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Full length Research Paper

Relationships between total chlorophyll and phytoplankton individuals of Rosetta branch of River Nile, Egypt

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Total chlorophyll concentrations of the phytoplanktonic samples of Rosetta branch of the River Nile at the stations before Edfina barrage (from station I to V) and after Edfina barrage (stations VI and VII) were studied during two successive years from (August 2006 to April 2008). At all stations, the total chlorophyll contents (mg L^{-1}) of the identified algae and he maximum quantitative algal individuals were reached their maximum peaks during summer 2007. Peak periods of total chlorophyll coincided with peak periods of the stations recorded high algal biomass. Phytoplankton in Rosetta branch of the River Nile at the most studied stations (I; II; IV; V and VI) had Chloro-character particularly in summer 2007. Positive relation was observed between the fluctuations of total chlorophyll contents of the phytoplankton and those of total number of individuals at all investigated stations of Rosetta branch.

Keywords: Microalgae biomass, algal chlorophylls, chlorophyll as indicator for algal biomass.

INTRODUCTION

Biomass of micro-algae is a good source of nutrients and biologically active ingredients. Accordingly, estimation of algal biomass is very crucial. Chlorophyll concentration was widely used as a common predictor's technique for monitoring the reliability picture of dissolved nutrients and algal biomass in aquatic habitats (Fogg, 1975**;** Tolstoy, 1979; Desortová, 1981; Vörös and Padisák, 1991; Kalchev et al., 1996; Halil et al., 2008). Chlorophyll *a* is the main photosynthetic pigment in all oxygen-evolving photosynthetic algae while other algal pigments have limited distribution and considered as accessory or secondary pigments (Akpan, 1994). It constitutes approximately 1-2% the dry weight of phytoplanktonic algae, its assessment is relatively easy, cheap and rapid to quantify in comparison to the analysis of a full suite of dissolved nutrients (Hakanson, 1994; Passavante and Feitosa, 2004; Brando et al., 2006; Shehata et al., 2008; Sobhy, 2008; Todd et al., 2008 and Santos et al., 2010). The determination of total chlorophyll, especially chlorophyll "a", is one of the most commonly used parameter for the estimation of the algal growth in the River Nile (Fayed and Shehata, 1976; Ibrahim, 1978; Badr, 1981; Shehata and Badr, 1985; Abdel-Hamid, 1991; Kobbia et al., 1991; Hammouda and Abdel-Hameed, 1994; Abd El-Karim, 1999; El-Attar, 2000; Shehata et al., 2008 and Sobhy, 2008). In this paper, we analyze the relationship between total chlorophyll contents of the phytoplankton and those of total number of individuals of Rosetta branch of River Nile.

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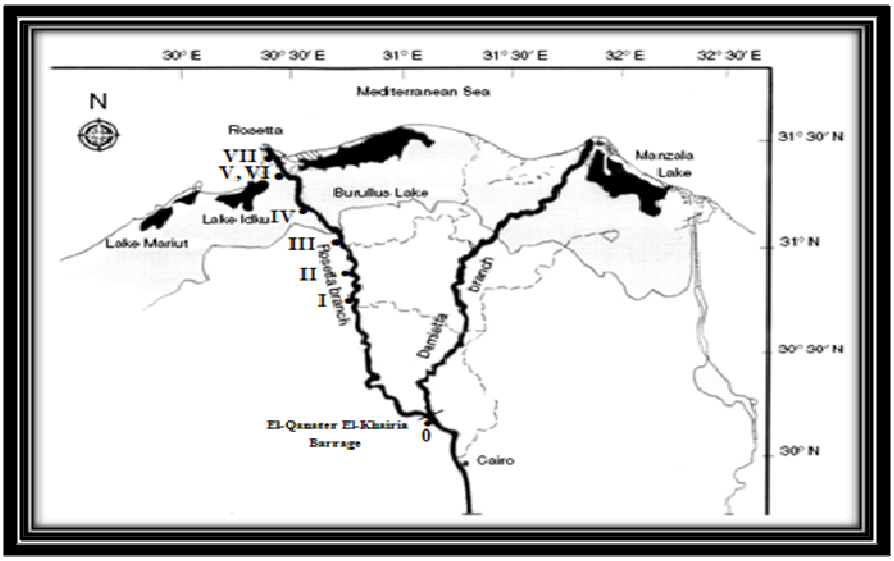
MATERIALS AND METHODS

