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Original Article

# Nutrients in Nong Khod Lake

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**Abstract**

Eutrophication is caused by excess nutrients in a lake, namely nitrogen and phosphorus. In addition, sunlight and warm temperatures are required for cyanobacteria grow. This study measured nutrient concentrations in Nong Khod Lake, where eutrophication is a serious problem and discuss possible nutrient sources. Twelve samples were collected from six sites on January 23, 2018 and were analyzed for total nitrogen (TN) and total phosphorus (TP) in both surface water and sediment and compared with Thailand's water quality standards. In addition, influence of land use pattern was considered.

Concentrations of TN and TP in the water ranged from 5.7 to 8.8 mg/L and 0.2 to 1.2 mg/L, respectively, while the concentration of TN and TP in sediments ranged from 12.2 to 40.6 mg-N/kg and 1.2 to 7.6 mg-P/kg, respectively. The point was obtained runoff from community area. Where was the highest of TN (8.8±0.2 mg/L), runoff was often worsened by human activities, and could contained nitrogen storm water flows directly into the lake. The point was obtained runoff from agriculture area and that $NH_4$-N concentration was the highest (2.9±0.2mg/L). In contrast, the point was obtained runoff from fresh market area and that cyanobacteria grow, this affected to $NO_3$-N concentration was the highest (0.07±0.0mg/L). Also TN and TP concentration of sediments were the highest (40.6±0.9 mg-N/kg and 7.6±0.7 mg-P/kg,
respectively). This percentage of water content in sediment was 57.8±0.3 that similarly clay. And average of pH was 8.3.

In conclusion, nutrient concentrations of Nong Khod Lake has revealed that related on source. Such as concentration of nitrogen related with runoff from land use pattern while phosphorus even related on sediment. The furfure work, maintain for Nong Khod Lake has been gradually improved. However, we have to survey water quality and sediment about TN and TP.

***Keywords*:** *Eutrophication, Nitrogen, Phosphorus, Water Quality*

## Introduction

Eutrophication in aquatic systems, such as rivers, lakes and estuaries, is associated with the inflow of nitrogen (N) and phosphorus (P) from land via surface runoff and soil erosion (Machito, 2001; Langhammer, 2002). Although eutrophication is a natural process in the aging of lakes and some estuaries, N and P enrichment due to intensified agriculture, urban development, industry and atmospheric deposition (particularly in agriculture area) is one of the leading problems facing some aquatic systems (Carpenter et al., 1998; Elrashidi, 2004; Howarth et al., 1996; Junhong et al., 2004). In the Kasumigaura lake basin of Japan, the loads of N and P in surface runoff are accounted for 68% and 81% of the annual loads, respectively (Suzuki & Tabuchi, 1984).

The water bloom of phytoplankton causes many negative problems on economy, society and environment. The major problems caused by eutrophication include loss of biodiversity of both plants and animals due to improper environmental conditions and problems of water purification systems for drinking water. The cyanobacteria bloom in particular also creates toxins such as microcystins, anatoxin-a and homoanatoxin-a, which directly affect the health of humans and animals. Moreover, eutrophication results in the loss of beautiful scenery due to unpleasant color and odor caused by rotten algae, which affects recreational activities (Paerl, 2018).

This study examined the nutrient concentrations in water and sediment of Nong Khod Lake. This work is hoped to provide a tool to support a proper Nong Khod Lake management in future.

## Study Objectives

The objectives of this study were to: 1) measure and report nutrient concentrations in Nong Khod Lake, and 2) discuss possible nutrient sources.

