Quantitative estimation of the phytoplankton community in Garmat-Ali River from Basrah, Iraq

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Abstract

The aim of the present quantitative assessment of the phytoplankton community along the Garmat-Ali River and to establish its relationship with the physical and chemical factors based on the changes occurring in the aquatic environment in Basra Governorate, including the decreasing of fresh water, this is due to the low discharge of fresh water coming from the upstream countries, rise in temperatures due to global warming, increased salt concentrations and other factors. Four locations were chosen in the region: Al-Najibiya, Al-Mashhab, Al-Salal and Al-Nagara station. The samples were collected quarterly in 2022. The results of the environmental variables showed that the water temperature was ranging from 11.8 - 33.4 °C, salinity from 2.6 - 9.5 PSU, hydrogen ion concentration -pH- from 7.3-8.6, dissolved oxygen from 1.6-11.7mg/l. total dissolved solids from 2350-9871 ppm, turbidity from 1.39-76.8 NTU, reactive phosphate from 0.01-0.21 mg/l. reactive nitrate from 0.51-19.9mg/l. and chlorophyll-a- from8.62-41.06mg/m3. Statistical analysis of the physical and chemical parameters was performed using SPSS statistics v.19 for one-way analysis of variance. Quantitative data showed that the total numbers of phytoplankton at all the study sites and in all seasons was 120120 cell/l. Al-Salal site showed the highest numerical density of 15,000 cell/l. in spring, while Al-Najibiya site represent the lowest numerical density of 2,500 cell/l. in winter.

key words: Phytoplankton, Garmat-Ali River, Basrah, quantitative estimation.

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Introduction

Oceans, seas and rivers cover 71% of the Earth's surface, and enjoy enormous diversity and a high percentage of living organisms on earth (Miller and Wheeler, 2012). This percentage of water plays a major role in the global carbon cycle, thus greatly influencing the speed and scale of climate changes, which can be observed in aquatic organisms (Field *et al.*, 2020). Moreover, living organisms in oceans, seas and rivers have huge social and economic value, through the production of food and feed, recycling nutrients and regulating carbon dioxide (Costanza *et al.*, 1997). Climate changes greatly affect living organisms in water, so there is a need to understand the main drivers of environmental changes and how to exploit these changes by those organisms without putting pressure on the surrounding ecosystem, where phytoplankton microorganisms develop the basis of the food chain and contribute significantly to the production of oxygen and sequestration of carbon dioxide (Hays and Robinson, 2005). Phytoplankton are productive and representing the basis of life in the ecosystem, and therefore studied as the main component of any freshwater system. It plays an important role in solving various environmental problems, producing useful materials and understanding the aquatic ecosystem (Kadeem et al.,2021).

Plankton consists of single-celled algae or in the form of colonies known as phytoplankton (which perform photosynthesis) their size does not exceed 200 microns. Phytoplankton are responsible for about 45% of the global annual primary production and serve as food for zooplankton, which in turn is an ideal sized food. For many commercial purposes, important fish and large aquatic mammals (Shekha et al., 2008).

Plankton is a vital component of marine life and fresh water ecosystems. Moreover, they also make important contributions to the global biogeochemical cycle and improve the accumulation of carbon dioxide in the atmosphere, as well as its pumping into deep sea areas (Soulie et al., 2022). Since phytoplankton are the main producers that constitute the first trophic level of the food chain in the aquatic system, qualitative and quantitative studies are of great importance to evaluate water quality (Chaturvedi et al., 1999; Ponmanickam et al., 2007).

In response to environmental changes, comprehensive knowledge of phytoplankton abundance and quality in relation to environmental status is essential for fish and shrimp culturing (Flores, 2000). Many studies have emphasized the importance of phytoplankton as bioindicators in various aquatic systems (Aziz, *et al*., 2003; Bellinger and Sigee, 2010).

Only a few studies have been conducted on water quality and phytoplankton diversity and abundance in the Garmat-Ali River (Hassan *et al*. 2011; Al-Biydani 2014). Hence, this study was conducted to evaluate the phytoplankton community in selected sites of the river and its relationship with the environmental variables.

