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Biodiversity and Distribution of Blue-Green Algae/Cyanobacteria and Diatoms in Some of the Egyptian Water Habitats in Relation to Conductivity

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Abstract: Benthic and planktonic algal samples were collected from different water habitats including River Nile, Springs of Bahariya Oasis (Western Desert), Ain Helwan (near Cairo), Ain El-Sokhna (near Suez town) El-Temsah Lake (Ismailia town), Hammam Musa Faroun (South Sinai) and Wadi El-Natrun Lakes (Western Desert).Qualitative distribution of blue-green algae (cyanobacteria) and diatoms was estimated in relevant with water conductivity. Conductivity ranged from 60 μScm^{-1} to 1213300μScm^{-1}. Ionic composition, however, varied greatly because of the influence of natural and anthropogenic factors. Sulphate and chloride were prevalent anions in samples from the majority of the sampling sites, while sodium was the dominated cation. Correlations between conductivity, [Na^+], and [Cl^-] were relatively high, indicating that highest values of conductivity were because of the increased concentration of these ions. A total of 353 blue-green algae and diatoms were identified in this investigation from which 128 taxa were photomicrographed aimed to present the diversity in morphological forms of the identified species. The saline waters were the most algologically productive habitats, followed by freshwaters, hypersaline waters and brackish waters. The results emphasized that, it is difficult to seggregate the taxa constituting the cyanobacteria into marine and freshwater species which is possible with diatom group which can be used more effectively in making assessment of ecological change.

Keywords: Biodiversity, blue-green algae, diatoms, conductivity

INTRODUCTION

The main water resource in Egypt is the River Nile, which originates in Lake Tanganyika at latitude 3°S, passing northward through several African countries to the shore of the Mediterranean Sea in Egypt at latitude 31°15 N (Zahran & Willis, 2003). Other surface water resources (lakes, streams, ponds, etc.) and/or underground water are also present in Egypt. Waters vary greatly in their mineral content and composition, mainly because of the variability in lithology, climate and vegetation.

Phycological reference works on Nile and springs (as cited in Hamed, 2005) , Lake Timsah (El-Shoubaky and Hamed,2006) and lakes of Wadi El-Natrun (Hamed *et a*l., 2007 a, b) are considered as the main sources of data for this work. Although, it is well known that conductivity in terms of salinity and concentrations of major ions have a strong influence on distributions of individual cyanoprokaryotes (Sigee, 2005) and diatom taxa (Cholonky, 1968), the relative importance of this factor has not been studies particularly in Egypt. Consequently, this paper provides biodiversity of blue-green algae (cyanobacteria) and diatoms with respect to water conductivity of some water habitats in Egypt.

MATERIALS AND METHODS

Samples Collection:

Benthic and planktonic algal samples were collected from 1990 to 2005 from sampling stations as shown in (Fig.1) as follows:

Warm and Hot Springs:

(Ain Helwan, Ain El Sokhna, Hammam Faroun ,Hammam Musa ,springs of Bahariya Oasis) by A.F. Hamed from April 1990 to September 1991.

Lake Nasser and River Nile from Aswan to Cairo by different authors as cited in A.F. Hamed 2005.

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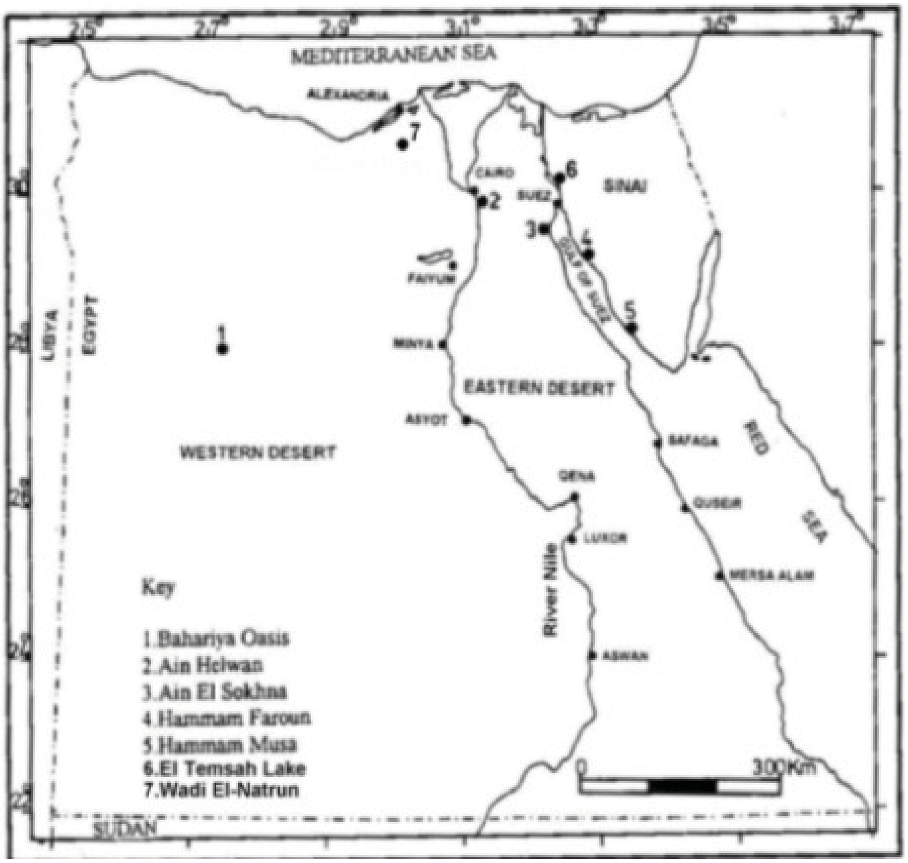

Fig. 1: The investigated localities.

El Timsah Lake by El-Shoubaky and Hamed, 2005 (two collections during Spring season of 2004 and Spring of 2006).

Saline lakes of Wadi El-Natrun by Hamed *et al*., 2007a,b (from January 2003 to February 2004).
Algal samples were collected seasonally at the majority sites especially those of thermal springs and Wadi El-Natrun Lakes.

Taxonomy:

Blue-green algae/cyanobacteria:

Traditional taxonomic criteria based on the morphological characteristics were used for identification (Geitler 1932; Gollerbach *et al*.1953; Desikachary 1959; Anagnostidis and Komárek 1985, 1988; Komárek and Anagnostidis 1986).

Diatoms:

Permenant diatom slides were prepared according to Jouse *et al*., (1949) and mounted using the method of Proschkina- Laverenko *et al*., (1974). The main diatom floras used for identification were those of Hustedt (1930, 1939, 1953, 1957) , Cleve-Euler (1951, 1952, 1953, 1955), Patrick and Reimer (1966, 1975), Jensen (1985) and Krammer and Lange-Bertalot (1986, 1988).

Photo-micrograph of the most identified taxa have been taken by using Karl Ziess microscope fitted with camera in the Laboratory of phycology, University of Rome "La Sapienza"

Water Chemistry:

Water chemistry samples were collected for determining conductivity, major cations and anions. Concentrations of major ions were determined by milliequivalents per litre ($meqL^{-1}$). Milliequivalents can be changed into parts per million (ppm) by applying the equation of Garg, 1978. Water conductivity was measured in situ by conductivity meter expressed by μScm^{-1} or derived from the total dissolved salts. Water chemistry results were represented graphically by bar diagrams according to Klimentov, 1983.

RESULTS AND DISCUSSION

Conductivity and Ion Concentrations:

Conductivity varied from 60 μScm^{-1}, corresponding to waters of River Nile, to 1213300μScm^{-1} representing the saline waters of Wadi El-Natrun lakes (Table 1.). Highest conductivities were observed in Hammam Musa (South Sinai ,Suez Gulf) , Ain El-Sokhna (Suez Gulf),El-Sabkha Lake (Wadi El-Natrun) , Hammam Faroun (South Sinai, Suez Gulf),El-Fasda Lake (Wadi El-Natrun) , El-Temsah Lake(Suez Canal) ,El-Khadra Lake (Wadi El-Natrun),El-Hamra Lake (Wadi El-Natrun), El-Zaagig Lake (Wadi El-Natrun)and El-Gaar Lake (WadiEl-Natrun). Highest conductivities were observed in the previous localities , influenced by marine waters (as in Hammam Musa, Ain El-Sokhna, Hammam Faroun) and by the geological and climate conditions (as in Wadi El-Natrun Lakes).

Sulphate and chloride were prevalent anions in samples from the majority of the sampling sites, while sodium was the dominant cation in all investigated sites except some localities such as River Nile , Ain El-Mahabes (Bahariya Oasis) and Ain El-Hobga Bahariya Oasis) where Mg^{2+} /Ca^{2+} were prevalent cations. (Table2).

Table 1: Water conductivity of the investigated localities.

Locality	Conductivity μScm^{-1}	Water habitat type
River Nile	60	Fresh Water Habitats
Ain Halfa (Bahariya Oasis)	592	
Ain El-Goag (Bahariya Oasis)	756	
Ain El-Ramla (Bahariya Oasis)	826	
Ain El-Mahabes (Bahariya Oasis)	904	
Ain El-Nibika (Bahariya Oasis)	982	
Ain El-Hobga (Bahariya Oasis)	1028	
Ain Helwan	8091	Brackish Water Habitats
Hammam Musa (South Sinai)	10164	
Ain El-Sokhna	15064	Saline Water habitats
El-Sabkha Lake (Wadi El-Natrun)	29734	
Hammam Faroun (South Sinai)	32332	
El-Fasda Lake (Wadi El-Natrun)	43006	
El-Temsah Lake (Suez Canal)	43500	
El-Khadra Lake (Wadi El-Natrun)	62204	
El-Hamra Lake (Wadi El-Natrun)	447933	Hypersaline Water habitats
El-Zaagig Lake (Wadi El-Natrun)	529852	
El-Gaar Lake (Wadi El-Natrun)	1213300	

Table2: Concentrations of major ions in the investigated localities in ppm.

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
TDS	36	296	378	413	452	464	514	4045	5082	7532	14867	16166	21503	21750	3112	223966	263926	606650
K^+	-	14.8	22.6	19.5	13.2	25.7	12.5	12.5	46.4	49.21	345	148.4	342	469.8	463	559	1545	2288
Na^+	-	48.7	54.9	49.6	30.5	47.8	28.7	1011.4	2486.8	1748.9	4703	4443.6	6506	13800	10057	84662	93264	93264
Mg^{2+}	8	36.4	38.6	21.1	55.8	36.4	45.8	150.6	512.8	321.1	34	526.3	283.8	1392	243.3	1873	431.8	104.6
Ca^{2+}	6	40	40	51.1	51.1	32.8	67.6	303	310.6	418.8	45.7	644.3	309	340	50.6	24.8	32	48
Cl^-	14	95.7	79.4	111.7	99.2	79.7	63.8	1388.2	3620.5	3546.4	2269	7659.5	5177	24140	6693	60992	72694	95071
SO_4^{--}	-	57.6	153.8	57.6	173.5	111.5	245.6	1214.9	3081.7	988.9	64118	2544.2	8247	2680	11568	84968	88348	95662
HCO_3^-	-	36.5	91.4	12.1	18.2	73.1	36.5	134.1	91.4	183.5	829	60.9	488	244	1493	2927	2408	2024
CO_3^{--}	-	72	36	72	57	42	36	156.1	43.8	0.0	222	108.1	150	150	6201	5418	6201	2781
$PO4^{---}$	0.21	4.7	4.7	4.76	4.76	4.7	4.76	9	0.95	2.38	3.4	9.5	1.88	0.153	4.6	2.9	1.66	2.5
NO_3^-	0.28	0.6	1.2	0.0	0.6	1.2	0.6	3.7	6.2	18.6	19.6	1.8	5.6	11.3	30.5	13	20.4	21

(-) indicates that the parameter was not precisely measured.