## Methodology

- **Study Area**

Nong Khod Lake is located in Ban Ped municipality within the Khon Kaen metropolitan area of Khon Kaen province and covers an area around 1.05 $km^2$ as shown in Figure 1. The lake's watershed is located within Ban Ped municipality, including agricultural, residential, and commercial land uses. Prior to 2018, water drained via a canal system to Khon Kaen municipality's storm water system, where it would drain to either the Nam Pong River or to Khon Kaen's wastewater treatment plant (Kuster & Kuster, 2017). However, beginning in 2018, a pump system was installed to pump water out of the lake via the same canal system. The present major of land use pattern were 3 patterns, including agriculture area (almost is rice paddy), community (villages, household, restaurant) and fresh market as shown in figure 2. Those arrows in the figure 2 mean runoff flow direction. Evidence of eutrophication of Nong Khod Lake was first recorded in 2007 based on monitoring by Regional Environment Office 10 (REO-10) (2007). Eutrophication in Nong Khod Lake can occur any time of theyear, especially in rainy season (July to October). Nitrogen and phosphorus are major nutrients that effect to eutrophication in the lake. The typical sources of that such as runoff from agriculture area, community area and fresh market area, where are non-points source. Nutrients from area are deposited into the lake by runoffsince runoff is drained to the lake.

- **Sampling methods**

Six locations were chosen in the lake for water and sediment sampling, as shown in Figure 2. The sampling points were chosen to examine factors such as points of effluent (runoff) discharge into the lake, land use pattern and nearness of sampling point to reference. Study points were designated 1a to 3a and reference points were designated 1b to 3b as shown in Figure 2. Points were chosen and the coordinates of those points were loaded into a GPS unit, which was used to locate the points in the lake while on a rowboat. Two samples were then collected at each location (a total of 12 samples) on 23 January 2018.

Water samples were collected in polyethylene bottles. The bottles were rinsed with lake water before collection and temperature/ pH were measured immediately after collection. Water samples for DO and BOD measurements were collected with 300mL BOD bottles with drop solution of manganese sulfate and alkaline Iodide azide at sampling point to fix samples. Water samples were transported to the laboratory (less than 2 h) and kept on ice (below 2°C). Analysis for TN and TP was carried out within 24 hours.

Sediment samples were collected with Eckman grab sampler at each point and measured pH immediately. Sediment samples were wrapped with polythene bags, kept on cooling stored and transported to the laboratory.

- **Analytical methods**

In case of water, transparency was measured at each sampling site with a Secchi disc (30 cm in diameter). The Modified Winkler-Azide Method was used to analyses water samples for DO and BOD. The water samples for TN, $NO_3$-N, $NH_4$-N, $NO_2$-N, TKN and TP were determined by the Standard methods for the examination of water and wastewater 21st ed. (APHA, AWWA, & WEF, 2005). At the same time, equipment was calibrated before. The mean of the duplicate measurements at each location was regarded as the final result at each location. Sediments were air-dried and removed large debris, stones and other coarse materials for chemical analysis. Water content of sediment determined by weighing before and after dried.

- **Statistical analysis**

The mean and standard deviation of the duplicate samples collected as each location for each parameters were calculated using Stata
statistical software.

**Results and Discussion**

Figure 3 shows the shape of Nong Khod Lake. The lake was shallow that area of 1.05 $km^2$ and average of depth was 3.1 m.

- **Concentration of nutrients in water**

**Physiochemical Properties**

Water characteristics from the six sampling locationsare shown in Table 1. Mean water
temperatures and pH at locations ranged between 24.2 and 25.2 ℃ and 8.2 and 8.4, respectively.

**Nitrogen**

Mean ammonium (NH4-N) concentrations ranged between 0.1 and 2.9 mg/L. The highest concentration of $NH_4$-N was at location 3a (2.9± 0.2 mg/L), that is same $NO_2$-N (0.6±0.0 mg/L) which are near the agricultural area. Mean concentrations of nitrate ($NO_3$-N) ranged between 0.02 and 0.07 mg/L. The highest concentration of $NO_3$-N was at location 2a (0.07±0.00 mg/L).
Generally, this got runoff from fresh market area. Also, cyanobacteria grows and dies in this area. That indicated an increasing $NO_3$-N

resulting from organic decomposition unless $NO_3$-N was produced by cell cyanobacteria. This was resulted $NO_3$-N concentration was the highest. Mean concentrations of TKN ranged between 5.3 and 8.6 mg/L and the highest was location 1a (8.6±0.4 mg/L), which generally obtained runoff from the residential community area. The highest concentration of TN was at location 1a (8.8±0.2 mg/L).

