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On the View of the Red Tide Phenomenon, Ecological Studies of Phytoplankton Community, in the Northern Waters of the Arabian Gulf

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Abstract. Biological, chemical and ecological investigations on samples collected during May to October 2000 had been achieved at six sites of southern Iraqi area of the gulf. No clear red tide had been detected, although some dinophyceae species were presented in some stations and occasions.The physico-chemical investigation of the south of Shatt Al-Arab River area showed marked increase in the salinity and decreased turbidity and chlorophyll a contents. However, no marked fluctuation of water temperature had been detected. No nitrite was detected at (Khur Al-Ummaia) and (Um Qasir) stations during August, while significant amount of nitrate was recorded during the same period. High nitrate also recorded in north Shatt Al-Arab (Khalid Bridge and paper factory stations) compared to other stations. Phosphate content had increased during August, and more values recorded at the Khur Zubair than that of the other stations. Relatively, high amount of silicates was found during September mainly at Khalid Bridge. The harmful red tide species *Dinophysis caudata* and *Amphora coffeaeformis* were found at some stations once during the whole investigated period. Diatoms dominated during the investigation period. No blue green and green algae had detected at the gulf site, *e.g.* Khur Al-Ummaia, Um Qasir and Khur Zubair Stations. Euglenophyceae species appeared at Khur Al-Ummaia Station. Total of 75 species (41 genera) were identified in the six sites,

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of which there were 51 species (26 genera) of Bacillariophyceae, 5 species (5 genera) of Cyanophyceae, 8 species (5 genera) of Chlorophyceae, 2 species (2 genera) of Euglenophyceae, and 9 species (4 genera) of Dianophyceae. *Glenodinium borgei* (Lemm.) Schill, and *Glenodinium pulvisulcus* (Ehr.) Stein appeared at Shatt Al-Arab River Stations (the estuary, Khalid Bridge and Paper factory) during the most of the sampling period.

Keywords: Phytoplankton, Red Tide, Shatt Al-Arab River, Arabian Gulf, Physico-chemical and Algal Classification.

Introduction

The Arab Gulf Bay ecosystem had been severely stressed by red tide bloom during spring-autumn of 2000. Red tide phenomenon had not been well studied in the area, however the appearance of dinoflagellates algae in abundant amounts was detected during July and August and affected Kuwait and Oman regions.

The abnormal production of all groups of phytoplankton (diatoms, dinoflagellates, and blue-green algae) leads to discoloration of surface waters. One manifestation of bloom is red tide. Red tides are not unusual phenomenon in the water bodies. As far back as the 1840s, recording of strong smell; eye, nose, and throat irritation; and large fish kills related to the event have been noted. As early as 1930, along the Indian coast some stray observations on Phytoplankton blooms otherwise called as red water phenomena were also, reported onwards.

The red tide at high concentrations (called a bloom) of the organisms may discolour the water. However, red tides are not always red. They can appear greenish, brownish and even purple in colour. Or, the water can retain its normal colour.

So, occurrences of red tide blooms are a common phenomenon in the most coastal waters of the world. Many red tides are non-toxic and benign but only few red tides caused by certain dinoflagellates are toxic.

There are unfortunately some of these phytoplankton are toxic, causing mass mortality of marine organisms. Husain and Faraj (2000) attributed the fishkill on the Kuwait Bay 1999 to the dinoflagellate *(Gymnodinium c.f. mikimotoi*). These organisms produce a toxin that harms fish and human. The impact to human health is primarily from eating seafood that has been contaminated with red tide toxins. Also,

there are concerns about toxic blooms that might cause serious damages of fish trading. *e.g.* Kuwait has lost about100 tons of fish mainly in mullets (*Liza macrolepis*) and sea bream (*Sparidentex hasta*) during the bloom of September 1999 **(**Husain and Faraj 2000**)**.

Al-Arajy (2001) studied some ecological factors on the Shatt Al-Arab area and the mouth of North West Arabian Gulf (Khour Al-Zubair) and attributed fish kills to the blooming of *Prymensium parvum* which caused the relatively rising temperature associated with high light intensity and moderate wind.

Another common cause of fish kills is oxygen-depleted water upwelling to the surface. So the red tide could be caused by; biology, chemical contents, physical environment or other factors. Each cause carries vastly different implications. Oxygen depletion raises no concerns about food security.

Studies on the physico-chemical features of Shatt Al-Arab had been made since 1965 or before (Mohammad, 1965; Arndt & Al-Saadi, 1975; Salman & Faris, 1977; Al-Hello and Al-Obaidy 1997 and Atte, 2004). The studies covered different fields *e.g.* the occurrence of zooplankton; distribution of rotifers invertebrates; the biological pollution of Bacteria; the effect of hydrocarbons; the effect of metals and heavy metals, lastly the nutrients, chlorophyll a and phytoplankton.

Recent work was done by Al-Shaheen (2002), who studied the physico-chemical characteristics of the drinking water at Basrah City station. Also, Atte (2004) studied the heavy metals at Shatt Al-Arab River.

Gleams on the History of the Red Tide

The red tide phenomenon had been recorded as early as 1840s in the Gulf of Mexico. Along the Indian coast, Revikala and Ramamurthy (1983), reviewed the study of the occurrence of Phytoplankton blooms with reference to marine fish production during the last two decades, *i.e.* from 1963 to 1982.

Prasad (1953) observed red water phenomenon caused by *Noctiluca* in the Palk Bay of the Indian East Coast, which was reported later to be lethal on Plankton caused by swarms of dinoflagellates (Prasad and

Sayaraman 1954). They also observed varying intensities of diatom peaks occur following *Noctiluca bloom.* Prasad (1956) further noticed that the bloom of *Rhizosolenia alata* and *Rhizosolenia imbricate* were dominant in March 1950 and February 1951 respectively. Furthermore, Subba Rao (1969) observed an extensive discoloration of coastal water off Waltair, Bay of Bengal, due to *Asterionella japonica* bloom. Ramamurthy (1968, 1970a, b and 1973) had recorded blooms of *Trichodesmium* in PortoNovo waters. Santha Joseph (1975) observed swarming of *Noctiluca miliaris* in August 1966, August 1967 and May 1968 in Vellar Estuary, while Venugopal *et al.* (1979) had also showed the occurrence of this species from off Cochin and Quilon.

In the west coast of India, and precisely, in Arabian Sea, Bhimachar and George (1950) observed, red water phenomenon caused by *Noctilucta., Gymnodinium, Coscinodiscus* and *Dinophysis* but no mortality, however, was observed. While Prakash and Sarma (1964) recorded the presence of *Gonyaulax polygramma* from the west coast of India off Cochin and there was virtual exclusion of Zooplankton, the bloom was non-toxic. Prabhu *et al*.(1965) found extensive greenish yellow patches of *Trichodesmium erythraeum* and *Trichodesmium hildebrontii* in Ullal (Mangalore). Nagabhushanam (1967) observed adverse effects to Tuna fisheries due to *Trichodesmium erythraeum* bloom in Minicoy Island. Colour of the water was deep brownish and it had a distinct iodoform odour. Qasim (1970) noted *Trichodesmium* bloom in Laccadive Island. No mortality of fish or other organisms was associated with this bloom (Ramamurthy *et al.* 1972). They also noted blooms of centric and pennate diatoms (consisted of *Asterionella sp., Thalassiothrix sp., Coscinodiscus sp., Melosira sp., Stephanopyxis sp.*) succeeded that bloom. Devassy (1974) reported the dominancy component of *Fragilaria oceanica* deve, in a mixed bloom of diatoms and blue green algae which occurred near Mangalore. He also reported *Nitzschia* and *Skeletonema* blooms from Cochin backwater. Devassy *et al.* (1978) noted *Trichodesmium* phenomenon in near shore water of Goa and reported that Phytoplankton and Zooplankton were fairly abundant. Verlancar (1978) studied blooms of *Trichodesmium erythraeum* at several places along the southwest coast of India during March 1977.

