Faculty of Resource Science and Technology

THE COMPOSITION AND BIOMASS OF PHYTOPLANKTON AT KAMPUNG MANGGUT, BATANG SARIBAS

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ABSTRACT

A study was carried out on the composition and biomass of phytoplankton at Kampung Manggut, Batang Saribas. Results showed that the number of diatoms was higher than dinoflagellates. The distribution of the phytoplankton was influenced by depth, station and other chemical factors such as phosphorus (PO_4^{3-}), ammonium (NH_4^+), nitrate (NO_3^-) and silicate (Si) concentrations. The phytoplankton was abundant at Station 2 (Tanjung Keranji) and 4 (Tanjung Baring). The dominant genera of diatoms found were *Coscinodiscus*, *Nitzchia*, *Navicula*, *Biddulphia*, *Pleurosigma* and *Lauderia*. The phytoplankton biomass (chlorophyll *a*) was higher at Station 2 and 5 (Kampung Serembang). Correlation analysis indicated that a chlorophyll a concentration was not significantly correlated with the chemical parameters either during ebbing or flooding tide.

Keywords: Diatom, Dinoflagellate, Phytoplankton biomass, Physico-chemical factors.

ABSTRAK

Kajian tentang komposisi fitoplankton dan biojisim di Kampung Manggut, Batang Saribas telah dijalankan. Keputusan telah menunjukkan bahawa bilangan diatom adalah lebih tinggi daripada dinoflagelat. Taburan fitoplankton telah dipengaruhi oleh kedalaman, stesen dan faktor kimia yang lain seperti fosforus (PO_4^{3}), ammonia (NH_4^+), nitrat (NO_3^-) and silikat (Si). Fitoplankton adalah lebih banyak di Stesen 2 (Tanjung Keranji) dan 4 (Tanjung Baring). Genera diatom-diatom dominan yang telah ditemui adalah Coscinodiscus, Nitzchia, Navicula, Biddulphia, Pleurosigma *and* Lauderia. *Walau bagaimanapun, biojisim fitoplankton (klorofil* a*) adalah tinggi di Stesen 2 dan 5 (Kampung Serembang). Analisis korilasi menunjukkan bahawa kepekatan klorofil* a *tidak mempunyai korelasi signifikan dengan parameter kimia sama ada semasa air surut atau pasang.*

Kata kunci: Diatom, Dinoflagelat, Biojisim fitoplankton, Faktor fiziko-kimia.

INTRODUCTION

River is a major aquatic habitat especially for fishes, sea grass, algae and small organisms such as plankton and bacteria. Rivers in Sarawak are very important to those who stayed along the riverside, for their food sources, socio-economic activities, transportation and water supplies, including sewage disposal. In Sarawak, rivers have become a port for commercial fisheries landing; for example contributed about 12% of local annual landing from Sungai Sibu Laut, Kuching (UKM, 1995).

Phytoplankton is a microscopic organism with a diameter in the range of 5µm - 500µm. This primary producer is very important in food chain within the freshwater, brackish and marine ecosystem. Phytoplankton is a holoplanktonic organism that belongs to a plankton group. Generally, this group lives in deeper water or sea floor based on tropic states and other factors that can influence their survival. Phytoplankton can also be used as an indicator in a water quality assessment.

According to Huszar and Caraco (1998), the composition of freshwater phytoplankton can be divided into three kingdom and seven divisions, but only six divisions are usually considered – cyanobacteria, chlorophytes, diatoms, chrysophytes, dinoflagellates and cryptophytes. Phytoplankton reproduces by cell fission to perpetuate their species. Diatoms have great frustules to protect the inner contents and which cannot decay although the cell is dead. As primary producers, phytoplankton can transformed the light energy to a chemical energy in aquatic ecosystem through a process of photosynthesis (Spector, 1984). They can also migrate vertically by using flagella and some independent locomotion (Staker and Bruno, 1980).

Chlorophyll *a* is the main green pigment for photosynthesis process. Chloroplast will absorb the sunlight to encourage the photosynthesis for survival. According to Sumich (1999), some phytoplankton species can produce more chloroplast to improve their ability to absorb light or the chloroplast will moved closer to the cell edges.

This study was carried out to determine the composition of phytoplankton and its biomass distribution (chlorophyll *a*) in Batang Saribas. The relationship between chemical factors with the chlorophyll *a* was also determined.

