Environmental factors affecting lacustrine phytoplankton dynamics in Central Kalimantan, Indonesia

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During 29 of 35 months from February 2004 to December 2006, I collected phytoplankton and recorded water level, water transparency (Secchi-disk value), water temperature, electrical conductivity, pH, dissolved oxygen and chlorophyll-a at the oxbow Lake Tehang and the backwater Lake Batu located in a floodplain of the Kahayan River system, Central Kalimantan, Indonesia, to extract environmental factors affecting the lacustrine phytoplankton community dynamics by using Multiple Correlation and Regression Analysis, ANOVA permutation test and two ordination techniques redundancy analysis (RDA) and canonical correspondence analysis (CCA). In 2004, the vertical distribution of phytoplankton was surveyed on October 3\textsuperscript{rd} – 4\textsuperscript{th} at Lake Tehang and on October 11\textsuperscript{th} – 12\textsuperscript{th} at Lake Batu to reveal the diel migration of phytoplankton. From March to July 2008, I collected phytoplankton and recorded above-mentioned environmental conditions, light intensity and amount of nutrients (orthophosphate, nitrate and ammonium) at open water zone and interrhizon area, i.e. macrophyte-covered water zone, of Lake Lutan to reveal the effects of the interrhizon on the phytoplankton community and environmental conditions. The main results were:

1) Phytoplankton on all observed lakes were represented by a total of 96 species (including Tabellaria spp. which obviously consisted of multiple unidentifiable species) belonging to eight classes, dominated by Euglenophyceae (38%), Bacillariophyceae (31%) and Chlorophyceae (21%). Number of species was 80 at Lake Tehang, 77 at Lake Batu and 74 at Lake Lutan. Only Cryptomonas sp. and Trachelomonas volvocina were abundant in all of the three observed lakes. In floral composition, Lakes Tehang and Batu were similar to each other but Lake Lutan was remarkably different from other lakes.

2) The long-term surveys in Lakes Tehang and Batu exhibited seasonal trends of phytoplankton population dynamics. Chlamydomonas sp, Cryptomonas sp. and Trachelomonas volvocina occurred throughout the year, while Peridinium sp. and Trachelomonas armata were abundant only in the flood season and Cymbella spp., Eunotia spp., Navicula spp., Euglena proxima, E. spirogyra, Phacus pleuronacles, Trachelomonas hispida and Trachelomonas spp. were abundant only in dry season.
3) Species diversity was higher and more stable in Lake Tehang which was more frequently disturbed by inundation of the Kahayan River, while Lake Batu was sometimes monopolized by dominant species which considerably reduced the evenness especially in the low water level season when the lake was not disturbed by water current from the Kahayan River. This result seemed to support the intermediate disturbance hypothesis accounting for high biodiversity in unsaturated community.

4) In the 24-hour survey, abundant species of phytoplankton showed different patterns of vertical distribution which were categorized into three types. As well as zooplankton, the phytoplankton species of Type I showed more intensive diel vertical migration than ever thought. Many species of this group were motile with flagella. A species of Type II also showed vertical migration but the cell aggregation in mid daytime was not so clear as the species of Type I. In Type III, there were several aggregations of cells at various depths and their vertical migration was unclear. Most species of Type III seemed less motile with no flagellum belonging to classes Bacillariophyceae and Chlorophyceae and one species of class Chlorophyceae had flagella but was so dominant that their overabundance obscured their vertical migration.

5) Biological factors such as phytoplankton density, biomass and diversity exhibited seasonal fluctuation. Unlike in lakes of high latitude, the phytoplankton biomass was not significantly correlated with chlorophyll-a, because the carbon content per cell was not significantly correlated with chlorophyll-a concentration in 6 of 9 abundant species.

6) Physico-chemical factors also exhibited seasonal fluctuation. RDA detected that biological factors were significantly correlated with water temperature, electrical conductivity and dissolved oxygen in Lake Tehang and with water temperature and water level in Lake Batu. CCA detected that abundant phytoplankton species were significantly affected by water temperature and water level in both Lakes Tehang and Batu. Multiple regression analysis also supported the results of CCA.

7) The comparison between open water (OW) and interrhizon (IR) of Lake Lutan revealed that the species richness was higher at IR (number of species: 73) than OW (59), though Simpson’s diversity index was not significantly different between the two sites. Many species were more abundant at IR, excluding Chlamydomonas sp. which was more abundant at OW. RDA revealed that the biological factors such as chlorophyll-a, density, biomass and diversity of phytoplankton were significantly correlated with water temperature and dissolved oxygen at OW and with water temperature and Secchi-disk, i.e. transparency, at IR, suggesting that the light irradiance into the water was limited by macrophyte cover and therefore the transparency of the water was a crucial factor at IR, while at OW where oxygen was almost exclusively produced by phytoplankton, the fluctuation
of dissolved oxygen was more correlated with phytoplankton density than at IR where macrophytes were another source of oxygen as well as phytoplankton. Also, it should be noted that the water temperature showed very small fluctuation but still exerted a crucial effect on the phytoplankton community at both sites surveyed. CCA found that abundant phytoplankton species were significantly correlated with Secchi-depth, water temperature and dissolved oxygen at OW and with light intensity, water temperature and dissolved oxygen at IR, as almost supported by multiple regression analysis.

8) Overall, although the seasonal fluctuation of water temperature was much smaller than in rivers and lakes of high latitude, the temperature as well as water level still affects the phytoplankton community in tropical oxbow and backwater lakes.