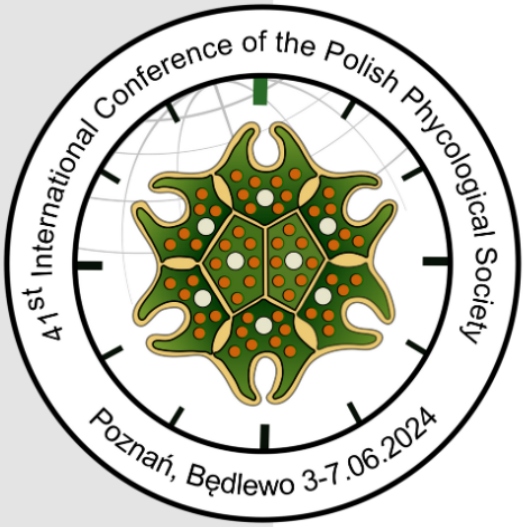

Diversity and ecology of algae: spatial and temporal changes

41ST INTERNATIONAL CONFERENCE OF THE POLISH PHYCOLOGICAL SOCIETY

ABSTRACT BOOK

3-7/6/2024

POZNAŃ, BĘDLEWO - POLAND

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UAM Wydział Biologii

41ST INTERNATIONAL CONFERENCE OF THE POLISH PHYCOLOGICAL SOCIETY

Diversity and ecology of algae: spatial and temporal changes

Poznań - Będlewo, Poland

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UCZELNIA BADAWCZA
INICJATYWA DOSKONAŁOŚCI

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INVITED ORAL PRESENTATIONS

Climate change and its consequences for the ecosystems

CHOJNICKI B.

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The currently observed climate change is manifested, among other things, by a rapid increase in global temperature. This unprecedented phenomenon is primarily due to the enormous emissions of greenhouse gases into the atmosphere by mankind. These shifts in physical parameters are only part of the changes that humans have made in the Anthropocene. However, global warming is a major challenge for the functioning of ecosystems, as most phenomena and processes in the biosphere are strongly temperature-dependent. The main goal of the lecture will be to present the effects of climate change on both aquatic and terrestrial ecosystems.

Taxonomy of cyanobacteria in the age of large-scale genomic datasets

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Cyanobacteria have been evolving for over three billion years and conquered all environments with sufficient light intensity. We recognize thousands of species. Morphological features suggested that cyanobacteria evolved into coherent and highly diversified groups. However, phylogenetic inferences based on 16S rRNA or whole genome sequences showed that most of the traditional cyanobacterial genera are polyphyletic. For example, *Synechococcus* diverged into 12 polyphyletic lineages. It led to the boom of new genera in the last decade because each polyphyletic lineage can be recognized as a new genus. Below the genus level, cyanobacterial taxonomy faces cryptic species, which cannot be recognized by morphology. We sought the species barrier using population genomics and understanding of the drivers of speciation. As a model, we selected cosmopolitan soil cyanobacterium *Microcoleus*. We found that the diversification was driven by both geographical distance and environmental conditions. We observed the whole spectrum from incipient species to fully diverged species with ongoing gene flow – the speciation continuum. The species concepts consider a species as a discrete unit. However, the *Microcoleus* has been diverging as a continuum with gene flow as many plants, animals, and microbes. We offer a probabilistic solution to the species problem (universal probabilistic concept of evolutionary lineages), which reflects the dynamics and incomplete divergence of the species. It can be applied to all domains of life because most of the lineages seem to be maintained by the gene flow.

Symbiosis and algal evolution: A general overview and focus on the diatom order Rhopalodiales

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The coming together of taxa from different lineages through the process of endosymbiosisis the accepted explanation for the origin and diversity of the many lineages of life that contain groups we call “algae”. Some of these symbioses are more than 1 billion years old, however some are surprisingly recent in their origin. These more recent symbioses can offer insights into the early process of endosymbiosis which might be hidden in those associations of a much longer duration. The focus of this talk is directed at a lineage of diatoms referred to as the Rhopalodiales, a group of canal raphe diatoms that bear symbiotic blue-green algae. Our approach to studying this group in a newly-funded project is described, looking at several facets of this association which include: taxonomy and revisionary studies of the diatoms; molecular data from the whole genome studies of the chloroplast and mitochondria of the diatoms and the blue-greens; biogeography of the taxa across both space and time; and ecological studies that test the idea of the diatoms carrying “luggage” of the symbiont. Preliminary data for this work has come from the study of types of the Rhopalodiales, a comparison of published diatom plastomes and mitogenomes and differences observed in genic and genomic change, as well as evolutionary rates of the group, newly assembled plastomes for Rhopalodia taxa and extinction rates for the group compared to other major freshwater diatom lineages. These data point to the importance of a phylogenetic perspective in studies of algal symbioses and that the process of endosymbiosis may be more challenging than most narratives portray.

Applying circular economy principles to restore freshwater ecosystems through the harvesting of algae and cyanobacteria combined with the transforming of biomass into valuable bioproducts

KOREIVIENĖ J.

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There are about 1.4 million lakes and reservoirs worldwide (≥10 ha), and almost one billion people living in their surroundings (Weyhenmeyer et al. 2024). As the world's population continues to grow, freshwater is becoming an increasingly valuable and limited resource. Inland waters suffer from nutritional disturbances, with about 1% of these waters classified as eutrophic. When 75% of a lake's catchment area is used for agriculture, the ecosystem is at high risk of eutrophication. Eutrophication exacerbates algal blooms directly threatening health of wildlife and humans, reducing ecosystem services and causing economic losses.

On the other hand, algae and cyanobacteria act as natural biofilters in ecosystems by capturing released inorganic phosphorus and nitrogen compounds from diffuse (e.g. agriculture) and point sources (e.g. carp fish farming, wastewater treatment plants, farmsteads). Harvesting excess algal biomass can serve as a nutrient recycling solution, supporting ecosystem restoration and mitigating the risks associated with toxic blooms. The tool can be part of other measures to combat eutrophication or have specific functions, such as protecting bathing sites from cyanobacterial toxins. Various technologies developed worldwide for the collection of algal biomass will be discussed.

As a renewable resource, harvested freshwater algal biomass can promote a circular economy that combines environmental cleanliness with valuable end products. *Cladophora* macroalgae aggregations are easier to harvest and are suitable for the production of various bioproducts such as extracts for cosmetics, slow-release fertilizers, biogas, feed additives for animals, etc. However, the cyanobacteria value chain faces significant challenges due to the potential toxicity of cyanobacterial blooms and strict regulation of biomass utilization in the European Union. The risks associated with cyanotoxins in aquatic ecosystems can be reduced by harvesting cyanobacteria biomass, but the development of new solutions is crucial for the utilization of toxic cyanobacterial biomass in low-risk applications to improve sustainability.

