Int. J. Chem. Sci.: 10(4), 2012, 1785-1798
ISSN 0972-768X
www.sadgurupublications.com

IMPACT OF INDUSTRIAL WASTE WATER ON THE PROPERTIES OF ONE MAJOR DRAINAGE IN THE REGION OF THE MIDDLE EUPHRATES / IRAQ

AYAD M. JEBUR ALMAMOORI*, FIKRAT M. HASSAN[a] and THAER I. KASSIM[b]

Biology Department, College of Science, University of Babylon, BABIL, IRAQ
[a]Department of Biology, College of Science for Women, University of Baghdad, BAGHDAD, IRAQ
[b]Genetic Engineering and Biotechnology Institute for Graduate Studies, University of Baghdad, BAGHDAD, IRAQ

ABSTRACT

This investigation was designed to study the effect of industrial waste water on water quality by measuring water chemistry, nutrients, heavy metals and phytoplankton. Fluctuation in these parameters occurred. positive and negative interaction had been recorded between air temperature, dissolved oxygen, oxygen percentage of saturation, nitrate, particulate chromium, dissolved copper, dissolved cadmium and phytoplankton total count with r value (0.648*, -0.662*, -0.662*, 0.605*, 0 .609*, -0.686*, 0.715**, 0.621*) respectively. We concluded that Industrial waste water have a considerable effects on water quality and on the interactions between different parameters.

Key words: Industrial waste water, Water quality, Heavy metals, Phytoplankton.

INTRODUCTION

Heavy metals are considered one of the most harmful industrial pollutants discharged into the environment because they cannot be degraded by chemical or biological processes. In addition, even if added to the environment in low concentrations, heavy metals can accumulate in plant and animal tissue. Although many of these elements are required by living organisms for their normal function at high concentrations, they become toxic; for example, copper is essential for plants and algae, but an excess of copper can cause the inhibition of photosynthesis and pigment synthesis as well as damage to plasma membranes. In the aquatic environment, heavy metals can be present as either dissolved elements or as suspended elements of biotic origin. Industrial discharge can have a variety of impacts on

*Author for correspondence; E-mail: aalmamoori@fsu.edu

phytoplankton in aquatic systems: first, heavy metals can inhibit biochemical and physiological process; and second, they can alter the structure and function of the algal community by promoting some species and inhibiting others[1,2]. For this reason the presence of pollution-tolerant species is often used as an indicator of pollution resulting from industrial discharge in aquatic systems[3,4]. The effluents also have considerable negative effects on the water quality of the receiving water bodies and as such, they are rendered not good for human use.

The aim of our study was to assess seasonal variation in water quality, elemental composition and phytoplankton taxonomic structure along a gradient of exposure to industrial wastewater disposal in the Euphrates River.

EXPERIMENTAL

Monthly water samples were collected at three selected sites in the "MN-00" streams that drain into the Euphrates River in southern Baghdad, Iraq, from November 2000 to October 2001 (Figure 1). Site 1 was located about 2 Km upstream of the drainage point of the industrial company; this site represents our control. Sites 2 and 3 are located downstream of the drainage point, 100 meter and 850 meter, respectively.

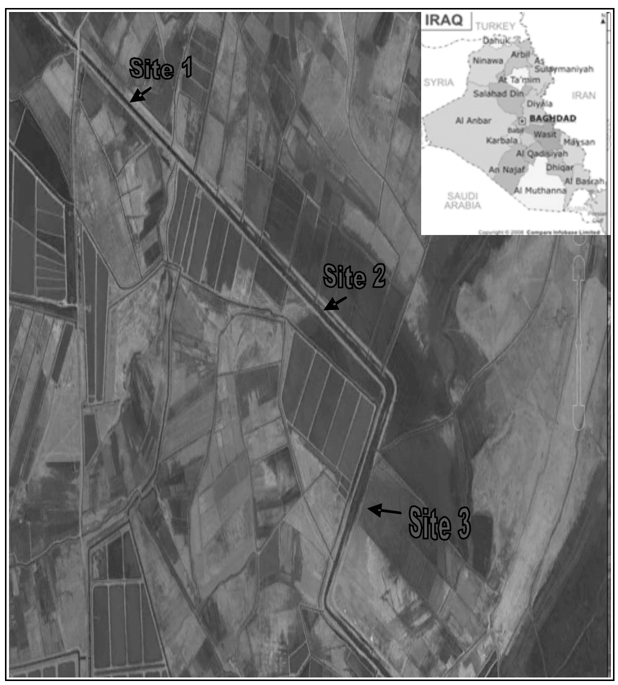

Fig. 1: Geographical location of study sites

In the laboratory, we quantified dissolved oxygen and percent oxygen saturation following the Azide method and according to American Public Health Association[5].

