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Original Article

Variation of phytoplankton biomass as Chlorophyll a in Banglang Reservoir, Yala Province

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Abstract

Environmental variables and phytoplankton biomass as chlorophyll a in Banglang Reservoir were investigated. Phytoplankton were collected monthly from May 2000 to April 2001 from four sampling sites including the inflow from Pattani River (from Betong District), the inflow site from Balahala Forest, the middle of the reservoir, and at the spillway that helds the water before drain. Samples were taken at three levels: water surface,10 meter, and 30 meter depth. Physico-chemical parameters were recorded such as nutrients (nitrogen and phosphorus), Secchi depth, alkalinity, temperature, pH, and turbidity. The results show that the average values of phytoplankton biomass at 10 meter depth were higher than that of the other depths. The maximum phytoplankton biomass was found at 10 meter depth at the inflow from the Balahala Forest sampling site in August, with a value of 12.57 mg/m^3. The minimum value was found at 30 meter depth in the middle of the reservoir in July. Factors affecting the variation of phytoplankton biomass in the Banglang Reservior were ammonia, alkalinity and turbidity.

Keywords: Chlorophyll a, water quality, Banglang Reservoir

1. Introduction

One of the most important living organisms in the aquatic ecosystem is phytoplankton. Phytoplankton, the primary producer, plays an important role in the material circulation and energy flow in the aquatic ecosystem. Its presence often controls the growth, reproduction capacity and population characteristics of other aquatic organisms. Thus, investigations of phytoplankton are essential for the evaluation of the water environment. Beyond primary producers, phytoplankton helps to purify dirty water or to improve the water quality by transforming inorganic matter into organic substances (Graham and Wilcox, 2000). Rapid growth of large amounts of phytoplankton (bloom) can result in deoxygenation, which leads to the catastrophic deaths of fish and other aquatic life. Planktonic bloom could also be responsible for changes in water color and objectionable smell that makes water reservoir unusable and unpleasant appearance.

Environmental and phytoplankton investigation in Banglang Reservoir have been carried out since 1985 (Choo-kajorn, 1985). The reservoir has a low abundance of species and a species composition (13 species) with a mesotrophic nutrient level. Ariyadej *et al*. (2004) reported that the Banglang Reservoir has a low production of phytoplankton biomass, a low phytoplankton density, and low nutrient con-centrations. However, the determination of phytoplankton biomass can be investigated in many ways; one is to measure chlorophyll a that is the fastest chemical measuring method

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(Vonshak, 1986) and chlorophyll a is a well accepted index for phytoplankton abundance and population of primary producers in an aquatic environment (Cambevy'rer *et al.*, 2005). Hence, the results are useful for the management of the Banglang Reservoir regarding the physical, chemical and biological conditions of the water. The principal aims of this research were to determine phytoplankton biomass as chlorophyll a and to study the relationships between chlorophyll a and physico-chemical factors in the Banglang Reservoir.

2. Site description

The Banglang Reservior (Figure 1) is the result of a dam built across the Pattani River at Ban Banglang, Sub-District Bajao, Bannang Star District, Yala Province. The dam is rock filled with clay core, located in the south of Thailand at 6º 9' 12.83'' N and 101º 16' 32.91'' E. The water storage area is 2.08 km^2, the crest is 120 m high, with a maximum water level of 115 m and a minimum of 83 m above sea level. The sedimentary rate is 0.4 million m^3 per year. This reservoir was constructed in 1981, being used mainly for urban water supply and irrigation as well as recreation and tourism purposes (Electric Generating Authority of Thailand, 1981). The reservoir has two major inflows, one from Balahala Florest (RB) and the other from the Pattani River (RP). Since the reservoir is situated in the Indochina Peninsula belt with northwestern monsoon, there is a long rainy season from May to December (8 months) and short summer phase from February to May (4 months) (http://www.tmd.go.th/programs/uploads/yearlySummary/weather2549-e.pdf)

