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Effect of Waste Discharges on Nutrients Content and Growth of *Chlorella* sp. from Shatt Al-Arab River

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Abstract. The effect of the industrial wastes, discharged by the fertilizer and paper plants, on the nutrient contents and other physico-chemical conditions of Shatt Al-Arab River waters has been presented. The effect of these waters on the growth of *Chlorella* sp. has been studied.

Appreciable variations in the nutrient contents and other physical and chemical factors were noted at different stations and times. Water temperature showed a seasonal change of 10ºC ranging from 11 to 21ºC. The data on chlorosity indicate that the study area was slightly influenced by the tidal currents and hence of the Arab Gulf salinity. The water of Shatt Al-Arab River tends to be alkaline. The values ranged from 7.2 as a normal value to 9.1 near the waste effluent of the fertilizer plant where the amount of NH_4^+ reached its maximum values. Similarly, nitrite and nitrate showed high values in the same area. Sulfate contents, on the other hand, were found to be high near the effluent of paper plant. All these variations have been discussed clearly. The present work shows a correlation between the different industrial wastes, discharged in Shatt Al-Arab River and the amount of nutrients in its waters.

The effect of Shatt Al-Arab River waters on the growth of *Chlorella* sp. was not clear. The increment in dry weight of *Chlorella* sp. in the tested water samples during 5 weeks did not exceed that in distilled water except the sample collected near the effluent of the fertilizer plant.

Keywords: Shatt Al-Arab River, fertilizer and paper plants, physico-chemical, nutrients.

Introduction

Investigations on physical, chemical and biological of the rivers are important to give baseline data for further work, and to evaluate the water quality for irrigation, fish culture and potable usage (Al-Asadi, 1991).

The effect of industrial wastes on those properties of natural waters is one of the most serious problems of water pollution (Olsson, *et. al*., 1995). Such wastes may change the character of an aquatic environment. One of these effects is the fertilizing effect of some wastes, which encourages the growth of plankton, algae and higher plants (Rounsfell & Everhart, 1953 and Al-Nashi, 2002). This may be due to the broken down of untreated wastes by bacterial activities to simple compounds such as nitrate, sulfate and phosphate. According to Bennet (1970) excessive phosphate and nitrates may stimulate algal blooms.

Shatt Al-Arab River suffers from the industrial wastes discharged by the fertilizer and paper plants factories, which may alter the quality of its water and aquatic life. Some limited studies on the physico-chemical features of Shatt Al-Arab were carried out; (Mohammad, 1965; Arndt & Al-Saadi, 1975; Salman & Faris, 1977; Al-Hello and Al-Obaidy, 1997 and Atte, 2004). Al-Imarah *et al.* (2001) studied monthly variations of nutrients and chlorophyll of Shatt Al-Arab River water at three stations and found that nitrate and nitrite have been decreased in winter and increased in summer, while phosphate showed decline during May 1998.

Abdulla & Rajab (1998) worked on *Chlorella vulgaris* Beijerinck, isolated from Shatt Al-Arab River, and Kasim (1998) on some green algae as fishery food production. However, very few preliminary investigations reported on the industrial pollution of this river (Al-Daham *et al*., 1981 and Salman and Al-Handal, 1981). Primary productivity found to be high (Hug *et al*., 1978). Al-Asadi (1977) worked on the effects of detergent on the growth of some planktonic green algae isolated from Shatt Al-Arab River and found that the detergent increases the algal growth.

Recent work was by Al-Shaheen (2002) on the physico-chemical characteristics of drinking water station at Basrah City. Also, Atte (2004) studied the heavy metals at Shatt Al-Arab River. The present study had two phases, the first aimed to study the nutrients content of Shatt Al-Arab River at the probably polluted regions (Al-Saad *et al*., 1996). Since such work on nutrients has received little attention. The second phase is to determine the effect of these waters on the algal growth of *Chlorella* sp. Physico-chemical analysis was carried out for the collected water sample.

The Study Area

The Tigris and Euphrates Rivers join at their lower reaches forming Shatt Al-Arab River. This large estuary runs in a southeastern direction to open in the Arab Gulf. The water of its mouth may reach a distance of 5 km inside of the gulf. Shatt Al-Arab supplies about 5×10^9 m^3 nutrient rich fresh water into the basin each year (Hartman *et al*., 1971). The length of Shatt Al-Arab River from Sinbad Island (Station III) to its mouth in the gulf reaches 139 km. Its width varies at different regions ranging from 0.4 km at Basrah to 1.5 km at its mouth. The water depth increases in general, towards the direction of the gulf varying from 7.5 m at Sinbad Island to 12.5 m at the mouth. The water level is affected by the high and low tides of the gulf. Hundreds outlets in the form of small rivers and canals are found on both sides of Shatt Al-Arab.

