Chlamydomonas*, *Navicula*, *Nitzschia*, *Stigeoclonium*, *Phacus*, *Phormidium*, *Anabaena, Trachelomonas, Fragilaria, Spirulina and Cosmarium*.

Phytoplankton abundance, biomass and primary production were estimated at two localities in the Pao-Cachinche reservoir. The reservoir receives tributaries with large amounts of nutrients from wastewater and from neighboring pig and poultry farms. Mean phytoplankton biomass was 92.1 mg chlorophyll a/m^2. Cyanobacteria accounted for more than 75% of total phytoplankton. The Pao-Cachinche reservoir can be considered as hypereutrophic, due to the high level of nutrients and biological production (Gonzalez *et al*., 2004).

The seasonal variations of chlorophyll a were examined by Kvrak and Gurbuz (2005) in relation to phytoplankton density and physico-chemical factors in Demirdoven Dam Reservoir (NE Turkey). Chlorophyll a concentrations showed positive correlation to phytoplankton density, water temperature and nutrient concentrations, and negative correlations to Secchi depth.

The present study aimed to investigate the algal communities of the wastewater treatment station in El- Gable Al-Asfar. Also to study some biological factors such as Chl. a, Gross and Net production, photosynthetic activity and respiratory rate.

Materials and Methods

1) Phytoplankton standing crop

Plastic bottles were filled with wastewater from the four tanks: PST, AT, FCT, ChT (primary sedimentation, aeration, final clearing, chloration) and effluent. 200 mL of the samples were preserved immediately with 4% formalin. Before counting, lugol's solution (10 g of pure iodine + 2 g of KI + 180 ml of dist. water + 20 ml glacial acetic acid) was added to the samples until the samples changed to faint tea color and sediment by centrifugation at 2000 rpm for 20 min. (APHA, 1995). The sediment sample was completed to a known volume of the sample. The cell was microscopically examined (from a well mixed sediment sample) and algal cells were counted. Types of algae were identified to species according to the key of Smith (1920), Dillard(1989,1990 and 1991), Dodge (1985), Mizuno(1990) and Heurck (1962).Cell counting was conducted on 20-fields of the cell. The number of phytoplanktonic organisms present in a sample was calculated according to the following formula:

$$\textbf{No. of phytoplankton (individuals/mL)} = Y \times \frac{\textbf{No. of fields in cell}}{\textbf{No. of fields counted}} \times \frac{\textbf{mL of conc. Sample}}{\textbf{mL of original sample}}$$

Where:

Y = the number of organisms present in the counted field.

2) Photosynthetic pigments

The photosynthetic pigments (chlorophyll a, b) were extracted via organic solvents (APHA, 1995).

3) Primary productivity

The rate at which the inorganic carbon is converted to organic carbon by phytoplankton (Primary productivity) was measured by oxygen method (APHA, 1995).The same procedure was carried out for the determination of the oxygen in the dark and light bottles for the calculations of the primary productivity.

Data analyses

a)Species richness (D*)* of phytoplankton communities in the sampling tanks and effluent were calculated according to Margalef's equation (1968) and Heip (1974).

Diversity index (Shannon - Wiener index)

Diversity index was used to evaluate the pollution status of aquatic ecosystem has been greatly recommended by (Staub *et al*., 1970; Washington, 1984 and Guhl, 1987).

In general, value less than 1 indicates instability or heavy pollution, while value exceeding 3 indicates stability or clean water (Wilhm and Doris, 1966), Shannon and Wiener (1963) or the diversity index was used to assess how widely dispersed species are in the sample, while evenness was calculated according to Heip (1974).

c)Trophic State Index (TSI $_{chl.}$)

The Trophic State Index is a numerical approach used mainly to classify the trophic state of the lakes (Carlson, 1977; Schultz, 1985).

The index value ranged between 0.0 and 100. TSI_{chl}. of 70 or greater indicates hyper eutrophic condition. The value between 50 and 70 signifies the eutrophic water. A water body of good quality must possess a TSI_{chl}. value less than 50.