The concentrations of Cr, Pb, Cu, Fe, and Cd were determined in all samples using a Shimadzu Crop. Model 680 Flame Atomic Absorption Spectrophotometer[5].

Also calculated: total alkalinity (mg/L) by titration[6]; total hardness (mg $CaCO_3$) by titration with Na_2EDTA solution[6]; magnesium (mg/L) and calcium (mg/L)[5]; Nitrate and nitrite concentrations (µg/L) using a spectrophotometer[7]; reactive phosphate (µg/L) using methods described earlier[7]; and reactive silicate (µg/L) based on color formation from silico-molybdate[7]. Finally, we determined total available carbon dioxide using methods described[8].

To examine the relationship between water quality and the phytoplankton community, we used a phytoplankton net to collect samples each month and preserved them using Lugol's solution[9]. We identified the samples to the lowest taxonomic level possible using taxonomic references[10,11]. We also used a haemocytometer to calculate the total number of phytoplankton cells after sedimentation from 1 L to 10 mL[12].

Statistical analyses

Analysis of variance (ANOVA) and revised least significant differences (RLSD) tests were used for statistical analysis with correlation coefficient between factors with significance level $P < 0.05$.

RESULTS AND DISCUSSION

Water chemistry

The annual mean of limnological characters in MN-00 drainage canal showed some significant differences between studied sites. The range of water temperatures (Figs. 2 and 3), conductivity, salinity and pH were 11.50-30.00°C, 3328.50-8100.50 µs/cm, 2.00-5.11 ppt and 7.01-8.50, respectively. The water was very hard 1170.00-4130.50 mg/L with magnesium values (184.50-989.10 mg/L) exceeding those of calcium values (135.00-380.40 mg/L), As expected, low dissolved oxygen (0.55-8.00 mg/L) (Fig. 4) was recorded due to high consumption of oxygen by aquatic organisms, and high concentrations of carbon dioxide were recorded (105.55 to 831.80 mg/L). Finally, alkalinity ranged between (100.00 to 370.50 mg/L).

Nutrients

Nitrate and phosphate concentrations increased 2-3 fold in sites 2 and 3 compared to Site 1; while concentrations of both nitrite and silicate were noticed a significant differences among all study sites (LSD = 2.5 at $P < 0.05$ and LSD = 0.86 at $P < 0.05$, respectively). Low water level in stream leads to mineralization of organic compound and as consequence of rainfall effect, this produced a high amount of Ammonia and that's cause increasing in nitrate and nitrate concentration[13] (Table 1).

Table 1: Range, mean, standard deviation (Std.) and correlation coffcient value (R) of water quality parameters of study sites. *mean significance interaction

Parameters		Site 1	Site 2	Site 3
Air temp. (C°)	Range	16.50-34.10	17.50-37.05	19.10-37.50
	Mean	26.0500	27.6917	27.6292
	Std.	6.74422	7.31135	7.51315
	R	0.648*	0.127	-4.273
Wat. temp (C°)	Range	11.50-30.00	12.50-28.50	15.50-28.50
	Mean	22.1875	21.8292	22.3958
	Std.	6.37392	6.03755	4.98190
	R	0.525	0.136	-5.057
E.C (μs/cm)	Range	3720.50-7000.00	3328.50-8100.50	4200.50-8000.00
	Mean	5471.8750	5409.2917	5576.1667
	Std.	971.05234	1496.68293	1263.84679
	R	0 .129	-7.222	-1.613
Sal. ppt	Range	2.30-5.00	2.10-5.10	2.00-5.11
	Mean	3.5075	3.5254	3.4388
	Std.	0.81282	1.00712	0.94785
	R	-5.072	0.009	-1.569
pH	Range	7.11-8.50	7.01-8.25	7.04-8.20
	Mean	7.7800	7.6042	7.4804
	Std.	0.47576	0.37890	0.40073
	R	-3.694	-1.485	0 .070