Study area

The study area extended through El-Gharbia and El-Beheira governorates, from which seven stations were selected to represent Rosetta branch of the River Nile (Map: 1); five stations before Edfina barrage (stations I, II, III, IV and V) and two stations after Edfina barrage (stations VI and VII). The stations were determined by using GPS (model: 315 MAGELLAN). Station (**I**), was represented in Kafr El-Zayat city, located at 30˚ 48` 55`` N and 30˚ 48` 23`` E; (**II**), was represented in Shabrakhit city, located at 31˚ 01` 53`` N and 30˚ 43` 13`` E; (**III),** was represented in El-Rahmania city,



Map 1. Stations of material collection on Rosetta branch of the River Nile.

located at 31° 06` 34`` N and 30° 38` 59`` E; (**IV)**, was represented in El-Mahmoudia city, located at located at 31° 11` 10`` N, 30° 31` 58`` E; (**V**), was represented in before Edfina barrage at Edfina city, located at 31° 18` 20`` N and 30° 31` 00`` E; (**VI**), was represented in after Edfina barrage at Edfina city, located at 31° 18` 23`` N and 30° 31` 01`` E and station (**VII**), Rashid city, located at 31° 24` 21`` N and 30° 25` 36`` E . All area of Rosetta branch after Edfina barrage receives the fresh Nile water through Edfina barrage as well as drainage water flowing from Lake Burollus through Brimbal Canal (Soliman, 1994). Also, The Mediterranean Sea water invaded Rosetta branch after the construction of Edfina barrage.

Collection of materials

Sampling of algae

Algal samples were collected from the previous seven stations according to Sourina (1981). Collection of samples was performed seasonally for two successive years from August 2006 to April 2008.

Counting of phytoplankton

According to Sourina (1981), after shaking from 10 ml concentrated material, an aliquot was withdrawn by a pipette and loaded into a Max Levy counting chamber haemocytometer. All the area was counted and the results were expressed as number of individuals per liter.

Extraction of total chlorophyll of phytoplanktonic samples

Total chlorophyll was extracted by dimethyl sulfoxide (DMSO) according to Burnison (1980) as follows.

Five ml of the algal suspension was centrifuged at 3500 rpm for 5 minutes. The supernatant was discarded and the residual pellet was resuspended in 5 ml of 95% DMSO, homogenized and kept for 5 minutes at 70 ℃ in water bath. Such extract contains total chlorophyll and cell carotenoids. The extracted cells were recentrifuged again at 3500 rpm for 5 minutes. The extracted solution was measured by reading the absorbance (A) of the pigment extract spectrophotometrically (PERKIN-ELMER LAMBDA 2 UV/VIS) at 666 nm. The chlorophyll concentration in the extract was calculated (mg L^{-1}) according to Seely et al (1972).

Total chlorophyll (mg L^{-1}) = A x **D** x **F**

(A) = reading at 666 nm. , (F) = 11.3 (factor). (D) = volume of extract / sample volume.

RESULTS AND DISCUCTION

The identified algae of Rosetta branch were represented by (269) algal taxa, related to 81 genera, belonging to six algal divisions. Bacillariophyta was the qualitatively dominant division (43.08%), followed by Chlorophyta (37.31%) and Cyanophyta (10.77%). Euglenophyta(5.38%), Pyrrophyta (2.69%), Rhodophyta (0.38%) and Xanthophyta 0.38% (table 1).

Table 1. Composition of algal divisions, genera and taxa of Rosetta branch of the River Nile. **O S**= Algal taxa in all stations, **(I, II, III, IV, V, Vi and VII)** = Algal taxa in each studied station respectively.