Materials and Methods

Phytoplankton and water samples were collected from 4 sites along the Garmat- Ali River Table (1) and Fig. (1) show the geographical location of the study sites.

Table 1: Coordinates of the study sites

stations	North	East
Al-Najibiya (St1)	N 30 34 15	E 47 45 26
Al-Mashhab (St2)	N 30 38 33	E 47 41 21
Al-Salal (St3)	N 30 39 41	E 47 38 59
Al-Nagara (St4)	N 30 37 24	E 47 40 02

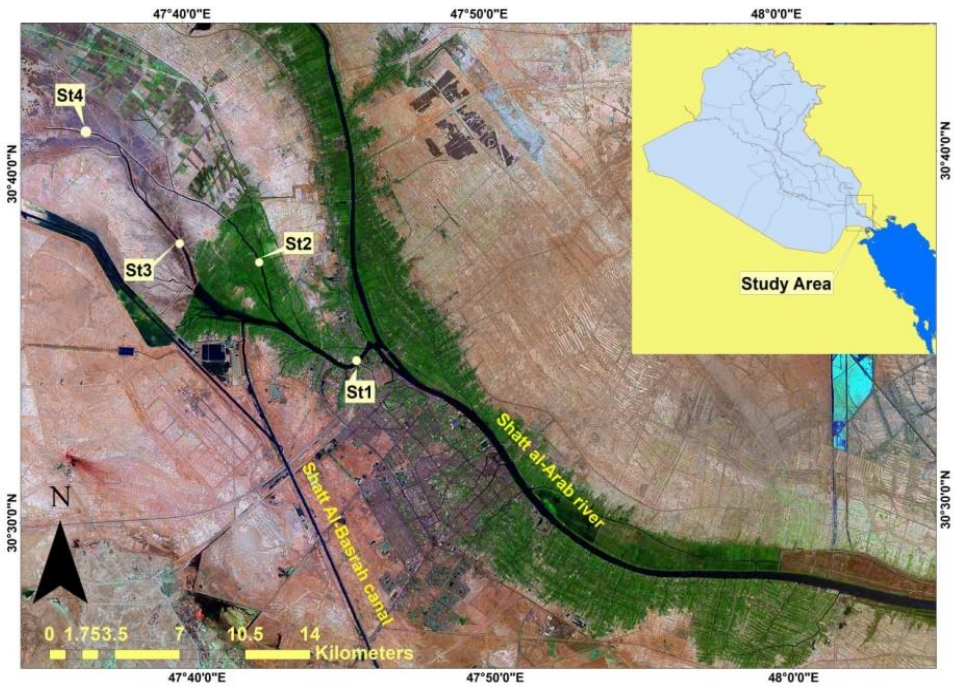


Figure 1: Sample collection sites

Environmental factors

Some environmental factors were directly measured and recorded in the field, such as water temperature, salinity, pH and total dissolved solids using a multi-meter model 340i device Germany. Turbidity was estimated by using a turbidity meter, Hanna instruments Hi 93703 which is of Chinese origin and is rated by Nephelometric Turbidity Unit (NTU). The Winkler method, called the Azid modification method, (Lind,1979) was followed in determining the concentration of dissolved oxygen in water, estimation of reactive phosphate and reactive nitrate were done according to APHA (2012).

Calculating of the concentration of chlorophyll-a- was done based on Lorenzen's equation described by Vollenweider (1974).

The quantitative Study of phytoplankton

Estimation of the numbers of phytoplankton in the study sites.
The process included two stages
1-Sample deposition and preservation
This was done according to the method explained by Hadi (1981) through the sedimentation process.
2-Counting phytoplankton by hemocytometer slide
It is a reliable method for counting algal cells, which was described by Martinez et al. (1975).
Phytoplankton were identified based on the following references: Edward and David. (2010), Guiry (2012), John and Robert. (2015), Orlando (2016), Al-Shaheen (2016) and Malgorzata et al. (2018).

Statistical analysis

The statistical program: Statistical Package for Social Science (SPSS) Ver.19 (Al-Rawi and Khalaf Allah, 1980) was used to conduct statistical analysis of the study results through the ANOVA test under the probability level ($P \leq 0.05$) to find the least significant difference (RLSD) between sites and Season.