Cont…

Parameters		Site 1	Site 2	Site 3
D.O. (mg/L)	Range	0 .55-7.71	0.91-6.00	0.92-8.00
	Mean	3.7342	3.5804	4.0129
	Std.	2.21833	1.69814	2.06113
	R	-0.662*	-3.613	0.218
D.O sat. (%)	Range	6.70-73.90	11.60-60.70	11.20-76.90
	Mean	41.7626	39.8883	42.9125
	Std.	21.30705	16.83082	20.86347
	R	-0.662*	-2.691	0.160
CO_2 (mg/L)	Range	105.55-831.80	266.70-426.90	288.50-633.80
	Mean	429.6792	332.9250	381.9583
	Std.	174.29352	47.05830	95.13457
	R	-2.855	-2.454	0.386
Alk. (mg/L)	Range	100.60-370.50	100.00-310.50	100.50-345.10
	Mean	246.5958	212.1417	231.5333
	Std.	76.86955	64.53241	71.62171
	R	0.315	-5.375	-5.014
Total hard. (mg/L)	Range	1180.50-1975.50	1170.00-3801.50	1191.50-4130.50
	Mean	1592.0833	1741.1250	1841.5000
	Std.	274.57809	702.45304	774.39228
	R	-8.798	-1.081	0.047
Calcium. (mg/L)	Range	140.04-340.30	140.04-380.40	135.00-324.30
	Mean	211.2783	229.3317	228.3667
	Std.	55.69919	63.40517	60.16457
	R	0.198	-6.218	-5.972
Magnesium (mg/L)	Range	201.90-798.50	184.50-909.40	205.50-989.10
	Mean	389.5942	387.9083	413.6250
	Std.	151.25294	182.83373	203.96621
	R	0.515	-1.166	-5.498
Nitrate. (µg/L)	Range	18.50-153.24	45.50-331.73	42.82-832.10
	Mean	71.1708	153.7521	287.6392
	Std.	41.82717	74.35911	237.18956
	R	-5.378	0.106	0.605*

Cont…

Parameters		Site 1	Site 2	Site 3
Nitrite. (μg/L)	Range	1.85-22.95	6.95-132.85	2.40-64.60
	Mean	7.3558	31.5315	15.7852
	Std.	5.41723	34.92338	17.55795
	R	-2.994	-1.563	0.37
Phosphate. (μg/L)	Range	2.50-45.40	9.65-72.45	10.75-74.08
	Mean	23.0542	35.8337	40.9617
	Std.	13.72518	19.65097	17.52673
	R	-8.318	0.360	0.340
Silicate (μg/L)	Range	2853.50-7542.90	2796.90-7481.50	3850.50-7934.50
	Mean	5957.8242	4863.5875	6301.2500
	Std.	1235.37274	1404.08870	1240.52161
	R	-3.380	-5.335	-5.335
Total count of phytoplankton Cell × 103/L	Range	4455.00-21287.00	34805.00-66142.00	18547.00-36764.00
	Mean	10178.9167	44269.3333	28355.3333
	Std.	5316.51695	9243.38368	5924.87815

* Significance differences at $P < 0.05$

Heavy metals

All highest values of dissolved chromium were recorded in site 2 due to this site considered the point of industrial discharge. Dissolved Cr, Pb, Fe, Cu and Cd ranged between (0.01-0.57 mg/L) and particulate Cr, Pb, Fe, Cu and Cd ranged between (0.01-20.21 mg/g). Fluctuations in concentration of these metals depends on metals speciation, transportation rate, electronegativity, and metal partitioning. Additionally, the differences between dissolved and particulate forms relates to adsorption processes, which effect the partitioning between these forms[14]. Finally, colloids play an important role in controlling elements behavior[15]. The study area is surrounded by many agricultural areas, so fertilizers may play an important role in increasing metals concentration in addition to industrial drainage. Moreover, each metal has additional specificity in sources, pathways and storage modes[16].

Phytoplankton

Temperature and dissolved oxygen have direct relationship with Phytoplankton community fluctuation and availability in this study (Fig. 3 and 4) and the water quality parameters relates with absence of many phytoplankton species[17] and some parameters have a vital role in shifting phytoplankton distribution[18,19].

