

The Relationships Between Environmental Factors and Phytoplankton Diversity Indices in some Estuarine Ecosystems of Vietnam

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Received 02 August 2016

Revised 16 August 2016; Accepted 09 September 2016

Abstract: This study was carried out from 2011, 2012 and 2015 with 4 times at 10 stations of each estuary from 7 estuarine ecosystems. They are Van Uc (Thai Binh river), Ba Lat (Red river), Thuan An (Huong river), Cua Dai (Thu Bon - Vu Gia river), Soai Rap (Dong Nai river), Co Chien (Tien river) and Dinh An (Hau river). The results showed that the physico-chemical parameters are mostly met the standard limit for aquatic lives, except for COD. The salinity level of the estuaries in Center and South are higher than the estuaries in North. Five algal divisions have been found in these estuaries are Bacillariophyta, Chlorophyta, Cyanobacteriophyta, Pyrrophyta and Dinophyta. Among of them, Diatom (Bacillariophyta) was the dominant division at all seven estuaries. The Diatom was the dominant group in density at all surveyed estuaries. The highest H index was recorded at Ba Lat (3.42) and the lowest registered at Soai Rap (2.85). The D index varied from 1.92 (Soai Rap) to 3.17 (Ba Lat). The single environmental variables that best correlated with H index was total N ($R^2 = 0.805$, $p < 0.01$) and the best correlation was between NO_3 and D index ($R^2 = 0.778$, $p < 0.05$).

Keywords: Environmental factors, phytoplankton diversity, estuaries ecosystems.

1. Introduction

Phytoplankton is the major contributors to the primary production in estuaries, coastal lagoons, and other intertidal habitats. Phytoplankton is important primary producers and the basis of the food chain in open water, some species on the other hand can be harmful to human and other vertebrates by releasing toxic substances (hepatotoxins or neurotoxins etc.) into the water. Phytoplankton community

composition responds sensitively to changes in water quality, making phytoplankton a useful biological quality parameter for water quality monitoring. It would be better to analyze the basic information of the phytoplankton in order to improve water quality and prevent the occurrence of water bloom [1].

The main objectives of the research were to determine water quality and phytoplankton diversity in the 7 estuarine ecosystems (Van Uc, Ba Lat, Thuan An, Cua Dai, Soai Rap, Co Chien and Dinh An), and to characterize the

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relationship between phytoplankton and environmental factors.

2. Sampling estuarine ecosystems and methods

Samples were repeatedly collected in 2011, 2012 and 2015 with 4 times at 10 stations of each estuarine from 7 estuarine ecosystems. They are Van Uc (Thai Binh river), Ba Lat (Red river), Thuan An (Huong river), Cua Dai (Thu Bon - Vu Gia river), Soai Rap (Dong Nai river), Co Chien (Tien river) and Dinh An (Hau river). Two samples were taken from each station: one for the phytoplankton and the other for physico-chemical analysis.

The water samples were collected by a batomet at the depth 50cm to 100cm [2]. Physico-chemical parameters: pH, Temperature and DO were measured with a TOA model WQC-24; Salinity was measured with a ATAGO model S10E; PO_4^{3-} , NH_4^+ and NO_3^- concentrations were measured with SERA test; COD, Total N and Total P were determined by the method of TCVN 6491-1999 and TCVN 5988-1995 [2].

Phytoplankton samples were collected by phytoplankton net No.64. Phytoplankton

samples were preserved in formaldehyde 4% solution and examined in the laboratory of Department of Botany and Microscope Laboratory, Faculty of Biology, VNU University of Science. The classification is based primarily on the references number 3, 4, 5, 6, 7 [3 - 7].

The species diversity were accounted according to Shannon index (H') and Margalef index (D). The biological indices were calculated according to the following equations [8, 9]:

$$-H' = -\sum p_i \ln(p_i),$$

where p_i = number of individuals of species i/total number of samples

$$S = \text{Number of species or species richness}$$

$$-D = (S-1)/\ln(N),$$

where S is the number of species, N is the number of individuals.

