

## Quantity and Distribution of Plant Nutrients on Eutrophication in Bang Pra Reservoir, Chonburi Province

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### ABSTRACT

The main objectives of this study were to study the quantity and variation of plant nutrients in water bodies supplied to Bang Pra reservoir including the characteristics of distribution and variation of plant nutrients and phytoplankton in Bang Pra reservoir. This study was conducted during March 2001 – February 2002.

In the inflowing brooks, the quantity of nitrite and total ammonia were significantly different ( $p < 0.01$ ) both in each brook and in each month. It was demonstrated that the quantity of nitrate and orthophosphate were significantly different ( $p < 0.01$ ) in each month but not different in each brook ( $p > 0.05$ ).

In Bang Pra reservoir, the quantity of nitrite in each water sample was different ( $p < 0.05$ ) and the quantity of total ammonia was significantly different ( $p < 0.01$ ). When considering both quantity of nitrite and total ammonia in each month, it was shown that they were significantly different ( $p < 0.01$ ). Statistical analysis indicated the significant difference of orthophosphate quantity ( $p < 0.01$ ) in each month but not in each water sample station ( $p > 0.05$ ). Given these conditions, Bang Pra reservoir can be classified as a eutrophic lake.

High quantity of plant nutrients in Bang Pra reservoir was mainly found at water sample stations of water receiving areas located at the mouth of brooks.

The biological analysis revealed that phytoplankton, which was mostly found in Bang Pra reservoir was *Aulacoseira*, in Division Chromophyta. Moreover, in June, November 2001, and January 2002, *Aulacoseira* was found in such large quantity compared to other months that these periods could be regarded as periods of phytoplankton bloom.

**Key words:** eutrophication, plant nutrients, phytoplankton, reservoir

### INTRODUCTION

Bang Pra reservoir is greatly affected by unsustainable developments such as the excessive utilization of chemical fertilizers by farmers and inadequate soil and water conservation in

agricultural areas that directly cause ecological transformation, especially from eutrophication. Eutrophication occurred in 1984 and exterminated a number of fish from the decomposition of exceeding algae blooms. Setkit *et al.* (1987) conducted a research on the types and nutritive

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importance of plant nutrients in Bang Pra reservoir. His study emphasized on the selection of appropriate species of fish released in the reservoir in order to eradicate excessive algae and aquatic plant blooms, which propounded the problem of exaggerated productivity and distribution of algae in the reservoir. This evidence apparently showed that Bang Pra reservoir was encountering with the substantial amount of phytoplankton. Furthermore, Chookajorn *et al.* (1991), reported to the Royal Irrigation Department, responsible for the reservoir, that in the dry season the excessive algae blooms had killed a number of fishes.

Accordingly, the importance of the eutrophication problem induced to this study, which was conducted based on the study on quantity and distribution of plant nutrients on eutrophication in Bang Pra reservoir in the Province of Chonburi. This research studied ecological characteristics of Bang Pra reservoir that leads to the eutrophication phenomena. This study justified the characteristics of plant nutrients and aquatic plant dispersions in the reservoir, including the environment that appeals to eutrophication.

## MATERIALS AND METHODS

The conditions of water sample collection were considered according to these followings.

1. A study on quantity and variation of plant nutrients in each area and season was investigated from five inflowing brooks supplying water into Bang Pra reservoir; the brook number one (A1 : Sukreap brook), the brook number two (A2 : Ruam brook), the brook number three (A3 : Tha Sai brook), the brook number four (A4 : Kru brook), and the brook number five (A5 : Nong Kor – Bang Pra brook). There were five water sample stations from five inflowing brooks and water sample composed of an equal mixture of surface was taken from each station.

