Effect of heated effluents discharged from Al-Hartha electricity power station on the ecosystem of the Shatt Al-Arab River II. Seasonal variations in abundance and distribution of algae

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Summary

Impact of heated effluents, discharged from Al-Hartha electrical power station on availability, abundance and distribution of algae in the Shatt Al-Arab River, was investigated on monthly basis from November 1997 to October 1998.Distance affected by heated wastes was determined by 1250m. A total of 79 algal species belong to 45 genera were identified. Diatoms (Bacillariophyta) formed 63 species, green algae (chlorophyta) 14 species and blue green algae (cyanophyta) 12 species, whereas both Euglenophyta and xanthophyta each were represented by one species only. Discharge points of cooling water accounted for the highest number of species (66 species). Also a remarkable increase in the total counts of algal cells was encountered closer to the discharge points (2296 cell/cm^2) in June. Diatoms were dominant followed by blue green algae and green algae. However, blue green algae dominated others near discharge points particularly during summer months.

Keywords: Al-Hartha electricity power station; Impacts of heated effluents; Shatt Al- Arab River; Algae

Introduction

Water pollution is one of the main and vital topics of great concern to human. However, in order to protect aquatic environments from deterioration or to keep pollutants in check, sources of pollution, quality and quantity of released substances, level of their dispersions and impact must be determined and avoided [1]. Water temperature is one of the physical factors that play a substantial role in water ecosystem through affecting several components including solubility of gases on which life is depend [2].[3]investigate the effect of electric power generation station in California where the highest summer water temperature was 40ºC.The study revealed that effluent discharge that causes increasing ambient water temperature above 33ºC cause notable mortalities in some macro-algal components. On the other hand,[4] deduced that heated effluents affect marine organisms although both primary production and biomass increase as a result of power plants discharges.[5] also found that heated effluents badly affect biodiversity of bottom fauna. Closer to outlet considerable similarities were observed in biotic communities of summer and spring.

[6] indicated that biomass of phytoplankton during spring blooming (10-12 mg/dcm^3) suffers a notable reduction in summer (1-2 mg/ dcm^3) due to the discharge of cooling waters, but blue-green algae were dominant. Several industrial plants were established in Basrah, mainly on banks of Shatt Al-Arab River, during the last three decades, namely paper plant, fertilizer plant, oil refineries and heated power generating stations. Impact of these enterprises on biotic components of aquatic ecosystem is serious due to untreated discharges that disturb ecological balance [7]. [8].[9]and[10] were among the former workers who studied phytoplankton population in the river but, unfortunately, no one has taken in consideration impacts of heated effluents. It is therefore, the present study was planned and implemented to investigate the impact of Al-Hartha electrical power plant on the abundance and distribution of algae on monthly basis.

Description of study area

Industrial enterprises normally established closer to water bodies due to their requirements of huge quantities of water for cooling purposes.Their dangers emerge from discharging untreated cooling water back to the source with temperature greatly exceeding the ambient environment.

Table (1) variations between temperatures (°C) of ambient water and discharged effluents from Al-Hartha electricity power station throughout the study period.

Months	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sep	Oct.
Inlets	17.7	14.7	12.0	17.0	19.4	22.2	28.8	29.0	31.0	32.4	26.8	26.0
Outlets	27.9	24.7	21.0	27.0	28.3	31.1	37.4	38.0	40.2	41.4	36.3	35.0
Differ.	10.2	10.0	9.0	10.0	8.9	8.9	9.4	9.0	9.2	9.0	9.5	9.0

Al-Hartha electric power generating station is established in 1979 and situated on bank of Shatt Al-Arab River, at 20 km northern Basrah city in Hemrenan village. The station consist four units to produce electricity, with individual capacity 200 mW/h. Two units only rehabilitated following 1991 war. Current production capacity is estimated by 400 mW/h. The station requires 74000m^3/h of water for cooling purposes. Three spots were selected to execute the work. The former designated by the symbol H1 is situated near inlet point northward the station, the second spot H2 lie closer to discharging point of heated effluents southward station and, the latter spot designated by H3 is 750 m apart from H2 (Fig.1).