One-way ANOVA analysis of variance was used to evaluate the relations between physico-chemical parameters and phytoplankton diversity indices with Excel 2010 software.

3. Results and Discussion

3.1. Environmental factors

Table 1. Values of physico-chemical parameters recorded in the estuarines

Estuarines		Water temperature ($^{\circ}C$)	Salinity (‰)	DO (mg/l)	pH	COD (mg/l)	PO_4 (mg/l)	NH_4 (mg/l)	NO_3 (mg/l)	Total N (mg/l)	Total P (mg/l)
Van	Min	24.28	5.04	2.62	7.71	14.00	1.08	0.25	7.38	1.00	0.08
Uc	Max	29.61	6.56	4.40	7.77	83.53	2.20	0.42	11.16	1.39	0.09
Ba	Min	24.26	2.47	1.96	7.72	12.12	1.08	0.27	6.76	0.63	0.05
Lat	Max	28.81	8.50	4.83	7.89	81.29	1.84	0.42	7.72	1.33	0.08
Thuan	Min	24.56	9.22	3.89	5.45	16.43	0.21	0.17	0.01	0.08	0.04
An	Max	30.32	30.66	8.13	7.51	78.53	1.88	0.48	5.44	1.13	0.40
Cua	Min	24.85	4.33	2.87	7.60	16.70	0.69	0.18	0.05	0.48	0.05
Dai	Max	29.46	29.90	6.80	8.30	79.30	1.86	1.17	3.42	0.90	0.48
Soai	Min	28.10	0.77	2.45	5.94	14.04	0.50	0.70	1.28	0.41	0.06
Rap	Max	29.08	26.80	4.57	7.76	79.78	0.59	0.92	2.51	0.53	0.11
Co	Min	28.30	0.14	2.62	7.52	6.24	0.28	0.53	3.96	0.55	0.09
Chien	Max	29.02	10.92	3.30	7.71	79.70	1.41	0.73	4.80	0.93	0.11
Dinh	Min	27.91	0.02	2.30	7.50	72.17	0.40	0.66	3.76	0.53	0.11
An	Max	28.50	10.26	3.08	7.77	94.51	0.56	0.92	4.44	0.78	0.14
QCVN 10 - 2008		30.00		≥ 4.00	6.50 - 8.50	4.00		0.50			

The results of physicochemical parameters recorded in different estuaries (Table 1) have shown that water temperature varied from 24.26°C in Ba Lat estuary in Spring to 30.32°C in Thuan An estuary in Summer. The salinity was ranging from 0.02 (Dinh An estuary) to 30.66‰ (Thuan An estuary). Dissolved oxygen (DO) was between 1.96 mg/L in Ba Lat estuary and 8.13 mg/L in Thuan An estuary. The lowest pH (5.45) was recorded in Thuan An estuary, whereas, the highest was 8.30 in Cua Dai estuary. The lowest (14.00 mg/L) and highest (94.51 mg/L) COD were found in Van Uc estuary and Dinh An estuary respectively. The phosphate concentration was ranging from 0.21 mg/L (Thuan An estuary) to 2.20 mg/L (Van Uc estuary). The lowest (0.18 mg/L) and highest (1.86 mg/L) ammonium concentration

were recorded in Cua Dai estuary, respectively. Nitrate concentrations varied from 0.01 mg/L in Thuan an estuary to 11.16 mg/L in Van Uc estuary. Total N was between 0.08 mg/L in Thuan An estuary and 1.39mg/L in Van Uc estuary. The lowest total P (0.04 mg/L) was recorded in Thuan An estuary and highest total P (0.14 mg/L) was recorded in Dinh An estuary.

Based on physico-chemical parameters, we considered: the salinity level of the estuarines in Center and South are higher than the estuaries in North. The temperature, pH, PO_4^{3-} , NH_4^+ , NO_3^- , total N and total P were within the acceptable levels and suitable for aquatic life. The DO, COD levels of all estuaries were higher than National technical regulations on surface water quality QCVN 10 - 2008.