2. A study on distribution and variation of plant nutrients in each area and season was

conducted by collecting water samples in Bang Pra reservoir. The conditions of water sample collection were considered from;

- Four samples were collected from the water receiving area (the water sample station number one (B1), two (B2), three (B3) and four (B4)).
- One sample was collected from the reservoir with eutrophication problem (the water sample station number five (B5)).
- One sample was collected in front of the dam (the water sample station number six (B6)).
- One sample was collected from the center of the reservoir (the water sample station number seven (B7)).
- One sample was collected from the pumping station of the Royal Irrigation Department that supplies raw water for consumption (the water sample station number eight (B8)).

Water samples from five inflowing brooks and from reservoir were collected throughout the year from March 2001 – February 2002.

The thermal stratification in Bang Pra reservoir was also examined according to area and season. There were eight study stations that were the same areas as the study on distribution of plant nutrients and phytoplankton in Bang Pra reservoir. All data collected in situ were depths, temperature and dissolved oxygen. Measurements were made at a series of depth intervals at every one-meter throughout water column at all stations.

Biological data examined phytoplankton taxa and their quantitative distribution in Bang Pra reservoir were collected at the same selected stations as water quality (B1, B2, B3, B4, B5, B6, B7, B7, and B8). At each station, ten liters of sample was equally taken from the surface of water (approximately one metre deep) using 37-micrometer mesh size of phytoplankton net every month from March 2001- February 2002. The ten ml. of phytoplankton sample taken from each station was immediately preserved with five % of

formalin solution.

Water samples collected from brooks were analyzed for their physical and chemical properties whereas water samples collected from Bang Pra reservoir were investigated physical, chemical and biological properties as shown in Table 1. Analytical procedures used for quantitative determination of the chemical properties were based on standard methods for the examination of water and wastewater (APHA, AWWA and WPCP, 1980)

The quantitative statistical determination was investigated by cluster analysis and multidimensional scaling (MDS) ordination (Clark and Warwick, 1994 and Ludwig and Renold, 1988).

## RESULTS

### Water quality of supplying brooks and Bang Pra reservoir

The results of the variation of plant nutrients in the five brooks demonstrated that the maximum average quantity of nitrate ( $3.16 \pm 4.01$  mg/l) was found in the brook number two while the maximum average quantity of nitrite ( $1.20 \pm 1.63$  mg/l), total ammonia ( $2.14 \pm 1.51$  mg/l) and orthophosphate combined ( $1.15 \pm 2.82$  mg/l) was found in the brook number three.

When considering the variation of plant nutrients of the five brooks by month, it revealed that the maximum average quantity of nitrate ( $6.03 \pm 3.30$  mg/l) reached its peak in December whereas the maximum average quantity of nitrite ( $1.80 \pm 2.97$  mg/l) reached its peak in July. For the maximum average quantity of total ammonia

**Table 1** Parameters and analytical methods of samples.

Parameters	Analytical methods
Physical	
Depth* (m)	Plummet
Temperature* (°C)	Thermometer
Dissolved Oxygen* (mg/l)	DO meter
Turbidity (NTU)	Nephelometric method
Transparency* (m)	Secchi disc
pH*	pH meter
Conductivity* ( $\mu$ s/cm)	Conductivity meter
Chemical	
Nitrate (mg/l)	Cadmium reduction column method
Nitrite (mg/l)	Griess-Ilosvay diazotization
Total ammonia (mg/l)	Nesslerization
Orthophosphate (mg/l)	Ascorbic acid method
Biological	
Chlorophyll a (mg/l)	Fluorescent techniques
Genus composition and abundance of phytoplankton	Sedgewick rafter counting chamber

\* Remark; Field study.

