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Assessment of Seasonal Nutrient Loads with Some Physica-Chemical Parameters around the Floating Community of Chhnok Tru in Tonle Sap Lake, Cambodia

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Abstract: *Tonle Sap Biosphere Reserve (TSBR), the largest productive freshwater lake in Southeast Asia regions, is recognized by UNESCO in 1997. TSBR gives a huge benefit to Cambodian, especially for riparian settlement along the lake. The surface area of TSBR changes from 250 000 to 300 000 ha in dry season with the level of water about 1.5m, while in rainy season the area is increased from 1 to 1.3 million ha with the level of water from 8 to 10m. TSBR absorbs huge amount of water from Mekong River, rich of nutrients and enrich biodiversity in the lake making the lake become unique. In addition, this study purposefully seeks to understand the nutrient loading during dry season and compare the result with rainy season in terms of some parameters: temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), total suspended solids (TSS), nitrogen (N) and phosphorus (P) concentrations. The result showed that the average concentration of N during dry season varied from 1.5mg/L to 8.3mg/L, while in rainy season the average concentration of N ranged from 0.18mg/L to 4.88mg/L. On the other hand, the concentration of P during dry season varied from 0.1mg/L to 0.57mg/L, while in rainy season was between 0.01mg/L and 0.08mg/L. It is noted that both N and P concentrations during dry season are observed higher than those during rainy season. This high value could draw a conclusion that anthropogenic inputs around floating villages of Chhnok Tru such as agricultural activities, animal and fish farming together with direct discharge of domestic waste and other natural processes are probably the major sources. It is further remarked that the climate condition could also be the coupling contributor to the extremely high concentration of the nutrients in water of the community.*

Keywords: Nutrient Loads, Concentration, Floating Community, Tonle Sap Biosphere Reserve

1. INTRODUCTION

Tonle Sap Biosphere Reserve (TSBR) was nominated the first biosphere reserve in Cambodia in October 1997 (Min & Cornelis, 2000). TSBR is one of the largest freshwater lake in Southeast Asia, located in the center of Cambodia. TSBR is the heartbeat of Mekong River connected by Tonle Sap River (TSR); the physical land of the lake undergone by two main seasons: dry and wet seasons. The overall flooding during dry season has been recorded around 3,000 km^2 (100 km long and 32 km wide) with 0.8 to 1 meters of water level while in wet season, the water level is from 10 to 12 meters with flooding area of 10,000 km^2 (THAY & Ulrich, 2004). Moreover, people living around TSBR in 1998 was around 3,505,448 and 4,356,705 in 2008 with the growth rate of 22.71 percent, while in 2013 it is estimated to be 4,719,967 people and the growth rate between 2008 and 2013 is 8.34 percent (NIS, 2013). In addition, TSBR is home to 100 species of fishes that regularly exist and more than 200 species have been recorded in TSBR (Zalinge, 2002). In this regard, fishes have been known to be a source of their everyday consumption. People living in the lake are heavily dependent on fishing while some living far away from the lake hinge on agricultural sector (rice production) especially during wet season (Keskinen, 2008). Meanwhile, Chhnok Tru is one of the busiest floating communities in TSBR, and there are many diverse economic lifestyles taking place in the lake at the present time. In addition, all kinds of wastes from their daily activities are directly disposed into the lake (Phanith, 2013). For this reason, pollution of nutrient from the anthropogenic is critical (Stevenson & Peter, 2013). One of the leading factors to nutrient loading is from their discharge of toilet septic tank. However, some parameters below are also considered as the effect for this problem

The water temperature in TSBR is ranked from 28 to 33^{o}C (Juha *et al*., 2003; Shakkula *et al*., 2004). Moreover, the increasing of temperature would reduce the oxygen supply

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in water, and it will cause fish die due to the abrupt fluctuations (rapidly cold and warm) in temperature (Kibria, 2014). Related to pH, aquatic organisms need certain level of pH concentration for their both reproduction and growth. The optimal pH concentration is between 6.5 and 8.0 (Addy *et al.*, 2004). On the other hand, the higher the pH (9-14), the more toxic of ammonia will be dangerous to fishes and other living organisms in the water (Kale, 2016). In addition, the solubility and biological activities of chemical constituents (nitrogen and phosphorus) have a strong relationship with pH (Silva & Kevin, 2016) in which the low range of pH can increase the more solubility of metals leading to higher toxics in the water, while the limiting of photosynthetic activities happens at high pH (Kale, 2016).