1= Nile, 2 = Ain Halfa (Bahariya Oasis), 3 =Ain El-Goag (Bahariya Oasis), 4 = Ain El-Ramla (Bahariya Oasis), 5 = Ain El-Mahabes (Bahariya Oasis), 6 = Ain El-Nibika (Bahariya Oasis), 7 = Ain El-Hobga (Bahariya Oasis), 8 =Ain Helwan, 9 = Hammam Musa,10 = Ain El-Sokhna, 11 = El-Sabkha Lake (Wadi El-Natrun), 12 = Hammam Faroun, 13 = El-Fasda Lake (Wadi El-Natrun), 14 = El-Temsah Lake, 15 = El-Khadra Lake (WadiEl-Natrun), 16 = El-Hamra Lake (Wadi El-Natrun), 17 = El-Zaagig Lake (Wadi El-Natrun), 18 = El-Gaar Lake (Wadi El-Natrun).

In accordance to the water type system proposed by Kimentov (1983), sodium chloride water type was the most dominated type. Magnesium sulphate was prevalent type only in Ain El-Mahabes, Ain El-Hobga, Ain El-Nibika and Ain El-Ramla (Fig. 2).

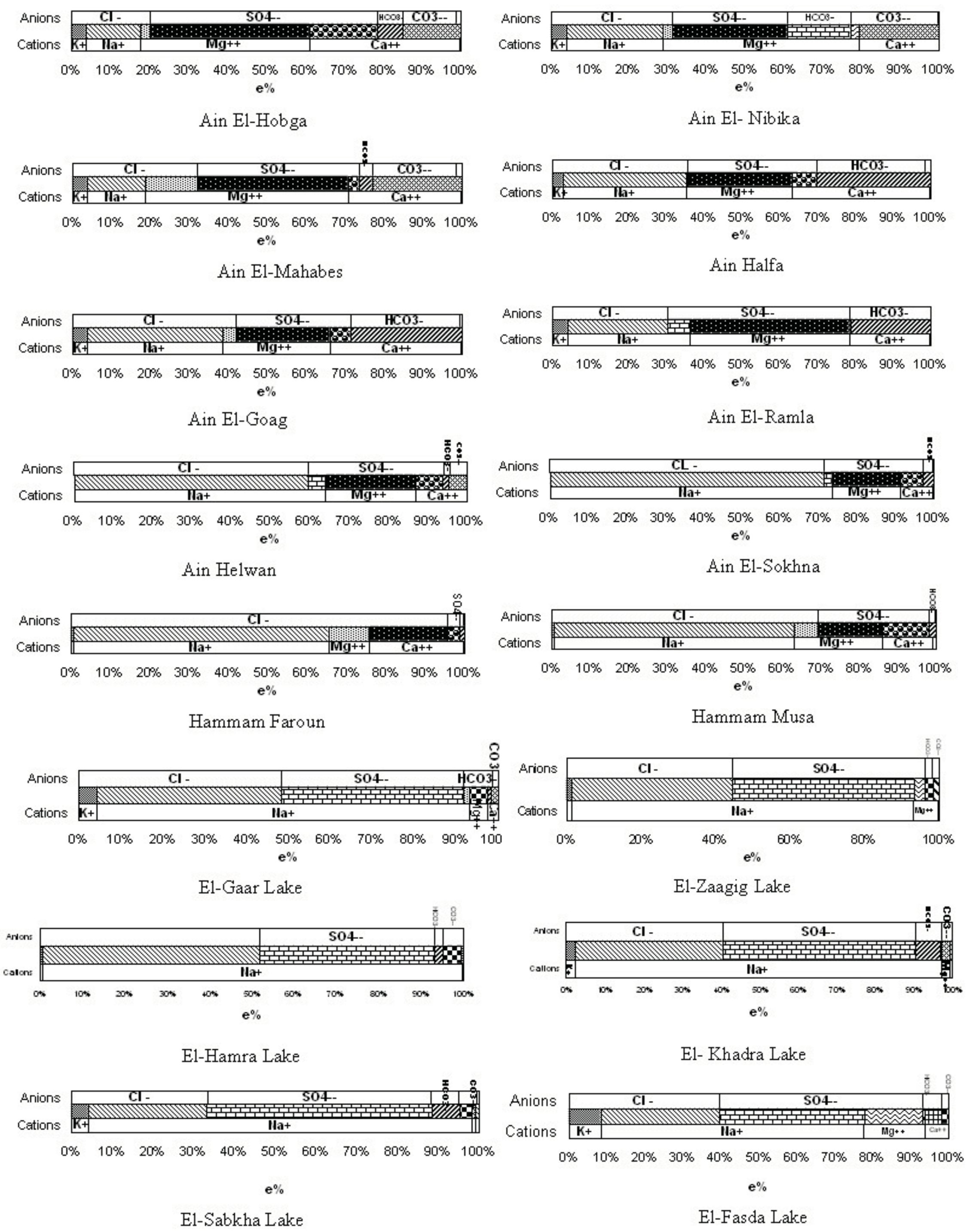

Fig. 2: Water chemistry type of the investigated localities

Correlations between conductivity, [Na^+], and [Cl^-] were relatively high, indicating that highest values of conductivity were because of the increased concentration of these ions. The investigated localities were belonged to four categories in referring with the classification of conductivity by Minaping, 2001: 1- Freshwater habitats (River Nile, Ain Halfa, Ain El-Goag, Ain El-Ramla, Ain El-Mahabes, Ain El-Nibika, Ain El-Hobga), 2-Brackish water habitats (Ain Helwan, Hammam Musa), 3-Saline water habitats (Ain El-Sokhna, El-Sabkha Lake, Hammam Faroun, El-Fasda Lake, El-Temsah Lake, El-Khadra Lake), 4- Hypersaline water habitats (El-Hamra Lake, El-Zaagig Lake, El-Gaar Lake). (Table1).

Distribution of Taxa in Relevance with Conductivity:
Blue-Green Algae (Cyanobacteria):

Qualitatively, the freshwater habitats were the most productive habitats for blue-green algae where 37 species were recorded, followed by saline (23 taxa), hypersaline (12 taxa) and brackish (11 taxa) water habitats. The widely distributed taxa inhabited the four water habitat types were represented by *Gloeocapsa gelatinosa, Gloeocapsa minor, Gloeocapsa turgida, Synechococcus elongatus, Synechocystis crassa, Synechocystis pevalekii, Oscillatoria claricentrosa, Oscillatoria geminata, Oscillatoria okeni, Oscillatoria tenuis* and *Lyngbya martensiana.* Species that thrived within the brackish-saline-hypersaline range of conductivity were recognized by *Synechocystis salina, Synechocystis sallensis, Gomphosphaeria aponina, Oscillatoria annae, Oscillatoria nigroviridis, Lyngbya convervoides* and *Lyngbya semiplena.* A bulk of taxa was frequently distributed within the ranges of fresh-brackish-saline water habitats of one hand and fresh-saline-hyperslaine water habitats of another hand. (Fig. 3)

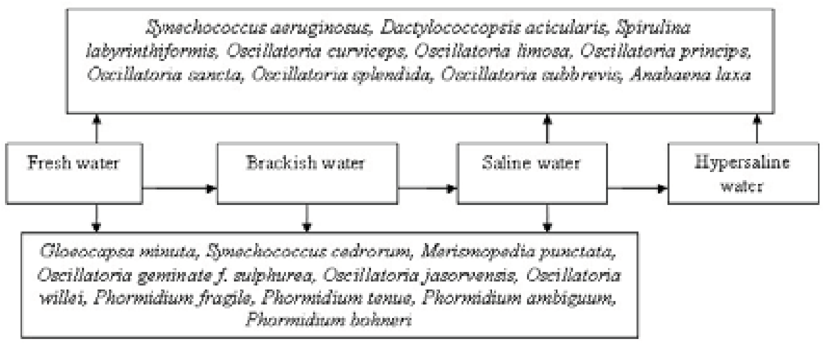

Fig. 3: Schematic representation of the distributed taxa along the water habitats.

In particular, *Oscillatoria* was the highly existed taxon which represented by 41 species, due to its wide tolerance for different environmental parameters, including salinity, pH and enrichement condition (Van Landinghan,1982).

In reference with the autecolgy of cyanoprokaryotes, some species were found to be as halotolerants (Van Landinghan,1982), such as *Gloeocapsa turgida*, *Merismopedia glauca*, *Spirulina major*, *Spirulina platensis*, *Oscillatoria nigroviridis*, *Oscillatoria princips, Oscillatoria tenuis*, *Phormidium ambiguum*, *Phormidium foveolarum*, *Phormidium fragile, Phormidium tenue*, *Lyngbya confervoides*, *Anabaena laxa*, *Anabaena torulosa* and *Nodularia spumigena*. The distribution of the previous species in this investigation was shown and confirmed such autecology.

In general, it is difficult to strictly seggregate cyanobacteria into marine and freshwater species (Thajuddin and Subramanian, 2005), where high percentages of species which were originally reported from freshwater sources by Geitler (1932) and Desikachary (1959), were also marine.

Diatoms:

The distribution of 189 diatom taxa along the investigated localities was analyzed in relevance with water conductivity by comparing this result with that of Potapova and Charles, 2003. It was cleared that, sixty one diatom species identified, their conductivity tolerances were confirmed and allocated within the ranges of low and high limits. In addition, the distribution of diatom species identified in this work were analyzed in reference with the halobien system (Kolbe, 1927, 1932 , Hustedt, 1953, 1957 , Simonsen, 1962, Ehrlich, 1975) which confirmed the results with the autecology of the most identified species.

In conclusion, this information improves our understanding of how diatoms are distributed in Egyptian water habitats with respect to conductivity and provides specific autecological data so that diatoms can be used more effectively in making assessments of ecological change.

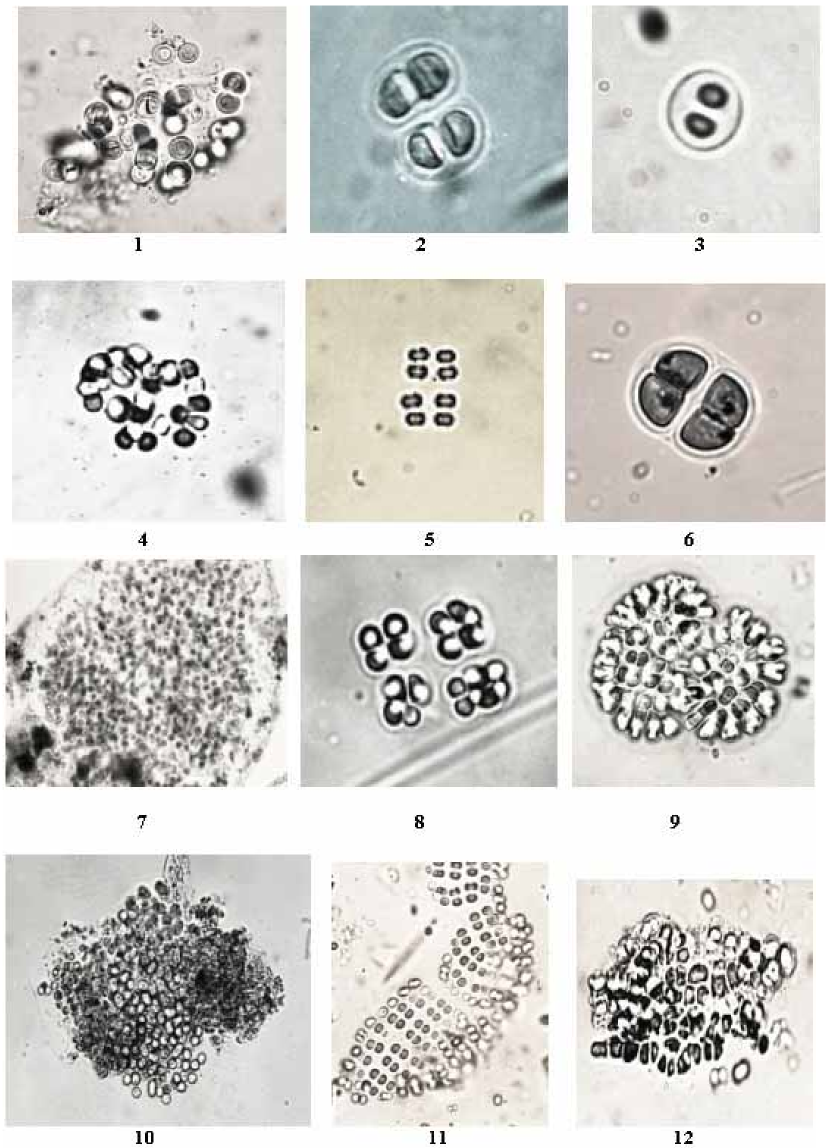

Plate I: *1- Gloeocapsa atrata* (600X)*, 2- Gloeocapsa decorticans* (600X)*, 3- Gloeocapsa gelatinosa* (600X)*, 4- Gloeocapsa lacustris* (600X)*, 5- Gloeocapsa minor* (600X)*, 6- Gloeocapsa turgida* (600 X)*, 7-Microcystis aeruginosa* (600 X), *8-Chroococcocidipsis thermalis* (700 X)*, 9- Gomphosphaeria aponina* (450 X)*, 10- Chlorogloea microcystoides* (400 X)*, 11-Pseudoholopedia convolute* (600 X), *12- Oncobyrsa cestiana* (600X).