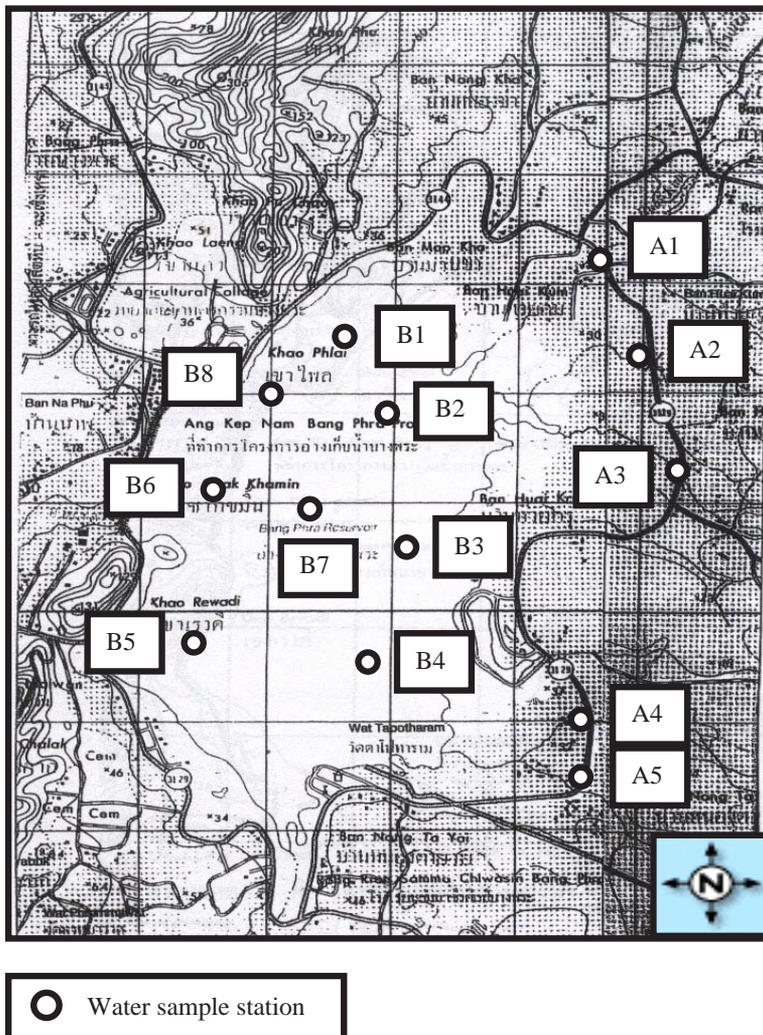
( $3.93 \pm 0.72$  mg/l) and orthophosphate ( $4.52 \pm 3.79$  mg/l), the results showed that both of them reached their peaks in October.

The study on the variation of plant nutrients in Bang Pra reservoir showed that nitrate at every water sample station was undetectable. However, both nitrite ( $0.68 \pm 0.53$  mg/l) and total ammonia ( $1.38 \pm 1.25$  mg/l) were found at the water sample station number one whereas orthophosphate ( $0.22 \pm 0.47$  mg/l) was found at the water sample

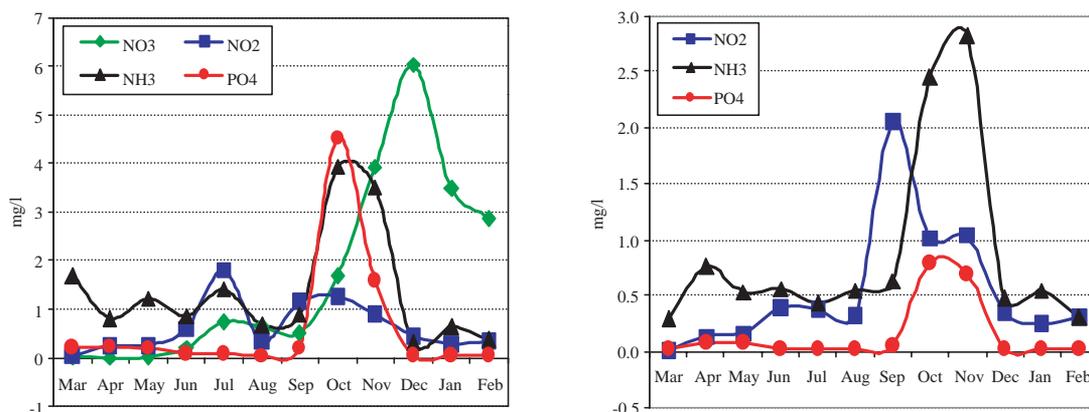
station number three.