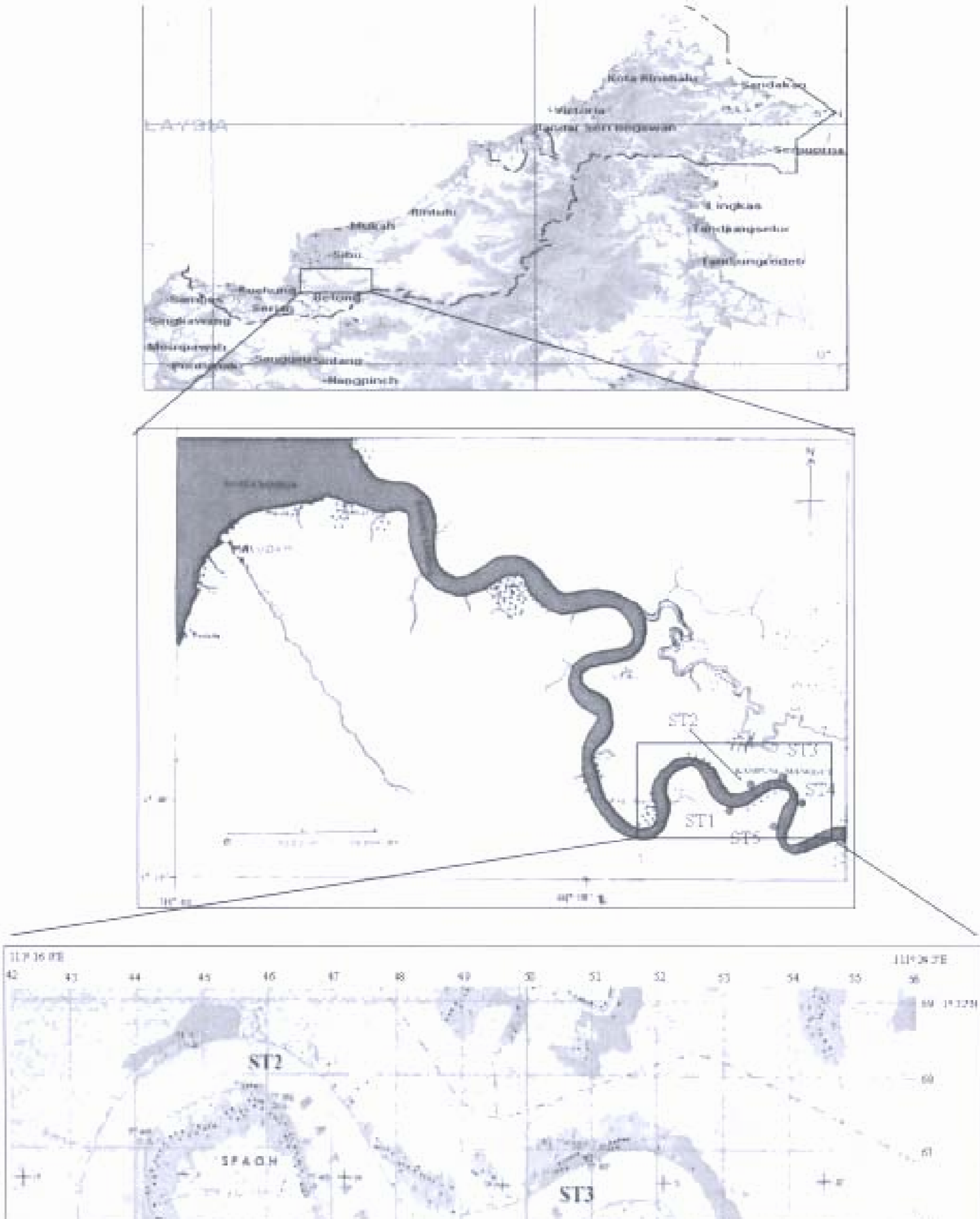
MATERIALS AND METHODS

Study Area

This study was carried out in Batang Saribas (Lat. $1^{0}51.0$'N, Long. $111^{0}35.0$'E), near Spaoh, Sarawak (Figure 1). Along this river, five midstream-sampling stations each at 2-km apart were established, beginning at Kampung Supa (Station 1) and brought up to the upstream (Station 2, 3, 4 and 5). The coordinates of these stations were determined using a map and Global Positioning System (GPS). The coordinates and depth of each sampling stations during ebbing and flooding tide are shown in Table 1. The samplings were carried out once, in August 2003.