Biodiversity of the Identified Species:
Blue-Green Algae (Cyanobacteria):

A total of 164 cyanobacterial taxa were identified in this investigation from the different water habitats (Table 3). All of them are microscopic, although large colonies or mats are quite conspicuous. Coccoid species occur as single cells (Plate II 1, 3, 4 and 5), colonies or masses of various shapes (Plate I,1,2,4,5,6) wherein cells are arranged in rows resulting in a flate plate (Plate I, 11 and Plate II 6), or are arranged radially in spherical colonies (Plate I and 9). Cell numbers may range from few to many, colonies may remain firmly attached with a distinct base and apex (Plate II 12). However, these are enclosed in a gelatinous sheath in consistency and thickness. Filamentous forms produce a row of cells, referred to as trichome. Trichomes may

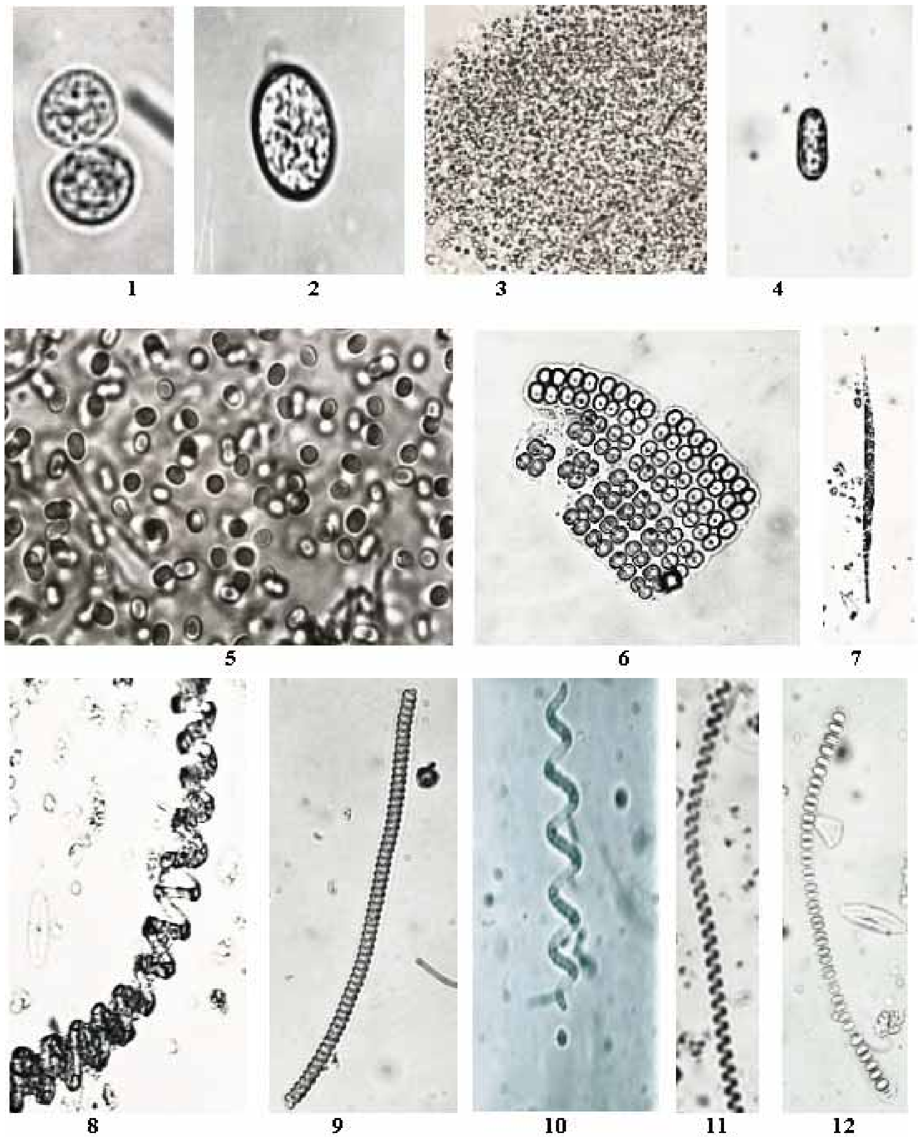

Plate II: *1- Synechococcus aeruginosus* (1000X)*, 2- Synechocystis crassa* (1500X)*, 3- Synechocystis sallensis* (600X)*, 4- Synechocystis salina* (400X), *5- Synechocystis pevalekii* (1500X)*, 6- Merismopedia glauca* (700X)*, 7- Dactylococcopsis acicularis* (600X)*, 8- Spirulina gigantea* (400X)*, 9- Spirulina labyrinthiformis* (450X)*, 10- Spirulina platensis* (450X)*, 11- Spirulina subtilissima* (600X)*, 12- Johannesbaptistia pellucida* (400X)

be simple, straight (Plate III 4, 6 and 10), and or permanently spirally coiled (Plate II 8, 9, 10 and 11). The trichome with the enclosing sheath is referred to as a filament (Plate IV, 8,9,10,12,13,14,16,17,18). Some filamentous species are characterized by true cell differentiation and form heterocystes with unlike vegetative cells (Plate V, 3, 4, 5, 6, 7 and 8). Other heterocystous cyanobacteria also form a second type, an akinate, which can germinate when conditions are suitable for growth (Plate V 2).

Diatoms:

One hundred eighty nine diatom taxa were identified. 18 species were belonged to Class Centrophyceae, while the rest of pennatophycean forms. Centric diatoms showed different morphological shapes , where frustules are circular in shape, usually united into long filaments (Plate V,9,10), valve margin with costae

Table 3: Distibution of blue-greens and diatom taxa along gradients of conductivity.Conductivity is in order of increasing from locality No. 1 to locality No. 18.

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Division Cyanophyta																		
Microcystis aeruginosa Kutz.	+										+		+			+		+
Microcystis elebans (Breb.) Kutz.										+								
Microcystis flos-aquae (Wittr.) Kirchner	+																	
Microcystis litoralis (Hang.) Forti										+								+
Microcystis wesenbergii (Komarek) Komarek in Kondrateve	+																	
Gloeocapsa atrata (Turp.) Kutz.									+									
Gloeocapsa crepidinum Thuret																+		
Gloeocapsa decorticans (A.Br.) Richter								+										
Gloeocapsa gelatinosa Kutz.			+			+		+	+	+			+			+		
Gloeocapsa limnetica Lemm.	+																	
Gloeocapsa minor (Kutz.) Hollerb.			+			+		+	+	+			+		+	+		+
Gloeocapsa minuta (Kutz.) Hollerb.	+					+			+	+				+				
Gloeocapsa montana Kutz.								+										
Gloeocapsa polydermatica Kutz.									+	+								
Gloeocapsa punctata Nag.													+					
Gloeocapsa turgida (Kutz.) Hollerb.	+			+		+			+	+	+	+	+		+	+	+	+
Aphanocapsa elachista W. et G.S. West	+								+									
Aphanocapsa grevillei (Berkeley) Rabenh.	+																	
Aphanocapsa reinboldii (Richter) Komarek et Anagnostidis	+																	
Aphanothece castangnei (Breb.) Rabenh.										+								
Aphanothece nidulans Richter,P.										+								
Aphanothece pallida (Kutz.) Rabenh.			+															
Synechococcus aeruginosus Nag.			+	+							+	+	+		+	+	+	+
Synechococcus cedrorum Sauv.				+		+			+		+	+	+					
Synechococcus elongatus Nag.						+			+	+	+	+	+			+	+	+
Synechocystis aquatilis Sauv.									+	+	+	+	+					
Synechocystis crassa Woronich.				+		+			+	+	+	+	+				+	+
Synechocystis pevalekii Ercegovic	+		+	+		+		+	+	+		+				+		
Synechocystis salina Wisl.									+	+		+				+		
Synechocystis sallensis Skuja									+	+	+	+	+		+	+		+
Rhabdoderma lineare Schmidle and Lauterborn												+	+		+			+
Gomphosphaeria aponina Kutz.								+	+	+		+			+			+
Merismopedia aeuriginea Breb.													+					
Merismopedia glauca (Ehr.) Nag.										+			+					
Merismopedia minima Beck.	+												+					
Merismopedia punctata Meyen	+								+	+		+	+					
Merismopedia tenuissima Lemm.	+								+									
Pseudoholopedia convolute (Breb.) Elenk.										+								
Dactylococcopsis acicularis Lemm.	+									+				+			+	
Dactylococcopsis elenkinii Roll												+						
Dactylococcopsis fasicularis Lemm.																+		
Dactylococcopsis mucicola Hussel										+								
Entophysalis granulosa Kutz.										+								
Chlorogloea microcystoides Geitler				+														
Johannesbaptistia pellucida (Dickie) Taylor et Drout										+	+							
Myxosarcina burmensis Skuja													+	+	+	+		+
Myxosarcina spectabilis Geitler									+							+		
Oncobyrsa cesatiana Rabenh.								+		+								
Oncobyrsa rivularis (Kutz.) Menegh.								+		+								
Arthrospira massartii Kuff.				+														
Spirulina gigantea Schmidle											+							
Spirulina labyrinthiformis (Menegh.) Gomont			+							+	+	+	+		+	+	+	+
Spirulina laxissima G.S. West	+																	
Spirulina major Kutz. Ex Gomont															+			
Spirulina platensis (Nordst.) Geitler											+				+	+		+
Spirulina platensis f.granulata Desikachary															+	+		
Spirulina subtilissima Kutz. ex Gomont			+						+	+	+	+	+			+	+	+
Oscillatoria agardhii Gomont					+													
Oscillatoria amphibia Ag.					+							+						
Oscillatoria anguina (Bory) Gomont			+	+														
Oscillatoria angustissima W.et G.S. West							+											
Oscillatoria animalis Ag. ex Gom.		+	+													+		
Oscillatoria animalis f. tenuior Stockmeyer		+	+				+											
Oscillatoria annae Van Goor									+		+		+			+		+
Oscillatoria boryana Bory ex Gomont																	+	
Oscillatoria brevis (Kutz.) Gomont						+												
Oscillatoria chalybea (Mert.) Gomont										+					+			
Oscillatoria chalybea var.*insularis* Gardner					+													
Oscillatoria claricentrosa Gardner						+		+			+		+				+	+
Oscillatoria claricentrosa f. bigranulata Rao,C.B.							+											
Oscillatoria cortiana Menegh. ex Gomont						+												
Oscillatoria curviceps Ag. ex Gomont			+				+				+					+	+	
Oscillatoria foreoui Fremy																		+
Oscillatoria geminata Menegh.				+		+		+	+	+	+	+	+		+	+	+	+
Oscillatoria geminat f. sulphurea (Stesz.) Elenk.		+	+	+	+	+	+	+	+	+		+						
Oscillatoria gracilis Bocher							+											
Oscillatoria jasorvensis Vouk.			+			+	+		+	+		+						
Oscillatoria laete-virens (Crouan) Gomont											+					+	+	
Oscillatoria limosa Ag. ex Gomont				+		+							+			+		+
Oscillatoria margaritifera (Kutz.) Gomont																+		+
Oscillatoria nigroviridis Thw. ex Gomont									+			+		+		+		+
Oscillatoria obscura Bruhl. et Biswas	+															+		
Oscillatoria okeni Ag. ex Gom.			+				+		+	+	+	+				+	+	+
Oscillatoria planctonica Wolosz.	+																	
Oscillatoria princips Vaucher				+									+			+		+
Oscillatoria proboscidea Gomont			+			+												
Oscillatoria pseudogeminata G.Schmid											+		+		+	+	+	+
Oscillatoria quadripunctulata Bruhl. et Biswas						+												

