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The Use of Phytoplankton Biodiversity Index for Predicting Water Quality at the Flood Control Area in An Giang Province, Vietnam

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Abstract

The study was conducted to assess biodiversity and water quality using the Shannon-Wiener biodiversity index (H') in the Bac Vam Nao flood control area, An Giang province in 2020. The finding shows that the composition of phytoplankton in the rainy season is more diverse than that in the dry season. The results of analysis of phytoplankton samples at three locations in the Bac Vam Nao flood control area recorded 71 species belonging to 5 different algae phyla, including Cyanophyta, Bacillariophyta, Chlorophyta, Charophyta and Euglenophyta. In which, Euglenophyta has the richest species composition with 25 species (accounted 35.2%) and the lowest is the Cyanophyta with 05 species (7%). The dominant species through two monitoring periods are those of the Bacillariophyta (Cyclotella meneghiniana, Melosira granulata) and Cyanophyta (Oscillatoria sp.). At the monitoring positions of the Bac Vam Nao flood control area, one toxic algae species and two harmful algae species were detected out of a total of 04 species of blue-green algae. The Shannon-Wiener (H') diversity index ranges from 0.56 to 4.18, the H' index in the dry season is higher than that in the rainy season. Surface water quality in Bac Vam Nao flood control area according to diversity index H' is classified from very polluted to clean. It is necessary to expand the scope of research areas to better understand the role of phytoplankton as a water quality indicator, serving effective water quality monitoring, reducing costs and environmental pollution due to the use of chemicals during water sample analysis.

1. Introduction

Water is essential for life. Monitoring changes in water quality due to people's livelihood activities and socio-economic development such as daily life, agriculture, industry and services is a very important task in environmental management. Monitoring results can be used to manage, improve and maintain water quality. Because of that, environmental monitoring is regulated in many legal documents of many countries around the world. Currently, in Vietnam, there are different types of monitoring such as background monitoring, continuous monitoring, impact monitoring and flux monitoring. When monitoring the environment, the physico-chemical parameters of the water environment can be selected or phytoplankton can be selected as an indicator because they live in that water environment, which can reflect the amount of water in the study area [1-2]. The physical, chemical and biological factors commonly observed in the water environment include temperature (^oC), pH, total suspended solids (TSS, mg/L), turbidity (NTU), dissolved oxygen (DO, mg/L), biochemical oxygen demand (BOD, mg/L), chemical oxygen demand (COD, mg/L), ammonium

nitrogen (NH_4^+-N, mg/L), soluble phosphorus (PO_4^{3-} -P, mg/L), heavy metals (Fe, Al, Mn, Cr, Cd), chloride (Cl^-), sulfate (SO_4^{2-}), pesticides, antibiotics, E. coli, and coliform (MPN/100mL) [3]. The selection of indicators for monitoring of water quality depends on the characteristics of the source of pollution [2-3]. Besides the physical and chemical parameters in the aquatic environment, phytoplankton (phytoplankton) were also selected because they can partly reflect the quality of the water environment, especially the content of organic substances and nutrients [4-5]. Some phytoplankton branches such as Bacillariophyta, Cyanophyta, and Chlorophyta can be used to market nutrient rich or organic polluted environments [4,6]. Cyanophyta is used as an indicator for fresh and organic-rich aquatic environments while Dinophyta (Pyrrophyta) is used to indicate brackish and saltwater environments [6]. In Vietnam, environmental monitoring is also very interested in the use of phytoplankton because they can help detect pollution problems quickly with low cost, causing less environmental pollution compared to chemical analysis. This study was conducted at Bac Vam Nao flood control area, An Giang in 2020 to assess phytoplankton diversity and water quality through phytoplankton diversity index. The results can provide more information about options in water quality monitoring.

2. Materials and methods

Phytoplankton samples were collected at three locations in Bac Vam Nao flood control area in March and September 2020 by Department of Environment and Natural Resources, An Giang province. Brief description of phytoplankton sampling locations is presented in Table 1.

Table 1. Description of phytoplankton sampling locations in Bac Vam Nao

Site	Coordinates	Brief description
VN1	549.706 1.191.018	The flood control sluice at the beginning of Than Nong canal is adjacent to Vinh An canal. Monitoring water quality of Than Nong canal, side canal of Bac Vam Nao area, Phu Vinh commune, town of Tan Chau.
VN2	557.041 1.177.484	Midpoint of Than Nong canal, adjacent to K26. Water quality monitoring of Than Nong canal, side canal of Bac Vam Nao area, Phu Xuan commune, Phu Tan district.
VN3	561.014 1.171.435	Flood control sluice at the end of Than Nong canal adjacent to Cai Tac canal. Water quality monitoring of Than Nong canal, side canal of Bac Vam Nao area, Phu Hung commune, Phu Tan district

Phytoplankton samples were collected by filtering 200 L of water through a 25 µm mesh. Concentrated samples were placed in 110 mL vials and fixed with 2-4% formaldehyde. Qualitative analysis was performed by microscopy in 10X-40X objective and imaging of phytoplankton was performed to determine morphological and structural features and classified according to [7-9]. Quantitative analyzes were performed by counting each phytoplankton according to the method of [10]. The density of phytoplankton was calculated according to the following Equation (1):

$$Y = \frac{X*V_c*1000}{N*A*V_t} \qquad (1)$$

Where: Y is phytoplankton density/(individuals/L); X is the number of phytoplankton individuals in the counted cells; Vc is the concentrated sample volume (mL); N is the number of cells counted; A is the volume of counted cells (1 mm^2) and V_t is the volume of water collected (mL).