Table 1: The location of sampling stations along Batang Saribas

STATION	LATITUDE (N)	LONGITUDE (E)	DEPTH (m)	
			FLOODING TIDE	EBBING TIDE
1	01^{0} 48'	111^{0} 39'	5.0	9.7
2	01^{0} 30'	111^{0} 23'	6.0	8.4
3	01^{0} 51'	111^{0} 35'	5.0	9.5
4	01^{0} 52'	111^{0} 32'	4.9	3.6
5			4.1	8.4



Scale 1cm: 25km

Figure 1: The map shows the location of the sampling stations (ST1, ST2, ST3, ST4, and ST5) along the Batang Saribas

Background of Batang Saribas

Batang Saribas is connected with Batang Layar, which then flows through the estuary into the South China Sea. There are many villages along the river such as Kampung Supa, Kampung Serembang and Kampung Manggut. This brackish river is surrounded by mangrove swamps, which is dominated by *Rhizophora* sp., *Avicenna* sp., *Xylocarpus* and *Nipa fructicans*. Batang Saribas is also influenced by tidal cycle and has a wide mudflat area during ebbing tide.

A very special attraction to the Batang Saribas is the presence of golden puffer fish (*Arothon*). This fish normally come to this area between July and September. The existence of this fish inspired the State Government of Sarawak for organizing the *Pesta Ikan Buntal* at Batang Saribas (Sarawak Tribune, 2002) on 26th August 2003.

Field Sampling

Phytoplankton Cells

At each station, a duplicate (n=2) water samples were collected using a Van Dorn water sampler at three different depths during ebbing and flooding tide. The water samples were filtered immediately using a 20µm sieve to collect the phytoplankton cells samples, and then stored in 100-mL opaque polyethylene bottles and preserved with Lugol's solution. The phytoplankton samples were brought back to the laboratory in a cooler box. One millimeter of the sample was transferred to a *Sedgewick Rafter Counting Chamber* and phytoplankton cells were counted under the compound microscope. Phytoplankton cells were identified until a generic level only.

Chlorophyll **a** *Analysis*

For chlorophyll *a* analysis, duplicate 1 liter (n=2) water samples were taken using a Van Dorn water sampler at three different depths during ebbing and flooding tide. The water samples were stored in an opaque polyethylene bottles and then brought back in a cooler box. These samples were filtered through 0.45μm membrane filter in the dark to avoid pigment breakdown. During the filtration, pressure used was not exceeded of 0.3atm to avoid rupture and deformation of small, delicate phytoplankton cells. Few drops of magnesium carbonate ($MgCO_3$) were added during filtration to prevent acidity on the filter and degradation of chlorophyll *a* (Parson *et al.*, 1984).

The membrane filters that contained phytoplankton samples were immersed in 15mL 90% acetone solution in a separate screw-cap tubes for chlorophyll *a* extraction. These tubes were covered with an aluminum foil and then stored in the refrigerator at 2^0C for 24 hours. The tubes were brought back to a room temperature and the volume of extract was brought up to the original level by addition of 90% acetone. The cells and the remaining filter paper were grinded using a glass tissue grinder. The samples were later centrifuge at 4000rpm in room temperature for 10 minutes.

The supernatant was decanted into a 1cm path length glass cuvette and the absorbance of chlorophyll *a* extract was measured at 750, 664, 647 and 630nm wavelength using PRIM Light and Advanced (SECOMAM) Spectrophotometer. The concentration of chlorophyll *a* pigment was then determined according to Parson *et al.* (1984).

Physicochemical Parameters

The physicochemical parameters of the river water such as temperature, salinity, pH dissolved oxygen (D.O.), transparency, and nutrients (phosphate (PO_4^{3-}), ammonium (NH_4^+), nitrate (NO_3^-)) were obtained from Magdelyn (2004), while data for silicate (Si) was taken from Azizah (2004).

Data Analysis

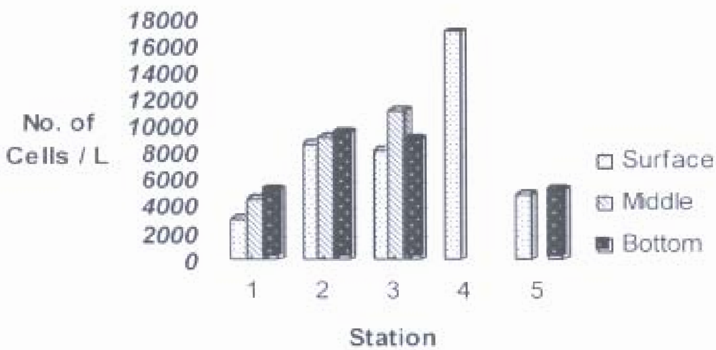
The number of phytoplankton cells, mean of chlorophyll *a* and physicochemical parameters were obtained from the duplicate samples at each depth (n=2). Comparison of mean of chlorophyll *a* concentration at each station and depths were carried out using a Two-way ANOVA (SPSS software statistical package Ver.11.5 (SPSS Inc., Chicago)). Correlation was also used to relate the chlorophyll *a* concentrations with nutrient concentrations (phosphorus, ammonium, nitrate and silicate).