Table 3: Continued

Oscillatoria raoi De Toni, J.										+								
Oscillatoria sancta (Kutz.) Gomont				+			+			+						+		
Oscillatoria splendida Grev. ex Gomont			+				+				+		+		+	+		
Oscillatoria subbrevis Schmidle				+		+					+		+			+		+
Oscillatoria subtilissima Kutz. ex De Toni																		+
Oscillatoria tenuis Ag. ex Gom.					+		+	+	+	+	+	+	+		+	+		+
Oscillatoria tenuis var.levis (Geitler) Gardner				+														
Oscillatoria terebriformis Ag.ex Gomont						+												
Oscillatoria thermarum Woronich.								+										
Oscillatoria willei Gardner		+	+	+		+	+	+	+	+		+						
Phormidium africanum Lemm.	+																	
Phormidium ambiguum Gomont			+			+		+	+	+	+	+						
Phormidium ambiguum var. major Lemm.								+		+								
Phormidium anomala Rao,C.B.			+															
Phormidium bohneri Schmidle						+	+	+	+	+								
Phormidium corium (Ag.) Gomont	+	+	+	+			+			+								
Phormidium foveolarum (Mont.) Gom.									+	+								
Phormidium fragile (Menegh.) Gom.			+	+		+	+		+	+								
Phormidium inundatum Kutz.					+													
Phormidium jadinianum Gomont										+								
Phormidium lucidum Kutz. ex Gomont			+				+											
Phormidium mucicola (Naum. et Huber. Pest.) Schwabe			+															
Phormidium stagnina Rao,C. B.						+												
Phormidium tenue Menegh. ex Gomont	+		+						+	+								
Lyngbya aestuarii (Mert.) Liemb.				+														
Lyngbya confervoides C.Ag. ex Gomont									+	+		+				+		+
Lyngbya dendrobia Bruhl.et Biswas	+																	
Lyngbya epiphytica Hieron								+	+									
Lyngbya lutea (Ag.) Gomont							+											
Lyngbya martensiana Menegh ex Gomont		+	+			+	+	+	+			+				+		
Lyngbya major Menegh. ex Gomont																+		
Lyngbya majuscule Harvey ex Gomont																+		
Lyngbya semiplena (C.Ag.) J. Ag. ex Gomont									+	+			+			+		
Planktolyngbya limnetica (Lemm.) Kom. Et Cron	+																	
Schizothrix penicillata (Kutz.)Gom.													+					+
Anabaenopsis circularis (G.S.West) Wolosz.et Miller	+												+					
Anabaenopsis cumingtoni Taylor	+																	
Anabaenopsis elenkinii Miller											+		+		+			+
Aphanizomenon flos-aquae (Linnaeus) Ralfs	+																	
Cylindrospermum alatosporum F.E. Fritsch												+						
Cylindrospermum iyengarii Radj													+			+		
Nostoc paludosum Kutz. ex Born et Flah.																+		
Anabaena affinis Lemm.											+		+		+	+	+	+
Anabaena ambiguua Rao, C. B.											+					+	+	
Anabaena bergii f. minor (Kissel.) Kossin.					+													
Anabaena circinalis Rabenh. ex Born. Et Flah.	+																	
Anabaena circinalis var. crassa Ghose																	+	
Anabaena constricta (Szaf.) Geitler						+				+		+						
Anabaena contorta Bach.			+															
Anabaena fertilissima Rao,C.B.																		+
Anabaena flos-aquae (Lyngb.) Breb.	+																	
Anabaena iyengarii Bharadawja											+		+		+	+	+	
Anabaena laxa (Rabenh.) Born. Et Flah.					+		+				+		+		+	+		+
Anabaena naviculoides Fritsch																+		+
Anabaena orientalis Dixit																+		
Anabaena oscillaroides Bory ex Born.et Flah.																+		
Anabaena sphaerica Born. Et Flah.											+		+			+	+	+
Anabaena torulosa (Carm.) Lagerh. ex Born.et Flah.														+				
Pseudoanabaena bipes Bocher			+	+														
Pseudoanabaena catenata Lauterb.											+		+		+			
Pseudoanabaena schmidlei Jaag.O.											+		+		+	+	+	
Nodularia spumigena Mertens ex Born. Et Flah.											+		+		+	+	+	+
Plectonema indicum Dixit										+								
Plectonema radiosum (Schiederm.) Gom.										+								
Homoeothrix balearica (Born.et Flah.) Lemm.										+								
Homoeothrix fusca Starm.									+									
Homoeothrix Juliana (Menegh.) Kirchn.									+									
Homoeothrix Juliana f. tenuis Singh,R. N.									+									
Leptochaete stagnalis Hansgirg											+							
Hammatoidea normanii W.et G.S.West									+									
Hammatoidea simplex Woronich.									+									
Calothrix braunii (A.Br.) Born. Et Flah.											+							
Calothrix contarenii (Zanard.) Born. Et Flah.										+								
Calothrix crustaceae Thuret									+									
Calothrix scopulorum (Weber et Mohr.) Ag. ex Born. et Flah.												+						
Dichothrix baueriana (Grun.) Born.et Flah.										+								
Division Bacillariophyta																		
Melosira distans (Ehr.) Simonsen	+																	
Melosira granulata (Ehr.) Ralfa																+		+
Melosira granulata var. *angustissima* (O.Mull.) Simonsen	+																	
Melosira granulata var. *granulata* f. *valida* (Hust.) Simonsen	+																	
Melosira moniliformis var. *subglobosa* Grun.										+								
Melosira nummuloids (Dillwyn) C.A. Agardh														+				
Melosira nyassensis O.Mull.	+																	
Martyana martyi (Heriband) Round														+				
Cyclotella glomerata Bachmann	+																	
Cyclotella kutzingiana Thwaites	+										+		+		+	+		+
Cyclotella meneghiniana Kutz.	+								+		+		+	+	+	+	+	

Table 3: Continued

Cyclotella ocellata Pant.	+																	
Stephanodiscus aegyptiacum (Ehr.) S.Meister	+																	
Coscinodiscus griseus Grev.												+						
Biddulphia aurita (Lyngb.) Breb.												+						
Biddulphia levis (E.) Hust.								+										
Terpsinoe Americana (Bail.) Ralfs								+		+								
Terpsinoe musica Ehr.																	+	
Fragillaria construens (Ehr.) Grun.	+																	
Fragillaria construens var.*subsalina* Hust.											+		+					
Fragillaria construens var. *venter* (Ehr.) Grun.													+		+	+		+
Fragillaria intermedia Grun.						+												
Synedra acus (Ehr.) Grun.	+	+				+		+	+	+		+		+				
Synedra acus var. *angustissima* Grun.			+				+											
Synedra acus var. *radians* Kutz.									+									
Synedra brevistriata Grun.	+																	
Synedra delicatissima W.Sm.											+							
Synedra nana Meist												+						
Synedra tabulata (Ag.) Kutz.	+							+	+		+	+	+		+	+	+	+
Synedra ulna (Nitzsch.) Ehr.						+					+		+			+	+	
Synedra ulna var. amphirhynchus Kutz.	+																	
Synedra ulna var.*biceps* Kutz.	+																	
Synedra ulna var. *danica* (Kutz.) Grun.						+												
Synedra ulna var. *impressa* Hust.	+																	
Diatoma anceps (Ehr.) Kirchn.					+	+												
Licmophora gracilis Hantzsch												+						
Achnanthes affinis Grun.													+					
Achnanthes altaica (Por.) A.Cl.													+		+		+	
Achnanthes brevipes var. *intermedia* Kutz.								+		+	+					+		+
Achnanthes clevei Grun.											+							
Achnanthes exigua Grun.			+															
Achnanthes hungarica Grun.													+			+		+
Achnanthes lemmermanni Hust.							+											
Achnanthes linearis (W.Sm.) Grun.											+		+					
Cocconeis pediculus Her.														+				
Cocconeis placentula Ehr.	+						+				+							
Cocconeis placentula var. *lineate* (Ehr.) V.H.													+				+	
Cocconeis placentula var.*euglypta* (Ehr.) Cl.													+			+	+	+
Amphiprora paludosa var.*subsalina* Cleve													+			+	+	
Rhoicosphenia curvata (Kutz.) Grun.														+				
Mastogloia braunii Grun.										+		+	+			+	+	
Mastogloia pumila (Grun.) Cl.										+						+		
Mastogloia smithii Thw. ex W.Sm.										+		+	+		+	+		
Frustulia rhomboids var. *saxonica* (Rabenh.) De Toni				+														
Diploneis boldtiana Cl.								+										
Diploneis elliptica (Kutz.) Cleve					+			+	+	+		+				+		
Diploneis interrupta (Kutz.) Cl.												+						
Diploneis oblongella (Nag. ex Kutz.) Cl.								+	+	+		+						
Diploneis ovalis Cleve								+		+			+			+		
Diploneis pseudovalis Hust.								+	+	+		+						
Diploneis puella (Schum.) Cl.										+								
Diploneis smithii (Breb. Ex W.Sm.) Cl.									+									
Diploneis smithii var. *pumila* (Grun.) Hust.								+	+			+						
Diploneis subovalis Cl.								+										
Amphora coffeaeformis (Ag.) Kutz.							+	+	+	+	+	+	+		+	+	+	+
Amphora commutate Grun.										+								
Amphora lineolata Ehr.												+						
Amphora ovalis Kutz.	+										+		+		+	+	+	+
Amphora ovalis var. *pediculus* Kutz.			+				+											
Amphora pediculus (Kutz.) Grun.	+																	
Amphora robusta Greg.										+								
Amphora veneta Kutz.								+				+						
Anomeoneis costata (Kutz.) Hust.															+			
Anomeoneis sphaerophora (Ehr.) Pfitzer											+		+		+	+	+	
Anomoeoneis spaerophora var. *sculpta* O.Mull.											+		+		+	+	+	
Navicula capitata Her.														+				
Navicula cincta Kutz.	+							+	+			+		+				
Navicula confervaceae (Kutz.) Grun.					+	+	+				+							
Navicula cryptocephala Kutz.			+		+		+						+		+	+	+	+
Navicula cryptocephala var. *veneta* (Kutz.) Grun.												+		+		+	+	+
Navicula cuspidate (Kutz.) Cl.											+		+		+	+	+	
Navicula cuspidate var. *ambigua* (Ehr.) Grun.											+							
Navicula digitoradiata (Gregory) Ralfs														+				
Navicula disjuncta Hust.									+	+								
Navicula erifuga Lange-Bertalot										+								
Navicula *forcipata* Grev.												+						
Navicula gastrum Her.	+							+	+	+								
Navicula halophila f. tenuirostris Hust.													+			+	+	
Navicula halophila var. *leptocephala* (Breb. ex Grun.) Patr.					+		+		+									
Navicula leptostriata Jorgensen										+								
Navicula lyra Ehr.													+					
Navicula mutica f. *lanceolata* Frenguelli	+																	
Navicula pupula Kutz.	+		+			+			+	+			+					
Navicula pupula var. *capitata* (Grun) Hust.	+																	
Navicula pygmaeae Kutz.													+					
Navicula radiosa Kutz.	+																	
Navicula radiosa var. *tenella* (Breb. ex Kutz.) Grun.													+					
Navicula rhynchocephala var. *amphiceros* (Kutz.) Grun.															+			
Navicula stankovicii Hust.										+								
Navicula tenelloids Hust.									+	+								
Navicula veneta Kutz.								+										
Stauroneis obtusa Lagerst.					+		+									+		