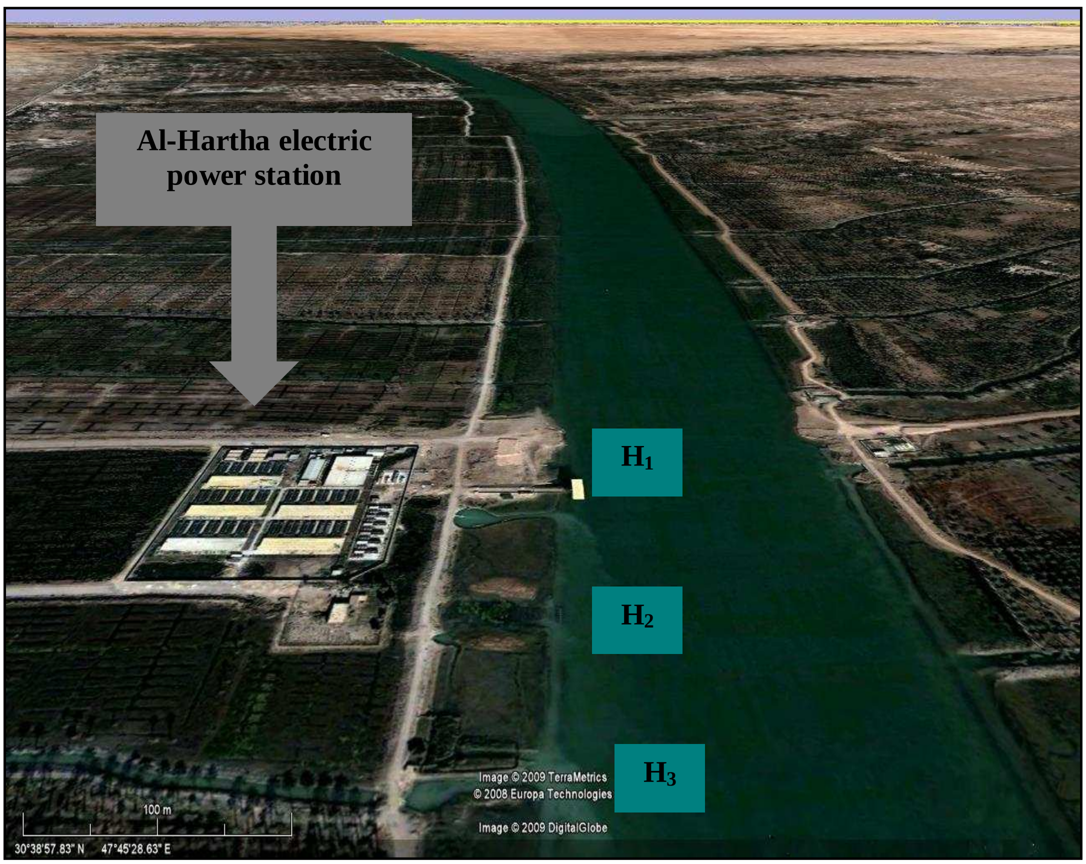

Figure (1): Illustrate Al-Hartha electricity power station and the three selected sites (H1, H2 and H3) for sampling

Materials and methods

Samples were collected, at ebb, on monthly basis from November 1997 to October 1998.[11] method described by Eton and [12], to prepare Algal samples to satisfy requirements of the present work, was adopted. Slides were fixed on rectangular wooden frame (7x2.5x1 cm). Five slides were fixed on each frame surface. They were mounted in groove built in the wood (depth 0.5 cm). Slides were tightly fixed inside the wood to avoid drifting with current. One piece of wood with five mounted slides was placed at each of the three selected sites. Precautions were taken in consideration not to allow the wood exposing to the atmosphere at low tides. Slides used to examine in duration of two weeks. Attached algae thoroughly scratched and preserved with 4% formalin in plastic vials (25 cm^3) for further investigation.