Spatial and temporal appearances of selected cyanobacterial metabolites in the Carpathian basin

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Freshwater cyanobacterial blooms are a common problem in many Hungarian ponds and lakes and wetlands. With the exceptions of some clay mine lakes, where periodic occurrences of high cell count of the eukaryotic *Prymnesium parvum* are appear, cyanobacteria are primarily the main taxa responsible for algal blooms in our region. This phenomenon, which has been widely reported in the literature during the last decades, involves many species, including *Microcystis aeruginosa, Raphidiopsis* (*Cylindrospermopsis*) *raciborskii*, *Chrysosporum* (*Aphanizomenon*) *ovalisporum*, *Planktothrix agardhii* and *P. rubescens*. Thus far, the presence of cyanobacterial peptides in Hungarian shallow lakes has been primarily attributed to the genera of *Microcystis*, *Planktothrix* and *Aphanizomenon*. In another study, we demonstrated the peptide metabolite-producing ability of terrestrial nitrogen-fixing cyanobacteria from different sites of the special alkaline habitats of Hungary. The isolated Nostoc-like strains could be classified into different chemotype groups based on their metabolic pattern. A total of 41 peptide-type metabolites were identified which belonged to 4 different peptide families. Cyanobacterial metabolites are increasingly studied, in regard to their biosynthesis, ecological role, toxicity, and potential biomedical applications and more and more detailed analyzes of its spatial appearance from all regions of the earth appear. However, the history of cyanotoxins and cyanobacterial metabolites prior to the last few decades is virtually unknown. Only a few paleolimnological studies have been undertaken to date. Despite the annual occurrence of local cyanobacteria blooms in Lake Balaton, the long-term

dynamic of some metabolites of such bloom forming cyanobacteria remains poorly understood in the largest shallow lake in Europe. Here, we present cyano peptide screening study from an incubated sediment core record from the lake Balaton. The anabaenopeptin and microginin dominant chemotypes were compared with the metabolite patterns of the recent cyanobacterial bloom forming species and strains. By a network analysis of the co-occurrence patterns among metabolites we investigated and identified the most crucial cyanobacterial chemotypes which responsible for the current blooms.

Resilience in diveristy: population genomics in environmental management

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Diversity within a population is important for resilience to environmental changes and for adaptation. I will use two opposing examples to demonstrate population genomics for environmental management. The first example shows how high intraspecific diversity in the cyanobacterium *Raphidiopsis raciborskii* gives rise to localised adaptation and speciation. The second example shows a loss of genetic diversity and connectivity in giant kelp in Tasmania, and how we are using this information to develop a restoration plan.

Several harmful cyanobacteria species occur globally, however, rapid adaptation to new environments can lead to unique physiology and local risk profiles. The global freshwater species *Raphidiopsis raciborskii*, has undergone recent range expansion. Local scale studies have shown high physiological and genomic diversity between strains of *R. raciborskii*, suggesting a highly variable species. To investigate the global genomic diversity and local adaptations of R. raciborskii we sequenced the full genomes of ~80 strains from 22 countries, spanning the continents Africa, America, Asia, Australia, and Europe. Comparative genomics shows speciation occurring through geographic isolation.

Tasmanian giant kelp, *Macrocystis pyrifera*, are a foundational species in rocky marine coastal areas, forming the structure of underwater forests. Over the last few decades ~95% of the giant kelp forests have been lost and are now listed as an endangered ecosystem. Population genomics of the remnant forests shows their structure and loss of connectivity, providing information needed for large-scale restoration.

These two examples demonstrate practical application of genomics in environmental management.

Riverine algal biodiversity under changing flow regime

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Human activities lead to changes in watershed flow regime and habitat degradation, resulting in a rapid decline in biodiversity, and damaging ecosystem functions, stability and resilience, and ultimately threatening human well-being and Sustainable Development Goals (SDGs) of the United Nations. As an important part of global biodiversity, the decline of aquatic biodiversity in rivers is much faster than that of terrestrial and marine ecosystems. Therefore, it is of great significance to study the hydrological processes of watersheds and river biodiversity, which has become a key scientific issue facing the sustainable development of mankind. Using an interdisciplinary approach, this study linked catchment hydrological variables with riverine algal communities with the aim of exploring the impacts and mechanisms of riverine algal composition and biodiversity under changing flow regimes.

Monthly samplings in five lowland streams with different flow regimes were conducted and we investigated the impacts of hydrological conditions and physico-chemical variables on the trait composition of diatoms growing on artificial substrates, biomass (chlorophyll a and ash free dry weight), and biofilm community functions (biochemical processes, i.e., biofilm metabolism and nutrient uptake rates measured in the laboratory). Instead of the commonly used annual-based hydrological indices, we calculated indices for shorter periods (14 and ~28 days) of the hydrological regimes. Results of species-based variation partitioning showed that short-period hydrological indices (10.10 ± 7.18%) contributed more to explain species distribution than physico-chemical variables (5.90 ± 3.83%), indicating the dominant role of hydrology in structuring the diatom community. Specifically, we found

different response patterns for different guilds and size classes to the hydrological and physico-chemical variables, and our results demonstrated that species tolerating high disturbance may be more appropriate as indicators of environmental disturbance than low-tolerant species. We also found dominant effects of short-period hydrological events on biomass and biofilm community functions. Despite an overall negative effect of high flow events and flow variations on biomass and biofilm community functions, positive effects on function-biomass ratios were also observed, indicating that the effects of flow regimes on biofilm are complex. In conclusion, our study highlights the importance of including short-period hydrological conditions in studies on environmental factors shaping benthic algae.

ORAL PRESENTATIONS

Towards understanding the mechanisms of cyanophage infection – combined proteomics and metabolomics

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Understanding the strategies and mechanisms employed by freshwater cyanophages to ensure their effective multiplication is very limited. Therefore, biochemical and physiological analyses are a major challenge in order to extend the knowledge of this phenomenon on the molecular level. In the presented research, a cyanobacterial physiology upon viral infection has been investigated on three viral-host models to describe the phage impact on the host metabolism alteration and, on the other hand, the cell response to the viral infection. The combined metabolomics and proteomics allowed comprehensive description of the changes related to the cyanophage infection. Different strategies and response patterns were observed on the proteome level - silent infection of *M. aeruginosa* vs global proteome modification of *A. flos-aquae* and *R. raciborskii* reflected by the reduction in the amount of proteins involved in carbon dioxide assimilation, in favor of the pentose phosphate pathway. The upregulation of proteins related to glycolysis and the Krebs cycle, the synthesis of nucleotides, amino acids and chaperones simultaneously with

the notable downregulation of proteins of the cores of photosystems, those involved in the photosynthetic electron transfer chain and pigment biosynthesis have also been documented. The metabolomic analysis indicated several crucial changes in the central metabolisms and confirmed that investigated phages induce the redirection of carbon and nitrogen flow to catabolic processes whereas photosynthetic activity is reduced. Overall, our observations indicate that the analysed freshwater cyanophages employ various mechanisms to control the biochemical pathways of the host and to redirect the energy and carbon flow to viral demand.

