# Relationship among Nutrients, Chlorophyll- *a*, Physical and Chemical Properties of Water in Srinadharin Reservoir, Kanchanaburi Province

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**Abstract**

On the relationships of nutrients determination, chlorophyll-*a*, physical and chemical properties of water in Srinadharin reservoir, Kanchanaburi province in order to access ecological status and changeability, and to correlate between them, field data collection was done at all 15 selected sampling stations representing upstream, midstream and downstream areas during April 2008 to March 2009. Chlorophyll-*a*, physical and chemical properties of water were collected at every 2- month intervals. Determinations were both made at in situ and in the chemical laboratory. The results revealed that Srinadharin reservoir was of oligotrophic status, containing an average of 4.099 $mg/m^3$ of chlorophyll-*a* and its water quality was appropriated for aquatic animals'living. The distribution of nutrients and chlorophyll-*a* were varied, depending on periods and collection areas. Nutrients and chlorophyll-*a* concentration in the upstream were higher than those in the middle and downstream sections. The average concentrations of nutrients were the highest in the rainy season, average in summer and lowest in winter, whereas the average chlorophyll-*a* concentrations were the highest in summer (5.307 $mg/m^3$), average in the rainy season and winter (4.591 and 2.399 $mg/m^3$), respectively. Chlorophyll-*a* concentration has positive correlation to total nitrogen, organic nitrogen, inorganic nitrogen, total phosphorus, ammonia nitrogen, water temperature and dissolved oxygen, while it has negative correlation to transparency, electrical conductivity and alkalinity. The results obtained from the study can be used as a guide equation to estimate fish yield and manage Srinadharin reservoir for future getting sustainable yield as well.

**Keywords**: Nutrients, Chlorophyll-*a*, Water Quality, Srinadharin Reservoir

## INTRODUCTION

Srinakarin Reservoir is a vast fresh water ecological system covering an approximate area of 419 $km^2$ in Kanchanaburi, a province in the west of Thailand. It abounds in diversity of aquatic animals and plays the key role as an important source of protein food from aquatic animals, in addition to its uses in electricity generation, irrigation, and flood alleviation. At present, water environment and aquatic animals are getting worse owing to human activities in and around the reservoir, namely, tourism, agriculture, and industry, as well as fishery with more advanced instruments, bearing adverse effects on its environment quality and aquatic animals, the products of which tend to be constantly decreasing. According to Thawan et al. (1984), who made a survey of fish population in the early period of water storage, fish product used to be up to 40.85 kilograms/rai/year. In 1994, there was another study on the change in the fish population with the result that the product decreased to 13.38 kilograms/rai/year (Boonyarat et al. 1994). Later, Jintana et al. (2002), conducting the survey of water biology and fishery resources, found that water quality differed and changed depending on various survey stations other than those in the month of the survey, and that average quantity of phytoplankton was 23.021 x 106 units/$m^3$ and the average product of the aquatic animals was only 1.53 kilograms/rai/year. The decrease of the aquatic animal products in the reservoir is a result of the physical, chemical, and biological changes of the environment in the water ecological system, including the constant change of the nutrient quantity needed for the growth of water creatures, which influences the potential of the aquatic animal products and causes the imbalance of the water ecological system.

Nutrients along with physical, chemical, and biological properties in water sources correlate with fishery products due to the fact that any reservoirs that provide sustainable aquatic animal products indicate the fertility of the water sources which every of the environmental factors, namely, producers, consumers, and decomposers as well as supporters, are in balance. Each of the environmental factors plays their roles effectively so as to transform inputs into outputs and to transmit energy through food chain to huge aquatic animals that can be harvested. This is to indicate the reservoirs'roles or potentials in generating the products. In this respect, nutrients are a supportive factor for the aquatic animals to grow and live, especially such important nutrients needed for the growth of the primary producers of the water sources or phyto plankton as nitrogen and phosphorus, all of which are important to the water ecological system. The phytoplankton include other factors use the nutrients to the photosynthesis, consequently generate the tissue of the phytoplankton, and transmit energy to other aquatic animals. Primary product of the water sources is the biomass of the phytoplankton resulting from the photosynthesis. All species of phytoplankton comprises chlorophyll-*a* as the main factor for the photosynthesis and is able to indicate the biomass of the phyto plankton (Ladda, 1999). The change of the nutrients can put impact on the quantity of the chlorophyll-*a*, it's potential for growth and multiplication of aquatic animals in the reservoirs.

