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IMPACT OF FISH CAGES ON THE NILE WATER QUALITY AT DAMIETTA BRANCH

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ABSTRACT

Damietta region has been drastically affected by increasing levels of pollution from point and non-point sources; domestic, industrial, agriculture as well as the extensive fish cages in the region. The aim of this study was to monitor the Nile water quality at Damietta region through measuring of physico-chemical parameters and some heavy metals; to investigate the impact of decision maker on fish cages removal from the study area. Water samples were collected along axial transect of Damietta branch twice; the first monitoring campaign was conducted at the end of autumn 2006 just after the removal of fish cages from the Nile while the second campaign was carried out at the end of winter 2007. A water quality index (WQI) was used as a simple pollution indicator to assess the effect of fish farming.

The results revealed that, DO concentrations ranged from 4.4 to 9.2 mg/l; BOD values are in the range of 1.1 - 4.6 mg/l, whereas COD ranges from 31.6 to 146 mg/l. Ammonia, nitrite and nitrate ranged from 0.246 to 0.480, 0.056 to 0.115 and 0.075 to 0.155 mg/l, respectively. Total phosphorus ranged from 0.014 to 0.199 mg/l. The Nile water quality at the study area has been improved after the removal of fish cages. Water quality index used supports this finding; water quality improved from "medium" during the first filed inspection into "good" quality during the second filed sampling at the end of winter 2007. Thus, fish cages removal from Damietta branch improved water quality.

Keywords: *Damietta Branch, Water Quality, Fish Cages, WQI.*

INTRODUCTION

The Nile River is considered one of the longest rivers in the world. It has a total length of about 6700 km; its length inside Egypt is approximately 1352 km. The Nile River travels 940 km behind the Aswan High Dam, and divides at El-Qnater barrage, into two branches, the western is the Rosette branch and the eastern is Damietta branch, enclosing in-between the Nile Delta where it is subject to different sources of pollution. Damietta branch begins at the Delta Barrage and ends 220 km downstream at Damietta Dam near Damietta city (APRP 2002). The Nile have been used in a variety of purposes including drinking / domestic water supply, agricultural irrigation, industrial uses, fisheries, navigation, recreation and others. Hence, the

Nile River is the main resource of fresh water in Egypt, with water allocation of 55.5 billion cubic meters per year.

With the increase of population growth and related human activities including agricultural and industrial developments, water demand in Egypt has been increased in one hand and on the other hand the availability of water of acceptable quality in Egypt is getting more restricted (Abdel Wahaab and Badawy 2004). Anthropogenic influences as well as natural processes degrade surface waters quality and impair their uses for agriculture, drinking, industry, and other purposes (Sanchez et al. 2007). Water pollution is considered one of the main environmental problems affecting Egypt; due to increasing agriculture projects, urbanization and industrial developments. The Damietta Branch receives polluted water from a number of agricultural drains, industrial effluents, domestic sewage as well as extensive fish farming activities (Abdel Wahaab and Badawy 2004). Consequently, management of water resources as well as monitoring of water quantity and quality has been considered as a national responsibility for achieving sustainable development in Egypt.

Fish cages at Damietta Branch have been developed since 1984 and are considered an important part of the fishing industry. Usually the cage size is 10_10_6 m (600m^3). The culturing time ranges between 7 to 9 months and the yield ranged between 4 and 6 tons per cage of good fish species. There were more than 1000 fish cages in the River Nile, within Damietta Governorate (Zyadah 1996). Environmental impacts of fish farming activities have received increasing attentions in the recent decades. The wastes produced in aquaculture farms are basically similar but they differ in the quantity and quality according to the species cultured and the type of fodder. According to Zyadah (1996), there are three main types of wastes in hatcheries or production farms: (1) residual food and fecal matter, (2) metabolic by-products and (3) residues of biocides. Fish farming leads to the enrichment of aquatic bodies with phosphorus, ammonia, copper, nutrients, urea and organic matter (Simoes et al. 2008). The bacterial decomposition of the organic matter results in high rates of dissolved oxygen consumption and production of anoxic gas. Changes in water quality due to increasing nutrients and decreasing dissolved oxygen can consequently affect fish population and aquatic life.

It is worth mentioning that the evaluation of water quality in developing countries has become an important issue especially due to the concern of fresh water scarcity in the future (Pesce and Wunderlin 2000). The present study was designed to investigate and assess the upgrading in water quality of the Nile at Damietta Governorate after removal of fish cages.