However, the other part of the world can be summarized as follows; Wood (1965) and Bowman and Lancaster (1965) observed blooms of

*Trichodesmium erythraeum*in in the Pacific Ocean, Sato *et al*. (1966) noted red tide of *Trichodesmium* in north eastern Brazil and related it to Tama dare fever.

First records of red tides in Atlantic Moroccan waters date from 1966. Since then, red tides have been recorded regularly during late summer and early autumn (Joutei *et al.* 2000). Kaas (2000) worked on the Danish coastal, had divided the harmful blooms, in his area, into two groups: the regular blooms and the exceptional blooms.

Robinson (1968) studied red tide of *Gonyaulax tamarensis* off the North East Coast of England. Red water due to *Noctiluca* was studied by Le Fevre and Grall (1970) of the Western coast of Britany.

Cosgrove *et al.* (2000) worked on the Murray River, Western Australia, on June 2 and June 8 1999 and found that the evidence gathered suggests that the dinoflagellate species observed in the Murray River at the time of the fishkills was *Gymnodinium galatheanum* Braarud.

Hodgkiss *et al.* (2000) mentioned that, Hong Kong is one of the most frequent sites of Harmful Algal Blooms in the world.

Gobler *et al.* (2004) showed phytoplankton communities in two New York estuaries that hosted blooms of the brown tide alga *Aureococcus anophagefferens* during 2000 and 2002.

The current study is partial report focusing on the nutrients and phytoplankton community composition analysis.

Study Area

Six sites were selected at different places covered the study area; three sites were selected around the local board of the gulf named stations 1, 2 and 3 (Khur Al-Ummaia, Um Qasir and khur Al-Zubair respectively). The other three stations were selected at Shatt Al-Arab River; stations 4 and 5 located at north of the river (near by Paper factory and Khalid Bridge respectively) and last station (6) at the mouth of the river, the estuary (Fig.1).

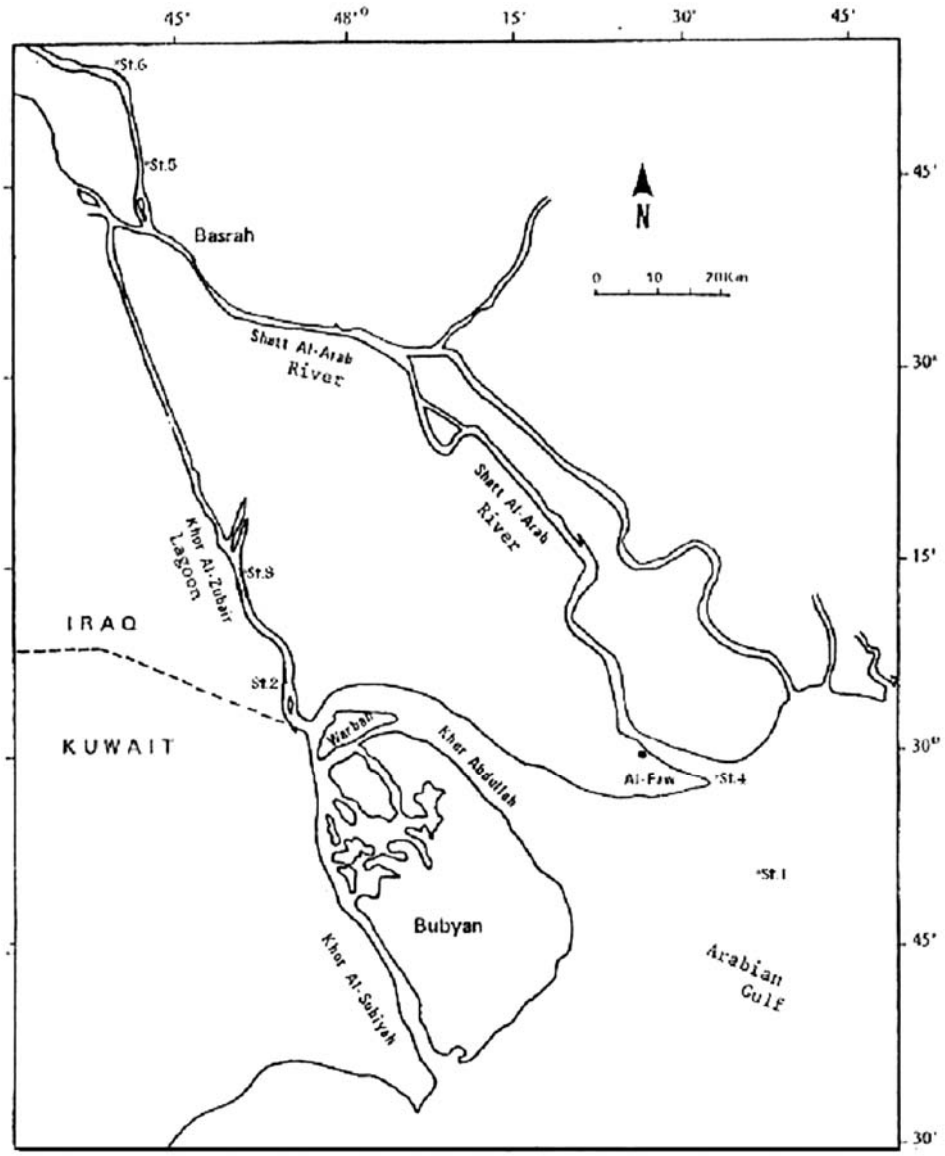

Fig. 1. The location of the six studied stations during the red tide 2000.

Material and Methods

Ecological studies of the phytoplankton blooms (red tide) along the Iraqi coastal and Shatt Al-Arab River were carried out during May, June, July, August, September and October 2000. The sampling was carried out between (10:00-12:00 am). Samples for phytoplankton community composition and nutrients analyses were collected from the selected stations; Deep Port (Khur Al-Ummaia), Um Qasir, Khur Al-Zubair, Khalid Bridge, Paper factory, and the estuary of Shatt Al-Arab River.

Electrical conductivity (EC) was determined using a conductivity meter type Kent Lie 5005. Nitrite was determined spectrophotometrically method for NO_2-N as described by Parsons *et al.* (1984). Nitrate nitrogen (NO_3-N) was reduced to nitrite according to Wood *et al.* (1967) as described by Parsons *et al.* (1984). Active phosphor (PO_4-P) and silicon SiO3 –Si were estimated by Murphy & Riley (1962) methods as described by Parsons *et al.* (1984).

Chlorophyll a estimation techniques were carried out by preparation of phytoplankton material in a Millipore filter apparatus, using an aqueous acetone solution (93.5%) as suggested by Furet (1979) and Hadi (1981) for extracting phytopigments from algal cells. Finally, estimation of chlorophyll a by spectrophotometer was carried out according to Vollenweider (1971).

One liter of the water sample was filtered through a Millipore filter apparatus using the following procedure: One liter water sample was thoroughly shaken and 1 ml. of 1%MgCO3 suspension was added to prevent the conversion of chlorophyll a to phaeophytin a, then transferred to a graduated cylinder, and poured gently over the Millipore funnel using a GF/C 42.5mm glass fibre filter paper.