Therefore, the study on the relationships of nutrients, chlorophyll-*a*, physical and chemical properties of water in Srinadharin reservoir,Kanchanaburi province, is a key issue in this regard in order to access the changeability and the distribution of nutrients, chlorophyll-*a*, and the physical and chemical properties of the water, including the correlation between them. These factors are the environmental indicator that might be applicable to the forecast of the aquatic animals in the reservoir and the database for the effective reservoir management for further sustainable fishery resources.

## MATERIALS AND METHODS

A complete set of water sampler and analyser, and field facilities were used in this study. Micronutrients, chlorophyll-*a* and some surface water qualities were collected at a depth of 30 cm. from the water surface at 15 selected sampling stations (SR1-SR15) throughout the reservoir representing upstream, midstream and downstream areas which included point sources and non point sources (Figure1). All environmental indices were carried out soon after collection and determined by using standard methods for the examination of water and wastewater (APHA *et al.*, 2000) as described in Table 1. The survey was made at two months, intervals from April 2008 to March 2009, totally 6 times over the year.

The data obtained were made correlation among macronutrients, chlorophyll-*a* and water qualities using Pearson's Correlation Coefficient.

The correlation between chlorophyll-*a* and all determined parameters as the following level:

| | | | |
|---|---|---|---|
| 0.71 | to | 1.0 | Highly positive correlation |
| 0.31 | to | 0.70 | Moderate positive correlation |
| 0.01 | to | 0.30 | Low positive correlation |
| -0.01 | to | -0.30 | Low negative correlation |
| -0.30 | to | -0.70 | Moderate negative correlation |
| -0.71 | to | -1.0 | Highly negative correlation |

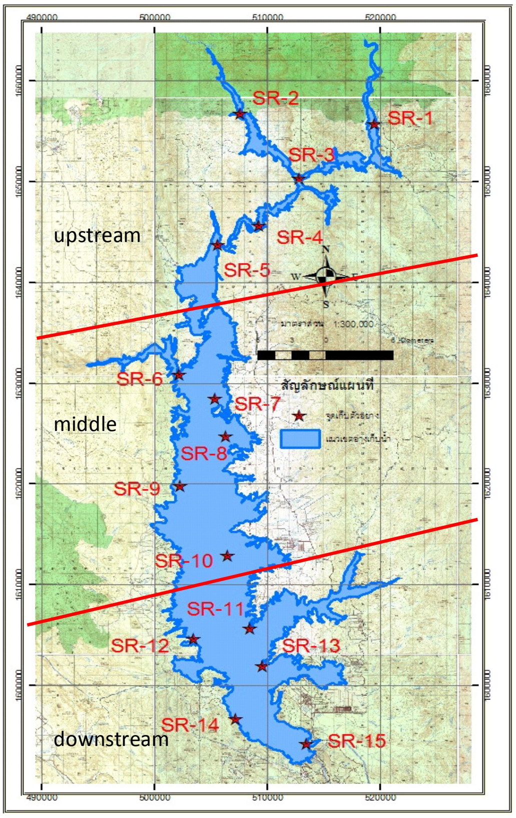


**Figure 1:** Surface water quality and aquatic ecology sampling stations Srinadharin Reservoir

**Table 1**: Environmental factors analysis

| order | Environmental factors | Analytical method | Reference |
|---|---|---|---|
| 1 | Chlorophyll-*a* | Spectrophotometric method | APHA. *et al* |
| 2 | Ammonia-nitrogen | Phenate method | (2000) : Standard |
| 3 | Nitrate-nitrogen | Colormetric method | methods for the |
| 4 | Inorganic-nitrogen | Total of ammonia, nitrite and nitrate (A) | examination of water and |
| 5 | Organic-nitrogen | Total nitrogen − (A) | wastewater |
| 6 | Total nitrogen | Kjeldahl Nitrogen method | |
| 7 | Orthophosphate-phosphorous | Ascorbic acid | |
| 8 | Total phosphorous | Ascorbic acid | |
| 9 | Alkalinity | Titration | |
| 10 | Water temperature | Multiprobe | |
| 11 | Transparency | Secchi disc | |
| 12 | Electrical conductivity | Multiprobe | |
| 13 | Dissolved oxygen | DO meter | |