RESULTS

Phytoplankton Cells

Figure 2 shows the number of phytoplankton (diatoms and dinoflagellates) at the study areas, sampled during ebbing and flooding tide. During ebbing tide, diatoms were more abundant at the Station 4 (surface water) but less at Station 1. However, the number of dinoflagellates was highest at the bottom layer at Station 1 and less at the bottom of Station 5.

(A)



(B)

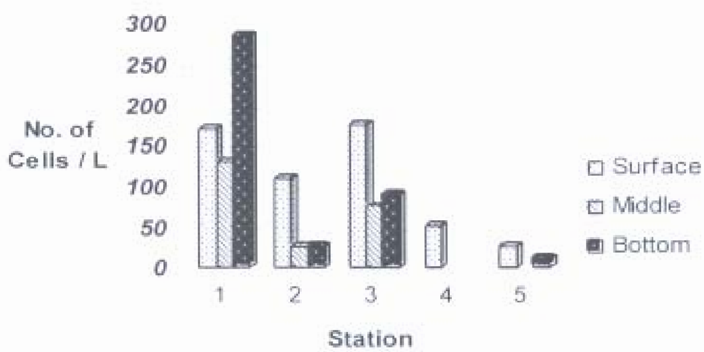
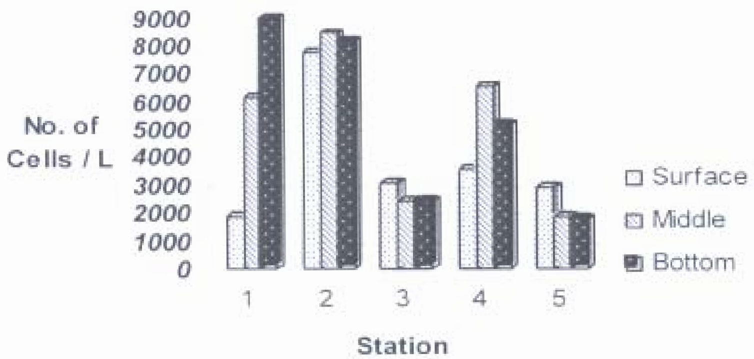


Figure 2: Number of diatoms (A) and dinoflagellates (B) cells at each station during ebbing tide.

Figure 3 shows the distribution of diatoms at each station during flooding tide. Generally, the diatoms were more abundant at Station 2 but less at Station 3 and 5. The highest number of diatoms was found in the bottom water at Station 1 and 2. Dinoflagellates however were only abundant in surface water at Station 3.

(A)



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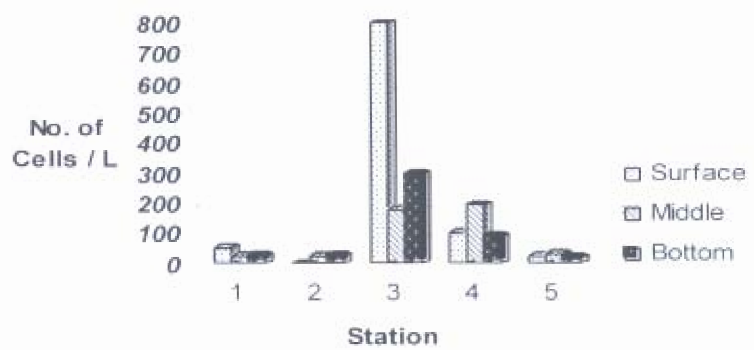


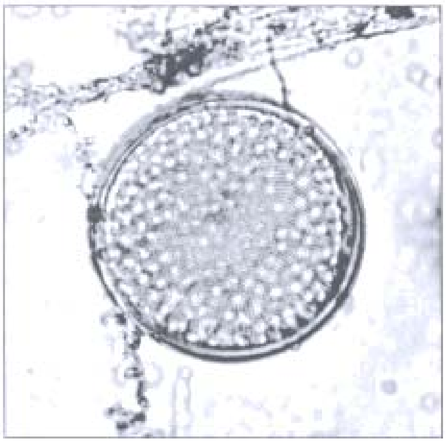
Figure 3: Number of diatoms (A) and dinoflagellates (B) cells at each station during flooding tide.