Seven stations were carefully selected along the Shatt Al-Arab River prior to the points of discharge and at distances from these points. The locations of these stations are given in Fig. 1.

Materials and Methods

1 – Water Analysis

Three sampling times were carried out, for physical, chemical and biological analysis. First sampling was on 15th January, the second on 18th February and the third sampling was on 1st April.

The pH values were measured by a Beckman pH-meter with an accuracy of ± 0.1. salinity and water temperature were determined by using an electric salinometer.

Chemical analysis of nitrite, nitrate, ammonium, silicate phosphate and sulfate had been carried out by DR/2 spectrophotometer, using the methods described by the American Public Health Association (1971).

2 – Isolation and Cultivation of Chlorella sp.

Chlorella sp., local strain, was isolated from Shatt Al-Arab River with the help of a phytoplankton net. Gross culture of algae had risen by cultivating the samples in Beyerinck liquid media (Stein, 1966). Purification and synchronization had been carried out according to Taha & Allam (1959). The filtrated water samples were autoclaved, and incubated with *Chlorella* sp. in sterilized, aerated and illuminated incubator. The dry weight and pH determination were carried out weekly.

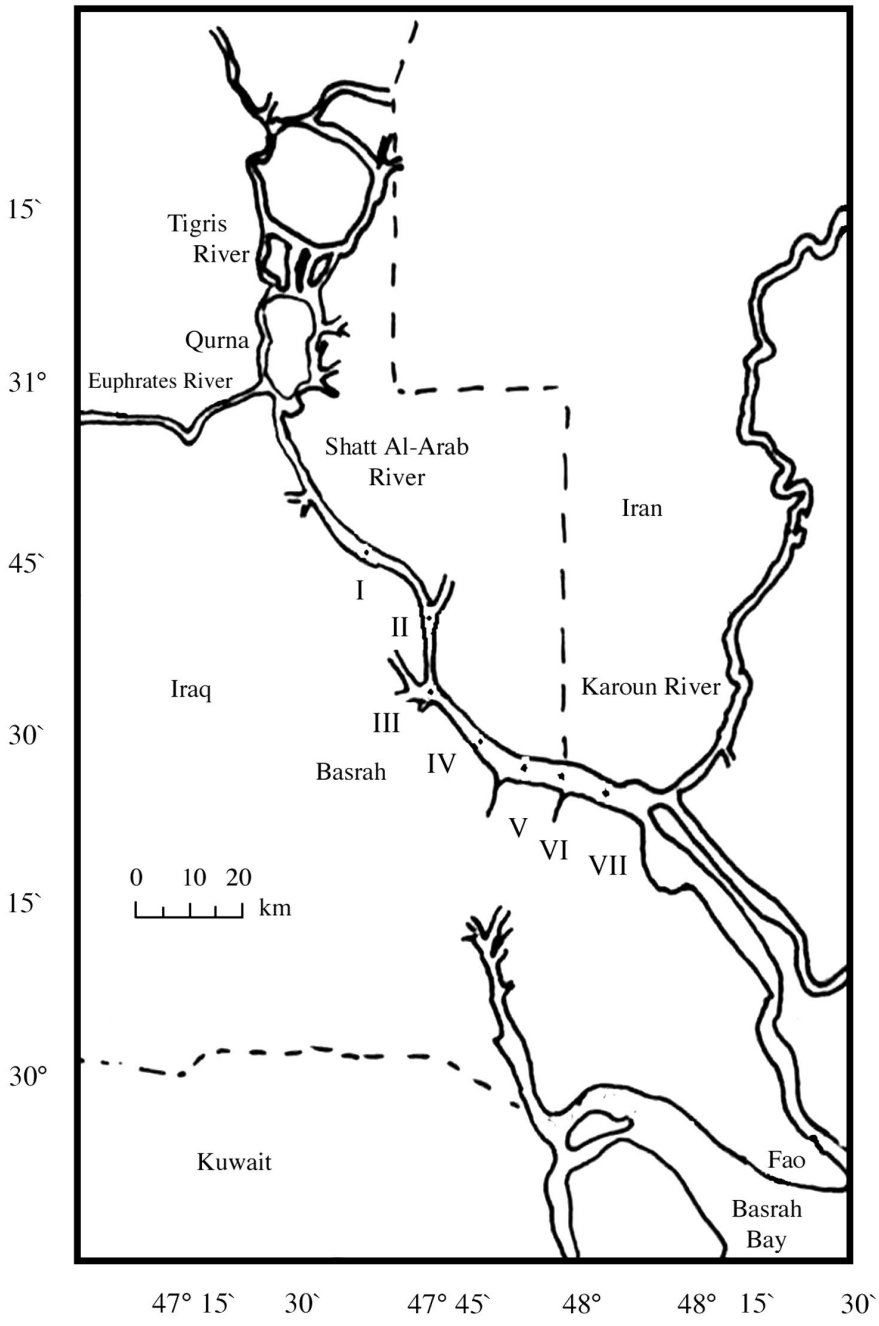

Fig. 1. Location of the seven studied stations at Shatt Al-Arab.

Results and Discussion

1 – Water Analysis