Algal divisions	T A S	%	I	%	II	%	III	%	IV	%	V	%	VI	%	VII	%
Cyanophyta	28	10.8	20	10.42	16	9.30	15	9.68	18	11.6	16	13.1	14	12.1	15	13.9
Bacillariophyta	112	43.24	78	40.63	64	37.21	57	36.8	47	30.3	30	24.6	40	34.5	39	36.1
Xanthophyta	1	0.38	1	0.52												
Pyrrophyta	7	2.70	3	1.56	4	2.33	2	1.29	3	1.94	4	3.28	6	5.17	6	5.56
Euglenophyta	14	5.40	13	6.77	13	7.56	14	9.03	14	9.03	9	7.38	8	6.90	6	5.56
Chlorophyta	97	37.45	77	40.10	75	43.60	67	43.2	73	47.1	63	51.6	48	41.4	42	38.9
Total	**259**	**100**	**192**	**100**	**172**	**100**	**155**	**100**	**155**	**100**	**122**	**100**	**116**	**100**	**108**	**100**

Table 2. Seasonal variations in total number of individuals of phytoplankton taxa of different algal divisions (x 10^6 L^{-1}) of Rosetta branch of the River Nile.at Kafr El-Zayat city (Station I).

Seasons → / Algal divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.799	0.779	0.1167	0.7217	0.699	0.369	0.1793	0.9492
Bacillariophycophyta	0.9623	0.2149	0.3002	0.7439	1.3385	3.9087	0.5664	1.0867
Xanthophycophyta	0.0199			0.0555	0.0599			
Pyrrophycophyta	0.1998	0.0299			0.0798	0.0198	0.0099	0.0998
Euglenophycophyta	0.3191	0.2693	0.0831	0.4996	0.1791	0.0297	0.0099	0.1996
Chlorophycophyta	4.795	3.9259	0.941	6.4418	12.5324	2.1266	0.4877	2.2475
Total number of individuals (N)	7.0951	5.219	1.441	8.4625	14.8887	6.4538	1.2532	4.5828

The maximum qualitative algal taxa at each studied station in table (1) was represented by 192, 172, 155, 155,122, 116 and 108 taxa respectively. Data related to seasonal quantitative estimation of phytoplankton of the branch at the studied seven stations (table 2, 3, 4, 5, 6, 7 and 8) revealed that, the main bulk of individuals of all divisions was recorded in summer 2007 (14.8887, 11.2464, 7.5011, 7.4864 and 4.2092 individuals L^{-1} at stations I, II, IV, V and VI respectively).This could be attributed to the flourished growth of green algae (had chloro-character), especially the high growth of *Pediastrum simplex* var. *doudenarium*, *Micractinium pusillum, Actinastrum hantzschii, Scenedesmus quadricauda, Coelastrum scabrum, Pediastrum simplex, Staurastrum paradoxum* and *Pediastrum duplex* var. *clathratum*. In spring 2007 and 2008, Chloro-Pyrro-character was recorded at station (VI), due to the increase in numbers of individuals of *Prorocentrum minimum* and *Peridinium aciculiferum* f. *inerme*, respectively. The maximum quantitative estimation of the phytoplankton productivity at station III (5.9709 individuals L-1) was detected during spring 2007, this was mainly due to the extensive growth of *Micractinium pusillum, Pediastrum simplex* var. *doudenarium, Actinastrum hantzschii* and *Dictyosphaerium pulchellum,* and in autumn 2007 at station VII (1.4575 individuals L-1)) mainly due to the high growth of *Synedra ulna* var. *danica* and *Pediastrum trum simplex* var. *doudenarium*.

The quantitative picture of phytoplankton of the studied stations was reached its lowest number in winter 2008 (1,253200 , 0.8353 and 0.7838 individuals L^{-1} at stations I, II and III respectively); in autumn 2006 at station IV (0.4274 individuals L^{-1}) and VII (0.0102 individuals L^{-1}) ; in summer 2006 at station V (0.403 individuals L^{-1}) and during spring 2008 at station VI (0.2508 individuals L^{-1}).