For qualitative analysis Non-diatomic algae were directly identified using compound microscope (Zess) under magnification lens 100 x 40x. Several references were consulted for identification including [13,14,15,16,17and18]. Diatomic species, however, were recognized following clearing their skeletons as known sub-sample was taken after vigorous shaking in test tube. Few drops of nitric acid were added to the sample and placed in water bath under boiling point for five minutes with stirring. The sample was allowed to be cooled then precipitated in centrifuge. For preservation, few drops of 4% formalin were added, with distilled water, to the precipitate. Identification based on guidelines provided by[19,20 and 21].

In quantitative analysis[22]method was adopted to calculate the number of algal cells. Haemocytometer slide (depth 0.1) was used for counting non-diatomic algal cells. A drop of the concentrated sample, after shaking, was placed on each of the counting chamber and covered. The slide left unattended for few minutes, for cell settlement, prior microscopic examination. The result expressed by a number of cells per cm^2 of the slide area mounted in the spot. Conversion factor was used as follows:

No. cells in 1cm^2 of the slide = No. counted cells in one microscopic field × conversion factor of water sample

Results

Table (2) shows the composition of algae, along with the dominant species, identified from samples recovered from the selected sites in the study area of Al-Hartha station. The study reveals that 79 species belong to 45 genera were isolated and identified. Diatoms ranked first comprising 52 species out of the total identified. They relate to 23 genera. Two of which belong to disc diatoms. Green algae (chlorophyceae) dominated others and were represented by 13 species that belong to 11 genera. Analysis of samples also detected 12 species of blue-green algae (cyanophyta).This is an unusual sign for natural habitat. However, identification confirmed they belong to 8 genera. One species of each euglenoid and yellow algae were collected during the whole study period.

To investigate the algal status at each selected spot, the study deduced that in site H1, representing the inlet point in the station, a total of 58 species (35 genera) was encountered. Diatoms come first in order of importance and consist of 38 species followed by blue green algae (7 species), whereas euglenoid and yellow algae were not found in this site. In the site H2 where cooling water initially discharged to the natural system 60 species were identified (31 genera). Again, diatoms occupied the first position (42 species), followed by blue green algae (10 species) and green algae (7 species), whereas yellow algae were represented by one species only. In the site H3, however, assigning the end of the area affected by cooling effluents in Al-Hartha station, a sum of 55 species (32 genera) was recognized. Diatoms exceeding other components as well and form 37 species of the total recognized count, followed by green algae (9 species), whereas blue green algae occupied the third position (7 species). Both euglenoids and yellow algae were represented by a single species each. The study showed dominance of some algal species at the two sites (H2 and H3) affected by heated effluents including the following: *Lyngbia* spp., *Oscillatoria amoena, O. subbrevis, Phormidium* spp., *Cocconeis placentula var euglypta, C. placentula ver lineate, Cymbella cistula, C. tumida, Fragillaria capucina, Navicula cryptocephala, N. rynchocephala, Nitzschia apiculata, N. disspata, N. obtosa, N. sigma, Rhiocosphenia curvata, R. gibba, Syndra ulna, Scendesmus opoliensis, S. quadraticata, Urnonema* sp., *Vaucheria* sp.