The funnel was rinsed with deionized water. The excess water of the filter paper also was squeezed and allowed to air dry out before the extraction of the phytopigments.

Phytoplankton were collected by mean of phytoplankton net (20 μg mesh) and preserved by 4% formalin. Algal taxa were identified using a light Zeiss Standard microscope. The diatoms were mainly identified according to Hustedt (1930 a, b, 1959, and 1962), Patrick and Reimer (1966 and 1975) and Germain (1981). Other algal taxa were identified according to Bourrelly (1966 and 1970), Pascher (1914 and 1925) and

Prescott (1954 and 1962). The nomenclature of algal taxa was mostly checked according to Whitton *et al.* (1978). Names of the diatoms were checked through Hartley`s checklist (1986).

Results

Physicochemical Analysis

All data were taken from Marine Science Centre's report (2000). The water temperature was recorded in Table 1. No much fluctuation was recorded during the investigation period. The minimum temperature was recorded at Station 6 (Paper Factory) in June, while the maximum temperature was recorded at Station 5 (Khalid Bridge) in July.

Table 1. Values of water temperature (°C) at different stations during the red tide period (May-October 2000) .

Sampling time	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	The estuary	Khalid bridge	Paper factory
May	30.5	26	28.2	29.5	26.3	26.3
June	29	26	25	29.6	26	24
July	–	29	29	–	32.5	30
August	–	31	31	–	32	30
September	–	28	28	–	27	26
October	–	–	–	–	28	28

The minimum value of salinity was recorded at Station 5 (Khalid Bridge) in August. The maximum one was recorded at Station 1 (Khur Al-Ummaia) in August as well (Table 2). The values of the salinity increase toward the gulf.

Table 2. Salinity values ‰ at different stations during the red tide period (May-October 2000).

Sampling time	Khur Al-Ummaia	Um Qasir	Khur Zubair	The estuary	Khalid bridge	Paper factory
May	39.4	30.2	23.5	10	2.19	2.3
June	21	35.8	29	20.6	2.4	2.1
July	–	36.5	32.6	–	2.3	2.1
August	40	39.5	35.5	32.5	1.5	2
September	–	39	33.4	–	2.05	2.0
October	–	–	–	–	45	42

The less values of turbidity during the investigation (Table 3) were recorded at Stations 2 (Um Qasir) and Station 3 (Khur Al-Zubair). It was found that the values of turbidity were relatively high at north Shatt Al-Arab River Stations (Khalid Bridge and Paper Factory).

Table 3. Water Turbidity (mg. l^{-1} Si Equiv.) at different stations during the red tide period (May-October 2000).

Sampling time	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	The estuary	Khalid bridge	Paper Factory
May	190	29	13	20	43	45
June	400	18	22	25	33	32
July	–	19	24	–	56	35
August	–	13	19	–	35	25
September	–	–	17	–	37	45
October	–	–	–	–	2.6	2

Chlorophyll a values were recorded in Table 4. The maximum values were recorded at Station 6 (Paper Factory) in August, while the minimum one was at Station 2 (Um Qasir) in June. Relatively higher values were recorded at Stations 5 and 6 than that of other stations.

Table 4. Chlorophyll a (mg.m^{-3}) at different stations during the red tide period (May-October 2000).

Chlorophyll a	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	The estuary	Khalid bridge	Paper factory
May	5.02	19.65	3.27	4.3	37.4	39.31
June	–	0.62	0.93	14.3	19.7	15.07
July	–	1.8	1.6	–	11.77	16.8
August	1.3	3.58	1.6	1.7	3.23	69.9
September	–	–	1.51	–	6.10	6.25
October	4.66	2.15	–	–	7.5	14.71

No nitrite was detected at Station 1 (Khur Al-Ummaia) and Station 2 (Um Qasir) during the sampling of August. The maximum value of nitrite was recorded at Station 5 (Khalid Bridge) in September. The nitrite values of the last station during the sampling period was found to be relatively higher than the other stations (Table 5).

Table 5. Nitrite-nitrogen (µg l^{-1}) at different stations during the red tide period (May-October 2000).

Nitrite NO_2-N	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	The estuary	Khalid bridge	Paper factory
May	0.05	0.15	0.12	0.06	0.26	0.2
June	–	0.07	0.09	0.04	0.12	0.06
July	–	0.08	0.09	–	0.26	0.09
August	N.D.	N.D.	0.07	0.2	0.16	0.07
September	–	–	0.09	–	0.52	0.05
October	0.102	0.11	–	–	0.063	0.04

Nitrate was found to be more during the July sampling at all stations (Table 6). Lowest value of nitrate was recorded at Station 4 (The Estuary) in May. The highest value was recorded at Station 3 (Khur Al-Zubair) in July. Less value were recorded at Stations 1 and 4 (Khur Al-Ummaia and The Estuary respectively) than those of other stations.

Table 6. Nitrate nitrogen (µg l^{-1}) at different stations during the red tide period (May-October 2000).

Nitrate NO_3-N	Khur Al-Ummaia	Um Qasir	Khur Zubair	The estuary	Khalid bridge	Paper factory
May	1.00	5.6	5.2	0.26	12.6	9.0
June	1.00	16.5	18.8	2.8	17.2	2
July	–	19.2	22.6	–	20.8	19.8
August	0.98	18.7	19.1	2.5	16.9	18.2
September	–	9.1	6.2	–	17	11.4
October	1.2	1.2			14.4	5.8

The maximum value of phosphate recorded during the investigation was at Station 3 (Khur Al-Zubair) in August, while the minimum value was recorded at more that one station, Station 4 (The Estuary) in June and Station 6 (Paper Factory) in August and October. More values of phosphate were recorded in August than that of other months, while more values were recorded at Station 3 than that of the other stations during the investigation (Table 7).

Table 7. Phosphate-phosphor (µg l^{-1}) at different stations during the red tide period (May-October 2000).

Phosphate PO_4 -P	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	The estuary	Khalid bridge	Paper factory
May	0.165	0.15	1.75	1.00	0.155	0.3
June	0.12	1.2	0.3	0.04	0.125	0.05
July	–	0.65	0.85	–	0.45	0.42
August	0.2	1.2	3.2	0.25	0.11	0.04
September	–	0.3	0.10	–	0.35	0.05
October	0.16	0.31	–	–	0.51	0.04

Regarding the silicate analyses (Table 8). The maximum value of silicate was recorded at Station 5 (Khalid Bridge) and minimum at Station 1 (Khur Al-Ummaia) and Station 2 (Um Qasir) in June and July respectively. High values of silicates were recorded at Station 5 (Khalid Bridge) during the investigation than that the other stations. Higher values of silicates were recorded during September than that the other months.

Table 8. Silicate-silicon (µg l^{-1}) at different stations during the red tide period (May-October 2000).

Silicate SiO_3 –Si	Khur Al-Ummaia	Um Qasir	Khur Zubair	The estuary	Khalid bridge	Paper factory
May	105	77	91	63	82	50
June	13	72	78	33	71	84
July	–	13	21	–	81	84
August	19	70	75	30	79	90
September	–	85	117	–	148	82
October	20	17	–	–	155	87

Phytoplankton Community's Analysis

Appearance of the phytoplankton during each sampling period (June-October) were listed in Tables 9-13 at the end of this paper, where isolation phytoplankton species were classified and listed.

In the June sampling period (Table 9), 39 species were recorded, 4 species from Cyanophyceae, 5 species from Chlorophyceae, one species

from Euglenophyceae, 7 species from Dinophyceae and 22 species from Bacillariophyceae.