Data on the water analysis of Shatt Al-Arab River during different times are shown in Figure 2. Although little differences were observed in the three sampling periods, appreciable variation in both physical and chemical characteristics of the water were encountered between different stations.

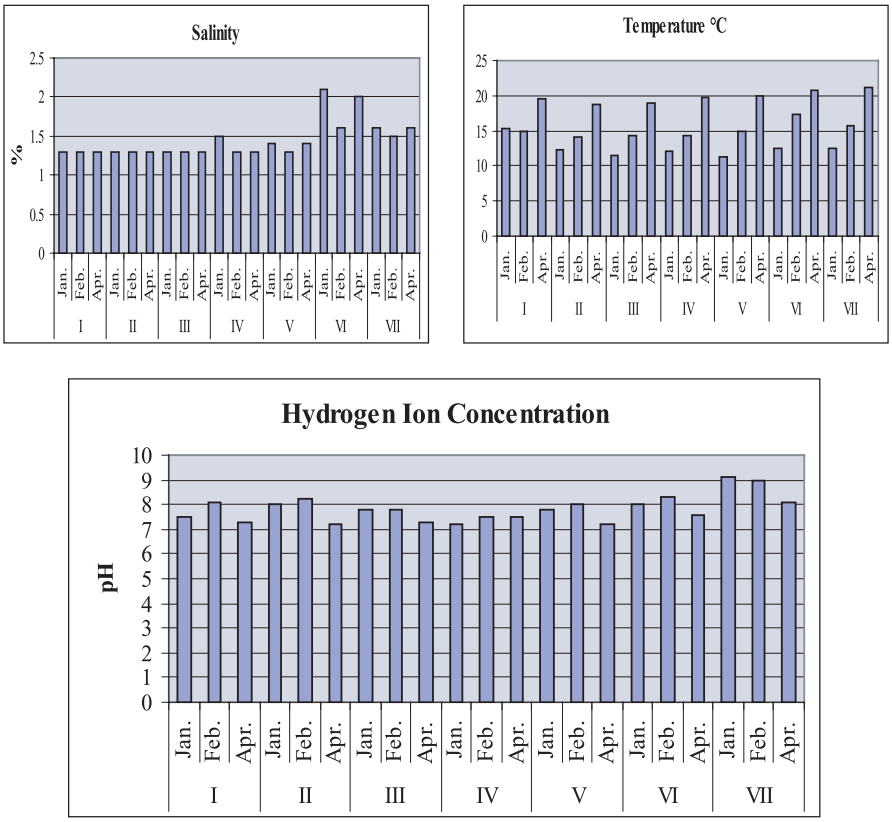

Fig. 2. Physical water analysis at different stations of Shatt Al-Arab River.

1.1 – Water Temperature

Maximum water temperature (21.2ºC) was recorded in April and minimum (11.3ºC) in January. They were, thus, subject to seasonal change of 9.9ºC. Arndt and Al-Saadi (1975) recorded a maximum water temperature of 32.5ºC in August and a minimum of 14.3ºC in January of 1973 at Shatt Al-Arab. Little differences were noticed among the different stations. This may be due to the difference in the sampling time.

1.2 – Salinity

Salinity ranged from (1.3 to 2.1 g l^{-1}). Values at lower regions of Shatt Al-Arab (Stations VI and VII) were higher than those of the upper regions (Stations I, II and III) these lower regions show gradual estuarine characteristics which are caused, more or less, by gulf water. These differences are mainly due to the seasonal variations of Shatt Al-Arab River water discharge and the tidal currents. In spite of the dilution with fresh water which comes from Tigris, Euphrates and Karun Rivers, the salinity of Shatt Al-Arab shows higher values even in the upper parts. These higher values might be attributed to the agricultural runoff and sewage waste disposal. Arndt and Al-Saadi (1975) stated that, this part of the river act as drainage for the irrigation of the agricultural fields nearby, where the soil has high salt content.

