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RESEARCH ARTICLE

Ecological Observation on Phytoplankton Species Composition in Wastewater Treatment Plant / Iraq

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Abstract

The present study focuses on phytoplankton species composition in wastewater treatment plant. Semi-monthly sampling was collected from three selected sites to implement in the study plant from November, 2012 to April, 2013. Phytoplankton and physicochemical parameters investigated in the present study.

The results showed the dominance of non-diatomic algae qualitatively and quantitatively. The non diatomic algae represented 55.7% of the total identified algae, where Cyanophyceae, Chlorophyceae and Euglenophyceae represented 31.2%, 11.5% and 6.1%, while each of Xanthophyceae and Chrysophyceae represented 2.04% and 0.68% for Rhodophyceae. Diatomic algae represented 44.2% of the total identified phytoplankton during the study period. The total number of phytoplankton ranged 2512-26649 cell x 10^3/l, while chlorophyll-a ranged 7.57-44.88 mg/l.

Nine species of phytoplankton recorded in the present study as a new record in Iraq. These are *Anabaena naviculoides, Arthrospria jenneri, Camptylonemopsis, Lyngbya polysiphoniae, Echinosphaerella limnetica, Excentrosphaera viridis, Sphaeroplea annulina, Trachelomonas dybowskii, Hemidinum nasutum.*

The physicochemical parameters were temperature (air and water), electric conductivity, salinity, pH, TDS and TSS. The study included dissolved oxygen, biochemical oxygen demand, total alkalinity, total hardness, calcium, magnesium, chloride, ammonia, nitrite, nitrate and phosphate. The study concluded that the major constituent of Almamierh wastewater treatment plant has level between medium to strong domestic wastewater.

Introduction

The water scarcity is a real threat to many regions worldwide due to the huge usages of water. That increased threefold compared with 1950, As one out of six people cannot get safe drinking water, and the lack of potable water and sewage disposal affect the health of 1.2 billion people annually (WHO and UNICEF, 2000).In treatment plant, there are diverse organisms such as viruses, bacteria, phytoplankton, protozoa, Helminths, Fungi and invertebrates that play a major role in the recycling of energy and nutrients flow in these systems (Hoogenboezem, 2007).

Algae are the base of the food web in all aquatic ecosystems and larger organisms produced and stabilized energy. In addition to its role in providing a significant portion of the oxygen to the water and supporting the food web, which includes a wide range of consumers (Zooplankton, larvae, pupae insects and the different types of animals) food and energy needed to sustain it (Stefels and Boekel, 1993). Despite the availability of a large number of studies on the temporal and spatial variation of the presence of phytoplankton, the density and composition of the community's rivers and lakes, but the information is still few about the density of phytoplankton in contaminated (sewage) water (Ramirez and Bicudo, 2005). Many authors recognized the importance of algal composition of the wastewater treatment either using them as treatment tools or to use the wastewater as media for getting mass algal culture (Moreno et al., 1990; Wong and Chan, 1990). While other authors investigated tolerance of different types of algae to pollution in diverse aquatic systems (Al- Saadi et al., 1989, Erganshev and Tajiev, 1986, Palmer, 1974). Pereira et al. (2001) found the wastewater treatment plant in northern Portugal as optimal habitat for Cyanophyceae. Silva (1998) found Chlorophyceae, Euglenophyceae, and Bacillariophyceae in addition to Cyanophyceae in wastewater treatment plant. Mahapatra et al. (2013) investigated the phytoplankton community and its effect on treatment efficiency in Vidyaranyapuram (India) sewage treatment plant.

Phytoplankton is the source of the primary production in aquatic systems and it plays an important role in self treatments in sewage water (Gani et al. 2011) , but the intensive growth of these algae, particularly blue-greens algae, releases dangerous toxins (Neurotoxin & Hepatotoxin) that affect the liver and nervous system of humans if they consume this water for drinking (Humpage et al., 200o, Hassan et al., 2004) . The study aims to focus on the dominant algae in domestic water treatment; moreover, the qualitative and quantitative study of phytoplankton and their relation to environmental factors.

Materials and Methods

The present study has chosen the main domestic treatment plant in Al-Hilla Province, Iraq that locally called Almamierh. Almamierh located just 1 km from Al Hilla River and 5 km from the centre of the Al-Hilla City.

Three sites were selected in treatment plant (inlet effluent, aeration and out effluent), at a rate of 12 samples in semi-monthly sampling for the period from November 2012 to April 2013 (Fig.1).

Phytoplankton samples collected by phytoplankton net (20 µm mesh size). The sample preserved with Lugol's solution (VollenWeider, 1974). A non-diatomic alga was identified by using the following references; Prescott (1982) and Desikachary (1959). While for diatomic algae identified after cleaning and mounting process (Hadi, 1984). The identification was made by following the references (Foged, 1976, Hustedt, 1985, Hadi et al., 1984, Germain, 1981, Al-Handal, 1994, Hassan et al., 2012, Al-Hassany and Hassan 2014).

