Research article

Variation of Important Nutrients Proportion on Phytoplankton Distribution in Bang-tabun Bay, Phetchaburi Province, Thailand

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Abstract Bang-tabun Bay, the estuarine area is situated close to the Phetchaburi river mouth, Phetchaburi Province. Petchaburi River flows in the west of the Kingdom and exits into the Gulf of Thailand. This research study was conducted with sample collection of aquatic environmental quality from September 2011 to May 2012. The results indicated the increasing level of NH_4^+, NO_2^-+NO_3^-, $Si(OH)_4$ and PO_4^{3-} in this area, which lead to the phytoplankton bloom phenomenon, thus, implied the mesotrophic to eutrophic status of the area. Three phyta and 54 genera of phytoplankton were discovered in the river mouth. The dominant groups were diatoms (*Thalassionema*), cyanobacteria (*Trichodesmium*), and dinoflagellates (*Ceratium*). In this study, *Ceratium* was classified to be the dominant group. Analysis of DIN:P and Si:P molar ratios of surface water were applied to examine the factors influencing the abundance of phytoplankton in the estuarine systems. Thus, the change of phytoplankton abundance should be considered to assess the water quality, and thereby more efficient aquatic environmental conservation of Bang-tabun Bay further.

Keywords nutrient proportion, phytoplankton, and Bang-tabun bay

INTRODUCTION

Bang-tabun Bay is located in the western part of the Gulf of Thailand. Petchaburi River is approximately 118 kilometer in length with the catchment of 6,219 square kilometer. Runs from Petchaburi province and flows toward the lower plain before discharging into the Gulf of Thailand (REO8, 2011). Pollution problems in the gulf can occur according to untreated municipal and industrial wastewater, eutrophication, trace metals contamination and petroleum hydrocarbon (Cheevaporn and Menasveta, 2003). Eutrophication can be defined as excessive by algae growth when high concentration of nutrients, particularly phosphates and nitrates enrich in the water body (Tantanasarit et al., 2013). The term 'harmful algal bloom' covers two characteristics that are caused by microalgae and negative impact on anthropogenic activities (Zingone and Enevoldsen, 2000). Regional Environmental Office 8 (REO8, 2011) reported that utilization of land along the

Petchaburi River was estimated to be 58% forest and 29% agricultural areas, in Phetchaburi province, respectively. Here, the river supports a resident population about 466,079 people or 1,772 people per square kilometer that related to the deterioration of water quality induced mainly by sewage, domestic discharges, and agricultural utilization (REO8, 2011). Those activities could be contributed to phytoplankton bloom phenomena along the coastal zones of this area.

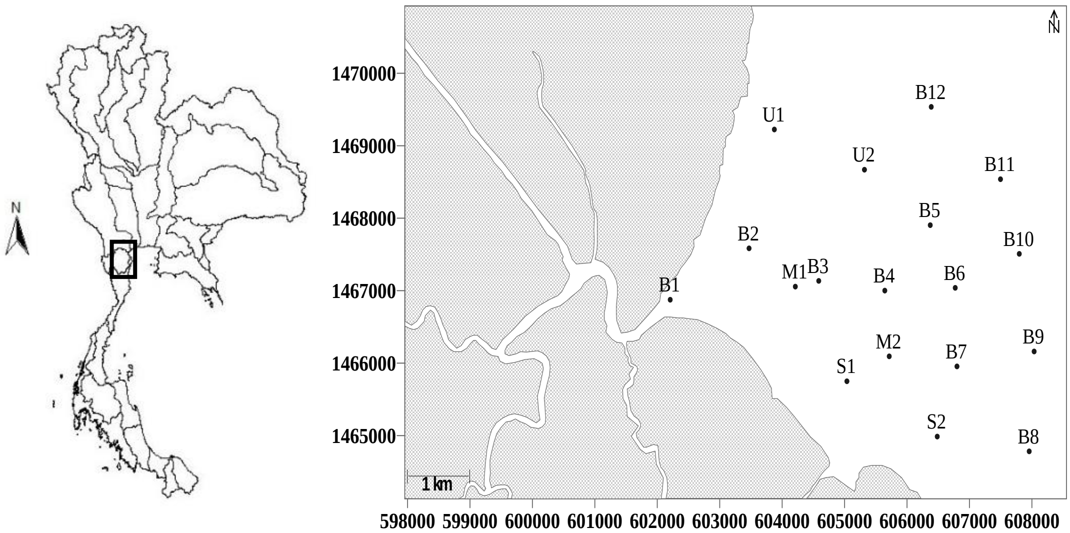
OBJECTIVE

This study aims to assess the aquatic environmental factors and related impacts by utilization to the variation of phytoplankton. The findings could be used to estimate a dissolved inorganic nutrient ratio that achieves levels for serious consideration of nutrient criteria for water resources conservation management and thereby sustainable utilization of this area.