1.3 – Hydrogen Ion Concentration

The hydrogen ion concentration ranged from a low value of pH 7.2 to a high one of 9.1. Al-Saadi *et al.* (1996) found that the pH values of Shatt Al-Arab water ranged between 6.8 and 8.3. The higher values had been recorded at Stations VI and VII (Fig. 2). The difference in the degree of pollution between these two stations and the others may be accounted for being nearer to the fertilizer plant where the amount of ammonia reached its maximum values. Despite the abnormal higher pH values (pH 9.0 and 9.1) recorded at Station VII , the pH values as recorded in the present investigation were well within the expected range of pH (6.5 to 8.5) in various kinds of natural unmodified waters (Lagler,1956).

1.4 – Inorganic Nitrogen

The ammonia contents of Shatt Al-Arab River showed a wide variation (Fig. 3). They varied from a minimum of 0.39 mg NH_3l^{-1} in February at Station I to 50.95 mg NH_3l^{-1} in April at Station VII. Apart from the abnormal higher values recorded at Stations III, IV and VII, the most frequent values of ammonia contents varied from 0.39 to 2.32 mg NH_3l^{-1}. Values recorded in April were found to be higher than those recorded in January and February. A very clear ascending trend was noticed in the summer months. The only explanation of this trend may be attributed to the lower temperature, which decreased the decomposition of matter to ammonia (Brezonik, 1972) or the acidic substances carried out by the rain water which may neutralize ammonia. On the other hand, Stanacke *et al.* (1999) worked on the Gulf of Riga, for a 6-year research programmed and showed that the river played a crucial role in the total input of nutrients of the Gulf. It exceeded the contributions from atmosphere, the combined emissions from cities and industries, and nitrogen fixation by organisms.

