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PHYTOPLANKTON FLORA AS A RESPONSE OF DRAINAGE INPUT IN EL-SALAM CANAL - EGYPT.

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ABSTRACT

There were a considerable variation of water quality in El salam canal; Hadous drain and Damietta branch of River Nile – Egypt. These resulted in the variation of phytoplankton flora at study area. 67 species of phytoplankton were recorded at River Nile (site I) with maximum mean individual numbers (4810.6×10^5 cell/L), Bacillariophyta was predominant group followed by Cyanophyta, Chlorophyta, Euglenophyta and Dinophyta. Hadous Draine sustained maximum mean species number 72 species but with low mean individual number (195×10^5 cell/L), meanwhile, El salam canal have local variation in phytoplankton standing crop (32-65 species). Cyanophyta or Chlorophyta were the predominant groups followed by Bacillariophyta and Euglenophyta in both El salam and Hadous water. Phycological monitor (Diversity, Saprobic indices and saprobic quotient) indicate that Hadous Draine has relative high polluted water and El Salam canal water more polluted than River Nile water. The matrix of biological (phytoplankton number and biomass standing crops) parameters and environmental variables of 36 samples were subjected to Canonical corresponding analysis and multivariate cluster analysis.

The results indicated that water quality of El-Salam Canal water was badly affected by the dumping of Hadous Drain water. The matter which indicated that the used mixing percentage should be change3d, unless, Hadous drain water would be tertiary treated before mixing with El salam canal water.

INTRODUCTION

El Salam Canal project has been constructed in 1987 to irrigate 650000 hectares of the newly reclaimed areas west and east Suez Canal by mixed water from River Nile and Hadous Draine (1: 1). El-Salam Canal starts near the so called Faraskour Barrage which was constr4ucted on Damietta Branch of the River Nile at El-Inaniya village (about 4 km. south Damietta City) where the canal upstream freshwater intake. Then the canal travels southeast about 88 km. to the Suez Canal, crossing it through a tunnel (1.3 km. long) under it bottom. Then El-Salam canal extends parallel to the road of El-Areish City **[Serag & Khedr (2001)].** Hadous Drain is the another source of water dumping into El-Salam Canal through a mixing pump station. Hadous Drain has been constructed in 1965 and receiving prencibally agriculture drainage water from 420000 hectares. Moreover, some domestic and industrial wastes are also discharged. It is known that one of the main cause of water pollution is the discharge of solid or liquid water products containing pollutants onto the land surface or into the aquatic habitats (Dix, 1981). Thus it was necessary to flow up the water quality of El-Salam Canal water especially it provide about 3 million of people with drinking water beside others water uses **[Zyadah (2005)].** However, the canal received very few investigations **[El-Attar (2000) and Touliabah (2002)].**

The relative influence of natural spatial and temporal variations of physico-chemical properties of water on the response of aquatic organisms is one of the most persiste problems in stream biomonitoring studies **[Ruszar & Caraco (1996) Shaaban-Dessouki (1995)].**

Changes in water quality exerts a selective action on flora and funa which constitute the living population of water and can be used to establish biological indices of water quality **[Palmer (1980)].**

In general, water quality deterioration due to pollution may be dramatically affecting phytoplankton of the aquatic ecosystem **[Leester (1975)].**

Phytoplankton can be considered as a mirror reflecting water quality were the changes in physico-chemical characteristics of any water mass usually lead to concomitant qualitative and quantitative changes in planktonic organisms **[Shaaban-Dessouki & Baka (1985) and Adam et al., (1990)].**

The major purpose of the present study is to follow up water quality and pollutionary status of El-Salam Canal water through studying

the physico-chemical properties of its natural water before and after mixing as well as changing in community structure and biodiversity of phytoplankton to clarify the degree to which the phytoplankton community response to the discharged effluent, particularly from Hadous Drain.

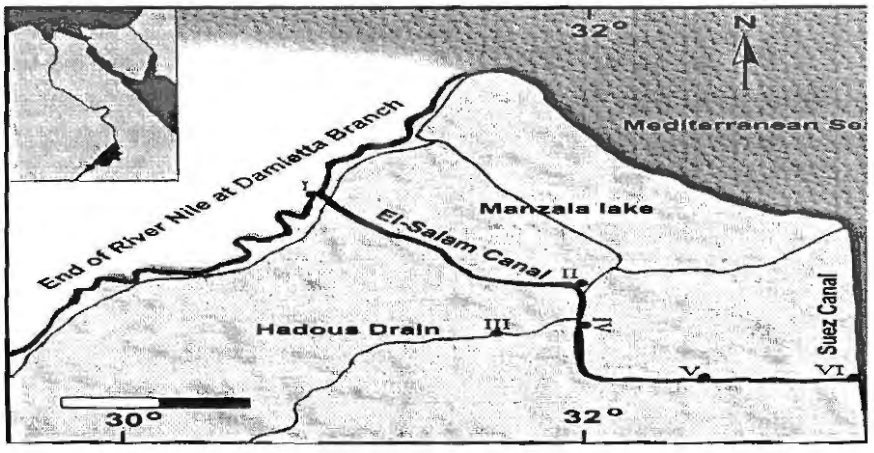

Fig. (1): A map showing the sampling sites.

River Nile (I); Up- stream (II); Hadous Draine (III); Mixed (IV); Down-stream(V); Up-Sahara (VI).