Dominant Genera of Diatoms

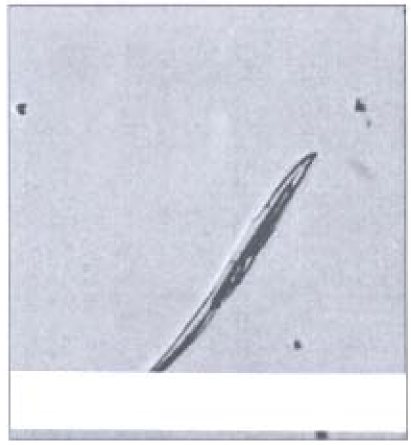
The dominant genera of diatoms at different tide levels and stations are shown in Table 2. The most widespread genera found at each station were *Coscinodiscus*, *Nitzchia*, *Navicula*, *Biddulphia*, *Pleurosigma* and *Lauderia*. Some of the representatives of these genera are shown in Figure 4.

Table 2: Dominant genera of phytoplankton sampled during ebbing and flooding tides at different station

STATION	GENUS	
	EBBING TIDE	FLOODING TIDE
1	*Coscinodiscus*	*Coscinodiscus*
	Nitzchia	*Nitzchia*
	Navicula	*Navicula*
	Biddulphia	*Biddulphia*
	Lauderia	*Lauderia*
2	*Coscinodiscus*	*Coscinodiscus*
	Nitzchia	*Nitzchia*
	Navicula	*Navicula*
	Biddulphia	*Lauderia*
	Lauderia	*Biddulphia*
3	*Coscinodiscus*	*Nitzchia*
	Nitzchia	*Coscinodiscus*
	Biddulphia	*Navicula*
	Pleurosigma	*Biddulphia*
	Navicula	*Pleurosigma*
4	*Nitzchia*	*Nitzchia*
	Coscinodiscus	*Coscinodiscus*
	Navicula	*Navicula*
	Pleurosigma	*Pleurosigma*
	Chaetoceros	*Lauderia*
5	*Nitzchia*	*Nitzchia*
	Coscinodiscus	*Coscinodiscus*
	Pleurosigma	*Navicula*
	Navicula	*Pleurosigma*
	Biddulphia	*Biddulphia*



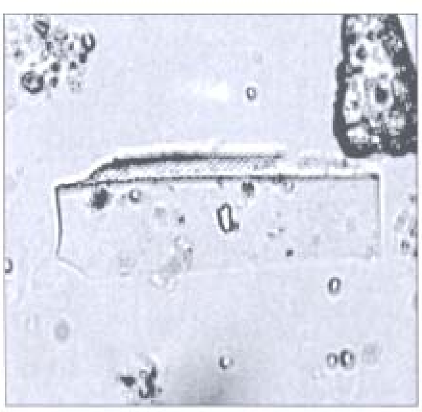
(a)



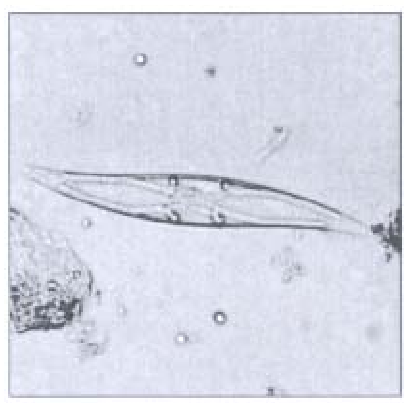
(b)

(c)

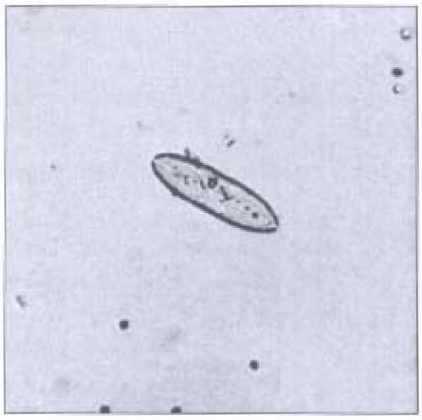
(d)



