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CHANGES IN PHYTOPLANKTON COMMUNITY STRUCTURE IN RELATION TO DIFFERENT WASTES DISCHARGING INTO ROSETTA BRANCH (EGYPT).

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Abstract

Six cruises to the polluted areas of Rosetta branch were carried out from January 2003 to November 2003 on bimonthly basis. Raw sewage from El-Rahawy drain and industrial effluents from Kafr El-Zaiyat factories represent the highly polluted area along Rosetta Nile branch. Dissolved oxygen was completely depleted at discharging area of raw sewage. Total organic nitrogen at two wastes was higher than inorganic forms. Ammonium concentrations loaded with raw sewage (2.87 mg/L) were much higher than that recorded in effluents of Kafr El-Zaiyat factories and exceed the maximum acceptable concentration (0.1 mg/L). Also, total organic phosphorus at the mixing areas of the two wastes increased than the upstream stations. Trace metal concentrations loaded with industrial effluents were distinctly high compared to domestic sewage either water or sediment. Phytoplankton communities at the discharging point of raw sewage and industrial waste showed an obvious decline compared to upstream and downstream stations. Bacillariophyceae dominated upstream of El-Rahawy stations, Chlorophyceae dominated downstream, while Cyanophyceae dominated mixing area. On the other hand, Chlorophyceae dominated at all stations of Kafr El-Zaiyat. This study aimed to avoiding discharge of raw sewage and industrial wastes into River Nile after explaining their hazardous impact on aquatic environment.

Key words: Rosetta branch, pollution, phytoplankton, chlorophyll *a*.

Introduction

Rosetta branch, one of the two main branches resulting from the bifurcation of River Nile. This branch has been subjected to intensive and diverse human activities including raw sewage from El-Rahawy Drain and industrial effluents from Kafr El-Zaiyat Factories.

Abou El- Kheir *et al.* (2000) indicated that, algal communities dominated by Bacillariophyceae, Chlorophyceae and Cyanophyceae at some industrially polluted water along Ismailia canal, Egypt. Also, their study clarified the impact of industrial effluents on diversity of the algal population. Taha *et al.*, (2001) stated that, *Nitzschia palea, N. obtusa, N. thermalis, Navicula pupula* from diatoms, *Carteria spp. and Chlamydomonas spp.*, from green algae, *Chroococcus minutus* and *Lyngbya limnetica*

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from blue green algae are indicators for industrial waste pollution (Iron and Steel Factories) River Nile. Konsowa and Taha (2002) reported that, the major peaks of phytoplankton at Rosetta branch were recorded in spring and winter and they also found that, Bacillariophyceae, Chlorophyceae and Cyanophyceae were the prevailing groups, while Dinophyceae and Euglenophyceae were rarely found. Abdo (2002) stated that, trace metals in Rosetta branch were found in the following order Fe > Mn > Pb > Zn > Cu > Cd. Sayed (2003) clarified that, industrial effluents from Kafr El-Zaiyat Factories affect on water quality, causing increase in some trace metals over the permissible limits set by the Egyptian Ministry of Health. Shaaban-Dessouki *et al.*, (2004) found that, phytoplankton inhabiting Rosetta branch were dominated by Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae and the minimum phytoplankton growth and diversity index was observed in drainage canal of Kafr El-Zaiyat Factory. Abdel-Aziz, (2005) observed that, Damietta and Rosetta branches are contaminated with different heavy metals such as: Fe, Zn, Cd and Pb that in turn change water body from being clear oligotrophic to an alarm case of eutrophic, which may effect on fish yield.

This study gives a clear image on deleterious and irreversible effects of raw-sewage and industrial wastes on some physicochemical characteristics, chlorophyll *a* and phytoplankton communities inhabiting Rosetta branch.

Materials and Methods

Materials:

Sampling stations begin 9 km from El-Kantar El-Khyria Barrage in the south and ends at Kafr El-Zaiyat (123 km) in the north. Water and sediment samples were taken from seven stations, Fig. (1); three represents El-Rahawy raw-sewage and four represents industrial waste of Kafr El-Zaiyat factories that denote the highly polluted area along Rosetta Nile branch.

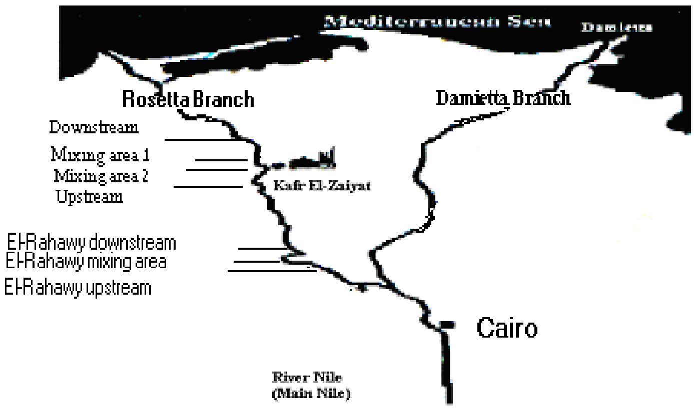

Fig. 1: Map showing the sampling stations at the polluted areas of Rosetta Branch

El-Rahawy upstream is located at about 250m before El-Rahawy Drain, mixing area represents the discharging point of the raw-sewage water into Rosetta branch, however El-Rahawy downstream is situated at about 500m from the mixing area of the drain. On the other hand, Kafr El-Zaiyat upstream is located upstream the two drains of Kafr El-Zaiyat factories, about 500m from the first waste, Kafr El-Zaiyat mix 1 represents the mixing area of the first drain of the Egyptian Salt and Soda Company, Kafr El-Zaiyat mix 2 is situated in front of Egyptian Financial and Industrial Company, while Kafr El-Zaiyat downstream is located downstream of Kafr El-Zaiyat factories, about 500m from mix 2.

