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

**Yupin Lerdburoos[1,*], Wit Tarnchalanukit[1], Prathak Tabthipwon[2], Ruangvich Yoonphand[2]**

[1] College of Environment, Kasetsart University, Bangkok 10900, Thailand.

[2] Faculty of Fisheries, Kasetsart University, Bangkok 10900, Thailand.

## 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.

*Key Words:* Nutrients/ Chlorophyll-*a*/ Water Quality/ Srinadharin Reservoir

## 1. 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.,

* Corresponding author.
E-mail address: lekky_31@hotmail.com
Tel: 084 640 1004

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 $10^6$ 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 correlate with fishery products due to the fact that any reservoirs that provide sustainable aquatic animal products indicate the fertility of the water which every environmental factor, namely producers, consumers, decomposers as well as supporters, are in balance. Each of the environmental factors plays its role effectively so as to transform inputs into outputs and to transmit energy through the food chain to large aquatic animals that can be harvested. This is to indicate the reservoir's role or potential in generating the products. In this respect, nutrients are a supportive factor for the aquatic animals to live on and grow, especially such important nutrients needed for the growth of the primary producers or phytoplankton as nitrogen and phosphorus, all of which are important to the water ecological system. The phytoplankton and other factors use the nutrients through the process of photosynthesis, in generating its tissue and transmitting energy to other aquatic animals. Primary product of the water is the biomass of the phytoplankton resulting from the photosynthesis. All species of phytoplankton use chlorophyll-*a* as the main factor for the photosynthesis and it is possible to indicate the biomass of the phytoplankton (Ladda, 1999). The change of the nutrients can have an impact on the quantity of the chlorophyll-*a*, its potential for growth and multiplication of aquatic animals in the reservoir.

Therefore, the study on the relationships of nutrients, chlorophyll-*a*, physical and chemical properties of water in Srinadharin reservoir, Kanchanaburi province to gain information on their changeability and distribution as well as physical and chemical properties of the water, including the correlation between them. These factors are the environmental indicators that might be applicable to the forecast of the aquatic animals in the reservoir and used as the database for effective reservoir management for further sustainable fishery resources.

## 2. 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-March 2009, totally 6 times over the year.

The data obtained were made correlation among micronutrients, chlorophyll-*a* and water qualities using

Pearson's Correlation Coefficient and to consider for future fish yield estimation in the reservoir.

The correlation between chlorophyll-*a* and all determined parameters (Kanlaya, 2008) as the following level:

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

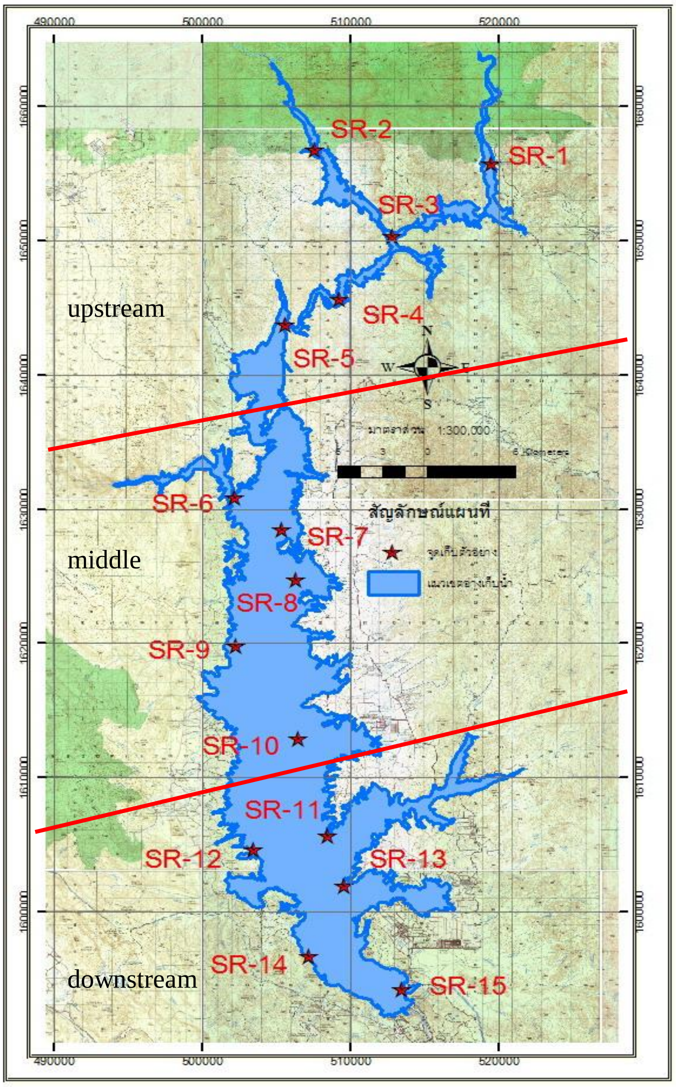


**Figure 1**: Surface water quality and aquatic ecology sampling stations Srinadharin Reservoir

**Table 1:** Environmental factor analysis

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

Note: Items 10-13 immediate analysis in the field

## 3. Results and Discussion

The yearly average value (Table 2) of each of the environmental factors of the reservoir was up to the standard for the water quality appropriate for the aquatic animals to live, except for the transparency, which was higher than the standard**.** The details of the changes and the correlation of each of the environmental factors are as follows:

### *3.1 The changes of the environmental factors*

*3.1.1 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 area (8.989 mg/m$^3$), followed by the middle and downstream areas 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 concentration in summer, average in the rainy season and low in winter, i.e. 5.307, 4.591 and 2.399 mg/m$^3$, respectively (Figure 3). This corresponded to the studies conducted by Thidaporn (1997) and Somlada et al. (2001) which found that in summer the average concentration of chlorophyll-*a* was high according to the increasing quantity of total phytoplankton, and by Sanders et al. (2001) which reported that the quantity of the chlorophyll-*a* changed 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 supplies from Kha Khaeng Creek and Jone Stream with fine depth and narrow stream compared with the middle and downstream areas with greater depth and width, and from weather factors, being hot in summer and high in light intensity and transparency, leading to high photosynthesis of the phytoplankton (Ladda, 1987). Furthermore, in the rainy season nutrients were eroded by flooding from land into the reservoir, consequently leading to the growth of the phytoplankton. As a result, chlorophyll-*a* concentrations in summer and in the rainy season were higher than those in winter.

Nonetheless, average chlorophyll-*a* concentration around the reservoir was low, which indicated low nutrient fertility due to the fact that it was a huge and deep reservoir for phytoplankton distribution. Compared with the classification of the water nutrient fertility by chlorophyll-*a* initiated by Ryding and Rast (1989) that chlorophyll-*a* could indicate the fertility of the water source, i.e. 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 the 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-phosphorus (mg/l) | nd | 0.011 | 0.067 | 0.02±0.022 |
| Total phosphorus (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±1.4 |
| Transparency (cm) | 60.00 | 190.00 | 490.00 | 193.28±84 |
| 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±1.13 |

