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Primary productivity of the Iraqi coastal waters and some affecting environmental factors

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Abstract

Monthly study was conducted on the net primary productivity and some environmental factors like water temperature, pH, salinity, conductivity, turbidity, light penetration, total suspended solids, total dissolved and alkaline substances, Chl.-a, dissolved oxygen in addition to some Nutrients like NO_3, NO_2, PO_4 and SiO_2, were studied in the areas near Umm Qasr Port and near Buoy 17, in addition to the Basra oil port area in the Iraqi coastal waters. The current study showed that the values of primary productivity ranged from 15.9-98.55 Cmg/l, and the pH and alkalinity were within the ranges prevailing in the Iraqi coastal waters and the temperature values were within their annual rates as they ranged from 14-34°C, while the values of the pH and alkalinity were within the ranges prevailing in the Iraqi coastal waters, the recorded values of light penetration were 14-250cm, while the turbidity values in the third station decreased, high values were recorded in the first and second stations and this is the case in the TSS and TDS values as well.

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Introduction

Oceans occupy approximately 70% of the Earth's surface, which plays an important role in the climatic conditions of the surrounding land areas. Therefore, information about the oceans, seas, and coasts primary productivity, physical factors, and nutrients are of utmost importance in understanding the operations of the many oceans as they were related to each other's right intimately (Tang *et al.*, 2002).

The Arabian Gulf forms an important part of the marine waters, extending from the Gulf of Oman in the south to the north the Iraqi coastal waters. The Iraqi coast is located in Basra Governorate, in southern Iraq, and it is part of the Arab coast over locking the Arabian Gulf with an estimated area of 64km, which is short when compared to the rest of the coasts of neighboring countries (Al-Mahmood *et al.*, 2018).

Study of primary productivity gives an estimate of the outputs of photosynthesis of the organisms produced or called autotrophs, that can produce carbohydrates and oxygen from carbon dioxide, water and light energy in the chloroplasts, or it is a process in which light energy is captured and stored by an organism and the stored energy is used to achieve cellular processes (Blankenship, 2002), oxygenic photosynthesis may be shown as an oxidation-reduction reaction (Falkowski and Raven 2007).

Therefore, it is extremely important when conducting a comprehensive environmental study of a region to highlight it as the first link in the food chain.

The net primary production (NPP) (the focus of the study) is the rate of photosynthesis, carbon fixation minus the percentage of carbon used in the cellular respiration process and cellular construction by self-feeding plankton and benthic flora (Boyd *et al.*, 2014).

There are several environmental factors spatial and temporal that affect the net primary production (Field *et al.*, 1988), of which: light, micronutrients, carbon dioxide and temperature. These factors were affected in turn by changes in the surrounding environment and atmosphere (clouds), the presence of sea ice and water mixing processes caused by wind, waves and water currents in addition to temperature changes (Boyd *et al.*, 2014).

The size composition of phytoplankton communities' affects primary production; the results showed that the chlorophyll-specific productivity of small-sized phytoplankton tends to be higher than that of large-sized phytoplankton (Malone 1980).

Moreover, changes in the magnitude of a total of primary productivity in the aquatic environment can strongly influence atmospheric CO_2 levels (and hence climate) on geological time scales, as well as set upper bounds for sustainable fisheries harvest (Falkowski *et al.*,1998). Phytoplankton is primarily responsible for primary production in a water community, which can constitute a high proportion of annual primary productivity. Although the production of phytoplankton in freshwater is usually a significantly higher level than at sea. Initial production levels are much higher in undernourished areas than previously assumed (Venrick *et al.*, 1973).

The comparison between natural societies in the aquatic ecosystem is only through knowing and estimating the primary productivity of phytoplankton, which motivates us to search for new sources of food and obtain a greater output from the organic materials adopted by aquatic organisms (Alkam and Shuwat, 2010).

The current study aims to estimate the primary productivity in the Iraqi coastal waters and to determine the environmental factors affecting it, The current study aims to estimate the primary productivity in the Iraqi coastal waters and to determine the environmental factors affecting it, As this region is very rich in nutrients carrying by outflow from Tigris and Euphrates inland water to the Iraqi coastal waters and Khor Abdullah region which result in high biological productivity (primary and secondary) which leads to being that region become nursery ground for the more trade fish of the Arabian Gulf.