MATERIALS AND METHODS

Six sites have been chosen according to the nature and direction of water from River Nile at (site I) and Hadous Draine (site III) through El Salam canal at (site II, IV, V and VI) Bimonthly surface water samples were regularly collected (during the first half of the day – 9-11 am) from November 2002 to September 2003. Collection was made by non-metallic sampler. The water samples were kept in the dark in ice box until reach the laboratory where the biological and chemical investigations were done as soon as possible. pH and temperature of water were determined in the field by the pH meter and thermometer, respectively. Others physico-chemical parameters of water were determined according to **[APHA (1996)]**. Algal species were identified according to **[Skuja (1948) and Hindak *et al.*, (1975)]** and counted using an inverted microscope, following sedimentation according to **[Utermohle (1936)]**.The phytoplankton biomass was calculated

according to **[Edler (1979)]**. Diversity index, Saprobic index and Saprobic equation were respectively performed according to **[Shannon & Weaver (1963); Sladecek (1973) and Dresscher & Mark (1976)].**

RESULTS AND DISCUSSION

As shown in Table 1, annual mean values of temperature at different sites were more or less similar relative warm during summer and relative cold during winter. Moreover, Temperature was correlated positively with Cyanophyta standing crop (r = 0.27). Variations affect the periodicity and succession of different groups of the algal communities **[Behrendt & (1990)]**. The minimum annual mean values of turbidity were recorded at the River Nile (4.09 NTU); meanwhile the maximum were recorded at Hadous Draine (44.7 NTU). At El salam canal the annual mean values of turbidity have a high local variation (9.3 - 35.71 NTU). The high turbidity may be due to re-suspension of sediment and high organic pollution of water. Turbidity levels control the species composition of phytoplankton **[De Seve (1993)]**.

The cited results (table 1) revealed a similar trend of annual mean values of electric conductivity, TDS, salinity and chloride were maximum (5616.67 µs/cm, 10636.17 mgL^{-1}, 10.53 % and 5.09 gL^{-1} respectively) at Hadous Draine (site III), whereas minimum values (1933.33 µs/cm 2104.67mgL^{-1}, 2.64‰ and 1.22 gL^{-1} respectively) were recorded at River Nile (site I). These variations may be due to that Hadous Draine receive agriculture drainage water from relatively saline soil. While water at El salam sites is mixed from 50% River Nile water and 50% Hadous Drainage water. **[Abdel-Hamid *et al.*, (1992) and Aziz *et al.*, (1996)]** reported that, the industrial and urbane discharge cause increasing in the electric conductivity, and salinity, TDS, and Chloride content in water. Salinity may be an important factor in increasing the tolerance of algae to toxicants, e.g. heavy metals **[Haglund *et al.*, (1996)]**. All sites lied in alkaline side where the annual mean pH values ranged between 7.21 at site I and 7.65 at site VI. Shaaban-Dessouki and **[Baka (1985)]** reported that the pH values of the River Nile water always shifted to alkaline side. **[Reid (1962)]** postulated that alkaline water is more productive than acidic one. However in shallow water, an increase of photosynthetic activity of algal population results in increasing pH value **[Deyab (1987)]**. The annual mean values of Ph alkalinity, total alkalinity, CO_2 and $T.CO_2$ were lowest at site I and highest at site III

(Hadous Draine). This difference might be related to water quality. It was found by **[Aziz *et al.*, (1996)]** that the effluent of both agriculture and urbane discharge cause increase in CO_2 concentration in water. While the industrial wastes affect the total CO_2 concentration according to the type chemical composition of the effluent. In fact, total alkalinity depends upon the type of discharged wastes **[Abdel-Baky (2001)]**. Total alkalinity value greater than 1.4 meq/L indicate eutrophic conditions **[Moss (1973)]**.

As shown in table 1, the maximum annual mean value of D.O (5.97 mg O_2/L) was recorded at River Nile site (I) with a minimum amount (2.15 mg /L) at Hadous Draine (site III) and moderate value at El salam canal. Data showed higher annual mean values of both BOD (18.23 mg O_2/L) and photosynthesis (0.15 mg-C/L/h) at Hadous Draine (site III), whereas the lower values (11.63 mg/L and 0.06 mgC/L/h respectively) were recorded at River Nile (site I).

Ammonia, nitrite, nitrate and organic nitrogen were highest (0.97, 0.18, 0.73 and 0.51 mg/L respectively) at Hadous Draine (site III) meanwhile, the lowest (0.25, 0.05, 0.28 and 0.35 mg/L respectively) at River Nile (site I). Abdel-Hamid et al. (1992) found that, along the river nile ammonia-N value fluctuated between 0.1 and 3.2 $mg.L^{-1}$ the high values were connected with highly polluted water. It has been reported that, industrial and urbane sewage water carried high amount of ammonia **[Soria *et al.*, (1987)]**. Whereas, NO_2 in the surface water increased with temperature as nitrifying bacteria became active **[Hu *et al.*, (2001)]**. Water with total soluble inorganic nitrogen greater than 0.3 mg/L was concerned to be eutrophic **[Vollenweider (1971)]**. From the present result, it may be conclude that, total soluble inorganic nitrogen within study area reach the eutrophic level.

Low PO_4 values were detected at River Nile (site I) and upstream (siteII), however a high value (0.05 mg/L) was detected at Hadous Draine (site III). On the other hand, there was a local variation of organic – p, with high value (0.89 mg/L) at Hadous Draine (site III), and low value (0.62 mg/L) at River Nile (site I). In this account, **[Soria *et al.*, (1987)]** reported that industrial and urbane sewage water carried high amount of phosphorus.

Table (1): Average of annual values of physico-chemical parameters in River Nile (site I), Hadous Draine (site III) and El Salam canal water (site II, IV, V and VI).

