Nutrient imbalance and diversity of plankton community in lagoon lakes around Lake Biwa

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There were a lot of environmental problems during the past eutrophication period in Japan. The situation has been improved after 1980's due to reduction of N and P loadings from point sources. However, potential fluxes of N from atmosphere and farmland may cause N/P imbalance in several aquatic environments, though there are no clear evidences how such nutrient imbalance influences aquatic ecosystems until now. In this study, we determined dissolved nutrients and sestonic C/N/P ratios in several lagoon lakes around Lake Biwa, the largest lake in Japan, and species composition of phyto- and zooplankton living there, to evaluate effects of the nutrient imbalance on diversity of plankton.

Methods

Field observations were made at Lakes Kohoku-nodanuma (KN), Hasu-ike (HI), Katada-naiko (KD), Yanagi-hirako (YH), Jinjo-numa (JI), Hamabun-numa (HN) in August and October 2014, February, May, and July 2015. >70% of land use in 4 lakes out of 6 was rice paddy except for KD (17%) and HI (52%). Water samples for chemical analyses and phytoplankton counts were collected at outlet, inlet and two pelagic sites in each lake. Zooplankton was collected with a 40-μm-mesh, and then preserved with 4-5% sugar-formalin. Water temperature, pH, EC and turbidity were measured with a Horiba U-50. The water samples were filtered in the laboratory. Nutrients (NH_4-N, NO_3-N, NO_2-N and PO_4-P) for the filtrates were measured. Suspended solid (SS), sestonic C, N, P and chlorophyll *a* concentration (chl. *a*) for the residuals were measured. Phyto- and zooplankton species in each preserved plankton samples were counted, and then diversity indices (H') were calculated.

Results

Water temperatures seasonally varied 10-29°C in all lakes studied. Chl. *a* largely varied with lakes, and lowest in HI (<15 μgL^{-1}) while highest in YH and JI (40-60 μgL^{-1}). SS showed similar trend with turbidity, and the correlation coefficient between them was high (r=0.79), while correlation coefficient between SS and chl. *a* was not so high (r=0.59). Both sestonic C/N and C/P ratios were higher than those of Redfield ratio, but lower than the threshold values in Healey and Hendzel (1979, 1980) in all lakes studied. Sestonic N/P ratios in all lakes ranged 5-25, being higher than that in Redfield ratio, suggesting relatively high nitrogen loading to the lakes. NH_4-N and PO_4-P were quite high in YH and JI compared with those in other 4 lakes. PO_4-P at inlet tended to increase with increasing land use of rice paddy. Correlation analyses showed that chl. *a* in pelagic sites were positively correlated with PO_4-P at inlet. The differences in DIN and DIP between inlet and outlet were also larger in both YH and JI, indicating large consumption of them within the lakes. H' in phytoplankton showed high values and large seasonal variability in KN, YH and JI, while not so high values and small seasonality in HI and KD, being negatively correlated with sestonic N/P ratios. On the contrary, H' in zooplankton were almost the same among the lakes except for that in KD, showing no relationship between H' and any sestonic C/N/P ratios.

Discussion

Chl. *a* was correlated with PO_4-P at inlet, which increased with increasing land use of rice paddy. Therefore, phytoplankton biomass depended on land use of rice paddy around watershed of the lakes studied. Species diversity in phytoplankton seemed to decrease with increasing sestonic N/P ratio, but

not in zooplankton. Probably, nutrient imbalance might affect phytoplankton diversity, while not apparently in zooplankton diversity, because other interaction like predation pressure might mask the bottom-up effect on zooplankton.

Keywords: Nutrient imbalance, biodiversity, small lagoon lakes around Lake Biwa

