Effects of environmental parameters and nutrients on phytoplankton communities around the shrimp farm complexes in Bushehr Province, in the Persian Gulf

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Abstract

The aim of this work was to be informed and aware of the red tide conditions before the entering of algal blooms in seawater supply canals of the shrimp farm and hatchery complexes in Bushehr Province. Field investigations and monthly samplings have been carried out to determine environmental parameters, nutrients, chlorophyll–a and phytoplankton in the southern part of the input water channels of Mond, Delvar and Heleh farmed shrimp complexes from April to December 2011. The identified phytoplankton belonged to three classes of *Bacillariophyceae*, *Dinophyceae* and *Cyanophyceae*. 12 genera belonging to *Dinophyceae*, 25 genera to *Bacillariophyceae* and two genera to *Cyanophyceae* were observed during the study. The highest average density of total phytoplankton was recorded at Heleh station at 18374 cells/Lit. The maximum density of phytoplankton was at Delvar station in December. The highest density of *Dinophyceae* was observed in August. *Alexandrium* sp., *Ornithocercus* and *Prorocentrum* sp. were the predominant species of *Dinophyceae* class. *Bacillariophyceaes* are thermo-tolerant and halo-tolerant while *Dinophyceaes* and *Cyanophyceaes* are thermo-intolerant and halo-intolerant. *Bacillariophyceaes* are silica limited while *Dinophyceaes* are phosphorus limited phytoplankton.

Keywords: Phytoplankton composition, Shrimp farm, Nutrients, Environmental parameters, Bushehr Province.

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Introduction

Phytoplankton community structure and abundance have been found to be changing as a result of water temperature (Richardson and Schoeman, 2004). Increasing linkages between nutrient loading and coastal marine harmful algal blooms have more recently been recognized (Smayda, 1997; Glibert and Burkholder, 2006). Whitney and Welch (2002) reported that during the El Nino 1997-98 condition, the sea surface temperature increased, while nutrient supply declined. Their results have shown that in El Nino condition, chlorophyll levels in surface waters varied depending on nutrient availability and phytoplankton abundance declined in the nutrient depleted waters.

On the basis of investigations conducted by Hodgkiss and Ho (1997) and also Bulgakov and Levich (1999), not only nutrient increase, but also nutrient imbalance, could favor certain phytoplankton species versus others. The loss of phytoplankton diversity and shifts in the specific composition of phytoplankton communities could influence the fate of primary production and modify the shape of the trophic web in coastal areas (Zingone and Enevoldsen, 2000).

The bloom of dinoflagellates and other phytoplankton groups such as diatoms, cyanobacteria and chlorophytes caused serious harm to the shrimp industry in recent decades (Jiasheng *et al.*, 1993; Jimenez, 1993; Lizárraga *et al*., 2002 ; Osuna and Rodringues, 2003).

Occurrence of the extensive bloom of *Cochlodinium polykrikoides* in the Persian Gulf in 2008 and 2009 brought considerable damage to the marine ecosystem. It led the Iranian Fisheries Science Research Institute to be concerned about the serious impact of this phenomenon on aquaculture activities and its social consequences. The present study was aimed to investigate phytoplankton composition and its relationship with environmental parameters and nutrients in the southern shrimp farms and hatchery complexes in Bushehr Province to be aware of the red tide condition before the entering of bloomer phytoplankton in seawater supply canals.

Materials and methods

With regard to the distribution of shrimp farms and hatcheries complexes along the coastal waters of Bushehr Province, three stations were selected in the southern water intake canal of Mond, Delvar and Heleh shrimp farms (Fig. 1 and Table 1).

Monthly samplings with three replicates were carried out in all studied stations from April 2011 to November 2011, during the regarding to shrimp hatcheries and farms activity season in Bushehr Province.

Geographic coordinates, meteorological conditions, temperature, salinity and pH was recorded and measured in each station.

Figure 1: The studied area and position of shrimp farm complexes in Bushehr Province, Persian Gulf.

Table 1: Geographical Position of studied stations, Bushehr Province waters, 2011.