Table (2) Shows the identified and dominates species of the main algal groups recovered from the three selected sites in Al-Hartha power station. Note: (-) absent; (+) present; (++) common; (+++) very common

List of Taxa	H_1	H_2	H_3
Cynophyceae			
Anabaena sp.	-	+	-
Aphanocapsa sp.	-	-	-
Chroococus turgidus	-	+	-
Gleocapsa sp.	-	-	+
Lyngbya spp	+++	+++	++
Oscillatoria amoena(Ktz)Gomont	+++	+++	+++
O. Formosa Bor.ex.Gom	++	++	++
O. subbrevis Schmidle	++	+++	+++
O. tenuis Ag.ex.Gom	+++	++	+
OScillatoria spp.	+	++	-
Phormidium spp	+	+++	+
Spirulina princes West and West	-	+	-
Bacillariophyceae			
Achnanthes affinis Grum	+	+	+
A. saxonica Krasske	-	+	+
Amphora ovalis	-	+	-
Amphora sp.	-	-	+
Bacillaria paradoxa Gmelin	+	+	-
Caloneis sp.	-	+	+
Cocconeis placentula var euglypta Ktz.	+	+++	+++
C. placentula var lineate(Her.)Cleve	++	+++	++
Cyclotella sp	+	-	-
Cymbella affinis Ktz	+	++	+
C. aspera(Her.)H.Pera.	+	++	++
C. cistula Kirch.	+	+++	+
C. cymbeliformis(Ktz.)Van Heurck	+	++	+
C. tumida(Bereb.)Van Heurck	+	++	+
Diatoma sp.	+	++	++
Diploneis sp.	+	-	+
Fragillaria capucina Decm.	+	+++	+++
Fragillaria sp.	+++	+	+
Gomphoneis sp.	-	+	-
Gomphonema spp.	+	-	-
Gyrosigma attemuatum Rabenh	++	++	+
G. exeimium(Thwaites)Bayar	+	+	-
G. scalpriodes(Rabenh)Cleve	-	-	-
Gyrosigma sp.	+	+	+
Licomphora sp.	-	+	-
Mastigloia smithii W.Smith	+	+	+
Melosira sp.	-	-	+
Navicula atomus Ktz.Grun	+	+	+
N. crptocephala Ktz.	+	++	+
N. mutica Ktz.	+	+	-
N. parva(Menegh)Cl.	+	+	+
N. rodiosa Ktz.	+	+	+
N. rhynchocephala Ktz.	+++	++	+
Navicula sp.	-	+	+
Nitzschia acicularis(Ktz)W.Sm.	+	++	++
N. apiculata(Gerg)Grun.	+	++	-
N. disspata(Ktz)Grun.	+	++	+
N. faciculata(Grun)Grun.	+	+++	-
N. filiformis(W.Smith)Van. Heur.	+	+++	-
N. obtosa W.Smith	+	+++	+
N. palae(Ktz)W.Smith	+	+	+
N. punictata(W.Smith)Grun.	+	-	+
N. sigma(Ktz)W.Smith	+	+++	-
Nitzschia spp.	+	-	-
Pleurosigma sp.	-	+	+
Rhiocosphenia curvata(Ktz)Grun.	+	+++	+

R. fossilis(Ktz)	-	++	+
Satauroneis sp.	-	-	+
Surirella ovata Ktz.	+	+	+
Surirella sp.	-	+	-
Syndra ulna(Nitz)Her.	-	+	+
Syndra sp.	+	-	+
Chlorophyceae			
Cladophora sp.	+	++	+
Chlorococcum sp.	+	-	+
Microcoleus sp.	+	-	-
Mougeotia sp.	+	-	+
Rhizoclonium sp.	+	+	-
Scenedesmus opliensis p.Rich	+	+	+
S. quadricauda(Turp.)de Bre.	+	+	+
Scenedesmus sp.	+	+	+
Spirogyra sp.	+	+	-
Stigeoclonium sp.	+	-	-
Ulothrix zonata(Webes&Mohr)Ktz	+	-	+
Uronema sp.	+	+++	+++
Zygnema sp.	+	-	+
Euglenophyceae			
Euglena sp.	-	-	+
Xanthophyceae			
Vaucheria sp.	-	+++	+++
Total No. of genera	31	32	31
Total No. of taxa	58	60	55
Cynophyceae	7	10	7
Bacillariophyceae	38	42	37
Chlorophyceae	13	7	9
Euglenophyceae	0	0	1
Xanthophyceae	1	0	1

Figure (2) shows monthly and localized variations in total count of algal cells, at the three selected sites, in one square centimeter during the study period. It is quite clear that site H2 showed the highest numbers of cells, throughout the year, followed by site H1. The latter almost resembles site H3 except in April and May when numbers were higher in site H1.