Sites / Parameters	I R.N	II S.C	III B.H	IV J.C	V J.C	VI S.C
Temp.°C	27.83	23.33	24.71	23.01	23.24	23.48
NTU	4.09	19.30	44.78	35.71	29.98	23.47
E.C.(µs/cm)	1988.33	2183.33	5616.67	4141.67	3616.67	3808.33
TDS mgL-1	2104.67	4315.33	10636.17	8371.33	7685.83	6607.17
Salinity %	2.64	4.23	10.53	8.29	7.63	6.64
Cl gL^{-1}	1.22	1.36	5.09	3.93	3.34	2.38
pH	7.21	7.45	7.43	7.48	7.54	7.65
ph. Alk ($meqL^{-1}$)	0.08	0.12	0.18	0.14	0.11	0.14
T.Alk ($meqL^{-1}$)	1.77	2.25	3.45	2.78	2.79	2.87
CO_2 (mgL^{-1})	3.06	3.78	6.16	4.53	4.82	4.92
T.CO_2 (mgL^{-1})	8.95	10.92	17.83	12.82	13.85	14.10
O_2 mgL^{-1}	5.97	5.23	2.15	4.19	5.36	5.64
BOD mgL^{-1}	11.63	12.13	18.23	15.77	13.81	13.37
photo.mg/L/h	0.06	0.10	0.15	0.12	0.15	0.05
NH_4 mgL^{-1}	0.25	0.28	0.97	0.60	0.55	0.50
NO_2 mgL^{-1}	0.05	0.06	0.18	0.11	0.09	0.07
NO_3 mgL^{-1}	0.28	0.30	0.73	0.70	0.57	0.58
ON mg L^{-1}	0.35	0.37	0.51	0.40	0.31	0.29
PO_4 mgL^{-1}	0.01	0.01	0.05	0.02	0.02	0.02
Org. PO_4 mgL^{-1}	0.62	0.66	0.89	0.76	0.78	0.77
T. PO_4 mgL^{-1}	0.63	0.67	0.90	0.78	0.80	0.84
Si mgL^{-1}	3.15	3.16	5.42	4.84	4.39	4.22
SO_4 mgL^{-1}	339.27	327.24	562.08	424.55	461.58	458.09
Mg mgL^{-1}	277.51	270.86	249.87	222.44	189.12	112.66
Ca mgL^{-1}	658.73	680.37	1038.67	936.17	866.47	882.50
Na mgL^{-1}	194.88	293.96	608.33	572.75	489.71	457.50
K mg L^{-1}	114.78	148.23	187.28	163.08	163.90	166.38
Cu mgL^{-1}	0.11	0.13	0.17	0.15	0.12	0.11
pb mgL^{-1}	0.22	0.20	0.35	0.29	0.27	0.25
Zn mgL^{-1}	2.41	2.81	13.18	9.50	5.83	3.90
Fe mgL^{-1}	2.09	2.20	3.89	2.89	2.79	2.68

Silica content varied between 3.15 mg/L at River Nile (site I) and 5.42 mg/L at Hadous Draine (site III). The increase in silicate may be attributed to the agricultural activities **[Juttner *et al.*, (1996) and El-Khatib (1991)]** reported that, Na^+ predominate K^+ in River Nile water. Sulphate content was high (562.08 mg/L) at Hadous Draine (site III) and low (339.27 mg/L) at River Nile (site I). This seemed to be in relation

with the higher salinity level at Hadous Draine than that at River Nile. The minimum silicate level at which diatom growth can occur is between 0.03 and 0.04 mg/L **[Serra *et al.*, (1984)]**, the concentration of SO_4 was found to be increased with increasing salinity and alkalinity **[Kebede *et al.*, (1994)]**. This may be due to oxidation of sulphide, sulphite and sulphur to sulphate **[Awadallah *et al.*, (1994)]**.

Contents of Mg, Ca, Na and K seemed most likely high at Hadous Draine (site III) but low at River Nile (site I). The same was also detected for copper, lead, zinc and iron. These variations appeared to depend on water pollution and salinity variation. From the above discussed physico-chemical results, it seems that, in general, the area attained to be polluted especially that of Hadous Draine and the down-stream water. Meanwhile, site II (up-stream) seems to be slightly polluted. It worth mentioning here, that, this site (II) is rich in hydrophytes.

A maximum number of phytoplankton species (72) was recorded at Hadous Draine, these may be due to that the nutrient rich and slight brackish stagnant water of Hadous Draine was favorable for several species of phytoplankton. Number of total phytoplankton standing crop was greatly higher at site I relative to the other sites (Table 2). However sites II, V and VI showed the least number comparing with the cell numbers at sites III and IV. The phytoplankton composed mainly of Cyanophyta, Chlorophyta, Bacillariophyta and Euglenophyta. Although River Nile water (site I) had the maximum individual number of phytoplankton (4810.5×10^5 cell/L) (table 2), it occupied the second rank of species number (68 species) after Hadous Draine (site III) which had a relative low individual number (920.05×10^5 cell/L). This might be due to the relative high pollution state of drainage water which reserved agriculture and domestic discharges. Physico-chemical analysis and biological indices of water quality indicated that the water of Hadous Draine (site III) is more polluted site through the investigated time. A high content of the agricultural containing organic pollutants in Hadous Drainage water beside the domestic sewage discharges could alter water quality. **[Abdel Baky (2001)]** concluded that, organic matter within domestic sewage discharge give a suitable medium for the growth of Euglenophyta. **[Hutchinson (1967)]** recorded great growth of Euglena in organically polluted bodies of water. The predominancy of Cyanophyta due to the high N and P content of Hadous Draine water, but Cyanophyta and Chlorophyta predominated with high nitrogen content of water **[Deyab *et al.*, (2002)]**.

Bacillariophyta dominated site number I (which represent the intake of the canal). This may be due to the industrial wastes of furniture factory which increase the silicon content of water. phytoplankton standing crop was least at El-salam canal (site II); a record of 28 species and195.7×10^5 cell/L was detected, this was mainly due to sharp decrease of Cyanophyta species, individual destruction during pumping water from River Nile to El salam canal and high mobility of water. On the other hand, a relative high phytoplankton species number (66 species) and individual number (977×10^5 cell/L) was recorded at site IV (down stream), a mixed site which affected by Hadous Draine water. Whereas, the phytoplankton standing crop decreased to 49 species and 226.1×10^5 cell/L at site V and to 38 species and 369.5×10^5 cell/L at site VI. This decrement seemed mainly due to high loss of Cyanophyta, Euglenophyta and Dinophyta species and individual at mixing station as a result of vigorous pumping of water. The variations of temperature are found to affect the periodicity diversity and succession of the phytoplankton group **[Behrndt (1990); Deyab (2003) and Deyab *et al.*, (2003)]** reported that the vigorous growth of Cyanophyta is correlated with the increase of phosphorus of surface water, whereas, silica depletion leads to a replacement of the large diatoms by large Cyanophyta.

Table (2): Annual variations in Cell Number (x 10^5) of total phytoplankton standing crop at six sites.