Table 9. Appearance of the phytoplankton at the six stations during June 2000.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Cyanophyceae						
01. *Arthrospira plattensis* (Nordst) Commont	–	–	–	–	+	–
02. *Lyngbya martensiana* Menegh. ExGomont	–	–	–	–	–	+
03. *Mersimopedia glauca* (Her.) Naeg.	–	–	–	–	–	+
04. *Oscillatoria subbrevis* Schmidle	–	–	–	–	–	+
Chlorophyceae						
05. *Actinastrum hantzschii* Lagerhier	–	–	–	–	+	+
06. *Caelastrum microporum* Nageli	–	–	–	–	+	–
07. *Scenedesmus acuminatus* (Lag.) Chodat.	–	–	–	–	–	+
08. *Scenedesmus dimorphus* (Turp.) Kuetz	–	–	–	–	–	+
09. *Scenedesmus quadricauda* Bred. Var. maximus West and West	–	–	–	–	+	+
Euglenophyceae						
10. *Lepocinclis ovum* (Her.) Le.	–	–	–	–	+	+
Dinophyceae						
11. *Ceratium furca* (Ehr.) Stein	+	–	–	–	–	–
12. *Ceratium fuscus* (Ehr.) Dujardin	+	–	–	–	–	–
13. *Ceratium massiliense* Jorg.	+	–	–	–	–	–
14. *Glenodinium armatum* Lev.	–	–	–	–	+	–
15. *Glenodinium borgei (*Lemm.)Schill	–	–	–	–	+	+
16. *Glenodinium pulvisulcus* (Ehr.) Stein	–	–	–	–	+	+
17. *Peridinium retiferum* Matz	+	+	–	–	–	–
Bacillariophyceae						
18. *Bacteriastrum delicatulum* Cleve	+	–	–	–	–	–
19. *Biddulphia sinensis* Greville	–	+	–	–	–	–
20. *Chaetoceros didyms* Her.	+	–	–	–	–	–

Table 9. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
21. *Cocconeis placentula* var. euglypta (Ehr) Cl.	–	–	–	–	+	–
22. *Cocconeis pediculus* (Ehr)	–	–	–	–	–	+
23. *Coscinodiscus eccentricus* Ehr.	–	+	+	–	–	–
24. *Coscinodiscus oculus-iridis* Ehr.	–	+	–	–	–	–
25. *Cyclotella meneghiniana* Kuetz	–	–	–	–	–	+
26. *Cyclotella striata* (Kuetz.) Grun.	–	+	–	–	–	–
27. *Cymatopleura elliptica* (Breb.)W. Smith	–	–	–	+	–	–
28. *Gyrosigma acuminatum* (Kuetz.) Rab	–	+	–	–	–	–
29. *Gyrosigma attenuatum* (Kuetz.) Rab.	–	–	–	–	+	–
30. *Gyrosigma tenuirostrum* (Grun.) Cleve-Euler	–	–	–	–	+	–
31. *Nitzschia seriata* Cleve	+	–	–	–	–	–
32. *Nitzschia sigma* (Kuetz.) W. Smith	–	–	–	–	+	–
33. *Nitzschia sigma* var. rigidula Grun.	–	+	–	–	–	–
34. *Surirella ovata* Kuetz.	–	+	–	–	–	–
35. *Synedra ulna* (Nitzsch.)Ehr.	–	–	–	+	+	–
36. *Thalassionema nitzschioides* (Grun.) Hust.	+	+	+	–	–	–
37. *Thalassiosira fluviatilis* Hust	–	–	–	–	+	–
38. *Thalassiothrix frauenfeldi* (Grun) Cleve and Moeller	+	+	+	–	–	–
39. *Thalassiothrix longissima* Cleve and Grun.	+	+	–	–	–	–

In the July sampling period (Table 10), 35 species were recorded, 2 species were from Cyanophyceae, 5 species from Chlorophyceae, one species from Euglenophyceae, 5 species from Dinophyceae and 22 species from Bacillariophyceae.

Table 10. Appearance of the phytoplankton at the six stations during July 2000.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Cyanophyceae						
01. *Arthrospira plattensis* (Nordst) Commont	–	–	–	–	+	–
02. *Mersimopedia glauca* (Ehr.) Naeg.	–	–	–	+	+	–
03. *Oscillatoria subbrevis* Schmidle	–	–	–	–	+	–
Chlorophyceae						
04. *Actinastrum hantzschii* Lagerhier	–	–	–	–	+	–
05. *Caelastrum microporum* Nageli in	–	–	–	–	+	–
06. *Pandorina morum* (Muell) Bory	–	–	–	–	+	–
07. *Pediastrum simplex* Meyen.	–	–	–	–	–	+
08. *Scenedesmus quadricauda* Bred. Var. maximus West and West	–	–	–	–	+	+
Euglenophyceae						
09. *Lepocinclis ovum* (Her.) Le.	–	–	–	–	+	–
Dinophyceae						
10. *Ceratium furca* (Ehr.) Stein	+	–	–	–	–	–
11. *Ceratium fuscus* (Ehr.) Dujardin	+	–	–	–	–	–
12. *Ceratium massiliense* Jorg.	+	–	–	–	–	–
13. *Glenodinium pulvisulcus* (Ehr.) Stein	–	–	–	+	+	+
14. *Peridinium retiferum* Matz	+	–	–	–	–	–
Bacillariophyceae						
15. *Amphipora alata* (Ehr.)Kuetz	–	–	–	–	+	+
16. *Bacteriastrum delicatulum* Cleve	+	–	–	–	–	–
17. *Chaetoceros didyms* Her.	+	–	–	–	–	–
18. *Chaetoceros affinis* Lauder	–	+	–	–	–	–
19. *Cocconeis placentula* var. euglypta (Ehr) Cl.	–	–	–	–	+	–
20. *Coscinodiscus eccentricus* Ehr.	–	+	+	–	–	–
21. *Coscinodiscus oculus-iridis* Ehr.	–	+	+	–	–	–
24. *Gyrosigma acuminatum* (Kuetz.) Rab	–	+	+	–	–	–
25. *Gyrosigma attenuatum* (Kuetz.) Rab.	–	–	–	–	+	–

Table 10. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
26.*Gyrosigma tenuirostrum* (Grun.) Cleve-Euler	–	–	–	–	+	–
27. *Nitzschia fasciculate* Grun.	–	–	–	–	+	–
28. *Nitzschia seriata* Cleve	+	–	–	–	–	–
29. *Nitzschia sigma* var. rigidula Grun.	–	+	+	+	–	–
30. *Pleurosigma delicatulum* W. Smith.	–	–	–	+	–	+
31. *Rhizosolenia fragilissima* Bergon	–	+	–	–	–	–
32. *Surirella ovata* Kuetz.	–	+	+	–	–	–
33. *Synedra ulna* (Nitzsch.)Ehr.	–	–	–	–	+	+
34. *Thalassionema nitzschioides* (Grun.) Hust.	+	–	–	–	–	–
35. *Thalassiosira fluviatilis* Hust	–	–	–	–	+	–
36. *Thalassiothrix frauenfeldi* (Grun) Cleve and Moeller	+	+	+	–	–	–
37. *Thalassiothrix longissima* Cleve and Grun.	+	–	–	–	–	

In the August sampling period (Table 11), 46 species were recorded, 4 species were from Cyanophyceae, 6 species from Chlorophyceae, 2 species from Euglenophyceae, 2 species from Dinophyceae and 32 species from Bacillariophyceae.