Results and Discussion

Biological parameters

Chlorophyll a and b

The seasonal variations of chlorophyll a and b in the tanks of the wastewater treatment system and effluent were shown in Table (1). The maximum chlorophyll a value of 251.6mg/L was recorded in the effluent water during summer, while a minimum value of 17.4mg/L was detected at primary sedimentation tanks during winter season. The values of chlorophyll b reaching a maximum value of 70.9mg/L at effluent water in spring season, while a minimum value of 2.9mg/L was detected at primary sedimentation tanks during winter season Chlorophyll a concentrations (Table 1) were positively correlated with total phytoplankton standing crop in all of the studied tanks during the four seasons. Average values for chlorophyll a ranged between 113.6mg/L as a maximum value obtained in effluent and 29.8 mg/L as a minimum value recorded for primary sedimentation tanks. Maximum concentration of chlorophyll a together with the highest phytoplankton standing crop was observed at effluent tanks during summer season. In line with our observations was Akbulut and Akbulut (2004) who studied phytoplankton and zooplankton structure of Sultan Marshes in Central Anatolia, they found that chlorophyll a concentrations were correlated with the total phytoplankton and with the increase during summer season.

Gross and Net production

The seasonal variations of the Gross and Net production in the tanks of the wastewater treatment system and effluent were shown in Table (1). In general, the highest value of gross production (3120 mg $C/m^3/h$) was observed in the effluent during the summer season, while the lowest value of 110.9 mg $C/m^3/h$ was observed in the primary sedimentation tanks during winter season. Concerning the average changes of gross production in the different seasons, the maximum value of gross production was presented in the summer season, while the lowest value was presented in the autumn season. On the hand, the distribution pattern of seasonal values could be arranged in the descending order: summer > spring > winter > autumn. Regarding the highest value of net production (1146 mg C/m^3/h) was found in the effluent during spring season, while the lowest value (90.5) mg C/m^3/h was found in the primary sedimentation tanks during autumn season. On the other hand, the distribution pattern of seasonal values could be arranged in the descending order: spring > summer > autumn > winter. The annual average of gross production fluctuated from 162.7 mg C/m^3/h at the primary sedimentation tanks as the minimum value to 2537 mg C /m^3/h at effluent as a maximum value then, there is a general increase in the values of the annual average toward the effluent which shows a hyper-eutrophic condition, this may be attributed to the very high load of nutrients which increase gradually reaching the maximum at the effluent. Several authors have cited the feasibility of using several species of algae as qualitative indicators for pollution. Fargasova (1996) stated that algae have been considered to be good indicators of the bioactivity of industrial wastes.

The Photosynthetic activity (P) and Respiratory rate (R)

The seasonal variations of the photosynthetic activity in the tanks and effluent of the wastewater treatment system were shown in Table (1). The minimum value of 209.6 mg O_2/m^3/h was recorded in the primary sedimentation tanks during winter season, while the maximum value of 3056.0 mg O_2/m^3/h was recorded in the effluent during spring season. The seasonal variations of the respiratory rate in wastewater treatment system were shown in Table (1). The maximum value of 5767.2 mg O_2/m^3/h was recorded in the effluent during summer season, while the minimum value of 86.1 mg O_2/m^3/h was recorded in the primary sedimentation tanks during winter season.

Phytoplankton community

Phytoplankton community is a good estimate of the current degree of eutrophication. Reduction in the number of dominant species, species diversity and the increase in cell count of one or two resistant algae are one of the changes observed in the phytoplankton populations of domestic and industrially polluted environments (Umamaheswara Rao and Mohanchand, 1988). This fact is stressed by Vilicic (1989). This represents the highest number of phytoplankton genera in this station.

The phytoplankton community was represented by a total of 61 species belonging to 36 genera and 7 classes in the investigated station, namely Chlorophyceae, Bacillariophyceae, Cyanophyceae, Euglenophyceae, Dinophyceae, Xanthophyceae and Cryptophyceae

The results of phytoplankton standing crop (Table 2)show wide variations from 914.6 x 10^4 individuals/L at the PST to 6442.6 x 10^4 individuals/L at the AT indicating a hyper-eutrophic condition, which is confirmed by a major of total phytoplankton standing crop. It is noticed that the phytoplankton standing crop values are high especially in the AT. This may be attributed to the high nutrients value through treated water resulting in a high degree of water eutrophication accompanied with a heavy bloom of phytoplankton. The present results agree with Abdalla *et al*. (1995 a and b).