Material and methods

Sampling

The present study samples were collected monthly from three stations for the period from February 2018 to January 2019 at a depth of 10-20 centimeters from below the surface of the water by means of a plastic container. A medium-sized Tugboat was used in the collection process. A set of environmental characteristics were measured in the field.

Study areas

The first station is located near the Port of Umm Qasr and represents the northern part of the creek and its coordinates N 30°06′ 47.3″ and E 47°55′ 14.7″, the water depth ranges between 12-15 meters and this station is characterized by frequent movement of commercial ships to and from the port. The edges of this plant were characterized by loose clay, free of plants, and water recedes from large areas during the tidal period. With high water turbidity due to the speed of tidal currents. As for the second station, it is located at the bottom approaches of Khor Abdullah near Buoy 17, which is a navigational channel and its coordinates E 19 48.9″ 48°, N 29° 53 26.2″ . This station is characterized by having large tidal areas with high turbidity water due to tidal currents. The depth of the canal in this region ranges between 10 and 13 m. As for the third station, it was near Basra Oil Port, which has open marine waters south of Khor Abdullah, which is an open water area and its coordinates E 29° 37′ 49.1″, N 22.1″ 48° 47′. This station is characterized by having a less turbid water compared to the previous two stations. Its water depth ranges between 10 and 30 meters, and the commercial and oil vessels waiting area is near the west and the Al-Umaya Port to the east. It is worth noting that all the study stations are poor in floating water plants.

Measurement of Physical and Chemical properties

Water temperature, pH, salinity, electrical conductivity and total dissolved solids AUS-made HORIBA U-5030 multimeter was used to measure water temperature, pH, salinity, electrical conductivity and total dissolved solids in the field.

Alkalinity Measurement

Alkalinity was measured by using the method of Lind (Lind, 1979).

Measurement of Light Transmittance

As for the light transmittance, it was measured using a Secchi disk, dyed white and black evenly with a diameter of 25cm. A graduated rope is connected to it to determine the depth. Three readings were taken to represent the light penetration and the result was expressed in centimeters according to the following equation: Light penetration = (d1+d2)/2 (Stirling, 1985).

Total Suspended Matter

The total suspended matter was measured by the method described by the American Public Health Association APHA (APHA, 2005).

Turbidity

The turbidity was measured using the TURBIDIMETTE LaMotte2020we type and were expressed in units NTU.

Chlorophyll-a

The method illustrated by Strickland and Parsons (1972) was used to measure the amount of chlorophyll-a in phytoplankton, by measure the dissolved oxygen concentration and expressed the results in mg/l.

Nutrients Estimate

The American Health Association method APHA (2005) was adopted to calculate (NO_3) Reactive Nitrate, Nitrite (NO_2), Reactive phosphate (PO_4) and Silica (SiO_2).

Primary productivity

Following the method described by Strickland and Parsons (1972) to measure the primary productivity by using transparent and opaque bottles of 125mL each, as the opaque bottles were coated with black paint and then coated with a layer of thick aluminum foil to ensure that the light did not penetrate inside. Immerse it in the plastic container, by which the water was collected from the field and then incubated at a depth of 15cm by hanging a suitable wooden rod attached to the plastic rafts prepared for this purpose, bearing in mind that the bosom place is far from any source of shade .The incubation process continued for a period of not less than three hours for each station. After the end of the incubation period, the samples were treated in the same way as the samples for the dissolved oxygen measurement were treated, and the results were expressed in (mg Carbon. M^3/hour) after converting the oxygen reading to carbon according to the following formula:

Gross photosynthesis, mg C/m^3 per hr =

$$\frac{605 \times f \times [V_{(LB)} - V_{(DB)}]}{N \times PQ}$$

Where,

f= thiosulfate titration product with potassium iodide (KIO_3)= 0.9.

V $_{(LB)}$= output of the measurement of dissolved oxygen in transparent bottles after the incubation process.

V $_{(DB)}$= the product of the measurement of dissolved oxygen in the dark bottles after the incubation process.

N= number of cuddling hours (three hours).

PQ = 1.2.