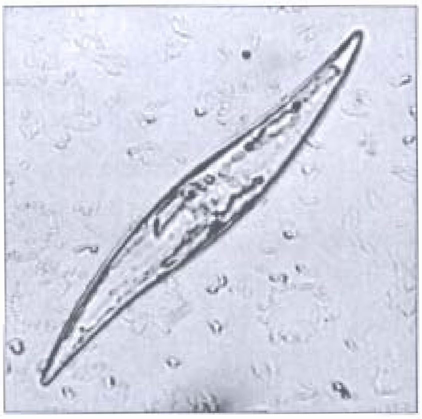
(e)

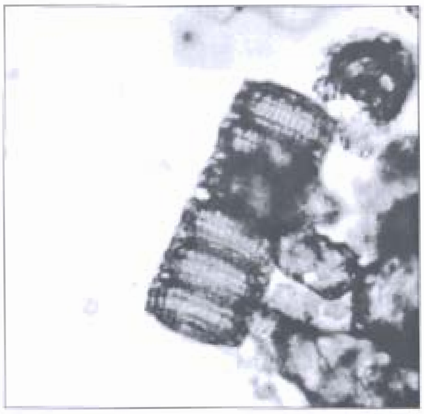


(f)

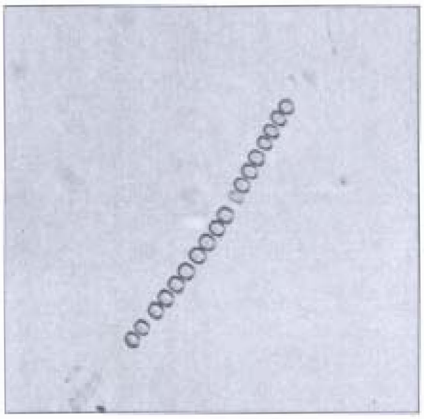


(g) (h)





(i) (j)



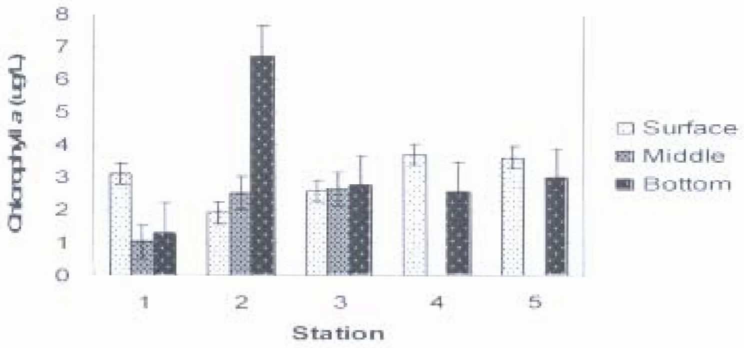
(k) (l)

Figure 4: Images of some representative genera of diatoms – (a) *Coscinodiscus*, (b) *Nitzchia*, (c) *Navicula*, (d) *Biddulphia*, (e) *Lauderia*, (f) *Pleurosigma*, (g) *Achnanthes*, (h) *Rhizosolenia*, (i) *Gyrosigma*, (j) *Melosira*, (k) *Thalasionema* and (l) *Thalasiosira* (40X magnification).

Chlorophyll *a*

The chlorophyll *a* concentrations at the study site are shown in Figure 5. During ebbing tide, the peak value was 6.37μg/L which occurs in the bottom water at Station 2, and minimum value (1.03μg/L) occurred in the middle water at Station 1. There was a significant different in chlorophyll *a* concentrations between Station 1, 2, 4 and 5 at all selected depths ($p < 0.05$) (Table 3). However at flooding tide, the highest mean concentration of chlorophyll *a* was 3.87μg/L in surface water at Station 3 and minimum (0.15μg/L) in surface water at Station 1. There was a significant different in chlorophyll *a* concentration between all stations ($p < 0.05$) (Table 4).

(A)



(B)

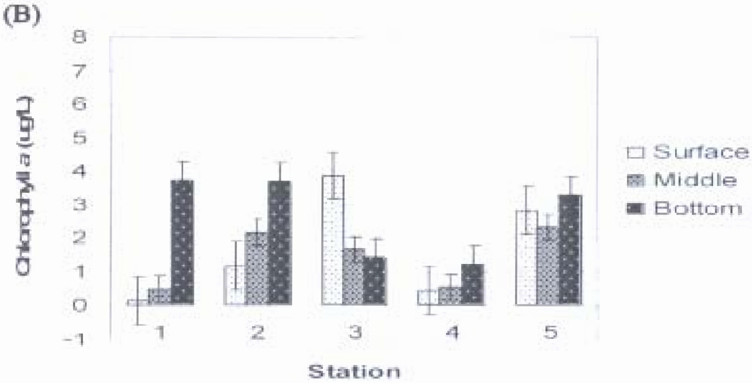


Figure 5: Mean concentration of chlorophyll a during ebbing (A) and flooding tide (B) in different depths at each station. Vertical bars indicate the mean ± 1.00 S.E. (n=2)

Table 3: Two way ANOVA analysis for chlorophyll *a* on different station during ebbing tide.