Table (1): Seasonal variations in Chlorophyll a and b (mg/L), Gross (mg $C/m^3/h$) Net production (mg $C/m^3/h$), Photosynthetic activity (P) ($mgO_2/m^3/h$) and Respiratory rate(R) ($mgO_2/m^3/h$) of phytoplankton crop in the study area.

Tanks	Seasons	Parameters					
		Chlorophyll a (mg/L)	Chlorophyll b (mg/L)	Gross (mg $C/m^3/h$)	Net production (mg $C/m^3/h$)	Photosynthetic activity ($mgO_2/m^3/h$)	Respiratory rate ($mgO_2/m^3/h$)
PST	Autumn	26.8	9.5	168.1	90.5	241.3	206.9
	Winter	17.4	2.9	110.9	78.6	209.6	86.1
	Spring	39.5	16.0	171.3	121.3	323.5	135.3
	Summer	35.4	18.5	200.6	165.1	416.8	118.7
AT	Autumn	76.3	29.0	915.7	694.3	1851.8	590.5
	Winter	70.9	21.7	890.3	499.1	1330.9	1043.2
	Spring	93.8	40.0	1002	980	2613.3	570.9
	Summer	95.2	39.1	1140	835.4	2227.7	812.3
FCT	Autumn	57.0	14.2	989.4	524.1	1397.6	1240.8
	Winter	36.9	8.1	1278	316.8	844.8	2561.9
	Spring	76.3	30.9	1463	701.3	1870.1	2030.7
	Summer	83.9	25.7	1358	630.2	1680.5	1940.8
ChT	Autumn	82.4	17.6	1292	805.1	2148.5	1297.3
	Winter	55.6	11.3	1634	260.1	693.8	3664.5
	Spring	108.1	45.7	1524	943	2514.7	1548.3
	Summer	117.3	43.0	1781	892.6	2380.8	2368.8
Effluent	Autumn	132.5	20.1	2126	886.2	2363.2	3305.1
	Winter	101.0	15.7	1983	532.6	1240.3	3868.0
	Spring	195.2	70.9	2919	1146	3056.0	4726.7
	Summer	251.6	48.9	3120	957.3	2552.7	5767.2

Primary Sedimentation Tank (PST), Aeration Tank (AT), Final Clearing Tank (FCT), Chloration Tank (ChT).

The phytoplankton community composition in the study area was rich in standing crop and somewhat poor in the species number which may be attributed to the presence of some stressors that have limited the species number to only the tolerant species to these environmental conditions. The present results show that Chlorophyceae was the predominant group than the others, where the nutrient concentrations were high. These results contradict with Abd El-Karim (1999) who stated that the green algae were the least group affected by the high nutrient concentrations compared with diatoms and blue green algae. In this investigation, the results are in agreement with Azab (1997) who stated that the most common genera found in wastewater treatment are *Chlorella, Scenedesmus, Oscillatoria, Ankistrodesmus, Phacus, Synedra, Chlamydomonas* and *Euglena*.

Table (2): No. of genera, No. of species, diversity, richness and evenness of total phytoplankton (individuals x 10^4/L).

Parameters	**Tanks**				**Effluent**
	PST	**AT**	**FCT**	**ChT**	
Total individuals	914.6	6442.5	3571.9	2306.2	3805.0
Total no of genera	36	36	36	36	36
No. of species	42	61	60	52	55
Richness	1.56	2.7	1.9	1.65	2.1
Diversity index	1.5	2.3	2.6	1.2	2.4
Evenness	0.57	1.4	1.7	0.74	1.7

Chlorophyceae

The population density of Chlorophyceae and their percentage of abundance to the total phytoplankton standing crop were shown in Tables 3&4. The maximum value of 4329.7 cells x 10^4 individuals/L was recorded in the AT, while the minimum value of 474.4 cells x 10^4 individuals/L was recorded in the PST. Chlorophyceae was represented by 32 species, belonging to 17 genera (Tables 3 and 4) and forming 59.7 % of the total phytoplankton community, thus they are the dominant group.