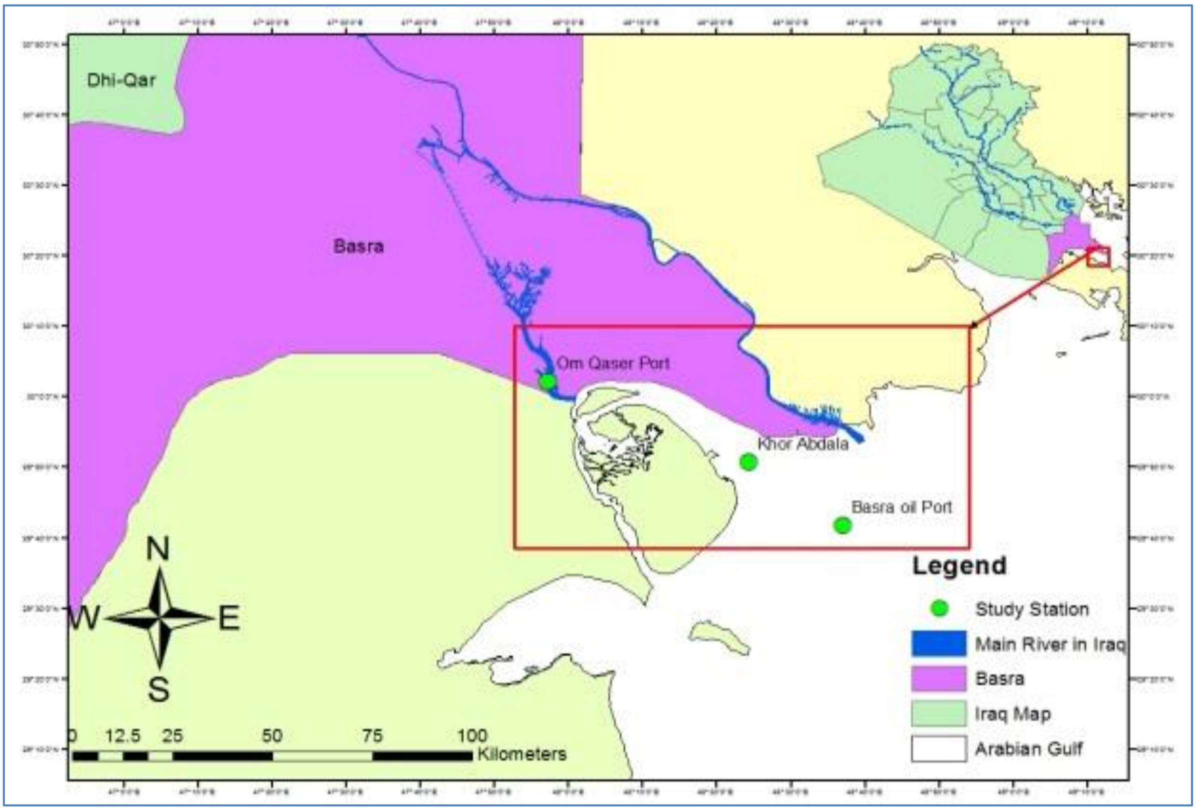

Fig. 1. A map showing the three study stations at the NW Arabian Gulf sampled for the period from February 2018 to December 2019.

Results

The current study showed that the minimum and maximum values of environmental factors and chlorophyll-a for all stations combined are as follow: W T 14-34 °C at station one and three, pH 7.7-8.5 at station three, Sal. 36.2-49.3‰ at station two and one, TDS 25.3-50mg/l at station three and one, DO 5.4-13.89mg/l at station three, L. p. 14-250cm at station one and three, TSS 0.04-0.34mg/l at station three and one, E C 45.7-77.1 MS/cm at station three and one, Alkalinity 60-70mg/l at station one (Table 1). While minimum and maximum values for nutrients and Chlorophyll-a are given as: NO_2 0.2-4.92 µg-at l^{-1} at station three, NO_3 0.65- 15.46 µg-at l^{-1} at station two and one, PO_4 0.001-0.22 µg-at l^{-1} at station three and one, SiO_2 0.239-3.902 µg-at l^{-1} at station three, Chlorophyll-a 0.53-13.88 mg/m^3 at station one and three (Table 2).

Table 1. Comparison of some physical and chemical properties measured in the current study with those previous studies of some coastal areas.