The total number of phytoplankton done by a hemocytometer method for non-diatomic algae and the micro-transect method for diatomic algae (Stein, 1973; Hadi 1984). Chlorophyll-a measured by following the method described by Aminot and Rey (2001). All the studied physicochemical factors followed APHA (2003) except nitrite; nitrate and phosphate followed Parsons et al. (1984). The statistical analysis was conducted by applying Canonical Corresponded Analysis (CCA) using the program Canoco Ver.4.5

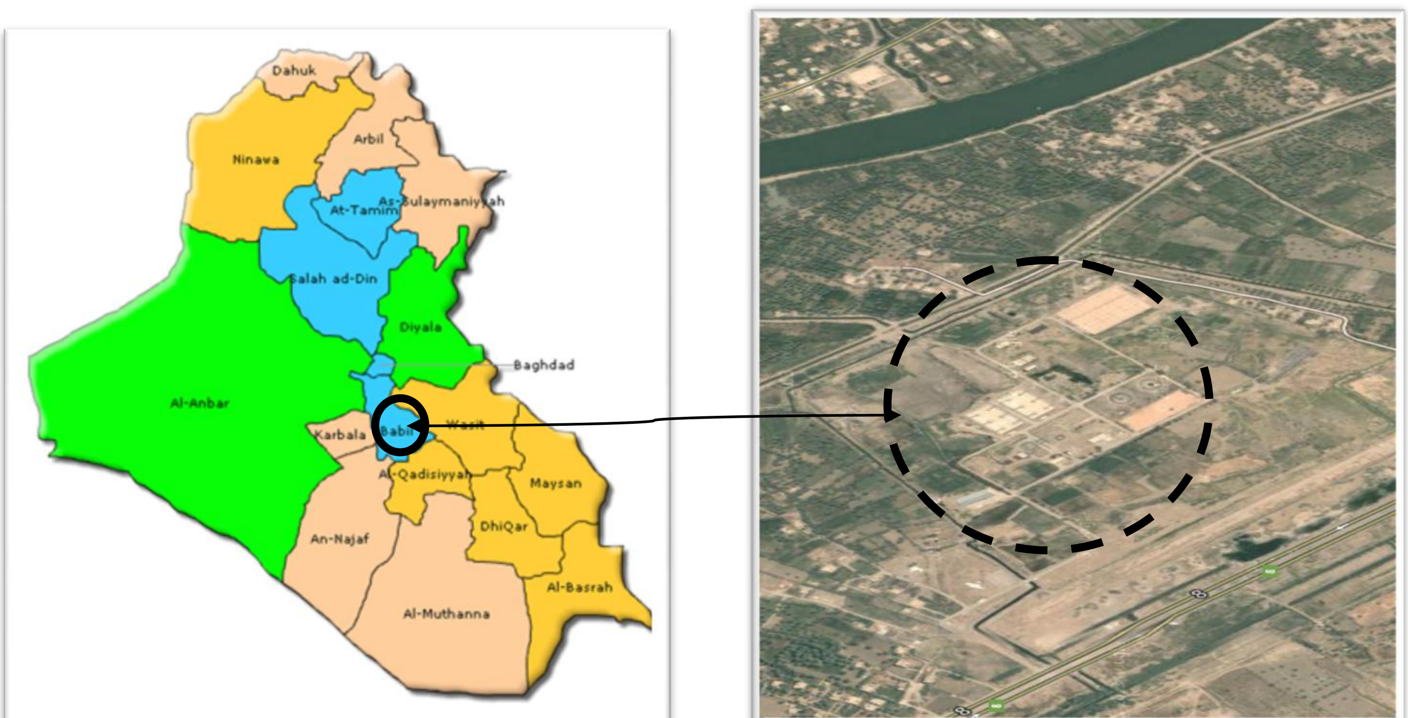

Figure 1: The study area

Results

A total of 147 species and 58 genera identified during the present study period. A total of 82 species of non-diatomic algae were predominate and represented by 40 genera in this study. Higher number of taxon observed in site 3(129 taxa and 49 genera) while other sites (1 and 2) were 87 and 89 species (belonged to 39 genera for each site), respectively (Table 1).

Nine species of phytoplankton in this study were new recorded
to Iraqi algal flora according to Maulood and Toma (2004). These species are as follows (Plate 1a and b):

A. Cyanophyceae:

- *Anabaena naviculoides* Fritsch

(Desikachary 1959. P:397,410 . Figures: 2 , 3.5-5 broad , as long as or shorter than broad)

- *Arthrospria jenneri* Stizenberger ex Gomont (Prescott 1973 . p:481 , pl:108, figures:22,23 . 6-8/µ in diameter; 4-5/µ long; distance between turns 12-14/µ)
- *Camptylonemopsis minor* Desikachary
  (Desikachary 1959. P:444 . figs:1,5 . 2.6-5.2 µ broad , 3.9-6.6 µ long)
- *Leptolyngbya polysiphoniae* (Frèmy) Anagonostidis (Lyngbya polysiphoniae Fremy)

(Desikachary 1959. P:306, figures: 5 , p:287 , up tp 200µ long , cells about to 2µ broad)

B. Chlorophyceae:

- *Echinosphaerella limnetica* G.M. Smith

(Prescott 1973 . pl:51, figures:1,2. Cells 9-12/µ in diameter, spines 2.5-3/µ wide at the base, 20-25/µ long.)