DO: It is vital to aquatic organisms in terms of breathing and healthy organism; on the other hand, lacking of photosynthesis will affect the concentration of dissolved oxygen in water. (Addy & Green, 1997). Moreover, oxygen in water is produced by three main sources: direct diffusion from the atmosphere, wind and wave action, and photosynthesis, which is the most significant sources that produce oxygen in daytime by aquatic plant and other phytoplankton (Francis & Ruth, 2003). Variation of DO has high dependence on temperature from light, and it changes accordingly through the day/night cycle and seasonal patterns (Ibanez, 2009). When the DO concentration is 2-4 mg/L in between, it will make fish distressed. The larger fish is sensitive to low DO concentration. Generally speaking, fish needs at least 5 mg/L of DO concentration for their healthy growth. (Francis & Ruth, 2003). In addition, In addition the higher DO (above 9mg/L) can bring the high growth rate of fish population (Bhusal, 2017).

TDS: The change of TDS and types of minerals dissolved in water will change taste of natural water (Nelson, 2002), and TDS toxicity is very harmful to many fish species during their life stages, especially at fertilizing periods (Duffy *et al.*, 2007).

EC: The ability of current conduction is an important estimator of the total amount of dissolved salt and ions in water. For instance, sedimentation and soil runoff result from rainfall are the other factors increasing the electrical conductivity in Place Greek Lake due to increasing a number of irons in solution (Moore *et al.*, 2008). Irons from dissolved solids in water create the ability to conduct an electrical current which can be measured by using a conventional conductivity meter or TDS meter (Iyasele *et al.*, 2015). Therefore, DO is very sensitive to high temperature, while the temperature and impurities (dissolved solids) are primary parameters to effect the electrical conductivity (Shrestha, 2017). More importantly, EC will be stable if the water temperature is 25°C, however, the higher in water temperature the increasing in EC in water as the result from more ionizations (Evine, 2010).

TSS are the solids in the water that can be trapped by 0.45 µm filter with evaporation at 105°C, and it is measured as mass (mg) or concentration (mg/L) of inorganic and organic matter in the water column. It refers to any kinds of suspended particle in water such as silt, clay, fine sand, plankton, microbes, algae, decay plants or animals, domestic wastes and sediment from agriculture runoff. Moreover, the inflow of these suspended solids in the lake are abundant during rainy season; as the result, the concentration of TSS is high in dry season (Rossl & Chevre, 2016). The presence of TSS in lake results in limiting the growth of organism and it also reduces light in water (Birkett *et al.*, 2007) since suspended solids absorb heat and increase temperaute in water (Mostafa & Peter, 2016).

Nitrogent & Phosphorus: Nitrogen in water has been a critical element, originally generated from soil fertilization, industrial and domestic waste including animals raising and inflow from surface water discharge and treated waste water (Makov, 2012), and these compounds play an essential role in pollution of surface water, air and sediments (Bamba *et al.*, 2017). Agricultural fertilizers, animal feed lots, industrial waste waters, salinity landfills, garbage dumps, manure and septic system are considered as the common sources for excess nitrate into lakes and streams (MPCA, 2008)Nitrate, formed of nitrogen and oxygen, is converted in many complex forms of nitrogen by bacteria and is a dangerous form of nitrogen in the water in which it can cause server illness in domestic animals and human, especially in infants. Human activities together with nitrate contained can attribute to a serious effect of toxicity on certain fishes, invertebrates and other aquatic animals due to the incapable of carrying oxygen through the conversion of oxygen-carrying pigments (Julio *et al.*, 2004). The richness of nitrate from such activities input to the lake will accrue in algal bloom and be the cause of fish kill (Phillipp & Victor, 2009). Moreover, nitrate uptake is very sensitive to optional growth of temperature between 10-35 °C, while there is less influences to ammonia uptake (Taziki *et al.*, 2015).