Methods:

Six cruises to the two polluted areas of Rosetta branch were carried out from January 2003 to November 2003 on bimonthly basis. Composite water samples were collected from sampling stations by Ruttner Sampler (1.5 L), while sediment samples were collected by Ekman Dredge. Air and water temperature and pH were measured using portable pH meter (Jenway, 3250).. Transparency was measured by black/white standard Secchi's disc 25cm diameter. Electrical conductivity was measured in situ by using portable Hyrolab Analyzer model 340i/set. Chemical oxygen demand (COD) was determined according to Strickland and Parson's Method, 1968. Total organic nitrogen was measured according to Mckenzie and Wallace (1954). Alkalinity, dissolved oxygen, NH_4-N, NO_2-N, NO_3-N, PO_4-P, total organic phosphorus (TOP) and SiO_3-Si were determined according to APHA, (1995). Trace metal concentrations in water and sediment were determined by Atomic Absorption Perkin Elmer Model (3110) according to APHA, (1995).

Samples for quantitative and qualitative analysis of phytoplankton communities were preserved immediately using Lugols Iodine solution and allowed to settle, by gravitation, for 5 days. Phytoplankton counting was applied by a Drop Method technique, (APHA,1995). The main references used for identification of algal taxa were Prescott (1978), Geitler (1980) and Lebour and Forssa (1986). Chlorophyll *a* concentrations were measured using Spectrophotometer (Kontron instruments, UVIKON 930).

Diversity index of phytoplankton species was calculated according to equation represented by Raymont (1980). $D = S - 1/\ln N$.

Where S= number of species in the population, N= number of individuals in the population.

Statistical analysis: Correlation (person), regression analysis and analysis of variance are obtained by Minitab Program (12.1) under windows.

Results and Discussion

Rosetta branch is subjected to different sources of pollution which affecting on its physical and chemical characteristics. This effect lead to qualitative and quantitative changes in planktonic organisms.

Temperature, depth, Secchi disc, conductivity, pH and CO_3 values are shown in Table (1). Temperature of effluents at Kafr El-Zaiyat (31.0˚C) were relatively higher than other selected stations, due to the cooling system by River Nile water that discharging again into the Nile. Depth values at the discharging area of El-Rahawy Drain (0.5m - 4m) were much lower than Kafr El-Zaiyat stations (3m - 15m). due to sedimentation of huge amounts of suspended matters loaded with raw sewage. Secchi disc readings at the discharging area of El-Rahawy drain (17 cm) were much lower than mixing area of Kafr El-Zaiyat factories (70 & 67 cm), due to the great amount of suspended matter poured into the branch. This view agrees with many investigators (Abdo, 2002 and Sayed, 2003). Also, the present study revealed a strong correlation between Secchi depth and chlorophyll *a* (r = 0.66) at the area of raw-sewage water. So the multiple regression equation of total chlorophyll *a* on the variable Secchi depth is: Secchi depth = 39.6 + 2.2 Chl.*a*. This regression model shows that increasing Secchi disc by one unit will cause increasing Chl. *a* by 2.2 unit. Also, the determination coefficient (R^2) revealed that, this variable is responsible for 43.9 % of variation in total chlorophyll *a* where P value = 0.003. The present correlation confirmed by Tilzer, (1988) who concluded that, Secchi readings has further more been used as first spot checks of eutrophication. High conductivity value at El-Rahawy drain (870 µmohs) compared to industrial area (612 and 680 µmohs) is mainly due to high ionic content that loaded with their effluents, where its values was negatively correlated with Transparency (r = - 0.919). This finding agrees with Abdo (2002) at El-Rahawy and Kafr El-Zaiyat stations and Taha *et al*., (2001) at the discharging point of Iron and Steel Factory at Helwan city. The dramatic changes in pH at mixing area of El-Rahawy Drain (5.1 to 9.1) and industrial wastewater (6.5 and 8.1) possibly due little or no buffering capacity remaining at these polluted area, beside the acidic waste disposal from the polluted area. This agree with Abdel-Hamid *et al*., (1992), Shaaban-Dessouki *et al.*, (2004). Over all, pH values were somewhat within the limits of the accepted level of Egyptian and international standards which has the limit between 6.5- 9.2 (Egyptian), 6.5- 9.2 (W.H.O) and 6.5 -8.5 (USEPA), as cited from El-Zeftawii (1994). Carbonate alkalinity at raw-sewage water was usually below the detection level, its value ranged from 0.0 to 18 mg/L due to the severe drop in phytoplankton crops and photosynthetic activity in front of its mixing area that leads to decrease in CO_2 contents and consequently CO_3 depletions. (Abdo, 2002).

The analyses of HCO_3, DO, chemical oxygen demand (COD), NH_4, NO_2 and NO_3 are given in Table (2). Maximum bicarbonate values were usually recorded at the discharging area of the two wastes (504.12 mg/L and 282.42 & 296.65 mg/L) compared to upstream stations (289 & 270 mg/L), due to dissociation of high organic matter that assist formation of HCO_3. Overall, River Nile water can be designate as very hard water (Total alkalinity > 100-mg/L) as reported by Boyd (1979). Dissolved oxygen concentrations ranged from 1.5 mg/L to 7.4 mg/L and from 1.0 to 9.6 mg/L in front of mixing areas of Kafr El-Zaiyat factories. On the other side, its values were completely depleted at raw sewage water, probably during the oxidation of organic matter present at high concentrations. This phenomenon was observed also, by Ghallab (2000), Abdo, (2002), Shaaban–Dessouki *et al*.,(2004).