- *Excentrosphaera viridis* Moore

(Prescott 1973, pl:46, figures:15,16 . cells 22-55/µ in diameter)

- *Sphaeroplea annulina* (Roth) C.A.Agardh

(Prescott 1973, PI. 12, figures: 5-8, Cells 27-72/µ in diameter, up to 20 times longer than wide)

C. Euglenophyceae:

- *Trachelomonas dybowskii* Drezepolski

(Prescott 1973. PI. 83, Figure: 21; PI. 84, fig. 6. 10-18/µ in diameter, 16-32/µ long)

D. Pyrrhophyceae :

- *Hemidinum nasutum* Stein

(Prescott 1973. PI. 90, Figures: 4-6. Cell 16-20/µ in diameter, 24-28/µ long)

Many dominant species observed in sites 1 and 2 (Table 2). There were: *Lyngbya epiphytica , L. nordgardii , , L. lagerheimmii , L. limnetica , L. versicolo , Oscillateria acutissima , O. angutissima , O. formosa , O. hamelli , O. limnetica , Oscillateria sp. , Phormidium fragile , P. tenue* and *Spirulina laxissima* .

While, at the site 3, the most dominant species were filamentous species such as; Lyngbya spp. Which appeared most of the months and in large numbers, and the most prominent types: *Lyngbya epiphytica , L. lagerheimmii , L. limnetica , L. versicolor , O. acutissima , O. angutissima , O. articulate , O. Formosa , O. limnetica , O. prolific , Oscillatoria sp.* and *Spirulina sp.* .

Total number of phytoplankton ranged 2542.4-26649.6 cell/ml at sites 2 and 3 in January2013 and December 2012, respectively. Cyanophyceae was the great majority and represented 72.3% (247895.2 cell x 10^3/ l) of the total number of phytoplankton. While Bacillariophyceae and Chlorophyceae represented 11% and 6.67%, respectively. Other algal groups represented as follows: 6.34, 3.46%, 0.07%, 0.07% and 0.01 for Chrysophyceae, Euglenophyceae, Xanthophyceae, Pyrrophyceae and Rhodophyceae, respectively. Some alga obtained high density at study sites. *Oscillatoria acutissima* recorded high total number (6479 cells/ml) at site 1 in November, 2012. Also, this species is present in most of the study months at sites 2 and 3. *Oscillatoria angutissima* and *Phormidium tenue* were observed at all study sites while *Oscillatoria limnetica* obviously existed in site 1. The present study recorded predominant of alga Spirulina at site 3. The most common diatomic taxa were *Cyclotella meneghiniana, Cymbella tumida* and *Nitzchia palea.*

Ankistrodesmus falcatus appearance of a few at site 1, but it was increased in number in November, 2012 at site 1. While *Chlamydomonas noticeably* found in winter months at site 3.

Mallomonas sp. (Chrysophyceae) recorded a dense existing (20741 cell/ml) at site 3, while *Euglena elastic* (Euglenophyceae) found at site 3 frequently and reached 186.39cell/ml in April 2013. *Batrachospermum moniliforme* (Rhodophyceae) found at site 3.

Chlorophyll-a ranged 7.570- 44.884 mg/l at sites 2 (both numbers) in October 2012 and January 2013, respectively. No variation found in chlorophyll –a concentration among sites and the study months.

The values of studied parameters ranged as follows (Table 2): 12-36ºC, 12-33 ºC, 1351-4221 µs/cm and 0.864-2.324‰ for temperature (air and water), electric conductivity (EC) and salinity. While 7.0-7.8, 1920-2851mg/l, 21-1788mg/l recorded for pH, TDS and TSS. Dissolved oxygen and biochemical oxygen demand ranged 0.6-5.9mg/l and 20-673 mg/l. Total alkalinity, total hardness, calcium, magnesium and chloride ranged 15-190 mg $CaCO_3$ /l, 860-3100 mg $CaCO_3$ /l,164.321-641.286mg/l, 26.549-629.126mg/l and 340.329-721.323mg/l. Nutrients ranged 0.194-19.891mg/l, 0.165- 5.339mg/l, 10.415-100.544mg/l and 22.379-196.6mg/l for Ammonia, nitrite, nitrate and phosphate.

CCA analysis presented in fig 2 showed a correlation between the studied factors in site 1 (part 1 of axis) and both Cyanophyceae and Bacillariophyceae. Cyanophyceae presence was related to Mg, BOD_5, TSS, Nitrite, Salinity and Alkalinity while Bacillariophyceae associated with pH, temperature, Chloride and phosphate. In part 2 axes, Euglenophyceae and Chlorophyceae associated with Ammonia and dissolved oxygen while Chrysophyceae and Xanthophyceae were correlated with Nitrate, TDS, Hardness and Ca. In site 2 (aeration site) Cyanophyceae associated closely with most of the studied factors, while Chlorophyceae and Chrysophyceae correlated with pH, dissolved oxygen, nitrate, Phosphate and Ca (first part of axes). Bacillariophyceae and Euglenophyceae associated with phosphate, BOD_5, temperature, TSS and ammonia (part 2 axes). Different manner occurred in site 3 (effluent site); Cyanophyceae, Bacillariophyceae, Chlorophyceae, Xanthophyceae, Pyrrophyceae and Rhodophyceae were related to TSS and chloride closely in part 2axes. In part 1 axes in site 3; Chrysophyceae correlated with pH, nitrite, phosphate and Mg, while Euglenophyceae correlated with temperature, nitrate, alkalinity and BOD_5.

