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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

In tropical regions, lake-floodplain system is one of the most important ecosystems for the provision of ecosystem services. In biogeochemical and ecological processes in the lake-floodplain, phytoplanktons provide a significant contribution to primary production, sustain networks of trophic interaction, and provide important food sources for zooplankton and fish. Nevertheless, our understanding of spatiotemporal change of phytoplankton, processes, and their driving factors (e.g., nutrients, seasonal changes of hydrology, and environmental impacts) in tropical lake-floodplain systems remain unclear due to the complex hydrology and nutrient cycle. Therefore, the objective of this study is to comprehensively understand processes and spatiotemporal changes in phosphorus and primary production in a large tropical lake floodplain system, Tonle Sap Lake (TSL), Cambodia, by developing simple process-based phosphorus dynamics and primary production models.

The phosphorus dynamics model was developed and applied in TSL for the period from September 1999 to December 2003 for elucidating the total phosphorus (TP) balance and the spatiotemporal distribution of its concentration. This phosphorus dynamics model is based on a hydrodynamics model (local inertial model) and integrates the major phosphorus processes in the lake and the TP inputs from tributaries and floating villages. The model reproduced the seasonality of TP concentration with its root mean square error (RMSE) of 12 and 16 μg/L for the calibration and validation periods, respectively. The TP concentration was increased during the low-water period. In addition, the model estimated that most of the external TP loading was settled down and the internal processes play an important role in phosphorus dynamics in the TSL.

The primary production model consists of three sub-models including sediment (SS), phosphorus (dissolved inorganic phosphorus, DIP, and particulate inorganic phosphorus, PIP), and phytoplankton (measure in terms of chlorophyll-a, Chl-a) to elucidate the phytoplankton growth and primary production in TSL. The result showed that the accuracy of simulated Chl-a concentration in terms of RMSEs in the calibration and validation were 18 and 10 μg/L during 2016 – 2019, respectively. The concentrations of SS, DIP, PIP, and Chl-a increased during the low-water period and decreased during the high-water period

when Mekong River reversal flowed into TSL via Tonle Sap River. The median specific growth and net growth rates of phytoplankton were 0.236 and 0.012 d^{-1} on average, respectively. The median specific growth rate in TSL was estimated to be in the middle of the rates of other lakes in the world. In addition, the sediment resuspension affected the phytoplankton biomass in TSL as the resuspension of bed sediment increases the PIP concentration and desorbs PIP from SS to be available DIP for phytoplankton growth.

By applying the calibrated and validated results during 2016 – 2019 as the baseline condition, the impact of environmental and social factors on eutrophication was analyzed using PP model. The results showed that the DIP concentration in tributaries was a higher influence on eutrophication than the PIP and SS concentration in tributaries. Among the internal loading from bed sediment, the DIP diffusion showed the highest impact on the eutrophic area. In the scenario analysis of wind from 1981 to 2015, the strongest wind was in 2000 and it had the highest impact on eutrophication. For the scenario of the population in 2080, its percentage of eutrophic area compared to the baseline eutrophic area could increase by 6.5% in October. The shifting vegetation types in the floodplain did not significantly change the eutrophic area in TSL, while deforestation highly impacted the eutrophication if the deforestation area became spare land. Based on spatial sensitivity analysis, the internal loadings of phosphorus from bed sediment and sediment resuspension were more influential to the Chl-a concentration than the external loadings from tributaries and villages. Although the village loading showed a minor influence on Chl-a concentration, it locally impacted the Chl-a concentration around those villages. The average total inorganic phosphorus retention time was 30 years. Therefore, 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.

The structures of the phosphorus dynamics and PP models are generally applicable to a variety of tropical lake-floodplain systems and possible to general tropical shallow lakes with proper spatial resolutions. The phosphorus dynamics model is simple and requires less input dataset compared to the PP model. However, the PP model could explicitly explain the processes of sediment, phosphorus, and phytoplankton in a more detailed and accurate manner, and thus it provides the choices to model applicants for a preferable version of the models according to their resources and objectives. The PP model assumes phosphorus as the limiting nutrient. Therefore, including other types of nutrients (e.g. nitrogen, silicate,) is preferable to predict phytoplankton biomass in other tropical lakes if phosphorus is not the limiting nutrient. The developed model simulations substantially promote our understanding of the dynamics of sediment, nutrient, and phytoplankton in the lake-floodplain system.