In terms of number of genus, the genus *Scenedesmus* has the highest number of genera (7), followed by *Oocystis* (4 genera). *Scenedesmus bijugatus* and *Scenedesmus obliquus* are the dominant species, forming 16.7 % and 13.9 %, respectively, of the Chlorophyceae. The species *Chlorella vulgaris* is the second dominant species forming 11.29 % of the Chlorophyceae, while *Chlamydomonas snowii* is the third dominant species forming 7.71 % of the Chlorophyceae. The fourth dominant species is the *Phacotus lenticularis* forming 5.87 % of the Chlorophyceae. On the other hand concerning the other species they occur rarely or occasionally (Table 4).

Table (3): Percentage abundance % of algae classes composition in the wastewater treatment system during the course of investigation.

Classes	Tanks				Effluent
	PST	AT	FCT	ChT	
Chlorophyceae	51.9	67.2	60.6	59.9	48.0
Cyanophyceae	23.9	14.0	15.3	17.4	15.3
Bacillariophyceae	7.6	13.5	18.1	18.6	33.5
Euglenophyceae	12.2	2.9	3.7	2.3	2.2
Cryptophyceae	3.1	0.24	0.17	0.0	0.0
Dinophyceae	1.3	0.59	0.80	0.0	0.0
Xanthophyceae	0.0	1.56	1.4	1.7	1.1

The present data indicated the presence of *Tetraedron minimum*, *Scenedesmus* spp. *Crucigenia tetrapedia, Ankistrodesmus* spp. and *Chlorella vulgaris* which are considered as eutrophic plankton types as in the findings of (Kobbia *et al*., 1993).

In this investigation, *Chlorella vulgaris* is a perennial species, present in the wastewater treatment system overall the year and contributes about 11.29 % by number of the total phytoplankton. According to Mihnea (1985), who supposed that the dominance of any species in polluted water for one season or more constituting about 10% of the total community may be considered as indicator species, *Chlorella vulgaris* is an indicator of pollution. This fact is stressed by EI-Sherif (1989) who recorded the genus *Scenedesmus* and the genus *Chlorella* among the dominant genera of the phytoplankton community in front of the outlet of the Umum Drain and in the surrounding, in EI-Mex Bay, Alexandria, which are contaminated with sewage and industrial wastes. *Chlamydomonas snowii* is the third dominant species in this class; according to Palmer (1969) the genus *Chlamydomonas* is considered as eutrophic genus and is used as indicator of high organic pollution.

Bacillariophyceae (Diatoms)

The population density of Bacillariophyceae and their percentage of abundance to the total phytoplankton standing crop were shown in Tables (3and 5). The maximum value of 6442.5 cells x 10^4 individuals/L was recorded in the AT, while the minimum value of 2306.2 cells x 10^4 individuals/L was recorded in the ChT. Bacillariophyceae is the second dominant group, they contribute 19.28% to the total phytoplankton standing crop and represented by 10 species belonging to 7 genera.

Table (4): Species composition, diversity, richness and evenness of Chlorophyceae (individuals x 10^4/L).