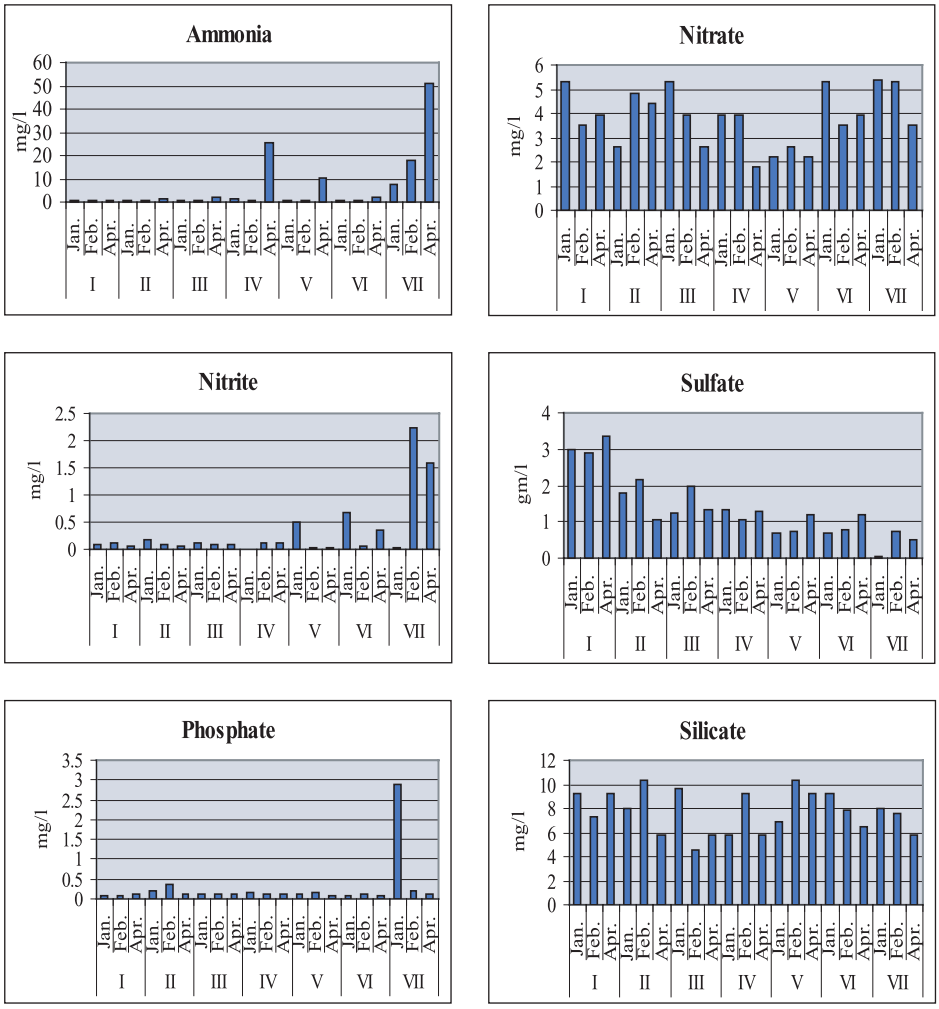

Fig. 3. Chemical water analysis at different stations of Shatt Al-Arab River.

Station VII is characterized with higher ammonia contents even more than the nitrate contents. This was expected since it represents the nearest station to the fertilizer plant discharge, the abnormal values for ammonia accompanied by higher pH values which caused an increase in the proportion of the unionized form of ammonia. Salman and Al- Handal (1981) considered the ammonia wastes of fertilizer plant as one of the most important pollutants of Shatt Al-Arab River. The relatively higher values of ammonia recorded at upper Stations (IV and V) during April are attributed mainly to the introduction of sewage and the decomposition of organic nitrogen to ammonia which diffused in the overly-

ing water as well as the absorption of ammonia from clay and sediments (Brezonik, 1972). These stations are characterized by their higher amount of organic matter in the sediments which has been carried with the sewage, by many side branches of Shatt Al-Arab River (Al- Saad *et al.*, 1996)

1.5 – Nitrate

The nitrate contents varied between 5.41 mg l^{-1} at Station VII and 1.75 mg l^{-1} at Station IV. The variations in the nitrate contents among stations were not clear although comparatively higher values were still recorded at Stations VI and VII. This may be due to the fertilizer plant discharge, Verdain (1964) indicated this also. Similar results were detected by Al-Imarah *et al.*, (2001) at the Shatt Al-Arab River during May and July 1998. The high values of nitrate at the other Stations (I, II and III) may be due to the sewage discharge, or the agriculture run off (Al-Saad *et al*., 1996).

1.6 – Nitrite

It has been observed that the nitrite values increased sharply from the first station to the last one with few exceptions. This was accompanied by an increase in the amount of ammonia in these stations. The ascending trend in nitrite values can be attributed to the nitrification process of ammonia by the nitrifying bacteria. Bensal (1976) attributed the same reason for his results. All the above favorable conditions were observed at Stations V, VI and VII which represent the fertilizer plant discharge area.

1.7 – Sulfate

The maximum value of sulfate was recorded at Stations I and II. These values are a direct result of the paper industry wastes discharged (Salman and Al-Handal, 1981). Figure 3 showed clearly a gradual decrease in the amount of sulfate from Station I to Station VII. A minimum value of 25 mg l^{-1} was recorded at the last station on January. In this respect Bremmeng and Kolster (1976) attributed the decrease of sulfate to the biological uptake.

1.8 – Phosphate

The phosphate contents ranged from a maximum value of 2.90 mg l^{-1} at Station VII in May and a minimum of 0.09 mg l^{-1} at Station I during January and February. These values were found to be lower than those recorded by Antoine and Shihab (1977) at Shatt Al-Arab River. Al-Sahaf (1976) recorded a value of 0.1 mg l^{-1} for Shatt Al-Arab River at three different stations (Qurna, Basrah and Fao). Little differences were observed during the sampling period

(Fig. 3). The lower phosphate amount at most stations in Shatt Al-Arab River may be attributed to the dilution of phosphate on silts and clay particles. While the higher content at Station VII was mainly due to the agriculture runoff and sewage wastes disposal.

1.9 – Silicate

The highest value of silicate (10.35 mg l^{-1}) was recorded at Stations IV and V during February. The amount of silicate in Shatt Al-Arab River decreased in the south eastern direction from Station I to VII. This may be attributed to the dilution of nutrient salts in a south eastern direction due to mixing of relatively nutrient enriched estuarine water with the gulf water. The lowest value of silicate was recorded at Stations III and IV which was found to be a result of special local conditions, such as the complete prevention of the release of silica from the sediment because of the covering of the diatom frustules. Antoine and Benson-Evans (1983) worked on the River Wye, Wales, UK and gave same explanation. High values of Stations I, II and V may be due to the process of vertical water mixing which occurs occasionally at these localities. The effect of the fertilizer plant wastes on the silicate contents was not clear, since no significant differences were observed between the values of Station VII and the other stations (Fig. 3). Silicate in this region showed a gradual decrease in summer. This means that a high degree of preservation of diatom frustules in the sediments occurred in these places during summer months.