Note: order 10-13 immediately analysis in the field

## RESULTS AND DISCUSSION

The yearly average value (Table 2) of each of the environmental factors of the ecological status of the reservoir was in standard level of the water quality appropriate for the aquatic animals to live, except for the transparency, which was in high level compared with the reference or standard value. The details of the changes and the correlation forms of each of the environmental factors are as follow:

**1. The changes of the environmental factors**

1.1 Chlorophyll-*a* The average yearly distribution value of the chlorophyll-*a* around the reservoir was 4.099 $mg/m^3$ (Table 3); averagely found highest in the upstream areas with 8.989 $mg/m^3$ fallowed by the middle and downstream with an average of 1.876 and 1.431 $mg/m^3$, respectively (Figure 2). Compared with seasonal changes, chlorophyll-*a* was found highest in summer, average in rainy and low in winter seasons with 5.307, 4.591 and 2.399 $mg/m^3$, respectively (Figure 3). This corresponded to the study conducted by Thidaporn (1997) and Somlada et al. (2001) that in summer the average concentration of chlorophyll-*a* was highly found according to the increasing quantity of total phytoplankton and was found highest in summer, and by Sanders et al. (2001) reported that the quantity of the chlorophyll-*a* changes according to season in the areas influenced by nitrate and phosphate. The mentioned difference resulted from the geographical difference; that is, the upstream areas of the reservoir was the water source supported by Kha Khaeng Creek and Jone Stream with fine depth and narrow stream compared with the middle and downstream areas with depth and width, along with weather factors regarding hot weather in summer, high light intensity, and transparency, leading to high synthesis of the phytoplankton (Ladda, 1987). Furthermore, in the rainy season nutrients were eroded by flooding from land into the reservoir, consequently the growth of the phytoplankton. As a result, chlorophyll-*a* in summer and in rainy seasons was higher than those in winter season.

Nonetheless, average chlorophyll-*a* concentration around the reservoir was in low level, which indicated low nutrient fertility due to the fact that it was a huge reservoir with width, depth, and vast area for phytoplankton distribution. Compared with the classification of the water nutrient fertility by chlorophyll-*a* initiated by Ryding & Rast (1989) that chlorophyll-*a* could indicate the fertility of the water source, in the water source with low fertility the chlorophyll-*a* of less than 4.7 $mg/m^3$ was found, in the water source with medium fertility the chlorophyll-*a* of between 4.7-14.3 $mg/m^3$ was found, and in the water source with high fertility of chlorophyll-*a* of over 14.3 $mg/m^3$ was found.

**Table 2:** The yearly average of all determined parameters in Srinadharin Reservoir between April 2008 to March 2009

| Environmental factors | Parameters | | | |
|---|---|---|---|---|
| | Minimun | Median | Maximum | Mean±SD |
| Chlorophyll-*a* ($mg/m^3$) | 0.103 | 1.702 | 25.121 | 4.099 ± 5.607 |
| Ammonia-nitrogen (mg/l) | nd | 0.065 | 0.155 | 0.067 ± 0.044 |
| Nitrate-nitrogen (mg/l) | nd | nd | 0.069 | 0.013 ± 0.017 |
| Inorganic-nitrogen (mg/l) | 0.013 | 0.083 | 0.177 | 0.085 ± 0.041 |
| Organic-nitrogen (mg/l) | nd | 0.246 | 1.925 | 0.336 ± 0.323 |
| Total nitrogen (mg/l) | 0.102 | 0.280 | 2.080 | 0.421 ± 0.332 |
| Orthophosphate-phosphorous (mg/l) | nd | 0.011 | 0.067 | 0.02 ± 0.022 |
| Total phosphorous (mg/l) | nd | 0.050 | 0.511 | 0.146 ± 0.151 |
| Alkalinity (mg/l) | 90.00 | 127.50 | 142.40 | 124.6 ± 10.86 |
| Water temperature (°C) | 26.00 | 29.70 | 32.00 | 29.15 ± 1.41 |
| Transparency (cm) | 60.00 | 190.00 | 490.00 | 193.28 ± 84.67 |
| Electrical conductivity (µS/cm) | 141.50 | 210.50 | 228.50 | 205.19 ± 18.39 |
| Dissolved oxygen (mg/l) | 5.63 | 7.54 | 10.60 | 7.84 ± 1.125 |