Figure (3) revealed percentage constitutions' of main algal categories at each site. The highest proportion (1915 cell/ cm^2) in total count was recorded in June from site H1 (water inlet), whereas the lowest value (783 cell/cm^2) was encountered in January. In site H2, representing the first position to discharge cooling water, the highest increase in the total count of algae (2296 cell/cm^2) was recorded in July and the minimum (1957 cell/cm^2) was detected in April. In H3, however, representing the end of the area affected by heated effluents, results indicated that trend is resembling what has been encountered in site H1 as the highest count of algae (2625 cell/cm2) was in June and the lowest (808 cell/cm2) in January.

Diatoms proportions were 70, 62.1 and 61.3% for H1, H2, H3 sites, respectively. Green algae (chlorophyta) accounted for 12.6, 5.0, and 6.3% for the above sites in the same order. Blue green algae (cyanophyta) constituted 16.0, 40.3, and 20.0 % for the above sites, whereas, percentage compositions of yellow algae (xanthophyta) were 0.5, 1.6, 0.6% in the above localities in the same order. Table (4) also indicates an increase in the number of the identified algal cells near discharging point of cooling water. It was accounting for 60 species (32 genera). A notable rise in number of species (mainly blue green algae) and a decline in genera were noted closer to discharging points of heated effluent.

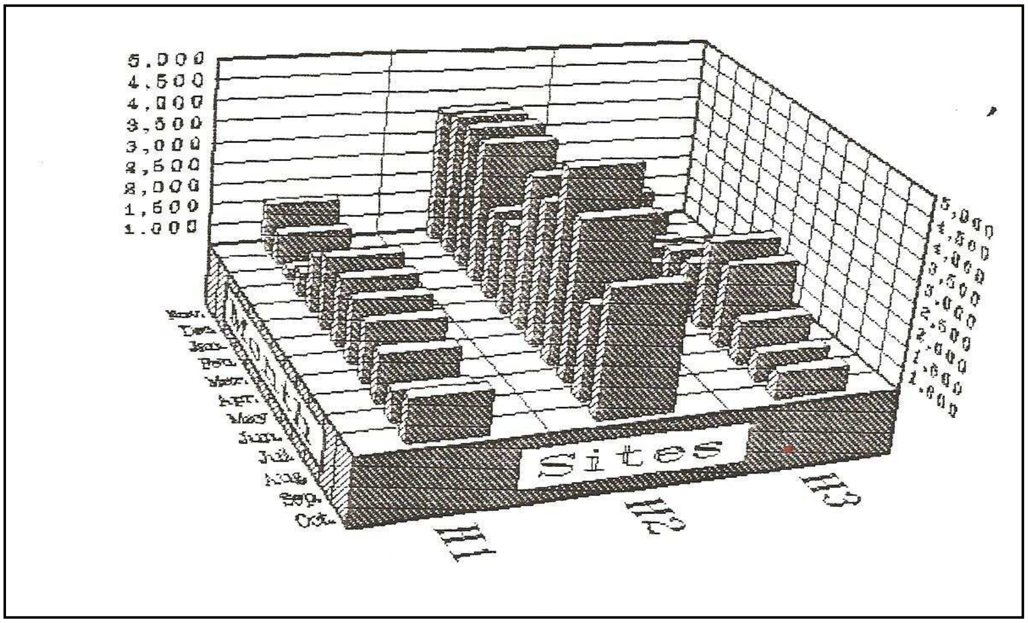

Fig.(2) monthly and localized variation in total count of algae(cell/cm^2)at The three site selected from Al-Hartha power station.