Table 1: Numbers of species, genera and the percentage of phytoplankton at Almamierh plant during the study period.

Class	Site1			Site 2			Site 3			Total		
	G	sp	%	G	sp	%	G	sp	%	G	sp	%
Cyanophyceae	12	14	38.2	**9**	**26**	**29.2**	**14**	**38**	**29.4**	**15**	**46**	**29.4**
Chlorophyceae	7	7	7.8	**9**	**10**	**11.2**	**8**	**9**	**7**	**14**	**17**	**7..0**
Euglenophyceae	4	6	6.7	**3**	**4**	**4.4**	**3**	**8**	**6.2**	**4**	**9**	**6.2**
Pyrrophyceae	-	-	-	-	-	-	**2**	**3**	**2.3**	**2**	**3**	**2.3**
Rhodophyceae	-	-	-	-	-	-	**1**	**1**	**0.7**	**1**	**1**	**0.8**
Chrysophyceae	1	1	1.1	**2**	**2**	**2.2**	**2**	**3**	**2.3**	**2**	**3**	**2.3**
Xanthophyceae	1	1	1.1	-	-	-	**2**	**3**	**2.3**	**2**	**3**	**2.3**
Bacillariophyceae												
Centrales	2	6	6.7	**2**	**5**	**5.6**	2	9	7	2	9	7
Pennales	38.2	34	38.2	**14**	**42**	**47.1**	**15**	55	42.6	16	56	42.6
Total	40	89		**39**	**89**		**49**	**129**		58	147	

Table 2: Identified wastewater phytoplankton during study sites.

* Species recorded for the first time in Iraq

Taxa	Sites 1	2	3
Cyanophyceae			
Anabaena naviculoides Fritsch*	+	-	-
A. sp.	+	-	-
Arthrospria jenneri Kuetz. *	+	-	-
Calothrix sp.	+	+	+

Camptylonemopsis minor Desikachary *	-	+	-
Camptylonemopsis sp	+	+	+
Chroococcus limnaticus var. *distans* G.M.Smith	-	-	+
C. Turgidus Kuetz.	-	-	+
Dactylococcopsis fascicularis Lemmermann	+	+	+
Gloeocapsa sp.	+	+	+
Lyngbya epiphytica Hieron	+	+	+
L. lagerheimmii (moeb) Gomont	+	+	+
L. limnetica Lemmermann	+	+	+
L. nordgardii Wille	+	+	+
L. polysiphoniae Fremy *	-	+	-
L. versicolor (wartmman) Gomont	+	+	+
Merismepdia glauca (Ehr.) Naegeli	+	-	+
Nostoc carneum Agardh	+	-	+
Nostoc sp.	+	+	+
Oscillateria acutissima Kufferath	+	+	+
O. amoena (Ktz) Gomont	+	+	-
O. amphibian agardh	+	-	+
O. amphigranulate var Goor	+	-	+
O. anguina (Bory) Gomont	-	+	-
O. angutissima West and West	+	+	+
O. articulate Gardner	+	+	+
O. chalybea Mertens	-	+	-
O. formosa Bory	+	+	+
O. hamelli Fremy	+	+	+
O. limnetica Lemmermann	+	+	+
O. minima Gicklhorn	-	+	+
O. prolific (Grev.) Gomont	+	-	+
O. splendid Greville	+	-	+
O. willei Gardner	+	-	+
Oscillateria sp.	+	+	+
Phormidium fragile Gomont	-	+	+
P. mucicola (Huber-pest and Naumann)	-	+	-
P. tenue (Menegh) Gomont	+	+	+
P. molle Gomont	-	-	+
Rivularia haematites (D.C.) C.A. Agardh	+	-	-
Spirulina laxa G.M. Smith	+	-	-
S. laxissima G.S. West	+	+	+
S. major Ktz.	+	-	-
S. subsalsa Orested	+	-	-
Spirulina sp.	+	-	-
Synechococcus aeruginosus Naegeli	+	-	+
Chlorophyceae			
Ankistrodesmus falcatus (Cord.) Ralfs	+	-	+
Chlamydomonas epiphytica G.M. Smith	-	+	-
C. snowii Printz	-	+	+
C. sp.	+	-	-