Site / Division	Site I		Site II		Site III		Site IV		Site V		Site VI	
	Number cell	Species number	Number cell	Species number	Number cell	Species number	Number cell	Species number	Number cell	Species number	Number cell	Species number
Cyanophyta	1608	15	50	3	583.75	16	745	8	105.5	5	258.75	4
Chlorophyta	1427	18	7	5	205	19	128.5	18	49.6	16	72.5	12
Euglenophyta	48	2	2	1	49.75	12	8.75	9	3.5	6	3.5	4
Dinophyta	32.5	3	2	2	12.85	3	6.75	3	2.5	2	3	3
Bacillariophyta	1695	29	134.75	17	68.7	22	88	28	65	20	31.75	15
Total	4810.5	68	195.75	28	920.05	72	977	66	226.1	49	369.5	38
Diversity	2.78		2.07		1.46		1.49		2.01		1.64	
Saprobity	1.79		2.04		2.96		2.06		1.74		2.63	

Site I (River Nile), site II (Up-stream), site III (Drain), site IV (Mixed), site V (Down stream) and site VI (up-sahara).

According to the frequency of abundance (Table 3), Cyanophytes, Merismopedia trolieri, Anabaena constricta, Anabaena variabilis, Oscillatoria woronichinii, Chrococcus dispersus, Chroococcus limneticus var. distans. Phormidium autumnale and Microcystis aeruginosa were the common species within site I. Meanwhile, Oscillatoria putrida, O. brevis, O. lemnetica O. nitida and Merismopedia tenuissima were the dominant species at site IV.

Beside Cyanophytes, there were some species participated in the dominancy of Chlorophyta standing crop, such as Chlorella vulgaris var. valgaris, Nodularia spumigena f. litorea, Pandorina morum, Ankistrodesmus acicularis, Scenedesmus quadricauda var. quadricauda, Crucigenia quadrata, Ankistrodesmus hantzschi var. gracile and Scenedesmus bijugatus var. bijugatus. valgaris, Nodularia spumigena f. litorea, Pandorina morum, Ankistrodesmus acicularis, Scenedesmus quadricauda var. quadricauda, Crucigenia quadrata, Ankistrodesmus hantzschi var. gracile and Scenedesmus bijugatus var. bijugatus. The increase of Chlorophyta standing crop of cell number may be attributed to high nutrient content especially nitrogen **[Deyab et al., (2001)]**. The most frequent species of diatoms which recorded within the different sites were Cyclotella meneghiniana, Navicula cincta, Synedra acus, Melosira varians, Nitzschia sublinearis, Gyrosigma macrum, Nitzschia denticula, Nitzschia acicularis, Nitzschia frustulum var. astatica, Melosira islandica and Nitzschia tibetana.

Table (3): Annual Variations in frequency of different taxa at different sites at the studied area.

Species	I	II	III	IV	V	VI	T.F
Cyanophyta							
Anabaena constricta (Szaf.)Geitl	3	0	0	0	0	1	4
Anabaena variabilis Kutz	3	0	3	0	0	0	6
Calothrix stagnale var.*angustatum* G.M. Smith	3	0	0	0	0	0	3
C. parietana (Nag.)Thuret	3	0	0	0	0	0	3
Chrococcus dispersus (Keissl.) Lemm.	0	0	2	2	2	2	8
Chroococcus limneticus var. *distans* G.M. Smith	3	0	0	0	0	0	3
Chroococcus limneticus var. *carneus* (Chod.) Lemm.	0	0	1	0	0	0	1
Chroococcus minutus (Kutz.) Naegeli	0	0	0	1	0	0	1
Coelosphaerium dubium Grun.	3	0	0	0	0	0	3
Cylindrospermum majus Kutz	4	0	0	0	0	0	4
Gloeocapsa aeruginosa (Garm.)	3	0	0	0	0	0	3
Gloeocapsa alpina f. *ambigna* (Kirchn.) Hollerb,	0	0	0	0	1	0	1
Gloeocapsa rupestris (Breb.) Kutz.	0	0	0	1	0	0	1
Gomphosphaeria lacustris var. *compacta* Lemm.	3	0	0	0	0	0	3
Merismopedia elegans A. Braun.	3	0	0	0	0	0	3
Merismopedia tenuissima Lemm	0	0	1	1	0	0	2
Merismopedia trolieri Bachm.	3	0	0	0	0	0	3
Microcystis aeruginosa Kutz.	5	0	0	0	0	0	5
Oscillatoria woronichinii Kutz.	4	0	0	0	0	0	4
Oscillatoria brevis (Kutz.) Gom.	0	0	0	2	0	0	2
Oscillatoria chalybea f. *conoidea* V. Poljansk	0	0	0	1	0	0	1
Oscillatoria lemnetica Lemm.	0	0	3	0	0	0	3
Oscillatoria nitida Kutz	0	0	0	1	0	2	3
Oscillatoria putrida Schmidle	0	0	0	6	2	3	11
Oscillatoria rupicola (Hansg.)	0	1	3	0	1	0	5
Oscillatoria simplicissima Kutz.	0	0	0	0	2	0	2
Phormidium autumnale (C.A.Ag.) Gomont	4	0	0	0	0	0	4
	14	1	6	8	5	4	38
Chlorophyta							
Actinastrum gracilimum G.M. Smith	3	0	0	0	0	0	3
Actinastrum hantzschii var.*gracile* Roll	3	0	4	1	3	0	11
Ankistrodesmus convolutus Corda G.M. Smith	3	0	0	0	0	0	3
Ankistrodesmus acicularis (A. Br.)	0	0	2	4	4	5	15
Ankistrodesmus angustus (Bern.) Korschik.	3	0	2	0	1	1	7
Ankistrodesmus fusiformis Chodat	0	0	0	1	0	0	1
Ankistrodesmus minutissima Korschik	0	0	3	0	0	0	3
Ankistrodesmus tatrae (Turn.) Lemm.	0	0	0	1	0	0	1
Botryococcus braunii Kutz.	3	0	0	0	0	0	3
Characium gracilipes Lambert	2	0	0	0	0	0	2