Table 3: Cotinued

Pinnularia brebissonii (Kutz.) Rabenh.						+									+	+		
Pinnularia major (Kutz.) Cl.					+		+						+		+	+	+	
Pinnularia microstauron (Ehr.) Cl.					+		+								+	+	+	
Pinnularia passargei Reich											+		+		+	+		
Pinnularia subsolaris (Grun.) Cl.						+	+											
Pinnularia viridis (Nitzsch) Ehr.					+		+											
Caloneis bannajensis Boye P.													+			+	+	
Caloneis bacillum (Grun.) Cl.					+													
Caloneis (Grun.) Krammer			+															
Caloneis oregonica var. *quadrilineata* (Grun. ex Cl.) Patr. Comb. Nor.											+							
Nedium affine (Ehr.) Pfitz.					+		+											
Nedium apiculatum Reim.																		+
Nedium bisculactum var. *subundulatum* (Grun.) Reim.								+										
Nedium dubium (Ehr.) Cl.											+		+				+	+
Nedium rudimentarum Reim																		+
Gyrosigma acuminatum (Kutz.) Rabenh.							+											
Gyrosigma attenuatum (Kutz.) Rabenh.	+																	
Pleurosigma delicatulum W.Sm.										+		+						
Pleurosigma elongatum W.Sm.													+			+	+	
Pleurosigma strigosum W.Sm.												+						
Cymbella affinis Kutz.	+										+							
Cymbella herbidica (Greg.) Grun.					+													
Cymbella minuta Hilse			+		+		+	+				+						
Cymbella pusilla Grun.									+		+		+		+	+	+	+
Cymbella prostrate (Berk.) Cl.																		
Cymbella tumida (Breb.) Van Heurck	+																	
Gomphonema gracile Ehr.	+						+		+									
Gomphonema gracile var. *dichotomum* W.Sm.								+										
Gomphonema intricatum Kutz.													+		+	+		
Gomphonema parvulum Kutz.					+	+		+			+		+		+	+	+	+
Gomphonema parvulum var. *micropus* (Kutz.) Cl.	+																	
Epithemia sorex Kutz.	+																	
Epithemia turgida (Ehr.) Kutz.													+		+			
Epithemia zebra (Ehr.) Kutz. f. *typica* Cleve Euler															+	+	+	
Rhopalodia constricta (W.Sm.) Krammer												+						
Rhopalodia gibba (Her.) O.Mull.	+				+		+			+					+		+	
Rhopalodia gibba var. *ventricosa* (Kutz.) H. and M. Perag.										+								
Rhopalodia gibberulla (Ehr.) O.Mull.					+		+	+		+	+		+		+	+		+
Rhopalodia musculus (Kutz.) O.Mull.											+		+		+	+	+	+
Hantzschia amphioxys (Ehr.) Grun.						+						+						+
Bacillaria paradoxa Gmelin	+												+			+		
Nitzschia acicularis W.Sm.																		+
Nitzschia acuta Hantzsch													+					
Nitzschia amphibia Grun.	+					+				+	+		+	+	+	+		
Nitzschia apiculata (Gregory) Grun.	+									+			+			+	+	
Nitzschia capitellata Hust.								+										
Nitzschia communis Rabenhorst													+	+				
Nitzschia constricta (Kutz.) Ralfs									+				+					
Nitzschia elegantula Grun.									+									
Nitzschia filiformis (W.Sm.) Hust.								+		+		+						
Nitzschia flexa Schumann											+							
Nitzschia fonticola Grun.								+	+							+		
Nitzschia frustulum (Kutz.) Grun.	+							+									+	
Nitzschia frustulum var. *perminuta* Grun.									+	+								
Nitzschia graciilis Hantzsch								+	+			+						
Nitzschia hungarica Grun.							+				+		+		+	+	+	+
Nitzschia hybrida Grun.																	+	
Nitzschia linearis W.Sm.											+					+		
Nitzschia microcephala Grun.	+										+	+	+			+	+	+
Nitzschia obtuse W.Sm.					+		+	+			+		+			+	+	+
Nitzschia obtuse var. *kurzii* Rabenh. Ex Cleve and Moller							+		+	+		+						
Nitzschia obtuse var. *scalpelliformis* Grun.								+		+	+		+		+	+	+	
Nitzschia palea (Kutz.) W.Sm.	+	+	+		+	+	+	+	+		+	+			+	+	+	+
Nitzschia perminuta (Grun.) Peragallo										+								
Nitzschia quadrangular (Kutz.) Lange-Bertalot								+										
Nitzschia recta Hantzsch											+							
Nitzschia scalaris (Ehr.) W.Sm.										+								
Nitzschia scalpelliformis Grun.	+																	
Nitzschia sigma (Kutz.) W.Sm.								+			+				+	+	+	
Nitzschia sigma var. *rigidula* Grun.							+											
Nitzschia sublinearis Hust.											+							
Nitzschia subtilis (Kutz.) Grun.											+							
Nitzschia thermalis (Ehr.) Auers.													+					
Nitzschia tryblionella Hantzsch.															+		+	+
Nitzschia tryblionella var. *debilis* (Arnott) A. Mayer									+									
Nitzschia tryblionella var. *victoriae* Grun.					+													
Nitzschia valedstriata Aleem and Hust.														+				
Nitzschia vitrea Norman											+				+	+	+	+
Cymatopleura solea (Breb.) W.Sm.	+																	
Campylodiscus clypeus Ehr.											+			+	+	+	+	+
Campylodiscus clypeus var. *bicostata* W.Sm.															+		+	
Campylodiscus echeneis Ehr.										+								
Surirella brebissoni Krammer and Lange-Bertalot															+			
Surirella elegans Ehr.					+		+											
Surirella ovalis Breb.	+						+				+				+			
Surirella peisonis Pantocsek																+		
Surirella striatula Turpin															+	+	+	+

1= Nile , 2 = Ain Halfa (Bahariya Oasis) , 3 =Ain El-Goag (Bahariya Oasis) , 4 = Ain El-Ramla (Bahariya Oasis) , 5 = Ain El-Mahabes (Bahariya Oasis) , 6 = Ain El-Nibika (Bahariya Oasis) , 7 = Ain El-Hobga (Bahariya Oasis) , 8 =Ain Helwan , 9 = Hammam Musa ,10 = Ain El-Sokhna , 11 = El-Sabkha Lake (Wadi El-Natrun) ,12 = Hammam Faroun , 13 = El-Fasda Lake (Wadi El-Natrun) , 14 = El-Temsah Lake , 15 = El-Khadra Lake (WadiEl-Natrun) , 16 = El-Hamra Lake (Wadi El-Natrun) ,17 = El-Zaagig Lake (Wadi El-Natrun) , 18 = El-Gaar Lake (Wadi El-Natrun).

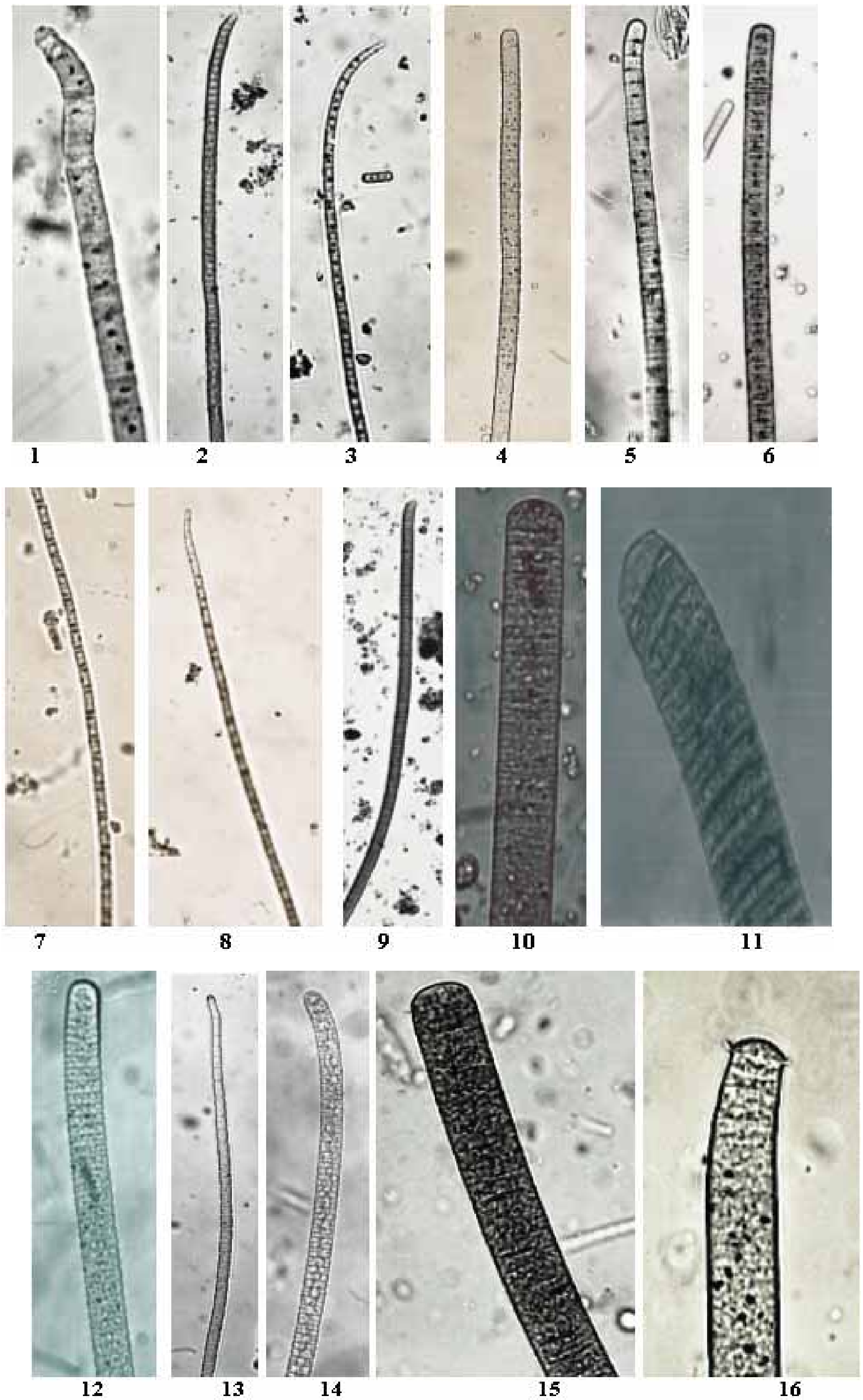

Plate III: *1- Oscillatoria anguina* (1500X), *2- O. animalis* (700X)*, 3- O. animalis f. tenuior* (700X)*, 4- O. annae* (700X), *5- O. chalybea var. insularis* (700X), *6- O. curviceps* (450X)*, 7- O. geminate* (1000X), *8- O. jasorvensis* (700 X), *9- O. laete-virens* (700X), *10-O.limosa* (700X)*, 11- O. margaritifera* (700X) , *12- O. nigroviridis* (700X)*, 13- O. okeni* (600X)*, 14- O. ornate* (700X)*, 15- O. princips* (600X)*, 16- O. proboscidea* (600X).