Chemical oxygen demand (COD) at mixing area of ERahawy drain (8.00 mg/L) was obviously higher than mixing areas of industrial waste (7.5 & 5.4-mg/L). Such increase probably explaining the high amount of organic matter loaded with domestic sewage. These data confirmed low self-purification of River Nile against raw sewage pollution where dissolved oxygen required for oxidation is more than actually occurred. In general, DO and COD are used as a basic water quality criteria to assess pollution status in water environment (Siliem, 1993).

NH_4-N concentrations was obviously increased at discharging area of El-Rahawy drain (2869 µg/L) compared to industrial waste water (352 & 310 µg/L), due to bacterial decomposition of organic matter and fecal pollution loaded with raw sewage. Shaaban-Dessouki, *et al.* (2004) realized this phenomenon to agricultural runoff. Abd El-Star, (1998), pointed that, ammonia in excess of 1-mg/L is considered as indicator of organic pollution and can be toxic to aquatic species in concentration over 2.5 mg/L. In general, NO_2-N were low at different stations compared to NH_4-N and NO_3-N concentrations.

High nitrate concentrations was recorded at upstream stations of industrial area (444 µg/L) when compared to raw sewage waste (246 µg/L), certainly realized to flowing a lot amount of drainage water loaded with fertilizers via some agricultural drains neighboring Kafr-El-Zaiyat area such as Zawiet El-Bahr Drain and Tala Drain. NO_3-N values correlate negatively with phytoplankton crop at Kafr El-Zaiyat (r= - 0.6) and El-Rahawy (r= - 0.3). This negative correlation may be indicates prefer consumption of nitrate contents by phytoplankton (Ahmed, 1983) and Abd Ellah & Konsowa, 2002).

Total organic nitrogen (TON), PO_4-P, total organic phosphorus (TOP) and SiO_3-Si concentrations are shown in Table (3). Orthophosphate concentration loaded with raw sewage (avg. 603 µg/L) increased than industrial wastes of Kafr El-Zaiyat (170 & 176 µg/L). High concentration of orthophosphate in the raw-sewage water derived mainly from domestic detergent, agricultural run off and decay of living cells. There was a significant positive correlation between pH and orthophosphate (r= 0.50) at Kafr El-Zaiyat.

This correlation was discussed by Bores (1991) who stated that pH is a key factor, involved both in chemical equilibrium of phosphate compounds and biochemical cell behavior. On the other hand, negative significant correlation between dissolved oxygen and phosphorus at El-Rahawy station (r = -0.662) agree with Shaaban-Dessouki *et al.*, (1993) who stated that poor phytoplankton and anaerobic condition of domestic waste water made phosphorus relatively high. Total organic nitrogen (TON) and Total organic phosphorus (TOP) at mixing areas of the two wastes under investigation were obviously high compared to other stations. This is due to decomposition processes, which depend on environmental conditions.

Shaaban–Dessouki *et al*., (2004) found that, wastewater represents the allochathonous source of organic phosphorous. Also, Soria *et al*., (1987) pointed out to urban sewage water that carry high amount of ammonia, organic nitrogen and organic phosphorus. On the other side, Flores & Barone (2000) stated that different algal species could exploit nutrient sources, both organic and inorganic, with varying capabilities.

Table (1): Physicochemical parameters at the polluted areas of Rosetta Branch in 2003

Parameters	Stations	El-Rahawy drain (raw sewage)			Kafr El-Zaiyat (industrial waste)			
		upsream	Mixing area	downstream	upstream	mix 1	mix 2	downstream
Temp. ˚C	Range	14.1 - 27.5	17 - 27	17 - 28.4	13.2 - 28.5	14.5 - 31.0	13.3 - 29.6	13.1 - 29
	Avg.	14.1	17.02	17	12.2	14.5	13.3	12.5
Depth m	Range	1.5 - 3.3	2.0 - 4.0	0.5 - 1.5	7.5 - 15	3.5 - 10	3.0 - 9.0	8.0 - 12.0
	Avg.	2.1	2.8	1.0	9.1	7.4	6.3	9.8
Secchi disc cm	Range	100 - 130	10.0- 20.0	23 - 1110	60 - 100	50 - 90	50 - 90	50 - 1100
	Avg.	113	17	65	78	70	67	73
Conductivity µmohs	Range	317 - 470	709 - 1010	415 - 1033	392 - 759	421 - 787	456 - 811	436 - 736
	Avg.	382	870	621	590	612	680	579
pH	Range	7.5 - 8.5	5.1 - 9.1	6.2 - 8.0	7.3 - 8.0	7.4 - 8.1	6.5 - 7.9	6.9 - 8.1
	Avg.	8.06	7.23	7.22	7.65	7.8	7.73	7.91
CO_3 mg/L	Range	6.0 - 87.0	0.0 - 18	0.0 - 94	0.0 - 81	18 - 77	0.0 - 115	20 - 137
	Avg.	43	3	38	43	46	42	59