Table 11. Appearance of the phytoplankton at the six stations during August 2000.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Cyanophyceae						
01. *Arthrospira plattensis* (Nordst) Commont		–	–	+	+	+
02. *Gomphosphaeria aponina* Kuetz.		–	–	+	–	–
03. *Mersimopedia glauca* (Ehr.) Naeg.		–	–	+	+	+
04. *Oscillatoria subbrevis* Schmidle		–	–	+	+	+

Table 11. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Chlorophyceae						
05. *Actinastrum hantzschii* Lagerhier		–	–	–	+	+
06. *Caelastrum microporum* Nageli in		–	–	–	+	+
07. *Pandorina morum* (Muell) Bory		–	–	–	+	–
08. *Scenedesmus acuminatus* (Lag.)Chodat.		–	–	–	+	+
09. *Scenedesmus dimorphus* (Turp.) Kuetz.		–	–	–	–	+
10. *Scenedesmus quadricauda* Bred. Var. maximus West and West		–	–	–	+	+
Euglenophyceae						
11. *Lepocinclis ovum* (Ehr.) Lemm.		–	–	+	+	+
12. *Phacus pleuronectes* (Muell.) Dujardin		–	–	–	–	+
Dinophyceae						
13. *Glenodinium borgei (*Lemm.) Schill		–	–	+	+	+
14. *Glenodinium pulvisulcus (*Her.) Stein		–	–	+	+	+
Bacillariophyceae						
15. *Amphipora alata* (Ehr.)Kuetz.		–	–	–	+	+
16. *Amphora coffeaeformis* Ag.		–	–	–	+	+
17. *Bacillaria paxillifer* (Muller) Heneley		–	–	+	–	–
18. *Biddulphia sinensis* Grecille		+	–	–	–	–
19. *Caloneis permagna* (Bail.) Cl.		–	–	–	+	–
20. *Chaetceros lorenzianus* (Grun)		+	+	–	–	–
21. *Cocconeis placentula* var. euglypta (Ehr.) Cl.		–	–	–	+	–
22. *Coscinodiscus asteromphalus* Ehr.		+	+	–	–	–
23. *Coscinodiscus eccentricus* Ehr.		+	+	+	–	–
24. *Coscinodiscus perforatus* Ehr.		+	+	–	–	–

Table 11. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
25. *Cyclotella meneghiniana* Keutz.		–	–	+	+	+
26. *Cyclotella striata* (Kuetz.) Grun.		+	+	+	–	–
27. *Cyclotella cistula* (Hemp.) Grun.		–	–	–	–	+
28. *Diploneis interupta* (Kuetz.) Cl.		+	+	–	–	–
29. *Diploneis ovalis* var.oblongella (Naeg.) Cl.		–	–	+	–	–
30. *Gyrosigma acuminatum* (Kuetz.) Rab.		+	+	+	–	–
31. *Gyrosigma attenuatum* (Kuetz.) Rab.		–	–	+	+	–
32. *Gyrosigma distorun* var. Pakeri Harriss)		+	+	+	–	–
33. Gyrosigma tenuirostrum (Grun.) Cleve-Euler		–	–	–	–	+
34. Mastogloia smithii var-amphicephala Grun.		–	–	–	+	–
35. Nitzschia granulata Grun.		–	–	+	–	–
36. Nitzschia sigma (Kuetz.) W.smith		–	–	–	+	–
37. *Nitzschia sigma* var. rigidula Grun.		–	+	+	–	–
38. *Nitzschia tryblionella* Hanz		–	–	–	+	–
39. *Podosira steliger* (Bail.) Ehr.		+	–	–	–	–
40. *Surirella gemma* (Ehr.) Kuetz.		+	–	–	–	–
41. *Surirella ovalis* Breb.		–	–	–	+	+
42. *Surirella ovata* Kuetz.		+	+	+	–	–
43. *Synedra ulna* (Nitzsch.) Ehr.		–	–	–	+	–
44. *Thalassionema nitzschioides* (Grun.) Hust.		+	+	–	–	–
45. *Thalassiothrix frauenfeldi* (Grun.) Cleve and Moeller		+	+	+	–	–
46. *Thalassiothrix longissima* Cleve and Grun.		–	–	–	+	+

In the September sampling period (Table 12), 34 species were recorded, 4 species were from Cyanophyceae, 5 species from Chlorophyceae, 2 species from Dinophyceae and 23 species from Bacillariophyceae.

Table 12. Appearance of the phytoplankton at the six stations during September 2000.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Cyanophyceae						
01. *Arthrospira plattensis* (Nordst) Commont	–	–	–	+	–	–
02. *Gomphosphaeria aponina* Kuetz	–	–	–	+	+	+
03. *Mersimopedia glauca* (Ehr.) Naeg.	–	–	–	–	+	+
04. *Oscillatoria subbrevis* Schmidle	–	–	–	+	+	+
Chlorophyceae						
05. *Actinastrum hantzschii* Lagerhier	–	–	–	–	–	+
06. *Scenedesmus acuminatus* (Lag.) Chodat.	–	–	–	–	+	+
07. *Scenedesmus dimorphus* (Turp.) Kuetz	–	–	–	–	+	+
08. *Scenedesmus opoliensis*	–	–	–	–	+	+
09. *Scenedesmus quadricauda* Bred. Var. maximus West and West	–	–	–	–	+	+
Dinophyceae						
10. *Glenodinium borgei (*Lemm.)Schill	–	–	–	–	–	+
11. *Glenodinium pulvisulcus (*Ehr.) Stein	–	–	–	–	–	+
Bacillariophyceae						
12. *Biddulphia sinensis* Grecille	–	+	–	+	–	–
13. *Cocconeis placentula* var. euglypta (Ehr.) Cl.	–	–	–	–	+	+
14. *Coscinodiscus asteromphalus* Ehr.	+	–	–	–	–	–
15. *Coscinodiscus eccentricus* Ehr.	–	+	+	–	–	–
16. *Coscinodiscus oculus-iridis* Ehr.	–	+	–	–	–	–
17. *Cyclotella meneghiniana* Keutz	–	–	–	–	+	+
18. *Cyclotella striata* (Kuetz.) Grun.	–	–	+	+	–	–
19. *Gyrosigma acuminatum* (Kuetz.) Rab.	–	–	+	+	–	–
20. *Gyrosigma attenuatum* (Kuetz.) Rab.	–	–	–	–	+	+

Table 12. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
21. *Mastogloia smithii* var-amphicephala Grun.	–	–	–	–	+	–
22. *Nitzschia fasciculata* Grun.	–	–	+	–	–	–
23. *Nitzschia granulate* Grun.	–	–	+	–	–	–
24. *Nitzschia sigma* (Kuetz.) W.smith	–	–	–	–	+	+
25. *Nitzschia tryblionella* Hanz	–	–	–	–	+	+
26. *Pleurosigma delicatulum* W. Smith.	–	–	–	–	+	+
27. *Rhoicosphenia cutvata* (Kuetz.) Grun	–	–	–	–	+	–
28. *Surirella caproniis* Breb.	–	–	–	–	+	+
29. *Surirella ovalis* Breb.	–	–	–	–	+	+
30. *Surirella ovata* Kuetz.	–	+	+	+	–	–
31. *Synedra ulna* (Nitzsch.)Ehr.	–	–	–	–	+	+
32. *Thalassionema nitzschioides* (Grun.) Hust.	–	+	–	–	–	–
33. *Thalassiothrix fluviatilis* Hust	–	–	–	–	–	+
34. *Thalassiothrix frauenfeldi* (Grun) Cleve and Moeller	+	+	–	–	–	–

In the October sampling period (Table 13), 36 species were recorded, 2 species were from Cyanophyceae, 4 species from Chlorophyceae, 8 species from Dinophyceae and 22 species from Bacillariophyceae.