3. Materials and Methods

Samples were taken monthly from May 2000 to April 2001 at four sites: inflow from Balahala Forest (RB), inflow from Pattani River (RP), the middle of the reservior (TZ), and at the spillway where the water is held before drain (LZ) (Figure 1). Water samples were collected at 0 m (water surface), 10 m and 30 m water depth at each sampling site using a Rattner water sampler of 1 liter and then filled into polyethylene bottles. The samples were kept in a cold container for further analysis. Analysis for measuring dissolved oxygen (DO) was titration based on Azide modification method, nitrate-nitrogen (NO_3-N) based on Cadmium reduction method, ammonia-nitrogen (NH_4-N) on Phenate method, phosphate phosphorus (PO_4-P) and total phosphorus (TP) based on Ascorbic acid method, alkalinity (ALK) by titration based on Sulfuric acid using Nepthyl-orange as indicator, turbidity with HACH model 2100 AN set. Water temperature (WAT), pH and Secchi depth (SD) were measured *in situ*. Chlorophyll a concentrations were determined and then used as an estimate of the phytoplankton biomass. Samples were taken with Ratter water sampler of 1 liter from different depths and filtered through a glass fiber filter (GF/C) with handle pump. The filtered papers were wrapped with foils and transported to the laboratory in a cold container. Chlorophyll a concentrations were measured after extraction with 90% acetone using spectrophotometric method according to the APHA, AWWA and WPCF (1998).

4. Statistical Analysis

Principal Components Analysis (PCA) in Multivariate

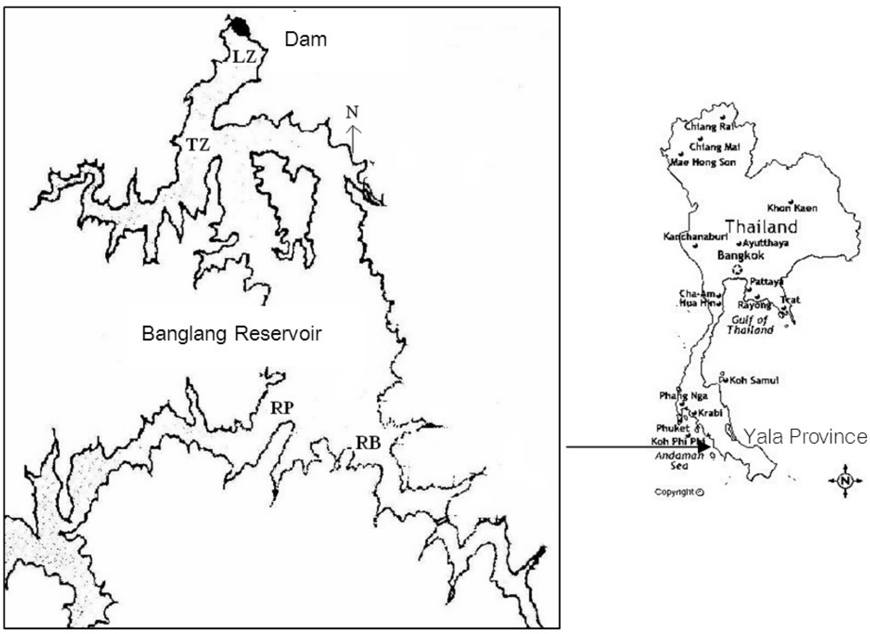


Figure 1. Sampling sites: inflow from Pattani River (RP), inflow from Balahala Forest (RB), the middle of the reservior (TZ), and the spillway (LZ) at the Banglang Reservoir dam.

Statistical Package (MVSP) was used to identify the phytoplankton biomass at each site. Correlation analysis in SPSS 10.1 for Windows was used to determine the correlation between phytoplankton biomass as chlorophyll a and physico-chemical parameters.

5. Results

5.1 Physico-chemical parameters

The physico-chemical parameters in Banglang Reservoir are presented in Figure 2. Nutrients gradually increased with depth. The ammonia concentrations ranged from undetectable to 0.81 mg/l and the highest value was recorded in November at RP. The nitrate concentrations ranged from undetectable to 0.26 mg/l with the highest value in December at RP. The phosphate concentrations reached a maximum of 0.81 mg/l at water surface in June at LZ. The total phosphorus values ranged from undetectable to 16.50 mg/l. Pattern values from each site were similar, with high concentrations in October 2000 and April 2001.