Phytoplankton structure and invasive cyanobacterial species of Northeastern Poland and their associations with environmental parameters

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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 such as waterfowl migration, wind, and human displacement. 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 depend on associations between abiotic (temperature, light access, concentrations of nutrients) and biotic (characteristics of local and invasive species) 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 Western Poland, is a freshwater, planktonic, filamentous, potentially toxic, and nitrogen-fixing Cyanobacteria. This study aimed to investigate the presence of invasive cyanobacterial species in Masurian and Suwałki Lakelands, reveal the composition of phytoplankton

communities, and determine the effect of environmental variables on invasive Cyanobacteria and other phytoplankton groups. Our study has been conducted in twenty-five lakes in August 2023. The lakes represented a geographical gradient from central Poland to the Northeast and different depths, sizes, and trophic statuses. According to performed analyses, the presence of *R. raciborskii* was recorded in five lakes: Szczęśliwickie (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, both in Masurian Lakeland. 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 were studied during the research. Their relationships with the invasive species and the whole structure of phytoplankton will be presented. In conclusion, investigated invasive cyanobacterial species have been found in a few Northeastern Polish temperate lakes but their number of individuals, accordingly the biomass was quite low. It has been observed that the phytoplankton communities changed based on the lakes and environmental parameters.

Marine endolithic Cyanobacteria – distribution and biodiversity

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Marine endolithic cyanobacteria are still a little known group of organisms. These extremophilic taxa occupy niches that are difficult for other organisms to colonize. Due to their ability to dissolve stones and other skeletal fragments, they bore into them and have the ability to function inside. However, this ability may also affect the structure and functioning of calcareous organisms. Therefore, it is important to better understand this group of organisms and their role in the marine environment.

The first step to better understanding marine endoliths is to learn about their diversity. The aim of the research was to identify organisms and determine their distribution in the coastan profile. Sampling of endoliths took place in different geographical areas, i.e. the coast of Sweden - the polar region, the Mediterranean coast of Croatia and the tropical coasts and caves of Japan, allowed to compare the differences in cyanobacterial distribution in terms of climate. Carbonate stones including microorganisms collected from the cliffs were dissolved using a buffer with a pH of approximately 5-6. By dissolving the stone, it was possible to extract endolithic organisms from the stones and perform microscopic analysis using an optical microscope. Photographic documentation was made and identification was carried out based on the available literature.

Endolithic organisms are still not precisely described and cataloged, which also makes their identification difficult. However, exploring their taxonomy and their biodiversity brings us closer to understanding their functions and role in marine ecosystems. Identification and documentation of these organisms help

to better understand marine endolithic Cyanobacteria. Attempts to isolate and cultivate species of endolithic cyanobacteria, although challengingenrich our knowledge about their unknown physiology. Comparison of both morphological and phylogenetic research and analyzes allow us to understand the real biodiversity of these organisms and the functions they perform in marine ecosystems.

A ~250-year long sedimentary DNA record of cyanobacterial Harmful Algal Blooms (cyanoHABs) from Lake Żabińskie, in North-Eastern Poland

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Lake Żabińskie in north-east Poland is a postglacial, currently eutrophic lake with algal blooms during the growing season and low water transparency. Presently highly productive with a calcium rich epilimnion and a seasonally anoxic hypolimnion, it has ideal conditions for biogenic varve formation and the preservation of sedimentary DNA, and has a rich history of paleolimnological research.

We applied PCR based techniques to reconstruct the history of occurrence of potentially toxic cyanobacteria over the past ~250 years, using a 171 cm long sediment core. Using the HEP primer pair for the detection of *mcyE/ndaF* genes involved in the biosynthesis of microsystin and nodularins, we detected potentially toxigenic cyanobacteria throughout the length of the core. This suggests that at the level of sampling resolution used, Lake Żabińskie has consistently been inhabited by potentially toxin producing species, before large scale fertilizer use in the catchment, and in comparison to other multi-proxy investigations from this lake, during periods of both relatively high and moderate human impact for this time period.

We conclude that using a PCR based methodology with a binary (presence/absence) approach may not be ideal when reconstructing the

presence of potentially toxigenic cyanobacteria in temperate lakes above a certain trophic status and level of human impact, and instead suggest a quantitative approach.

Climate change and nutrient fluctuation affect the phytoplankton community through complex pathways in a deep mesotrophic lake

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Climate change, which acts globally and at regional/local scales, is promoting the symptoms of eutrophication in freshwaters. This factor, together with the increase in nutrients, act as major threats to lake ecosystems, and it is more urgent than ever to face both environmental challenges simultaneously to preserve water quality and protect the remaining biodiversity. We investigated the phytoplankton response to the interaction between temperature and nutrient fluctuations in a deep mesotrophic subalpine lake by using long-term observational data from Lake Iseo (Italy). We hypothesized that water warming should act on phytoplankton biovolume, composition, and diversity through direct and indirect pathways, resulting in changes in phytoplankton community structure. Between 1993 and 2021, we observed a decline in the lake's physicochemical quality in the water column. The results highlighted a rate of temperature increase of 0.02°C y^{-1} across the studied period, which accelerated after the last complete mixing events (2005 and 2006) to reach 0.08°C y^{-1} during the last decade. As a consequence of water warming, we observed a severe modification of nutrient cycling, reflected by the overall increase in nutrient concentrations. We showed that the interaction between temperature and nutrients and the deterioration of the physicochemical parameters of the lake led to a remarkable taxonomical and functional reorganization of the phytoplankton community. Especially, the phytoplankton biovolume directly increased with warming, and the temperature increase combined with higher nitrogen concentrations promoted Cyanobacteria to the

detriment of other phytoplankton groups. Other nutrient variations, such as the DSi:TP ratio, considerably structured the community composition, especially Bacillariophyceae. More importantly, the modification of physicochemical parameters caused by the last complete mixing events resulted in a profound and long-term shift in the phytoplankton community. This study shows that in the next years, phytoplankton in deep subalpine lakes will undergo drastic changes, and that total mixing events might act as tipping points for community transformation. Our findings highlight the significance of disentangling the mechanisms by which nutrients and temperature may control the phytoplankton assemblages using robust interpretative models and long-term datasets.