Table (2): Chemical parameters at the polluted areas of Rosetta Branch in 2003

Parameters	Stations	El-Rahawy drain (raw sewage) Upstream	El-Rahawy drain (raw sewage) mixing area	El-Rahawy drain (raw sewage) downstream	Kafr El-Zaiyat (industrial waste) Upstream	Kafr El-Zaiyat (industrial waste) mix 1	Kafr El-Zaiyat (industrial waste) mix 2	Kafr El-Zaiyat (industrial waste) downstream
HCO3 mg/L	Range	98 - 602	267 - 914	111 - 491	90 - 449	98 - 471	131 - 460	134 - 527
	Avg.	289	504.12	325.87	270	282.42	296.65	310.57
D.O mg/L	Range	2.6 - 12.5	0.0 - 0.0	0.0 - 9.9	1.1 - 9.3	1.5 - 7.4	1.0 - 9.6	1.0 - 10.2
	Avg.	7.2	0.0	4.6	6.7	5.5	5.5	5.4
COD mg/L	Range	0.49 - 20.58	2.45 - 18.25	0.43 - 18.34	0.34 - 11.20	0.24 - 26.30	0.29 - 13.12	0.55 - 16.72
	Avg.	6.97	8.0	7.2	3.8	7.5	5.4	5.9
NH4-N µg/L	Range	23 -43	1065 - 5633	57 - 1897	213 - 580	191 - 599	55 - 614	238 - 598
	Avg.	35	2869	1070	341	352	310	366
NO2-N µg/L	Range	0.22 - 6.33	1.35 - 9.19	0.73 - 7.80	21.7 - 73.4	39.1 - 88.2	32.5 - 64.8	23.0 - 56.1
	Avg.	2.43	6.09	4.85	49.51	68.34	44.14	41.71
NO3-N µg/L	Range	130 - 477	281- 546	128 - 332	220 - 587	249 - 615	221 - 639	172 - 564
	Avg.	246	375	220	444	410	441	381

Iron represents the main component of trace metals followed by Mn, Ni, Zn, Pb, Cu and Cd at the two wastes under investigation (Table, 4) .

The present results revealed a negative correlation between iron concentrations in water and total phytoplankton crop (r= -0.62, r= -0.3) at Kafr El-Zaiyat and El-Rahway respectively. Rai *et al.* (1981) claimed that, high concentrations of heavy metals are toxic for the photosynthetic activity through the effect on the degradation of chlorophyll *a* and plasma membrane. Concerning El-Rahawy area, there were strong positive correlation existed between heavy metals in sediment and organic matter content (TON and TOP) as follows (Fe, r= 0.66, 0.60), (Mn, r= 0.515, 0.53), (pb, r= 0.513, 0.38) and (cd, r= 0.63, 0.54). This is reflected the role of organic matters in the accumulation of heavy metals in river sediments. This view is supported by Fjeld *et al.* (1994) who observed variation of heavy metals to corresponding variation in organic matter of sediment.

Table (3): Chemical parameters at the polluted areas of Rosetta Branch in 2003

Parameters	TON mg/L		PO_4-P µg/L		TOP µg/L		SiO_3-Si mg/L	
Stations	Range	Avg.	Range	Avg.	Range	Avg.	Range	Avg.
El-Rahawy drain (raw sewage)								
upsream	0.14 - 0.51	0.39	6.0 - 53	21.5	6 -146	65	0.06 - 2.48	1.1
mixing area	0.65 - 9.79	3.09	174 - 1285	602.8	47 - 696	345	0.55 - 4.06	1.98
downstream	0.38 - 2.67	1.10	71 - 1132	375.6	34 - 224	97	0.08 - 4.11	1.5
Kafr El-Zaiyat (industrial waste)								
upstream	0.30 - 3.09	1.30	112 - 141	125.6	12 - 153	92	0.1 - 5.33	2.0
mix 1	0.73 - 6.07	3.53	87 - 230	169.6	59 - 175	123	0.0 - 6.84	2.4
mix 2	1.69 - 6.59	4.60	137 - 219	176.3	53 - 147	85	0.12 - 6.99	3.2
downstream	0.69 - 4.37	2.38	124 - 204	163.2	29 - 112	71	0.12 - 5.05	1.9

Despite the mixing areas of the two wastes under investigation loaded with high concentrations of heavy metals than upstream, it is opportunity to point out to its low than permissible level in surface water reported by Egypt Environmental Affairs Agency (EEAA, 1994) (Fe, 1.5 ppm; Mn, 1.0 ppm; Ni, 0.1 ppm; Pb, 0.5 ppm; Co, 2 ppm; Zn, 5 ppm; Cd, 0.05 ppm; Cu, 0.5 ppm and Hg, 0.005 ppm). But, accumulation of a tiny amount of trace metals is highly toxic causing suffocation of fish, beside adverse changes in arteries of kidneys and livers, which lead to cancer in human (APHA, 1995).

Total phytoplankton crop (Table, 5) at the discharging point of raw sewage (106 x 10^4 l^{-1}) and industrial waste (808 & 750) showed an obvious decline compared to upstream (310 & 1016 x 10^4 l^{-1}) and downstream (223 & 865 x 10^4 l^{-1}) sites respectively. This finding explain their deleterious impact on growth and development of phytoplankton. Negative correlation between its crops and iron concentrations (r = -

0.62, r = -0.3), as well as weak negative correlation with some nutrients (NH_4; r = - 0.12 & - 0.35; NO_2 r= - 0.5 & - 0.25; NO_3 r= - 0.065 & - 0.354; TON r= - 0.12 & - 0.1; PO_4 r= - 0.41 & - 0.5; TOP r= - 0.10 & - 0.30; Si r= - 0.664 & 00.18) confirmed this view.

This is in close agreement with Taha, *et al.,* (2001) and Abd El-Karim (1999). Phytoplankton densities at upstream station of Kafr El-Zaiyat (1016 x 10^4 l^{-1}) were much higher than raw-sewage water (310 x 10^4 l^{-1}) due to abundance colonial forms of green algal such as *Scenedesmus ecornis, Coelastrum microporum* and *Scenedesmus quadricauda var. maximus*.

Depending on percentage abundance, Bacillariophyceae dominated upstream of El-Rahawy stations, Chlorophyceae dominated downstream, while Cyanophyceae dominated mixing area. The dramatic shifts probably due to the component of raw sewage wastes and eutrophication that probably inhibit or stimulate some algal species. Tilman *et al*. (1996) stated that, eutrophication (as a result of sewage, industrial and agricultural run off) may be lead to shifts in phytoplankton composition.