Row	Station	Geographical position
1	Mond shrimp farm	N 28° 09' 393" E 51° 15' 549"
2	Delvar shrimp farm	N 28° 43' 968" E 51° 02' 418"
3	Heleh shrimp farm	N 29° 08' 037" E 50° 37' 000"

Water samples to study phytoplankton, chlorophyll-a and nutrients (silicate, phosphate, nitrate, nitrite and ammonia) were collected using a Ruttner bottle (Hydro-Bios Model).

Phytoplankton samples were fixed with Lugol's solution and transported to the National Shrimp Research Center laboratories, located in Bushehr. Fixed specimens were allowed to settle for two weeks and then identified using an inverted microscope of Nikon, Model Eclipse Tis. Phytoplankton sampling was done based on MOOPAM (2010) and their identification was done based on Newell and Newell (1977); Sournia (1978); Andrew (2005) and Hoppenrath *et al*. (2009).

Water temperature and pH values were recorded using a pH meter (model WTW) and salinity was recorded with an Atago S/Mill refractometer. Nutrients and chlorophyll-a were analysed by using HACH spectrophotometer Model DR 4000, according to the methods of MOOPAM, 2010 and Clesceri *et al*. (1989). All measurements were performed with three replicates.

Recording and data processing and statistical analysis were done using EXCEL 2007 software.

Results

The averages of air and water temperatures were 29.4°C and 28.3°C, respectively. The minimum water temperature was 19.0 °C in April and its maximum value reached 34.2°C in July at Delvar station. The correlation coefficient of water temperature with density of *Bacillariophyceae, Dinophyceae* and *Cyanophyceae* was 0.99, -0.95 and -0.49, respectively.

The average salinity was 41.2 ppt. The highest salinity value was 45.2 ppt in July at Delvar station and its minimum value was 38.2 ppt in July at Mond station. The correlation coefficient between salinity and phytoplankton density at different stations was -0.99. The correlation coefficient of salinity with density of *Bacillariophyceae*, *Dinophyceae* and *Cyanophyceae* were 0.95, -0.88 and -0.64, respectively.

A summary of results of nutrients including silicate (SiO_4^{-4}), nitrate (NO_3^-), nitrite (NO_2^-), ortho-phosphate (PO_4^{-3}), ammonia (NH_3) and chlorophyll-a are presented in Tables 2 and 3.

The average pH was 8.46 in the studied waters. The highest level of pH was 8.88 which was recorded in May at Mond station and the minimum level was 8.20 at Delvar station in September, and also was the same at Heleh in October.

The correlations between the density of *Dinophyceae* and concentration of phosphate, silicate and nitrate were 0.83, -0.90 and 0.46, respectively. A reverse trend was observed between *Bacillariophyceae* and phosphate and silicate, for which correlation coefficients were -0.99 and 0.96, respectively.

Table 2: Concentration of nutrients (ppm) and chlorophyll-a (mg/m^3) in different stations, Bushehr Province waters, 2011.

Nutrient	Mond	Delvar	Heleh	Average
SiO_4^{-4}	0.83 ± 0.07	1.04 ± 0.08	0.94 ± 0.09	0.94 ± 0.04
PO_4^{-3}	0.20 ± 0.02	0.10 ± 0.01	0.16 ± 0.02	0.15 ± 0.01
Chlorophyll-a	2.22 ± 0.18	2.31 ± 0.36	1.46 ± 0.11	1.99 ± 0.14
NO_3^-	0.04 ± 0.00	0.04 ± 0.00	0.03 ± 0.01	0.03 ± 0.01
NO_2^-	0.006 ± 0.000	0.011 ± 0.001	0.010 ± 0.001	0.009 ± 0.000
NH_3	0.13 ± 0.01	0.17 ± 0.01	0.14 ± 0.01	0.94 ± 0.04

Table 3: Concentration of nutrients (ppm) and chlorophyll-a (mg/m^3) in different months, Bushehr Province waters, 2011.