When considering the variation of plant nutrients in Bang Pra reservoir for each month, it revealed that nitrite ( $2.05 \pm 0.59$  mg/l), total ammonia ( $2.82 \pm 1.02$  mg/l) and orthophosphate ( $0.80 \pm 0.41$  mg/l) reached their peaks in September, November and October, respectively.

The biological study in Bang Pra reservoir demonstrated that there were seven divisions of phytoplankton in total: Cyanophyta, Chlorophyta,



**Figure 1** The monitoring stations of field data collection in the five brooks located around Bang Pra reservoir and the monitoring stations of field data collection in Bang Pra reservoir.



**Figure 2** The average quantity of plant nutrients in the five brooks (A) and in Bang Pra reservoir (B).



**Figure 3** The characteristic of *Aulacoseira*. (<http://keisou.hp.infoseek.co.jp/chuusin/Aulacose/aulsei.html>)

Chromophyta, Chrysophyta, Bacillariophyta, Euglenophyta, Pyrrophyta and four unidentified genera. Both identifiable and unidentifiable genera totaled to 75 genera. The most prevalent phytoplankton found in Bang Pra reservoir was in genus *Aulacoseira*, Division Chromophyta. In addition, it was discovered that 84.47% of phytoplankton found in Bang Pra reservoir was *Aulacoseira*.

## DISCUSSION

### Water quality and seasonal distribution of plant nutrients in the inflowing brooks and Bang Pra reservoir

The consequences of the variation of plant nutrients; nitrate, nitrite, total ammonia and orthophosphate in the brooks carrying water into Bang Pra reservoir, showed that the quantity of plant nutrients in the hot season (March to May) was low compared with those in the rainy (June to October) and cold (November to February) season. During the rainy season, plant nutrients in the five brooks would first increase in June and increase a second time in October due to the high rainfall in the beginning and the end of the rainy season that vastly carried plant nutrients into the five brooks. During the cold season, plant nutrients in each brook would decrease but remained higher than that during the hot season. Therefore, it could be concluded that the rain was a significant factor of washing and carrying plant nutrients remaining in the surrounding areas into the five brooks.

However, it could not be clearly concluded why each brook had different amount of plant nutrients. After surveying the surrounding areas of the five brooks located around Bang Pra reservoir, since most areas are agricultural areas having

similar characteristics. Consequently, it might be likely that different agricultural activities such as kinds and quantity of fertilizers used in agricultural area might cause plant nutrients remaining in agricultural area to be carried into the five brooks in different quantities.

Another assumption considering different quantities of plant nutrients in each brook might be that agriculturists have inappropriate water and soil conservation plan causing different remaining plant nutrients in the agricultural area.

The water analyses results at Bang Pra reservoir showed that the physical and chemical quality of water met the level of water quality standard of Thailand (Water quality division, 1991) and water quality for fishery purposes (Duangasawadi and Somsiri, 1985). Despite the change in seasons from hot to rainy season and from rainy to cold season, water quality in Bang Pra reservoir remained in acceptable standard but slightly changed.

During the hot season, nitrate in the reservoir was very low and undetectable. This was because nitrate could not be washed from the surrounding areas into Bang Pra reservoir due to lack of rain. Moreover, nitrate found in each brook was rather low as well. Considering the variation of nitrite, total ammonia and orthophosphate in various seasons, it showed that those plant nutrients were lowest during the hot season whereas they had large amount in the beginning and the end of the rainy season. This was because plant nutrients found in the five brooks carrying water into Bang Pra reservoir during those periods were high too. During the cold season, plant nutrients began to decrease and with little change in scattering in every water sample station.