Chlorococcum humicola Neag.	-	+	+
Closteridiopsis longissima lemmerman	+	+	+
Echinosphaerella limnetica G.M. Smith *	-	+	-
Excentrosphaera viridis Moore *	-	+	-
Sphaeroplea annulina (Roth) C.A.Agardh *	+	-	-
Scendesmus acuminatus Var. minar G.M. Smith	+	-	-
Schizomeris leibleinii Kuetzing	-	-	+
Spirogyra proticalis (Muell.) petit	-	-	+
Stigeoclonium subcecandum Ktz.	-	+	-
Tetradron regular Ktz.	+	+	-
Treubaria setigerum (Archer) G.M. Smith	+	+	-
Ulothrix zonata (Weber & Mohr) Kuetzing	+	+	+
U. tenerrima ktz.	+	-	-
Euglenophyceae			
Euglena elastic prescott	+	-	+
E. polymorpha Dangeread	+	-	+
E. proxima Dangeread	+	-	-
Euglena sp.	+	+	+
Lipocinalis shagnophila	-	-	+
Phacus caudataus Huebner	+	+	-
Phacus sp.	+	+	+
Trachelomonas dybowskii drezepolskii *	+	-	-
Trachelomonas volvocina Ehrenbergo	+	-	-
Pyrrophyceae			
Hemidinum nasutum Stein *	+	-	-
Peridinium pussilum (Penard) Lemmerman	+	-	-
Peridinium sp.	+	-	-
Rhodophyceae			
Batrachospermum moniliforme Roth	-	-	+
Chrysophyceae			
Dinobryon bavaricum Imof.	+	+	-
Dinobryon sp.	+	-	-
Mallomonas sp.	+	+	+
Xanthophyceae			
Characiopsis acuta (A.Braun) Borzi	+	-	-
C. Longiceps (Rabenh.) Borzi	+	-	-
Chlorochromonas minuta lewis	+	-	+
Bacillariophyceae			
Centrales			
Cyclotella comta (Ehr.) Kuetzing	+	+	+
C. kuetzingiana var. radiosa Pricke	+	-	-
C. meneghiniana Kützing	+	+	+
C. ocellata Pantocsek	+	+	+
C. striata (ktz) Grunow	+	-	-
Melosira italic (Ehr.) Kuetzing	+	-	+
M. granulate (Ehr.) Ralfs	+	+	+

M. varains Agradh	+	-	-
M. distance (Ehr.) Kuetzing	+	+	-
Pennales			
Amphiprora alata kutz.	+	-	-
Asterionella sp.	+	-	-
Cocconeis placentula Ehrenberg	+	+	+
Cymbella affinis (Kuetzing)	+	+	+
C. cuspidata Ktz. Var. anglica lagst	+	+	+
C. cymbiformis (Ktz.) Van Heurck	+	+	+
C. hustedtii Krasske	+	-	-
C. tumida (Breb.) van. Heurck	+	+	+
C. ventricosa Kuetzing	+	+	+
Cymatopleura elliptica (Breb.) W.Smith	+	+	+
Diatoma elongatum (Lyngb.) Agardh	+	+	-
D. hiemala (Roth) Heiberg	+	+	+
D. vulgare Bory	+	+	+
Diploneis Ovalis (Hilse) Cleve	+	+	+
D. pseudovalis Hustedt	+	-	+
Eunotia praerupta Ehrenberg	-	+	+
Fragilaria brevistriata var. *inflate* (Pant.) Hustedt	+	+	+
F.capucina var. *gracilis* (Oster.) A.Cleve	+	+	+
F. crotonensis Kitton	+	+	+
Fragilaria sp.	+	+	+
Gomphonema constrictum Ehrenberg	+	+	+
G. longiceps Ehr.	+	+	-
Gyrosigma scalproides (Rabenhorst) Cleve	+	+	+
Gyrosigma spenceri (Quek.) Griff et Henfr	+	-	-
Gyrosigma sp.	+	-	-
Meridion circulare Agardh	+	+	-
Navicula anglica Ralf	+	-	-
N. bacillum Ehrenberg	+	+	+
N. cryptocephale Kuetzing	+	+	+
N. crptocephlae var. *veneta* (Ktz.) Cleve	+	+	+
N. cuspidata (Ktz.) Kuetzing	+	+	-
N.dicephala var. *neglecta* (Krasske) Hust.	+	-	-
N. halophila (Grun.) Cleve	+	+	+
N. lanceolata (Ag.) Kuetzing	+	+	-
N. psuedotuscula Hustedt	+	+	-
N. virtea (Oester.) Hustedt	+	+	+
Nitzschia acuta Hantzsch	+	+	-
N. amphibia Grunow	+	-	-
N. angustata (W.Smith) Grunow	+	+	+
N. dissipata (Ktz.) Grunow	+	+	+
N. hantzschiana Rabenhorst	+	+	-
N. hungarica Grunow	+	+	-
N. linearis W.Smith	+	+	-
N. lottoralis Grunow	+	+	-

N. longissima (Breb.) Ralfs	+	-	-
N. palea (Ktz.) W.Smith	+	+	+
N. puctata (W.Smith) Grunow	+	-	+
N. recta Hantzsch ex Rabenh.	+	+	+
N. sigma (Ktz) W.Smith	+	-	-
N. sigmoidea (Ehr.) W.Smith	+	+	+
N. vermicularis (Ktz.) Hantzsch	+	+	-
Surirella ovate Kützing	+	+	+
Syndra acus Kützing	+	-	+
S. tabulate var. *fasciculate*	+	+	+
S. ulna (Nitz.) Ehrenberg	+	+	+
S. ulna var. *longissima* (W.Smith) Brun	+	-	+

Table 3: Range (Mean ± SD) of Physicochemical parameters for Almamierh plant.