Microscopic stowaways: Waterbirds as dispersal vectors of microalgae

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Animal-mediated dispersion is one of the most common and long-studied mechanisms in ecology. Among animals, waterbirds are highly mobile, migrate in huge flocks and have long migratory routes, thus, they can be considered as the main vehicles for the transport of many aquatic plants in freshwater systems both at local and regional scales. Endozoochory by waterbirds has been demonstrated for a range of aquatic invertebrates, soft plant parts and seeds. However, very few publications have exclusively investigated the endozoochory of microalgae.In our work, we investigated the role of different waterbird species in algae dispersion. We collected faecal samples from eight migratory waterbird species in an isolated nature reserve in Hungary (Andaháza) and analysed their microalgae flora. Our goal was to determine: (1) which algae species can the waterbirds disperse; (2) which algae traits play the most important role in survival during the digestion; (3) which waterbird traits have effect on the composition of dispersed microalgae species.The waterbird faeces contained 157 algal species. Most of the species belonged to the Chlorophyta (38%) and Bacillariophyta (22%) phyla. The highest number of algae taxa was observed in the samples taken from *Gallinago gallinago* (26 species) and *Lymnocryptes minimus* (20 species). Among algae traits, morphological properties (i.e. silicious cell wall, extracellular sheath) had significant influence for the surviving of algae during the endozoochory. In case of waterbirds the amount and composition

of dispersed algae species were determined by the traits associated with the diet of the waterbirds (i.e. trophic niche, beak morphology). Our study supports that migratory waterbirds are probable dispersers of several algae species, however the role of the different waterbird species in algae dispersion are divergent.

Hidden Treasures: Exploring unique and rare algae in the Okavango Delta, Botswana

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Algal research in many African countries, particularly southern Africa, remains limited, with numerous species yet to be documented. The lack of phycologists conducting research in Africa contribute to this issue, leaving vast gaps in our understanding of algal biodiversity across the continent.

The Okavango Delta, situated in Botswana, is renowned for its diverse ecosystems and protected status. In contrast to extensive research on terrestrial and aquatic flora and fauna in the delta, the first comprehensive studies of algal populations have received minimal attention and are still underway. This presentation aims to address the knowledge gap by presenting the findings of a study focused on the diversity and distribution of algal species in the Okavango Delta. Many of the rare and interesting species found during surveys of the delta, represent new geographical records for southern Africa.

The findings contribute significantly to our understanding of algal biodiversity in the Delta's and emphasize the need for continued exploration and conservation efforts.

Unraveling the diversity of cyanobacteria and heterotrophic bacteria in biological soil crusts of hot and cold deserts

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Biological soil crusts (BSC) are extremely important communities of microorganisms in arid and semi-arid environments. They inhabit the surface layer of soil and are composed of autotrophic and heterotrophic components. Cyanobacteria, algae, lichens, and, in more developed parts, also bryophytes and mosses are responsible for carbon sequestration, while heterotrophic bacteria, archaea, and fungi decompose organic carbon compounds derived from photoautotrophs. Cyanobacteria, fungi, and lichens aggregate soil particles increasing soil stability and water storage capacity. Additionally, some cyanobacteria and bacteria assimilate atmospheric nitrogen making it accessible for other microorganisms. We studied the components of biological soil crusts: cyanobacteria and heterotrophic bacteria communities in two deserts - a cold, mountainous desert of the Eastern Pamir Mountains (Tajikistan) and a hot desert in California (USA). The aim of the study was to reveal the diversity and taxonomic structure of BSC regarding environmental factors, comparing the BSC from two types of deserts: hot and cold, and to assess the genetic potential to produce cyanotoxins. 21 samples were collected from deserts in California (including one bordering sample from Nevada) in the USA and 26 samples from the Eastern Pamir Mountains in 2015 and 2017 respectively. To identify Bacteria and Cyanobacteria we performed metagenomic sequencing of V3-V4 hypervariable region of the 16S rRNA gene using Illumina

MiSeq platform. Additionally, marker genes of microcystins (mcyE+ndaE and mcyD), saxitoxin (sxtA), anatoxin (anaC) and cylindrospermopsin (cyrL) were targeted.The analysis of the environmental parameters indicated higher total nitrogen, organic carbon, sodium, and potassium concertation in Pamir (PA) than in California (CA). The electric conductivity was, in turn, higher in CA. There were no statistically significant differences in pH, as well as in total calcium and magnesium. The structure of bacterial communities at the phylum level was similar in the two types of deserts with a predominance of Pseudomonadota (Proteobacteria) and a high contribution of Cyanobacteria, Bacteroidota, and Actinomycetota (Actinobacteria) forming together core phyla. Within cyanobacterial communities analyzed at the family level, visible differences with higher contributions of Chroococcidiopsidaceae, Coleofasciculaceae, and unknown Oxyphotobacteria in California were noted. In Pamir, in turn, Nodosilineaceae and Nostocaceae prevailed accounting together for 54% of the cyanobacterial reads. It was also discovered that the communities in California contained more unique cyanobacterial sequences than Pamir. The highest influence on the distribution of cyanobacterial samples in PCA analysis had TN, TK, Fe, and TC with most of the Californian samples located opposite to these parameters while the samples from Pamir were more evenly distributed spanning a wide range of environmental factors. From marker genes encoding toxin biosynthesis pathways, we amplified mcyE+ndaE gene fragments and mcyD in almost 30% samples in California and 27% samples in Pamir. No saxitoxin, anatoxin, or cylindrospermopsin gene were detected in studied BSCs from hot and cold deserts.

Responses of *Anabaena azollae* for different organic fertilizers; cow dung and banana peel water

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Organic farming is becoming popular around the globe due to increased public consciousness related to human health risks and environmental impacts associated with using commercial inorganic fertilizers. Nitrogen (N) limitation in organic fertilizers is one of the main constraints which discourage farmers from using them in their fields. *Azolla* sp. is a floating aquatic fern that contains 4-5% of N content from its dry weight. Furthermore, the presence of symbiont *Anabaena azollae* (cyanobacteria) enhances the N content through the N-fixation. Therefore, Azolla sp. is a potential N source in the production of organic fertilizers. This study aimed to determine the responses of both *Azolla* sp. and *Anabaena azollae* in liquid cow dung (CD) and banana peel (BP) water and finally to determine the better medium for the growth of *Azolla* sp. The 0.25g of *Azolla* sp. was cultured in each water (control) and two treatments such as liquid CD, and BP in a concentration series with triplicates. The CD and BP treatment series were prepared with changing volume ratios such as, 1:0 (T0), 1:1 (T1), 1:2 (T2), 1:3 (T3), 1:4 (T4) and 1:5 (T5). The biotic parameters of *Azolla* sp. (wet weight, surface area, relative growth rate and total nitrogen content) and *Anabaena azollae* (heterocyst frequency (HF) and the total number of *Anabaena* filaments (TF)) were measured at three-day intervals throughout the experiment. Additionally, the water quality parameters (pH, temperature, conductivity, turbidity and salinity) were measured at three-day intervals during the 21 days of the experimental period.The significantly high wet weight (0.314 g), surface area (16.097 cm^2) and relative growth rate (0.012 g/g/day) of *Azolla* sp. were recorded at T0 in the BP series ($p<0.05$). Also, the highest total

nitrogen content (TN) of *Azolla* sp. was recorded as 3.092 mg N/mg in T0 of the BP series where only the liquid CD was available in the growth media. The rapid growth of *Azolla* sp. was observed in that treatment within the first 02 weeks. When considering the measurements of *Anabaena azollae*, the maximum HF was recorded as 19.35 % in T0 of the BP series while the highest TF was reported as 21 in both T1 in the CD series and T0 in the BP series. A moderately strong correlation (r = 0.3548) was recorded between the HF of *Anabaena azollae* and the total nitrogen content (TN) of *Azolla* sp. Additionally, the RGR of *Azolla* sp. showed a significant positive correlation with both TF and HF of *Anabaena azollae* under both treatment series. For example, the BP series showed a strong correlation between TF and RGR (r = 0.887, p=0.000) (R2 = 78.46%) as well as between HF and RGR (r = 0.726, p=0.000) (R2 = 52.55%). These correlations indicate the potential use of RGR of the *Azolla* sp. Which is easy to measure to use in predicting/extrapolating microscopic observations such as HF or TF of *Anabaena azollae*. Overall, our results suggested that the fertilizer with only cow dung (CD) was the best treatment for increasing the growth and the total nitrogen content of *Azolla* sp. These insights help to develop organic fertilizers using "*Azolla - Anabaena*" the existing Pteridophyte – Blue green algae ecological interaction.