Note: nd = not detection

**Table 3:** The concentration of chlorophyll-*a* ($mg/m^3$) in terms of time and area in Srinakarin Reservoir between April 2008 to March 2009

| Chlorophyll-*a* Concentration ($mg/m^3$) | | | | |
|---|---|---|---|---|
| **Month** | **Minimun** | **Median** | **Maximum** | **Mean±SD** |
| April | 1.154 | 2.865 | 21.188 | 4.976 ± 5.490 |
| June | 0.476 | 1.607 | 24.465 | 4.611 ± 7.412 |
| August | 0.937 | 1.604 | 25.121 | 4.571 ± 6.664 |
| October | 0.291 | 0.582 | 18.645 | 3.162 ± 5.743 |
| December | 0.103 | 0.976 | 8.354 | 1.637 ± 1.997 |
| February | 0.474 | 3.696 | 15.051 | 5.639 ± 4.699 |
| **Season** | | | | |
| Summer | 0.474 | 3.165 | 21.188 | 5.307 ± 5.033 |
| Rainy | 0.476 | 1.606 | 25.121 | 4.591 ± 6.926 |
| Winter | 0.103 | 0.922 | 18.645 | 2.399 ± 4.296 |
| **Area zone** | | | | |
| Upstream | 0.474 | 8.229 | 25.121 | 8.989 ± 7.389 |
| Middle | 0.103 | 1.202 | 8.049 | 1.876 ± 1.898 |
| Downstream | 0.258 | 1.442 | 5.626 | 1.431 ± 1.039 |
| **Yearly average** | **0.103** | **1.702** | **25.121** | **4.099 ± 5.607** |

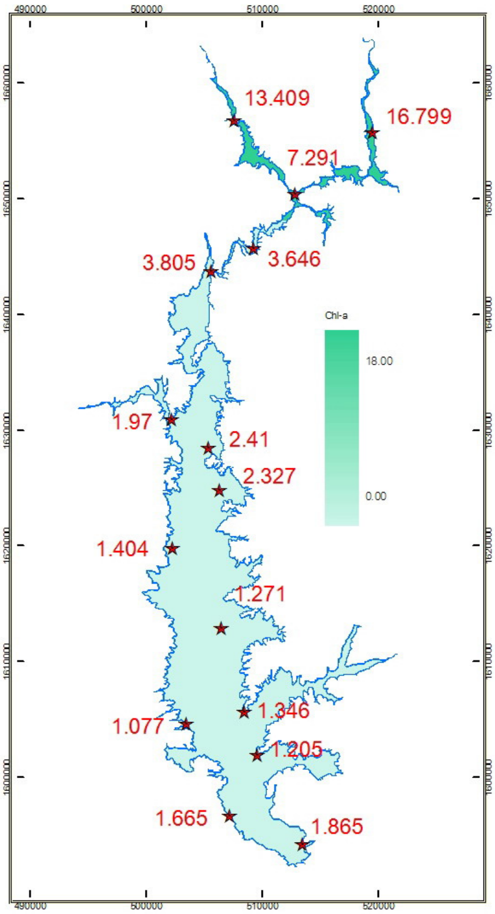


**Figure 2**: The distribution of average chlorophyll-*a* ($mg/m^3$) in Srinadharin Reservoir during April 2008 to March 2009