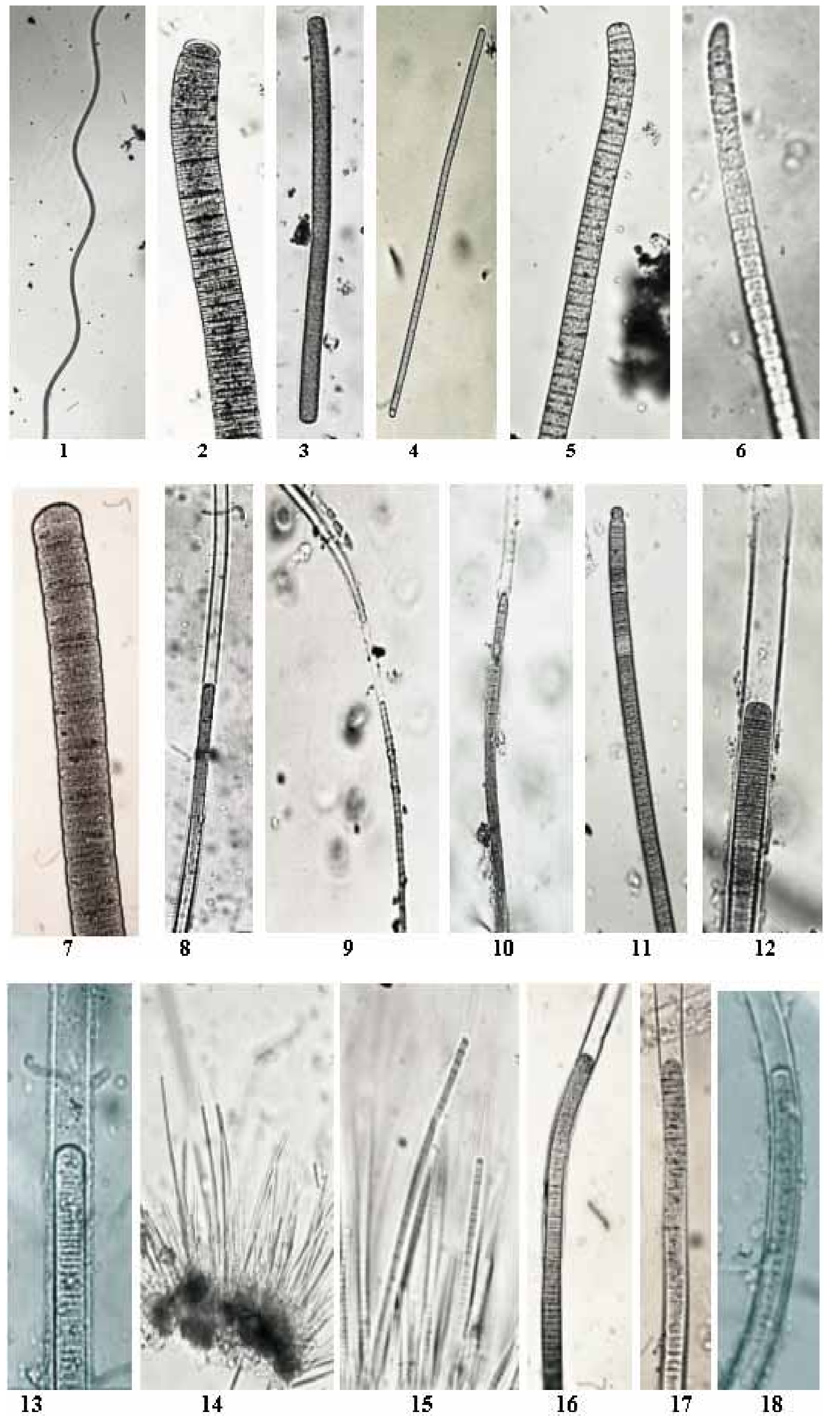

Plate IV: *1- Oscillatoria pseudogeminata* (1500X), *2- O. sancta* (650X), *3- O. subbrevis* (700X), *4- O. subtilissima* (900X), *5- O. tenuis* (600X), *6- O. willei* (600X), *7- O. sp.* (600X), *8- Phormidium ambiguum* (700X), *9- Ph. Bohneri* (700X), *10- Ph. Corium* (700X), *11- Ph. Lucidum* (700X), *12- Lyngbya aestuarii* (600X), *13- L. confervoides* (600X), *14, 15- L. epiphytica* (1500X), *16- L. martensiana* (600X), *17- L. semiplenea* (600X), *18- L. majuscule* (600X).

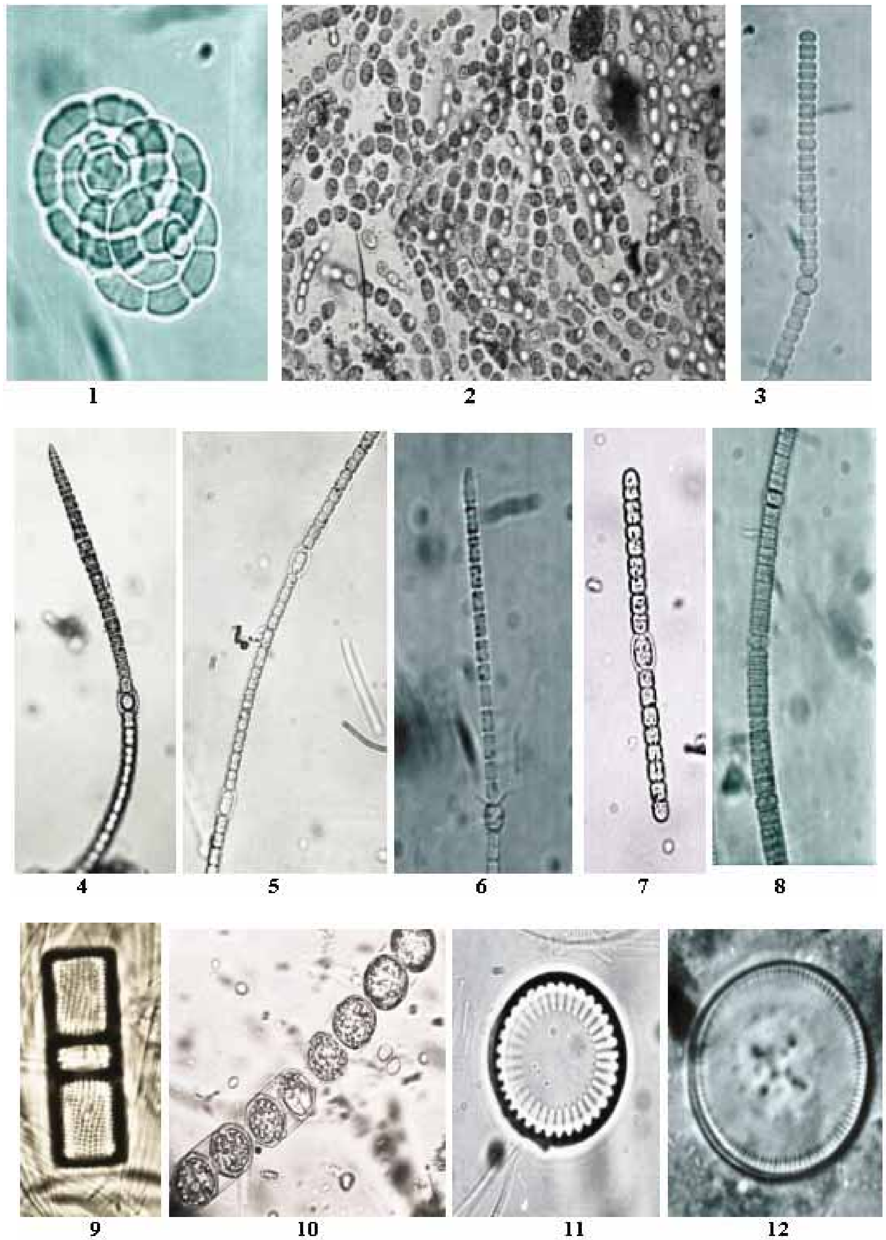

Plate V: *1- Anabaenopsis Elenkinii* (600X), *2- Nostoc sp.* (600X) , *3- Anabaena affinis* (600X), *4- Anabaena bergi f. minor* (600X), *5- Anabaena inaequalis* (600X), *6- Anabaena iyengarii* (600X), *7- Anabaena laxa* (600X), *8- Nodularia spumigena* (600X), *9- Melosira granulata* (1200X), *10- Melosira moniliformis var. subglobosa* (1200X), *11- Cyclotella meneghiniana* (1200X), *12- Cyclotella kützingiana* (1500X).

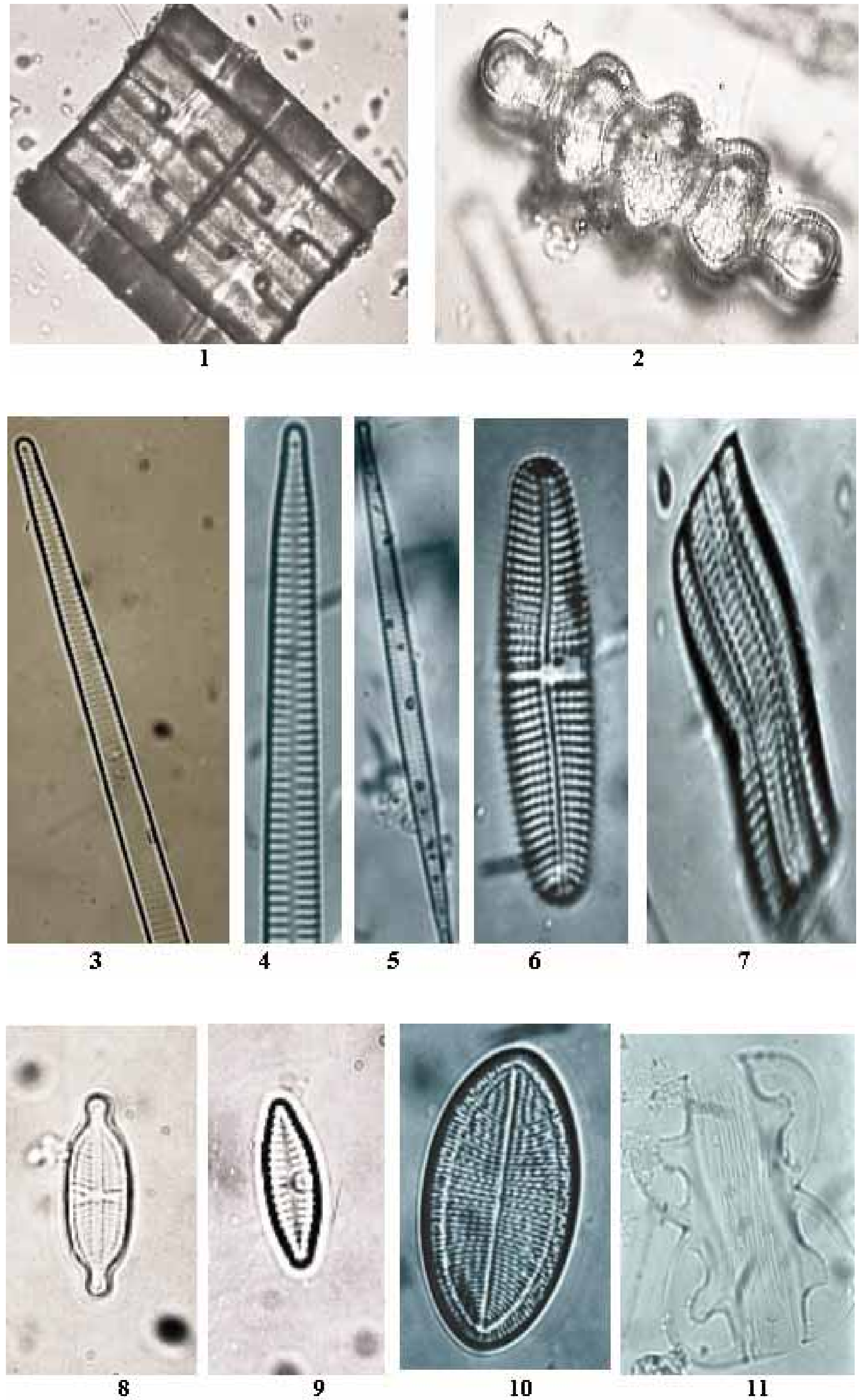

Plate VI: *1,2- Terpsinoe Americana* (700X), *3- Synedra acus* (1200X), *4-Synedra ulna* (1200X), *5- Synedra tabulate* (1200X), *6,7- Achnanthes brevipes var. intermedia* (1200X), *8- Achnanthes exigua* (1200X), *9- Achnanthes lanceolata var. rostrata* (1200X), *10- Cocconeis placentula var. euglypta* (1200X), *11- Amphiprora paludosa var. subsalina* (900X).