Characium limneticum Lemm.	1	0	0	0	0	0	1
Chlorella vulgaris var. *vulgaris* f.*vulgaris* Beij.	4	0	0	0	0	0	4
Chlorellidiopsis separalibis Pascher	0	0	1	0	0	0	1
Chlorococcum humicola (Naeg.)	3	0	0	0	0	0	3
Chlorococcum wimmeri Lemm.	0	0	0	1	0	0	1
Coccomyxa lacustris Kutz.	0	0	0	0	0	2	2
Coelastrum microporum Naeg.	4	0	0	0	0	0	4
Crucigenia apiculata (Lemm.) Schmidle	0	0	2	1	0	0	3
Crucigenia irregularis Wille	0	0	0	0	0	1	1
Crucigenia quadrata Morren	4	3	2	1	0	2	12
Crucigenia tetrapedia (Kirch.)W.et W.	0	0	0	0	1	0	1
Dictyosphaerium chrenbergianum Nag.	3	0	0	0	0	0	3
Eudorina illinoisensis O. Mul.	0	0	0	2	0	0	2
Gonium pectorale (Turp.)	0	0	2	0	0	0	2
Kirchneriella obes Korsh.	0	0	1	0	0	0	1
Kirchneriella subsolitaria G.S.West	2	0	0	0	0	0	2
Meringosphaera spinosa Prescott	2	0	0	0	0	0	2
Oocystis crassa Wittrock	0	0	0	0	1	1	2
Oocystis elliptica var. *elliptica* W.West	0	0	0	0	0	1	1
Pandorina morum (O.Mul.) (Bory)	4	0	6	4	3	6	23
Pediastrum simplex var. *duodenarium* (Bailey) Raben-horst	3	0	0	0	0	0	3
Protoccoccus viridis Kutz.	0	0	0	1	0	0	1
Scenedesmus arcuatus var. *arcuatus*	0	0	1	0	0	0	1
Scenedesmus bicaudatus var. *intermedius* (Chod.)	0	0	1	0	0	0	1
Scenedesmus obliquus var. *obliquus* (Trup.)Kuetz	0	0	0	0	1	0	1
Scenedesmus acuminatus var. *bernardii* (Smith) Dedus	0	0	0	0	1	1	2
Scenedesmus acuminatus (Turp.)	0	0	0	0	2	0	2
Scenedesmus acuminatus var. *acuminatus* (Lagerh.) Chod.	0	0	4	5	0	0	9
Scenedesmus acuminatus var. *biseriatus* Reinsch	0	0	1	1	1	0	3
Scenedesmus bijugatus (Turp.) Kuet var. *bijugatus*	0	0	2	1	2	1	6
Scenedesmus bijugatus (Turp.) Lagerheim	0	0	0	0	1	0	1
Scenedesmus bijugatus var. *alternans* Reinsch	0	0	0	1	0	0	1
Scenedesmus quadricauda Hansg.	0	0	4	1	0	0	5
Scenedesmus quadricauda var. *danubialis* (Hortob.)	0	0	0	0	2	0	2
Scenedesmus quadricauda var. *granulata (Hortob.)*	0	0	2	0	1	1	4
Scenedesmus quadricauda var. *quadricauda* (Trup.) Brebis	2	0	0	1	2	3	8
Schizochlamys gelatinosa Reinsch	0	0	1	1	0	0	2
Staurastrum gracile Lemm	0	0	0	0	1	0	1
Tetraedron triangulare (Turp.)	0	0	0	1	0	0	1
Tetraedron trigonum (Naeg.) Hansg.	1	0	1	0	0	0	2

	18	1	19	18	16	12	
Euglenophyta							
Euglena acus Ehr.	0	2	2	3	1	0	8
E. caudata Hubner	0	0	4	0	0	0	4
E. elastica Prescott	0	0	0	1	0	0	1
E. elegans Ehr.	0	0	1	0	0	0	1
E. geniculata (Duj.) em. Schmidle	0	0	1	0	0	0	1
E. mutabilis Schmitz	0	0	0	1	0	0	1
E. physeter Fott	0	0	0	0	0	1	1
E. variabilis Klebs	0	0	1	1	0	0	2
E. velata KLEBS	0	0	5	0	0	0	5
E. viridis Ehr.	0	0	2	1	0	0	3
Lepocinclis fusiformis var. *major* Fritsch& Rich	0	0	0	0	1	0	1
L. ovum (Ehr.)	0	0	0	1	1	0	2
L. playfairiana Deflandre	0	0	0	0	0	4	4
Phacus agilis Skuja	0	0	0	0	1	1	2
Ph. brachykentron Pochm	0	0	1	0	0	0	1
Ph. brevicaudatus (Klebs)	0	0	3	0	0	0	3
Ph. caudatus Hubner	0	0	6	3	0	1	10
Ph. chloroplastes far. *Incisa* Prescott	2	0	0	0	0	0	2
Ph. curvicauda SWIR	0	0	0	0	1	0	1
Ph. pleuronectes (Muller)	0	0	0	0	1	0	1
Ph. pusillus Lemm.	0	0	0	1	0	0	1
Strombomonas fluviatilis Lemm. Defl.	0	0	2	1	0	0	3
Trachelomonas labiata TELING	1	0	2	0	0	0	3
	2	1	12	9	6	4	
Dinophyta							
Exuviaella compressa Ostenfeld	3	0	5	3	0	2	13
Glenodinium kulczynskii (Wolosz) Schiller	2	1	0	2	0	0	5
Glenodinium pulvisculus FOTT	0	0	1	1	1	2	5
Katodinium vorticella (STEIN) FOTT	3	0	0	0	0	0	3
Peridinium cinctum var. *tuberosum* (Meunier) Lindeman	0	0	1	0	0	0	1
Peridinium volzii Lemm.	0	2	0	0	2	1	5
	3	2	3	3	2	3	
Xanthophyta							
Ophiocytium capitatum var. *longispinum* (Moebius)L.	2	0	0	0	0	0	2
Bacillariophyta							
Achnanthes conspicua A. Mayer	0	0	3	0	0	0	3
Achnanthes Jentzschii (Grun.)	0	1	0	0	0	0	1
Achnanthes linearis var. *pusilla* Grun.	0	0	0	1	0	0	1
Amphiprora alata Lemm.	0	0	1	0	0	0	1