Quantitatively, at station (I), Xanthophyta, Pyrrophyta and Euglenophyta, had no role in the algal biomass at station (I), while Pyrrophyta and Euglenophyta, they had generally low quantitative values in the algal standing crop of stations (II, III, IV, V, VI). Regarding to Cyanophyta, Pyrrophyta and Euglenophyta, they had no role in the algal biomass at station VII.

The results of total chlorophyll contents of the recorded algae of Rosetta branch before and after Edfina barrage during the whole period of study were represented in (table 9, Figure 1-7). At all stations, the total chlorophyll contents of the identified algae were

reached their maximum peaks during summer 2007 (23 - 15.63 - 18.33 - 9.66 - 20.98 - 13.34 and 12.15 mg L^{-1} respectively) comparing with the total chlorophyll contents in other seasons. Whereas the lowest values of total chlorophyll contents of the phytoplankton were

Table 3. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile at Shabrakhit city (Station II).

Seasons → / Algal Divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.1489	0.4992	0.4997	0.2331	0.5876	0.579	0.0496	0.2191
Bacillariophycophyta	0.1039	0.0226	0.1831	0.3828	0.5955	1.1937	0.5081	0.3233
Pyrrophycophyta	0.0297	0.0748		0.0111	0.09	0.0297	0.0198	0.0099
Euglenophycophyta	0.0838	0.1544	0.0501	0.0666	0.1635	0.0595	0.0099	0.0693
Chlorophycophyta	0.9551	1.8725	1.1	0.9659	9.8098	2.3651	0.2479	0.8964
Total number of individuals (N)	1.3214	2.6235	1.8329	1.6595	11.2464	4.227	0.8353	1.518

Table 4. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile at El-Rahmania city (Station III).

Seasons → / Algal Divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.3039	0.105	0.2496	0.6108	0.6539	0.2333	0.0595	0.1193
Bacillariophycophyta	0.0595	0.0022	0.019	0.3624	0.1313	1.4529	0.4066	0.1962
Pyrrophycophyta	0.0248	0.3298			0.0648	0.0266	0.0099	0.0198
Euglenophycophyta	0.0838	0.045	0.2494	0.1665	0.109	0.4132	0.0198	0.0693
Chlorophycophyta	0.9955	0.6769	2.2731	4.8312	4.4601	1.5799	0.288	0.398
Total number of individuals (N)	1.4675	1.1589	2.7911	5.9709	5.4191	3.7059	0.7838	0.8026

Table 5. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile at El-Mahmoudia city (Station IV).

Seasons → / Algal Divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.4618	0.0496	0.0665	0.1998	0.422	0.1063	0.0694	0.1493
Bacillariophycophyta	0.0146	0.0009	0.0114	0.3658	0.2557	0.6069	0.4005	0.2716
Pyrrophycophyta	0.075	0.0197	0.0083	0.0111	0.0698	0.0232	0.0099	0.0298
Euglenophycophyta	0.1499	0.0197	0.0499	0.111	0.0694	0.0165		0.0496
Chlorophycophyta	1.5914	0.3375	0.8991	1.0993	6.6842	0.5687	0.2882	0.6675
Total number of individuals (N)	2.2927	0.4274	1.0352	1.787	7.5011	1.3216	0.768	1.1678

Table 6. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile before Edfina barrage at Edfina city (Station V).

Seasons → / Algal divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.0493	0.0545	0.0501	0.1443	0.3097	0.0533	0.0297	0.0598
Bacillariophycophyta	0.0091	0.0023	0.0179	1.4189	0.4767	0.7131	0.3364	0.1698
Pyrrophycophyta	0.0049	0.0109		0.0111	0.07	0.04	0.0099	0.0899
Euglenophycophyta	0.0196	0.0436	0.0166	0.0444	0.0875	0.0067		
Chlorophycophyta	0.3201	2.57	2.5741	1.5771	6.5425	1.0133	0.1787	0.6781
Total number of individuals (N)	0.403	2.6813	2.6587	3.1958	7.4864	1.8264	0.5547	0.9976

Table 7. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile after Edfina barrage at Edfina city (Station VI).