Although each water sample station had similar trend in changing and distributing of plant nutrient, it still had different amount of plant nutrients due to its location. For instance, water sample stations that were the representatives of water receiving areas mostly had larger amount of

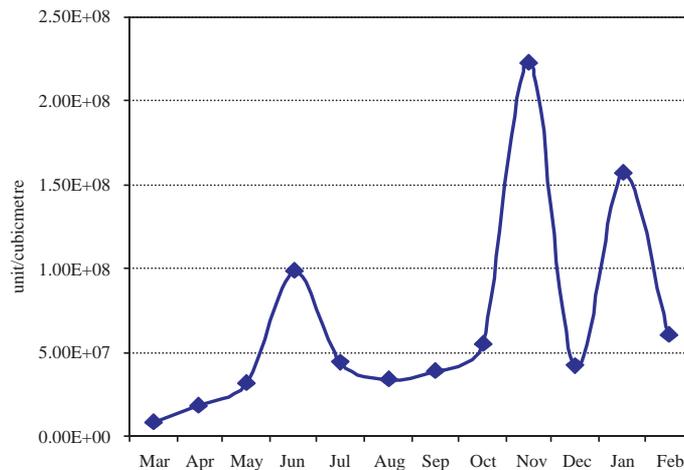
plant nutrients than other stations located far from that area.

Apart from that, this study also revealed that phosphorus was the limiting factor in the water quality of Bang Pra reservoir. This was because when considering the N:P ratio referring to the criteria of Sven-Olof and Walter (1989), it showed that the N:P ratio of Bang Pra reservoir, which was equal to 9.477 was higher than the criteria of Seven-Olof and Walter (1989) who stated that if a ratio of N:P exceeding seven, phosphorus would be a limiting factor.

Furthermore, when using chlorophyll a in order to compare with Helmut (1991) for classifying the fertility of water in Bang Pra reservoir, it revealed that a range of chlorophyll a in Bang Pra reservoir was between 0.6062 – 1.8146 mg/l, which was higher than that in a eutrophic lake, 0.01 – 0.50 mg/l (Helmut, 1991).

The change of phytoplankton in each water sample station was not different at 0.5 limit. Nevertheless, phytoplankton found each month were different at a significant level of 95 %. Phytoplankton in Bang Pra reservoir were scattered in the similar quantity in almost every water sample station whereas they had exponentially different quantity in each month. Phytoplankton were low during the hot season whereas they were relatively high during the rainy and cold season. This was because plant nutrients in Bang Pra reservoir during the hot season were lower than those during the rainy and cold season.

In June or the rainy season, phytoplankton swiftly increased in every water sample station and its total amount equaled to 784,260,000 units per cubic metre. The main genus of phytoplankton found was *Aulacoseira*, Division Chromophyta. This increase of phytoplankton was a phenomenon of phytoplankton bloom. This was due to the large amount of rainfall in June that carried the remaining plant nutrients in the agricultural area into Bang Pra reservoir. Moreover, plant nutrients substantially supplied from the five brooks were



**Figure 4** The average quantity of phytoplankton in the Bang Pra reservoir.

also a vital factor that increased plant nutrients in Bang Pra reservoir during this period.

After June, phytoplankton in every water sample station began to decrease until October. However, in November, quantity of phytoplankton suddenly increased to the maximum, equaling 1,786,430,000 units per cubic metre. This showed that there was phytoplankton bloom again. This study also revealed that phytoplankton at the water sample station number two, four and seven had considerably increased, equaling to 3,444,700,000, 325,095,000 and 256,655,000 units per cubic metre, respectively. The main genus of blooming phytoplankton, *Aulacoseira* was most commonly found. The significant cause of the blooming of this genus was that during the end of the rainy season, Bang Pra sub-watershed received the most rainfall, thereby causing large amount of plant nutrients carried into the brooks and subsequently into the reservoir. When water in the five brooks containing a large amount of plant nutrients flowed into the reservoir, it undoubtedly caused a swift growth of phytoplankton.