Amphiprora paludosa var. *subsalina* Cl.	0	0	2	0	0	0	2
Amphora monoglica var. *cornuta*	0	0	0	1	0	0	1
Bacillaria paradoxa Ehr.	0	0	0	1	0	0	1
Caloneis amphisbaena (Bory) Cl.	0	0	1	1	0	0	2
Cocconeis scutellum Ehr.	0	0	0	0	1	0	1
Cocconeis pediculus Ehr.	0	2	1	1	0	0	4
Cocconeis placentula Ehr.	0	0	0	0	1	0	1
Cyclotella bodanica var. *lemanensis* Kutz.	0	0	1	0	0	0	1
Cyclotella meneghiniana Kutz.	4	4	6	6	6	6	32
Cymatopleura solea var. *regula* Lemm.	0	0	0	0	1	0	1
Gomphonema angustatum Ehr.	1	0	0	0	0	0	1
Gomphonema longiceps var. *subclavatum* Grun	0	1	1	2	0	0	4
Gomphonema olivaceum Kutz.	0	0	0	0	0	3	3
Gomphonema parvulum var. *lagenulum* Kutz.	0	0	1	0	0	0	1
Gyrosigma attenuatum (Kutz.) Rabenh.	0	1	2	1	0	0	4
Gyrosigma acuminatum (Kutz.) Rabenh.	0	0	1	0	0	0	1
Gyrosigma macrum W.Sm.	0	0	1	2	1	2	6
Melosira islandica O.Mull	4	1	0	3	3	0	11
Melosira varians Lemm.	2	2	3	5	3	3	18
Navicula cincta (Ehr.) Kutz.	0	0	3	4	2	5	14
Navicula diluviana Kutz.	1	0	0	0	0	0	1
Navicula fossalis Krasske	0	0	0	2	0	0	2
Navicula graciloides Grun.	0	1	1	0	0	0	2
Navicula placentula (Ehr.) Grun.	0	0	0	0	0	1	1
Navicula placentula f. lanceolata Ehr.	0	1	0	0	0	0	1
Navicula pygmaea Ehr.	0	0	0	1	0	0	1
Navicula tuscula (Ehr.) Grun.	0	1	1	0	0	0	2
Neidium productum (W.Sm)	0	0	0	2	0	0	2
Nitzschia acicularis W. Sm.	0	0	4	0	1	0	5
Nitzschia filiformis (W.Sm.)Hust.	0	0	0	0	0	2	2
Nitzschia bremensis Hust.	0	0	0	0	1	0	1
Nitzschia denticula Grun.	1	2	2	1	1	3	10
Nitzschia frustulum var. *asiatica*	0	0	3	4	0	2	9
Nitzschia hungarica (Greg.) Grun	0	0	2	1	1	0	4
Nitzschia longissima f. *parva*	0	0	1	1	0	0	2
Nitzschia longissima f. *parva* var. *reversa*	0	0	4	2	0	0	6
Nitzschia paleacea Grun.	0	0	2	3	0	3	8
Nitzschia stagnorum Rabenh	0	0	2	1	3	0	6
Nitzschia sublinearis Hust.	0	4	6	3	1	1	15
Nitzschia thermalis Hust.	0	0	2	0	0	0	2
Nitzschia tibetana Hust.	0	0	1	3	1	1	6
Nitzschia tryblionella var. *levidensis* (W. Sm.) Grun.	1	1	1	0	0	0	3
Pleurosigma subsalsum Grun.	0	0	0	1	0	0	1
Stauroneis baicalensis Grun.	0	2	0	0	1	0	3
Stauroneis montana Krassake	0	1	0	1	0	0	2

Stephanodiscus dubius Grun.	0	0	0	0	1	1	2
Surirella didyma var. *minor* Kutz.	0	1	0	0	0	0	1
Surirella ovata var. *crumena* Ag.	0	0	1	0	0	0	1
Synedra acus Kutz.	3	3	3	5	3	4	21
Synedra tabulata (Ag.) Kutz	0	0	0	0	1	0	1
Synedra ulna (Nitzsch) Ehr.	0	0	0	1	3	0	4
Synedra ulna var. *aequalis* Ehr.	1	0	0	0	0	0	1
Synedra ulna var. *contracta* Kutz.	0	1	0	0	0	0	1
	9	18	30	28	20	15	
No of Taxa	47	22	70	67	48	37	

The most frequently abundance Euglenophyta was at Hadous Draine (site III), *Phacus caudatus, Euglena acus, Euglena velata, Euglena caudata, Euglena variabilis* and *Euglena viridis)* were the frequent spp. The results which may confirm a highly pollutionary status of the site III **[Shaaban-Dessouki *et al.*, (1994)].** Dinophyta represented mainly by *Exuviaella compressa, Peridinum volzii, Katodinium vorticella, Glenodinum kulezynskii* and *Glenodinium pulvisculus* were the most frequently abundance Dinophyta at different sites. *Exuviaella compressa* prefer to inhabit in polluted water **[El-Adl (2000)]**. In Table 4, the average annual of total phytoplankton standing crop biomass was ranged between 62.7 and 2512 mgL^{-1} at site II and III (Hadous Draine) respectively. In generally, phytoplankton standing crop biomass was as follows: III> V> IV> VI> II > I.

Table (4): Total Biomass (mg/L) of different groups and total phytoplankton standing crop at the six sites. Site I (River Nile), site II (Up-stream), site III (Drain), site IV (Mixed), site V (Down stream) and site VI (Up-sahara).

Phylum / Site	Cyanophyta		Chlorophyta		Euglenophyta		Dinophyta		Bacillariophyta		Total
	Bioma.	%	Bioma.	%	Bioma	%	Bioma	%	Bioma	%	Bioma
I	4	6.4	57	91	0.3	0.48	0.2	0.32	1.2	1.9	62.7
II	10	5.9	0.72	0.43	50	29.6	0.8	0.42	107	63	168.8
III	75	3.0	1530	61	564	22	22	0.9	321	12.7	2512
IV	235	22	443	41.8	135	12.7	8	0.75	239	22.5	1060
V	48	3	1265	82	44	2.8	0.9	0.06	173	11.3	1530
VI	54	19	125	43.8	29	10	4	1.4	73	25.6	235
total	426	7.6	3421	60.9	822	14.6	36	0.64	914	16.3	5619

The data showed that the total annual biomass standing crop was higher during summer and spring (especially July and March) than autumn and winter months (Table 5).