The Pearson Correlation Coefficient (r) was used to find positive and negative correlations between physical, chemical and biological environmental variables, in addition to using the statistical program; Canonical Correspondence Analysis (CCA), which shows the strength of the influence of environmental factors on the presence and spread of phytoplankton that appear or occur more frequently than other species during the study period, by using the statistical program Canoca (Ter et al., 1995).

Results

Physical and chemical properties of the water in Garmat-Ali. The rates of some physical and chemical characteristics of the study sites were evaluated, namely water temperature, salinity, pH, dissolved oxygen, total dissolved solids, turbidity, effective phosphorus, effective nitrate, and chlorophyll-a. as shown in Table (2).

Table 2: Spatial variation of Physico-chemical characteristics of water at the 4 stations in Garmat-Ali river, Basrah

Parameters sites	C°	Sal. g/l	pH	Do mg/l	TDS ppm	TUR NTU	PO_4 mg/l	NO_3 mg/l	Chla. a mg/m^3
St1									
Winter	11.8	2.65	7.9	9.5	2830	3.15	0.03	2.02	41.06
Spring	22.3	2.6	7.3	6.1	2350	12.8	0.03	3.22	29.8
Summer	33.4	9.5	7.53	1.6	8934	15.76	0.21	19.9	8.62
Autumn	21.6	5.75	7.6	5.2	6330	14.6	0.07	6.3	9.47
St2									
Winter	12.18	5.43	8.51	10.8	5740	21.2	0.04	0.51	16.77
Spring	17.8	6.5	8.09	8.5	5660	76.8	0.02	4.32	39.32
Summer	33.3	9.4	7.36	2.5	9871	1.84	0.01	6.9	15.24
Autumn	22.9	6.16	7.88	7.2	6970	8.41	0.04	1.98	15.03
St3									
Winter	13.65	4.82	7.96	11.2	4750	33.5	0.06	0.63	12.72
Spring	18.8	5.5	8.34	7.65	4320	18.6	0.06	3.76	28.33
Summer	31.8	9.49	7.45	3.3	8410	16.3	0.2	8.89	19.65
Autumn	26.6	5.77	7.76	6.25	6800	13.3	0.03	2.85	8.91
St4									
Winter	13.89	3.86	8.00	11.7	3800	18.1	0.09	0.94	35.56
Spring	16.3	5.0	8.64	7.65	4562	1.39	0.05	3.98	26.6
Summer	32.5	9.39	7.5	3.2	9750	8.54	0.08	3.49	19.8
Autumn	22.9	6.22	7.9	6.4	6690	5.33	0.04	1.77	17.35

Table (3) Showed the Pearson correlation coefficient between environmental variables during the study period. It is apparent from the Table that some variables had a strong correlation with each other, while others had a weak correlation. The greater the correlation value or the closer it was to one, the greater the correlation (positive), and the relationship was direct and vice versa.

Table 3: Pearson correlation coefficient (r) between variables at the Garmat-Ali river

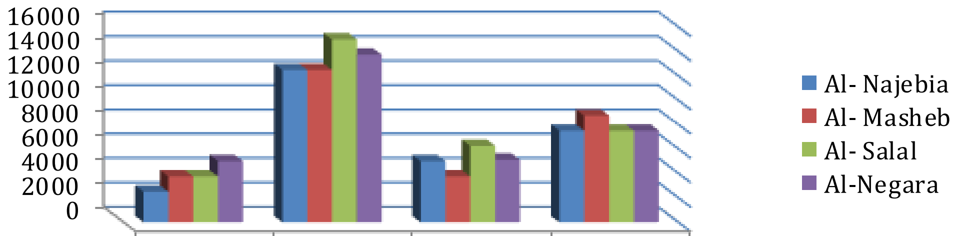
Variables	C°	Salinty	pH	DO	TDS	TUR	PO_4	NO_3	Chla.a
°C	1								
Salinity	.95**	1							
pH	- .95**	- .98**	1						
DO	.35	-.90**	.87**	1					
TDS	-.32	.22	-.37	- .08	1				
TUR	- .63	- .73*	.80**	- .81**	-.67	1			
PO_4	.87*	.95**	-.89**	-.90**	-.07	-.55	1		
NO_3	.94**	.92**	-.88**	-.99**	.06	-.43	.94**	1	
Chla. a	- .68	- .70*	.80**	.47	-.80**	-.06	-.48	-.44	1

The results of the statistical analysis showed that there were significant differences between the seasonal temperature rates and for all sites under the probability level of $p \leq 0.05$. No significant differences in salinity rates were observed between the seasons, except for the Summer, which differed significantly from the rest of seasons $p \leq 0.05$.

