

Phytoplankton Structure and Invasive Cyanobacterial Species of Polish Temperate Lakes: Their Associations with Environmental Parameters and Findings About Their Toxic Properties

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Abstract : Due to eutrophication connected to the growing human population, intensive agriculture, industrialization, and reinforcement of global warming, freshwater resources are changing negatively in every region of the World. This change also concerns the replacement of native species by invasive ones that can spread in many ways. Biological invasions are a developing problem to ecosystem continuity and their presence is mostly common in freshwater bodies. The occurrence and potential invasion of the species depends on associations between abiotic and biotic variables. Due to climate change, many species can extend their range from low to high latitudes and differ in their geographic ranges. In addition, the hydrological issues strongly influence the physicochemical parameters and biological processes, especially the growth rates of species and bloom formation of Cyanobacteria. Among tropical invasive species noted in temperate Europe, *Raphidiopsis raciborskii*, *Chrysosporum bergii*, and *Sphaerospermopsis aphanizomenoides* are considered a serious threat. *R. raciborskii* being the most important one as it is already known as a highly invasive species in almost all around the World, is a freshwater, planktonic, filamentous, potentially toxic, and nitrogen-fixing Cyanobacteria. This study aimed to investigate the presence of invasive cyanobacterial species in temperate lakes in Northeastern Poland, reveal the composition of phytoplankton communities, determine the effect of environmental variables, and identify the toxic properties of invasive Cyanobacteria and other phytoplankton groups. Our study was conducted in twenty-five lakes in August 2023. The lakes represent a geographical gradient from central Poland to the Northeast and have different depths, sizes, and trophic statuses. According to performed analyses, the presence of *R. raciborskii* was recorded in five lakes: *Szcześliwickie* (Warsaw), *Mikołajskie*, *Rekąty*, *Sztynorckie* (Masurian Lakeland), and further East, in *Pobondzie* (Suwałki Lakeland). On the other hand, *C. bergii* was found in three lakes: *Rekąty* (Masurian Lakeland), *Żabinki*, and *Pobondzie* (Suwałki Lakeland), while *S. aphanizomenoides* only in *Pobondzie* (Suwałki Lakeland). Maximum phytoplankton diversity was found in Lake *Rekąty*, a small and shallow lake mentioned above. The highest phytoplankton biomass was detected in highly eutrophic Lake *Suskie*, followed by Lake *Sztynorckie*. In this last lake, which is also strongly eutrophic, the highest biomass of *R. raciborskii* was found. Cyanophyceae had the highest biovolume and was followed by Chlorophyceae in the entire study. Numerous environmental parameters, including nutrients, were studied, and their relationships with the invasive species and the whole phytoplankton community will be presented. In addition, toxic properties of environmental DNA results from each lake will also be shown. In conclusion, investigated invasive cyanobacterial species were found in a few Northeastern Polish temperate lakes, but the number of individuals was quite low, so the biomass was quite low. It has been observed that the structure of phytoplankton changed based on lakes and environmental parameters.

Keywords : biological invasion, cyanobacteria, cyanotoxins, phytoplankton ecology, sanger sequencing

Conference Title : ICCR 2024 : International Conference on Cyanobacteria Research

Conference Location : Venice, Italy

Conference Dates : November 11-12, 2024