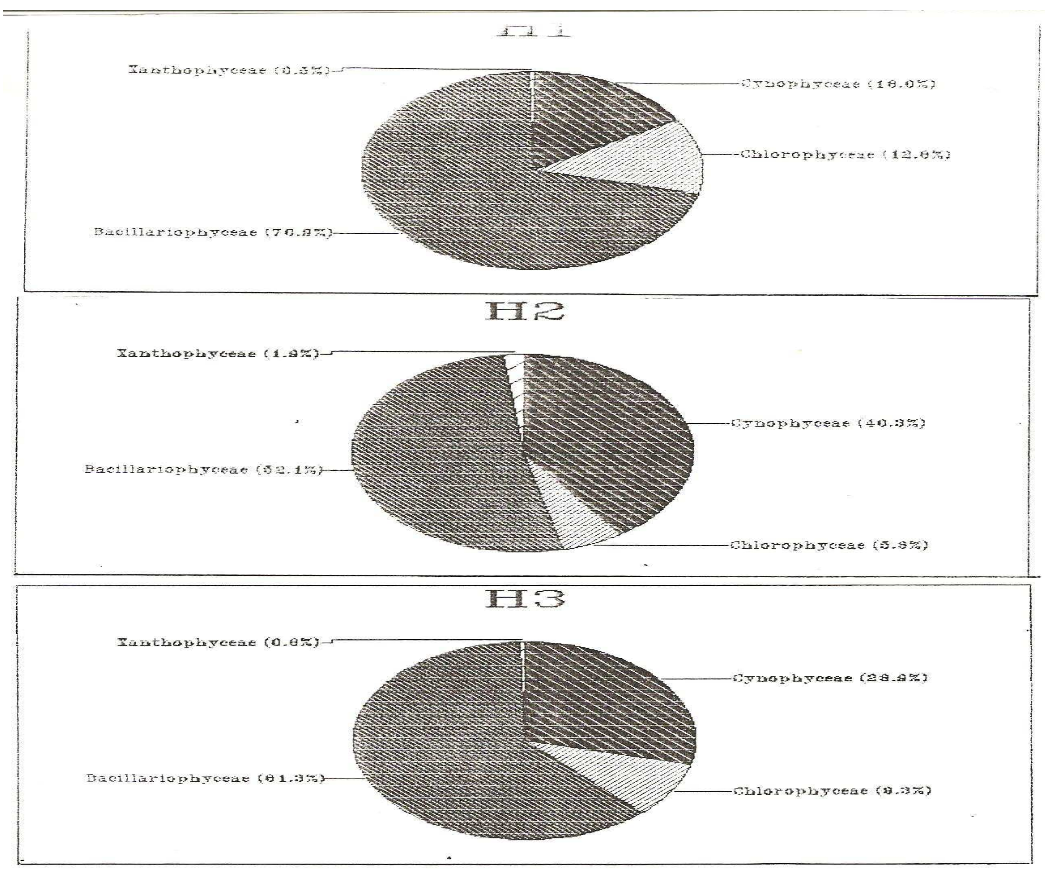

Fig.(3) Percentage composition of the main algal groups at the three Selected site in Al-Hartha thermal energy station

Discussion

The present work revealed that heated effluents of Al-Hartha power station, to some extent, provided suitable conditions for occurrence of aquatic organisms closer to the discharge point. This fact, however, was true during winter months when water temperature was around 20-25ºC. In other periods (mainly summer months) density of aquatic organisms including algae declined sharply. It is therefore, the depletion in algal genera closer to discharging effluents may be related to the considerable rise in water temperature. It is obvious, that relatively small and sudden variations of temperature can be more harmful than larger and more gradual changes.

Heated effluents serve to eliminate weak resistance species i.e. green algae and replaced with more tolerable, but nuisance ones. The blue green algae reflected a notable rise in the number of their species. Green algae suffered decline in abundance (7 species) closer to discharging point of heated effluents. Bader *et al*. (1972) achieved similar conclusions in their investigation on the impact of heated effluents on California. When water temperature exceeded 33º C, they encountered mass mortalities of the majority of chlorophyta, in particular during summer.