Seasons → / Algal divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.1748	0.0198	0.0914	0.0333	0.1498	0.2399	0.0297	0.0299
Bacillariophycophyta	0.0135	0.1856	0.0157	0.3844	0.2856	1.5975	0.4281	0.0122
Pyrrophycophyta	0.0049	0.0448		1.6217	0.7873	0.0066	0.0198	0.0898
Euglenophycophyta		0.0147	0.0166	0.0111	0.0125	0.0265		
Chlorophycophyta	0.0843	0.1283	1.3408	0.4775	2.974	0.7927	0.2981	0.1189
Total number of individuals (N)	0.2775	0.3932	1.4645	2.528	4.2092	2.6632	0.7757	0.2508

Table 8. Seasonal variations in total number of individuals of taxa of different algal divisions (x 10^6 L^{-1}) in the phytoplankton of Rosetta branch of the River Nile at Rashid city (Station VII).

Seasons → / Algal divisions ↓	Summer 2006	Autumn 2006	Winter 2007	Spring 2007	Summer 2007	Autumn 2007	Winter 2008	Spring 2008
Cyanophycophyta	0.0248		0.0833	0.0111	0.025	0.1397	0.0496	0.0099
Bacillariophycophyta	0.0051	0.0003	0.0184	0.3922	0.2734	0.6456	0.4412	0.335
Pyrrophycophyta	0.0049		0.0083	0.211	0.0125	0.0366	0.0099	0.0199
Euglenophycophyta			0.025			0.0198		
Chlorophycophyta	0.0696	0.0099	1.2079	0.0555	0.2374	0.6158	0.3976	0.0199
Total number of individuals (N)	0.1044	0.0102	1.3429	0.6698	0.5483	1.4575	0.8983	0.3847

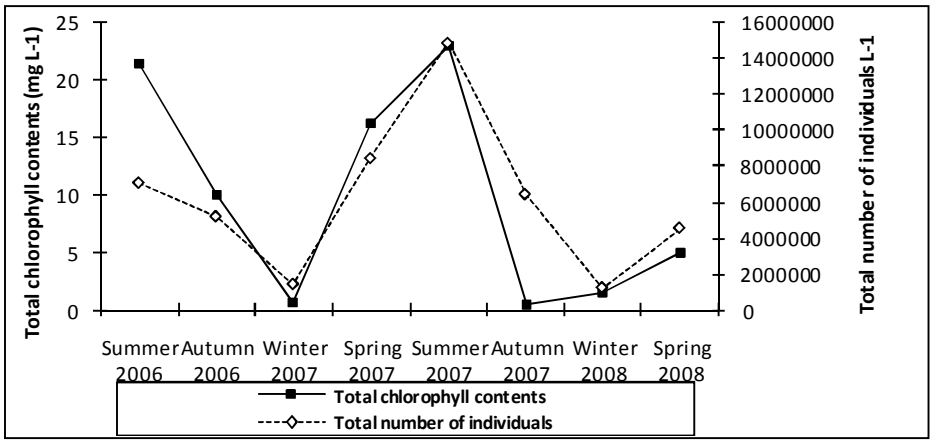


Figure 1. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch at Kafr El-Zayat city (station I) during two successive years

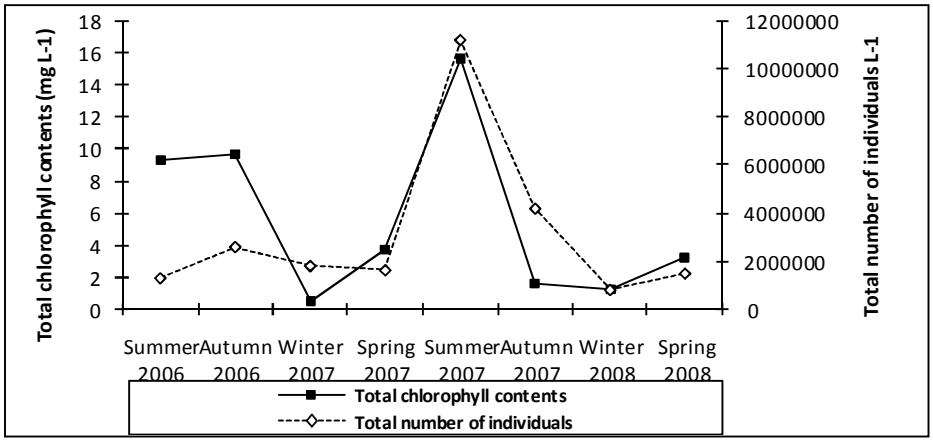


Figure 2. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch at Shabrakhit city (station II) during two successive years.