Spatial and temporal changes in autotrophic euglenids communities – based on the group specific DNA metabarcoding approach

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Autotrophic euglenids predominantly inhabit small aquatic ecosystems, particularly ponds. Often, they constitute a dominant component of phytoplankton in such bodies of water, sometimes with more than 100 species reported in an individual reservoir. Despite their cosmopolitan distribution, the abundance of euglenid species varies significantly across habitats. It is believed that they prefer nutrient-rich waters abundant in organic matter, yet the direct factors influencing species richness, diversity, and composition remain poorly understood.

This study aimed to determine the spatial and temporal dynamics of autotrophic euglenid communities in small bodies of water in Poland, along with the physical, chemical, and environmental factors shaping these communities. Employing an euglenid-specific barcoding approach targeting the V2 region of 18S rDNA, we investigated the biodiversity and species composition of autotrophic euglenids over several years in 20 water bodies representing various types of habitat typical for them: fish ponds, rural ponds, cattle watering holes, midfield ponds, and park ponds. Additionally, to assess the influence of distance and potential species migration between habitats, we chose water bodies from three regions of Poland at varying distances from each other. Furthermore, our objective was to examine the impact of time on euglenid assemblages: whether they remain stable or exhibit seasonal or long-term variations. We also examined temporal changes in species

distribution, including the occurrence of rare species, species previously unrecorded in Poland, or species limited to specific locations.

Diversity and bioactivity of metabolites produced by two Baltic filamentous cyanobacteria, *Pseudanabaena galeata* CCNP1313 and *Nostoc edaphicum* CCNP1411

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In the Baltic Sea, summer blooms of cyanobacteria are usually dominated by filamentous forms. Of these, the representatives of the Nostocales order, *Nodularia spumigena* and *Aphanizomenon flosaque*, have been thoroughly studied. In contrast, the existing knowledge about other Baltic filamentous species is limited.Our screening experiments performed on Baltic cyanobacteria isolates resulted in a selection of two strains, CCNP1313 *Pseudanabaena galeata* and CCNP1411 *Nostoc edaphicum*. The genome of both strains were sequenced and the presence of several biosynthetic gene clusters encoding non-ribosomal peptides and polyketides were identified and characterized. In the genome of N. edaphicum, four gene clusters, including those involved in the biosynthesis of cyanopeptolins, nostocyclopeptides and anabaenopeptins are present. Genome mining of *P. galeata* also revealed the presence of genes of non-ribosomal peptide/polyketide synthetases and a ribosomally-synthesized peptide. Chemical analyses (LC-MS/MS and NMR) of N. ednaphicum, confirmed the presence of cyanopeptolins, nostocyclopeptides and anabenopeptins. They also revealed the production of numerous structural variants of the peptides, the majority of which belongs to new analogues of the compounds. As a result of our study on the two filamentous strains, the list of known nostocyclopeptieds was extended from 3 to 9 and cyanopeptolins from 227 to 307. Based on the

available resources it can be concluded that *N. edaphicum* CCNP1411 produces the highest number of non-ribosomal peptides (belonging to the same class) of all studied microorganisms. In *P. galeata* CCNP1313, several biosynthetic gene clusters were also recognized, including III PKS-encoding sequence. In parallel, chemical analysis revealed the presence of over 60 new peptides in *P. galeata* cells. Unfortunately, neither of them could be assigned to specific gene. Our interest in the two cyanobacterial strains was primarily caused by a potent and multidirectional activity of their metabolites observed in a wide array of biological assays, including anticancer, antiviral and enzyme inhibition effects. However, only in the case of *N. edaphicum* the compounds responsible for the activity were identified. For example, cyanopeptolins with arginine in a structure inhibited SARS-CoV-2 infection and were active against trypsin, while those with leucine inhibited proliferation of Hela cell line and were active against elastase. As these activities might play important role for cyanobacteria survival and in their interaction with other organisms, the discovery of cyanometabolite structure, mechanism of action and biotechnological potential has both a practical and cognitive aspect.

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Changes in algae communities in the microlayer of various types of substrate

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Periphyton, composed mainly of algae and microorganisms, plays a crucial ecological role in the littoral zones of both deep lakes and shallow water bodies, which are aquatic ecosystems often dominated by macrophytes creating distinct habitats and thus providing an essential substrate for periphyton colonization. Variations in substrate architecture are key factors shaping the composition and stability of periphyton communities. Our objective is to demonstrate how differences in substrate types, referring to particular macrophyte and macroalgal species that differ spatially and morphologically and represent different ecological types of aquatic vegetation, influence the structure and composition of periphyton communities. By examining the nature of the substrate for periphyton colonization, we seek to uncover patterns in algal community dynamics and the character of underlying mechanisms driving these variations.

Periphyton samples were collected from two types of macrophyte habitats - the first of simple build (helophytes and nympheids) and the second containing the complicated architecture of plant stems (elodeids). Periphyton samples were collected based on the average length/biomass of plants per unit water ecosystem area. This method allowed us to compare periphytic communities growing on different macrophyte habitats, which varied morphologically and spatially.

Substrate architectural differences (density, texture) strongly influenced the abundance/biomass and species richness of periphytic communities, as well as the habitat selectivity of certain epiphytic algae species. Most epiphytic species belonged to diatoms, which were followed by green algae and cyanobacteria. Diatoms such as *Achnanthidium minutissimum*, *Amphora ovalis*, *Cocconeis* spp., *Gomphonema* spp. or *Navicula cryptocephala* revealed significantly higher densities in the zone of elodeids, while green algae prevailed among nymphaeids. In the *Chara* bed the continuous increase in the numbers was observed from spring to autumn, while in the rush zone the abundance peak of periphyton was observed in the summer. In most cases, results show that species composition of epiphytic algae was different, but diversity values were rather similar for most the macrophytes. Periphyton dominated by filamentous green algae may reach high numbers and biomass due to the inability of consumers to remove this group of algae. Furthermore, seasonality, as well as physical-chemical parameters may also structure periphytic communities within the littoral zone of various water bodies. Understanding these dynamics can have much broader ecological implications and is crucial for exploring substrate-mediated changes in periphyton communities and establishing effective conservation strategies in aquatic ecosystems.