Water temperature were mostly high, reaching a maximum of 32°C, with a minimum of 17°C. Water temperatures and dissolved oxygen were highest at the surface and decreased with increasing depth. Dissolved oxygen concentrations varied between 0.35 and 8.6 mg/l. and the maximum value was found in June at RP. Alkalinity values were mostly low. The maximum value (235 mg/l) was observed in February at RB 10 m depth, and the minimum (15 mg/l) in February at RB 30 m depth. pH values at each site were similar all year around with a range of 6.04 to 7.77. The highest value was observed in September at water surface and the lowest in July at 30 meter depth at TZ. Turbidity values ranged from 0 to 299 NTU. The highest turbidity value was found in October at TZ 30 m depth and the lowest in June at the surface and 10 m depth, at RB, RB, TZ and LZ. The Secchi depth are presented in Figure 3. The values range from 1.4 to 5.05 m with the highest depth at TZ in April and the lowest at RP in September.

5.2 Chlorophyll a

Phytoplankton biomass as chlorophyll a in Banglang Reservior ranged from 0 to 12.57 mg/m^3. Chlorophyll a mostly exhibited high concentrations at 10 m depth. The highest concentration occurred in August at RB. The minimum chlorophyll concentration was founded in July at TZ (Figure 4). Similarities in the chlorophyll a concentration patterns were observed between RP and RB as well as coincidences with TZ and LZ .

The average concentrations of chlorophyll a were used in the Principle Component Analysis among different sites. The first axis indicates 89.25% valued from 1.397 to 7.374. The highest chlorophyll a concentration came from