Therefore, the present work shows a positive correlation between the different industrial wastes, discharged on Shatt Al-Arab River, and the nutrients amount of its waters. Fertilizer plant wastes increased the ammonia contents at the discharge area while paper plant caused a sharp increase in the amount of sulfate.

2 – Algal Growth

Dry weight data of algal growth of *Chlorella* sp. incubated in filtered and purified water from different stations along Shatt Al-Arab River were shown in Figure 4. It can be seen that the growth of *Chlorella* sp. in the water samples collected from Stations I and VII of the nearest to paper and fertilizer plant, was higher than that of the other stations. This may be due to the sewage discharged by these two plants.

However the differences between the growth of *Chlorella* sp. in the control and other water samples were not significant. So that, no clear idea can be taken from the data of algal growth. Jarvinen *et al.* (1999) found that increasing the amount of ammonia-N had no effect on primary productivity, also Karjalainen *et*

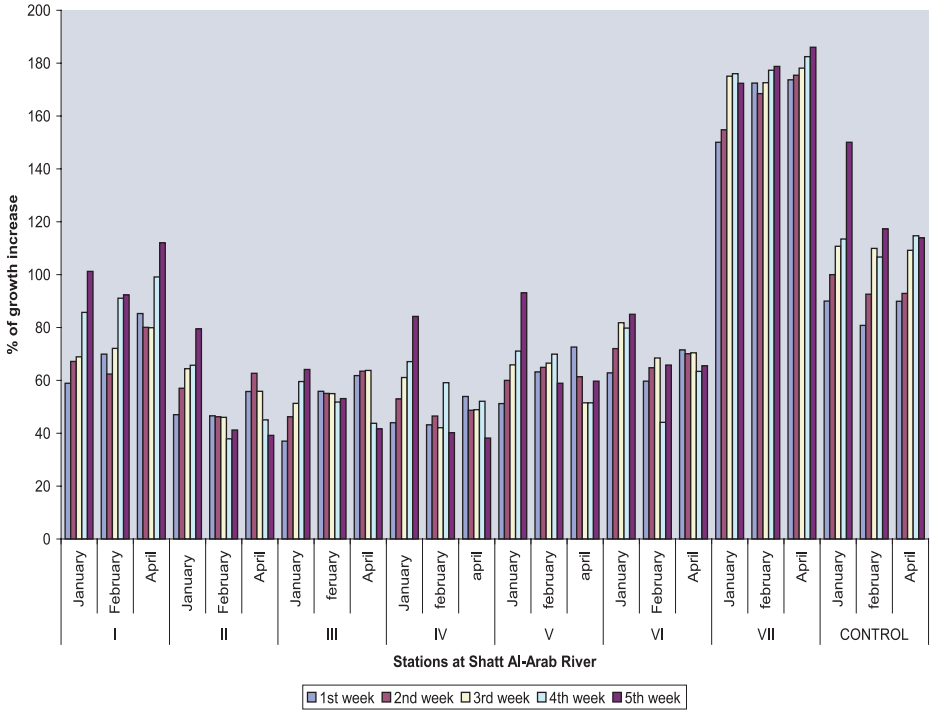

Fig. 4. The percentage treatment in dry weight (mg/l) of the *Chlorella* sp. after incubation in purified water from different stations along the Shatt Al-Arab River.

al. (1998) stated that the available nitrogen did not increase chlorophyll a concentration in any experiments compared with the controls. This may also be due to the variation of the chemical components of the water samples. Accordingly, it can be concluded that the wastes of fertilizer and paper plants did not reach the amount favorable for the algal bloom of *Chlorella* sp. in Shatt Al-Arab River.

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References

Abdulla, D.S. and **Rajab, T.M.A.** (1998) Composition of *Chlorella vulgaris* Beijerinck isolated from Shatt Al-Arab River, *Marina Mesopotamica*, **13** (1): 121-127.

Al-Asadi, M.S.A. (1977) "Preliminary studies on effects of detergent on the growth of some Planktonic green algae," *Journal of the Asiatic Society of Bengladesh*, **2:** 83-91.

