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Thesis Outline

Theng Vouchlay

Chapters 1 and 2: Introduction and Literature Review

Many studies have focused on the processes and driving factors of phytoplankton and primary production in temperate lakes. However, our understanding of phytoplankton productivity and relevant processes (e.g., nutrient dynamics, hydrology, and anthropogenic impacts) in tropical lake-floodplain systems remained unclear due to their complex hydrology and nutrient dynamics. That limited understanding is partly because multidimensional process-based nutrient and primary production models have not been developed or applied for tropical lake-floodplain systems. Therefore, this study aimed to elucidate spatiotemporal dynamics and dominant processes of phosphorus and primary production in a large tropical lake-floodplain system, Tonle Sap Lake (TSL). The specific objectives of this research are:

1) To develop a simple phosphorus dynamics model to elucidate phosphorus dynamics in tropical lake-floodplain systems,
2) To develop a primary production model to assess phytoplankton dynamics in tropical lake-floodplain systems,
3) To utilize the primary production model to investigate the productivity of TSL, and
4) To elucidate the effects of environmental and social factors on eutrophication and propose effective approaches to mitigate eutrophication in TSL.

This thesis was divided into seven chapters. Chapter 1 is the introduction. In Chapter 2, the nutrient dynamics and primary production and their modeling were reviewed. Chapter 3 is the description of the study area and data for Chapters 4, 5, and 6. Chapter 7 concluded all outcomes of this study together with the remaining research gaps and recommendations for further research and the environmental management of TSL.

Chapter 3: Study Area and Data: Tonle Sap Lake

TSL was selected as the study area in this study. TSL is the largest tropical lake-floodplain system in Cambodia, being influenced by the seasonal flood pulse of Mekong River. All hydrology,

hydrodynamics, and water quality data were described and divided into two periods, 1999 – 2003 for Chapter 4 and 2016 – 2019 for Chapters 5 and 6.

Chapter 4: Development of Simple Phosphorus Dynamics Model for a Large Tropical Lake-Floodplain

The objective of this chapter was to develop a simple phosphorus model in two-dimension and applied it to understand the phosphorus dynamics in TSL. The model reproduced the seasonality of total phosphorus concentration with its root mean square error of 12 and 16 µg/L for the calibration from September 1999 to December 2002 and validation during 2003, respectively. The model analysis in TSL revealed that the internal processes are likely more influential to the total phosphorus concentration in the lake than the external processes (i.e., influx and outflux via the boundary). During the reversal flow from Tonle Sap River to the lake (in May/June–September), the inundated area and water volume of the lake were increased. In this period, the total phosphorus concentration interestingly decreased due to the low total phosphorus concentration in the tributaries and rainwater and the high net settling, although the total phosphorus inputs from the villages and the rewetting process in this period were higher than those in the normal flow (in October – May).

Chapter 5: Development of Primary Production Model for a Large Tropical Lake-Floodplain

This chapter aimed to develop a two-dimensional primary production model, which included the processes of sediment, phosphorus, and phytoplankton, to elucidate phytoplankton biomass and growth rates in TSL. The root mean square error of the simulated chlorophyll-a concentration was 18 and 10 µg/L in the calibration from November 2016 to July 2018 and validation from August 2018 to July 2019, respectively. The model analysis in TSL revealed that the increase of phytoplankton biomass was caused by the high available dissolved inorganic phosphorus due to the internal loading during the low-water period. In contrast, the net reduction rate and the smallest specific growth rate of phytoplankton were found in September when the net sedimentation was dominant.

Chapter 6: Effects of Environmental and Social Factors on Eutrophication in Tonle Sap Lake

The objectives of this chapter were to elucidate the effects of environmental and social factors on the primary production in TSL and to propose an effective countermeasure against lake eutrophication. The results showed that the dissolved inorganic phosphorus concentration in tributaries was a higher influence on eutrophication than the exchangeable particulate inorganic phosphorus and suspended solid concentration in tributaries. Based on spatial sensitivity analysis, the internal loadings of phosphorus from bed sediment and sediment resuspension were more influential to the chlorophyll-a concentration than the external loadings from tributaries and villages. The countermeasures against eutrophication in less than 10 years are to reduce both phosphorus loading from bed sediment and external loading from tributaries and villages.

Chapter 7: Conclusion and Recommendation

Two versions of two-dimensional process-based models were successfully developed, a simple phosphorus dynamics model and a primary production model, to elucidate phosphorous dynamics and phytoplankton biomass and productivity in tropical lake-floodplains. The developed models substantially help us understand the sediment and phosphorus dynamics and phytoplankton productivity in tropical lake-floodplains.