Table 13. Appearance of the phytoplankton at six stations during October 2000.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
Cyanophyceae						
01. *Mersimopedia glauca* (Ehr.) Naeg.	–	–	–	–	+	–
02. *Oscillatoria subbrevis* Schmidle	–	–	–	–	+	–
Chlorophyceae						
03. *Coelastrum microporum* Nageli in A.Braun	–	–	–	–	+	–
04. *Scenedesmus dimorphus* (Turp.) Kuetz	–	–	–	–	+	+

Table 13. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
05. *Scenedesmus quadricauda* Bred. Var. maximus West and West	–	–	–	–	+	+
06. *Scenedesmus opoliensis*	–	–	–	–	–	+
Dinophyceae						
07. *Ceratium furca* (Ehr.) Stein	+	–	–	–	–	–
08. *Ceratium fuscus* (Ehr.) Dujardin	+	–	–	–	–	
09. *Ceratium massilliense* Joeig.	+	–	–	–	–	–
10. *Ceratium tripos* (O.Muell.) Nitz.	+	–	–	–	–	–
11. *Dinophysis caudata* Sav. Kent.	+	–	–	–	–	–
12. *Glenodinium borgei (*Lemm.)Schill	–	–	–	–	–	+
13. *Glenodinium pulvisulcus (*Ehr.) Stein	–	–	–	–	+	+
14. *Peridinium retiferum* Matz	+	–	–	–	–	–
Bacillariophyceae						
15. *Amphipora alata* (Ehr.)Kuetz	–	–	–	–	+	+
16. *Bacteriastrum delicatulum* Cleve	+	–	–	–	–	–
17. *Chaetoceros didyms* Her.	+	–	–	–	–	–
18. *Cocconeis asteromphalus* Ehr.	–	–	–	–	+	+
19. *Coscinodiscus oculus-iridis* Her.	+	–	–	–	–	–
20. *Cyclotella meneghiniana* Kuetz	+	–	–	–	+	+
21. *Gyrosigma acuminatum* (Kuetz.) Rab	–	–	–	–	–	+
22. *Gyrosigma attenuatum* (Kuetz.) Rab.	–	–	–	–	–	+
23. *Gyrosigma balticum* (Kuetz.) Rab.	–	–	–	–	+	–
24. *Mastogloia smithii* var- amphicephala Grun.	–	–	–	–	+	–
25. *Melosira varians* C.A.Ag.	–	–	–	–	+	–
26. *Nitzschia fasciculate* Grun.	–	–	–	–	+	–
27. *Nitzschia longissima*	–	–	–	–	–	+
28. *Nitzschia sigma* (Kuetz.) W.smith	–	–	–	–	–	+
29. *Nitzschia seriata* Cleve	+	–	–	–	–	–
30. *Pleurosigma delicatulum* W. Smith.	–	–	–	–	+	+

Table 13. Contd.

Algal name	Khur Al-Ummaia	Um Qasir	Khur Al-Zubair	Zubair bridge	Khalid bridge	Paper factory
31. *Rhoicosphenia curvata* (Kuetz.) Grun.	–	–	–	–	+	–
32. *Surirella capronii* Breb.	–	–	–	–	+	–
33. *Surirella ovalis* Breb.	–	–	–	–	+	+
34. *Surirella ovata* Kuetz.	+	+	+	+	–	–
35. *Thalassionema nitzschioides* (Grun.) Hust.	+	+	–	–	–	–
36. *Thalassiothrix frauenfeldi* (Grun) Cleve and Moeller	+	+	–	–	–	–

Spatial and Temporal Distribution of Algae

Tables 14 and 15 represented the presence of different species occasionally at all stations during the study period of investigation. From that table, total phytoplankton identified were 75 species (41 genera), mostly were Bacillariophyceae (diatoms), 51 species (26 genera), the second group was Dinophyceae 9 species (4 genera), the third was Chlorophyceae 8 species (5 genera), the forth group was Cyanophyceae 5 species (5 genera), last group was Euglenophyceae 2 species (2 genera).

Distribution of Cyanophyceae, Chlorophyceae, Euglenophyceae and Dinophyceae species

The Cyanophyceae species was found to be distributed at Stations 4, 5 and 6 (The Estuary, Khalid Bridge and Paper Factory respectively). Some of them appeared during all time of sampling period, like; *Mersimopedia glauca* and *Oscillatoria subbrevis*. Other had appeared in only one month of study time, like; *Lyngbya martensiana* or more than one month (Table 14).

The species of Chlorophyceae occurred mostly at the last two Stations (Khalid Bridge and Paper Factory), like; *Scenedesmus quadricauda* Bred. Var. maximus, which appeared during all the time of sampling at the two mentioned stations. While other species occurred in one time only (July) like; *Pediastrum simplex* (Table 14).

Table 14. Spatial and temporal distribution, of Cyanophyceae, Chlorophyceae, Euglenophyceae and Dinophyceae occurrence, at different stations (1-6), during the study period (June-October 2000).

Species names	(June)	(July)	(Aug.)	(Sept.)	(October)
Cyanophyceae 5 species (5 genera)					
Arthrospira plattensis (Nordst)Commont	5	5	4-5-6	4	–
Gomphosphaeria aponina Kuetz	–	–	4	4-5-6	–
Lyngbya martensiana Menegh. ExGomont	6	–	–	–	–
Mersimopedia glauca (Ehr.) Naeg	6	4-5	4-5-6	5-6	5
Oscillatoria subbrevis Schmidle	6	5	4-5-6	4-5-6	5
Chlorophyceae 8 species (5 genera)					
Actinastrum hantzschii Lagerhier	5-6	5	5-6	6	–
Caelastrum microporum Nageli	5	5	5-6	–	5
Pandorina morum (Muell) Bory	–	5	5	–	–
Pediastrum simplex Meyen	–	6	–	–	–
Scenedesmus acuminatus (Lag.) Chodat	6	–	5-6	5-6	–
Scenedesmus dimorphus (Turp.) Kuetz.	6	–	6	5-6	5-6
Scenedesmus opoliensis	–	–	–	5-6	5
Scenedesmus quadricauda Bred. Var. maximus West and West	5-6	5-6	5-6	5-6	5-6
Euglenophyceae 2 species (2 genera)					
Lepocinclis ovum (Ehr.) Le	5-6	5	4-5-6	–	–
Phacus pleuronectes (Muell.) Dujardin	–	–	6	–	–
Dinophyceae 9 species (4 genera)					
Ceratium furca (Her.)Stein	1	1	–	–	1
Ceratium fuscus (Ehr.) Dujardin	1	1	–	–	1
Ceratium massiliense Jorg	–	–	–	–	1
Ceratium triops (O.Muell.) Nitz	–	–	–	–	1
Dinophysis caudata Sav. Kent.	–	–	–	–	1
Glenodinium armatum Lev.	5	–	–	–	–
*Glenodinium borgei (*Lemm.) Schill	5-6	–	4-5-6	6	6
Glenodinium pulvisulcus (Ehr.) Stein	5-6	4-5-6	4-5-6	6	5-6
Peridinium retiferum Matz	1-2	1	–	–	1

Regarding the Euglenophyceae, two species were found, *Phacus pleuronectes* species appeared once in August at Paper Factory station and *Lepocinclis ovum* species at rather than Paper Factory station during June, July and August.