Al-Asadi, M.S.A. (1991) *The Effect of Ecological Factors on Algae in Six Algerian River Sites,* Ph.D. Thesis, University of Wales College of Cardiff, U.K.

Al-Daham, N.K., Sarker, A.L. and **Nasiri, S.K.** (1981) Industrial pollution of inland water in Iraq – A fishery problem, *The Arab Gulf*, **13:** 17-25.

Al-Hello, A.A. and **Al-Obaidy, A.M.** (1997) The chemistry of Shatt Al-Arab Water from Qurna to Al-Fao, *Marina Mesopotamica*, **12** (1): 190-201.

Al-Imarah, F.J.M., Allaywi, Y.J. and **Moanis, F.S.** (2001) Monthly variations in the levels of nutrients and chlorophyll in Shatt Al-Arab Water, *Marina Mesopotamica*, **16** (1): 347-357.

Al-Nashi, A.A. (2002) The eutrophication of Al-Daghara River and its effect on the water of the Eifak City, *Al-Kadissia J.*, **7** (1): 52-59.

Al-Saad, H.T., Al-Kafaji, B.Y. and **Sultan, A.W.** (1996) Distribution of trace metals in water, sediment and biota samples from Shatt Al-Arab Eustury, *Marina Mesopotamica*, **11** (1): 63-77.

Al-Saadi, H.A., Al-Edany, T.Y. and **Neama, J.D.** (1996) On the distribution and ecology of aquatic plants in the Shatt Al-Arab River, Iraq, *Marina Mesopotamica*, **11** (1): 49-62.

Al-Sahaf, M. (1976) *Pollution Control and Water Resources in Iraq*, Baghdad, Al-Hurria Printing House.

Al-Shaheen, M.A.G. (2002) *Species Composition of Algae and its Ability to Produce Toxins in Drinking Water Stations at Basrah City, Iraq*, M.Sc. Thesis, Basrah University.

American Public Health Association (A.P.H.A.) (1971) *Standard Methods for the Examination of Water and Waste Water*, 13th Ed. New York.

Antoine, S.E. and **Benson-Evans, K.** (1988) Environmental and hydrological characteristics of the River Wye System, Wales U.K., *Acta Hydrochim. Hydrobiol.*, **16:** 3-37.

Antoine, S.E. and **Shihab, A.F.** (1977) On the distribution of organic nitrogen and phosphate in polluted Al-Khora River and of Shat Al-Arab at Basrah, Iraq, *Journal of Asiatic Society of Bangladesh*, **2:** 35-41.

Arndt, E.A. and **Al-Saadi, H.A.** (1975) Some hydrographical characteristics of the Shatt Al-Arab and adjacent areas, *Wiss. Zeitschr. Univ. Rostock. Math. net. Riehe*., **58:** 789-796.

Atte, R.S. (2004) *Water Quality Criteria in the Shatt Al-Arab River and the Main Drainage System with Levels of Some Heavy Metals Pollutants*, Ph.D. Thesis, Agri. Coll., Basrah Univ., Iraq.

Bennet, G.W. (1970) *Management of Lakes and Ponds*, New York: Reinhold Publishing Corporation.

Bensal, M.K. (1976) Nitrification in natural stream, *Journal of Water Pollution Control Federation*, **48:** 2380-2393.

Bremmeng, G.S. and **Kolster, A.E.** (1976) A ground water influenced with special redox and sulphate condition, *Nordic Hydrology*, **7:** 307-320.

Brezonik, P.L. (1972) *Nitrogen Sources and Transformation in Natural Water*, New York: A Wiley Interscience Publication.

Hartman, M.H., Seibold, L.E. and **Walger. E.** (1971) Oberflachen-Sediment persischen Golf and Golf Von Oman. I. Geologischer Rahman und erste sedimentologische Ergebiss, *Meteror" Fersch. Ergebrisse, Reihe.*, **4:** 1-76.

Huq, M.F., Al-Saadi, H.A. and **Hadi, R.A.** (1978) Preliminary studies on the primary production of North-West Arab Gulf during post-monsoon period, *Journal of the Oceanographical Society of Japan*, **34:** 78-80.

Jarvinen, M., Salonen, K., Sarvala, J., Vuorid, K. and **Virtanen, A.** (1999) The stoichiometry of particulate nutrients in Lake Tanganyika – implication for nutrient limitation of phytoplankton, *Hydrobiologia*, **407:** 81-88.