MATERIALS AND METHODS

Nine sampling locations were selected along the fish cages area at Damietta region. Two field trips were conducted, the first was at the end of autumn 2006, just after the removal of fish cages and the second was at the end of winter 2007. Nine sampling locations were selected; starting from upstream of Kafer Al-Arab to downstream of Damietta dam (Table 1). Water samples were collected from the central area of the studied sites for analysis.

Physico-chemical characteristics; in terms of pH, Total Dissolved Solids (TDS), Turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorus (TP), Ammonia, Nitrate and Nitrite were analysed. Heavy metals concentrations (Cu, Mn and Zn) were investigated. All physico-chemical parameters unless otherwise stated were conducted according to standard methods (APHA 1999). Heavy metals were determined using flame atomic absorption spectrophotometer (Perkin Elmer, 2380).

The water quality index (WQI) is a simple mathematical model used to transform large quantities of water quality data into a single number which summarize different water quality characteristics (Gupta et al. 2003; Smith 1990). The WQI proposed in this work is composed of nine measurable parameters namely; temperature, pH, turbidity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, ammonia nitrogen, nitrite nitrogen and total phosphorus; based on the specific objectives of this work and consulting a wide range of literature reviews (Gupta et al. 2003; Pesce and Wunderlin 2000; Prati et al. 1971; Seilheimer et al. 2009; Simoes et al. 2008). The water quality index was calculated for each sampling point using the following empirical equation in order to investigate the impact of fish cages removal (Pesce and Wunderlin 2000).

$$WQI = k\frac{\sum_i C_i W_i}{\sum_i W_i} \qquad (1)$$

Where, k is a subjective constant representing the visual impression of river water quality. WQI is usually ranges from 0.25 (highly polluted water) to a maximum value of 1.0 (good quality water). Ci is the value assigned to each measured parameter after normalization on a scale from 0 to 100 (Table 2). Zero indicates water that is not suitable for the intended use without further treatment and 100 represents perfect water quality. Wi is the relative weight assigned to each parameter. A maximum weight of 4 was assigned to parameters of relevant importance for aquatic life such as DO and ammonia, while the minimum value (unity) was assigned to parameters with minor relevance such as temperature and pH (Sanchez et al. 2007). These normalized values are then translated into statement of water quality including excellent, good, medium, bad and very bad. In this work, the constant k was not considered in order not to introduce a subjective evaluation as reported in the literature (Stambuk-Giljanovic 1999).

RESULTS AND DISCUSSION

One initial step of result evaluation is to compare the data of the current study with previous studies in the presence of fish cages as well as comparing the obtained data with the Egyptian Environmental Regulations Law No. 48 of 1982 (Table 3). The results of the physico-chemical and heavy metal parameters are listed in Tables 4 and 5 and changes in water quality parameters due to removal of fish cages are shown in Figures 1 and 2.

3.1. Physico-chemical Characteristics

The surface water temperature for the two field trips ranged from 17 to 20^{o}C; with no significance variation is associated with sampling time. pH is an important indicator of water quality and the extent of pollution, especially at industrial pollution sources

(Jonnalagadda and Mhere 2001). pH values at the sampling sites ranged between 7.0 - 7.7, with an average value of 7.4 ± 0.06. It is worth mentioning that all pH values are within the permissible limits stated in Law No. 48 of 1982 (7.0 - 8.5). Total dissolved solids (TDS) in all water samples did not exceeding 340 mg/l, with an average of 325 ± 8.6. Low values of TDS were recorded during the second field trips during winter 2007. This may be attributed to the high rate of drainage water from rain precipitation, in addition to the low rate of evaporation (Squires and Sinnu 1986). The turbidity values of the water samples ranged from 2.2 to 6.9 NTU, with an average value of 4.1 NTU.

Dissolved oxygen concentrations ranged between 4.4 and 9.2 mg/l, with an average value of 6.7 ± 1.6 mg/l. DO is a crucial factor to sustain aquatic life and indicates the health status of any aquatic ecosystem (Stambuk-Giljanovic 1999). The lowest DO values were recorded just after the removal of fish cages (Figure 1). This is due to consumption of dissolved oxygen in the degradation of organic matter. After approximately ten weeks DO values increased significantly, which confirm improving of water quality. Previous investigations of DO in September 2005 indicated lower values of DO of 3.3 - 4.2 mg/l in the presence of fish cages activities in the vicinity of Damietta region (El-Hourany region and Damietta Dam) (El-Sheltawy et al. 2007). The DO value reached to 9.0 mg/l at the southern part of Nile Damietta branch after the removal of fish cages. Significant improvement in water quality was recorded comparing to previous studies, where DO was only 6.2 mg/l (APRP 2002).