Overall, the variation in concentration of nitrogen corresponded with land use patterns. It can conclude that the contents of nitrogen were affect from land use pattern.

**Phosphorus**

Mean phosphorus concentrations ranged between 0.2 and 1.2 mg/L. The highest concentration of this was at location 2b (1.2±0.3 mg/L) in spite of runoff not draining into the lake nearby. However, it should be noted that phosphorus tends to accumulate in sediments and is also released from lake sediment. In January and February, rain fell and there was runoff into the lake at that time. Including other factors influencing phosphorus include mineral stability, mineralogy, pH, temperature, prevailing redox reactions and the concentration of iron, aluminum and calcium (Stump & Morgan, 1970; Yi et al., 2008). In this case, the depth at location 2b ranged between 6 to 7 m and pH 8.2±0.2. Van Hullebusch et al. (2003) found that a lower quantity of phosphorus was release at neutral pH than at pH 10 in oxic conditions and aluminum treatment was not efficient in preventing the release of phosphorus.

**Concentration of nutrients in sediment**

Mean TN sediment concentrations ranged from 49.5 to 57 mg/kg, while mean TP ranged from 12.2 to 40.6 mg/kg.. The highest of TN and TP concentration wasfound at location 2a (40.6± 0.9 mg-N/kg and 7.6±0.7 mg-P/kg). Generally, this area receives substantial runoff from fresh market area and urban runoff from the surrounding community. Characteristics of sediment, which in this area is like clay, determine whether phosphorus adsorbs to the sediment. As suggested by Black (1968) and Onianwa (2013) the relationship with the clay content is probably due to phosphorus being released in a soluble form from the weathering of primary phosphorus-bearing minerals and P additions as plant residues. Pettersson (1998) suggested that number of environmental factors are important in the mobilization processes. Bar-Yosef, B (1988) was suggested that phosphorus solution concentration as a function of pH. Moreover Hartono et al. (2005) suggested that TP sorption experiments in acid upland soils in Indonesia showed that soils varied widely in their capacity to sorb TP. The investigated pH ranged between 7 to 8.

## Conclusion

In conclusion, the research indicated that nutrient concentrations in the surface water and sediment are very high and indicative of eutrophic conditions. The major water quality problems were ammonia-nitrogen, high turbidity, and high organic matter (biochemical oxygen demand, BOD),
respectively. The major sources of water pollution were runoff from residential communities and agriculture are as adjacent to the lake, especially in rainy season. In general, the nitrogen concentrations in the water seem to vary with proximity to runoff point sources, while phosphorus concentrations in the water seem to be dependent on sediment conditions.

## Suggestion

Future work should identify specific sources of nutrients loading in the lake via a water and nutrient loading budget. It is recommended to develop a numerical water quality model to assess the conditions in the lake.

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**Table 1** Water quality in Nong Khod Lake

| Parameter | units | Points | |
|---|---|---|---|
| | | Sampling points | Reference points |

| | | 1a | 2a | 3a | 1b | 2b | 3b |
|---|---|---|---|---|---|---|---|
| pH | | 8.2±0.1 | 8.4±0.6 | 8.2±0.3 | 8.4±0.1 | 8.2±0.2 | 8.3±0.3 |
| W.T | (C°) | 24.6±0.2 | 24.5±0.1 | 24.8±0.2 | 24.2±0.2 | 24.3±0.1 | 25.2±0.2 |
| $NO_3$-N | (mg/L) | 0.04±0.01 | 0.07±0.00 | 0.05±0.00 | 0.02±0.00 | 0.06±0.00 | 0.05±0.00 |
| $NO_2$-N | (mg/L) | 0.2±0.0 | 0.5±0.02 | 0.6±0.0 | 0.1±0.01 | 0.3±0.0 | 0.04±0.00 |
| TKN | (mg/L) | 8.6±0.1 | 6.9±0.1 | 5.6±0.1 | 8.1±0.1 | 5.3±0.1 | 7.4±0.1 |
| $NH_4$-N | (mg/L) | 0.2±0.0 | 1.6±0.2 | 2.9±0.2 | 0.1±0.0 | 0.6±0.1 | 0.4±0.0 |
| TN | (mg/L) | **8.8±0.2** | 7.4±0.1 | 6.3±0.1 | 8.2±0.2 | 5.7±0.0 | 7.5±0.1 |
| TP | (mg/L) | 0.9±0.1 | 0.4±0.1 | 0.7±0.2 | 0.2±0.1 | **1.2±0.3** | 0.3±0.1 |
| TN:TP | | 9.8 | 18.5 | 9.0 | 41.0 | 4.8 | 25.0 |