As for the pH no significant differences were observed between all season's ($p \leq 0.05$). The Summer season differed significantly from the rest of seasons with regard to the rates of dissolved oxygen, total dissolved salts, effective phosphorus, and effective nitrite ($P \leq 0.05$). Some stations also differed significantly from each other regarding the values of turbidity rates. The results showed that the average values of chlorophyll-a- for the two winter seasons, Spring differed significantly from Summer and Autumn (Table 2).

Quantitative study of phytoplankton

The results showed that the total numbers of phytoplankton in all the study sites and for all seasons amounted to 120120 cell/liter. The Al-Salal site had the highest numerical density of 15,000 cell/liter during the spring season, while the Al-Najibiya site showed the lowest numerical density of 2,500 cell/liter during the Winter season (Fig. 2). The highest percentage of phytoplankton (45%), appeared during the spring season, while the winter season had the lowest percentage, reaching 12%, (Fig. 3).



	winter	spring	summer	autumn
Al- Najebia	2500	12500	5000	7500
Al- Masheb	3750	12500	3750	8750
Al- Salal	3750	15000	6250	7500
Al-Negara	5000	13750	5120	7500

Figure 2: Numbers of phytoplankton recorded at the study sites as cell/liter

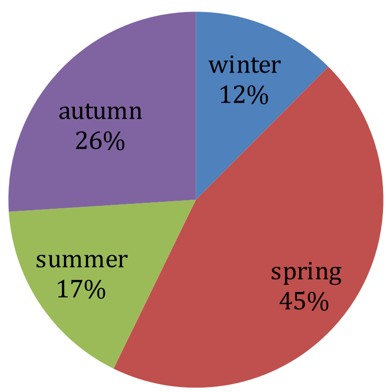


Figure 3: Seasonal percentages of phytoplankton numbers at Garmat -Ali river all the stations were combined together

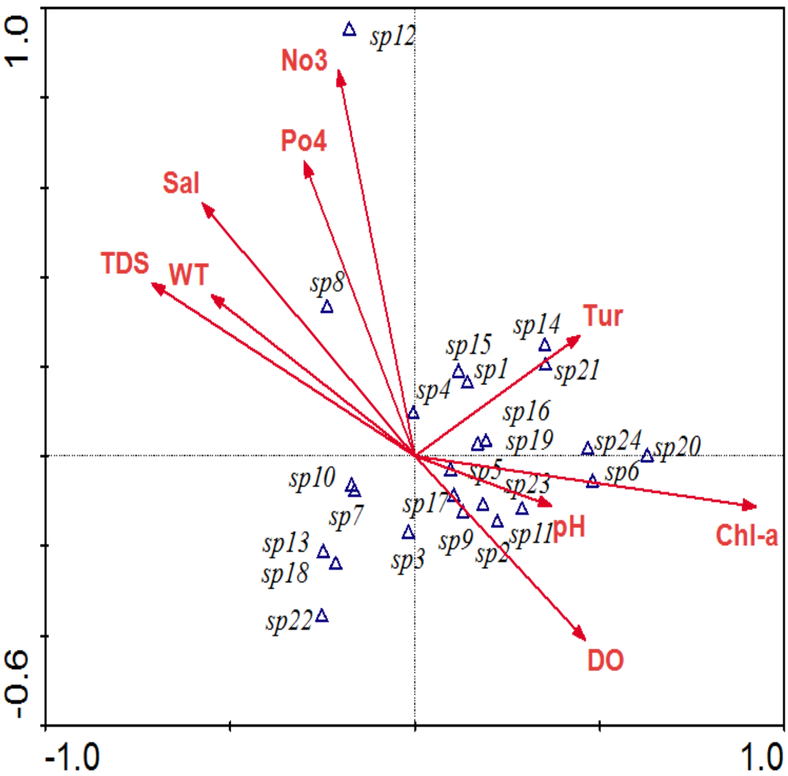


Figure 4: CCA analysis, showing the strength of the various environmental factors on the different species of phytoplankton.