Note: nd = non detection

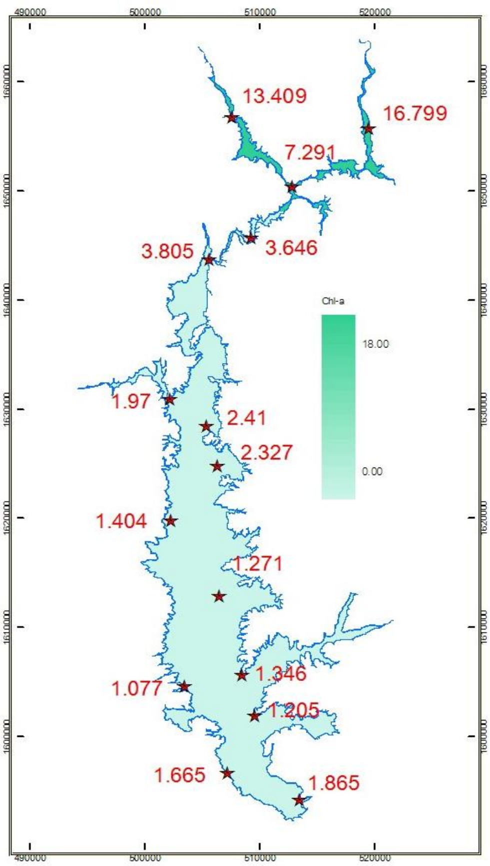


**Figure 2:** The distribution of average chlorophyll-*a* (mg/m$^3$) in Srinadharin Reservoir during April 2008 to March 2009

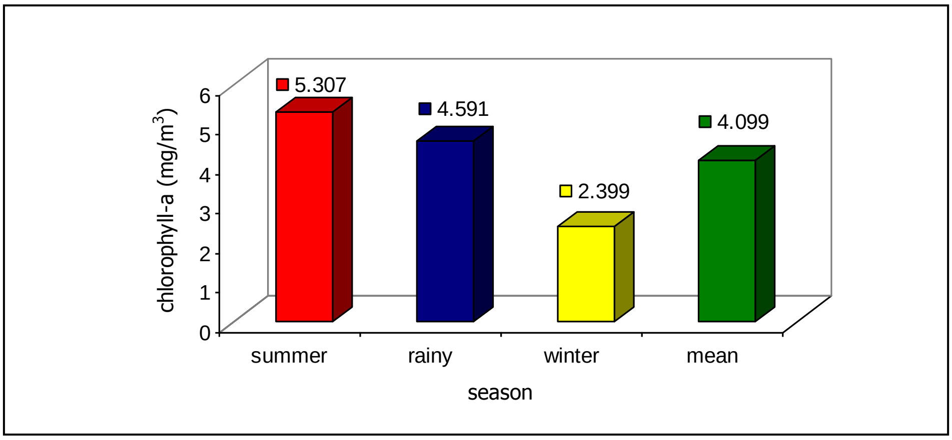


**Figure 3:** The seasonal average of chlorophyll-*a* (mg/m$^3$) in Srinadharin Reservoir between April 2008 to March 2009

**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** |

*3.1.2 Nutrient* Almost all of the 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 locations and periods data collections. 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 area was the water source and that in each period the decomposition of organic substances into inorganic substances were different; in summer, high temperature led to the decomposition of organic substances into inorganic substances that the phytoplankton could highly use, whereas lower temperature in winter resulted in less decomposition

(Ladda, 1999). 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 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 phytoplankton.

*3.1.3 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 $2^{nd}$ surface water quality standard, and water quality standard for the protection of freshwater animals, except for the water transparency which the appropriate level for the living of the aquatic animals, namely between 30-60 cm. The water transparency was a factor indicating the concentration of the phytoplankton; 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 Srinakarin Reservoir is a vast and deep one. As a result, the change of the environmental factors gradually took place.

### *3.2 Correlation between the environmental factors*

*3.2.1 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 phytoplankton and water plant used to synthesize protein for their growth (Wu and Chou, 2003).

**Table 4:** The correlation coefficient between chlorophyll-*a* and micronutrients 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* |

Remark : * = Correlation is significant at the 0.05 level.
** = Correlation is significant at the 0.01 level.

*3.2.2 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 = - 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 phytoplankton (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 the chlorophyll-*a* had correlation to the transparency. 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** |

Remark : * = Correlation is significant at the 0.05 level.
** = Correlation is significant at the 0.01 level.

## 4. Conclusion and Recommendation

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

The status and distribution 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 according to period and location determination. At the upstream the average concentration of the nutrients is high and they tend to distribute into the midstream 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 environmental indicators from this study can be applied to the form of the correlation to catching aquatic animals in terms of Linear Regression Equation for the purpose of predicting the catch of aquatic animal in the Srinadharin reservoir. In addition, it can be used as the important database for responsible departments in the management of any reservoirs for further sustainable fish yields along with the awareness of the worthy use of the natural resources in the reservoir.

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