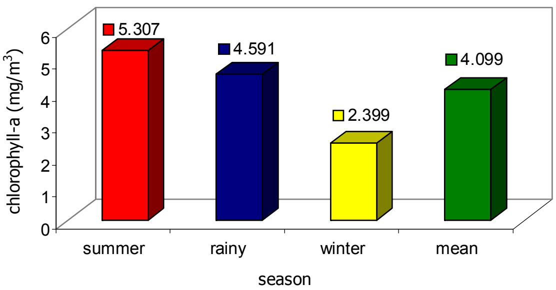


**Figure 3**: The seasonal average of chlorophyll-*a* ($mg/m^3$) in Srinadharin Reservoir during April 2008 to March 2009

1.2 Nutrient The concentration and distribution of nutrients, namely, nitrogen in terms of ammonia, nitrate, inorganic nitrogen, organic nitrogen, and total nitrogen, and phosphorus in terms of orthophosphate phosphorus and total phosphorus, almost all of which had fine distributions around the reservoir depending on location and period determination. At the upstream areas overall average nutrient concentration was high and tended to distribute to the middle and downstream areas. Compared with period determination, the nutrients were averagely most found in the rainy season and less found in summer and winter respectively. In this regard, the difference was due to the fact that the upstream areas was the water source and that in each period the decompositions of organic substances into inorganic substances were different; in summer, high temperature led to the decompositions of organic substances into inorganic substances that the phytoplankton could highly use, whereas lower temperature in winter resulted in fewer decompositions (Ladda, 1987). Meanwhile, in the rainy season nutrients were eroded from land into the reservoir, leading to overall high nutrients compared with other periods. In addition, in the upstream areas with high nutrient concentrations, the chlorophyll-*a* was highly found as well. The nutrients found could be used for the growth of the phytoplankton, which corresponded to the report by Alam et al. (2001) that the concentrations of the nutrients, especially ammonia and nitrate affected the increase and change of the phytoplankton.

1.3 Water Quality The overall status of both physical and chemical water quality that was important for the growth of the phytoplankton and aquatic animals along the length of the reservoir was averagely in 2nd surface water quality standard, standard for control the drainage of the wastewater into public water source or environment (Ministry of Natural Resources and Environment, 2007), and water quality standard for the protection of freshwater animals, except for the water transparency which was somewhat high compared with the appropriate level for the living of the aquatic animals, namely between 30-60 cm (Maitri, 1987). The water transparency was a factor indicating the concentration of the phyto plankton; any areas with high water transparency value and low nutrient distribution value consequently had low concentration of the phytoplankton. However, high water transparency value a little bit affected the living of the aquatic animals since Srinadharin reservoir is vast with depth and width. As a result, the change of the environmental factors gradually took place.

**2. Correlation between the environmental factors**

2.1 Correlation between chlorophyll-*a* and nutrients

Chlorophyll-*a* had medium positive correlation to total nitrogen (r = 0.371**) and organic nitrogen (r = 0.350**), and had low positive correlation to inorganic nitrogen (r = 0.285**), total phosphorus (r = 0.239*), and ammonia nitrogen (r = 0.227*) (Table 4). According to the analysis, the nutrients of both nitrogen and phosphorus influenced the products of the phytoplankton. Kontas et al. (2004) stated that inorganic substance was the nutrient that indicated the fertility of the phytoplankton. Moreover, Lunven et al. (2005) reported that the quantity of the inorganic nitrogen of less than 0.2 micromole/$dm^3$ affected the limit of the product of the phytoplankton, which corresponded to the study of Nissanka et al. (2000) said that chlorophyll-*a* was directly influenced by soluble phosphorus, total phosphorus, alkalinity and electrical conductivity; the study of Somlada et al. (2001) reported that the quantity of the chlorophyll-*a* around upstream Songkhla Lake changed according to the quantity of nitrogen; the study of Amphorn (2001) also reported that the quantity of the chlorophyll-*a* around the Wachiralongkorn Reservoir had positive correlation to ammonia, nitrate, and orthophosphate; the study of Angkhana (2006) reported that in the Pasak River the quantity of the chlorophyll-*a* had correlation to phosphorus; the study of Camdevyven et al. (2005) said that if the water ecological system had the diversity in the phytoplankton or primary producer measured by the concentration of the chlorophyll-*a*, the chlorophyll-*a* had positive correlation to ammonia-nitrogen; and the study of Alam et al. (2001) found that the decreasing concentration of ammonia and nitrate put impact on the increase and change of the phytoplankton population. In this respect, like ammonia, nitrate is the nutrient that the phyto plankton and water plant used to synthesize protein for their growth (Wu & Chou, 2003).