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Information on *Prymnesium parvum* - taxonomy, occurrence, bloom intensity, ecology

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Prymnesium parvum N. Carter 1937 (known as a "golden algae") is a single-celled flagellum organism, with two equal-sized flagella located at the top of the cell, and a rigid haptonema between these flagella with elongated or oval cell, truncated at the top.

Prymnesium parvum is tolerant to a wide range of temperatures and salinities, which allows to inhabit more or less saline inland ecosystems. Additionally, the nutrient enrichment of freshwater bodies also contributes to the its wide occurrence. It is mixotrophic organism: autotrophic and/or heterotrophic, and it can produce toxins with the potential effects: ichthyotoxic, cytotoxic, hemolytic, hepatotoxic, neurotoxic, antibacterial, allelopatic.

This alga was responsible for mass fish kills in aquatic ecosystems located in different countries, e.g. in USA, Israel, China, Norway, Finland, Greece, Hungary. It was noted that the first record of fish kill caused by *Prymnesium parvum* was observed in Europe in the late 1930s in Denmark. It was observed that under physiological stress (nutrient limitation), *Prymnesium parvum* can produce toxins, identified as prymnesins, that are lethal to fish. They can disrupt gill function, preventing oxygen exchange and ultimately leading to suffocation. In Poland, this species was detected for the first time during the ecological disaster in the Odra River in 2022. It was proved that the fish kills usually occur when *Prymnesium parvum* density exceeds 50-100 million cells per Liter.

Green algae in aerial biofilms of building materials from Central Poland and their growth strategy on a micro-scale

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Terrestrial 'green' biofilms colonizing artificial substrates in the temperate climate zone in many cases are composed of coccal and filamentous green algae from Chlorophyta and Streptophyta infrakingdoms. The real taxonomic diversity of these biofilms depends highly on the environmental conditions in microhabitats and the ecological tolerance of taxa with less impact on the type of substrate where the biofilm is developing. In fact, since aerophytes are spread from one surface to another *via* wind, the biofilms of the surrounding area play also an important role in the taxonomic diversity of a particular green coating.

We have analyzed the diversity of aerophytes in 12 biofilms collected from brick and plaster walls in different places of Łódź City (Central Poland). Field surveys were done in two days of July when no important changes in atmospheric conditions were detected. Sampling spots differed in the relative humidity of the substrate, the height from the ground and the percentage of shading.

Algal morphotypes were isolated and cultivated on agar media and the polyphasic approach was adopted for the identification of strains. Strains were characterized using LM, CLSM and TEM observations and molecular studies of 18S-26S rRNA and rbcL markers.

Most of the biofilms were composed of Trebouxiophyceae representatives from Prasiola (*Stichococcus bacillaris, Pseudostichococcus monnalantoides, Deuterostichococcus epilithicus* and Diplosphaera chodatii) and Watanabea (*Chloroidium saccharophilum*) phylogenetic clades and in some cases Chlorophyceae from the *Bracteococcaceae* family (*Bracteacoccus minor*). In two biofilms growing in the most humid places, a streptophyte from *Klebsormidium* genus was also noted.

To characterize the potential impact of aerophytes on the structure of substrates five taxa strains were selected and inoculated on experimental brick and plaster substrates, and incubated both in lab and environmental conditions. After 3 months of incubation, the observations of biofilm formation were done in LM, CLSM and SEM. This short period allowed us to see already some differences in the growth strategy between microalgae taxa and visualize in some cases microfractures of substrates that may be a result of algal growth.

Post-mining reservoirs as promising habitats for diatoms in the era of climate change

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Electricity production in Poland is based mainly on the processing of brown coal. Mines of this raw material constitute one of the largest open-pit mining branches in Poland, ccontributing to short- and long-term negative environmental effects. One of the biggest impacts of mining operations is the groundwater drainage within a radius of several kilometres from the open pit itself. Mines must develop and implement reclamation plans to limit water outflow from the region. Part of this plan is the establishment of post-mining reservoirs which are created by flooding depleted opencast. These reservoirs are not included in the Water Management Plan and therefore are not subject to water monitoring or legal protection. PAK KWB Konin S.A. is the third largest brown coal mining company in Poland, operating in the Greater Poland Voivodeship. In the area belonging to this company, there are several brown coal opencasts, and several reservoirs were created after a flooded opencast with water from local streams and mine drainage water. One of these reservoirs is the Bogdałów reservoir which is located in Bogdałów village. The water surface is 10.8 ha, designed to store water for fire-fighting purposes, and is surrounded by forest. The main object of the current study was to determine the diversity of the diatom communities in Bogdałów post-mining reservoir. For this purpose, several benthic samples were collected from the sandy bottom and the submerged vascular plants in 2015, 2016, and 2022 respectively with the glass

pipette (sand) and toothbrush (plants). Morphological analysis with LM and SEM, and phylogenetic analysis of several monoclonal diatom strains isolated from benthic samples were used to determine the diversity of diatom communities. Based on LM and SEM observation over 190 diatom taxa were identified in the examined samples including a large variety of *Aneumastus* D.G. Mann and A.J. Stickle, *Diploneis* Ehrenberg ex Cleve, and *Nitzschia* Hassall species. Based on morphological studies supported by phylogenetic analysis the interspecific diversity of small-celled *Nitzschia* species was illustrated, among which *N. nandorii* Olszyński, Zakrzewski & Żelazna-Wieczorek was described.

Charophytes and their ecosystem services in the era of climate change

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Aquatic plants play a crucial role in maintaining healthy lake ecosystems by promoting clear water conditions, which is one of the most important ecosystem services they are related to in lakes. Macroscopic algae from the family Characeae, commonly referred to as charophytes or stoneworts, exhibit exceptional efficiency in maintaining water clarity. This engineering role of charophytes becomes even more critical as climate change is predicted to exacerbate water eutrophication. In this study, we focused on direct and indirect feedback relationships with phytoplankton and water parameters, particularly inorganic carbon cycling. We compared the composition

and biomass of phytoplankton in lakes with abundant vegetation dominated by (1) charophytes (six *Chara*-lakes*)* and (2) angiosperms (six *Potamogeton*-lakes), located in two distant and climatically different regions of Poland (western – warmer, and north-eastern – cooler), with air temperature differences corresponding to the predicted global warming-related temperature rise. Although we expected that climatic differences would have a greater impact on the structure of phytoplankton assemblage, significantly lower values of the total phytoplankton biomass, and the biomass of diatoms and cyanobacteria occurred in *Chara*- vs *Potamogeton*-lakes. Noteworthy, much greater biomass characterised charophytes in both regions, exceeding 2 kg dry weight per 1m^2 of the lake bottom. Since charophytes are known to produce carbonate encrustations, mainly calcium carbonate, constituting even up to 86% of the summer maximum dry weight of the standing crop we analysed the fate of inorganic carbon accumulated this way in *Chara* spp. and *Nitellopsis obtusa* from the above six *Chara*-lakes. Our study evidenced that charophytes can be highly efficient in inorganic carbon burial in sediments which seems very promising for atmospheric CO_2 trapping. However, the process of inorganic carbon cycling through $CaCO_3$ precipitation in charophyte encrustations appears more complex than previously thought. It involves species-specific proportions of both burial and dissolution, warranting further research to quantify the extent of this variability and its implications for carbon sequestration.