Parameters	Sites		
	St.1	St.2	St.3
Air temperature C°	13 – 36 (21.5 ± 6.06)	15 – 36 (22 ± 6.24)	12 – 36 (22.07±6.32)
Water temperature C°	12-33 (19.08± 6)	12 – 28 (18.797 ± 5.20)	12 – 29 (18.53±5.48)
EC µs/cm	1911 – 4221 (3625.3±673.30)	1817- 3941 (3319.1±596.1)	1351–4061 (3174.5±762.7)
Salinity ‰	1.22 – 2.77 (0.44±2.32)	1.164-2.53 (2.13±0.39)	0.86-2.59 (2.03±0.49)
pH	7.3 – 7.8 (7.68 ± 0.12)	7.2 – 7.8 (7.60±0.17)	7 – 7.8 (7.69±0.18)
TDS (mg/l)	2452 – 3651 (2821.75±293.80)	2241–2785 (2524.42±152.97)	1920-2851 (2431.58±261.47)
TSS (mg/l)	52– 407 (179.08±79.29)	448- 1788 (960.75±346.09)	21 – 64 (35±12.00)
DO (mg/l)	0.6 – 2.1 (1.2 ± 0.48)	1.3 – 4.9 (2.87±1.14)	1.8 – 5.9 (3.93±1.3)
BOD_5 (mg/l)	170 – 673 (373.33±182.97)	120 – 317 (197.83±48.11)	20 – 63 (38.50±11.45)
Total alkalinity (mg $CaCO_3$ /l)	30 – 190 (112.64±42.3)	15 – 170 (109.83±43.40)	23 – 162 (98.33±42.81)
Total hardness (mg $CaCO_3$ /l)	1010 – 2500 (1455.4±400.90)	900- 3100 (1592.5±569.23)	860 – 2400 (1431.66±450.43)
Calcium (mg $CaCO_3$ /l)	188.38–360.72 (253.93±57.90)	188.38-641.29 (279.87±123.60)	164.32-480.96 (272.59±88.42)
Magnesium (mg $CaCO_3$ /l)	33.81 - 480.89 (199.63±105.65)	26.55-629.13 (199.99±47.83)	31.47-485.84 (187.39±83.07)
Chloride (mg/l)	382.86-719.77 (552.26±109.21)	382.42-719.13 (550.07±113.99)	340.33-721.32 (551.76±120.29)
Ammonia (mg/l)	4.65 –19.89 (12.33±4.59)	0.76- 16.92 (8.84±5.45)	0.19- 12.93 (6.02±2.12)
Nitrate (mg/l)	10.42 - 84.2 (35.68±16.13)	27.59- 97.96 (63.06±24.01)	10.49-100.54 (56.57±20.62)
Nitrite (mg/l)	0.17 – 2.86 (1.75±0.67)	0.28- 5.75 (3.23±1.50)	0.20-5.34 (2.81±1.05)
Reactive Phosphate (mg/l)	80.25- 196.60 (155.67±42.73)	60.74-162.80 (90.92±31.17)	22.38-75.17 (44.78±17.91)
Chlorophyll-A (mg/l)	10.66 – 37.12 (18.19±7.11)	7.57 – 44.88 (20.71±9.81)	8.32-39.89 (18.61±9.10)
Total Phytoplankton cell*10^3/L	5038- 18729(10264 ± 3909)	2512-26557 (8139±3488)	5323 -26650 (10154±4696)