Organic Matter Indicators

When organic matter in water is decomposed by aerobic microorganisms, the amount of oxygen absorbed biologically increased. BOD concentrations ranged from 1.1 to 4.6 mg/l, with higher values of 1.9 - 4.6 mg/l for water samples collected during the first field trip and lower values of 1.1 - 2.9 mg/l for those collected during the second field trip (Figure 1). High BOD values reflects high levels of organic matter in the aquatic ecosystems, which adversely affect the water quality (Jonnalagadda and Mhere 2001). COD values in the second field trip (31.6 - 95 mg/l) are much lower than those values of the first trip (38.6 - 146 mg/l). It is obvious that COD values during first field trip are higher than permissible limits of the Egyptian standards. This indicates the presences of high level of organic contaminants due to the excessive death of the fish population after legal removal of all fish cages. The majority of COD measures for both trips are still relatively higher than those values measured on September 2005 which ranged from 24 - 47 mg/l (El-Sheltawy et al. 2007).

There are certain important limitations of BOD as an indicator of organic pollution. When small amount of toxic metallic ions are present in samples, a deceptively low BOD value is observed owing to the inhibition of bacterial activity. For example, 0.01mg/l of copper (algaecide) materially depresses the result of the BOD test. However, that is indicated the reasons for lowering BOD values when compared to COD values at the same sites of the present study. Furthermore, some toxic wastes have a high chemical demand for oxygen but indicate a comparatively low BOD even in the presence of large organic matter (Mahida 1983).

Nutrients And Heavy Metals :

Nutrients such as nitrogen and phosphorus are essential for aquatic life but excess nutrients inputs into aquatic environments lead to eutrophication and can harmfully affect the aquatic habitat. Photosynthesis and respiration play an important role in the self purification of natural waters. Nitrate is the final stable form of oxidation / decaying of organic matter from domestic, industrial, agriculture sources. Concentrations of nitrate ranged from 0.075 to 0.155 mg/l. Nitrate concentrations are considerably higher in the first trip than those of the second field trip (Figure 2). This may be attributed to nitrification process of ammonia and nitrite; and was enhanced by the biochemical decomposition of descending dead fish by the nitrate nitrifying bacteria, and transformation of organic nitrogen to ammonia and nitrifying ammonia to nitrate.

The concentrations of nitrite in the water samples showed relatively higher values (0.064 - 0.114 mg/l) at the first field trip compared to those values (0.056 - 0.110 mg/l) at the second field trip as shown in Figure 2. The decrease of nitrite content may be principally due to the increase of its oxidation to nitrate and reduction of nitrate to ammonia as well as its uptake by plankton (Awadallah and Moalla 1996).

Ammonia concentrations ranged from 0.246 to 0.480 mg/l for water samples collected during the study period. The maximum value of ammonia was just under the Egyptian permissible limits (0.5 mg/l). The sources of ammonia in the current study could be generated from the decaying of died fishes during the removal of fish cages. However, the low ammonia concentration may be due to the increase of plankton population where the phytoplankton utilizes ammonium ions in preference to other inorganic nitrogen.

The average TP concentration was 0.105 ± 0.06 mg/l. In contrast to nitrite and nitrate, higher values of TP (0.139 - 0.199 mg/l) were recorded for water samples collected during second field trip compared to lower values (<0.100 mg/l) to be measured in water samples collected during first field trip as explained in Figure 2. This could be explained as much phosphate is used by microorganisms during higher rate of organic matter decay after excessive death of fish population following removal of fish cages. Also, low concertinos of total phosphorous during autumn may be attributed to consumption by algae, bacteria or aquatic weeds (Awadallah and Moalla 1996). Moreover, total phosphorus might be increased during winter due to the input from agricultural drainage and soil flushing.