The effect of some environmental factors on some phytoplankton species Fig. (4) showed the extent of the relationship between the environmental factors and species frequency through the Canonical Correspondence Analysis (CCA) by using the ready-made statistical program CanocoVar. 2004. It is a method of multiple statistics that helps in clarifying the relationships between the biological communities and the environmental variables that affect community composition.

Table 4: The species considered the most frequent in their appearance during the study period are showed in Figure 4.

Sp1	*Scendesmus acuminatus*	Sp13	*Monoraphidium contortum*
Sp2	*Amphora ovalis*	Sp14	*Scendesmus sp.*
Sp3	*Halamphora sp.*	Sp15	*Calonis permagna*
Sp4	*Nitzschia sp.*	Sp16	*Tabellaria sp*
Sp5	*Cyclotella sp.*	Sp17	*Keratococcus bicaudatus*
Sp6	*Chlorella vulgaris*	Sp18	*Monoraphidium sp.*
Sp7	*Navicula sp.*	Sp19	*Crucigenia fenestrate*
Sp8	*Kirchneriella iunaris*	Sp20	*Peridinium sp.*
Sp9	*Chroococcus turgidus*	Sp21	*Oscillatoria sp.*
Sp10	*Chlamydomonas reinhardtii*	Sp22	*Caloneis amphisbaena*
Sp11	*Tabellaria flocculosa*	Sp23	*Surirella sp.*
Sp12	*Amphipleura pellucida*	Sp24	*Micractinium pusillum*

Discussion

The water temperature is directly proportional to the air temperature. It is known that the Garmat-Ali River is located in the city of Basrah, which is characterized by a hot, dry climate in the summer and a cold, humid climate in the winter. Therefore, these conditions were reflected by the water temperature and showed significant differences between seasons, this is a logical result that is consistent with all local studies (Moyel and Hussain, 2015; Abdul-Razak et al., 2016). The salinity and TDS of the Garmat-Ali River is related to the amount of drainage coming from the Al-Hamar Marsh and the amount of rainfall, as well as the influence of some tributaries and rivers that flow into it, such as the Suwaib River and the Karun River, it was shown through statistical analysis of the Pearson correlation coefficient that salinity has a positive, direct relationship with water temperature ($r = 0.95$ $P \leq 0.05$) and this is consistent with the study of Al-Biydani (2014); Al-Shaheen (2016) and Al-Waeli (2021). As for the pH, Iraqi waters are alkaline as a result of the natural components of the Mesopotamia, the water of the Garmat-Ali River is characterized by being alkaline throughout the year (Hussein et al., 1991). We noted from the results of the study that most of the high values of dissolved oxygen were recorded in winter and spring seasons, and that the lowest values were recorded in summer and autumn seasons, and this is consistent with most of the local studies (Hassan et al., 2011, Al-Biydani, 2014 and Al-Shaheen, 2016). Among the factors that affected the reduction of oxygen concentration are high temperatures, which enhance the evaporation of gases from the water. The amount of gases dissolved in water is inversely proportional to the temperature, as well as the decomposition of organisms and the high concentration of salts. Turbidity can be used to monitor water quality and safety, because rapid changes in turbidity can be an indicator of significant pollution in surface water or groundwater bodies (WHO, 2017).

Excess reactive phosphate can accumulated in river sediment soils as organic and inorganic matter, and this matter can act along with decomposing plants as internal sources of nutrients in the water column (Colon and Schaffine, 2017), and any increase in phosphate concentrations in the water may lead to the phenomenon of eutrophication (Sharpley, 2001). The results indicated that there were no significant differences between sites and seasons in the concentration of phosphate in the water.