Source of Variation	SS	df	Mean Square	F	$p<0.005$
Station	11.134	4	2.783	6.765	0.004
Depth	4.395	2	2.197	5.341	0.020
Interaction	29.911	6	4.985	12.117	0.000

Table 4: Two way ANOVA analysis for chlorophyll *a* on different station during flooding tide.

Source of Variation	SS	df	Mean Square	F	$p<0.005$
Station	16.485	4	4.121	8.487	0.001
Depth	8.326	2	4.163	8.573	0.003
Interaction	22.531	8	2.816	5.800	0.002

Correlation

Result from the correlation analysis (Table 5 and 6) showed that there was no significant correlation between chlorophyll *a* (phytoplankton biomass) and nutrients (i.e. phosphate, ammonium, nitrate and silicate) both during ebbing and flooding tides.

Table 5: The correlation between different parameters (chlorophyll *a*, phosphorus, ammonium, nitrate and silicate) measured during ebbing tide

Parameters	Chl *a*	PO_4^{3-}	NH_4^+	NO_3^-	Si
Chl *a*	1.000	.209	-.201	-.369	.269
PO_4^{3-}	.209	1.000	-.342	-.152	.187
NH_4^+	-.201	-.342	1.000	.274	.226
NO_3^-	-.369	-.152	.274	1.000	-.164
Si	.269	.187	.226	-.164	1.000

Table 6: The correlation between different parameters (chlorophyll a, phosphorus, ammonium, nitrate and silicate) measured during flooding tide

Parameters	Chl *a*	PO_4^{3-}	NH_4^+	NO_3^-	Si
Chl *a*	1.000	.430	.363	.083	.129
PO_4^{3-}	.430	1.000	-.212	.062	.206
NH_4^+	.363	-.212	1.000	.052	.300
NO_3^-	.083	.062	.052	1.000	.022
Si	.129	.206	.300	.022	1.000

DISCUSSION

Phytoplankton is an aquatic organism that is very important as a food sources for fishes and zooplankton in freshwater, brackish and marine water. Distribution of the phytoplankton such as diatom may be influenced by the temperature, salinity, pH and nutrients (phosphate (PO_4^{3-}), ammonium (NH_4^+), nitrate (NO_3^-) and silicate (Si)).

According to Elizabeth and Amha (1994), a very good reason for higher ratio of chlorophyll *a* in deeper water to phytoplankton distribution is degradation products and increased chlorophyll *a* content per cell with depth. Basically, higher chlorophyll *a* concentration (phytoplankton biomass) indicates the major distribution of phytoplankton cells, either diatoms or dinoflagellates in the water column such as in Station 2 and 5. Pigment content of phytoplankton cells are relatively higher in deeper waters than those light exposed in the surface water (Reynolds, 1984; Elizabeth & Amha, 1994).

The number of phytoplankton was higher at Station 2 and 4 during flooding and ebbing tide. The exposure to adequate light and temperature encouraged the growth and photosynthesis process of the phytoplankton. However, high light and temperature can also break and destroy the chloroplast. Total number of phytoplankton cells in Station 3 also at a higher rate. Phytoplankton samples were not taken in the mid- and bottom water at the Station 4 and in the mid-water at Station 5 during ebbing tide because the water was too shallow.

Nutrients such as phosphate (PO_4^{3-}), ammonium (NH_4^+), nitrate (NO_3^-) and silicate (Si) are the major regulators on phytoplankton abundance and composition (Hecky & Kilham, 1988; Howarth et al., 1988; Fisher et al., 1995; Hashimoto & Nakano, 2003). Phosphorus, which is available in the form of phosphate (PO_4^{3-}), is an important factor that encouraged the phytoplankton growth especially for diatoms. The influx of detergents from laboratories and household discharge increased the amount of phosphorus in the water system. The unexpected phytoplankton growth caused the algal blooms. In this study, correlation analysis shows direct rate between chlorophyll *a* and phosphorus. That is mean, when the phosphorus contents increased, the concentration of chlorophyll *a* was higher. Phosphorus has been used to predict the taxonomic composition of phytoplankton at the division level (Smith, 1986; Trimbee & Prepas, 1987; Sandgren, 1988; Canfield *et al*., 1989; Jensen *et al*., 1994; Watson *et al*., 1997; Huszar, 1998).