3.2. Phytoplankton composition and abundance

Table 2. Number of species of phytoplankton groups in the estuaries

Divisions	Van Uc	Ba Lat	Thuan An	Cua Dai	Soai Rap	Co Chien	Dinh An
Bacillariophyta	50	52	50	49	24	37	25
Chlorophyta	4	4	-	4	1	2	2
Cyanobacteriophyta	4	4	2	2	-	1	1
Pyrrophyta	6	6	6	-	-	-	-
Dinophyta	-	-	-	17	6	-	-
Total	64	66	58	72	31	41	28

Note: - not found

The number of phytoplankton species in each estuary was shown in Table 2. Ba Lat estuary had the most abundant of algal species with 66 species of four divisions. While there was only 28 algal species had been recorded at Dinh An estuary.

Five algal divisions have been found in these estuaries are Bacillariophyta, Chlorophyta, Cyanobacteriophyta, Pyrrophyta and Dinophyta. Among them, Diatom (Bacillariophyta) was the dominant division at all seven estuaries. The proportion of this algal group was from 68% (at Cua Dai estuary) to 90% (at Co Chien estuary).

Four algal divisions have been found in Van Uc, Ba Lat and Cua Dai estuary. The green

algae (Chlorophyta) was absent from Thuan An estuary. While Soai Rap estuary did not have representatives of Blue-green algae (Cyanobacteriophyta); Van Uc, Ba Lat, Thuan An, Co Chien and Dinh An estuaries lacked of Dinophyta species. The Pyrrophyta has been found only in Van Uc, Ba Lat and Thuan An.

Figure 1 showed the phytoplankton density of each estuary. Van Uc and Ba Lat estuaries (two estuaries at the North of Vietnam) had the high number of phytoplankton species (64 and 66 species respectively) but the density of this group was low (under 15000 cell/liter). Whereas, Soai Rap and Co Chien estuaries with respectively 31 and 41 algal species had much higher density (more than 30000 cell/liter).

Our study also showed that the Diatom was the dominant group in density at all surveyed estuaries. The density of this group was generally higher than other groups from 3-8 times (Figure 2).

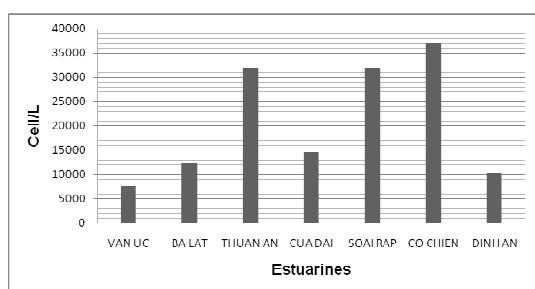


Fig. 1. Phytoplankton density of the estuarines.

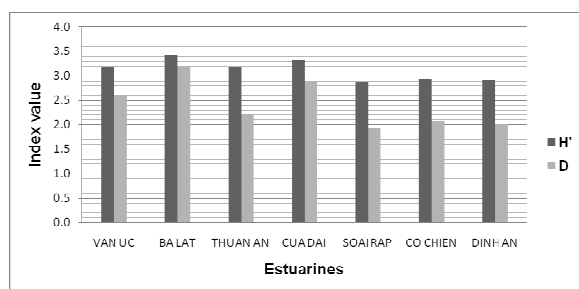


Fig. 2. Value of phytoplankton diversity indices.

Figure 2 showed the phytoplankton diversity indices of the estuaries. The highest Shannon index (H index) was recorded at Ba Lat estuary and the lowest registered at Soai Rap estuary. The Margalef index (D index)

varied from 1.92 (Soai Rap estuary) to 3.17 (Ba Lat estuary). The phytoplankton diversity indices values of the estuaries in North and Centre were higher than these values of the estuaries in South of Vietnam. The number of species, D index and H index were similar variability.