Abd El-Karim, (1999) recorded the inhibitory effect of high nutrient level at the polluted stations during his study on Damietta Nile branch. On the other hand, Chlorophyceae occupied the first dominant position at all selected stations of Kafr El-Zaiyat. This is realized to the dominance of green algal species in the form of colonies of numerous cells arranged in groups or series such as *Protococcus viridis, Scenedesmus ecornis, Kirchneriella contorta, Coelastrum microporum* and *Scenedesmus quadricauda var. maximus*. Also, uptake of silica during the abundance of diatom (r= -0.50), may be support further growth of green algae which are not require silica. (Owens, 1970).

During this investigation, a total of 111 species of green algae were identified as shown in Table (6). 107 species were observed at Kafr El-Zaiyat area while 40 species were recorded at El-Rahawy area. Chlorophyceae at El-Rahawy area dominated by *Chlorella vulgaris* Beijerinck, *Scenedesmus ecornis* (Ehrenb.)Chodat, *Kirchneriella contorta* (Schmidle) Bohlin and *Protococcus viridis* Agaradh, while at Kafr El-Zaiyat industrial area dominated by *Chlorella vulgaris* Beijerinck, *Protococcus viridis* Agaradh, *Scenedesmus ecornis* (Ehrenb.)Chodat, *Kirchneriella contorta* (Schmidle) Bohlin, *Coelastrum microporum* Naeg. and *Scenedesmus quadricauda var. maximus* W & G.S. West.

A total of 69 diatom species were identified during this investigation and are shown in Table (7). All species were recorded at Kafr El-Zaiyat while only 36 of them were observed at El-Rahawy. Diatoms at El-Rahawy area dominated by *Cyclotella ocellata* Pant, *C. operculata* kutz., *Melosira granulata* (Ehrenb.) Ralfs and *M. granulata var. angustissima* Muller, while at Kafr El-Zaiyat industrial area dominated by *Cyclotella meneghiniana* kutz, *C. operculata* kutz, *Synedra ulna* (Nitzsch) Ehrenb, *Nitzschia holsatica* Hust, *Melosira granulata* (Ehrenb.) Ralfs and *M. granulata var. angustissima* Muller and these algae are considered as biological indicators at the two wastes under investigation.

Table (4): Trace metal concentrations in water (µg/L) and sediment (µg/g) at the polluted areas of Rosetta Branch

Parameters	Stations	El-Rahawy drain (raw sewage)			Kafr El-Zaiyat (industrial waste)			
		upsream	mixing area	downstream	upstream	mix 1	mix 2	downstream
Fe	Water	1.68	4.41	3.43	2.57	2.80	3.32	3.82
	Sedim.	22.74	31.50	25.76	34.30	35.24	35.43	32.44
Mn	Water	0.15	2.48	0.28	0.37	0.65	0.65	0.44
	Sedim	1.17	5.58	2.46	10.90	14.40	7.69	11.26
Ni	Water	0.35	0.46	0.43	0.35	0.44	0.38	0.42
	Sedim	1.10	2.69	1.21	2.23	2.53	2.39	2.72
Zn	Water	0.25	0.40	0.34	0.22	0.36	0.43	0.25
	Sedim	-	-	-	-	-	-	-
Pb	Water	0.06	0.12	0.10	0.08	0.14	0.32	0.12
	Sedim	0.51	1.36	1.06	1.38	1.49	1.98	1.27
Cu	Water	0.05	0.08	0.07	0.08	0.06	0.18	0.07
	Sedim	0.30	0.87	0.50	0.76	1.10	1.16	1.52
Cd	Water	0.02	0.04	0.02	0.01	0.02	0.01	0.01
	Sedim	0.11	0.20	0.13	0.14	0.21	0.16	0.14

Table (5): Phytoplankton crop (Cells X 10 4 l -1) and percentage abundance of their classes, chlorophyll a concentrations and diversity index

Parameters	Stations	El-Rahawy drain (raw sewage)			Kafr El-Zaiyat (industrial waste)			
		Upstream	mixing area	Downstream	Upstream	mix 1	mix 2	Downstream
Total Crop	density	310	106	223	1016	808	750	865
Chlorophyceae	density	93	35	81	641	518	478	585
	%	30.1	33.2	36.3	63.1	64.1	63.7	67.7
Bacillariophyceae	density	111	33	76	262	188	228	168
	%	35.9	31.3	34.2	25.8	23.3	30.4	19.5
Cyanophyceae	density	103	37	63	102	91	29	100
	%	33.2	35.0	28.3	10.1	11.3	3.8	11.6
Cryptophyceae	density	2.3	0.3	2.3	5.7	4.0	2.7	4.0
	%	0.8	0.3	1.0	0.6	0.5	0.4	0.5
Euglenophyceae	density	0.3	0.0	0.3	1.3	3.3	7.7	6.0
	%	0.1	0.0	0.1	0.1	0.4	1.0	0.7
Chrysophyceae	density	0.3	0.0	0.0	4.3	3.0	5.3	1.0
	%	0.1	0.0	0.0	0.4	0.4	0.7	0.1
Chloro. *a*	Conc.	19.51	not recorded	14.70	58.3	50.4	48.0	53.7
Diversity	Index	3.16	0.48	1.98	4.06	2.32	2.04	3.78

Table (6): Species composition of green algae recorded in the selected stations of Rosetta branch 1- El-Rahawy area 2- Kafr El- Zaiyat industrial area