Species	PST	AT	FCT	ChT	Effluent
Ankistrodesmus convulatus Corda	0.00	35.3	28.0	16.2	14.9
A. folctus var. *mirabilis* (West & West) G. S. West	0.00	108.2	77.5	20.19	96.73
A. fusiformis	20.0	96.43	31.5	14.98	43.6
Cladophora sp.	6.7	30.0	13.51	0.00	5.53
Chlamydomonas snowii Printz	60.0	210.52	203.8	130.61	179.5
C. sp.	61.7	158.0	141.66	97.5	56.73
Chlorella vulgaris Beyerinck	85.03	540.1	251.4	135.01	137.52
Colastrum microporum Naegeli	11.3	155.0	81.9	25.71	67.84
Colesterium sp.	5.9	37.5	16.8	0.00	40.6
Cosmerium laeve var. octangularis	3.3	13.7	10.0	0.00	5.9
Cosmerium sp.	5.3	15.8	8.1	0.00	6.5
Crucigenia quadrata Morren	13.7	76.9	58.2	42.33	33.9
C. tetrapedia (Kirch.) West & West	0.00	20.7	13.6	8.95	15.3
Kirchneriella obesa (W. West) Schmidle	25.23	187.03	100.0	95.1	85.62
Lagerheimia ciliata (Lag.) Chodat	5.19	31.0	14.5	8.2	20.99
Oedogonium Vaucherii (Lecl.) A. Braun	0.00	32.5	17.0	11.6	8.71
Oocystis crassa Wittrock in Wittrock and Nordstedt	13.1	26.6	23.3	19.2	18.51
O. lacustris Chodat	0.00	30.65	24.0	20. 7	0.00
O. parva West & West	13.22	38.7	23.5	22.9	25.93
O. solitaria Wittrock in Wittrock and Nordstedt	27.5	193.0	125.31	40.17	75.22
Pandorina sp.	0.00	48.3	19.0	15.72	10.11
Pediastrum duplex var. *latydisca*	0.00	39.0	21.3	2.1	10.9
Phacotus lenticularis Ehr.	59.7	194.29	130.3	112.0	101.57
Scenedesmus acuminatus (Log.) Chodat	0.00	99.32	45.0	40.1	25.66
S. bijugatus (Turp.) Lagerheim	42.67	901.71	223.6	200.5	330.53
S. denticulatus Lagerheim	2.32	36.9	12.0	7.3	0.00
S. longus var. *naegelii* (De Bréb) G. M. Smith	0.00	82.5	51.0	29.1	0.00
S. obliquus (Turp.)Kütz.	10.0	672.86	256.0	187.3	292.21
S. quadricauda (Turp.) in De Bréb and Godey	2.56	111.46	79.1	33.6	91.2
S. sp.	0.00	39.0	21.3	10.9	2.1
Spirogyra sp.	0.00	11.9	10.0	6.1	8.3
Tetraedron minimum (A. Braun)Hansgirg	0.00	54.86	30.1	28.2	15.99

Navicula cryptocephala is the leading species forming 27.54 % of the total Bacillariophyceae, while *Nitzschia filiformis* is the second dominant species, contributing 20 % by number of diatoms. The third leading species, *Synedra ulna* contributes 9.58 % by number of diatoms, while the other species are present in different percentage in the Bacillariophyceae community. The genus *Navicula* in general is considered as eutrophic genus, and the species *Navicula cryptocephala* is a pollution and eutrophic indicator**.** In this connection, Jüttner *et al*. (1996) recorded that some species, such as *Gomphonema parvulum, Navicula atomus, Navicula cryptocephala* and *Nitzschia palea*, were present with significantly high abundance at the organically enriched kathmandu valley sites in the Middle Hills of Nepal, a polluted area by sewage.

The horizontal distribution of Bacillariophyceae at different tanks and effluent indicate that, members of this group attained their maximum population density in the AT and effluent and their least densities in the PST. This can be explained by heavy loading of nutrient salts, which depress the population density of diatoms and the species number.

Table (5): Species composition, diversity, richness and evenness of Bacillariophyceae (individuals x 10^4 /L).

Species	PST	AT	FCT	ChT	Effluent
Cyclotella meneghiniana Kütz	0.00	97.03	76.1	52.8	82.0
C. ocellata Pant	0.00	68.57	56.0	19.2	25.9
Cymbella minuta Hilse ex Rabehorst	1.0	7.9	5.6	2.99	0.00
Fragillaria construens (Ehr.) Grun	8.7	56.3	51.63	17.5	44.0
Gomphonema ventricosum W. Greg	2.3	81.7	77.6	69.08	38.72
Navicula cryptocephala Kütz	24.6	148.05	136.0	99.5	496.57
N. tuscula Ehr.	10.0	90.5	71.2	53.11	42.79
Nitzschia filiformis (W. Sm.) Van Heurk	0.00	191.43	86.7	79.0	299.32
N. fonticola Grunow in Cleve & J. D. Möller	16.7	49.3	35.0	24.8	73.6
Synedra ulna (Nitzsch.) Ehr.	6.5	77.29	49.1	11.5	170.27
Total individual	914.5	6442.5	3571.9	2306.2	3805.0
No. of species	7	10	10	10	9
Richness	0.92	0.99	1.03	1.08	0.85
Diversity index	1.6	2.14	2.16	2.03	5.04
Evenness	0.07	0.79	0.79	0.75	0.19