It was noted from the results that most of the high concentrations of reactive nitrate were recorded during the summer and the low values were recorded during the winter. This may be due to the high water temperature during the summer, which led to an increase in the process of reducing nitrite to nitrate (Hussain et al.,1991), one of its sources in the Garmat-Ali River may be the decomposition of dead organisms in the side branches of the river (Hussein et al., 1991), or the dissolution of atmospheric nitrogen gas directly into the water and transforming it into another form (Dewald et al., 2020).

It was observed from the results that the increase in chlorophyll-a- values was bimodal, the first increase occurred in winter and this high increase continued until spring, and this may be due to the large amount of nutrients released from neighboring agricultural lands as a result of rainfall in these two seasons, which causes erosion of the soil loaded with these materials to the Garmat-Ali River, especially the phosphorus (Al-Biydani, 2014; Al-Waeli and Athbi, 2021).

Plankton are strongly influenced by climatic changes, chemical stresses, and hydrological conditions. Their sensitivity to these fluctuations leads to constant changes in the societies and adaptation to environmental factors as well as to changes in available resources. The presence, distribution, spread and movement of living organisms in aquatic environments is affected by an interconnected group of living and non-living factors (physical, chemical and biological), and this effect is either direct or sometimes indirect (Dudgeon, 1995).

The response of living organisms is affected by these factors that have a close relationship with each other, and the intersection of environmental factors is an important factor in the distribution and spread of living organisms, as it is extremely difficult to link the presence of species to a specific environmental factor (Ribeiro et al., 1995).

Fig. (4) showed the amount of mutual influence between species and physical and chemical characteristics at the study stations drawn using the Canoca statistical program. Each of the following shapes, represented by an arrow, indicates the measured physical and chemical properties, and the location of a species indicates the extent of the relationship between that species and that property, whether this relationship is significant or insignificant, negative or positive.

Conclusion

The highest density of phytoplankton was in the cold seasons; spring and winter compared to the hot seasons; summer and autumn.

The physical and chemical factors of the water of the Garmat-Ali River fall within the natural ranges, and no extremes of any environmental factor was observed during the study period.

The waters of the Garmat-Ali River showed an abundance of specific species at the expense of diversity.

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التقدير الكمي لمجتمع العوالق النباتية في نهر كرمة علي، البصرة، العراق

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المستخلص

هدفت الدراسة إلى التقييم الكمي للعوالق النباتية على طول نهر كرمة علي وعلاقتها بالعوامل الفيزيائية والكيميائية استناداً إلى التغيرات التي تحدث في البيئة المائية في محافظة البصرة، بما في ذلك ندرة المياه العذبة، وذلك بسبب قلة المياه العذبة القادمة من دول المنبع، وارتفاع درجات الحرارة بسبب ظاهرة الاحتباس الحراري، وزيادة تركيز الأملاح وعوامل أخرى، وتم تحديد أربعة مواقع للدراسة: (النجيبية، المسحب، الصلال، النكارة)، جمعت العينات فصليا عام 2022. بينت نتائج المتغيرات البيئية ان درجة حرارة الماء 11.8-33.4 م°، الملوحة 2.6-9.5 PSU، تركيز أيون الهيدروجين – pH 7.3-8.64، الأوكسجين المذاب 1،6-11.7 ملغم/ لتر، المواد الصلبة الذائبة 2350-9871 ppm، العكورة 1.39-76.8 NTU، الفوسفات 0.01-0.21 ملغم/لتر، النترات 0.51-19، 9 ملغم/لتر، والكلوروفيل -أ- 8.62-41.06 ملغم/م^3. تم إجراء التحليل الإحصائي للمعلمات الفيزيائية والكيميائية باستخدام البرامج الإحصائية لتحليل التباين أحادي الاتجاه. أظهرت البيانات الكمية أن العدد الكلي للهائمات النباتية في جميع مواقع الدراسة وفي جميع المواسم بلغ 120120 فرداً/لتر. وسجل موقع الصلال أعلى كثافة عددية 15000 خلية/لتر في فصل الربيع، فيما سجل موقع النجيبية أقل كثافة عددية 2500 خلية/لتر شتاءً.

الكلمات المفتاحية: العوالق النباتية، نهر كرمة علي، البصرة، التقدير الكمي.

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