Phosphorus is formed by natural processes and human activities. These are the main sources of reaching phosphorus into the natural water which can attribute to the growth of plants and algal (Filippelli, 2009). Phosphorus, formed in both organic and inorganic matter, is the important indicator to determine eutrophication level in lake and pond as the result of orthophosphate that converts from the dissolved phosphorus (Rathore *et al.*, 2016), and the excessive concentration of phosphorus is a primarily supporter to high growth of phytoplankton by cyanobacteria (Rabalais, 2002). Therefore, significant anthropogenic activities are the major inputs of phosphate–phosphorus (PO_4^{3-}–P) in the water body due to household wastes, agricultural and industrial practices together with natural events of rock weathering and phosphate cycle in water (Fadiran *et al.*, 2007). As the result, the explosive loads of total phosphorus will degrade the water quality in addition to algae growth, and it leads to decreasing aquatic diversities since decomposing dead planktons can cause toxins to water in both anaerobic and aerobic conditions (Dale *et al*., 2003). The purpose of this research is to assess the nutrient concentrations (N/P) and to investigate some physico-chemical parameters (temperature, pH, EC, DO, TDS and TSS) around the floating community of Chhnok Tru by considering rainy and dry seasons.

2. METHODOLOGY

2.1 Study Site

Chhnok Tru village is one of the floating communities, located in TSBR, which consists of three floating villages: Chhnok Tru, Kampong Preah and Seh Slab. The assessment focuses on nutrient loading from floating community. However, the study does not take into account in terms of natural events and groundwater discharge into the lake. The study mainly focuses on nutrients loading in which nitrogen is measured as a form of nitrate-nitrogen (NO_3^--N), and phosphate-phosphorus (PO_4^{3-}-P) is for phosphorus. Moreover, the results were compared for both dry season and rainy season with Sub-degree of water quality standard in public lakes and reservoirs for bio-diversity conservation from Ministry of Environment (MoE) in 1999 (Sub-decree N27, 1999). There are 1083 Cambodian families accounted for 55.18%, while Vietnamese and Cham are 780 families (41.47%) and 63 families (3.35%), respectively. Among the overall families, there are 74.47% attending primary school, secondary school 6.41%, high school 2.10% and 17.02% did not attend the school (Phanith, 2013). The study is focused mainly on floating village in Chhnok Tru community (Figure 2.1), and this floating community is considered to be a busiest/activest community which has extreme impacts on the water quality of TSBR. The points of sampling is selected based on GPS with approximately 50m to 100m intervals around this busiest floating community. Moreover, the sampling of this study was conducted on June 7th, 2017 in rainy season while the dry season was on April 6th, 2018.