Cyanophyceae

The class Cyanophyceae is the third dominant group in the wastewater treatment station. Members of this class occupied the third predominance position in the investigated area. Species number, diversity, richness and evenness of Cyanophyceae are shown in Tables (3 and 6). The maximum population density value of 904.21 x 10^4 individuals/L was recorded in AT, while the minimum value of 218.33 x 10^4 individuals/L was recorded in PST. The class was represented by 10 species belonging to 7 genera. The first dominant species is *Spirulina platensis* contributing 28.5% by number of the total Cyanophyceae. The second dominant species is *Chroococcus turgidus* contributing 23.5% by number of the total Cyanophyceae, while *Oscillatoria rubescens* is the third dominant species contributing 16.4% by number to the total Cyanophyceae (Table 6). In the present work high percentage of the species *Microsystis aeruginosa* indicate eutrophication of the examined water according to the previous studies. Our results agree with EI-Sherif (1989) who reported that Cyanophyceae were more frequent in the spring and the summer, and were dominated by *Spirulina platensis*, *Chroococcus dispersus* and *Oscillatoria formosa*. In this connection, Laal *et al*. (1994) reported that Myxophycean members, viz. *Microcystis princeps*, *Oscillatoria* spp. and *Spirulina princeps* were available during summer probably attributed to increase in organic matter. This fact, is stressed by Kassim *et al*. (1996) who reported that the Cyanophyceae group, generally occurred during warmer months, and he found that high densities of the blue-green algae in summer might be correlated with high temperatures and dissolved organic matter. The present results are in agreement with the findings of the previous authors where Cyanophyceae has its maximum growth in autumn and summer.

Table (6): Species composition, diversity, richness and evenness of Cyanophyceae (individuals x 10^4/L).

Species	PST	AT	FCT	ChT	Effluent
Anabaena catenula (Kütz.)	0.00	12.9	8.0	0.00	10.1
Chroococcus limneticus Lemmermann	10.0	45.8	18.3	12.11	23.53
C. turgidus (Kütz.) Naegeli	70.2	195.7	131.4	126.57	98.64
Lyngbya major Meneghini	0.00	16.3	10.1	9.3	7.8
Microsystis aeruginosa Kütz.	10.3	17.51	16.7	15.71	8.22
Oscillatoria rubescens De Condolle	16.3	201.5	42.51	75.53	98.76
Phormidium foveolarum Gomont	28.93	51.4	50.2	10.27	31.0
P. interruptum Kütz.	33.5	81.0	38.7	19.78	56.0
P. molli	22.3	46.7	40.12	37.6	38.9
Spirulina platensis (Nordst.) Geitter	26.8	235.4	190.0	95.43	208.0
Total individual	218.33	904.21	546.03	402.3	580.95
No. of species	8	10	10	9	10
Richness	0.9	0.99	1.05	0.96	1.04
Diversity index	1.3	1.57	1.5	1.54	1.52
Evenness	0.05	0.58	0.55	0.06	0.56

Euglenophyceae

Euglenophyceae class represented by 6 species belonging to 2 genera. The results of population density and percentage of abundance revealed that Euglenophyceae showed high representation with great fluctuation in AT (Tables 3 and 7). The maximum population density value of 187.5 x 10^4 individuals/L was recorded in AT, while the minimum value of 52.99 x 10^4 individuals/L was recorded in ChT. The class Euglenophyceae is the fourth dominant group in the wastewater treatment system; they are always used as pollution indicators. According to Heinonen (1980) who stated that all Euglenoids are included among the eutrophic species.

The first dominant species is *Euglena virdis* forming 24.45 % of the Euglenophyceae. The second dominant species is *Euglena pisciformis* forming about 21.3 % of the Euglenophyceae. The third dominant species is *Euglena sp.* forming 19.96 % and *Phacus pyrum* contributing 17.85 % of the Euglenophyceae. On the other hand the other species contribute to the Euglenophyceae by low percentage such as *Phacus caudatus* and *Phacus* sp. During this study *Euglena viridis* was the most dominant species of the Euglenophyceae group forming 24.45%. This may be explained by the high nutrients and organic matter concentrations of the present wastewater treatment system. Also, indicates the eutrophication of the examined water according to the previous authors.