Month	SiO_4^{-4}	PO_4^{-3}	Chloroph	NO_3^-	NO_2^-	NH_3
April	0.35 ± 0.06	0.12 ± 0.04	7.60 ± 1.06	0.04 ± 0.01	0.01 ± 0.001	0.19 ± 0.02
May	2.78 ± 0.26	0.26 ± 0.05	1.25 ± 0.16	0.03 ± 0.00	0.01 ± 0.002	0.11 ± 0.01
June	1.12 ± 0.07	0.14 ± 0.03	0.91 ± 0.10	0.05 ± 0.01	0.01 ± 0.002	0.22 ± 0.00
July	1.29 ± 0.18	0.26 ± 0.03	1.39 ± 0.17	0.06 ± 0.01	0.00 ± 0.001	0.20 ± 0.02
August	0.81 ± 0.12	0.05 ± 0.01	2.60 ± 0.24	0.01 ± 0.00	0.01 ± 0.001	0.11 ± 0.01
September	0.47 ± 0.05	0.09 ± 0.01	0.88 ± 0.06	0.03 ± 0.00	0.01 ± 0.001	0.12 ± 0.01
October	0.27 ± 0.02	0.16 ± 0.01	1.26 ± 0.13	0.02 ± 0.00	0.01 ± 0.001	0.11 ± 0.01
November	0.39 ± 0.04	0.15 ± 0.01	0.07 ± 0.01	0.03 ± 0.00	0.01 ± 0.001	0.09 ± 0.01
Average	0.94 ± 0.04	0.15 ± 0.01	1.99 ± 0.14	0.03 ± 0.01	0.01 ± 0.000	0.14 ± 0.00

Based on the analysis of data, the correlation coefficients of ammonia and nitrite with total phytoplankton were -0.99 and -0.83, respectively.

The correlation coefficient between phosphate and density of total phytoplankton; *Bacillariophyceae*, *Dinophyceae* and *Cyanophyceae* were 0.98, -0.97, 0.90 and 0.58, respectively.

Correlation coefficients between chlorophyll-a and nitrate with phytoplankton density were 0.84 and 0.89, respectively.

The average concentration of silicate at Mond, Delavar and Heleh stations were 0.83, 1.04 and 0.94 ppm, respectively. The correlation coefficient *Bacillariophyceae*, *Dinophyceae* and *Cyanophyceae* with silicate were 0.99, -0.94 and-0.51, respectively.

39 genera of 3 phytoplankton classes were identified. The identified phytoplankton belonged to three classes of *Bacillariophyceae* (61.7%, 13,281±7,226 cell/L, 25 genera), *Dinophyceae* (29.3%, 6,303±8,268 cell/L, 12 genera) and *Cyanophyceae* (9.1%, 1,956±806 cell/L, 2 genera) (Fig. 2). The maximum average density of total phytoplankton was 21,539 cell/L and their temporal maximum average density was 54,623 ± 22,569 cell/L in August (Fig. 3). The highest spatial average density of total phytoplankton was 23,632±4,000 cell/L in Mond station (Fig. 4).

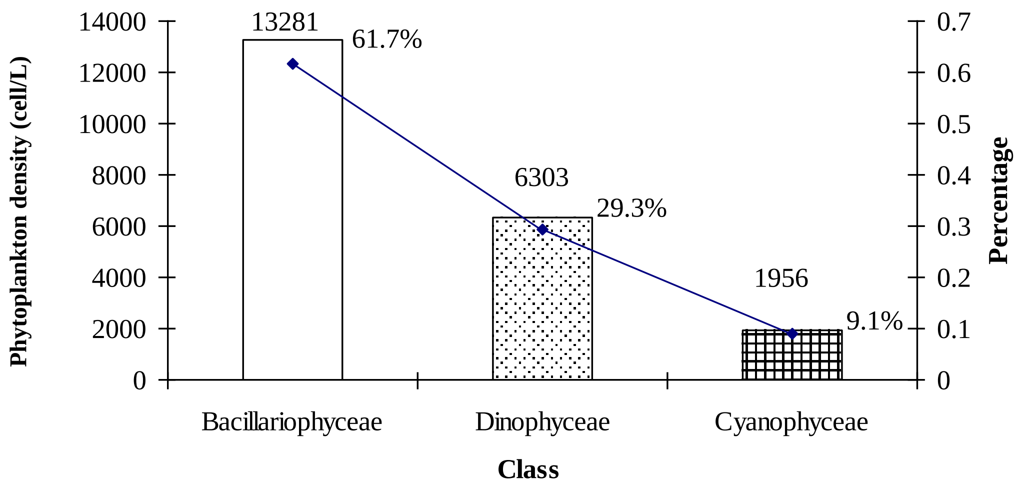

Figure 2: Density and percentage of different classes of identified phytoplankton, Bushehr Province, 2011.