METHODOLOGY

Sampling Sites and Survey Plan

The surveys were conducted at 18 sampling stations covered Bang-tabun Bay, the stations of which were grouped into two different characteristics: sub-tidal channel (B1-B12) and bivalve culture flat areas in the upper (U1 and U2), middle (M1 and M2), and lower (S1-S2) areas, spanning from September 2011 to May 2012 (Fig.1). According to the rainfall patterns, Thailand is under the influence of monsoon winds (TMD, 2012). The seasons can thus be divided into rainy season (May- September), and winter season (October-February).



sub-tidal channel (B1-B12) and bivalve culture flat areas in the upper (U1 and U2), middle (M1 and M2), and lower (S1-S2)

Fig. 1 Survey stations of 18 major stations within two different characteristic of Bang-tabun Bay, Petchaburi Province, Thailand

Sample Collection and Analysis

The general water quality factors, namely temperature, dissolved oxygen (DO), salinity, and pH were measured with a multi-parameter probe (YSI-6600 Sonde instrument) at the sampling sites. Samples of surface water (30 cm deep) were pre-filtered through GF/F (Whatman) and then stored at 4^{o}C before transporting to the laboratory for analysis of nutrients, including ammonium (NH_4^+), nitrite and nitrate (NO_2^-+NO_3^-), silicate ($Si(OH)_4$), and orthophosphate (PO_4^{3-}), with a SKALAR segmented flow analyzer. The samples for chlorophyll *a* (Chl *a*) and total suspended solids (TSS) measurement were analyzed by the spectrophotometric method and the freeze-dried technique, respectively. Phytoplankton samples were collected and preserved in formaldehyde buffered solution before being classified and enumerated with a Sedgewick-Rafter counting chamber under a light microscope.

Data Analysis

Comparisons of water quality in terms of temperature, salinity, DO, pH, Chl *a*, and TSS among the sampling periods and zones were performed using average levels and distribution characteristics. Least Significant Differences (LSD) or Tamhane's T2 of Post Hoc test of the one-way analysis of variance (ANOVA) was used for the environmental variation comparison, and the level of confidence greater than 95% ($p < 0.05$) was considered to indicate a statistically significant impact. The Mann-Whitney test was used where a normal distribution was not observed. The relationships between nutrients as dissolved inorganic nitrogen (DIN; NH_4^++NO_2^-+NO_3^-) and orthophosphate phosphorus (P), Chl *a*, and total phytoplankton density were analyzed using the Spearman rank correlation coefficient (r_s). In this study, a confidence interval of more than 95% ($p < 0.05$) was considered to indicate a statistically significant impact.

RESULTS AND DISCUSSION

Environmental Factors

The results indicated that freshwater runoffs had influence on water quality in the Bang-tabun Bay, which in turn contributed to varying water quality by seasonal variation. Water temperatures was slightly decreased with the seasons ($p < 0.05$), and low level of salinity was detected during September 2011 due to the large freshwater discharges into the Bang-tabun Bay. The pH level varied from 7.22 to 8.67 for the entire study area. DO varied and was markedly decreased to unsuitable levels (< 4 mg/l) during the rainy season. Levels of TSS and Chl *a* were between 5.40 to 147.65 mg/L and 3.58 to 29.64 μg/L, respectively, with the both of highest levels in May 2012. Thongdonphum et al. (2011) reported that Chl *a* of approximately 10 μg/L has been regarded as the initial level for eutrophication in the estuarine zone. The Mae Klong River (in the eastern part), had Chl *a* levels 1.34 to 14.69 μg/L (Thongdonphum et al., 2013), while the Tha Chin Estuary, located closely to the study area, had a very high levels of Chl *a* in excess of 20 μg/L and reached 535 μg/L when *Noctiluca* red tide outbreak is occurred (Meksumpun and Meksumpun, 2008).

Table 1 Water quality (mean±SD) in the Bang-tabun Bay during the study periods

Parameters	Study periods		
	September 2011	December 2011	May 2012
Temp (°C)	30.65 ± 0.95	25.27 ± 0.64	30.92 ± 0.63
Salinity (psu)	18.17 ± 5.17	21.70 ± 1.11	21.64 ± 2.96
DO (mg/L)	6.03 ± 2.74	7.79 ± 0.95	3.41 ± 0.58
pH	7.89 ± 0.31	8.49 ± 0.15	7.47 ± 0.13
Chl *a* (μg/L)	11.98 ± 4.92	10.39 ± 5.07	12.31 ± 5.83
TSS (mg/L)	20.45 ± 16.37	15.68 ± 13.34	78.98 ± 45.67
NH_4^+ (μM)	30.71 ± 11.25	43.25 ± 13.98	40.98 ± 8.82
NO_2^-+NO_3^- (μM)	6.01 ± 4.17	2.78 ± 2.62	8.00 ± 2.84
$Si(OH)_4$ (μM)	126.65 ± 52.07	68.15 ± 28.47	137.98 ± 32.88
PO_4^{3-} (μM)	2.77 ± 1.58	2.00 ± 1.29	3.53 ± 0.78