Karjalainen, H., Seppala, S. and **Walls, M.** (1998) Nitrogen, phosphorous and Daphnia grazing in controlling phytoplankton biomass and composition – an experimental study, *Hydrobiologia*, **363:** 309-321.

Kasim, T.I. (1998) *Production of Some Phyto- and Zooplankton and their use as Live Food for Fish Larvae*, Ph.D. thesis, College of Science, Basrah University, Basrah, Iraq.

Lagler, K.F. (1956) *Freshwater Fishery Biology*, Iowa: WM. C. Brown Comp., Publisher.

Mohammad, M.B.M. (1965) Further observations on some environmental conditions of Shatt Al-Arab, *Bulletin of the Biological Research Centre*, Baghdad, **1:** 71-79.

Olsson, P.E., Kiling, P., Petterson, C. and **Silver, J.** (1995) Interaction of cadmium and osetradiol-17 Bon metanothionein and vitelloyen synthesis in rain bow trout *Onchychus mykiss*, *Biochem. J*., **307:** 197-203.

Rounsfell, G.A. and **Everhart, W.H.** (1953) *Fishery Science, its Methods and Application*, New York, John Wiley & Sons, Inc.

Salman, N.A. and **Al-Handal, A.Y.** (1981) The effect of industrial pollution on the aquatic life in Shatt Al-Arab River, *Paper Read at First symposium on Future Development of Water Resources in the Gulf and Arabian Peninsula, 1-5 March 1981, Kuwait University.*

Salman, N.A. and **Faris, A.A.** (1977) Some observation on some physico-chemical features of two side branches of the Shat Al-Arab River, *Bulletin Basrah natural History Museum*, **4:** 41-49.

Stanacke, P.,Vagstad, N., Tamminen, T., Wassmann, P., Jansons, V. and **Loigu, E.** (1999) Nutrient runoff and transfer from land and rivers to the Gulf of Riga, *Hydrobiologia*, **410**: 103-110.

Stein, J.R. (1966) Growth and mating of gonium pectoral volvacales in defined media, *Journal of Physiology*, **2:** 23-28.

Taha, E.D.M. and **Allam, A.M.** (1959) Physiological and biochemical studies as influenced by culture conditions, V. growth and cell protein of *Chlorella ellipsoida* as influenced by culture conditions, *Archir fur Mikrobiologie*, **34:** 393-400.

Verdain, J. (1964) Changes in Western Lake Erie during the period 1984-1962, *Verh. International Ver. Limnology*, **15:** 639-644.

تـاثيـر طرح الفضلات على المحتوى المغذي ونمو طحلب *Chlorella* sp. المعزول من نهر شط العرب

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المستخلص. دُرس تأثير الفضلات الصناعية المطروحة في شط العرب من قبل معمل إنتاج الأسمدة ومعمل صناعة الورق على المكونات المغذية والظروف الفيزيائية والكيميائية لمياه شط العرب وتأثير هذه المياه على نمو طحلب الكلوريلا.

وجد أن هناك فروقات واضحة بالنسبة للمكونات المغذية والظروف الفيزيائية والكيميائية في مختلف المحطات ومختلف الأوقات. أظهرت درجة الحرارة تغيراً موسمياً يتراوح بين (١١-٢١) درجة مئوية . وبينت الملوحة أن المنطقة المدروسة متأثرة قليلا بتأثير تيارات المد والجزر، وبالتالي تأثير ملوحة الخليج العربي. مياه شط العرب تميل إلى القاعدية والقيم تتراوح بين ٢ ,٧ كقيمة طبيعية وبين ١ ,٩ بتأثير فضلات مصنع الأسمدة عند بلوغ الأمونيا القيمة القصوى. أما بالنسبة للنتريت والنترات فقد شوهدت زيادة في نفس المنطقة. وكذلك أملاح الكبريت هي الأخرى لوحظ ارتفاعها بتأثير معمل الورق. كل التغيرات نوقشت بوضوح. هذه الدراسة أوضحت العلاقة بين الفضلات الصناعية المطروحة وكمية المواد المغذية في مياه الشط.

كما بينت الدراسة بأن تأثير مياه شط العرب على نمو طحلب الكلوريلا لم يكن واضحًا. فزيادة الوزن الجاف للطحلب في عينات المياه المفحوصة خلال خمسة أسابيع لم تزد عن تلك التي زرعت في الماء المقطر، ما عدا العينات المأخوذة بالقرب من معملي الأسمدة والورق. وقد تم خلال البحث متابعة تأثير طرح فضلات المعملين على نمو هذا الطحلب.