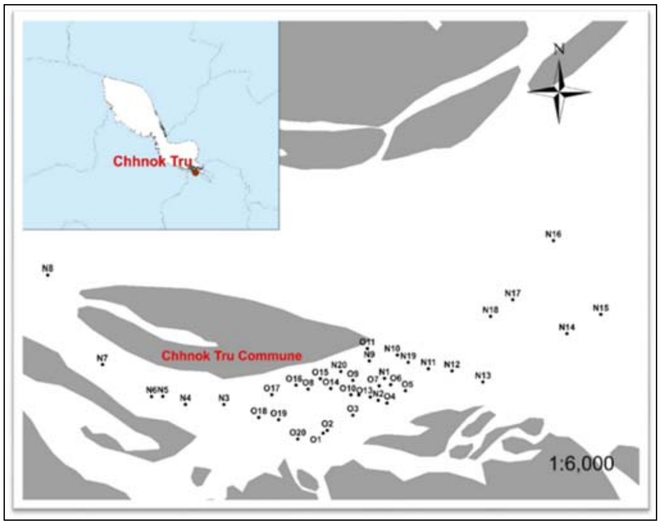

Fig.2.1. Study Sites

2.2 Sample Collection

The sampling points of the study were selected using GPS coordinate system. There are 29 sampling sites were conducted in rainy season while 40 sampling sites were conducted in dry season. In dry season, the water depth of TSBR is commonly ranged from 0.5m to 3.5m. Furthermore, the water samples were collected using boat at three different levels of water depth: 0.5m below the surface, the middle of total depth and 0.5m above the bottom of the lake. The experiments of the water samples were conducted at both field and laboratory based on procedures and data required. Temperature, pH, electrical conductivity, dissolved oxygen and total dissolved solids were collected and measured at the field (Figure 2.2). While the water samples of total suspended solid (TSS), nitrogen and phosphorus were stored in clean plastic bottles of 500mL, put in the icebox to conserve the temperature of around 4^oC and brought to laboratory of ITC (Institute of Technology of Cambodia) for analysis.

2.3 Analytical Methods

The temperature, pH, dissolved oxygen, electrical conductivity and total dissolved solid are measured at the field by the equipment models listed in Table 2.1.

Table 2.1 Model of equipment measure in the field

Parameters	Model of Equipment
pH	LAQUA act (pH/ORP/D) meter D-75
Temperature	LAQUA act (pH/ORP/D) mater D-75
DO	LAQUA act (pH/OPR/D) meter D-75
EC	EC meter MC-31P

The other parameters such as N, P, TDS and TSS were analyzed in ITC laboratory (Table 2.2). Nitrate-nitrogen and phosphate-phosphorus were measured by using Hach reagent and test kit and followed by the spectrophotometer as the principle (colorimeter). Moreover, nitrogen and phosphorus are measured in the form of nitrate-nitrogen (NO_3^--N) and phosphate-phosphorus (PO_4^{3-}-P). These two parameters are shown in mg/L. For TSS, it was determined by gravimetric method that 0.45µm of glass fiber filter were used. For achieving this method, several steps were required. First, the glass fiber filter was weighted and dried at 105 ^oC in an oven supported by aluminum dish for 3 hours (well note down with sample site or other important information on the dish). Next, discarded humidity in the desiccator for 20 minutes, and the glass filter was re-weighed and recorded. Then, the 200 mg/L of water was filtered on the dried glass filter preparation by using vacuum filter machine. After that, the glass filter was taken out and dried it again as the same condition of previous manual. Lastly, the filter was weighted and recorded the result for calculating with following formula:

$$\text{TSS} = \frac{(\text{A} - \text{b})\text{x } 1000}{\text{Volume of sample (ml)}} \quad (\text{eq. } 1)$$

Where:
A = weight of filter + dired residue (mg)
B = weight of filter (mg)

Table 2.2: Parameter for analysis in ITC lab

Parameters	Method
NO_3^- -N	Hach reagent and Test kits (using NitraVer 5 Nitrate Reagent Powder Pillow)
PO_4^{3-}	Hach reagent and Test kit (using PhosVer 3 Phosphate Power Pillow)
TSS	Gravimetric method by using glass microfiber filters

3. RESULTS AND DISCUSSION

The results of the physico-chemical parameters and nutrient loaded in Chhnok Tru Floating Community from 29 sites during rainy season and 40 sites during dry season. The study showed that the concentration of Temperature, pH, EC, TDS, TSS were observed to be slightly different between dry and rainy season and compare to to Sub-degree N27 of MoE, 1999. Moreover, DO, N and P were highlighted in this study for further discussion.