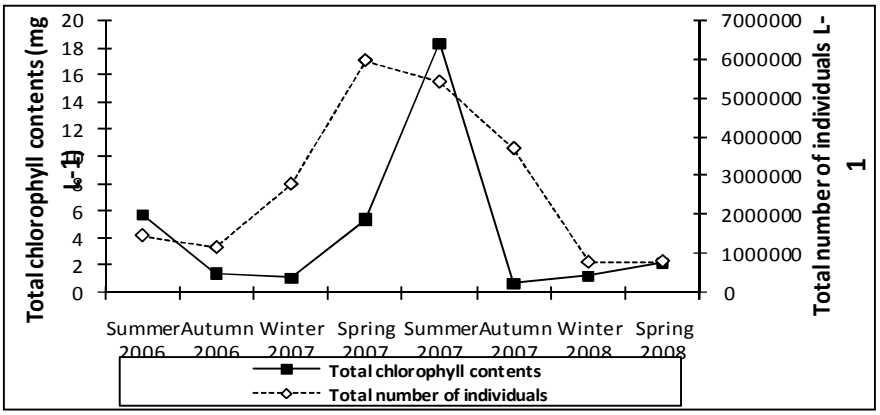


Figure 3. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch at El-Rahmania city (station III) during two successive years.

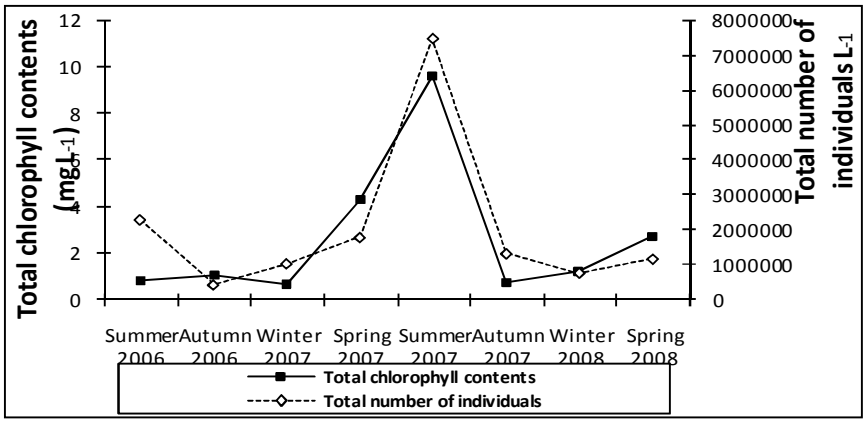


Figure 4. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch at El-Mahmoudia city (station IV) during two successive years.

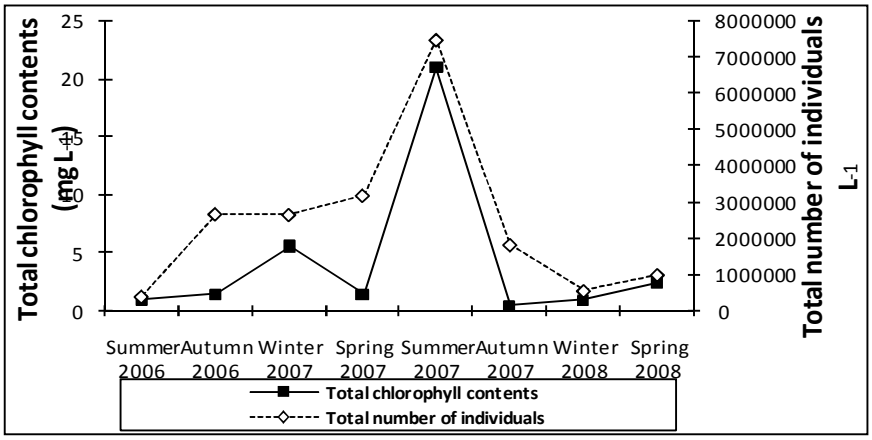


Figure 5. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch before Edfina barrage at Edfina city (station V) during two successive years.