Source	Country	Term	WT (°C)	PH	Sali.)‰(	Tur. NTU	TDS mg/l	DO mg/l	L. P. cm	TSS mg/l	EC MS/cm	Alk. mg/l
Ghani (1988)	Iraq	Mini.	12	7.3	-	-	-	6	-	-	-	
		Maxi.	31	8.6	-	-	-	9	-	-	-	
Al-Sakaini (1990)	Iraq	Mini.	11	7.11	25.4	-	-	4.2	10	-	-	
		Maxi.	29.5	8.22	37	-	-	7.9	60	-	-	
Al-Handal and Al-Rikabi (1994)	Iraq	Mini.	11	-	25.7	-	-	-	11	-	-	
		Maxi.	29	-	37.8	-	-	-	55	-	-	
Al-Yamani *et al.*, (1997)	Kuwait	Mini.	22.4	-	34	-	-	-	-	-	-	
		Maxi.	25.6	-	41	-	-	-	-	-	-	
Al-Aarajy (2001)	Iraq	Mini.	28	-	37.8	-	-	3.72	-	-	-	
		Maxi.	28.6	-	38.5	-	-	6.15	-	-	-	
Glibert *et al.*, (2002)	Kuwait	Mini.	31	-	40.1	-	-	-	-	-	-	
		Maxi.	36	-	42.6	-	-	-	-	-	-	
El-Serehy and Al-Darmaky (2003)	UAE	Mini.	22.4	8.15	39	-	-	5.6	-	-	-	
		Maxi.	23	8.23	40	-	-	7	-	-	-	
Ramezanpoor (2004)	Iran	Mini.	5.6	-	1.9	-	-	4.09	65	-	-	
		Maxi.	26.3	-	11.6	-	-	8.82	100	-	-	
El-Sammak *et al.*, (2004)	Kuwait	Mini.	15	6.95	32	-	1.78	4.91	-	-	-	
		Maxi.	32	8.5	62	-	125	8.25	-	-	-	
Al-Yamani *et al.*, (2004)	Kuwait	Mini.	10	7.6	33	-	0.3	2.1	-	-	-	
		Maxi.	36	9.7	44	-	27.6	20.7	-	-	-	
Al-Harbi (2005)	Arabian Gulf	Mini.	10	-	37	-	-	-	-	-	-	
		Maxi.	36	-	40	-	-	-	-	-	-	
Al-Jamali *et al.*, (2005)	Qatar	Mini.	20.8	-	43	-	-	3.5	-	-	-	
		Maxi.	21.8	-	43.1	-	-	3.9	-	-	-	
Al-Yamani *et al.*, (2006)	Kuwait	Mini.	15.1	8.16	18.79	-	-	2.27	-	-	-	
		Maxi.	31	8.6	40	-	-	4.97	-	-	-	
Gupta *et al.*, (2006)	India	Mini.	-	-	0.61	-	89	-	-	-	-	
		Maxi.	-	-	4.33	-	380	-	-	-	-	
Ismail *et al.*, (2007)	Kuwait	Mini.	13	8.2	40.5	-	-	4.2	-	-	-	
		Maxi.	36	9.2	44.5	-	-	5.7	-	-	-	
Al-Yamani *et al.*, (2007)	Kuwait	Mini.	-	-	18.2	-	-	-	-	-	-	
		Maxi.	-	-	44.9	-	-	-	-	-	-	
Al-Handal (2009)	Iraq	Mini.	17.9	-	22.1	-	-	-	-	-	-	
		Maxi.	19.2	-	38.3	-	-	-	-	-	-	
Al-Shawi (2010)	Iraq	Mini.	9	7.2	32.82	-	106	5.5	8	-	-	
		Maxi.	33.5	8.4	52.43	-	642	9	44.5	-	-	
present study	Iraq	Mini.	14	7.7	36.2	0.64	25.3	5.4	14	0.04	45.7	60
		Maxi.	34	8.5	49.3	81	50	14	250	0.34	77.1	73

Table 2. Comparison of some results of chlorophyll-a concentrations and measured nutrients in the current study with those of previous studies of some coastal areas.