Heavy metals can enter rivers and streams from different sources, including natural and anthropogenic sources within the catchments and directly from effluent discharges. The concentrations of Manganese in the water samples ranged from 0.049 - 0.893 mg/l. It is clear that, six out of nine samples collected during the first trip have higher concentrations of Manganese than those of the second trip with two samples above the Egyptian standards limits (0.541 and 0.893 mg/l for samples 5 and 6 respectively). Zinc concentrations ranged from 0.087 mg/l (second field trip) to 1.99 mg/l (first field trip). The increase in zinc concentration during the first field trip may be attributed to the residual food stuff and the quantity of this food used in fish cages, in addition to agricultural runoff into the Nile River at the study area. Water-sediment exchange may also increase the concentration of this metal in the water column. From the hydro-biological point of view, the relative decrease in zinc concentration may be attributed to the decrease in the decomposition rate of organic matter during the second field trip and the consumption of this metal by phytoplankton. It was found that the potential pollutants resulting from industrial drainage, domestic sewage, agricultural drainage and urban runoff lead to the increase of heavy metal concentration in water. Copper concentrations in water samples fluctuated between 0.052 and 0.627 mg/l. The high concentrations of copper in water samples at the first field trip might be attributed to the remobilization of copper from the bottom sediment during the removal of fish cages; as copper sulfate is usually used in aquaculture (Simoes *et al.* 2008). Low concentrations of copper during second field trip may be due to its tendency to form complexes with organic matter, where about 90% of Cu in water could form a complex with humic matter (Kendrick et al. 1992; Zyadah 1996).

Water Quality Index :

Evaluation of overall water quality index is not easy to achieve, where its criteria should be applied according to the uses of the water bodies (Simoes et al. 2008). WQI promote adequate classification of water quality and allow the public and decision makers to receive water quality information (Pesce and Wunderlin 2000). Water quality index approach was applied to test the hypothesis that the removal of fish cages from this polluted region would improve the water quality. According to Sanchez et al (2007) WQI is classified as follows: 0 - 25 (very bad), 26 - 50 (bad), 51 - 70 (medium), 71 - 90 (good) and finally 91 - 100 (excellent).

Figure 3 shows water quality index calculated using equation 1 and normalized factors described in Table 2. WQI indicate more biodegradations conditions with moderate water quality after removal of fish cages and improving of the aquatic system into good class water quality during the second field investigation at the end of winter 2007. WQI for data collected from the first filed trip ranged from 62 to 73.6; expect the first sampling point which used as reference station. The WQI values increased during the second filed trip (72 - 76.5). Thus the use of WQI can give an indication of the Nile water quality at Damietta Branch and keep tracks of any changes overtime as well as describing the effect of aquaculture. Therefore, water quality indices can provide a simple and understandable tool for decision makers on the quality and possible uses of a given water body (Bordalo *et al.* 2001).

CONCLUSION

The physical and chemical parameters including heavy metals were measured in water samples collected from the Nile River, Damietta Branch just after the removal of all fish cages and then after a period of ten weeks to follow up the water quality improvement.

Previous studies indicated that the Nile River with in Damietta governorate was suffering from increasing levels of COD, BOD and ammonia concentrations. Excretions from the extensive fish cages were indicated as one of the main causes in addition to discharging of El-Serw El-Aala drain and domestic waste. The physical and chemical parameters including heavy metals that monitored in the current study indicated that Nile water quality at Damietta region has been improved after the removal of all fish cages.

Dissolved oxygen concentrations that measured during first field trip (4.4 - 6.5 mg/l) were relatively lower than DO values of those collected during second field trip (6.9 - 9.2 mg/l). In contrast, concentrations of BOD and COD of first field trip are much higher than those of second field trip; 39 - 146 mg/l compared to 31 - 95 mg/l for COD. This indicates the presence of high organic matter load just after fish cages removal and consequently death of fish. Hence, DO, BOD and COD are usually used in assessing water quality to evaluate the organic load and the extent to which aquatic environments are affected by anthropogenic pollution. Values of nitrite and nitrate during the first field trip were relatively higher compared to those for water samples collected during second field trip; assuming higher rate of organic matter decay and nitrification process straight after removal of fish cages. Low concentrations in total phosphate were recorded during first field trip. This is due to biological consumption of soluble reactive phosphate. Water quality index was applied to assess the water quality classification based on the use of standard measurable parameters for water characterization (Chapman 1996; Sanchez *et al.* 2007).

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Table 1 : Description of the sampling points from the Nile River Damietta Branch in the vicinity of Damietta Government.

Sample	Location name
1	Kafer Al-Arab (South Faraskour Bridge; in the front of Yunus Brick Factory)
2	500 m to the north of Faraskour Bridge
3	In front of the drinking water compact unit of Faraskour City
4	5 km to the north of Al-Ebedia
5	El-Kaheel (In front of Kafer El-Battikh Electric Power Station)
6	El-Bostan (In front of the intake of El-Bostan drinking water treatment plant)
7	Al-Adleia (Entrance of Salam Canal)
8	Al-Adleia (In front of the intake of Al-Adlia drinking water treatment plant)
9	Damietta (Damietta Dam); El-Sadd

Table 2 : Parameters considered in the water quality index calculation adapted from Pesce and Wunderlin (2000) and Sanchez *et al.* (2007).