According to Huszar and Caraco (1998), diatoms were positively correlated with pH, dissolved oxygen and total nutrients. However, green algae would decrease when ammonium (NH_4^+) and total nutrients are higher. The presence of ammonium may indicate the influx of organic material such as sewage, organic chemical and waste and organic decomposition (Choong, 1998). Results from the present study showed that the ammonium was lower than the chlorophyll *a* concentration in Batang Saribas, while, the comparison in correlation showed the increasing of ammonium can decrease the concentration of chlorophyll *a*.

Higher concentration of silicate (Si) could increase the growth and abundance of diatoms (Harris & Baxter, 1996). During the present study, the concentration of silicate was higher than the concentration of ammonium and phosphate which may encourage the diatom growth. This led to high abundance of diatom at the study areas especially at Station 1, 2 and 4. Higher concentration of silicate showed the higher concentration of phosphorus in the correlation analysis in the present study. However, both of these nutrients (silicate and phosphorus) showed the benefit and important in phytoplankton abundance and growth.

The present study showed the inverse relationship between nitrate (NO_3^-) and salinity during ebbing tide. Elizabeth and Amha (1994) stated that the phytoplankton growth and chlorophyll *a* declines when the nitrate becomes depleted in a high salinity water. The relationship between nitrate and silicate varied during flooding and ebbing tide in this present study. This is caused by the effluent of freshwater into the seawater. In this study, nitrate concentration was higher at the nearby estuary (Kampung Supa) but the salinity and chlorophyll *a* concentration was lower.

Besides of these nutrients, temperature and salinity may influence the abundance and distribution of phytoplankton. In this study, correlation analysis showed the inverse relation among temperature, phosphate and salinity. Bouman (2003) stated that the phytoplankton community structure is likely regulated by temperature of the water. In the present study, the inverse relation can be observed among salinity with phosphate and ammonium in the correlation analysis. Temperature is an important indicator of the physicochemical properties of the marine environment to the dynamics of plankton community, such as water column stability and nutrient availability (Carder *et al.*, 1999; Sathyendranath, *et al.*, 2001; Bouman *et al.*, 2003).

The higher salinity near to the river mouth likely influenced the mixing of water from upstream and sea during tidal period. According to Elizabeth and Amha (1994), nutrient supply of the water was also contributed by a rainfall and drainage from the catchment's areas during rainy season especially in large river system. The outflow of freshwater into the seawater may influence the salinity concentration in this study area. In the previous study in Mississippi River, nitrate concentration was higher at the nearby estuary but low in salinity and chlorophyll *a* concentration (Liu & Dagg, 2003). The present study showed that the salinity was higher at Station 1 but decreased at the Station 2, 3, 4 and 5.

CONCLUSION

The results in this study showed the composition and biomass of phytoplankton at Kampung Manggut, Batang Saribas. Generally, the number of diatoms was dominated the study area than the dinoflagellates. The genera of diatoms, such as *Coscinodiscus* spp., *Nitzchia* spp., *Navicula* spp., *Biddulphia* spp., *Pleurosigma* spp. and *Lauderia* spp. were widespread in this study.

This present study showed that the diatoms were more abundant at the Station 4 (surface water) but less at Station 1, while the dinoflagellates were highest at the bottom layer at Station 1 and less at the bottom of Station 5 during ebbing tide. During flooding tide, the diatoms were more abundant at Station 2 but less at Station 3 and 5, while the dinoflagellates were only abundant in surface water at Station 3.

In the chlorophyll *a* analysis, there was a significant different in chlorophyll *a* concentrations between Station 1, 2, 4 and 5 at all selected depths ($p < 0.05$) during ebbing tide while the chlorophyll *a* concentration was significantly different between all stations ($p < 0.05$).

Changes of chemical parameter such as phosphate (PO_4^{3-}), ammonium (NH_4^+), nitrate (NO_3^-) and silicate (Si) may affect the number of phytoplankton and its biomass. However, the correlation analysis showed that there was no significant different between chemical factors such as phosphate, ammonium, nitrate and silicate with chlorophyll *a* concentration.

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