**Table 2** Nutrient concentrations in sediment.

| Parameters(units) | | Points | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sampling points | | | Reference points | | |
| | | 1a | 2a | 3a | 1b | 2b | 3b |
| Water contents (%) | | 54.0±3.4 | 57.8±0.3 | 55.7±0.6 | 49.5±0.9 | 50.3±0.9 | 49.5±1.0 |
| pH | | 8.6±0.1 | 8.3±0.3 | 7.5±0.2 | 8.8±0.1 | 7.5±0.3 | 7±0.1 |
| TN | (mg-N/kg) | 25.7±1.0 | **40.6±0.9** | 21.5±1.3 | 33.1±1.1 | **12.2±0.2** | 22.4±0.5 |
| TP | (mg-P/kg) | 3.7±0.6 | **7.6±0.7** | 2.9±0.6 | 5.1±0.7 | 2.7±0.5 | **1.2±0.3** |

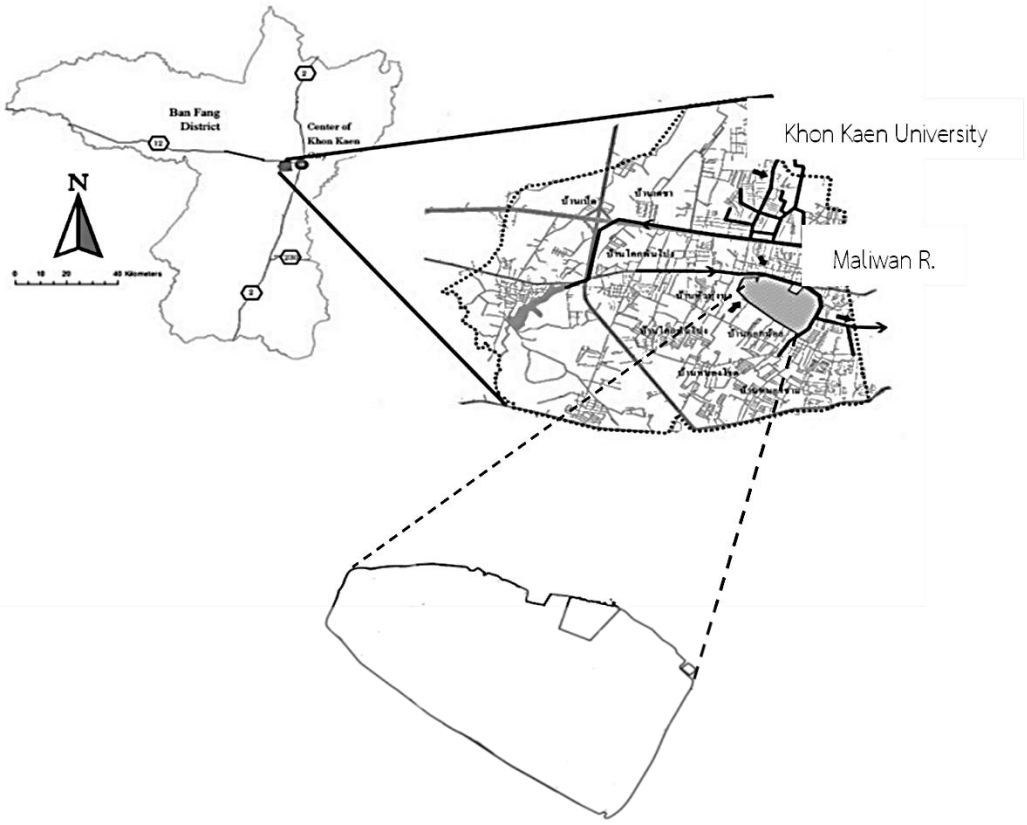


**Figure 1** Location of Nong Khod Lake

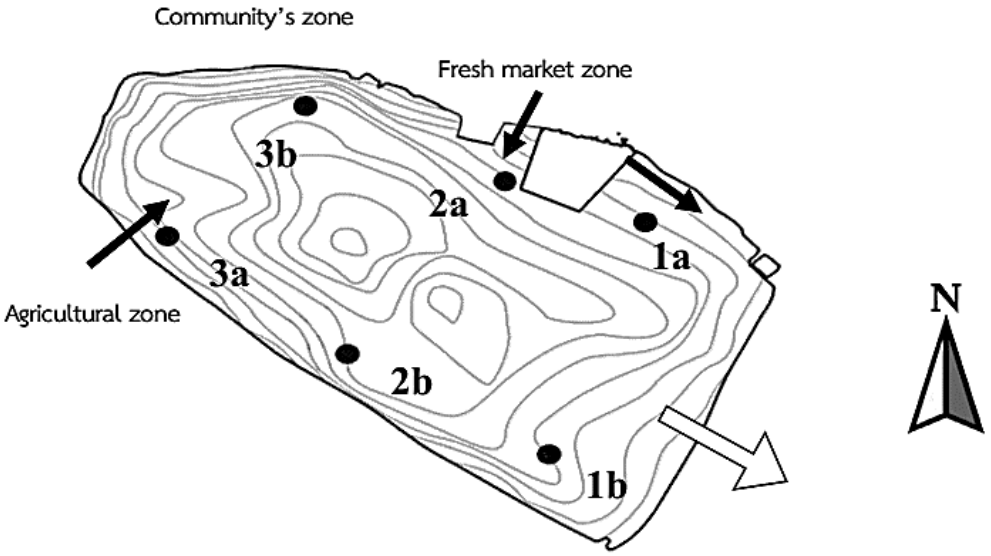


**Figure 2** Sampling points of Nong Khod Lake

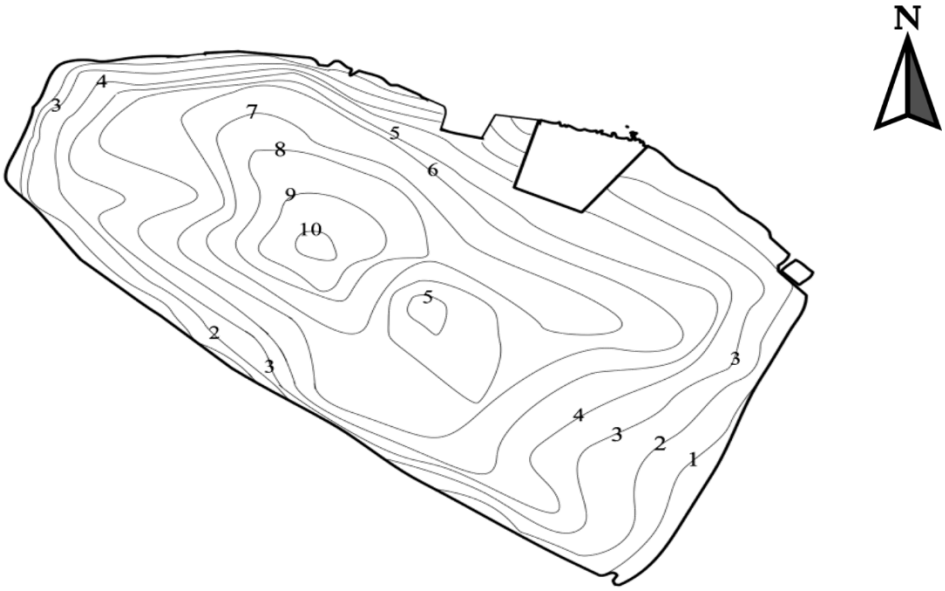


**Figure 3** Shape of Nong Khod Lake, measured in 23 February 2018