During the cold season, phytoplankton decreased again in December. This was because some parts of plant nutrients in Bang Pra reservoir began to sink into the bottom of the reservoir while

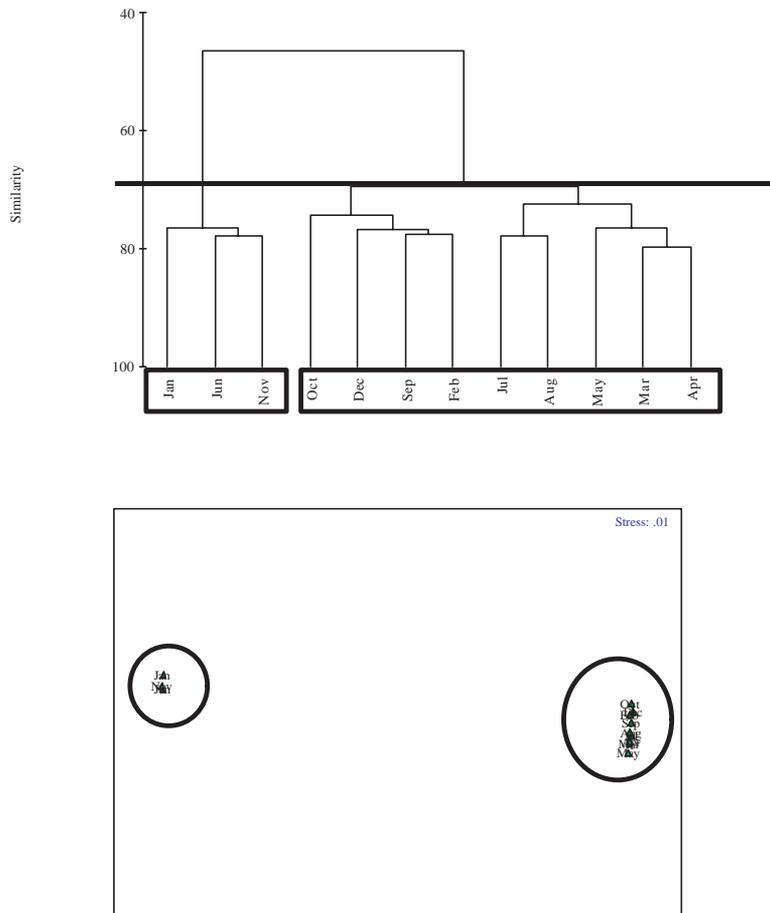
other parts were used by living organisms. However, in January, there was a tremendous increase in the amount of phytoplankton equaling 1,252,185,000 units per cubic metre. There were largest amount of phytoplankton, equaling 189,135,000 units per cubic metre in the water sample station number two. The main genus of phytoplankton found was still *Aulacoseira*, which was the same genus appearing in June and November, when the blooming occurred. *Aulacoseira* bloom occurred in January because some parts of plant nutrients in Bang Pra reservoir still remained from the rainy season. This enabled phytoplankton to use these plant nutrients for their growth. Moreover, in January, total ammonia in Bang Pra reservoir in every water sample station increased again because total ammonia found in the five brooks during the mentioned period increased simultaneously. This might possibly bring about phytoplankton bloom in Bang Pra reservoir in January.

Another potential assumption that might lead to phytoplankton bloom in Bang Pra reservoir in January was a phenomenon of thermal stratification. This study discovered that in December, there was a trend of thermal stratification in the reservoir. This caused the

lower part of the water mass to be unmixable with the upper part of water mass. Accordingly, the remaining plant nutrients in the bottom of reservoir could not be carried to mix on the surface of the reservoir. This caused little amount of plant nutrients in the surface of the reservoir in December when compared with those in January. In January, there was no thermal stratification in Bang Pra reservoir. Consequently, plant nutrients existing in the bottom of the reservoir could be carried to mix with the upper part of the water mass. This caused the surface of the reservoir to have large amount of plant nutrients again in January and

phytoplankton bloom occurred once again.