Table (5): Total Biomass (mg/L) of different groups and total phytoplankton standing crop at the six months (November, January, March, May, July, September).

Phyllum / Months	Cyanophyta		Chlorophyta		Euglenophyta		Dinophyta		Bacillariophyta		Total	
	Bioma.	%	Bioma.	%	Bioma.	%	Bioma.	%	Bioma.	%	Bioma.	%
November	62.7	15.8	50	12.6	138.3	34.8	5	1.3	140.5	35	397	7
January	20.2	5.7	37	10.5	260	73	0.16	0.05	36.7	10.4	354	6
March	83.4	5.9	964	68	213	15	20.5	1.5	129.5	9.2	1411	25
May	81.6	7.3	794	71	83	7.4	2.96	0.3	160.9	14	1122	20
July	115.6	7.5	118	73	42	2.7	4.8	0.3	259.5	17	1539	27.4
September	63.4	8	458	58	85	10.6	2.15	0.3	187	23	796	14.2
Total Biomas	426.9	7.6	3421	60.9	821.8	14.6	35.57	0.63	914	16.3	5619	100

Chlorophyta formed 60.9% of the total annual biomass standing crop, giving its maximum percent (82%) within site No. V, which represented the down stream water (after mixing) of the canal. However, Chlorophyta formed 42% within the mixed site (IV). Meanwhile, it formed 60% of the total biomass at Hadous drain (Site III). It is clear also from table 4 that Bacillariophyta formed 16.3% of the total annual biomass standing crop, representing the second group, giving its

maximum (63%) within site II (upstream water of the canal). Nevertheless, it formed 12.7% at the Drain and 22.5% within the mixed water (site IV). This fluctuation of Bacillariophyta may be attributed to different sources of pollutants; reactive silica **[Bibson (1981)]** and sewage pollution **[Schelske *et al.*, (1978)]**. Euglenophyta formed 14.6% of the total annual biomass, giving its maximum percent 22% within Hadous Drain water. It was reported by **[Shaaban-Dessouki *et al.*, (1994)]** that Euglenophyta inhabited highly organic polluted water. As regard Cyanophyta and Dinophyta, they6 formed only 7.6% and 0.64% of the total annual biomass standing crop respectively (Table 4).

As illustrated in table 5, maximum annual biomass was recorded during summer and spring. This was mainly due to the dominance of Chlorophyta which formed 73%; 71%; and 68% during July, March and May respectively. However, minimum percent 12.6% and 10.5% were recorded during November and January. **[Kebede & Ahlgren (1996)]**, reported that increase of water temperature and nitrogen often accompany with growing of Chlorophyta.

In contrast to Chlorophyta, Euglenophyta attained it maximum biomass during November and January (34.8% and 73% respectively). Meanwhile, Bacillariophyta reached it maximum 35% during November. In the polluted estuary of the River Nile, Bacillariophyta and Euglenophyta alternately occupied the top of dominance. Nevertheless, Bacillariophyta decreased with increasing the organic pollution giving away to Euglenophyta **[Shaaban-Dessouki *et al.*, (1994)]**. Generally speaking, the irregularities, fluctuation and changes of phytoplankton standing crop could be attributed to the abrupt changes in the physico-chemical properties of water at the studied areas.

As regard the biological assessment of water quality, the mean value of diversity index among the different sites ranged from 2.78 at site I to 1.46 at site II. This range indicates that, this area is moderately polluted (Table 2). Meanwhile, the values of Saprobic index fluctuated between 1.74 at site V and 2.96 at site IV, indicating a range of clean to heavily contaminated area. The lower values were recorded at site II and site V may be due to the presence of some hydrophytes (*Ceratophyluum demersum* and *Potamogeton pectinatus*) which could make biological filtration for water **[Serag & Khedr (2001)]**. The saprobic quotient indicating β – mesosaprobic condition of the study area with slight pollution, The saprobic quotient varied between 0.46 at site V and 0.59 at site II. Biological parameters (Number and Biomass) were used in the

multivariate cluster analysis (Figure 2) to find out the similarity between different sites using Bray–Curtis dissimilarity index. It is worth to mentioning that biological characteristics of polluted water at site (III) tended to be more similar to those in mixed water at site (IV) with relative similarity coefficient (62 %) and they clustered in one sub-group, both of them were clustered with site (V) in one large group. Site (II) and site (I) were different from other groups and each other. This may be due to different in the type and quantity of pollutants, which are received by each site.

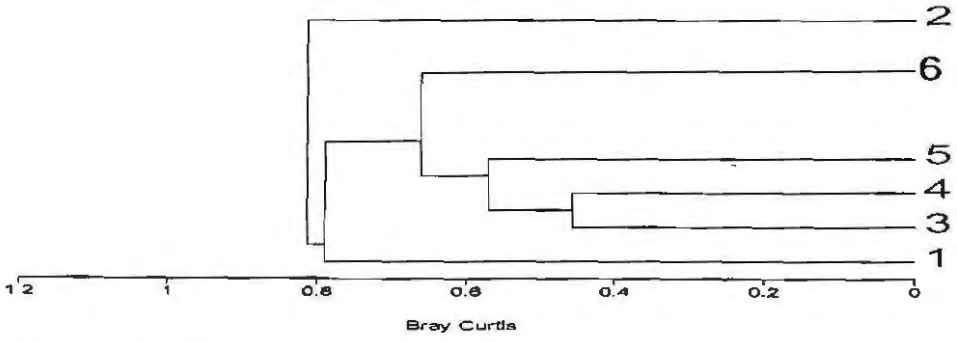

Fig. (2): Similarity Dendrogram between six sites [Site I (River Nile), site II (Up-stream), site III (Drain), site IV (Mixed), site V (Down stream) and site VI (Up-sahara)]. during the investigation period according to the abundance of the phytoplanktonic groups using Bray – Curtis measure.