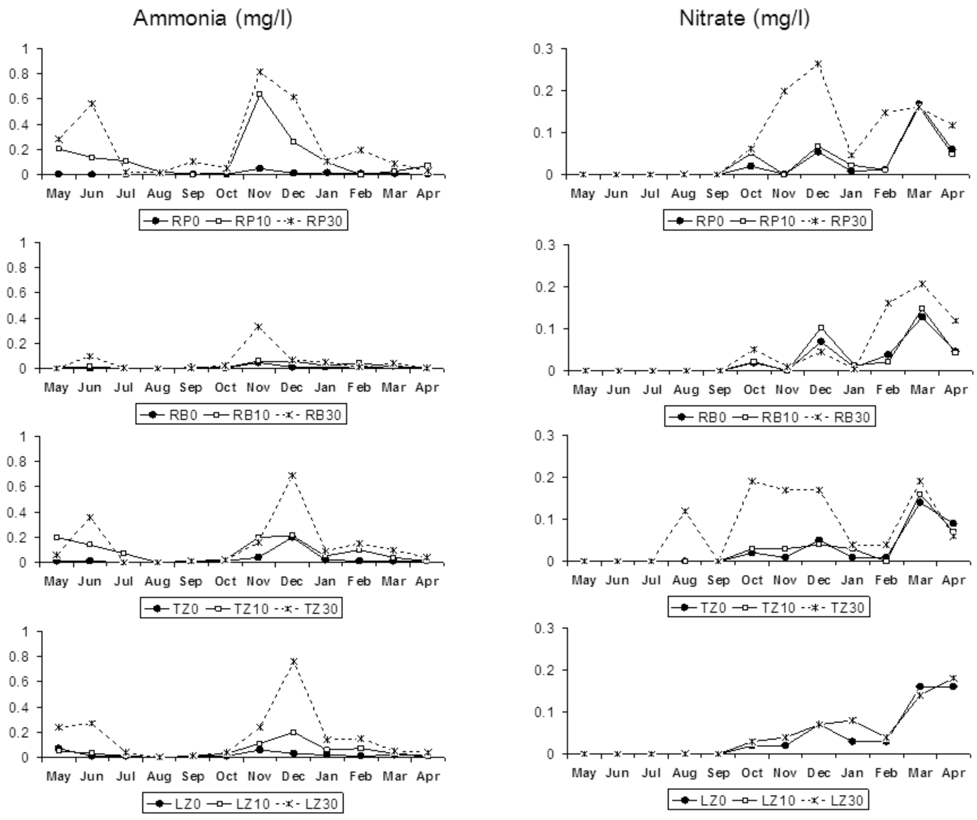


Figure 2. Physico-chemical parameters at the inflow from the Pattani River (RP), the inflow from Balahala Forest (RB), the middle of the reservoir (TZ) and the spillway (LZ) of the Banglang Reservoir from May 2000 to April 2001.