Species of green algae	1	2	Species of green algae	1	2
Actinastrum hantzschii Lagerh.	+	+	*Golenkinia radiata* Chodat	+	+
Actinastrum sp	-	+	*Micractinium pusillum* Fresenius	-	+
Coelastrum microporm Naeg.	-	+	*M. subsolitrarium* Van Goor	-	+
C. sphaericum Naeg.	-	+	*M. pusillum var. longisetum* Tiffany	-	+
C. reticulatum (Dangeard) Senn	-	+	*M. quadrisetum* (Lemm.) G.M. Smith	+	+
C. quadrata Morren	+	+	*M. pusillum var. elegans* G.M. Smith	-	+
C. rectangularis (A.Braun) Gray	+	+	*Errerella bornhemiensis* Conrad	-	+
C. tetrapedia(Kirch.)W.& G.S.West	+	+	*Tetraedron minimum* (A.Braun)Hansgirg	+	+
Scenedesmus quadricauda (Trup.)de Breb.	+	+	*T. trigonum var. gracile* (Naeg.) Hansgirg	-	+
S. quadricauda var. alternas G.M. Smith	-	+	*T. muticum* (A.Braun) Hansgirg	-	+
S. incrassatulus Bohlin	-	+	*T. triangulare* Korshikov	-	+
S. sempervirens Chodat	+	+	*Monoraphidium contortum* Thurct	-	+
S. ecornis (Ehrenb.)Chodat	+	+	*M.mirabile* (W.& G. S.West) Pankow	-	+
S. opliensis Richter	-	+	*Quadrigula pfitzerii* (Schroder) G.M.Smith	-	+
S. dimorphus (Turpin)Kuetz.	-	+	*Nephrocytium lunatum* W.West	-	+
S. quadricauda var. maximus W & G.S. West	+	+	*Chlorella vulgaris* Beijerinck	+	+
S. spinosus Chodat	-	+	*C. pyreniodosa* Chick	+	+
S. baculiformis Chodat	-	+	*Coenochloris pyrenoidosa* Korshikov	-	+
S. bijuga var. major (Turp.) Lagerh.	-	+	*Ankistrodesmus falcatus* Corda Ralfs	+	+
S. intermedius Chodat	+	+	*A. falcatus var. mirabilis* (West & West) West	+	+
S. acutiformis Schroeder	+	+	*A. falcatus var. acicularis* (Braun) G. S. West	-	+
S. bijuga (Turp.) Lagerh.	+	+	*A. convolutus* Corda	+	+
S. bicaudatus Dedusenko	+	+	*A. setigerus* (Schrooder) G. S. West	+	+
S. hystrix Lagerh.	-	+	*A. nitzschiodes* G. S. West	+	+
S. arcuatus var. platydisca G.M. Smith	-	+	*Kirchneriella contorta* (Schmidle) Bohlin	+	+
S. parisiensis Chodat	-	+	*K. subsolitaria* West	-	+
S. obliquus (Turpin) Kuetz.	-	+	*K. obesa* (West)Schmidle	-	+
S. opoliensis var. carinatus Lemm.	-	+	*K. lunaris* (Kirchner) Moebius	-	+
S. opoliensis var. opoliensis P.Richter	-	+	*K. irregularis* Korschikov	-	+
S. quadricauda var. longispina Chodat	-	+	*K. dianae* (Bohlin) Comas	+	+
S. acutus Meyen	-	+	*K. subcapitata* Korschikov	+	+
Tetrallantos lagerheimii Teiling	-	+	*Selenastrum minutum* (Naeg.) Collins	+	+
Pediastrum simplex Meyen	-	+	*S. gracile* Reinsch	-	+
P. sturmii var. radians (Lemm.) Reinsch	-	+	*S. bibraianum* Reinsch	-	+
P. tetras (Ehrenb.) Ralfs	-	+	*Closteridium lunula* Reinsch	-	+
P. duplex Meyen	+	-	*Closterium acerosum* (Schrank)Ehren.	-	+
P. angulosum (Ehrenb.Meneghini	-	+	*Cosmarium regnesii* Reinsch	+	-
P. simplex var. biwaense Negoro	-	+	*C. blyttii* Wille	+	-
P. clathratum (Schroter) Lemm.	-	+	*C. exiguum* Archer	-	+
Dictyosphaerium pulchellum Wood	+	+	*C. humile* (Gay) Nordstedt	-	+
D. ehrenbergianum Naeg.	+	+	*C. humile Var. striatum* (Boldt) Schmidle	-	+
D. subsolitarium Van Goor	+	+	*Staurastrum pingue* Teiling	+	-
D. elegans Bachman	-	+	*S. setigerum* Cleve	-	+
Lagerheimia subsalsa Lemm.	-	+	*S. sebaldii var. ornatum* (Reinsch) Nordstedi	-	+
L. genevensis Chodat	-	+	*S. paradoxum* Meyen	-	+
L. genevensis var. subglobaa Lemm.	-	+	*Chlamydomonas globosa* Snow	+	+
L. ciliata (lagerh.) Chodat	-	+	*Pandorina morum* (Mueller) Bory	+	+
L. quadriseta (Lemm.) G.M. Smith	-	+	*Eudorina elegans* Ehrenb.	-	+
Oocystis Lacustris Chodat	-	+	*Elakatothrix gelatinosa* Wille	+	+
O. solitaria Wittrock	+	+	*Planktonema lauterbornii* Schmidle	+	+
O. elliptica W. West	-	+	*Nephroselmis minuta* (N. Carter) Butcher	-	+
O. parva W.& G. S. West	-	+	*Goniochloris pulchra* Pascher	-	+
O. pusilla Hansgirg	+	+	*G. mutica* (A.Braun)Fott	-	+
O. borgei Snow	-	+	*G. fallax* Fott	-	+
Westella botryoides (W.West) De Wildemann	-	+	*Ophiocytium capitatum* Wolle	-	+
Selenastrum minutum (Naeg.) Collins	+	+	*Protococcus viridis* Agaradh	+	+

Cyanophyceae dominated the mixing area of raw sewage, contributed 35% of the total crop. However it occupied the third position at all stations of Kafr El-Ziat area. This explain withstand of blue green algae against anaerobic conditions, high nutrients and organic matter at domestic sewage rather than industrial wastes of Kafr El-Ziat. This finding agrees with Taha, *et al.*, (2001) and Abou El-kheir *et al*. (2000) who stated that Cyanophyceae is a characteristic group of organically rich water.