The diversity of organisms was tested by calculating the Shannon-Wiener diversity index (H') according to the Equation (2):

$$H' = -\sum p_i \,.\, ln(p_i) \qquad (2)$$

Where: $p_i = n_i/N$; n_i is the number of individual i; N is the total number of individuals in the samples. Water quality is classified according to three pollution levels based on H' values. H'>3

indicates good water quality or unpolluted water. 1≤H'≤3 indicates moderate water pollution, H'<1 indicates heavily polluted water [11].

3. Results and discussion

3.1 Structure of species composition

Table 2. Structure of phytoplanktonspecies in Bac Vam Nao flood control area

No.	Phyla	March		September		Whole year		Overall	
		No. species	%	No. species	%	No. species	%	No. species	%
1	Cyanophyta	3	6.5	3	5.6	1	3.4	5	7.0
2	Bacillariophyta	10	21.7	11	20.4	4	13.8	17	23.9
3	Chlorophyta	13	28.3	15	27.8	11	37.9	17	23.9
4	Charophyta	1	2.2	7	13.0	1	3.4	7	9.9
5	Euglenophyta	19	41.3	18	33.2	12	41.4	25	35.2
	Total	46	100	54	100	29	100	71	100

The results of analysis of phytoplankton samples at 3 locations in the Bac Vam Nao flood control area in 2020 (Table 2) have recorded 71 species belonging to 5 different algae phyla, including Cyanophyta, Bacillariophyta, Chlorophyta, Charophyta and Euglenophyta. In which, Euglenophyta has the richest species composition with 25 species (accounted 35.2%) and the lowest is the Cyanophyta with 05 species (7%).

The results in March (dry season) recorded 46 species belonging to 5 different algae phylums, including Cyanophyta, Bacillariophyta, Chlorophyta, Charophyta and Euglenophyta. In which, Euglenophyta has the most abundant species composition with 19 species (ratio 41.3%) and the lowest is Charophyta with 01 species (ratio 2.2%). The results in September (rainy season) recorded 54 species belonging to 5 different phylums of algae, including Cyanophyta, Bacillariophyta, Chlorophyta, Charophyta and Euglenophyta. In which, Euglenophyta has the richest species composition with 18 species (33.2%) and the lowest is cyanophyta with 03 species recorded (5.6%).

The comparison between the two observations in 2020 shows that the total number of species in the September monitoring period increased compared to the March period (8 species). In which, Charophyta increased 06 species, Chlorophyta increased 02 species, Bacillariophyta increased 01 species and Eye algae decreased 01 species. Cyanophyta, Bacillariophyta, Chlorophyta, Charophyta and Euglenophyta are the algae that appear in the whole year with a total of 29 species, accounting for 40.8% of the total number of species present in both monitoring periods. The results of the variation in the number of species of algae between the two monitoring periods show that the phytoplankton at three locations in the North Vam Nao flood control area in 2020 has seasonal fluctuations, focusing mainly on into phylums adapted to weak currents and rich in organic matters. The number of phytoplankton species recorded at 3 locations in the North Vam Nao flood control area through 2 monitoring periods in 2020 ranged from 30 to 42 species, reaching the lowest and highest values at the same location at the end of Than canal, agriculture borders Cai Tac canal (VN3) in March and September, respectively. In general, the number of species at the monitoring locations of the Bac Vam Nao flood control area is higher in the rainy season than in the dry season, fluctuating from December 5 to 12 species, the most variation is at the end of Than Nong canal adjacent to Cai Tac canal (VN3).

3.2 Density and dominant species composition

The density of phytoplankton at the sites through 2 monitoring periods in 2020 ranged from 282 to 550 individuals/L in March and from 5,677 to 8,942 individuals/L in September (Table 3), reaching the lowest value and the highest at the same position at the end of Than Nong canal adjacent to Cai Tac canal (VN3) respectively in the dry season and the rainy season. The cell density recorded at the monitoring sites in the rainy season was higher than in the dry season from 5,127 to 8,660 individuals/L, the highest variation was at the end of Than Nong canal adjacent to Cai Tac canal (VN3).