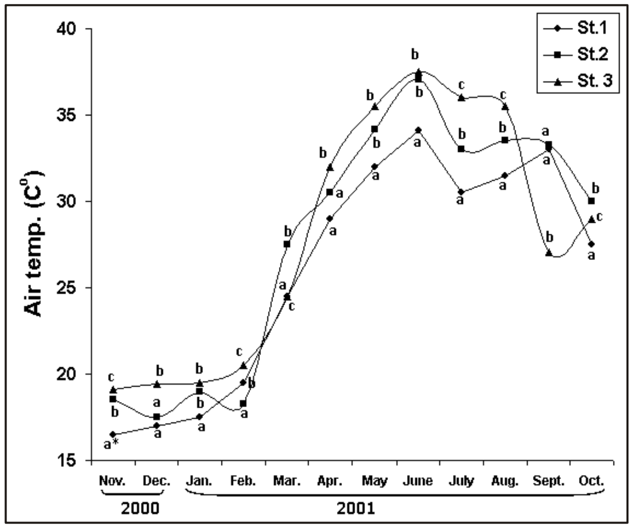

Fig. 2: Monthly variations for air temperature

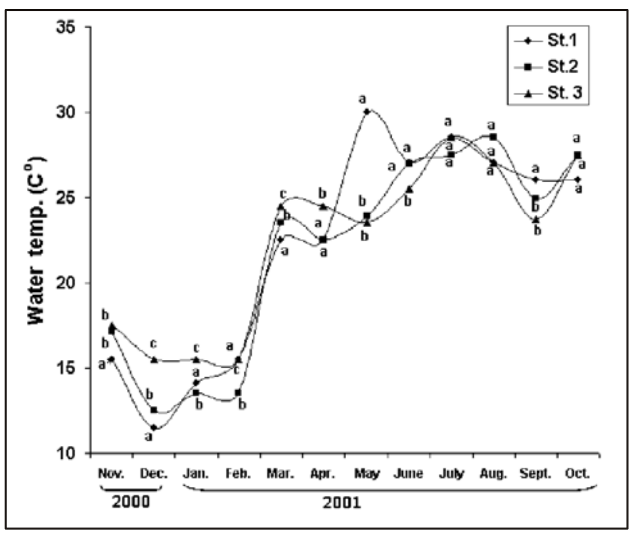

Fig. 3: Monthly variations for water temperature

The increas in nitrate concentration leads to acidify the ecosystem and that causes shifting in phytoplankton community composition and Nutrient-depletion in stationary growth phase reduced the cellular content of Chl *a* and carotenoids and effect on phytoplankton as consequences of Industrial waste water impact[20] (Figure 5).