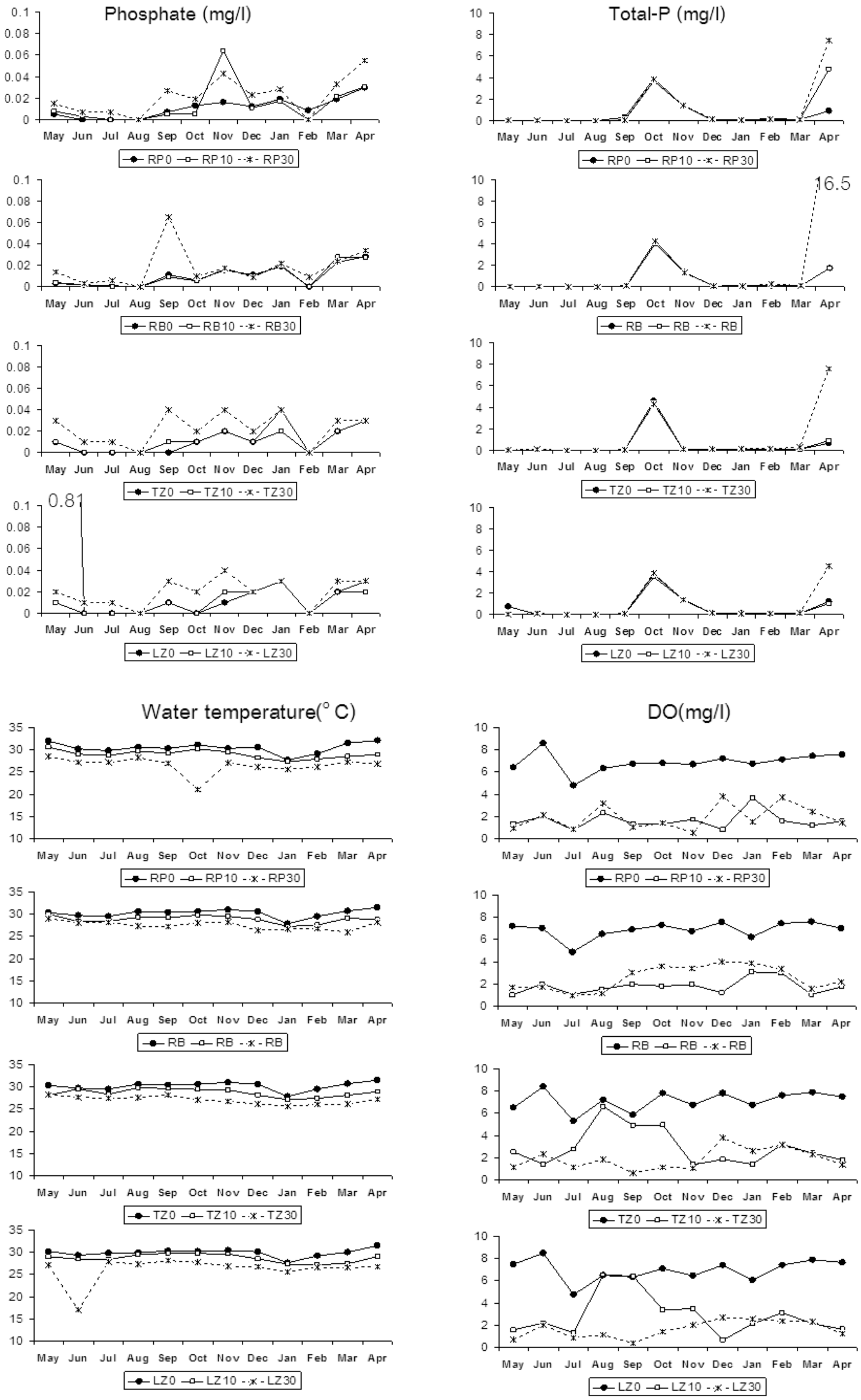
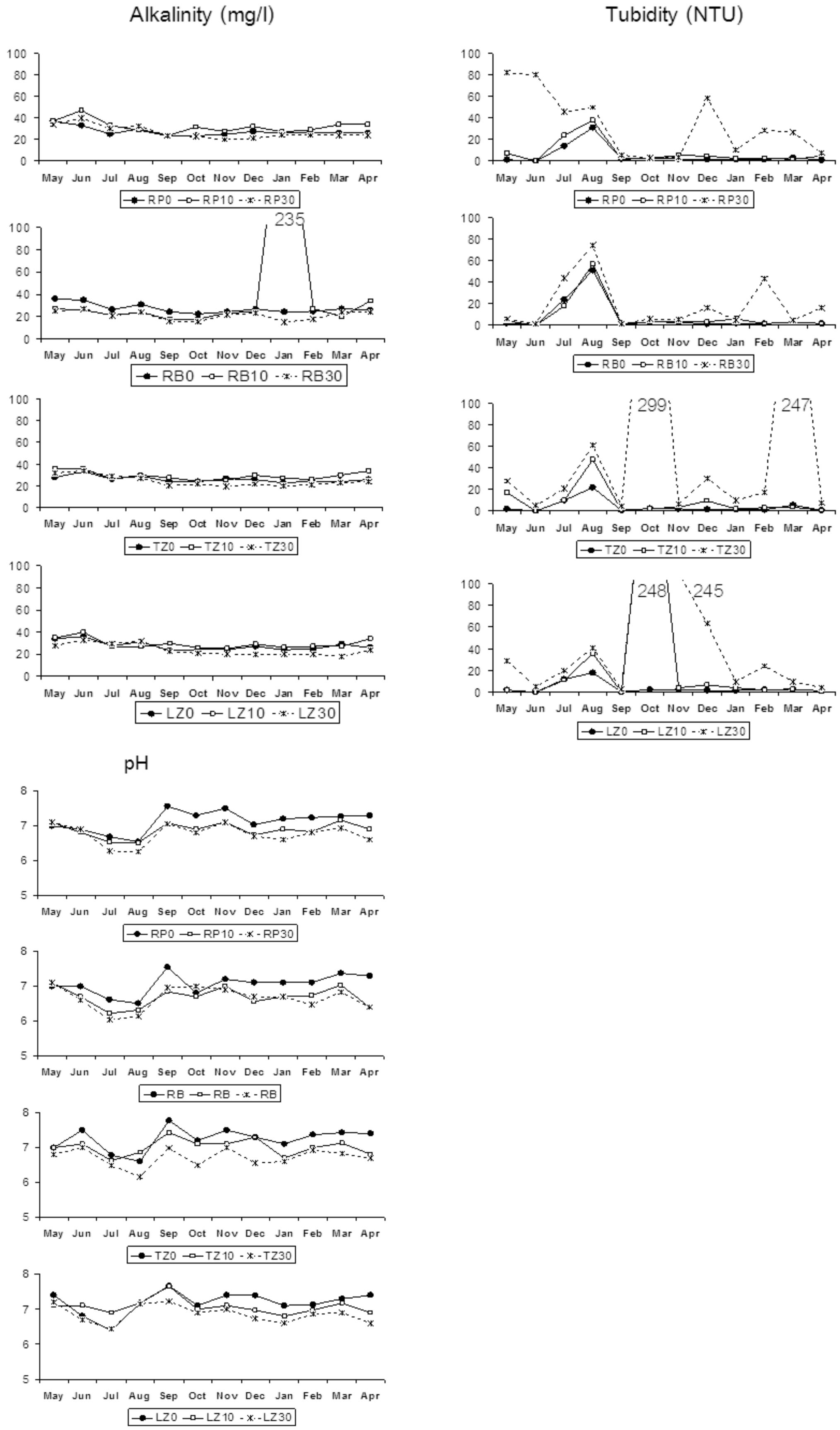