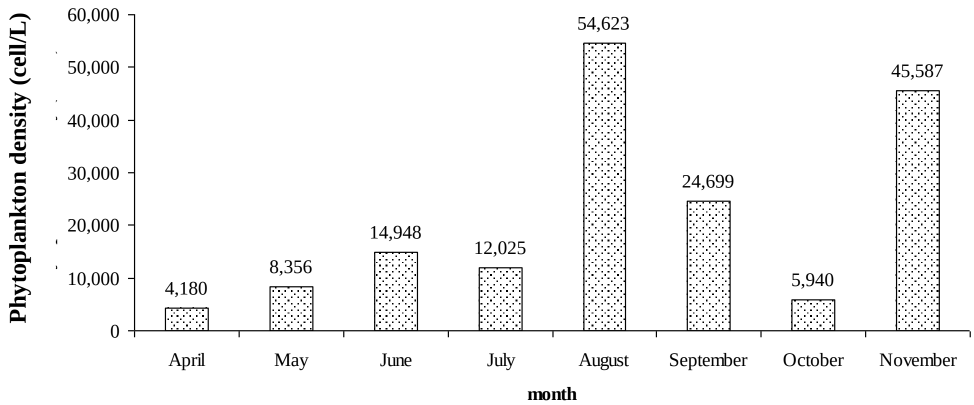

Figure 3: Density of phytoplankton (cell/L) in different months, Bushehr Province, 2011.

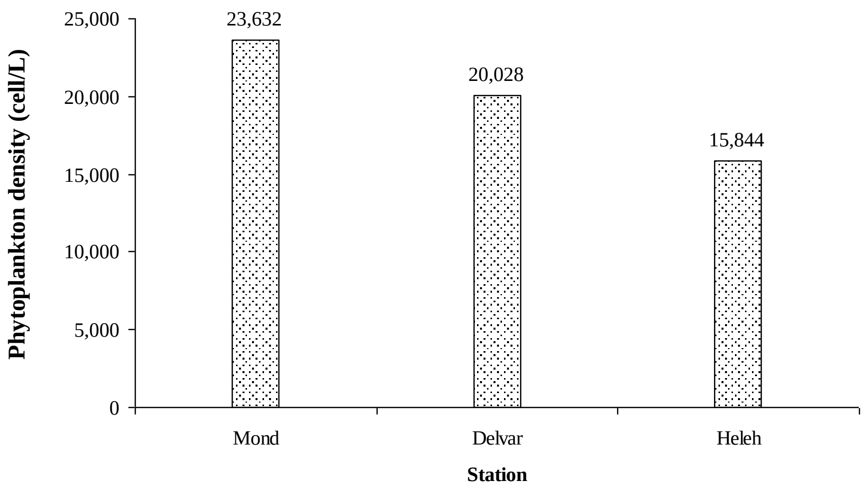

Figure 4: Density of phytoplankton (cell/L) in the studied stations, Bushehr Province, 2011.

Discussion

Based on the results obtained, the average water temperature in the studied stations increased from 22.0°C in April to 33.6°C in July, and then decreased to 23.5°C in November. A strong positive correlation between *Bacillariophyceae and* water temperature was observed implying that in the surveyed area, when the water temperature increases, the density of *Bacillariophyceae* increases. The results revealed that the *Bacillariophyceae* are thermo-tolerant algae, while *Dinophyceae and Cyanophyceae* are thermo-intolerant algae. These results are consistent with the findings of Izadpanahi *et al*. (2005). The salinity decreased from 42 ppt in August to 39.7 ppt in September and then increased to 42.3 ppt in November. Due to the mixing of low salinity water of Mond River with seawater, the water salinity at Mond station has the lowest values in Bushehr coastal waters. The salinity in Bushehr coastal waters is affected by the general trend of salinity variations in the Persian Gulf which depends on the current entering the Persian Gulf from the Indian Ocean and Oman Sea, and mixing of low salinity freshwaters of Mond and Heleh Rivers with high saline seawater (Kampf and Sadrinasab, 2006). A high negative correlation between these data shows that in the surveyed area, by increasing the salinity, the density of phytoplankton decreases. The results revealed that the *Bacillariophyceae* are halotolerant algae while *Dinophyceae and Cyanophyceae* are halointolerant algae. These results are consistent with the findings of Izadpanahi *et al*. (2005).