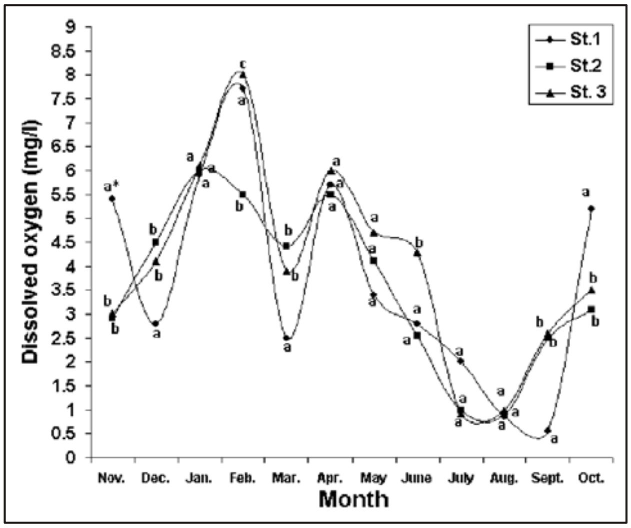

Fig. 4: Monthly variations for dissolved oxygen

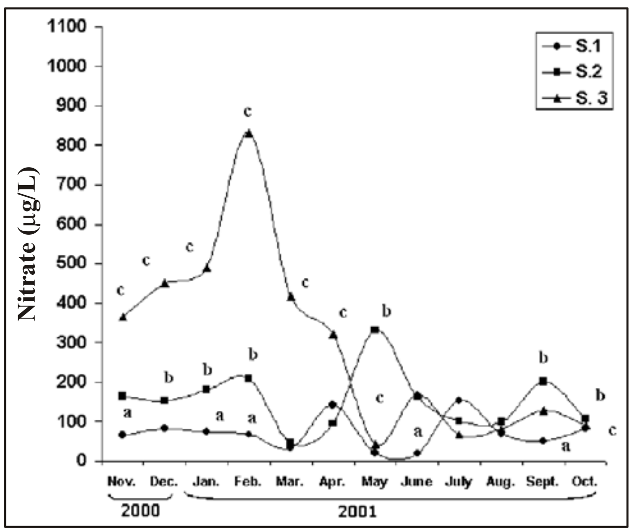

Fig. 5: Monthly variations for Nitrate

Heavy metals have a great relationship with phytoplankton such particulate chromium and dissolved cadmium (Fig. 6 and 7). Heavy metals, depending on their oxidation states, can be highly reactive and, as a consequence, toxic to most organisms[21]. Increasing eutrophication due to human activities such industrial waste leads to great effect on phytoplankton population dynamics, composition and abundance[22].

Lastly, the decreasing in total numbers of phytoplankton associated with environmental factors, which lead to fluctuation in phytoplankton class numbers (Table 3).

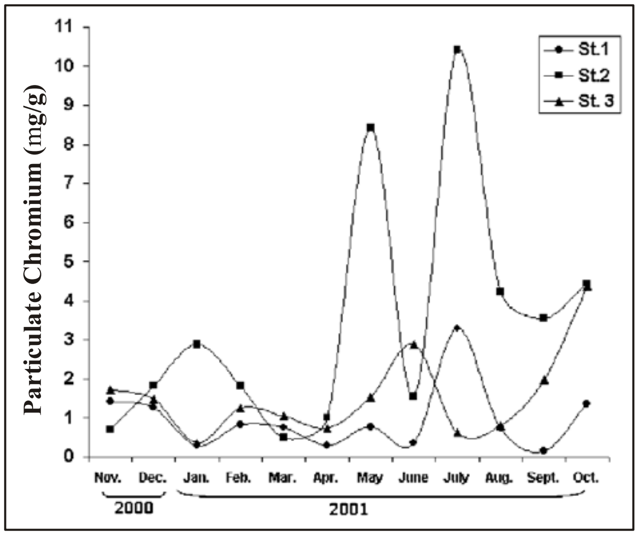

Fig. 6: Monthly variations for particulate chromium

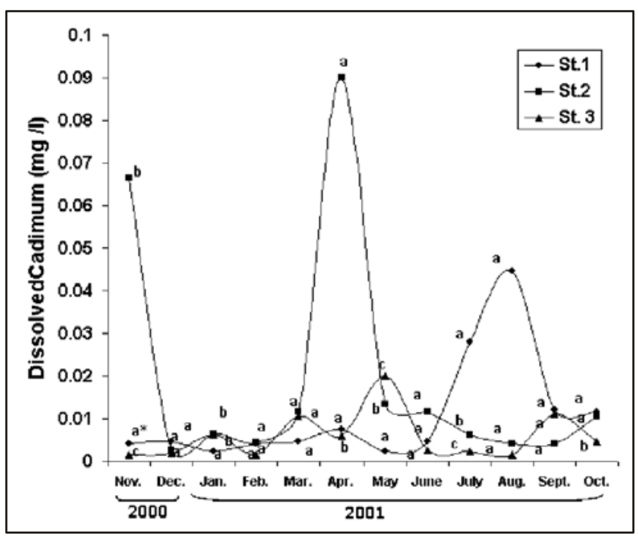

Fig. 7: Monthly variations for dissolved Cadmium

Table 2: Range, mean, standard deviation (std.) and correlation coffcient value (R) of dissolved and particulate heavy metals parameters of study sites. *mean significance interaction