3.1 Dissolved Oxygen (DO)

The water depth and hydrological conditions were the other factors that can result in low DO concentration in water because of temperature penetrated. Results showed that DO value in the rainy season was changed from 2.02 to 5.57 mg/L and 1.68 to 5.61mg/L in the surface and bottom samples, respectively. On the other hand, in the dry season, DO value was changed from 1.63 to 6.12 mg/L, 2.21 to 5.66 mg/L, and 2.07 to 5.71 mg/L within the surface, middle and bottom samples, respectively (figure 3.1). As a result, in both seasons in Chhnok Tru of TSBR, the DO concentration was quite similar since the lowest value of DO was 1.68mg/L, and 5.57mg/L was the highest value in rainy season, while in dry season it was 1.63mg/L for the lowest, and 6.13mg/L was the highest. According to Ibanez (2009), DO might be changed mainly due to seasonal patterns of day and night cycle in term of temperature fluctuations. As the result, it showed that the temperature values in both rainy and dry seasons are not so different; therefore, it may lead to similar DO concentrations in both dry and rainy seasons in Chhnok Tru. In comparison to Sub-degree N27 of MoE in 1999, almost all water samples show DO concentration were fitted to the standard. However, it was remarked that DO concentration was low for sample water located nearby the floating houses since direct disposal of domestic waste could increase the biological activities, which resulted in low DO concentration.

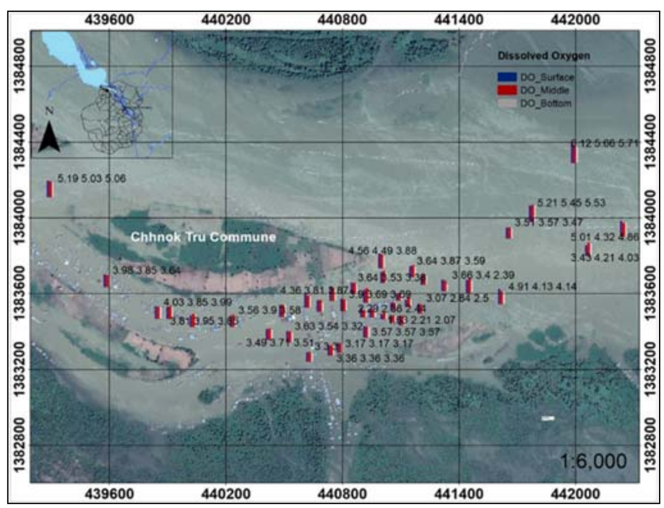

Fig. 3.1. DO concentration during dry season

3.2 Nitrogen (NO_3^--N)

The study found that the average concentration of N in dry season ranged from 1.5mg/L to 8.3mg/L as shown in Figure 3.2, while in rainy season the average concentration of N ranged from 0.18mg/L to 4.88mg/L. This study showed that the concentration of N in dry season was higher than rainy seasons. It could be explained that agricultural activities could affect as most of local communities in Chhnok Tru planted their crops during dry season (Silva, 2014). It indicated that high N concentration was recorded in late dry season which was the early period of growing crops. Additionally, activities of making Prahok (fish paste) have commonly become popular for people living in Chhnok Tru community in dry season (Phanith, 2013). So, fish heads and all kind of wastes from fish cleaning which highly contained in nitrogen, as the result, the concentration of N became highly noticeable in dry season.

The extremely high concentration of N were recorded for 40 sampling points. The laboratory analysis shows its concentration ranges from 1.5 mg/L to 8.3 mg/L during dry season. This value shows significant higher than the standard value of 0.1 mg/L to 0.6 mg/L by Sub-degree N27 of MoE in 1999. One of the factor contributing to the high concentration of N may be sourced from human activities in the Chhnok Tru floating community such as fertilizer use, fish farming, direct discharge of domestic wastes, business activities, and dry climate. For instance, discharge of toilet septic tank can become a main source of nitrogen input in to TSBR due to direct input feces in lake. Another source as example could be fish farming together with animals raising. The highest N concentration was recorded for sites located closest. Furthermore, water samples closer to floating households showed as well the extremely high concentration of N. The business activities such wastes from fish processing for Prahok coupling with fish/animal raising could the source of N loading.