Table (7): Species composition of diatoms recorded in the selected stations of Rosetta branch

Diatom species	1	2	Diatom species	1	2
Melosira granulata (Ehrenb.) Ralfs	+	+	*N. lapidosa* Brabke	-	+
M. granulate var. angustissma Muller	+	+	*N. exigua* Gregory O. Muller	-	+
Cyclotella meneghiniana kutz.	+	+	*N. mutica var. ventricosa* (Kutz.) Cleve	-	+
C. operculata kutz.	+	+	*N. tuscula* (Ehrenb.) Grun	-	+
C. ocellata Pant	+	+	*N. laterostrata* Hust	-	+
C. glomerata Bachmann	+	+	*N. menisculus* Schumann	-	+
C. kutzingiana Thwaites	+	+	*N. lanceolata* Agardh	-	+
C. bodanica Eulenst	-	+	*N. vitrea* (Ostrup) Hust	-	+
C. antiqua W.Smith	-	+	*N. minima* Grun	-	+
Stephanodiscus hantzschii Grun	-	+	*Gomphonema acuminatum* Ehrenb.	-	+
Diploneis ovalis var. oblongella (Nageli) Cleve	+	+	*Amphora ovalis* Kutz.	+	+
Fragilaria construens (Ehrenb.) Grun	+	+	*A. coffeaeformis* Agardh	-	+
F. gracillima Mayer	-	+	*A. ovalis var. pediculus* Kutz.	+	+
F. brevistriata Grun	-	+	*A. delicatissima* Krabke	-	+
Synedra ulna (Nitzsch) Ehrenb.	+	+	*A. veneta* Kutz.	-	+
S. acus Kutz.	+	+	*Cymbella minuta* Hilse ex Rabenh	+	+
S. affinis Kutz.	+	+	*Nitzschia thermalis* Kutz.	+	+
S. ulna var. aequalis (Kutz.) Hust	-	+	*N. thermalis var. minor* Hilse	+	+
S. gaillonii (Bory) Ehrenb.	-	+	*N. acicularis* W.Smith	+	+
S. ulan var. oxyrhynchus (Kutz.)Van Heurck	+	+	*N. filiformis* (W. Smith) Grun	+	+
S. actinastroides Lemm.	-	+	*N. holsatica* Hust	+	+
S. acus var. angustissma Grun	+	+	*N. palea* Kutz.	+	+
S. nana Meister	+	+	*N. closterium* (Ehrenb.)W. Smith	+	+
S. affinis var. obtusa Hust	+	+	*N. hungarica* Grun	-	+
Eunotia pectinalis (Kutz.)Rabenh	+	-	*N. commutata* Grun	-	+
Cocconeis pediculus Ehrenb.	+	+	*N. dissipatae* (Kutz.)Grun	-	+
C. placentula Ehrenb.	+	+	*N. angustata* (W. Smith) Grun	-	+
Gyrosigma acuminatum (Kutz.) Rabenh	-	+	*N. sigmoidea* (Ehrenb.)W.Smith	+	+
Pleurosigma elongatum W.Smith	-	+	*N. frustulum* (Kutz) Grun	-	+
Caloneis bacillum (Grun.) Mereschkowsky	+	+	*N. amphibia* Grun	-	+
C. amphisbaena (Bory) Cleve	-	+	*Surirella ellegans* Ehrenb.	+	+
Navicula similis Brabke	+	+	*Cymatopleura solea* (Breb.) W. Smith	-	+
N. subtilissima Cleve	+	+	*C. elliptica* (Breb.) W. Smith	-	+
N. pupula Kutz.	+	+	*Diatoma elongatum* Agardh	+	+
N. cryptocephala Kutz.	-	+			

A total of 37 species of Cyanophyceae were identified. 27 of them were observed at Kafr El-Zaiyat while 26 were recorded at El-Rahawy region. The most abundant species at El-Rahawy regions were *Microcystis aeruginosa* Kutz., *Lyngbia limnetica*, *Phormidium retzii*, *Merismopedia major*, *Aphanoteca hidulance*, *Spirulina major* and *Spirulina platensis.* Blue greens at Kafr El-Zaiyat industrial area dominated by *Spirulina laxissima, Merismopedia elegans*, *Lyngbya limnetica* Lemm., *Chroococcus limnelicus* Lemm, *Phormidium retzii* Gomont, and *Microcystis aeruginosa* Kutz. In this respect Taha, *et al.*, (2001) recorded *Chroococcus minutus* (Kutzing) Nageli, *C. disperses* Lemm., *Gomphosphaeria aponina* Kutz and *Lyngbya limetica* Lemm at industrial waste pollution of Iron and Steel Factories (Helwan, Egypt).

Cryptophyceae at Kafr El-Ziat area increased than El-Rahawy waste, to give details on the passive impact of domestic sewage on member of this class that completely depleted during most investigated period. *Cryptomonas ovate* Ehrenb and *C. erosa* Ehrenb were the leader species of Cryptophyceae during this study.

Euglenophyceae and Chrysophyceae were not recorded at the discharging area of El-Rahawy Drain but observed at mixing areas of Kafr El-Ziat.

Also, Descy, (1987) recorded similar observation at stations exposed to industrial wastewater in Meuse River (Belgium). However, Shaaban-Dessouki (2004) stated that, discharged water at El-Zaiyat seemed to suppress the development of Euglenophyta. Diversity index values at El-Rahawy area ranged from 0.48 at the mixing area of El-Rahawy drain to 3.16 at the upstream station, while at Kafr El-Ziat region varied from 2.04 at the mixing area of the second factory to 4.06 at the upstream station. This finding mainly due to low transparency, depletion of dissolved oxygen and high ammonoium concentrations at domestic sewage which mainly inhibit proliferation of many algal species. Wilhm and Torris (1968) indicated that diversity index values less than 1 indicate instability or heavy pollution while, values exceeding 3 indicate stability or clean water.