Parameters		Site 1	Site 2	Site 3
Diss. Cr (mg/L)	Range	0.01-0.04	0.01-0.57	0.01-0.15
	Mean	0.0228	0.1870	0.0431
	Std.	0.01218	0.20430	0.03767
	R	-4.347	0.365	-4.690
Part. Cr (mg/g)	Range	0.14-3.29	0.48-10.42	0.36-4.37
	Mean	0.9576	3.4398	1.5630
	Std.	0.85145	3.11033	1.11903
	R	-1.686	-1.931	-0.686*
Diss. Pb (mg/L)	Range	0.01-0.23	0.02-0.11	0.02-0.25
	Mean	0.0461	0.0415	0.0577
	Std.	0.05775	0.02722	0.06295
	R	-2.375	-8.676	0.062
Part. Pb (mg/g)	Range	0.11-5.21	0.19-4.70	0.11-0.377
	Mean	1.4076	1.4038	0.325
	Std.	1.51372	1.46227	0.108
	R	0.191	-2.255	0.206
Diss. Cu (mg/L)	Range	0.01-0.05	0.01-0.38	0.01-0.05
	Mean	0.0223	0.0494	0.0175
	Std.	0.01201	0.10320	0.01160
	R	0.500	0.715**	-4.719
Part. Cu (mg/g)	Range	0.08-1.65	0.06-0.88	0.01-1.40
	Mean	0.4511	0.3994	0.4463
	Std.	0.46410	0.25821	0.44084
	R	0.273	-3.232	-1.029

Cont…

Parameters		Site 1	Site 2	Site 3
Diss. Fe (mg/L)	Range	0.01-0.09	0.01-0.07	0.06-0.07
	Mean	0.0328	0.0399	0.0399
	Std.	0.02370	0.02532	0.02278
	R	-1.468	0.213	-5.212
Part. Fe (mg/g)	Range	1.14-8.63	2.98-15.98	4.06 -20.21
	Mean	4.4092	10.2542	10.7968
	Std.	2.38116	4.91190	5.17055
	R	0.031	0.235	-2.070
Diss Cd (mg/L)	Range	0.01-0.04	0.01-0.07	0.001-0.02
	Mean	0.0108	0.0142	0.0049
	Std.	0.01280	0.01795	0.00552
	R	0.621*	0.397	-1.876
Part. Cd (mg/g)	Range	0.01-0.40	0.01-0.48	0.001-0.68
	Mean	0.0786	0.0860	0.1024
	Std.	0.11376	0.12769	0.18684
	R	0.059	-1.449	-4.985

Significance differences at P < 0.05

Table (3): Percentage for recorded algae classes in sites (1, 2, 3) during study period

Sites \ Classes	Cyanophyceae	Euglenophyceae	Dinophyceae	Rhodophyceae	Chrysophyceae	Xanthophyceae	Bacillariophyceae	Chlorophyceae
1	16.9	3.3	-	-	3	1.6	64.4	10.1
2	21.4	5.5	1.5	0.7	3.11	-	45.2	22
3	15.9	2.8	-	-	-	1.4	60.8	18.8

- Not present

CONCLUSION

We conclude that industrial waste water has a greatly effects on properties on water quality of on major drainage in the region of middle Iraq. The dramtic fluctuation of water quality parameters in this drainage due to high effluent of industrial wate water, which in turn has a vital effect on relationship between phytoplankton and water quality characteristics.

ACKNOWLEDGMENT

We are highly grateful to Dr. A. Randall Hughes (Coastal & Marine Laboratory, The Florida state (University) for reviewing this paper and for her valuable advices.

REFERENCES

1. Y. Saygi and S. A. Yiğit, Heavy Metals in YeniçaÄŸa Lake and its Potential Sources: Soil, Water Water, Sediment and Plankton. Environ. Monit Assess, **184**, 1379-1389 (2012).
2. N. Shikazono, K. Tatewaki, K. M. Mohiuddin, T. Nakano and H. M. Zakir, Sources, Spatial Variation and Speciation of Heavy Metals in Sediments of the Tamagawa River in Central Japan, Environ. Geochem. Health, **34**, 13-26 (2012).
3. T. Noriko, H. Shighisa and S. Yoshio, Seasonal Changes in Species Composition and Production of Periphyton in an Urban River Running Through a Pb and Copper Mining Region. Japan. J. limnol., **51**, 225-235 (1990).
4. D. G. Woodfine, M. Havas and J. Acreman, Nickel and Copper Tolerance of Phytoplankton Isolated from a Recovering Lake Near Sudbury, Canada. Geochemistry: Exploration, Environ. Anal., **2(2)**, 203-207 (2003).
5. APHA (American Public Health Association), Standard Methods for Examination of Water and Wastewater, 20th Ed., Washington DC, USA (1998).
6. G. T. Lind, Handbook of Common Methods in Limnology, 2nd Ed., London (1979) p. 1991.
7. T. R. Parsons, Y. Mait and C. M. Laulli, A Manual of Chemical and Biological Methods for Seawater Analysis, Pergamone Press, Oxford (1984) p. 1991.
8. R. A. M. Hadi, Algal Studies on the River U.S.K. Ph. D. Thesis, Univ. College, Cardiff, U.K. (1981).