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Toxic cyanobacteria in Uzbekistan rice fields – toxicity genes found in water samples indicating a possible risk

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Food production in Central Asia relies on rice production that requires a substantial amount of fertilizers for nitrogen supply. Because of high economical and environmental cost of artificial fertilizes, an alternative solution is being considered with the use of biofertilizers. Due to the specific nature of paddy fields being seasonally overflown with water, biofertilizers used there consist mostly of cyanobacteria. However, many agronomic practices and progressing water pollution result in excessive growth of cyanobacteria, which increases risk of cyanotoxins presence and accumulation that can endanger food production.

For initial toxins assessment in typical rice field, we collected water and soil samples from regions of water drainage from rice fields in the Rice Research Institute located near Tashkent. Isolated biological material and DNA was used to perform microscope analysis and PCR amplification with specific markers. We confirmed presence of cyanobacteria in all samples. Species isolated from the samples included *Cylindrospermum stagnale*, *Calothrix* sp., *Cronbergia siamensis, Lyngbya sp., Phormidium spp., Leptolyngbya spp., Pseudanabaena sp., Microcoleus sp., Aphanocapsa sp., and Chroococcidiopsis sp.* Some of identified taxa are known to have a capability to produce toxins: anatoxins,

saxitoxins, cylindrospermopsin and microcystins. We have amplified fragments of cylindrospermopsin (*cyrL*) and saxitoxin (*sxtA*) genes as well as fragments of microcystins mcy gene cluster: *mcyA* and *mcyE* in some of the samples. No anatoxin encoding genes were detected in the samples.

These findings lead to concern about the potential of toxin secretion by cyanobacteria in rice fields. Recent studies suggest that prolonged exposure to toxins in irrigation water may result in their accumulation in plants or in disruption the germination and growth of rice. Not only can it lead to loss of productivity, but also this possesses a health risk to communities relaying on rice as an important part of their food production industry.

Population-genomics based revision of the crust-forming cyanobacterium *Microcoleus* spp.

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Microcoleus is a genus of cosmopolitan filamentous cyanobacteria, which plays a vital role as a pioneering organisms and primary producers in various terrestric and subaerophytic habitats worldwide. *Microcoleus vaginatus*, a model species for this genus, is a key component of biological soil crusts, complex microbial communities essential for primary production in diverse terrestrial environments. While *Microcoleus vaginatus* has been extensively studied for its ecological significance and morphological traits, recent research indicates multiple distinct species within the *M. vaginatus* group, challenging its classification as a single species. Population genomics and phylogenetic analyses have facilitated a deeper understanding of cyanobacterial taxonomy, leading to the recognition of previously overlooked diversity. In our previous studies, we identified numerous putative species within the *M. vaginatus* group through a multidisciplinary approach. In this study, we describe 7 novel species of *Microcoleus* in the *M. vaginatus* group and set a new epitype for the model species *M. vaginatus*, as well as previously described *M. autumnalis*, *M. terrestris* and *M. favosus*. This research contributes to a more comprehensive understanding of terrestrial cyanobacterial biodiversity and highlights the need for revised taxonomic frameworks in cyanobacterial classification.

Ecological, genetic, and spatial processes cause diversification in the global continuum of *Microcoleus* species

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The notion of the speciation continuum explains speciation as a gradual and continuous process and represents a continuum of barriers to gene flow. Quantifying gene flow and investigating evolutionary factors influencing it between diverging species remains crucial for understanding microbial speciation. Here, we explored diversification patterns, species boundaries, and the genetic underpinnings shaping the differentiation of the cosmopolitan cyanobacterium *Microcoleus vaginatus*. With a dataset comprising 291 genomes, of which 202 strains and eight herbarium specimens were sequenced for this study, we discovered a global continuum of at least twelve distinct *Microcoleus* species. Notably, each species exhibited varying levels of gene flow, and their relative positions along the speciation continuum have been determined. The diversification of *Microcoleus* commenced 29.6 million years ago, propelled by selection pressures and influenced by ecological, genetic, and spatial factors. Whole-genome scans uncovered evidence of genetic divergence and selection within the genomic regions containing genes related to stress response and secondary metabolite biosynthesis. This study offers novel insights into microbial species and presents evidence for a whole-genome divergence of *Microcoleus* through periodic allopatric speciation, ecological speciation, and extensive gene flow.

Cryptomonads in Hungary: taxonomy and distribution

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In this study, we present a summary of the current diversity and distribution of cryptomonads in Hungary, focusing on the occurrence and autecology of taxa. The main aim was to collect and organise current taxonomic knowledge, providing a clearly useable identification key for light microscopy and producing a well-illustrated species description. The species list is based on the REBECCA database, while the Hungarian distribution of these taxa is based on the Hungarian monitoring database. In this study, a total of 38 cryptomonad taxa (species) belonging to the following genera *Hemiselmis* (1), *Chroomonas* (4), *Komma* (1), *Cryptomonas* (23), *Cryptochrysis* (3), *Plagioselmis* (2), *Rhodomonas* (4) are presented with line drawings/ 3D models and their identification key, ecology or distribution in Hungary is discussed.

Raphidiopsis raciborskii response to chill/light stress

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The intense proliferation of cyanobacteria in aquatic ecosystems leads to many environmental and economic problems. The presence of the highly adaptive but also invasive species *Raphidiopsis raciborskii* has been increasingly observed worldwide. However, the adaptation mechanisms of both toxic and non-toxic strains of this species to various environmental conditions, including these associated with low temperature and high light (chill/light stress), common in temperate climates, have not been investigated. The aim of our study was to gain more insight into potential adaptations of photosynthetic apparatus of several *Raphidiopsis raciborskii* strains varying in their origin and toxicity. For this purpose, the growth rate and several parameters related to photosynthetic activity were monitored: pigment accumulation, chlorophyll fluorescence and photosynthetic electron flow determined by PAM fluorimetry, oxygen evolution during light phase and release during respiration measured using Clark electrode, accumulation of photosynthetic products (NADPH), the expression of genes involved in light phase of photosynthesis. Furthermore, the toxicity and the transcripts level of genes involved in the cylindrospermopsin (CYN) production were determined. The results indicate that the tested strains

have different models of response to chill/light stress. Physiological parameters were mildly affected by the chill/light stress and mostly stabilized by the end of the stress conditions. Similarly, investigated gene expression patterns suggests that the response to the environmental stress seems to be highly individual adaptation of photosynthetic apparatus, regardless of the toxicity. On the other hand, chill/light stress seems to affect metabolic processes involved in the regulation or CYN accumulation that suggest a possible selection of toxic strains. Observed changes in physiology, gene expression patterns, and toxin production indicate high species plasticity resulting in rapid adaptation and resilience to the investigated environmental conditions.