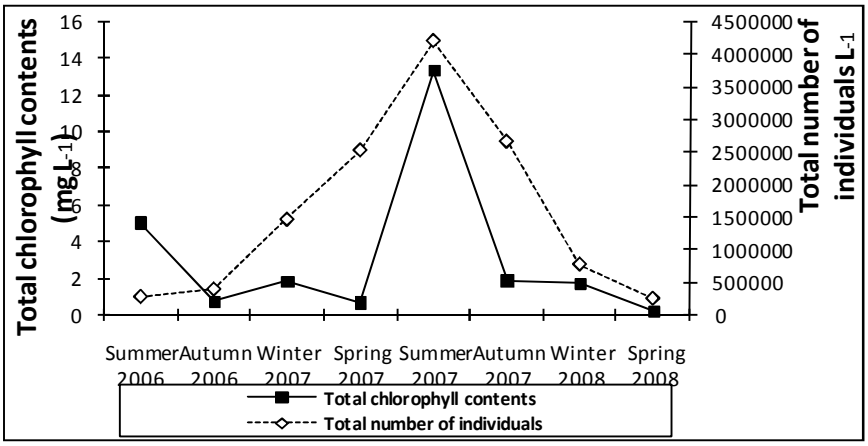


Figure 6. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch after Edfina barrage at Edfina city (station VI) during two successive years.

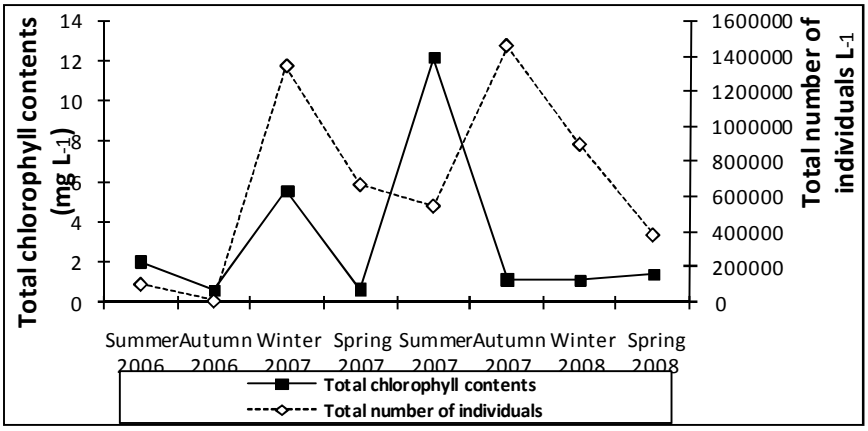


Figure 7. Relationship between total chlorophyll contents and total number of individuals of Rosetta branch at Rashid city (station VII) during two successive years.

detected in autumn 2007 (0.47 – 0.68 and 0.47 mg L^{-1} in stations I, III and V respectively); in winter 2007 (0.47 and 0.67 mg L^{-1} at stations II and IV respectively); during spring 2008 (0.21 mg L^{-1}) at station VI and during autumn 2006 (0.60 mg L^{-1}) at station VII.

Station (I) showed the highest maximum peaks in total chlorophyll, maximum quantitative algal individuals and qualitative algal taxa. The present study showed that, Peak periods of chlorophyll coincided with peak periods of the stations recorded high algal biomass. This is in agreement with the observations of Ekpenyong, (2000); Marisol and Jordi, (2000); Descy *et al* (2005); Todd *et al* (2008); Elewa *et al* (2009); Senthil, *et al* (2009). A more or less positive correlation was observed between the fluctuations of total chlorophyll contents of the phytoplankton and those of total number of individuals at all investigated stations of Rosetta branch.

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