9. R. A. Vollen Weider, A Manual on Methods for Measuring Primary Production in Aquatic Environments, International, Boil, Program Handbook 12, Blackwell Scientific Publications Ltd. Oxford (1974) p. 225.

10. F. Hustedt, The Pennate Diatoms, a Translation of Husted's "Diekiese, 2Teil", with Supplement of N. H. Jensen, Koeltz Scientific Books Koenigstein (1985) p. 918.

11. H. Germain, "Flore des Diatomées, Eaux Douces Et Saumâtres, Soc. Nouv. Ed. Boubée, Paris (1981) p. 444.

12. J. E. Furet and K. Benson. Evans, An Evaluation of the Time Required to Obtain Complete Sedimentation of Fixed Algal Particles Prior to Enumeration, Br. Phycol. J., **17**, 253-258 (1982).

13. V. Salvadó, X. D. Quintana and M. Hidalgo, Monitoring of Nutrients, Pesticides and Metals in Waters, Sediments and Fish of a Wetland, Arch. Environ. Contam. Toxicol., **51**, 377-386 (2006).

14. F. M. Hassan, M. M. Saleh and J. M. A. Salman, Study of Physicochemical Parameters and Nine Heavy Metals in the Euphrates River, Iraq. E-J. Chem., **7(3)**, 685-692 (2010).

15. J. Dominik, D. A. L. Vignati, B. Koukal, M. H. Pereira De Abreu, R. Kottelat, E. Szalinska, B. Bas and A. Bobrowski, Speciation and Environmental Fate of Chromium in Rivers Contaminated with Tannery Effluents, Eng. Life Sci., **7(2)**, 155-169 (2007).

16. D. R. Thévenot, R. Moilleron, L. Lestel, M. Ch. Gromaire, V. Rocher, Cambier Ph., Bonté Ph., J. L. Colin, C. D. Pontevès and M. Meybeck, Critical Budget of Metal Sources and Pathways in the Seine River basin (1994-2003) for Cd, Cr, Cu, Hg, Ni, Pb and Zn. Science of the Total Environment, **375**, 180-203 (2007).

17. H. F. Olguin, Puiga, C. R. Loez, A. Salibian, Topalianml, P. M Castane and M. G. Rovedatti, An Integration of Water Physicochemistry, Algal Bioassay, Phytoplankton, and Zooplankton for Ecotoxicological Assessment in a Highly Polluted Lowland River, Water, Air and Soil Pollution, **155**, 355-381 (2004).

18. T. R. S. Shekhar, B. R. Kiran, E. T. Puttaiah, Y. Shivaraj and K. M. Mahadevan, Phytoplankton as Index of Water Quality with Reference to Industrial Pollution, J. Environ. Biol., **29(2)**, 233-236 (2008).

19. D. J. S. Montagnes and D. J. Franklin, Effect of Temperature n Diatom Volume, Growth Rate, and Carbon and Nitrogenc Content: Reconsidering some Paradigms, Limnol. Oceanogr., **46(8)**, 2008-2018 (2001).

20. P. Henriksen, B. R. H. Kaas, H. M. Sørensen and A. H. L Sørensen, Effects of Nutrient-Limitation and Irradiance on Marine Phytoplankton Pigments, J. Plankton Res., **24(9)**, 835-858 (2002).

21. K. T. G. S. Sigaud, M. A. S Leita˜o and O. K. Okamoto, Heavy Metal-Induced Oxidative Stress in Algae, J. Phycol., **39**, 1008-1018 (2003).

22. W. X. Wang and R. C. H. Dei, Effects of Major Nutrient Additions on Metal Uptake in Phytoplankton Environmental Pollution, **111** (2001), 233-240 (2000).

Accepted : 24.08.2012