Source	Country	Area name	Term	Chl.-a mg/m3	NO_2 µg-at l^{-1}	NO_3 µg-at l^{-1}	PO_4 µg-at l^{-1}	SiO2 µg-at l^{-1}
Ghani (1988)	Iraq	Khor Al-Zubair	Mini.	0.32	0.54	0.96	0.64	2.50
			Maxi.	1.59	0.80	120	2.95	54
Al-Handal and Al-Rikabi (1994)	Iraq	Iraqi coast	Mini.	0.01	0.00	0.00	0.04	4.10
			Maxi.	3.75	1.86	3.14	0.70	80
Al-Yamani *et al.*, (1997)	Kuwait	Kuwaiti coast	Mini.	-	-	10.0	0.10	-
			Maxi.	-	-	10.6	0.40	-
Al-Aarajy (2001)	Iraq	Khor Abdullah	Mini.	13.21	0.62	1.83	1.85	7.12
			Maxi.	43.92	1.12	11.42	2.15	16.25
Glibert *et al.*, (2002)	Kuwait	Kuwaiti coast	Mini.	-	-	5	2	12.1
			Maxi.	-	-	70	4	24.1
Al-Yamani *et al.*, (2004)	Kuwait	Kuwaiti coast	Mini.	-	0.00	0.00	0	-
			Maxi.	-	4.80	27.1	5.7	-
El-Sammak *et al.*, (2004)	Kuwait	Kuwaiti coast	Mini.	-	0.002	0.30	0.24	-
			Maxi.	-	6.10	0.60	0.60	-
Ramezanpoor (2004)	Iran	Anzali	Mini.	-	-	0.47	-	-

Source	Country	Area name	Term	Chl.-a mg/m³	NO_2 µg-at l⁻¹	NO_3 µg-at l⁻¹	PO_4 µg-at l⁻¹	SiO2 µg-at l⁻¹
		Lagoon	Maxi.	-	-	3.60	-	-
Al-Jamali *et al.*, (2005)	Qatar	Qatar Lagoon	Mini.	-	0.00	0.00	0.00	-
			Maxi.	-	40	85	43.0	-
Al-Yamani *et al.*, (2006)	Kuwait	Kuwaiti coast	Mini.	0.53	0.00	0.00	0.00	1.98
			Maxi.	23.66	0.50	14.12	5.16	52.48
Ismail *et al.*, (2007)	Kuwait	Kuwaiti coast	Mini.	1.40	0.00	0.00	0.00	0.00
			Maxi.	55.3	2.99	5.67	3.04	32.31
Al-Yamani *et al.*, (2007)	Kuwait	Kuwaiti coast	Mini.	0.10	0.003	0.00	0.00	0.00
			Maxi.	31	5.31	111.3	9.10	0.00
Al-Handal (2009)	Iraq	Iraqi coast	Mini.	-	0.53	2.10	0.56	31
			Maxi.	-	0.72	38.7	38.7	75
Sundaramanickam *et al.*, (2008)	India	India coast	Mini.	-	0.205	-	0.186	4.83
			Maxi.	-	2.68	-	2.48	52.32
Harnstrom *et al.*, (2009)	India	India coast	Mini.	1.67	-	9.68	0.001	9.93
			Maxi.	4.87	-	17.74	0.009	24.47
Al-Shawi (2010)	Iraq	Iraqi coast	Mini.	0.69	0.03	3.78	0.4	10.91
			Maxi.	22.65	5.31	40.86	11.62	217.6
present study	Iraq	Iraqi coast	Mini.	0.53	0.2	0.65	0.001	0.239
			Maxi.	13.88	4.92	15.46	0.22	3.902

Fig. (2) shows the recorded values of net primary productivity during the study period of the three stations. Station one and two exhibit almost similar pattern of primary productivity, with a rise in February followed by a gradual decline towards June (21.9, 15.9mg C/m³-h), and a rise in July with a peak in January (71.4, 67.6 mg C/m³-h). However, the situation is rather different, at station three (Fig. 2), as the peak is occurred in March (95.6mg C/m³-h) and another slight increase in May with a decline in June (40.11 6 mg C/m³-h) and an increase in July and August, but the major peak occurred in November and December (98,89.6mg C/m³-h) and a decline then after. Significant differences were recorded between the three study stations ($p<0.05$). Fig. (3) showed the percentages of net primary productivity rates in the study stations, which indicates a clear increase in the third station from the rest of the stations.