In the studied area, the main cause of nutrient variation is the outflow of nutrient rich effluent from the shrimp complexes. Study on the variations of the silicate concentrations showed that its average increased from 0.35 ppm in April to 2.78 ppm in May and then declined to 0.27 ppm in October (Table 3). A strong positive correlation between *Bacillariophyceae* and silicate is due to their high affinity to silicate. The *Bacillariophyceae* cell walls consist of silica. They require the presence of bioavailable silicate or silicic acid in their growth environment (Smayda, 1997). In the present work, the population of *Dinophyceae* changed with variations in *Bacillariophyceae* population.

Our results showed that by changing the balance of Si:P, when the SiO_4^{-4} concentration decreased, the density of *Bacillariophyceae* decreased and *Dinophyceae* dominated groups in the area. The composition of nutrients in each area depends on the sources of these nutrients, texture of sea bottom, construction of artificial islands, destruction of the coast and seabed drying. Aein Jamshid *el al*. (2010) reported that *Cochlodinium polykrikoides*, which belongs to the class *Dinophyceae*, is a phosphorus limited species.

The long-term investigation of Philippart and his co-worker showed that phytoplankton production during the spring and summer blooms was phosphorus limited. They reported that diatoms are silicon limited and flagellates are nitrogen limited (Philippart *et al*., 2007). Our results are consistent with these findings with an exception that *Dinophyceae* are phosphorus limited not nitrogen limited.

Ammonia and nitrite are nitrogen wastes, which are toxic to aquatic life, released by aquatic animals, so their relationship with phytoplankton is negative. The concentrations of these parameters are affected by some bacteria such as *Nitrosomonas* in nitrification or, and another group of bacteria such as *Pseudomonas* in denitrification (Simon and Klotz , 2013).

The linear regression analysis of the density of phytoplankton with concentrations of chlorophyll-a and nitrate showed a strong positive relationship between these parameters and phytoplankton (Fig. 5). The analysis of linear regression between *Dinophyceae* and phosphate showed a strong positive relationship, whereas its regression with silicate had a strong negative relationship (Fig. 6).

Comparison of the phytoplankton density in the present study with the results of Eco-Zist (1976) and Izadpanahi *el al*. (2005) showed that total phytoplankton density increased in the studied area. Based on the above researches, the phytoplankton composition in Bushehr Province waters changed. The abundance percentage of high risk toxin producers and bloomer class of *Dinophyceae* increased from 7.5% in 1976 to 29.3% in 2011, whereas the percentage of *Bacillariophyceae* decreased from 73.1% in 1976 to 61.7% in 2011 (Table 4).