Chlorophyll *a* (Chl *a*) concentrations at Kafr El-Zaiyat area were much higher than El-Rahawy. This is follow to large extent oscillation of phytoplankton communities (r = 0.63 at El-Rahawy; r = 0.71 at Kafr El-Zaiyat) This agrees with Abou El- Kheir *et al.*, (2000), Taha and Farghaly (1994) and Abd El- Karim (1999). Kafr El-Zaiyat stations are highly eutrophic compared to El-Rahawy sites according to Trifonova, (1989) who reported that, Chlorophyll *a* concentrations below 1.5 µg/L characterized oligotrophic water, values of 1.5- 10 µg/L were considered as mesotrophic and more than 25 µg/L highly eutrophic.

Table (8): Species composition of blue green algae recorded in Rosetta branch

Blue green algae	1	2	Blue green algae	1	2
Chroococcus minutus (Kutzing) Nageli	+	+	*P. laminose* (Agardh) Gomont	-	+
C. limneticus Lemm.	+	+	*Oscillatoria tenuis* C. A. Agardh	+	+
C. turgidus (Kutzing) Nageli	+	+	*O. princeps* Vaucher	-	+
Merismopedia tenuissima Lemm.	+	+	*O. limosa* C. A. Agardh	+	-
M. punctata Meyen	+	+	*Spirulina princeps* (W & G. West) G. S. West	+	+
M. elegans A.Braun	-	+	*S. major* Kutz.	+	-
M. convoluta var.minor (Wille) Tiffany	-	+	*S. laxissima*	+	+
M. major (G.M. Smith) Geitler	+	-	*S. platensis* (Nordstedi) Geitler	-	+
M. glauca (Ehrenb.)Nageli	-	+	*Anabaena circinalis* Rabenh.	-	+
Microcystis aeruginosa Kutz.	+	+	*A. flos- aquae* Breb.	-	+
M. flos-aquae (Wittrock) Kirch.	+	+	*A. inaequalis* (Kutzing) Bornet & Flahawt	+	+
Gomphosphaeria lacustris Chodat	+	-	*Radaisia violacea* Fremy	+	-
G. aponiana Kutz.	+	-	*Nostoc verrucosum* (Vaucher) Hist.	-	+
G. compacta (lemm.) Strom	+	+	*N. Kihlamanii* Lemm.	+	-
Eucapsis minuta F.E.Fritsch	-	+	*N. pruniforme* C.A. Agardh	+	-
Aphanotheca nidulans P. Richter	+	+	*N. carneum* Agardh	+	-
Gloeocapsa sanguinea Kuetz.	+	+	*Anabaenopsis circularis* (G.S. West) Wolosz	-	+
Lyngbya limnetica Lemm.	+	+	*Pleurodiscus boriaquenae* Tiffany	+	-
Phormidium retzii Gomont	+	+			

Conclusion

It is very important to prevent or to a lesser extent treat discharging wastes into aquatic environment, where it inhibits planktonic algae and consequently decrease fish production. Organic matter loaded with the two wastes increase accumulation of heavy metals in river sediments, that should be remove through periodical dredging. Heavy metals precipitate at high pH and dissolve in acidic side, so pH values should be optimize.

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التغير في مجموعات العوالق النباتية تبعا لنوع المخلفات في فرع رشيد (مصر)

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بدأت هذه الدراسة من يناير 2003الي نوفمبر 2003 لدراسة الخصائص المختلفة للمياه والرسوبيات في موقعين أساسيين للتلوث هما مصرف الرهاوى (صرف صحي) والمنطقة الصناعية بكفر الزيات (صرف صناعي) حيث يمثلان أهم مصادر التلوث في فرع رشيد.

تهدف الدراسة إلى تجنب صرف أي مخلفات في مياه نهر النيل لما لها من تأثيرات ضارة على البيئة المائية وكذلك الغذاء الطبيعي للأسماك ممثلا بالطحالب الدقيقة.

أوضحت النتائج أن الأكسجين الذائب كان منعدم تماما في مياه الصرف الصحي وكانت قيم النيتروجين العضوي الكلى في المخلفات الصحية والصناعية أعلى من القيم المقابلة للنيتروجين الغير عضوي. تركيز الأمونيوم في مخلفات الصرف الصحي تزيد كثيرا عن قيمها في الصرف الصناعي وتزيد أيضا عن المسموح بها عالميا. أما الفسفور العضوي الكلى وكذلك العناصر الثقيلة في منطقتي الصرف تزيد عن القيم المقابلة في مياه فرع رشيد فى المواقع التي تسبق هاتين المنطقتين. ولوحظ أن تركيز العناصر الثقيلة في رسوبيات الصرف الصناعي كانت أعلى من القيم المقابلة في الصرف الصحي.

أما بالنسبة للمحصول الكلى للعوالق النباتية أمام منطقة الصرف الصحي والصناعي كان أقل كثيرا مقارنة بمياه فرع رشيد قبل وبعد صرف هذه المخلفات والتي لها أيضا تأثير سلبي واضح على الكثافة العددية للعوالق النباتية كما ونوعا. فكانت الدياتومات سائدة في مياه فرع رشيد قبل منطقة مصرف الرهاوى بينما سادت الطحالب الخضراء المزرقة في مياه الصرف الصحي والطحالب الخضراء بعد منطقة صرف هذه المخلفات. وفى الجانب الأخر كانت الطحالب الخضراء هي السائدة في كل المقاطع المختارة للمنطقة الصناعية بكفر الزيات.