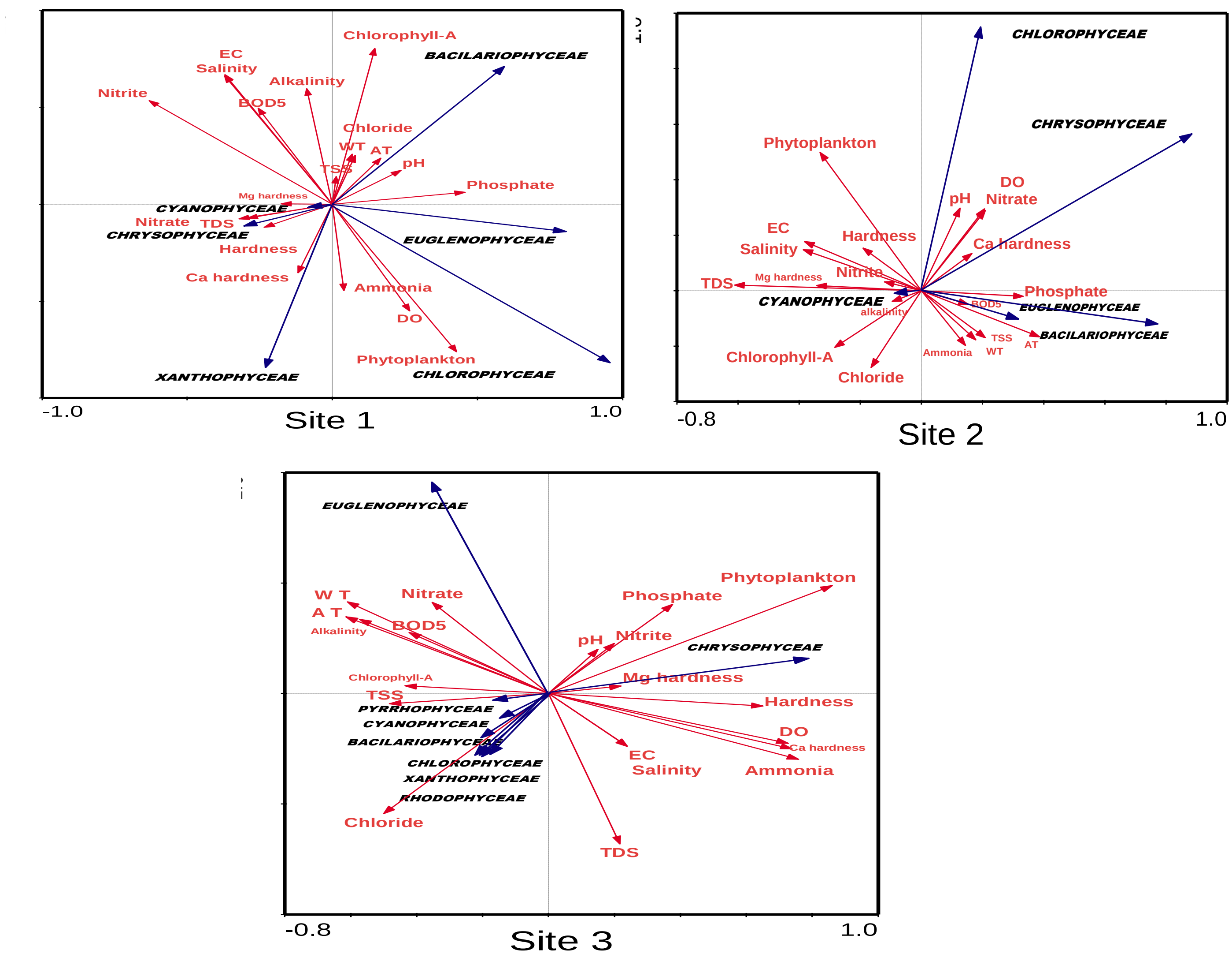

Figure2: Correlations between water quality parameters and phytoplankton groups in study sites according to CCA.