Table 3. Density of phytoplankton in Bac Vam Nao flood control area

Site	Number of species		Density (individuals/L)	
	March	September	March	September
VN1	32	41	550	5,677
VN2	34	39	337	7,687
VN3	30	42	282	8,942

In the dry season, Bacillariophyta dominate at the locations in the monitoring period. In which, at the beginning of Than Nong canal adjacent to Vinh An-VN1 canal, *Cyclotella meneginiana* species predominates with the rate of 34.7% (Table 4); At the midpoint of Than Nong canal adjacent to K26 canal (VN2) and at the end of Than Nong canal adjoining Cai Tac canal (VN3), *Melosira granulata* species predominated with 16.6% and 32.3% respectively. These are typical freshwater algae species, which are not toxic or harmful, so they have little adverse impact on the aquatic environment.

In the rainy season, *Oscillatoria sp*. (Cyanophyta) is dominant at locations in the monitoring period, specifically: at the top of Than Nong canal adjacent to Vinh An canal (VN1), with the rate is 75.7%; at the midpoint of Than Nong canal adjacent to K26 canal (VN2), with the rate is 71.5%; At the end of Than Nong canal, adjacent to Cai Tac canal, VN3 dominates with the rate of 93.9%. This is a harmful algae because it often secretes toxins, causes blooms in the aquatic environment and can be detrimental to other organisms, so it is necessary to take appropriate control and treatment measures before use.

Table 4. Dominant species of phytoplankton in Bac Vam Nao flood control area

Site	March		September	
	Dominant species	%	Dominant species	%
VN1	*Cyclotella meneghiniana*	34.7	*Oscillatoria* sp.	75.7
VN2	*Melosira granulata*	16.6	*Oscillatoria* sp.	71.5
VN3	*Melosira granulata*	32.3	*Oscillatoria* sp.	93.9

From the above observation results, the species structure and dominant species composition in the Bac Vam Nao flood control area have changed markedly through 2 monitoring periods in 2020. The number of species and the density of cells in the year 2020 in the rainy season increases significantly compared to the dry season. This shows that the phytoplankton is seasonally changed.

3.3 Assessment of water quality using Shannon – Wiener biodiversity index (H')

The calculation results show that the diversity index (H') of phytoplankton at three locations in the Bac Vam Nao flood control area through two monitoring periods in 2020 ranges from 0.56 to 4.18 (Table 5), of which H' index is highest at the midpoint of Than Nong canal adjacent to K26 canal (VN2) in the dry season and lowest at the end of Than Nong canal adjacent to Cai Tac canal (VN3) in the rainy season. The diversity of phytoplankton at the monitoring sites tends to change with the seasons, the H' index in the dry season is higher than that in the rainy season. Water quality according to biological index of phytoplankton tends to decrease from “Clean” to “Pollution” at the beginning

of Than Nong canal adjacent to Vinh An canal (VN1) and at the middle of Than Nong canal borders the K26 canal (VN2). Particularly, at the end of Than Nong canal bordering Cai Tac canal (VN3), the water quality according to H' has fluctuated from "Clean" to "Very polluted" level (Table 5).

Table 5. Diversity index H' of phytoplankton in Bac Vam Nao flood control area

Site	March		September	
	H'	Predicted water quality	H'	Predicted water quality
VN1	3.51	Clean	1.56	Polluted
VN2	4.18	Clean	1.38	Polluted
VN3	3.56	Clean	0.56	Very polluted

4. Conclusion

The results show that the composition of phytoplankton has a low diversity. The species composition includes typical freshwater species and is widely distributed. In the rainy season, the species composition is more diverse than that in the dry season. The number of species and the density of phytoplankton at the monitoring sites in the rainy season were higher than that in the dry season, the highest variation was at the end of Than Nong canal adjacent to Cai Tac canal. The dominant growth species through two monitoring periods are those belonging to the Bacillariophyta and Cyanophyta. In which, Bacillariophyta species such as *Cyclotella meneginiana* species dominate at the beginning of Than Nong canal adjacent to Vinh An canal, and *Melosira granulata* species dominate at the middle position of Than Nong canal adjacent to K26 canal, and at the end of Than Nong canal adjacent to Cai Tac canal in the dry season. *Oscillatoria* sp. (Cyanophyta) dominates at all three locations in the rainy season. At the monitoring positions of the Bac Vam Nao flood control area, 01 toxic algae species and 02 harmful algae species were detected out of a total of 04 blue-green algae species. The diversity index (H') of phytoplankton at monitoring locations during the year ranges from 0.56 to 4.18, the highest at the midpoint of Than Nong canal adjacent to K26 canal in the dry season. The diversity of phytoplankton at the monitoring sites tends to change with the seasons, the H' index in the dry season is higher than that in the rainy season. Surface water quality in Bac Vam Nao flood control area according to the diversity index H' at 2/3 monitoring locations tends to decrease from "Clean" to "Pollution" level. At the end of Than Nong canal, adjacent to Cai Tac canal, VN3 tends to decrease sharply from "Clean" to "Very polluted".

The results of the study provide scientific information regarding the use of phytoplankton index for surface water quality screening. This method could help to predict quickly water quality with cheap and clean for the enviroment. However, further studies should be continued to enhance the accurracy of the method.

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