2 Master projects in Limnology: Cyanobacteria-driven nutrient cycling and its consequences for phytoplankton habitat colonization, diversity and ecosystem functioning

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Start date

FLEXIBLE but BEFORE SPRING 2018

Application

The project is already open for application of **two** Master candidates, both with strong working ethic and motivation. **One** with interest in research on sediment and water biogeochemistry and **one** with motivation for conducting research in ecology. Driving license of the candidate is preferable. Research projects of 30, 45 and 60 credits can be formulated. Please contact Oskar Agstam-Norlin (**oskar.agstam@slu.se**) and Pablo Urrutia-Cordero (**pablo.urrutiacorder@ebc.uu.se**) for further information.

Project overview and objectives

The proposed interdisciplinary project at the interface between biogeochemistry and community ecology is a collaboration between Uppsala University (Limnology Unit, Department of Ecology and Genetics) and SLU (Department of Aquatic Sciences and Assessment). The project aims to investigate experimentally the role of cyanobacteria (blue-green algae) as biological drivers of lake N and P cycling and its consequences for phytoplankton community dynamics in a metacommunity context. Specific objectives are:

(1) *Evaluate* how a model cyanobacterium alters N and P cycling under low levels of lake productivity.

(2) *Investigate* whether cyanobacteria-driven changes in bioavailable N and P pools affect habitat colonization success of other phytoplankton under different levels of phytoplankton dispersal rates.

(3) *Explore* whether these mechanisms alter phytoplankton community diversity and ecosystem functioning, i.e., phytoplankton community biomass production.

Scientific background

Most lakes worldwide have low nutrient concentrations, which limits productivity at the basic trophic level (phytoplankton) and this concomitantly impairs higher trophic levels. Here **cyanobacteria can be important biological drivers of N and P cycling**, both through fixation of atmospherically-derived N_2 gas and access to organic sediment-bound P pools that are not available for other phytoplankton. Studies have shown that cyanobacteria can increase bioavailable N and P pools (dissolved fraction of N and P) in the water column through cell lysis, metabolic wastes, parasitism or zooplankton grazing. Although there is important knowledge on the physiology behind N fixation, **little is known about the mechanisms and extent to which cyanobacteria can transform phosphorous (the most limiting factor in freshwaters) fractions in the sediments and its consequences for pelagic community dynamics and ecosystem functioning.**

Recent experimental findings showed that a cyanobacterium (*G. echinulata*; **Fig. 1**) can increase network complexity of phytoplankton communities and suggest that these effects are likely a result of alterations in nutrient cycling patterns. But how does cyanobacterial-driven nutrient recycling affect phytoplankton colonization success and subsequently community assembly and ecosystem functioning? There is increasing evidence that regional community dynamics driven by organism dispersal and immigration processes can have strong effects on local diversity patterns and functioning of ecosystems (cf. 'metacommunity framework'). Species sorting, that is the selection by abiotic and biotic local environmental conditions, has been reported as a predominant mechanism in determining community composition of microbial communities. Hence, **the strong, local interacting effects of cyanobacteria with other phytoplankton species are very likely to modulate community assembly processes in this spatial context.**

Hypotheses, project description and methods

The main hypotheses of the project are that *(i) besides increasing the dissolved fraction of N, the presence of cyanobacteria transforms non-bioavailable P in the sediment to a bioavailable form that is translocated to the water column, (ii) an increase in both dissolved N and P pools in the water promotes a preferable niche for many immigrant species by alleviating nutrient limitation and this increases phytoplankton diversity and community-level biomass production and (iii) increasing species dispersal rates does not enhance colonization in local units without cyanobacteria as much as those with cyanobacteria present due to constrains by nutrient limitation.*

To test these hypotheses, **the Master students will run a microcosm experiment in a metacommnity context using the cyanobacterium *G. echinulata* as model species**. The experiment will run for about six weeks in cylindrical containers with lake water and sediment collected from Lake Erken (~ 70km from Uppsala; **Fig 2**). The experimental design will consist of three abundance levels of *G. echinulata* colonies in sediments (none, low and high) and three levels of phytoplankton dispersal rates (none, low and high; achieved through the inoculation of external water from nearby lakes).

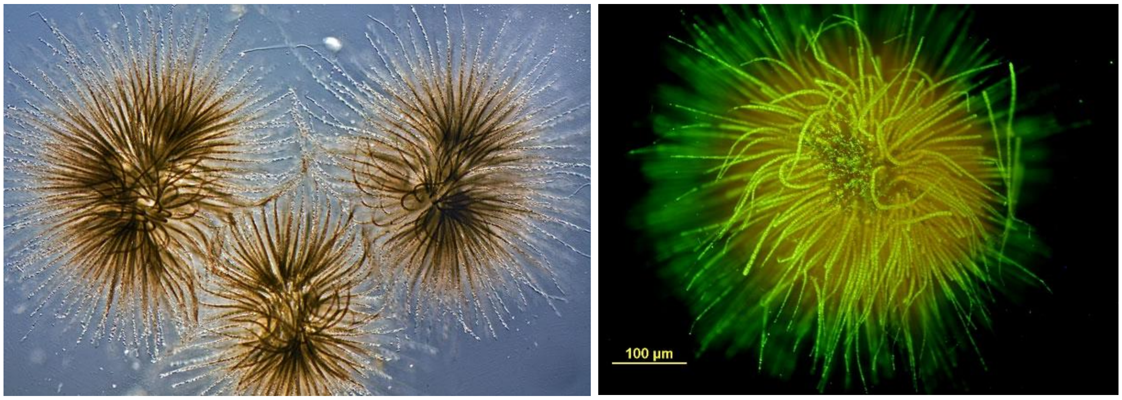

Fig. 1. Microscopic pictures of the model cyanobacterium *Gloeotrichia echinulata* with radiating filaments and basal heterocysts visible. Source left picture: http://www.plingfactory.de. Source right picture: Barry Rosen

Water samples will be taken and analyzed for diversity and biomass estimates of the phytoplankton community on an inverted microscope. In addition, water samples will be analyzed for dissolved fractions of N and P in the water, and sediment samples for sequential P fractionation and elemental analysis (total N and P-species pools with focus on organic P). This experimental set-up will then allow quantifying changes in bethic-pelacic N and P cycling dynamics over time and link them to changes in compositional diversity and functioning of the phytoplankton community in a spatial (metacommunity) context.

Fig. 2. Field pictures from the field station at Lake Erken. Left picture: *Gloeotrichia echinulata* bloom in the lake during summer 2017. Right picture: Ice breaking period in the lake during spring 2017. Source: Pablo Urrutia Cordero

Significance and project outcome

Understanding ecosystem processes regulating the cycling of limiting nutrients and its consequences for biological diversity and ecosystem functioning is of fundamental interest in both biogeochemistry and ecology. This also of utmost importance given the unprecedented rates at which human activities are altering the global abiotic environment and structure of ecosystems. **We anticipate this collaborative project to generate at least one high-impact scientific publication,** as well as new theories and hypotheses to test mechanisms by which cyanobacteria modify nutrient pools and how this feedbacks on community assembly processes and stability of ecosystem functioning across multiple temporal and spatial scales.