Parameters	**Wi**	**Normalization factor Ci**										
		100	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**0**
Ammonia	4	<0.01	<0.05	<0.10	<0.20	<0.30	<0.40	<0.50	<0.75	<1.00	≤1.25	>1.25
BOD-5	3	<0.5	<2	<3	<4	<5	<6	<8	<10	<12	≤15	>15
COD	3	<5	<10	<20	<30	<40	<50	<60	<80	<100	≤150	>150
DO	4	≥7. 5	>7. 0	>6. 5	>6. 0	>5. 0	>4. 0	>3. 5	>3. 0	>2. 0	≥1. 0	<1. 0
Nitrite	2	<0.005	<0.01	<0.03	<0.05	<0.10	<0.15	<0.20	<0.25	<0.50	≤1. 00	<1.00
pH	1	7	7-8.5	7-9	6.5-7	6.5-7	6.- 9.5	5-10	4-11	3-12	2 -13	1-14
Temperature	1	21/16	22/15	24/14	26/12	28/10	30/5	32/0	36/-2	40/ - 4	45/ - 6	45/<-6
T. Phosphorus	1	<0.05	<0.05	<0.05	<0.10	<0.10	<0.15	<0.15	<0.20	<0.20	<0.30	<0.30
Turbidity	2	<5	<10	<15	<20	<25	<30	<40	<60	<80	≤100	>100

All values, except pH, in mg/l

Table 3 : Egyptian standard regularities of article 60 -law No. 48/1982 regarding minimum standards for the water quality of the Nile River.

Parameter	**Egyptian Regulation (mg/l)**	**Parameter**	**Egyptian Regulation (mg/l)**
pH	7.0 – 8.5	Temperature	Over usual by 5 Cº
DO	5	Iron	1
TS	500	Manganese	0.5
BOD	6	Copper	1
COD	10	Zinc	1
Ammonia	0.5	Cadmium	0.01
Nitrate	45	Lead	0.05

Table 4 : Water characteristics of the Nile River – Damietta Branch (Autumn 2006).

Sampling point	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Temperature ºC	17	18	18	17	19	20	20	20	19
pH	7.20	7.20	7.20	7.15	7.20	7.10	7.00	7.00	7.1
TDS (mg/l)	340	340	335	330	335	335	320	310	320
Turbidity (NTU)	3.0	2.4	2.6	3.2	3.3	4.6	6.2	6.3	2.2
DO (mg/l)	6.5	6.3	6.1	5.4	5.5	4.9	4.8	4.7	4.4
BOD (mg/l)	2.2	2.0	2.4	2.9	2.6	3.2	4.6	3.7	1.9
COD (mg/l)	48.9	89.1	113.6	146.0	142.1	128.6	95.7	80.1	38.6
Ammonia (mg/l)	0.432	0.461	0.366	0.381	0.328	0.354	0.278	0.314	0.480
Nitrite (mg/l)	0.064	0.072	0.072	0.086	0.112	0.115	0.114	0.101	0.081
Nitrate (mg/l)	0.086	0.103	0.104	0.100	0.138	0.155	0.152	0.132	0.113
T Phosphorus(mg/l)	0.014	0.020	0.040	0.045	0.030	0.078	0.080	0.100	0.060
Copper (mg/l)	0.209	0.157	0.105	0.105	0.105	0.627	ND	0.418	ND
Zinc (mg/l)	0.136	0.909	0.500	0.364	0.273	1.999	0.227	1.104	0.500
Manganese (mg/l)	0.217	0.487	0.433	0.271	0.541	0.893	0.108	0.162	0.298

Table 5 : Water characteristics of the Nile River – Damietta Branch (Winter 2007).