In this trend, Palmer (1969) recorded dense blooms of the genus *Euglena* in small and organically polluted bodies of water, and he noted that the genus *Euglena*, tops a list of sixty most tolerant genera to pollution. He included also the genus *Phacus* as pollution indicator, while on the species level; he included *Euglena gracilis* and *Euglena viridis.* In this connection, Munawar (1972) mentioned that *Euglena acus* grows abundantly in sewage ponds and Euglenoids are usually used as biological indicators of organically polluted water and the mass occurrence of the species was conditioned by the abundance of organic matter. According to Mihnea (1985), *Euglena* spp. are regarded as indicators of water pollution and they are usually abundant in water rich in organic matter. In this connection, Umamheswara Rao and Mohanchand (1988) reported that the planktonic Cyanophyceae, Chlorophyceae and Euglenophyceae grew abundantly in water bodies receiving sewage effluents, which are very rich in nutrients and organic matter. These findings are similar to that have been obtained in the present study (Tables 4, 6 and 7). During this study *Euglena viridis* was the most dominant species of the Euglenophyceae group forming 24.45%. This may be explained by the high nutrients and organic matter concentrations of the present wastewater treatment system. Also, indicates the eutrophication of the examined water according to the previous authors.

Dinophyceae

Members of this class were rarely found especially in the effluent where it was absent. Tables (3 and 8) represented the species number, diversity, richness and evenness of this group. The results revealed that the values of 12.0, 37.6 and 28.7 x 10^4 individuals/L form 1.3, 0.59 and 0.8 % of the total phytoplankton crop in PST, AT and FCT, respectively. This class was represented by only one species, belonging to one genus *Gymnodinium* sp.

Table (7): Species composition, diversity, richness and evenness of Euglenophyceae (individuals x 10^4 /L).

Species	PST	AT	FCT	ChT	Effluent
Euglena pisciformis Klebs	42.7	21.14	17.53	13.6	25.66
E. sp.	18.3	45.3	30.25	16.29	2.9
E. viridis Ehr.	0.00	67.8	53.5	0.00	17.2
Phacus caudatus Huebner	11.3	20.4	0.00	0.00	5.8
P. Pyrum (Ehr.) Stein	22.9	20.0	17.53	15.0	25.66
P. sp.	16.5	12.86	12.64	8.1	5.5
Total individual	111.7	187.5	131.45	52.99	82.72
No. of species	5	6	5	4	6
Richness	0.57	0.66	0.56	0.48	0.75
Diversity index	1.5	1.62	1.9	1.4	1.54
Evenness	0.079	0.08	0.1	0.09	0.07

The contribution of the Dinophyceae to the total phytoplankton standing crop was little and almost non significant. Abd El-Hamid (1991) and Toulaibah (1996) reported that, the concentration of this group to the total phytoplankton crop and its species composition were almost non significant. In this investigation, the maximum density of Dinophyceae was recorded during summer; this is supported by the positive correlation with the water temperature. Reynolds (1984) concluded that Dinophyceae in any water body grow best in summer. Also, Pfiester (1990) stated that Dinophyceae usually reach to maximum density during the summer months. Dinophyceae attained its highest regional value at AT. This may be explained by the high nutrient concentrations. This agreement with Stewart and Wetzel (1988) who stated that, the Dinophyceae increase with increase of nutrients. During this study it was found that , the high population density of Dinophyceae at El-Gable Al-Asfar station was attributed mainly to the high growth of only *Gymnodinium* sp.

Cryptophyceae

Species number, diversity, richness and evenness of Cryptophyceae are shown in Tables (3 and 8). The highest Cryptophytes density of 28.3 x 10^4 individuals/L was found in PST. He less occurrences of this group were observed in FCT and it absent in ChT and effluent.

Only one species represented this group during the study period, *Cryptomonas reflexa* which appears only at PST, AT and FCT (Table 8). In general *Cryptomonas sp.* prefers to live in lakes enriched with nutrients and they are considered as indicators of eutrophication (Rosén, 1981).

It could be concluded that the examined wastewater is eutrophic because of the dominance of certain eutrophication indicator species (*Scenedesmus obliquus, Chlorella vulgaris*, *Chlamydomonas snowii*, *Spirulina platensis*, *Navicula cryptocephala* and *Euglena viridis*) and also due to the high load of organic matter and nutrients which enhance phytoplankton growth.