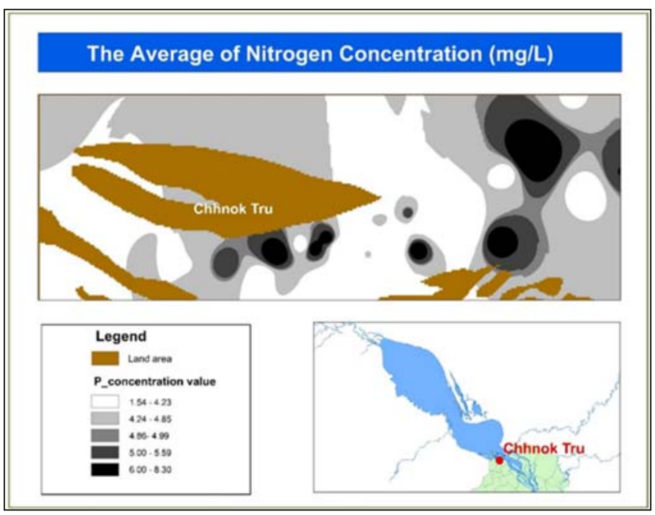

Fig.3.2 The Average of N concentration during dry season

3.3 Phosphorus(PO_4^{3-}-P)

The study has revealed that the average concentration of P in dry season is varied from 0.1mg/L to 0.57mg/L as shown in figure 3.3, while the rainy season was between 0.01mg/L to 0.08mg/L. It is remarked that the average concentration of P in dry season is higher than rainy season.

In comparison, the P concentration was ranged between 0.005mg/L to 0.05mg/L, while the lowest concentration of P in dry season is 0.1mg/L; therefore, the P concentration in dry season is over standard to all sample sties. Moreover, the sample water from sites nearby household and agricultural sites show more than ten times of P concentration if it is compared to Sub-degree N27 of MoE in 1999. Another source of P could be attributed to fish farming. Likewise to nitrogen loading, activities of making Prahok are also the factor could result in high P concentration in Chhnok Tru community, and together with the direct input from discharging toilet septic tank of floating houses.

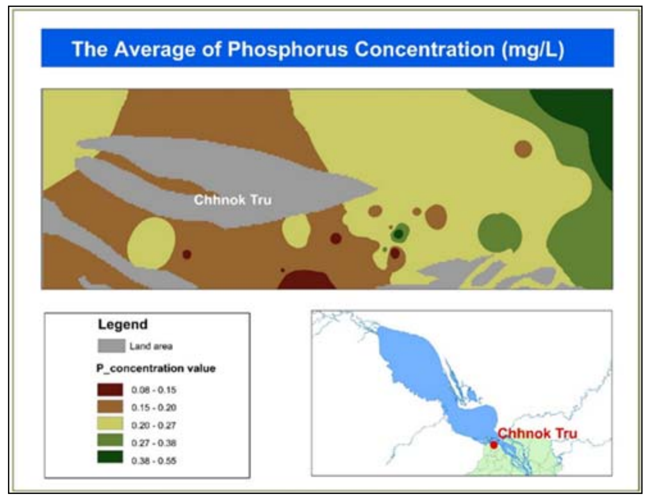

Fig. 3.3 The average concentration of P during dry season

4. CONCLUSIONS

The seasonal patterns of rainy and dry season can affect the water quality in Chhnok Tru community of TSBR. Such changes may associate with chemical and physical properties of/in the lake. In the comparison to Sub-degree of MoE in 1999, the results of some parameters such as water temperature, pH, EC, TDS and TSS of both seasons were acceptable for the standards. However, nutrient enrichment into the lake was commonly recognized by human activities and climate condition. The high N and P concentrations in water of the studied community were recorded of 8.3 mg/L and 0.57 mg/L, respectively. It is further noticed that climate condition could generally contribute to the seasonal changes of nutrient concentration since high nutrient values of water sample from dry season were observed. In addition, this loading of N and P may result from anthropogenic activities of floating community of Chhnok Tru. Agricultural lands of the community villagers during dry season have been considering as the main source of N/P into the water. On the one hand, domestic wastes together with fish farming also contributed to nutrients loading in the lake adding with some activities of making Prahok (fish paste). However, this research of nutrient loading was not wisely assessesed as it is only one of the floating communities while other floating communities of whole lake were not studied. Therefore, the further study on other sites such as Chong Kneas, Kampong Luong, or Bak Prea should be conducted wisely in the lager sites for further validation in order to make a precise conclusion.

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