Sampling point	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Temperature ºC	18	17	17	18	19	19	20	20	19
pH	7.50	7.51	7.44	7.56	7.58	7.61	7.68	7.71	7.70
TDS (mg/l)	315	315	320	325	325	325	325	325	325
Turbidity (NTU)	3.0	3.2	3.1	3.3	4.7	4.8	6.9	4.5	5.6
DO (mg/l)	6.9	7.3	7.0	8.0	8.3	7.9	8.7	9.2	9.0
BOD (mg/l)	1.4	1.3	1.1	1.9	2.4	2.1	2.6	2.9	2.9
COD (mg/l)	31.6	44.6	47.5	50.7	63.4	95.0	95.0	71.1	44.3
Ammonia (mg/l)	0.404	0.441	0.355	0.342	0.260	0.247	0.295	0.325	0.427
Nitrite (mg/l)	0.057	0.056	0.059	0.065	0.093	0.094	0.105	0.110	0.106
Nitrate (mg/l)	0.077	0.080	0.084	0.075	0.114	0.126	0.140	0.143	0.147
T Phosphorus(mg/l)	0.199	0.163	0.159	0.157	0.143	0.148	0.139	0.155	0.163
Copper (mg/l)	0.105	ND	0.052	0.105	0.105	0.261	0.105	ND	ND
Zinc (mg/l)	0.126	0.307	0.109	0.303	0.113	0.087	0.202	0.350	0.500
Manganese (mg/l)	0.32	0.05	0.05	0.19	0.35	0.22	0.05	0.38	0.43

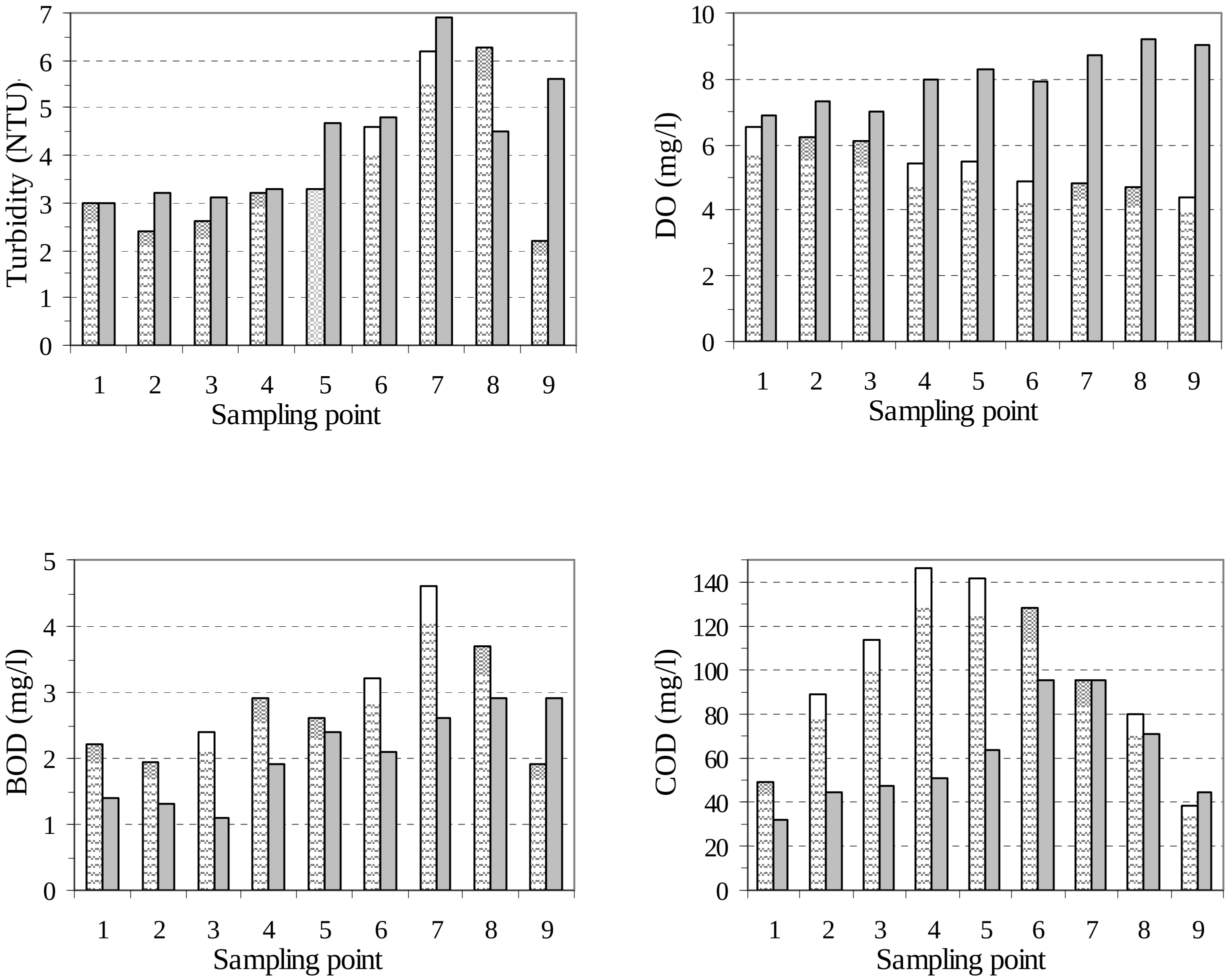


Figure 1 : Concentrations of Turbidity, DO, BOD and COD in water samples collected from the River Nile within Damietta Governorate during autumn 2006 -after fish cages removal (dotted columns) and winter 2007 (gray solid columns).