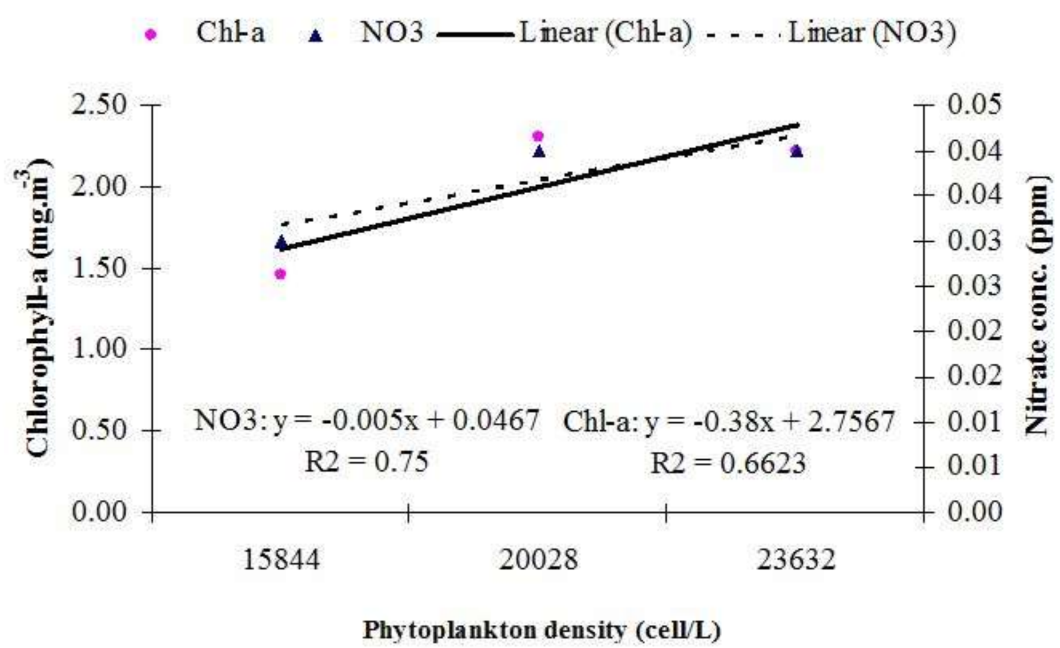

Figure 5: Regression of chlorophyll-a (mg.m^{-3}) and nitrate concentration (ppm) vs. phytoplankton density (cell/L) in the studied stations, Bushehr Province, 2011.

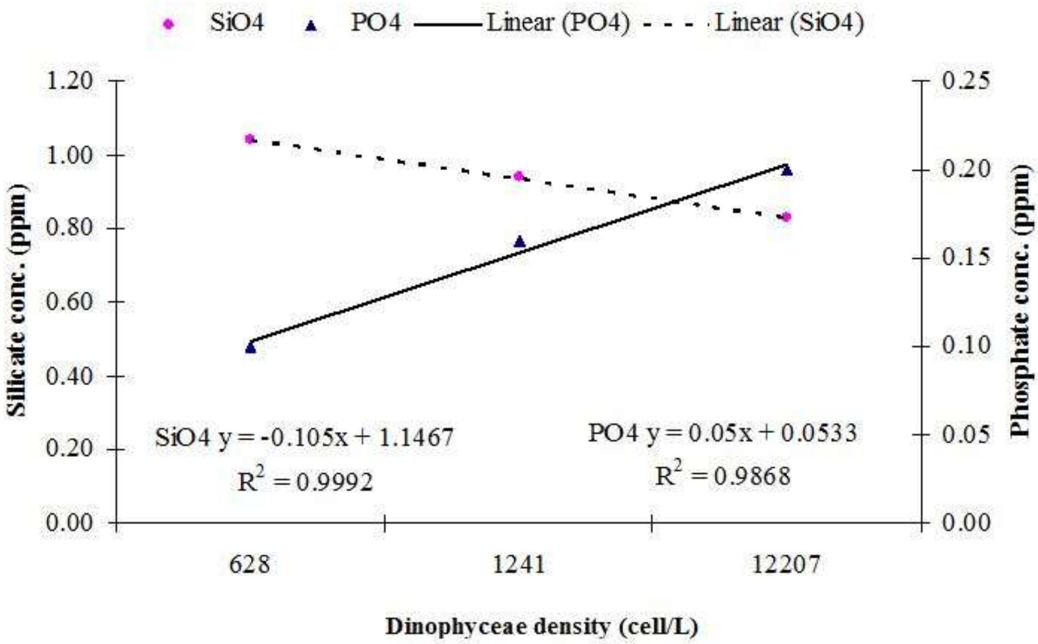

Figure 6: Regression of silicate (ppm) and phosphate concentrations (ppm) vs. *Dinophyceae* density (cell/L) in the studied stations, Bushehr Province, 2011.

Table 4: The abundance percentage and density of different classes of phytoplankton in Bushehr Province waters.

Research Reports	Total phytoplankton density (cells/L)	Abundance%	
		Dinophyceae	*Bacillariophyceae*
Eco-Zist, 1976	4300	7.5	73.1
Izadpanahi, 2005	1312	20.3	26.2
The present work, 2011	21538	29.3	61.7

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