**Table 4:** The correlation coefficient between chlorophyll-*a* and macronutrients in Srinadharin Reservoir during April 2008 to March 2009

| parameters | Correlation Coefficient |
|---|---|
| Ammonia-nitrogen | 0.227* |
| Nitrate-nitrogen | 0.173 |
| Inorganic-nitrogen | 0.285** |
| Organic-nitrogen | 0.350** |
| Total nitrogen | 0.371** |
| Orthophosphate-phosphorous | 0.164 |
| Total phosphorous | 0.239* |

Note : * = Correlation is significant at the 0.05 level
** = Correlation is significant at the 0.01 level

2.2 Correlation between chlorophyll-*a* and water quality

Chlorophyll-*a* had medium positive correlation to water temperature (r = 0.445**) and dissolved oxygen (r = 0.355**), and had medium negative correlation to transparency (r = -0.534**), electrical conductivity(r = -0.451**), and alkalinity (r = -0.410**) (Table 5). According to the analysis, water temperature and dissolved oxygen had positive correlation to the chlorophyll-*a* and both factors provided the average value that was appropriate for the living of the aquatic animals and the distribution of the phytoplankton. Water temperature influenced the control of the growth and distribution of the phyto plankton (Piamsak, 1995), which corresponded to the study of Thidaporn (1997) reported that the quantity of the chlorophyll-*a* had positive correlation to water temperature; the study of Angkhana (2006) found that and the study of Maitri & Jaruwan (1985) also reported that in any periods with light the phyto plankton had photosynthesis and generated oxygen for the water sources. This meant that with high quantity of the phytoplankton the level of the chlorophyll-*a* was high, resulting in much oxygen in the water sources. Regarding the factor that had negative correlation to the chlorophyll-*a*, specifically the transparency, in the upstream areas with low transparency the average quantity of the chlorophyll-a was found more than that in the middle and downstream areas with high transparency. Moreover, this corresponded to the study of Amphorn (2001) found that the chlorophyll-*a* had negative correlation to the transparency of the water in the Wachiralongkorn Reservoir and the study of Pornpimol (2007) also found that the transparency of the water was a factor that apparently played role for the concentration of the phytoplankton.

**Table 5:** The correlation coefficient between chlorophyll-*a* and water qualities in Srinadharin Reservoir during April 2008 to March 2009

| parameters | Correlation Coefficient |
|---|---|
| Water temperature | 0.445 ** |
| Transparency | -0.534 ** |
| Electrical conductivity | -0.451 ** |
| Dissolved oxygen | 0.355** |
| Alkalinity | -0.410** |

Note : * = Correlation is significant at the 0.05 level

## CONCLUSION AND RECOMMENDATION

Srinadharin reservoir has the average value of chlorophyll-*a* of 4.099 mg/m$^3$ and is regarded as oligotrophic status. Chlorophyll-*a* concentration at the upstream is higher than those in the middle and downstream areas and the chlorophyll-*a* is found highest in summer, average in the rainy season and low in winter.

The status and distribution of the nutrients of nitrogen and phosphorus around the reservoir is not over the 2$^{nd}$ surface water quality standard and not hazardous to the living of the aquatic animals, as well as changes depending on period and location determination. At the upstream the average concentration of the nutrients is high and they tend to distribute into the middle and downstream areas. Furthermore, they are found most in the rainy season and less in summer and winter respectively.

As to the correlation of the environmental factors, the chlorophyll-*a* has positive correlation to total nitrogen, organic nitrogen, inorganic nitrogen, total phosphorus, ammonia nitrogen, water temperature, and dissolved oxygen, whereas has negative correlation to transparency, electrical conductivity, and alkalinity.

The results obtained from the study can be applied to estimate fish yield and manage Srinadharin reservoir for getting future sustainable yield.

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