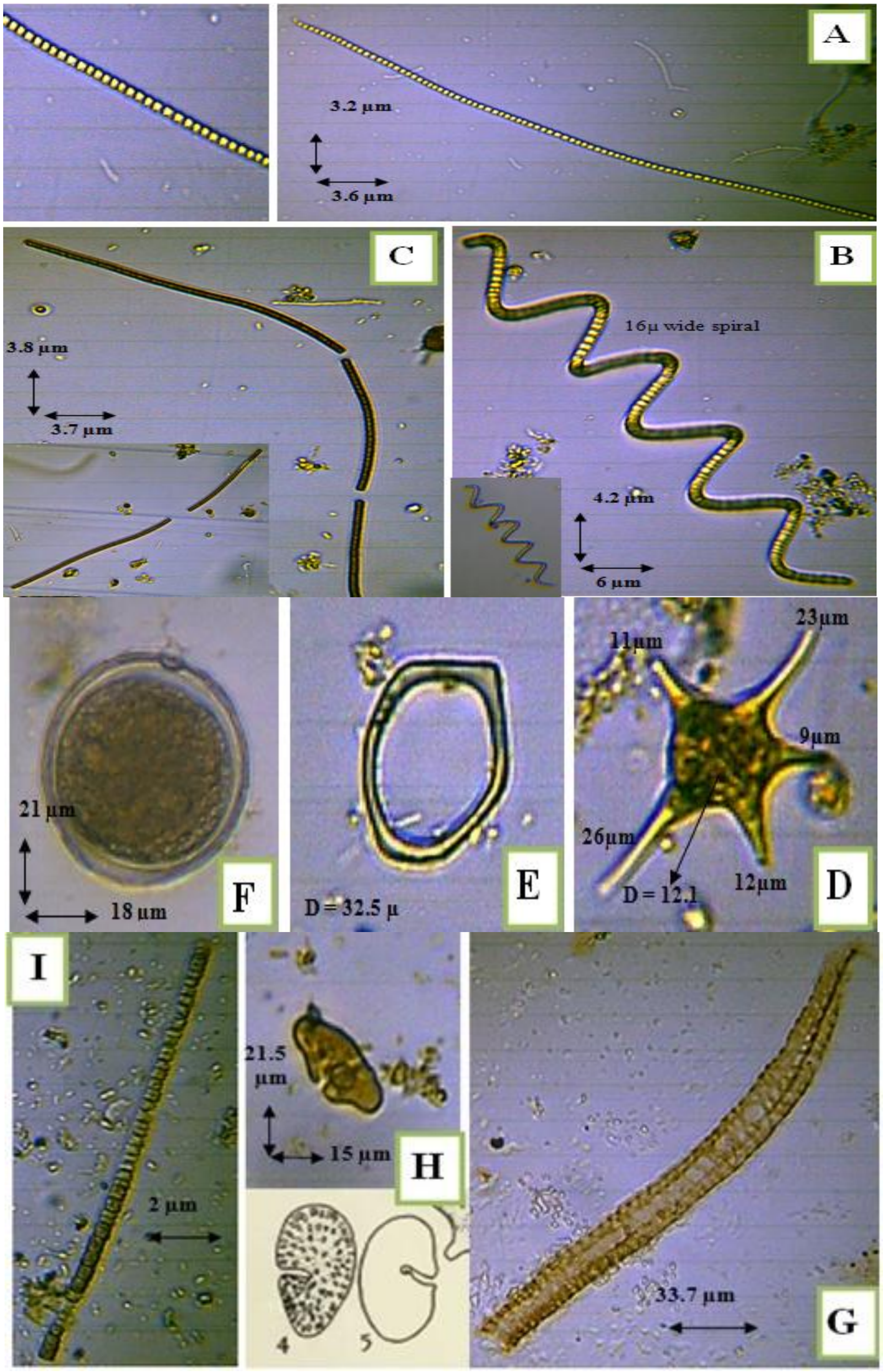

Plate1: Photos of new record to algal flora in Iraq during the present study**.**

A: *A. naviculoides* B: *A. jenneri* C: *C. minor* D: *L. polysiphoniae*
E: *E. limnetica* F: *E. viridis* G: *S. annulina* H: *T. dybowskii*
I: *H. Nasutum*

Discussion

The phytoplankton population structures are affected by surrounding environmental changes in aquatic systems (Zębek, 2004). Since the availability of nutrients and suitable water temperature led the growth of a diverse group of algae and may be suitable for a few algal groups, moreover some other abundant groups can effect the presence of another alga (Joseph and Joseph, 2002). These were appearing obviously during the current study. Cyclotella meneghiniana, Cymbella tumida and Nitzchia palea were found in this study area frequently, which indicated to inorganic nutrient enrichment in untreated sewage (Al-Hansan et al., 1990). Also, numerous studies have confirmed the possibility of the growth of algae effectively in the environment rich in organic matter and metals in the wastewater (Pittman et al., 2011). But the increase of organic pollutants led to increased toxic algal groups, despite that these toxins break down when adding chlorine for the purpose of sterilization by chlorination (Wang et al., 2007).

In the present study, it was observed that the non-diatomic algae was predominate algae during the study period. That may be due to the effect of different pollutants (Palmer 1969; Bellinger and Sigee, 2010). The total number of diatomic algae in this study recorded less than the non- diatomic algae. This finding differs from that recorded in Iraqi natural aquatic systems, in which the diatomic algae are dominate algal groups (Sulaiman et al., 2000; Hassan et al., 2011, Maulood et al., 2013).

Different number of phytoplankton recorded in the study sites, where in site 1 (In-Effluent) and site 2 (Aeration) were 89 taxa while in site 3 (Out-Effluent) which represented the treated water that was 129 taxa. This difference was may be due to the physical and chemical properties as well as the quality of water for each site where the great similarity in the qualitative composition between the three study sites may be due to the main source of water (Al-Sarraf, 2006).

The abundance of Cyanophyceae in wastewater in this study was in accordance with other published manuscripts (Fulke et al., 2013; Ghughtai et al., 2013; Kaparapu and Geddada, 2013).

The occurrence of Bacillariophyceae in the wastewater represented its high ability to environmental change, which led to use some abundant diatomic species as bioindicators for organic pollution or heavy metals such as Cyclotella and Nitzschia (Palmer, 1969). Moreover, the Iraqi aquatic systems contain high concentrations of silica (Hassan. 1997) which is necessary for the growth of this group in addition to the possibility of these algae to withstand changes in environmental conditions (Graham & Wilcox, 2000). The presence or absent of some phytoplankton species at different sites that may be as a response to their eco-physiological response to pollution (Guo et al., 2010).

Chlorophyceae found in the aeration tank where the high rate of dissolved oxygen helps to bloom phytoplankton. As well as the latter Chlorophyceae species that appeared in the treated water and this may be due to improved water quality after passing through the stages of treatment.

Other phytoplankton species such as; Trachelomonas dybowskii (Euglenophyceae) and Hemidinum nasutum indicated to wastewater pollution and to tolerant the salinity and pH (Al-Saadi et al., 2002).

The physicochemical characteristic of site 1 (Effluent) was showed medium to strong domestic wastewater composition according to typical guide of domestic wastewater (UN Department of Technical Cooperation for Development, 1985), also these results were in accordance with arid and semi-arid neighbouring countries (Al-Salem, 1987, Mohammed et al., 2012). High values of organic content, TDS, TSS, Chloride, nitrate and phosphate represented strength level in the present study at site 1. While the value of pH was typical values that may be due to buffer potential of the Iraqi water (Hassan et al., 2010). The aeration process in site 2 affected the physicochemical characteristic in this site. This process led to decrease of most of studied parameters except some of them that may be due to high concentration of EC and chlorides (Mohammed et al., 2012), which have role in treatment processes, on the other hand, the effect of phytoplankton obviously shown in site 2 and site 3.

The study recorded high density of phytoplankton in wastewater, which has a role in treatment plant. Cyanophyceae was dominant in the study treatment plant more than other classes of phytoplankton. Many phytoplankton species that have recorded may be used as bioindicators to pollution by wastewater and ecosystem health. The domestic wastewater of the Hilla city ranged between medium to strong.

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