The notable increase in number of species adjusted to both sites (H2 & H3) of cooling water discharge is due to the remarkable abundance of blue green algae which accounted for 10 species. This coincided with(23)and(6)findings. However, the study revealed that some diatomic genera were abundant (Table1), namely, *Cymbella* spp., *Fragillaria* spp., *Rhiocosphenia* spp., *Cocconeis placentula*, *Achanthes* spp. and *Nitschia* spp. This may be attributed to their ability to tolerate severe environmental conditions mainly elevated temperature (24).

On the other hand, an apparent abundance in genera of cyanophyta (i.e. *Phormdium* spp, *Lyngbia* sppand *Oscillatoria* spp.) was detected. This is in agreement with(25) who also deduced their dominance with the rise in temperature.(26) achieved similar conclusions as well.(27) and(28) were of the opinion that temperature and nutrients are the two vital factors in the abundance and blooming of algae, but the reduced solubility of oxygen at higher temperatures causes deoxygenating and may lead to heavy mortalities among inhabitants.

References

1-T.A.Olsen and F.J.Burgess.Pollution and Marine Ecology. John Wileyand Sons, Inc. New York.:364pp.(1967).

2- Mellanby, K. The Biology of Pollution. London:60pp. .(1972).

3- R.G.Bader,M.A.Rossler,and,A.Thorhavg. Thermal pollution of Tropical Marine Estuary. Marine pollution and sea life, Marina Ruivo(Ed.), Fishing News Book Ltd. 425-427pp. (1972).

4-S.K.Yi.Effect of cooling Water System of a power plant on marine organisms:1.Effect on primary production. Bull. Korea Fish. Soc. Vol.20, No.,5: 381-390pp. (1987a).

5-S.K. Yi.Effect of cooling Water System of a power plant on marine organisms:1.Effect on benthic organisms. Bull. Korea Fish. Soc. Vol.20,No.,5: 391-407pp.(1987b).

6-A.T.Smin.Changes in the composition and quantitative relations of the phytoplankton in heated lake near Koni in(Poland). EKOL.POL.Vol.36,No.1-2:133-297pp.(1988).

7- N.A.Awad.Effect of water disposal from pulp and paper factor and fertilizer industries on water quality of Shatt Al-Arab estuary. MSc thesis, College of Science, University of Basrah:126p.(1979).

8-V.Kell and A.Saad.Investigation on the phytoplankton and some Environmental parameter of Shatt Al-Arab(Iraq). Int. Rev. ges. Hydrobiol. 60(3): 405-421pp.(1975).

9-H.A.Hameed.Studies of ecology of phytoplankton of Shatt Al-Arab River at Basrah, Iraq.MSc. Thesis, University of Basrah, Iraq. (1977).

10-M.F.Huq,H.A.Al-Saadi and H.A.HameedPhytoplankton ecology of Shatt Al-Arab River at Basrah, Iraq.Verh. Internat. Verein. Limnol. 20:1552-1556pp.(1978).

11-A.J.Brook.The bottom living algal flora of slow sand filter bed to establishment species on the bed.Hydrobio.6(1):333-351pp. (1954).

12-J.W.Elton and B. Moss.The estimation of numbers and pigment content in Epipelic algae population. Limnology and Ocanography.11(4): 584-595pp.(1966).

13- G.M.Smith. The fresh water algae of the united state.2nd ed. McGrow-Hill Book VCo.,New York.719p. (1952).

14-G.W.Prescott.How to know fresh water algae.2nd William Co. Publishers Dubugue, Iowa,348p.(1970)

15-G.W.Prescott. How to know fresh water algae. WM.C.Brown Company Publishers,U.S.A.,293p. .(1979).

16-A.K.M.Nurl-Islam.Studies of the genus *Vaucheria* (Xanthophyceae) in Iraq. Int.Revue. ges. Hydrobio. 69 (61): 877-702pp.(1984).