Figure 2. (Continued)



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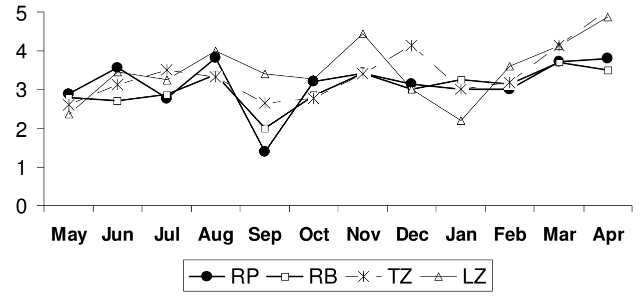

Figure 3. Secchi depth at the inflow from the Pattani River (RP), the inflow from the Balahala Forest (RB), the middle of the reservoir (TZ) and the spillway (LZ) of the Banglang Reservoir from May 2000 to April 2001.

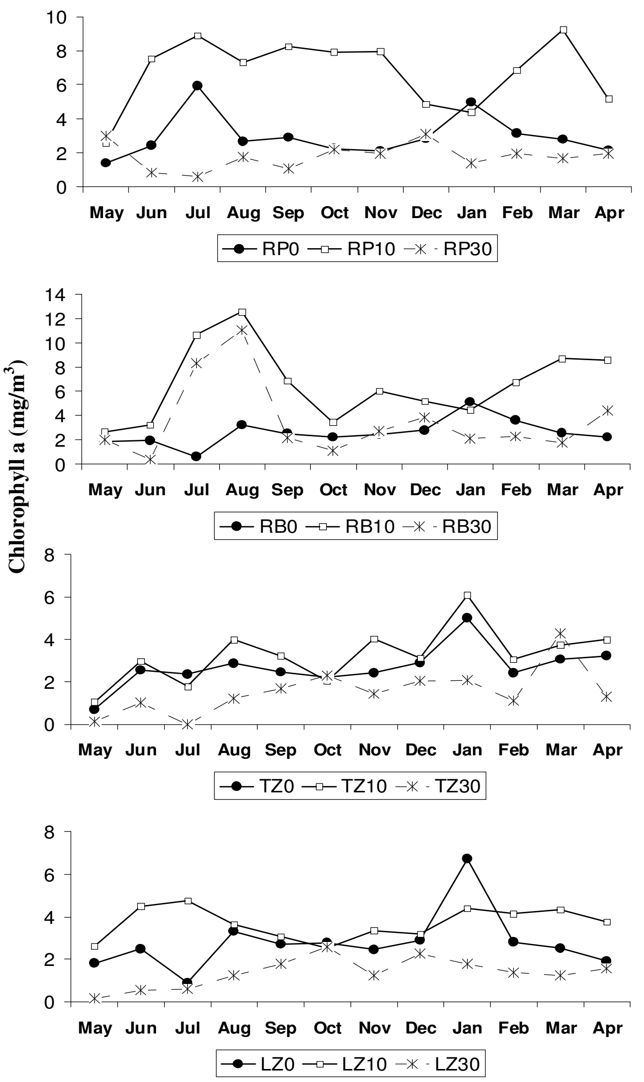

Figure 4. Chlorophyll a concentrations at the inflow from the Pattani River (RP), the inflow from the Balahala Forest (RB), the middle of the reservoir (TZ) and the spillway (LZ) of the Banglang Reservoir from May 2000 to April 2001.