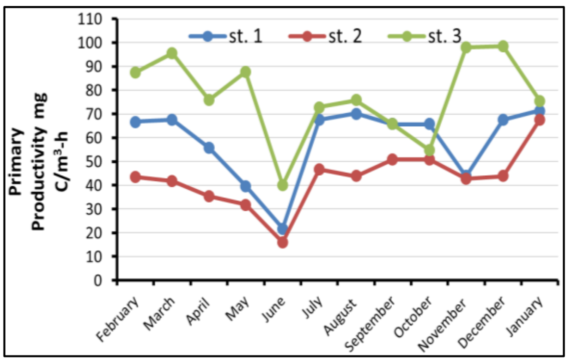

Fig. 2. Monthly variation of net primary productivity at the three stations of the NW Arabian Gulf during the period from February 2018 to January 2019.

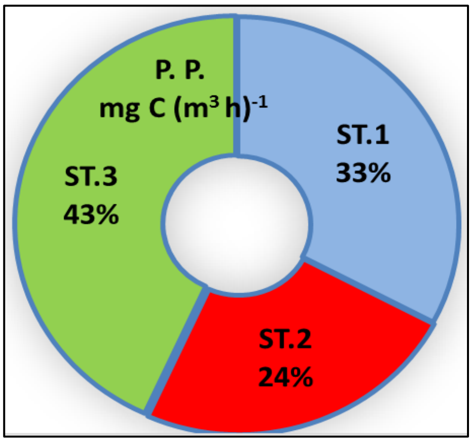

Fig. 3. the rates of net primary productivity values at three study stations.

The current study showed that the minimum and maximum values of environmental factors and chlorophyll-a for all stations combined are as follow: W T 14-34 °C at station one and three, pH 7.7-8.5 at station three, Sal. 36.2-49.3 ‰ at station two and one, TDS 25.3-50 mg/l at station three and one, DO 5.4-13.89 mg/l at station three, L. p. 14-250cm at station one and three, TSS 0.04-0.34 mg/l at station three and one, E C 45.7-77.1 MS/cm at station three and one, Alkalinity 60-70 mg/l at station one (Table 1). While minimum and maximum values for nutrients and Chlorophyll-a are given as: NO_2 0.2-4.92 µg-at l⁻¹ at station three, NO_3 0.65- 15.46 µg-at l⁻¹ at station two and one, PO_4 0.001-0.22 µg-at l⁻¹ at station three and one, SiO_2 0.239-3.902 µg-at l⁻¹ at station three, Chlorophyll-a 0.53-13.88 mg/m³ at station one and three (Table 2).

Table 3. Comparison some of the results of primary productivity values measured in the current study with previous studies of some coastal areas in the Arabian Gulf and Shatt Al-Arab.

Source	Country	Area name	Term	p.p.	Method	Date
Huq *et al.*, (1978)	Arabian Gulf	NW Arabian Gulf	Mini.	10.7	DO	Oct. and Nov. 1978
			Maxi.	31.6	mg C (m^3 h)$^{-1}$	
Jacob *et al.*, (1979)	Kuwait	Kuwaiti coast	Mini.	Average	Chl.-a	March to May 1978
			Maxi.	867	mg C (m^3 h)$^{-1}$	
Jacob *et al.*, (1980)	Kuwait	Kuwaiti coast	Mini.	70	Chl.-a	Jan. to Mar. 1979
			Maxi.	660	µg C $l^{-1}h^{-1}$	
Literathy *et al.*, (1988)	Kuwait	Kuwaiti coast	Mini.	0.2	^{14}C	1993 to 1994
			Maxi.	1.6	µg C $l^{-1}h^{-1}$	
Subba Rao *et. al.*, (1999)	Kuwait	Kuwaiti Coast (red tide)	Mini.	507.9	Chl.-a	11-12 May. 1997
			Maxi.	571.2	µg C $l^{-1}h^{-1}$	
Al-Yamani *et al.*, (2006)	Kuwait	Kuwaiti coast	Mini.	11.4	DO	Mar. 1997 to Mar. 1998
			Maxi.	610	µg C $l^{-1}h^{-1}$	
Quigg *et al.*, (2013)	Qatar	Qatar coast	Mini.	0.14	Chl.-a	Feb. 2010 July 2010
			Maxi.	0.97	mg C (m^3 d)$^{-1}$	Feb. 2011 May 2011
Qurban, (2019)	Saudi Arabia	Saudi coastal	Mini.	< 1	DO	2010 to
			Maxi.	25	µg C $l^{-1}h^{-1}$	2013
present study	Iraq	Iraqi coast	Mini.	15.90	DO	Fab. 2018 to Jan. 2019
			Maxi.	98.55	mg C (m^3 h)$^{-1}$	
Huq *et al.*, (1981)	Iraq	Shatt Al-Arab	Mini.	6.03	DO	Sep. 1976 to Aug. 1977
			Maxi.	37.6	mg C (m^3 h)$^{-1}$	
Al-Saadi and Antoine (1981)	Iraq	Shat Al-Arab (Al-Ashar channel)	Mini.	301.9	DO	Fab. 1978 to Jan. 1979
			Maxi.	730.59	mg C (m^3 h)$^{-1}$	
Schiewer *et. al.*, (1982)	Iraq	Shatt Al-Arab	Mini.	0.1	Chl.-a	
			Maxi.	118	µg C $l^{-1}h^{-1}$	
Hadi *et al.*, (1989)	Iraq	Estuary of Shatt Al-Arab	Mini.	18.5	Chl.-a	November 1988
			Maxi.	52.9	µg C $l^{-1}h^{-1}$	
Al-Saadi *et al.*, (1989)	Iraq	Estuary of Shatt Al-Arab	Mini.	5.44	DO	Feb. to Mar. 1985
			Maxi.	10.3	µg C $l^{-1}h^{-1}$	
Al-Essa, *et al.*, (2007)	Iraq	Shatt Al-Arab	Mini.	28.2	Chl.-a	July 1998 to June 1999
			Maxi.	92	mg C (m^3 d)$^{-1}$	