17-A.Y.Al-Handal,S.A.Al-Assa and Al-Mukhtar, M.A..Occurrence of some Filamentous algae in the river Shatt Al-Arab. Marina Mesopotamia. 4(1):67-81pp. (1989).

18-A.A.Al-Saboonchi,A.A.Ghani,and M.M.Abdul-Hussein.Non-diatom algae from Shatt Al-Arab River, Iraq. Marina Mesopotamia.5(1):89-125pp.(1990).

19-A.Cleven-Euler.Die Diatomean Von Shwedes and final kungl. SV.VCT.Akod-Hande. (1952).

20.F.Hustedt.Bacillariophyta(Distomeae).Dr.A.Pascheri Die. susswasser- Flora Mitteleuropas. 466p. (1976).

21-A.Y.Al-Handal,A.R.M.Mohamed and D.S.Abdulla.TheDiatom flora of the Shatt Al-Basrah Canal, South Iraq. Maarina Mesopotamia, 6(2):109-118pp.(1991).

22-M.R.Martnez,R.P.Chakroff and, J.B.Pantastico.Not on direct phytoplankton counting technique using the haemocytometer.Phil.Agr. 59:1-12pp. (1975).

23-J.Carnis.Ecological management problem caused by heated wastewater discharge in to the aquatic environment. Water Resource. Bull. 6(1):868-878pp.(1970).

24-M.Hichman and D.M.Kalrer.The growth of some epiphytic algae in lake receiving thermal effluent. Arch. Hydrobiol.74(3):403-426pp. .(1974).

24-M.Hichman and D.M.Kalrer.The growth of some epiphytic algae in lake receiving thermal effluent. Arch. Hydrobiol.74(3):403-426pp. .(1974).

25-F.E.RoundThe Biology of algae.2nd Edward Arnold, London.278p.(1973).

26-A.H.Al-Mousawi and B.AWhitton.Influence of environmental factors on rice-field soil from the Iraqi marshes. Arab Gulf J.Sci.Res.1(1):237-253pp.(1983).

27-Z.Zhong.Marine planktology.China Ocean Press,454pp. .(1989).

28-J.W.Moor.Composition and structure of algal communities in a tributary stream of lake antario.Con.J. Bot.50:1663-1674pp. .(1972).

تأثير المتدفقات الحارة لمحطة كهرباء الهارثة على النظام البيئي لنهر شط العرب
I I. الاختلافات الفصلية في كثافة وتوزيع الطحالب

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الخلاصة

درس تأثير المتدفقات الحارة لمحطة كهرباء الهارثة الحرارية على كثافة وتوزيع ووفرة الطحالب في نهر شط العرب وعلى أساس شهري للمدة من تشرين الثاني 1997 إلى تشرين الأول 1998. وحددت المنطقة المتأثرة بالمتدفقات الحرارية بـــ1250 م. وبلغ عدد أنواع الطحالب المشخصة 79 نوعا تعود إلى 45 جنسا. وأسهمت الدايوتومات بـــ 63 نوعا والطحالب الخضراء بـــ 14 نوعا والطحالب الخضراء المزرقة بـــ 12 نوعا. بينما الطحالب اليوغلينية والصفراء تمثلت بنوع واحد فقط لكل منهما. وتميزت منطقتي تصريف الماء الحار بارتفاع عدد الأنواع المشخصة (66 نوعا). وسجلت أعلى زيادة في العدد الكلي لخلايا الطحالب (2296 خلية/سم2) قرب منطقتي تصريف الماء الحار خلال حزيران. وكانت السيادة للدايوتومات تلتها الطحالب الخضراء المزرقة ومن ثم الطحالب الخضراء ثم الطحالب الصفراء واليوغلينية. وأظهرت الطحالب الخضراء المزرقة سيادة واضحة قرب منطقتي تصريف الماء الحار بالأخص خلال أشهر الصيف.