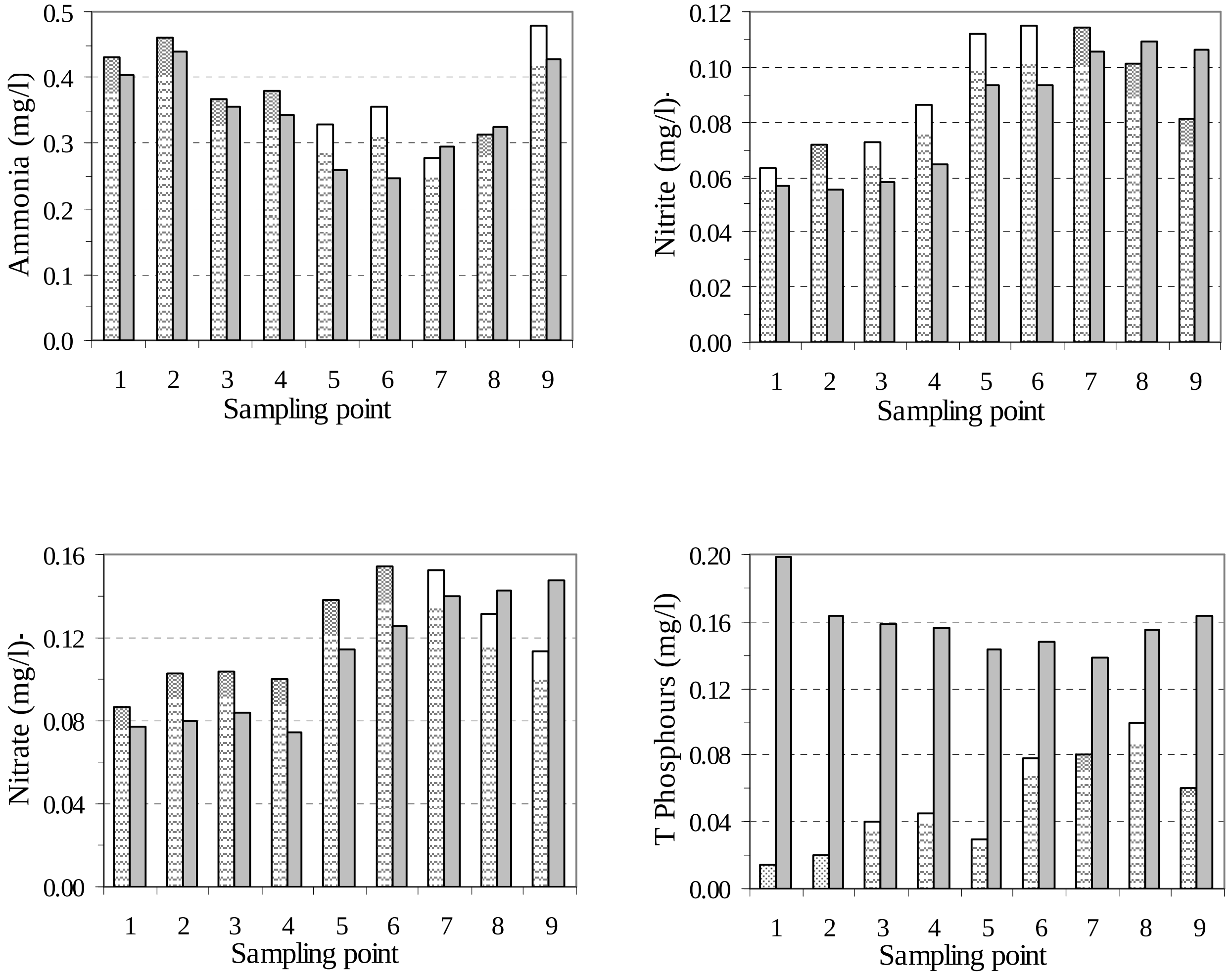
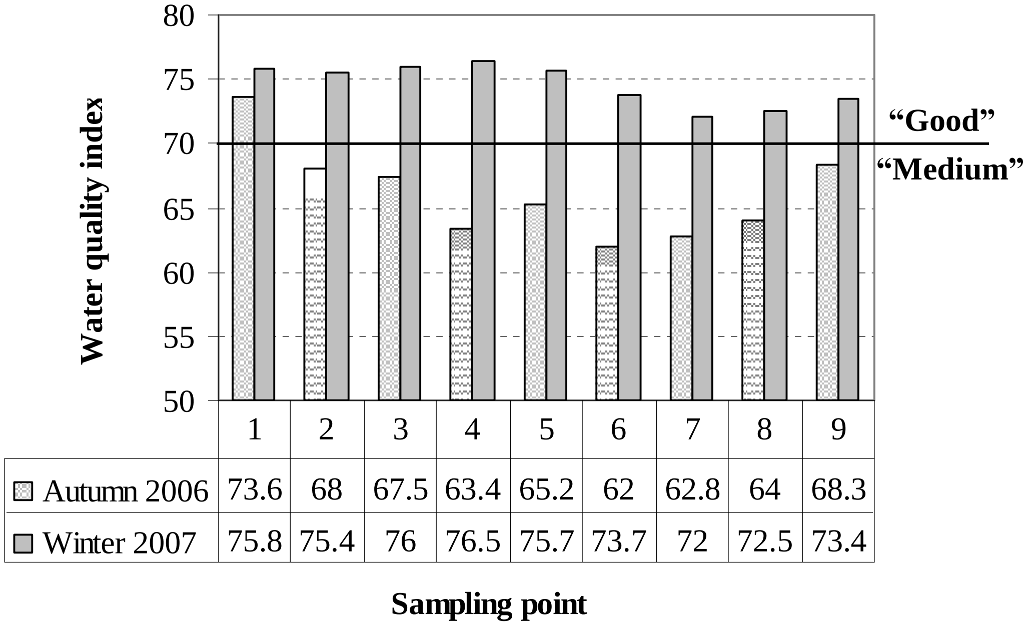