Xanthophyceae

The results present in Tables (3 and 8) revealed that, Xanthophyceae completely disappeared from the PST along the year of investigation. The maximum population density of 100.2 x 10^4 individuals/L was recorded in AT while the minimum value of 39.2 x 10^4 individuals/L was recorded in ChT (Table 8). One species of Xanthophyceae belonging to one genus was identified, *Heterococcus* sp.).This class was scarcely and sporadically compared with other phytoplankton classes.

Table (8): Species composition, diversity, richness and evenness of Cryptophyceae , Dinophyceae and Xanthophyceae (individuals x 10^4/L).

Species	PST	AT	FCT	ChT	Effluent
Cryptophyceae					
Cryptomonas reflexa Skuja	28.3	15.2	5.86	0.0	0.0
Total individual	28.3	15.2	5.86	0.0	0.0
No. of species	1	1	1	0.0	0.0
Richness	0.0	0.0	0.0	0.0	0.0
Diversity index	0.0	0.0	0.0	0.0	0.0
Evenness	0.0	0.0	0.0	0.0	0.0
Dinophyceae					
Gemnodinium sp.	12.0	37.6	28.7	0.0	0.0
Total individual	12.0	37.6	28.7	0.0	0.0
No. of species	1	1	1	0.0	0.0
Richness	0.0	0.0	0.0	0.0	0.0
Diversity index	0.0	0.0	0.0	0.0	0.0
Evenness	0.0	0.0	0.0	0.0	0.0
Xanthophyceae					
Heterococcus sp.	0.0	100.2	51.6	39.2	40.02
Total individual	0.0	100.2	51.6	39.2	40.02
No. of species	0.0	1	1	1	1
Richness	0.0	0.0	0.0	0.0	0.0
Diversity index	0.0	0.0	0.0	0.0	0.0
Evenness	0.0	0.0	0.0	0.0	0.0

Trophic State Index

The trophic state index was calculated from chlorophyll a values and shown in Table (9). The highest TSI value (84.82) was observed at effluent during summer season and the lowest value (62.84) was obtained at PST tank during autumn season. According to Carlson (1977) and Schultz (1985) the effluent considered to be hyper eutrophic, while PST considered to be eutrophic.

Table (9): Trophic State Index TSI.

Seasons	Tanks				Effluent
	PST	AT	FCT	ChT	
Autumn	62.84	73.1	70.23	73.85	78.51
Winter	77.11	72.37	65.92	69.96	75.84
Spring	66.64	75.12	73.13	76.45	82.37
Summer	65.63	75.3	74.03	77.32	84.82

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دراسات على الفلورا الطحلبية و العوامل الفيزيوكيميائية في نظام معالجة مياه الصرف الصحى (الجبل الأصفر)
2- العوامل البيولوجية

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أوضحت النتائج ان الفلورا الطحلبية مثلت بسبعة أقسام وهي Chlorophyceae, Cyanophyceae, Bacillariophyceae كمجموعات اساسية تلتها مجموعة Euglenophyceae بينما كانت مجموعات Cryptophyceae, Dinophyceae, Xanthophyceae نادرة الوجود0

كانت الطحالب الخضراء هي السائدة وكونت نسبة 59.7% من المحصول القائم للهائمات النباتية وكان ترتيب الطحالب العصوية الثانية من حيث السيادة ومثلت 19.7% وتلتها الطحالب الخضراء المزرقة في المرتبة الثالثة بنسبة 15.6% 0

سّجلت أعلي قيمة لمحتوي كلوروفيل ا (251.6مج/لتر) وكلوروفيل ب (90.7 مج/لتر) في الدفق في فصل الصيف وكانت اقل قيمة 26.8 و 9و2مج/لتر في حوض الترسيب الأولي في فصل الخريف0 كما سّجلت أعلي قيمه للناتج الصافي Gross production (3120مج ك/ م^3 /س) والناتج الكلي (الغير صافي) Net production (164مج ك/ م^3 /س) في الدفق في فصلي الصيف والربيع علي التوالي بينما سجلت أقل قيمة (110.9مج ك/ م^3 /س و 78.6 مج ك/ م^3 /س) في حوض الترسيب الأول خلال فصل الشتاء0