The study on the variation of phytoplankton was consistent with the determination of cluster analysis and multidimensional scaling (MDS) ordination. Cluster analysis (above) and MDS (below) showed that the groups of phytoplankton found in June, November and January were highly diversified and the most well distributed when compared with other phytoplankton groups. Therefore, the diversity and distribution of phytoplankton in each month could be divided into two groups as shown into Figure 5; the first group consisted of June, November and January



**Figure 5** The dendrogram for hierarchical clustering of phytoplankton found in Bang Pra reservoir (above) and the MDS ordination of phytoplankton, which were separated as two groups, stress value = 0.01 (below).

whereas the second group comprised March, April, May, July, August, October, December and February.

When considering the quantity and dominant species of phytoplankton found in the reservoirs in Thailand (Chantsavang *et al.*, 1989, Dumrongtripob and Janesirisak, 1996, Kasisuwan and Sukkasem, 1994, Mapairoj and Traichaiyaporn, 1996, Pitaktansakul, 2000, Somsiri *et al.*, 1995 and Sukollapun and Chabjinda, 1997), it showed that the amount of phytoplankton were normally somewhat low when compared with those found in Bang Pra reservoir, except at the Lumtakong reservoir, Nakhon Ratchasima province (Kakkaeo *et al.*, 2002) where it contained large quantity of phytoplankton similar to Bang Pra reservoir. The Lumtakong reservoir is known as a eutrophic reservoir. In addition, there were other reports concerning a phenomenon of phytoplankton bloom. For instance, the study of Kakkaeo *et al.* (2002) at the Lumtakong reservoir found that in December 1998, there was a rapid increase in quantity of blue green algae, equaling 2,200,000,000 units per cubic metre. This amount approximated to quantity of phytoplankton that bloomed mostly in Bang Pra reservoir in November, equaling 1,786,430,000 units per cubic metre.

After studying dominant species of phytoplankton found in various reservoirs in Thailand (Chantsavang *et al.*, 1989, Dumrongtripob and Janesirisak, 1996, Kasisuwan and Sukkasem, 1994, Mapairoj and Traichaiyaporn, 1996, Pitaktansakul, 2000, Somsiri *et al.*, 1995 and Sukollapun and Chabjinda, 1997), it was found that phytoplankton, which was the dominant species was mostly in Division Cyanophyta, genus *Oscillatoria*, *Anabaena* and *Microcystis*; these are dramatic bloom species or dominant species found in a eutrophic lake. This was consistent with the study of Sven-Olof and Walter (1989) and Maitland (1978) who stated that phytoplankton, in Division Cyanophyta, genus *Oscillatoria*, *Aphanizomenon* and *Microcystis* or

*Diatoms*, genus *Melosira*, *Fragilaria*, *Stephanodiscus* and *Asterionella*, are the main groups of phytoplankton found in a eutrophic lake. However, *Aulacoseira*, the dominant genus of phytoplankton in Bang Pra reservoir, has never been found or reported to bloom in any eutrophic lake before.

## CONCLUSION

The seasonal change played an important role in the amount and variation of plant nutrients in the five brooks.

The quantity and change of plant nutrients in Bang Pra reservoir mainly depended on plant nutrients carried from the five brooks that supply water to Bang Pra reservoir. The trophic state of Bang Pra reservoir was a eutrophic lake and the distribution of plant nutrients in this reservoir was mostly found at the inflowing stations to the reservoir than other water sample stations located far away from the water receiving areas.

The biological consequences showed that *Aulacoseira* was the dominant genus found in Bang Pra reservoir, particularly with the high peaks in June, November 2001 and January 2002.

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