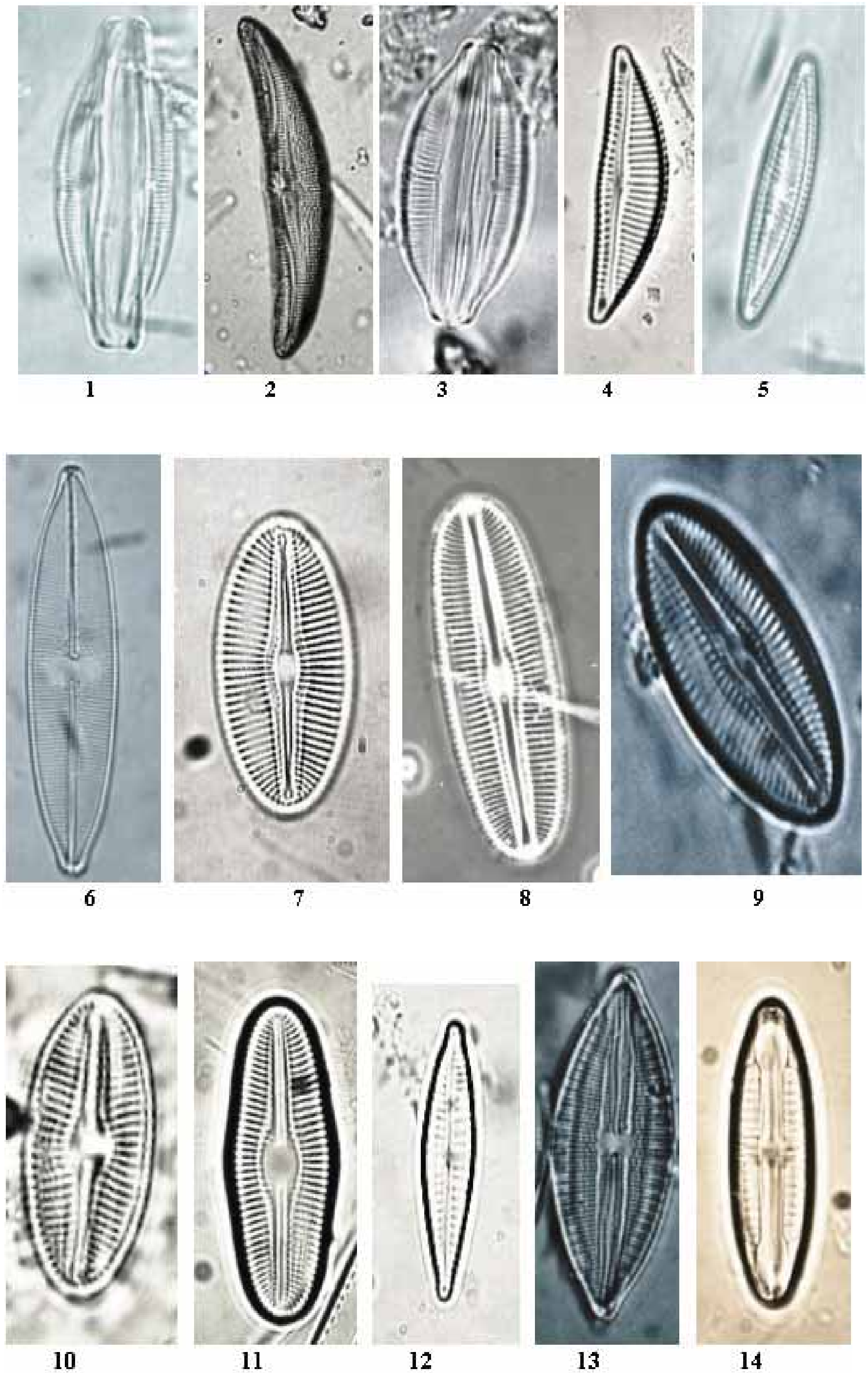

Plate VII: *1- Amphora coffeaeformis* (1200X), *2- Amphora robusta* (1200X), *3- Amphora veneta* (1200X), *4- Cymbella herbidica* (1200X), *5- Cymbella pusilla* (1200X), *6- Caloneis bannajensis* (1200X), *7- Diploneis elliptica* (1200X), *8- Diploneis oblongella* (1200X), *9- Diploneis ovalis* (1200X), *10- Diploneis pseudovalis* (1200X), *11- Diploneis sp.* (1200X), *12- Gomphonema parvulum* (1200X), *13- Mastogloia smithii* (1200X), *14- Mastogloia braunii* (1200X).

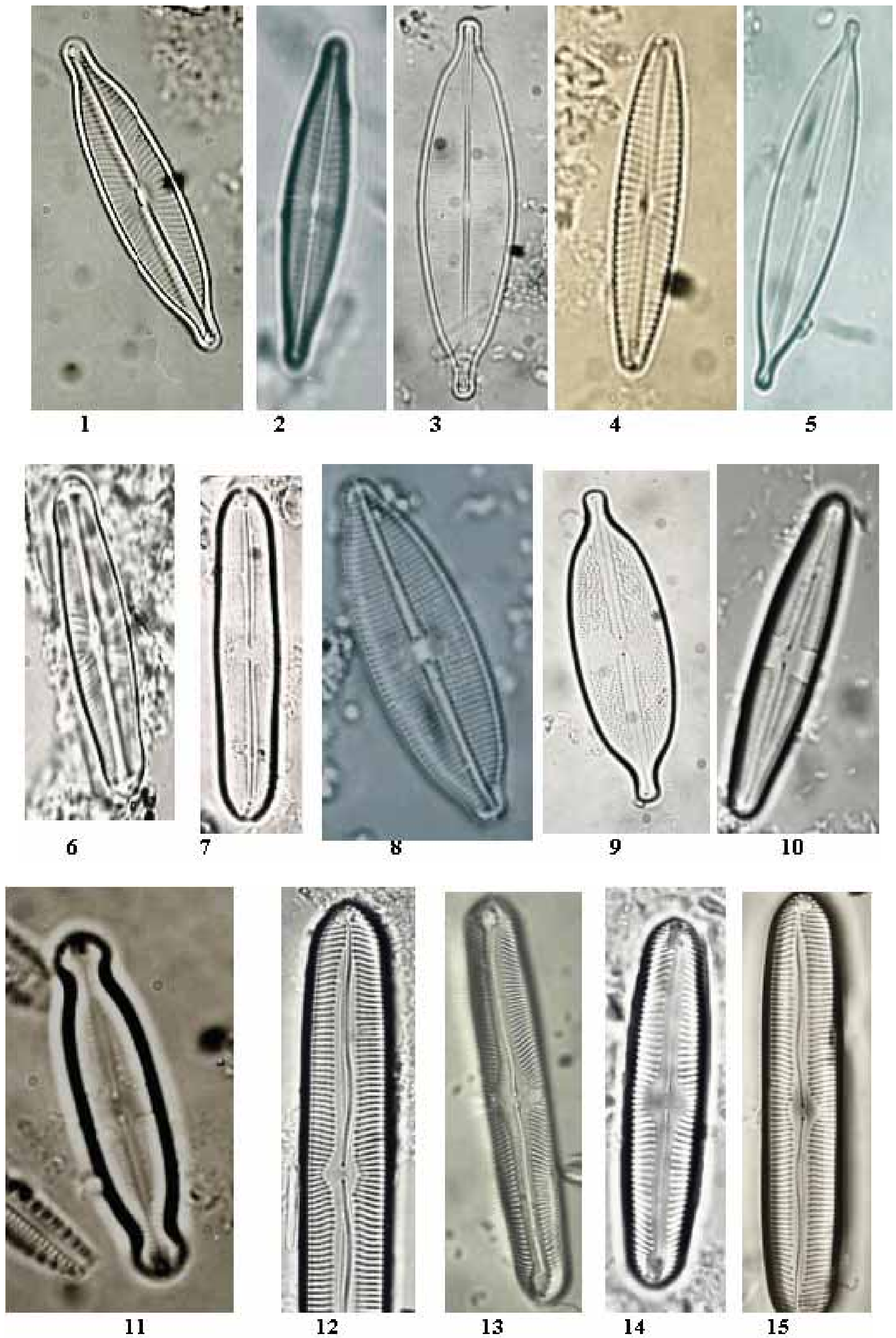

Plate VIII: *1- Navicula cryptocephala* (1200X), *2- Navicula cryptocephala var. veneta* (1200X), *3- Navicula cuspidate* (1200X), *4- Navicula heufleri var. leptocephala* (1200X), *5- Navicula halophila f. tenuirostris* (1200X), *6- Navicula pupula* (1200X), *7- Neidium bisculatum var. subundulatum* (1200X), *8- Nedium dubium* (1200X), *9- Anomoeonies sphaerophora* (1200X), *10- Stauroneis obtuse* (1200X), *11- Pinnularia interrupta f. minutissima* (1200X), *12- Pinnularia major* (100X), *13- Pinnularia microstauron* (1200X), *14- Pinnularia subsolaris* (1200X), *15- Pinnularia viridis* (1200X).

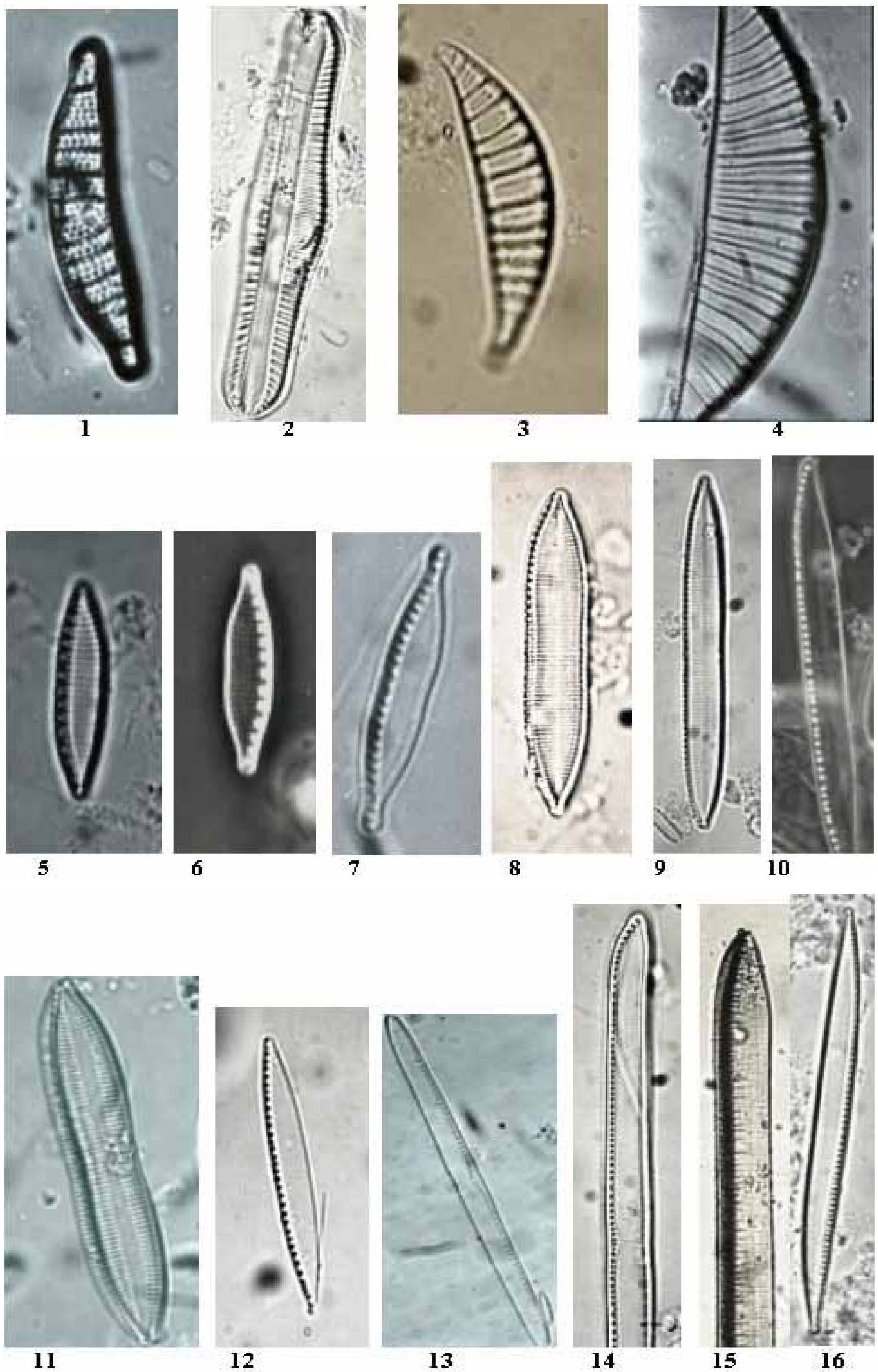

Plate IX: *1- Epithemia turgida* (1200X), *2- Rhopalodia gibba* (1200X), *3- Rhopalodia gibberulla* (1200X), *4- Rhopalodia musculus* (1200X), *5- Nitzschia amphibian* (1500X), *6- Nitzschia elegantula* (1500X), *7- Nitzschia microcephala* (1500X), *8- Nitzschia apiculata* (1500X), *9- Nitzschia constricta* (1500X), *10- Nitzschia filiformis* (1500X), *11- Nitzschia hungarica* (1500X), *12- Nitzschia palea* (1500X), *13- Nitzschia obtuse* (1500X), *14- Nitzschia obtusa var. kurzii* (1200X), *15- Nitzschia scalaris* (1200X), *16- Nitzschia sigma* (1500X).