The levels of NH_4^+ and NO_2^-+NO_3^- varied significantly ($p < 0.05$) with seasons. Levels of NH_4^+ varied from 13.89 to 71.86 μM, with the highest level found in December 2011. NO_2^-+NO_3^- concentrations ranged between undetectable to 15.82 μM. High concentration levels were found in

September 2011, which was probably the results of land utilization of agriculture, of which rice fields and aquaculture areas that covering the river mouth (REO8, 2011). $Si(OH)_4$ concentrations ranged from 24.94 to 241.72 μM with high concentration levels particularly in the rainy season ($p < 0.05$). PO_4^{3-} levels ranged from 0.63 to 5.65 μM with noticeably higher levels than the recommended level of 0.48 μM from the ASEAN marine water quality (Chongprasith et al., 1999).

Phytoplankton Distribution

Phytoplankton community variation was related to local nutrient loads and hydrographic condition, turbulence and human impact (Álvarez-Góngora and Herrera-Silveira, 2006). The phytoplankton community consisted of 54 genera, namely 4 Cyanophyceae, 7 Chlorophyceae, 33 Bacillariophyceae (diatoms), 1 Dictyochophyceae, and 9 Dinophyceae (dinoflagellate). The amount of phytoplankton varied from 180 to 1.37×10^5 unit cells/L with the highest density in December 2011. The results showed that dinoflagellate was the most dominant group. Other species, such as *Trichodesmium* sp., *Protoperidinium* sp., and *Noctiluca scintillans*, were also found, while *Ceratium* sp. was dominant species when the red tide phenomenon is occurred. The results of statistical analysis implied that dissolved inorganic nutrients had influenced on phytoplankton density. Spearman rank correlation coefficient (r_s) indicated that phytoplankton density highly significant ($p < 0.01$) received enhancement from NO_2^-+NO_3^-, $Si(OH)_4$, and PO_4^{3-} (r_s = -0.762, -0.745, and -0.484, respectively). Those nutrients play the key roles of phytoplankton blooming, while NH_4^+ concentration were surplus for phytoplankton growth in this area.

Nutrients Proportion for Phytoplankton

The results of nutrient proportion were calculated for dissolved inorganic nitrogen (DIN; NH_4^++NO_2^-+NO_3^-), orthophosphate (P; PO_4^{3-}) and silicate (Si; $Si(OH)_4$) and compared with Redfield ratios of N:Si:P (16:16:1) based on the work of Brzezinski (1985). The results of DIN:P and Si:P molar ratios varied by season and were mostly higher than Redfield ratios, especially in December 2012 when there is an accumulation process in the water column. In this study, the levels of DIN:P ratios had related to phytoplankton density with the power function of $Y = 828.1e^{0.109X}$ in which $r^2 = 0.344$, when Y = phytoplankton density and X = DIN:P levels (Fig. 2). Such variation reflected high load of nutrients that involved the natural runoff and agricultural land uses which was consequentially influence such nutrient loads (Thongdonphum et al., 2011). Thus, PO_4^{3-} levels could be monitored and used for managing water quality.

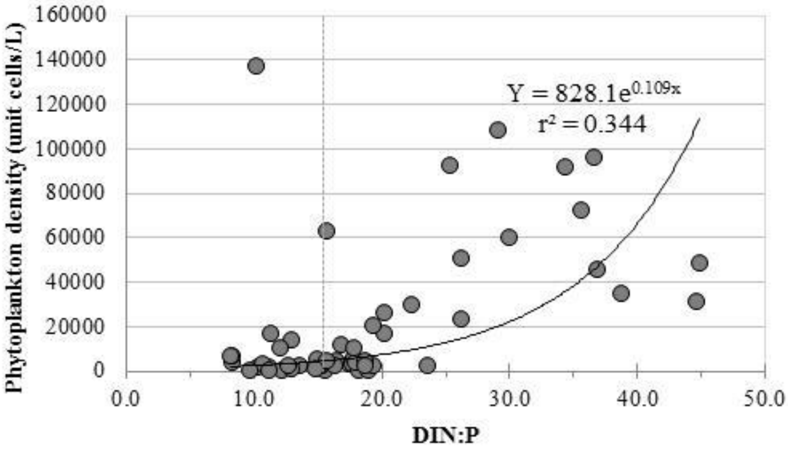


Fig. 2 Relationships between of DIN:P ratios and phytoplankton density found in the Bang-tabun Bay during study periods

CONCLUSION

This study has revealed that phytoplankton can play an important role in nutrients, particularly phosphate from the water column as the crucial influencing factor of phytoplankton growth. DIN levels were surplus for the Bang-tabun Bay. The levels of phosphate could be used to monitor and manage eutrophication and/or red tide phenomenon. The study results could be applied to estimate the level of phytoplankton density for more efficient management of water resources and utilization.

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