By using the canocal corresponding analysis (CCA) varies the physico-chemical parameters and phytoplanktonic groups (Figure 3). The correlations between the abundance of different phytoplankton groups and the environmental variables are followed. A positive correlation is expressed by relatively long vector roughly pointed into the same direction, whereas arrow pointing into the opposite direction indicates a negative correlation. Thus Cyanophyta and Euglenophyta were positively correlated with ammonia, BOD, total CO_2, organic nitrogen, organic phosphorus, temperature, nitrite and nitrate. In contrast, to Cyanophyta and Euglenophyta, Chlorophyta, Bacillariophyta, Dinophyta were negatively correlated with the above–mentioned parameters. However, they were positively correlated with dissolved oxygen, pH and PO_4, Mg, K and Na, salinity and Chloride. Pollution level or quality of natural

water and of wastewater is determined by physical/chemical, Saprobiological, radiological and recently also by cytogenetic and genotoxic analyses **[De- Serres (1992) and Gong *et al.*, (2001)]**.

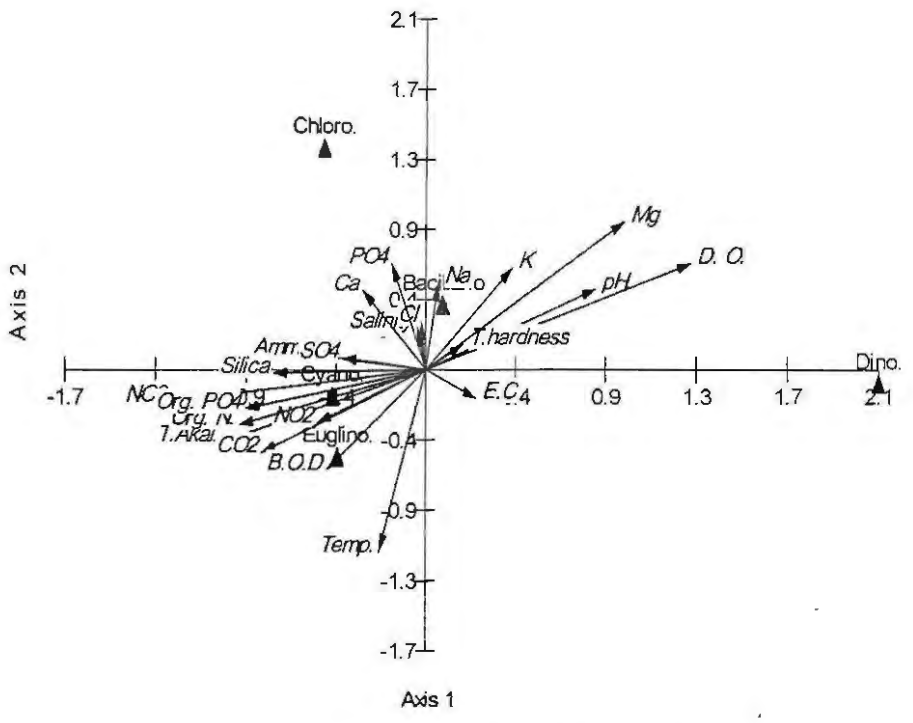

Fig. (3): Canoco analysis plot of physico-chemical and biological parameters

From the above mentioned results and discussion, it is clear that El-Salam Canal was subjected to moderate pollution as a result of receiving Hadous Drain water as a polluted and eutrophic biotope. The matter which is connected with an expected problems from the water usage as well as ecological points of view. Therefore, a water quality management programme should be strictly initiated, starting with changing the used mixing percentage between the River Nile water and Hadous Drain water, unless the Hadous Drain water will be subjected to a tertiary treatment before dumping into the Canal.

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إستجابة الفلورا الطحلبية لتدفق مياه الصرف بترعة السلام – مصر

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تضمن البحث دراسة العوالق الطحلبية لثلاثة مناطق هى نهر النيل وترعة السلام ومصرف حادوس حيث توجد ثلاث أنواع من جودة المياه. بينت النتائج انه إلى جانب الإختلاف الواضح فى الخصائص الفيزيائية والكيميائية للمياه أن هناك إختلافا كميا ونوعيا فى العوالق الطحلبية التى تقطن هذه المناطق. وقد وصل عدد الخلايا أقصاها فى منطقة نهر النيل متمثلا فى ٦٧ نوع معظمها من الدياتومات التى تبعت بالطحالب الخضراء المزرقة ثم الطحالب الخضراء فالطحالب اليوجيلينية ثم الدينوفلاجيلات بينما فى مصرف حادوس تم تسجيل ٧٢ نوع بعدد خلايا كلى أقل من السابقة. أما بالنسبة لترعة السلام فاختلف عدد الأنواع من موقع إلى آخر وكذلك عدد الخلايا وكان أغلب الأنواع من الطحالب الخضراء المزرقة أو الخضراء التى تبعت بالدياتومات والطحالب اليوجيلينية كما فى هو الحال فى مصرف حادوس.

باستخدام الدلالات البيولوجية الطحلبية مثل Diversity index, Saprobic index and Saprobic quotient تبين أن مياه مصرف حادوس كان أكثر تلوثا نسبيا يليها مياه ترعة السلام بينما مياه نهر النيل كانت الأقل تلوثا مما يدل على أن مياه ترعة السلام تأثرت تأثرا ملحوظا بمياه مصرف حادوس والأنشطة البشرية على طول القناة.

كذلك تم إستخدام مصفوفات نتائج العوالق الطحلبية والخصائص الكيميائية والفيزيائية للمياه لتحاليل الإحصائية المتقدمة مثل Canonical corresponding analysis and multivariate claster analysis.

وعامة بينت النتائج أن جودة مياه ترعة السلام تأثرت سلبيا نتيجة الخلط بمياه مصرف حادوس

الأمر الذى يبين أن نسبة الخلط المطبقة حاليا يجب إعادة النظر فيها وتغييرها إلا إذا تم معالجة مياه مصرف حادوس معالجة ثلاثية قبل الخلط بمياه نهر النيل فى ترعة السلام.