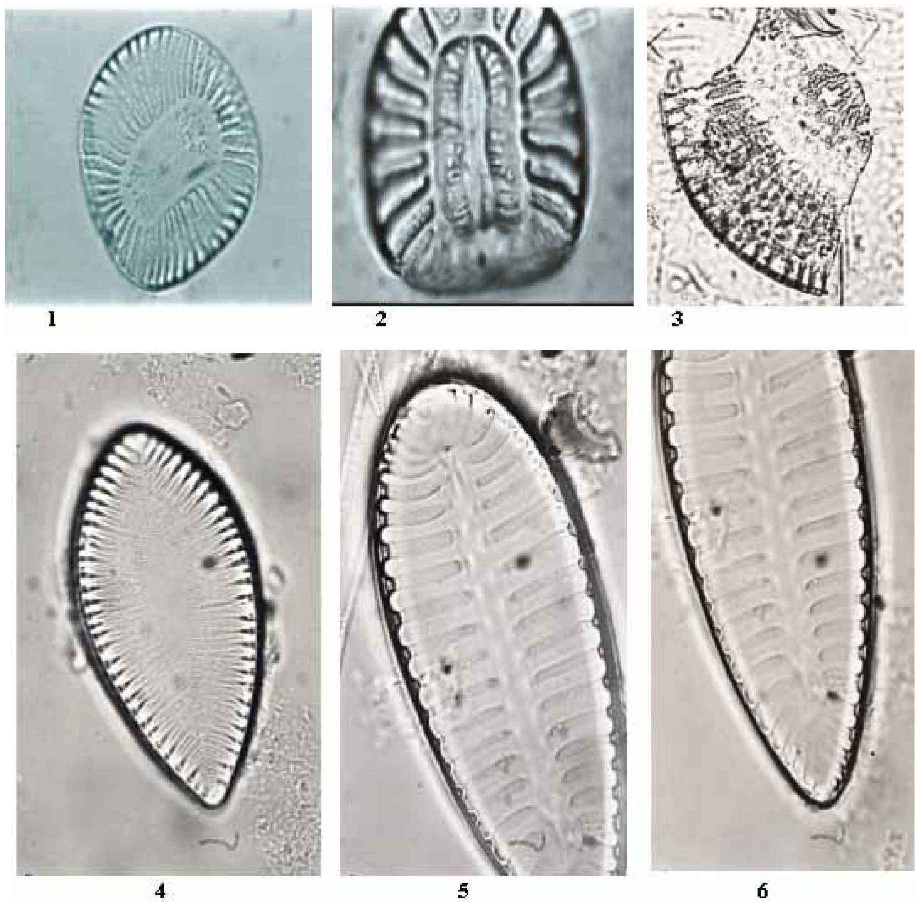

Plate X: *1- Campylodiscus clypeus* (1000X), *2- Campylodiscus clypeus var. bicostata* (1000X), *3- Campylodiscus echeneis* (1000X), *4- Surirella ovalis* (1100X), *5, 6- Surirella elegans* (1100X).

ornamentation which differ from that of the central area (Plate V, 11 and 12). The frustule of certain centric diatom species showed three circular undulation (Plate VI, 2). Valves of the pennate diatoms are generally elongated (linear) with their markings arranged in transverse rows along each margin. Frustule may be linear, solitary with striae forming pseudoraphe on both valves (Plate VI, 3,4 and 5) or may be raphed which is evident on at least on one valve (Plate VI, 8, 9 and 10). Valves not similarly ornamented where raphe on the valve, and opposing valve with pseudoraphe (Plate VI, 10). Valves may be symmetrical about the transapical plane and asymmetrical about the apical plane (Plate VII, 1, 2, 3, 4 and 5). Other pennate diatoms, their valves are symmetrical about both the transapical and apical plane (Plate VIII), while some are represented by symmetrical valves along the apical axis and a symmetrical along the transapical axis (Plate VII 12 and Plate X 4 5 and 6). Valves with longitudinal shaddow –lines or blank spaces (Plate VIII 7 and 9), or may bearing raphe enclosed in a siliceous rib (Plate VII, 7, 8, 9, 10 and 11). The central area of the valve extending laterally to the margins, where straie are absent along lateral margins of the central area (Plate VIII, 10), or striae are present (Plate VIII, 1, 2, 3, 4 and 5). In some pennatophycean species, raphe may be enclosed in a keel on one margin of the valve (Plate IX, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16). The keel may extend along both margins of each valve (Plate X, 4, 5 and 6).

REFERENCES

Anagonstidis, K. and J Komárek, 1985. Modern approach to classification system of cyanophytes. 1. Introduction.- *Arch. Hydrobiol. Suppl.,* 71 (1/2) Algological studies, 38-39: 291-302.

Anagonstidis, K. and J Komárek, 1988. Modern approach to classification system of cyanophytes. 3. Oscillatoriales- Arch. Hydrobiol. Suppl., 80 Algological studies, 50/53: 327-372.

Cholonky, B.J., 1968. *Die Ökologie der Diatomeen in Binnengewässern*. J. Cramer, Lehre. 4.

Cleve-Euler, A., 1951. *Die Diatomeen von Schweden und Finnland. Teill I.* K. Sevenska Ventensk-Akad. Handle. Ser. 2(1): 163.

Cleve-Euler, A., 1952. *Die Diatomeen von Schweden und Finnland. Teill V.* K. Sevenska Ventensk-Akad. Handle. Ser., 3(3): 153.

Cleve-Euler, A., 1953. *Die Diatomeen von Schweden und Finnland. Teill III.* K. Sevenska Ventensk-Akad.Handle. Ser., 4(5): 255.

Cleve-Euler, A., 1955. *Die Diatomeen von Schweden und Finnland. Teill IV.* K. Sevenska Ventensk-Akad. Handle. Ser., 5(4): 232.

Desikachary, T.V., 1959. *Cyanophyta*. Indian Council of Agricultural Research. New Delhi., pp: 686.

Ehrlich, A., 1975. The diatoms from the surface sediments of the Bardawil lagoon (Northern Sinai)- Paleoecological significance. Nova Hedwigia, *Beihft.*, 53: 253-277.

El-Shoubaky, G.A. and A.F. Hamed, 2006. The Characteristic Algal Mats and Flora of El-Timsah Lake. *CATRINA*, 1(2): 75-80.

Garg, S.P., 1978. Ground water and tube wells. Oxford and IBH Pub. Co. New Delhi, Bombay, Calcutta., pp: 245.

Geitler, L., 1932. *Cyanophycehae*. – In: Rabenhorst's Kryptogamen Flora, 14. Leipzing, Akad. Verlag, pp:1196.

Gollerbach, M.M., E.K. Kosinskaja and V.I. Polanskii, 1953. Freshwater algae of USSR, *Cyanophyta*.- Pub. Sov. Nauka, Moscow, pp: 652.

Hamed, A.F., 2005. Survey of distribution and diversity of blue green algae (Cyanobacteria) in Egypt. *Acta Bota. Hung.*, 47(1-2): 117-136.

Hamed, A.F., B.B. Salem and Abd H.M. El-Fatah, 2007a. Floristic Survey of Blue-Green Algae / Cyanobacteria in Saline-Alkaline Lakes of Wadi El-Natrun (Egypt) by Remote Sensing Application. J. Applied Sciences Research, 3(6): 495-506.

Hamed, A.F., B.B. Salem and H.M. Abd El-Fatah, 2007b. The Diatom Flora of Wadi El-Natrun and its Ecological Implications. Research J. Agriculture and Biological Sciences, 3(4): 329-350.

Hustedt, F., 1930. *Bacillariophyta (Diatomae)*. In A. Pascher, Die Susswasser-Flora Mitteleuropas. Heft 10. Gustav Fischer, Jana, Germany., pp: 468.

Hustedt, F., 1939. Systematische und okologische untersuchungen uber die Diatomeen-Flora von Java, Bali und Sumatra. *Arch. Hydrobiol.*, Suppl. 15: 131-177, 187- 295, 393-506, 638-790, Suppl., 16: 1-155, 274-394.

Hustedt, F., 1953. Die systematisk der diatomeen in ihren Beziehungen zur Geologie und okologie nebst einert Rivision des Halobien-Systems. Svensk Botanisk Tidskrift., 47(4): 509-519.

Hustedt, F., 1957. Die Diatomeenflora des Fluss-Systems der Weser in Gebiet der Hansestadt Bremen. Abh. Naturw. Ver. Bremen, 34: 181-440.

Jensen, N.G., 1985. *The pennate diatoms*. A translation of Hustedt' s “Die Kieselalgen, 2. Teil.” Koeltz Scientific Books, Koenigstein., pp: 918.

Jouse, A.P., A.I. Proschkina-Laverenko and V.C. Sheshykova, 1949. *Diatom analysis.*Vol. I. Pub. “Geol. Liter”. Leningard., pp: 339.

Klimentov, P.P., 1983. *General Hydrogeology*. Mir. Pub. Moscow., pp: 239.

Kolbe, R.W., 1927. Zur okologie. Morphlogie und Systematik der Brackwasser-Diatomeen. Phanzenforschung, 7: 1-146.

Kolbe, R.W., 1932. Grundlinien einer algemeinen okologie der Diatomeen. Erge bnisseder Biologie. Berlin., 8: 221-348.

Komárek, J. and K. Anagonstidis, 1986. Modern approach to the classification system of cyanophytes. 2. Chroococcales. – Arch. Hydrobiol. Suppl., Algological Studies, 73: 157-226.

Krammer, K. and H. Lang-Bertalot, 1986. *Bacillariophyceae.* Naviculaceae. Gustav. Fisher Verlag. Stuttgart. New York., pp: 876.

Krammer, K. and H. Lang-Bertalot, 1988. *Bacillariophyceae.* Nitzschiaceae. Gustav. Fisher Verlag. Stuttgart. New York., pp: 821.

Mianping, Z., 2001. On Salinology. *Hydrobiologia*, 466: 339-347.

Patrick, R. and C.W. Reimer, 1966. *The diatoms of the United States*- Acad. Nat. Sci. Philadelphia. Monograph, 13(1): 1-688.

Patrick, R. and C.W. Reimer, 1975. The diatoms of the United States- Acad. Nat. Sci. Philadelphia. Monograph, 13(2,1): 1-213.

Potapova, M. and D.F. Charles, 2003. Distribution of benthic diatoms in US rivers to conductivity and ion composition. Freshwater Biology, (48)8: 1311-1328.

Proschkina – Laverenko, A.I., S.I. Gleser, A.P. Jouse, I.V. Makarova and V.S. Schesschykova-Poretzaja, 1974. The diatoms of USSR. Fossil and recent-Vol. I. Pub. House "Sov. Nauke." Leningard Branch. pp: 372.

Sigee, D.C., 2005. *Freshwater Microbiology*: Biodiversity and dynamic interactions of microorganisms in the aquatic environments. John Wiley and Sons, pp: 544.

Simonsen, R., 1962. Untersauchungen zur systematic und okologie der bodendiatomeen der westlichen Ostree. Syst. Beih. Intern. Rev. Gesamt. *Hydrobiol.*, 1: 144, pls 1-4.

Thajuddin, N. and G. Subramanian, 2005. Cyanobacterial biodiversity and potential applications in biotechnology. Current Science, 89(1): 47-57.

Van Landingham, 1982. Guide to the identification, environmental requirements and pollution tolerance of blue green algae. EPA 600/ 3-82-073.

Zahran, M.A. and A.J. Willis, 2003. Plant Life in the River Nile in Egypt. MARS Publishing House.