Statistical analysis

Using the multilingual XLSTAT-Premium 2018.1 software was used to analyze the values of environmental factors in the three stations studied. Fig. (4) shows the PCA analysis to link the net primary productivity of the study stations with the environmental variables studied during the year, where the numbers (1, 2 and 3) indicate the study stations during 12 months.

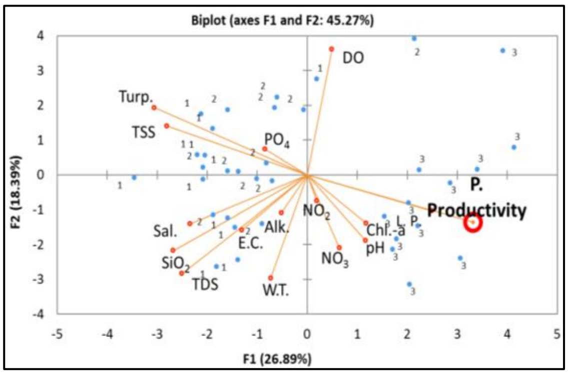

Fig. 4. PCA analysis of F1 and F2 vectors of net primary productivity correlation factors with environmental variables studied during the months of the year 2018-2019 in the northwest Arabian Gulf.

Fig. showed that light penetration was a very influencing factor, and Chlorophyll-a, pH, NO_2 and NO_3 are the second most influencing factors, while the other factors such as WT, Alkalinity, EC, TDS, SO3 and Sal. had less impact on the net primary productivity. It is apparent that the third station was the highest productive during most months of the year.

Also, through the tree drawing that were drawn by the above statistical program (Fig. 5), we can see three groups that are most closely related to each other, the first group has included most of the months of the first station, while the second and third group has included most of the time of the second and third stations. This was manifested by Fig. (6), which divided the stations according to their relationship to each other in terms of the impact of the primary productivity studied on these stations, and found that the first and third stations are linked together while the second station was linked to the other two stations by a smaller percentage.

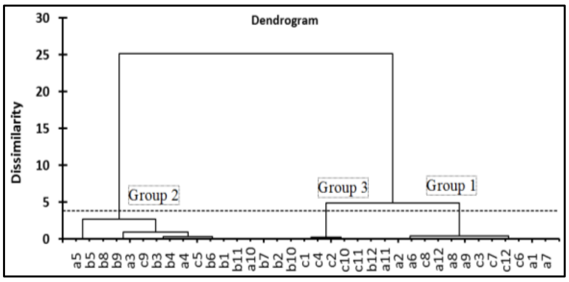

Fig. 5. Tree diagram for similarity between net primary productivity at the three stations during the period's February 2018-January 2019 at the NW Arabian Gulf .a= first station, b= second station, c= third station. As for the numbers, they represent the months of the year.