Figure 2 : Concentrations of Nutrients in water samples collected from the River Nile within Damietta Governorate during autumn 2006 -after fish cages removal (dotted columns) and winter 2007 (gray solid columns).



	1	2	3	4	5	6	7	8	9
▨ Autumn 2006	73.6	68	67.5	63.4	65.2	62	62.8	64	68.3
■ Winter 2007	75.8	75.4	76	76.5	75.7	73.7	72	72.5	73.4

Figure 3 : Water quality index used to assess water quality of the Nile River - Damietta Branch.

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الملخص العربى

تأثير الأقفاص السمكية على نوعية مياه النيل بفرع دمياط

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يعتبر نهر النيل المورد الرئيسى للمياه العذبة فى مصر، ولقد زاد تلوث نهر النيل في الآونة الأخيرة بسبب زيادة السكان ومختلف الأنشطة البشرية ذات الصلة. وبالأخص فإن نهر النيل بمنطقة دمياط قد تأثر بشكل جذري بزيادة مستويات التلوث من المصادر المنزلية، الزراعية والصناعية بالإضافة إلي إنتشار الأقفاص السمكية في المنطقة علي نطاق واسع. هدفت هذه الدراسة إلى رصد نوعية مياه نهر النيل بمنطقة دمياط وذلك من خلال قياس المؤشرات الفيزيائية والكيميائية وبعض المعادن الثقيلة. وذلك بهدف تتبع التحسن في موصفات مياه نهر النيل بفرع دمياط. ولقد تم تجميع عينات المياه من فرع دمياط في نهاية فصل خريف عام ٢٠٠٦ بعد إزالة الأقفاص السمكية مباشرة ثم في نهاية فصل الشتاء ٢٠٠٧، وقد أثبتت النتائج أن نوعية مياه نهر النيل فى العينات التي تم تجميعها في فصل الشتاء ٢٠٠٧ كانت أفضل من تلك التي تم تجميعها في فصل الخريف ٢٠٠٦، خاصة أن الدراسات السابقة أكدت وجود تركيزات عالية للمؤشرات الدالة على التلوث أثناء وجود تلك الأقفاص. وقد أكدت النتائج والنماذج الرياضية لمعايير جودة المياه علي تحسين جودة المياه بعد إزالة الإقفاص السمكية، وبالتالي المساهمة في الحفاظ على البيئة المائية وحماية الصحة العامة.

JOESE 5

IMPACT OF FISH CAGES ON THE NILE WATER QUALITY AT DAMIETTA BRANCH

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