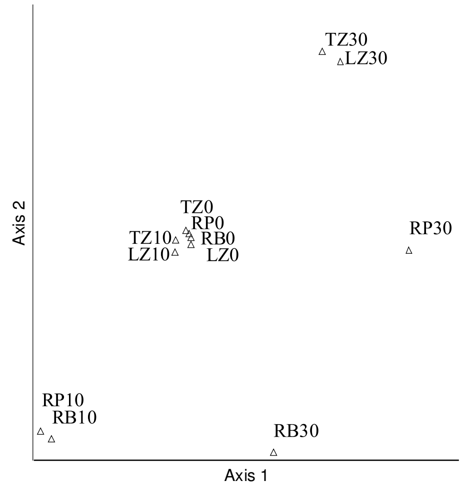

Figure 5. PCA of chlorophyll a concentrations at the inflow from the Pattani River (RP), the inflow from Balahala Forest (RB), the middle of the reservoir (TZ) and the spillway (LZ) of the Banglang Reservoir from May 2000 to April 2001.

10 meter at RB and RP, the lowest from 30 meter at TZ and LZ (Figure 5).

5.3 Relationship between chlorophyll a and selected physico-chemical parameters

Correlation coefficient analysis between chlorophyll a and physico-chemical parameters for each site at three different depths are presented in Table 1. In general, there are no significant correlations between chlorophyll a and nutrients. Only the ammonium value shows a significant correlation with chlorophyll a at TZ30 and LZ30. In addition chlorophyll a concentrations were found to have a relation with alkalinity at TZ0, TZ 30 and LZ 30; turbidity at RB 30 and TZ 30.

6. Discussion

Water quality at the surface water from RB, TZ and LZ was similar. This is probably the result of water intake in larger quantities into the reservoir. The reservoir received not only water from the Balahala fertile forest but also from the rain of northwest monsoon almost the whole year (http://www.tmd.go.th/programs/uploads/yearlySummary/weather2549-e.pdf). Drainage of excess water and transmission of the water for hydroelectric power created a circulation in reservoir. Nutrient concentrations were particularly high in deep water (30 m) which were related to the liberation from the sediments and the decomposition of organic matters (Calijuri *et al*., 2002), except of phosphate with a high value of 0.81mg/l in May at the surface at LZ. During that month, detergents consisting of phosphorus were used for the rubber sheets washing near LZ. Hinder *et al.* (1999) reported that higher nutrient concentrations might be linked

Table 1. Correlation coefficients between chlorophyll a and selected environmental variables. * P< 0.05 , ** P< 0.01. TP = Total Phosphorus, DO = Dissolved Oxygen, ALK = Alkalinity, TURB = Turbidity, SD = Secchi Depth.

	NO_3	NH_3	PO_4	TP	DO	ALK	SD	TURB
RP0m	0.078	-0.12	-0.153	-0.293	-0.542	0.038	-0.243	0.229
RP10m	-0.114	0.197	0.013	-0.042	-0.28	-0.208		0.149
RP30m	0.294	0.544	0.162	0.16	0.294	-0.426		0.154
RB0m	0.114	0.215	0.25	-0.133	0.253	-0.528	0.279	-0.075
RB10m	-0.114	0.197	0.013	-0.042	-0.28	-0.208		0.149
RB30m	-0.231	0.224	-0.292	0.014	-0.502	0.169		0.872**
TZ0m	0.105	0.236	0.665	-0.075	0.158	0.599*	0.344	0.043
TZ10m	-0.278	0.309	0.553	-0.242	-0.196	-0.599		-0.059
TZ30m	0.125	0.687*	0.302	0.08	0.28	0.691*		0.661*
LZ0m	-0.118	-0.068	-0.196	-0.107	-0.082	-0.371	-0.414	-0.122
LZ10m	-0.192	0.205	-0.009	-0.516	-0.255	0.027		-0.487
LZ30m	0.131	0.633*	0.373	0.448	0.293	0.616*		0.421