In case of the Dinophyceae, 4 genera of 9 species were recorded at different stations. Five species, *Ceratium furca*, *Ceratium fuscus*, *Ceratium massilliense Ceratium tripos* and *Dinophysis caudate*, those species appeared only at station 1 (Khur Al-Ummaia) during June, July and October sampling, the last species appeared during October only. The species *Glenodinium borgei* and *Glenodinium pulvisulcus* appeared at Stations 4, 5 and 6 (The Estuary, Khalid Bridge and Paper Factory) respectively during the sampling period. *Glenodinium armatum* was recorded at Station 5 (Khalid Bridge) during June only. The species *Peridinium retiferum* was recorded at Stations 1 and 2 (Khur Al-Ummaia and Um Qasir).

Distribution of Diatoms

1. *Diatom that appeared at only one station*
   a. Khur Al-Ummaia Station: 3 species were recorded at this station, *Bacteriastrum delicatulum*, *Chaetoceros didyms* and *Nitzschia seriata* species had appeared during June, July and October (Table 15).
   b. Um Qasir Station: 4 species appeared at this station, *Chaetoceros affinis* and *Rhizosolenia fragilissima* species had appeared in July, while *Podosira steliger* and *Surirella gemma* species had appeared in August.
   c. Khur Al-Zubair Station: 2 species were recorded at this station, *Bacillaria paxillifer* species had appeared in August and *Nitzschia granulata* species had appeared in August and September.
   d. The Estuary Station: Also 2 species were recorded at this station, *Cymatopleura elliptica* species appeared in June and *Diploneis ovalis* var.oblongella species appeared in August.
   e. Khalid Bridge Station: 4 species were recorded; *Caloneis permagna* and *Cyclotella cistula s*pecies appeared in August. *Gyrosigma balticum* and *Melosira varians* species appeared in September. Species *Mastogloia smithii* var- amphicephala appeared in August, September and October. And *Rhoicosphenia curvata* species appeared in September and October.

2. *Diatom appeared at two Stations*

Nine species of diatoms were found to appear at Stations 5 and 6 (Khalid Bridge and Paper Factory) during the sampling periods, they were; *Amphipora alata*, *Amphora coffeaeformis*, *Cocconeis asteromphalus*, *Cocconeis placentula* var. euglypta, *Gyrosigma tenuirostrum*, *Nitzschia sigma*, *Nitzschia tryblionella*, *Surirella capronii* and *Surirella ovalis* species (Table-15).

Three species of diatoms were found to appear at Stations 2 and 3 (Um Qasir and Khur Al-Zubair) during August sampling, they were; *Chaetoceros lorenzianus*, *Coscinodiscus perforatus* and *Diploneis interupta*.

One species, *Biddulphia sinensis* was found at Stations 2 and 4 (Um Qasir and The Estuary). Also, one species, *Nitzschia fasciculate* was found at stations 3 and 5 (Khur Al-Zubair and Khalid Bridge).

3. *Diatom appeared at three Stations*

Ten species were recorded to appear at three stations. Three species of diatoms were found to appear at Stations; 1, 2 and 3 (Khur Al-Ummaia, Um Qusir and Khur Al-Zubair respectively) during the sampling period, they were; *Coscinodiscus oculus-iridis*, *Thalassionema nitzschioides* and *Thalassiothrix frauenfeldi*. 4 species of diatoms were found to appear at Stations; 2, 3 and 4 (Um Qusir, Khur Al-Zubair and The Estuary respectively) during the sampling period, they were; *Coscinodiscus eccentricus*, *Cyclotella striata*, *Gyrosigma distorun* var. Pakeri and *Nitzschia sigma* var. rigidula, other 3 species of diatoms were found to be appeared at Stations; 4, 5 and 6 (The Estuary, Khalid Bridge and Paper Factory respectively) during the sampling period, they were; *Gyrosigma attenuatum, Pleurosigma delicatulum* and *Synedra ulna*.

4. *Diatom appeared at four or more stations*

Four species were recorded at four stations; *Surirella ovata* species appeared at Stations 1, 2, 3 and 4 (Khur Al-Ummaia, Um Qasir, Khur Al-Zubair and The Estuary respectively) during the sampling period. *Thalassiothrix longissima* species appeared at Stations 1, 2, 5 and 6 (Khur Al-Ummaia, Um Qasir, Khalid Bridge and Paper factory respectively). *Cyclotella meneghiniana* species appeared at Stations 1, 4, 5 and 6 (Khur Al-Ummaia, The Estuary, Khalid Bridge and Paper factory

respectively), and *Gyrosigma acuminatum* species appeared at Stations 2, 3, 4 and 6 (Um Qasir, Khur Al-Zubair, The Estuary and Paper Factory respectively) during the sampling period.

5. *Diatom appeared at four or more stations*

From Table 15; 2 species had appeared at 5 stations; *Coscinodiscus asteromphalus* appeared at Stations 1, 2, 3, 5 and 6 (Khur Al-Ummaia, Um Qasir, Khur Al-Zubair, Khalid Bridge and Paper Factory respectively) and the other one, *Thalassiosira fluviatilis* appeared at Stations 2, 3, 4, 5 and 6 (Um Qasir, Khur Al-Zubair, The Estuary, Khalid Bridge and Paper Factory respectively).

Table 15. Spatial and temporal distribution of Bacillariophyceae (diatoms) occurrence, at different stations (1-6), during the study period (June-October 2000) .

Species names	(June)	(July)	(Aug.)	(Sept.)	(October)
Bacillariophyceae 51 species (26 genera)					
Amphipora alata (Her.)Kuetz.	–	5-6	5-6	–	5-6
Amphora coffeaeformis Ag.	–	–	5-6	–	–
Anomoeneis costata (Kuetz.) Hust.	–	–	–	–	–
Bacillaria paxillifer (Muller) Heneley	–	–	3	–	–
Bacteriastrum delicatulum Cleve	1	1	–	–	1
Biddulphia sinensis Greville	2	–	2	2-4	–
Caloneis permagna (Bail.) Cl	–	–	5	–	–
Chaetoceros didyms Ehr.	1	1	–	–	1
Chaetoceros affinis Lauder	–	2	–	–	–
Chaetoceros lorenzianus (Grun)	–	–	2-3	–	–
Cocconeis asteromphalus Ehr.	–	–	–	–	5-6
Cocconeis placentula var. euglypta (Ehr) Cl.	5	5	5	5-6	–
Cocconeis pediculus (Ehr)	6	–	–	–	–
Coscinodiscus asteromphalus Ehr.	–	–	2-3	1	5-6
Coscinodiscus eccentricus Ehr.	2-3	2-3	2-3-4	2-3	–
Coscinodiscus oculus-iridis Ehr.	3	2-3	–	2	1
Coscinodiscus perforatus Ehr.	–	–	2-3	–	–
Cyclotella cistula (Hemp.) Grun.	–	–	5	–	–
Cyclotella meneghiniana Kuetz.	6	5	4-5-6	5-6	1-5-6
Cyclotella striata (Kuetz.) Grun.	2	2-3-4	2-3-4	3-4	–

Table 15. Contd.