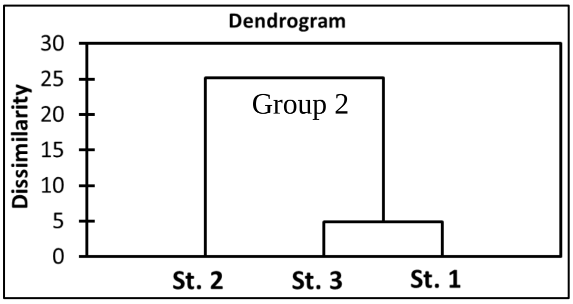

Fig. 6. Summary of the tree diagrams for the similarity rate between the net primary productivity of the three stations of the NW Arabian Gulf.

Discussion

Primary production varies temporarily and spatially in response to factors that limit or stimulate photosynthesis and the growth of phytoplankton (Sundaramanickam *et al.*, 2008). In addition, the primary productivity in the marine environments is affected by the physical system components (Environmental factors such as light, temperature, and water dynamics), chemical (inorganic and organic nutrients) and biological components (phytoplankton and higher levels of nutrition) (Shulenberger and Ried 1981). Among the three stations, maximum primary productivity was found at station 3 with a rate of 43% while the lowest Primary Productivity was observed at station 2 with a rate of 24%, and the medium value was observed at Station 1, which has a rate of 33% of the total ratio of the net primary productivity of the three stations (Fig. 3). A significant difference was observed in Net Primary Production among station 3 and station 2 and to a lesser degree between the station 2 and station 1 during the study period (Fig. 5 and 6).

Perhaps the reason behind the high productivity in station 3 is the lack of turbidity in the water and consequently, higher penetration of incandescent light waves (Blankenship 2002), and this is what appeared in the results of statistical analysis (Fig. 4), as well as station 3, is characterized by the fact that the currents in it are much less than that at station 1 and significantly less at station 2.

It is quiet useful to obtain enough light penetration, to initiates addition to the presence of some corals (Zewde *et al.*, 2018) that have a major role in the supply of nutrients to the nutrient cycle. Likewise, it is noticed that the percentage of diatoms at station 3 was higher than that at other two stations, and therefore the rate of photosynthesis was higher and this leads to an increase in the initial productivity (Lavaud, 2007).

By comparing the present results with those of the studies carried out in the region (Table 1), we conclude that the pH and alkalinity values are the basic, and the a predominant characteristic of the marine waters, whereas the values of transparency also showed that the third station is less cloudy than the first and second stations, as the water has more depth and alower current speed and it is an open water area. Temperature values at all stations were close to each other because the three stations are subject to the same climatic conditions. The salinity and conductivity values recorded relatively lower values in the third station, while they were higher in the first and second stations, as the last two station are subjected to the conditions of higher evaporation, which results in an increase in salinity values, and the TSS and TDS values were carved in the same direction.

Chlorophyll-a reported in the present study is almost of moderate values (0.53-13.88 mg/m^3), when compared with the available previous results obtained in the region (Table 2), indicating that the area is rather less turbid than areas like Khor Al-Zubair (Ghani, 1988) and some turbid lagoons in the region Iraqi coast (Al-Handal and Al-Rikabi, 1994). However, Al-Arajy (2001) recorded some higher limit of productivity (13.21-43.92 mg/m^3) Khor Abdullah. Meanwhile, Ismail *et al.* (2007) registered some higher values from the coastal region of Kuwait (1.4-55.3 mg/m^3).

The productivity values (Table 3) exhibited great variations, due mainly to the different methods used in estimating. Lest values (0.2-1.6 µg Cl^{-1}h^{-1}) were expressed by the 14C method (Literathy *et al.*, 1988), whereas, the DO method reported moderate values 10.7-610 µg µg Cl^{-1}h^{-1} (Table 3), and the highest values were given by the chlorophyll-a method (70-867 10 µg Cl^{-1}h^{-1}).

However, the values obtained by the DO method showed that the Iraqi coastal waters are less productive than the Kuwaiti waters. Meanwhile, the chlorophyll method indicated that the Kuwaiti waters are in some time, more productive than the Shatt Al-Arab River (table 3).

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