to higher concentrations of suspended particles. Phytoplankton biomass is determined by a seasonal cycle which effects the fluctuations of environmental variables such as solar irradiance and nutrient levels (Harris, 1986). Since, the Banglang Reservoir is situated in the Indochina peninsular belt with northwest monsoon, so there is a long rainy season (8 months) and a short dry season (4 months). The reservoir receives a large water volume of 862 to 1,364 million m^3 a year (Ariyadej *et al*., 2004). Therefore, the physico-chemical values were slightly different at the same level almost the whole year. Chlorophyll a concentrations near the outflow zones (LZ and TZ) were lower than that at RP and RB throughout the year. This was probably due to the drainage of excess water at 30 m depth out of the dam. As mentioned above, the phytoplankton biomass as chlorophyll a were observed throughout the water column (from the surface down to 30 m depth), although Secchi depth was less than 6 m. According to Graham and Willcox (2000), under these conditions of light deprivation, algae are capable of adjusting their position in the water column by using specific organelles such as flagella or intracellular structures known as gas vacuoles. The correlation between chlorophyll a and Secchi depth was not recorded.

Chlorophyll a concentrations at 30 m depth were poor, although the ammonium values were mostly high. This might be due to light limitation for phytoplankton growth in the reservoir. The minimum appearance was at LZ30m where water is help before discharge and the drainage of excess water at 30 m from the dam caused a reduction of phytoplankton. Phytoplankton biomass mostly exhibited high concentrations at 10 m depth. They were probably caused by a high light intensity that made temperature and irradiance too high in the water surface (Figure 2). Therefore, some phytoplankton moved downward to deeper layers with unique constituents such as flagella or gas vacuoles (Graham and Willcox, 2000) to obtain the optimum levels of light and nutrients. The highest phytoplankton biomass was observed at RB 10 m. This site was an effluent area of water from Balahala fertile forest. Water was quite clear and the current was attenuated. These conditions provided an optimal environment for phytoplankton growth. It was found that no correlation between chlorophyll a and nutrients (NO_3, PO_4, TP) exists. As a result, nitrate concentrations in the reservoir were slightly low (Akbay *et al*., 1999) to be a potential limitation of the phytoplankton growth. The N : P ratios at the Banglang Reservoir were generally lower than those found in the other reservoirs. This might be unsuitable for phytoplankton assimilation as well as reducing the total biomass (Harris, 1986).

Chlorophyll a was correlated with ammonium at TZ 30 m and LZ 30 m depth. There was a high turbidity including suspended particles and nutrient concentrations at these sites and depths compared to other sites which influenced the phytoplankton growth. The nutrient levels in the reservoir were low to medium (Akbay *et al*., 1999). Other factors, such as ALK and TURB are likely to be positively correlated with chlorophyll a at TZ 0 m, TZ 30 m and RB 30 m, TZ 30 m dept respectively.

Concentrations of phytoplankton biomass as chlorophyll a ranged from 0 to 12.57 mg/m^3, averages ranged from 1.4 to 6.6 mg/m^3. These values were relatively low compared to the other researchers. Based on the average of TP and chlorophyll a values, the water quality of the reservior could be classified as oligo-mesotrophic status (Wetzel, 2001). Comparison with other reservoirs, the states of water quality in the Banglang Reservoir were similar to the Keban Dam Reservoir in Turkey (Akbay *et al*., 1999) and Huai Mae Yen Reservoir in Thailand (Wannasai, 2000). Chlorophyll a were different among sites and depths. There were a number of factors which affected the variations of phytoplankton. Internal influences such as physiological differences among phytoplankton species give a specific form of phytoplankton growth (Akbay *et al*., 1999).

Finally, these results supported that an overall impact on the phytoplankton biomass in the Banglang Reservoir, came from the unsuitability of certain physical and chemical conditions such as light and turbidity. In addition, enormous amount of water which flowed into the reservoir and later drained out resulted in water movement throughout the time and brought nutrients and phytoplankton with it. Other consequences were the increasing turbidity and the reducing availability of phosphorus to phytoplankton (Knoll *et al*., 2003). Attenuation of phytoplankton might come from grazing zooplankton that showed a high complexity. Other relative conditions were the situation of the water supply, the usage of water supply, and the periphery, depth, and shape of the reservoir, and the transmission of the water (Wetzel, 2001).

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