Species names	(June)	(July)	(Aug.)	(Sept.)	(October)
Cymatopleura elliptica (Breb.) W. Smith	4	–	–	–	–
Diploneis interupta (Kuetz.) Cl.	–	–	2-3	–	–
Diploneis ovalis var.oblongella	–	–	4	–	–
Gyrosigma acuminatum (Kuetz.) Rab.	2	2-3	2-3-4	3-4	6
Gyrosigma attenuatum (Kuetz.) Rab.	5	5	4-5	5-6	6
Gyrosigma balticum (Kuetz.) Rab.	–	–	–	–	5
Gyrosigma distorun var. Pakeri (Harriss)	–	–	2-3-4	–	–
Gyrosigma tenuirostrum (Grun.) Cleve-Euler	5	5	6	–	–
Mastogloia smithii var- amphicephala Grun.	–	–	5	5	5
Melosira Granulata (Ehr.Ralfs)	–	–	–	–	–
Melosira varians C.A.Ag.	–	–	–	–	5
Nitzschia fasciculate Grun.	–	5	–	3	5
Nitzschia granulata Grun.	–	–	3	3	–
Nitzschia longissima	–	–	–	–	6
Nitzschia seriata Cleve	1	1	–	–	1
Nitzschia sigma (Kuetz.) W.smith	5	–	5	5-6	6
Nitzschia sigma var. rigidula Grun	2	2-3-4	3-4	–	–
Nitzschia tryblionella Hanz.	–	–	5	5-6	–
Pleurosigma delicatulum W. Smith	–	4-6	–	5-6	5-6
Podosira steliger (Bail.) Her.	–	–	2	–	–
Rhizosolenia fragilissima Bergon	–	2	–	–	–
Rhoicosphenia curvata (Kuetz.) Grun.	–	–	–	5	5
Surirella capronii Breb.	–	–	–	5-6	5
Surirella gemma (Her.) Kuetz.	–	–	2	–	–
Surirella ovalis Breb.	–	–	5-6	5-6	5-6
Surirella ovata Kuetz.	2	2-3	2-3-4	2-3-4	1-2-3-4
Synedra ulna (Nitzsch.) Ehr.	4-5	5-6	5	5-6	–
Thalassionema nitzschioides (Grun.) Hust.	1-2-3	1	2-3	2	1-2
Thalassiosira fluviatilis Hust	5	5	2-3-4	6	–
Thalassiothrix frauenfeldi (Grun) Cleve and Moeller	1-2-3	1-2-3	–	1-2	1-2
*Thalassiothrix longissima C*leve and Grun	–	–	–	–	–

Discussion

Temperature had no virtual effect on red tide if any in this study. It was known by the Oman's scientific team that the killfish occasion in coastal water of Oman during August 2000 (Herring 2002), was due to the sudden change in temperature. The QuikScat data revealed that during the fish kill the winds in the region changed from their usual southerly direction to a more easterly direction. These winds dragging across the surface of the Gulf of Oman effectively pushed the warm surface water eastward, away from Oman, thereby allowing the deeper, oxygen-poor waters to upwell along the coast.

Connell *et al*. (2001) observed blooms of *H. akashiwo* in the west coast (Hood Canal, WA during Sept. 2000) and east coast and conclude that neither the environmental factors responsible for bloom formation nor its toxicity are clearly understood. Such blooms, however, do not necessarily indicate toxicity to the members of marine ecosystem.

Chlorophyll a was high at Khalid Bridge and Paper Factory stations which coincided with increase in nitrite, nitrate and phosphate at the same stations. Al-Asadi *et al.* (2005) stated that there is little effect of N & P on chlorophyll a, while Karjalaninen, *et al.* (1998) stated that nitrogen and phosphorus had no effect on chlorophyll contents of phytoplankton. Salaman and Al- Handal (1981) considered the ammonia wastes of fertilizer plant as one of the most important pollutants of Shatt Al-Arab River, while Brezonik (1972) explained the mechanism of decomposition of clay and sediment. Cochlan & Bronk (2001) used ^{15}N-isotope techniques to determine N uptake kinetic parameters and N nutrition and characterize the ambient nutrient fields at both bloom and non-bloom sites. Cosgrove *et al*. (2000) attributed that with only low levels of H2S and NH3, and satisfactory O2- concentrations, none of those physical parameters of the water could be linked to the fishkill of algal bloom.

Chlorophyll a contents was not very high during the period of investigation. Rao *et al.* (1999) reported very high contents of chlorophyll a during the red tide bloom in Kuwait.

Two species of phytoplankton which caused harmful red tide were found during the investigation. *Dinophysis caudata* of dinophyceae was found at Station 1 Gulf Water (Khur Al-Ummaia) during October only

and *Amphora coffeaeformis* of Bacillariophyceae which appeared far from the Gulf Water at Stations 5 and 6 (Khalid Bridge and Paper Factory) during September 2000. The appearance of the former species at this station might have come from the other part of the Gulf Water, and/or the later species was not dominant so has no bloom. Other species that caused harmless red tide also was found *e.g*. *Ceratium furca*, *Ceratium fuscus*, *Ceratium massilliense* and *Ceratium tripos*, they appeared only at station 1, Gulf Water (Khur Al-Ummaia) during June, July and October sampling.

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دراسة عن المد الأحمر (تزهـــر الهـــائمـــات النباتية) في منطقة شمال غرب الخليج العربـــي

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المستخلص. لم تسجل بوضوح ظاهرة المد الأحمر رغم وجود بعض الأنواع المسببة للظاهرة في المنطقة المدروسة، مع ظهورها في منطقة عمان والكويت في نفس الفترة والتي سجلت فيها وفيات للأسماك.

أظهرت الدراسة الفيزيائية الكيميائية عدم وجود تغيرات ملحوظة بين المحطات الستة بالنسبة لدرجة الحرارة، تزايد الملوحة، وتناقص العكورة، والمحتوى الكلوروفيلي كلما كان الاتجاه نحو جنوب شط العرب.

لم يسجل أي وجود للنتريت في محطتي مياه الخليج وأم قصر خلال شهر آب، بينما سجلت معدلات أكثر للنترات في المحطتين خلال نفس الشهر. وجدت أن معدلات النترات في شمال شط العرب (محطتي جسر خالد ومعمل الورق) هي الأكثر من بقية المحطات. لوحظ زيادة عامة في معدلات الفوسفور لشهر آب عن بقية الشهور، وزيادة في محطة خور الزبير عن باقي المحطات. كما سجلت كذلك زيادة للسليكون في شهر أيلول عن بقية الشهور وزيادة في محطة جسر خالد عن بقية المحطات.

ظهرت الهائمات المسببة للمد الأحمر الضار(*Dinophysis caudata* and *Amphora coffeaeformis*) في بعض المحطات، ومرة واحدة خلال فترة البحث.

تم تعريف وتصنيف ٥٧ نوعًا لـــ٤١ جنسًا من الطحالب في المحطات الستة المدروسة، ٥١ نوعًا لـــ ٢٦ جنسًا تنتمي لطحالب الدايوتومات، و٥ أنواع لـــ ٥ أجناس تنتمي للطحالب الخضراء المزرقة، و٨ أنواع لـــ ٥ أجناس للطحالب الخضراء، و٦ أنواع لجنسين من الطحالب اليوغلينية و٩ أجناس ل ٤ أنواع من طحالب الدينوفايسي.

طحالب الدايوتومات مسيطرة في ظهورها (طاغية التواجد) عن بقية الطحالب خلال فترة البحث. لوحظ عدم وجود الطحالب الخضراء المزرقة في كلٍ من محطات مياه الخليج وأم قصر وخورالزبير. تركزت الطحالب اليوغلينية في محطة مياه الخليج عنها في المحطات الأخرى بينما لم تظهر خلال شهر أيلول في جميع المحطات.

جنسي *Glenodinium borgei* (Lemm.) Schill و *Glenodinium pulvisulcus* (Ehr.) Stein موجودا في محطات شط العرب (المصب وجسر خالد ومعمل الورق).