3.3. Correlation analysis

Statistical relationships between the phytoplankton diversity indices and the physico-chemical environment variables at the estuaries were explored (Table 3). The single environmental variable that was best correlated with H index was total N ($R^2 = 0.805$, $p < 0.01$), followed by NO_3^- ($R^2 = 0.778$, $p < 0.05$) and NH_4^+ ($R^2 = 0.647$, $p < 0.01$). The best correlation was between NO_3^- and D index ($R^2 = 0.778$, $p < 0.05$), followed by total N ($R^2 = 0.606$, $p < 0.01$) and NH_4^+ ($R^2 = 0.593$, $p < 0.01$). This shows that nitrogen is an important environmental factor for the growth of phytoplankton. The abundance of phytoplankton depends on the nutrient nitrogen in the water. There was a weakly correlation between pH, temperature, salinity, DO, PO_4^{3-} , total P and phytoplankton diversity indices ($p < 0.05$).

Table 3. R^2 and p (T-Test) value

Physico-chemical	H index		D index	
	R^2 value	p value	R^2 value	p value
pH	0.104	0.0011	0.315	0.0003
Water temperature ($^{\circ}\text{C}$)	0.099	0.0011	0.014	0.0003
Salinity (‰)	0.287	0.0011	0.205	0.0003
DO (mg/l)	0.365	0.0440	0.483	0.0481
PO_4 (mg/l)	0.192	0.0011	0.360	0.0044
NH_4 (mg/l)	0.647	0.0011	0.593	0.0003
NO_3 (mg/l)	0.778	0.0148	0.777	0.0131
Total N (mg/l)	0.805	0.0011	0.606	0.0003
Total P (mg/l)	0.307	0.0010	0.144	0.0011

4. Conclusion

The physico-chemical parameters are mostly met the standard limit for aquatic lives, except for dissolved oxygen (DO) and chemical oxygen demand (COD). Five algal divisions have been found in these estuaries are Bacillariophyta, Chlorophyta, Cyanobacteriophyta, Pyrrophyta and Dinophyta. The Diatom is the dominant group in number species and density. Statistical relationships between the H index, D index and the physico-chemical environment variables have shown that nitrogen is an important environmental factor for the growth of phytoplankton.

Acknowledgments

This study was funded by the project "Investigation biodiversity of the estuarine ecosystems Vietnam", Ministry of Agriculture and Rural Development.

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Mối tương quan giữa chỉ số môi trường với chỉ số đa dạng thực vật nổi của một số cửa sông Việt Nam

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Tóm tắt: Nghiên cứu được thực hiện trong năm 2011, 2012 và 2015 với 4 đợt thu mẫu tại 7 cửa sông, mỗi cửa sông có 10 điểm thu mẫu. Các cửa sông đó là cửa Văn Úc (sông Thái Bình), cửa Ba Lạt (sông Hồng), cửa Thuận An (sông Hương), cửa Đại (sông Thu Bồn - Vu Gia), cửa Soài Rạp (sông Đồng Nai), cửa Cổ Chiên (sông Tiền) và cửa Định An (sông Hậu). Số liệu thủy lý hóa cho thấy tất cả các chỉ số đều phù hợp cho đời sống thủy sinh vật, trừ chỉ số DO và COD. Nồng độ muối ở các cửa sông miền Trung và miền Nam cao hơn miền Bắc. Có 5 ngành thực vật nổi đã tìm được ở các cửa sông đó là Bacillariophyta, Chlorophyta, Cyanobacteriophyta, Pyrrophyta và Dinophyta. Tảo Silic

(Bacillariophyta) là nhóm ưu thế. Chỉ số đa dạng H' cao nhất là ở cửa Ba Lạt (3,42) và thấp nhất là ở cửa Soài Rạp (2,85). Chỉ số đa dạng D biến động trong khoảng 1,92 (cửa Soài Rạp) đến 3,17 (cửa Ba Lạt). Kết quả phân tích tương quan 1 biến cho thấy chỉ số H' tương quan cao nhất với tổng N ($R^2 = 0,805$, $p < 0,01$) và chỉ số D tương quan cao nhất với NO_3 ($R^2 = 0,778$, $p < 0,05$).

Từ khoá: Yếu tố môi trường, đa dạng thực vật nổi, hệ sinh thái cửa sông.