The effect of carbon dioxide and temperature elevation on the performance of freshwater bloom-forming cyanobacteria and their potential to invade coastal Baltic Sea waters

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Cyanobacterial blooms are increasing global problem due to eutrophication and climate change. The levels of key climatic variables, i.e. carbon dioxide concentration and temperature, are projected to increase further and favor more blooms of cyanobacteria. Here, we investigated the biomass yield of several most commonly freshwater bloom-forming cyanobacteria (the genera of *Aphanizomenon, Chrysosporum, Cuspidothrix, Dolichospermum, Limnothrix, Planktothrix, Raphidiopsis*) in response to CO_2 and temperature elevation. We

also determined their potential to survive in coastal waters of the Baltic Sea – one of the largest brackish seas worldwide that exhibits a high salinity gradient and sensitivity to blooms of marine cyanobacteria. Experiments were conducted under two climate conditions (ambient: 20°C/430 ppm of CO_2, elevated: 26°C/1200 ppm of CO_2) using different media for growth (control culture medium, seawater of different salinity originated from different coastal Baltic Sea). Incubation of cyanobacteria in control medium at elevated temperature and CO_2 resulted in higher biomass yield of strains in comparison to ambient conditions. At elevated level of temperature and CO_2, *Raphidiopsis raciborskii* reached the highest biomass yield (5360 – 8690 µg chl. *a* dm^{-3}). In contrast, studied strains of this species at ambient conditions achieved much lower biomass which ranged 214 – 966 µg chl. *a* dm^{-3}. The experiments also showed that some freshwater species could thrive in seawater of different salinity, however, this ability was highly strain specific and depended on seawater source and climate. Elevated climate conditions did not always accelerate the growth of seawater invaders: the effect of climate varied by strain and seawater source. Interestingly, cylindrospermopsin-producing *Aphanizomenon gracile* could prosper in each of the studied seawater types. Moreover, this strain could thrive in seawater even when the marine resident *Nodularia spumigena* was present. To conclude, populations of freshwater bloom-forming cyanobacteria incubated in nutritious culture medium grow faster and reach higher biomass at elevated temperature and CO_2 levels. In hotter and richer in carbon dioxide climate, *Raphidiopsis raciborskii* may be the most successful among bloom-forming cyanobacteria. Moreover, toxic and bloom forming freshwater cyanobacteria have the potential to thrive in the coastal Baltic Sea in studied climatic conditions. Depending on the region, elevation of CO_2 and temperature can either increase, reduce or have no significant influence on the invasive potential of freshwater cyanobacteria invaders to inhabit coastal Baltic Sea.

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Algae in chromate sewage: composition, functioning and potential benefits

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The crucial role of algae in the development and survival of life on Earth is widely known. These delicate organisms demonstrate an astonishing ability to expand and survive in extreme environmental conditions. The high resistance of algal communities to environmental extremes has been confirmed by our multidisciplinary research on a unique aquatic phytobial biocenosis, conducted since 2019. This biocenosis formed naturally over the course of 20 years and has functioned as a filter for Cr-polluted infiltrates at a chemical plant in southern Poland. The communities were recorded in the infiltrate purification system, which includes two open ditches collecting Cr(VI)-leachates with Cr(VI) content of up to 123 mg/L, exceeding the norm by a factor of 6250, and a settler accumulating the Cr(III) solution that arises after chemical Cr(VI) reduction. Here we present a comprehensive taxonomic analysis of the communities, also including vascular plants and microbiomes, together with analyses of Cr accumulation and the mechanisms of Cr binding to algal biomass, and a consideration of methods for utilizing this biomass. In the ditches we identified 112 species: 77 algae, 20 vascular plants and 15 bacteria. The filamentous algae exhibited hyperaccumulation of chromium (up to 16230 mg/kg dry mass). We found that algal detoxification of Cr(VI) consisted mainly of biological reduction followed by Cr(III) biosorption. Three *Tribonema*

(Xantophyceae) species dominating the Cr(VI)-exposed communities – *T. vulgare* Pascher, *T. microchloron* Ettl and *T. viride* Pascher – are likely responsible for the effective Cr(VI) bioremediation. Diatom (Bacillariophyceae) populations also developed there, with as many as 44 taxa identified. Among them the biotechnological potential of the three most resistant taxa should be analyzed further: *Gomphonema acuminatum* Ehrenberg, *Melosira varians* C. Agardh and *Nitzschia frustulum* (Kützing) Grunow. The algal communities obtained from different sites of the chromium infiltrate treatment system varied in their taxonomic and chemical composition. *Cladophora* sp. dominated the settler community and was selected for the design of further chromium bioremediation technology. Chromium-containing *Cladophora* sp. was confirmed to be a suitable material for conversion in subcritical water. The process resulted in the selective extraction and hydrolysis of polysaccharides and their separation from heavy metals remaining in the solid residue.

POSTERS

Taxonomical identification of benthic diatoms from North Celebes, Indonesia

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With more than 17,000 islands and a coastline spanning approximately 81,000 kilometres, Indonesia boasts mega-biodiversity in marine resources, including diatoms. The importance of benthic diatoms in marine ecosystems makes them useful for decisions regarding conservation and understanding ecological and biogeographical matters. Unfortunately, the northern part of Celebes has not been explored and sampled yet. This study aimed to provide a list of diatoms based on their morphological characteristics. Sampling was conducted in North Celebes, Indonesia, in 2022, where samples were taken from sediment substrate. Water quality is measured as supporting parameters, including temperature, salinity, pH, TDS (total dissolved solids), and EC (electric conductivity). The research findings include 113 taxa from 35 genera. Further taxonomic investigation is required for several taxa, which are highly probable candidates for being described as species new to science. During the counting process, Paralia sulcata emerges as the most abundant species, whereas Amphora and Diploneis exhibit significant diversity, comprising 11 and 10 species, respectively. These findings confirm that the marine waters of Celebes serve as habitats for diatoms, offering opportunities to discover new diatom taxa previously undocumented in scientific literature.

Airborne cyanotoxins - the least known route of exposure

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Marine and lake bioaerosols are explored by many institutes around the world. At the same time, the presence of airborne cyanobacteria and their toxins is the least-studied problem in both aerobiological and phycological studies. The inhalation of cyanotoxins also remains an underexplored threat. In this presentation, we will introduce the issues related to the research of airborne cyanotoxins and their potential risk to public health. We will try to answer the question: why is this route of exposure to cyanobacterial toxins the least understood? Moreover, we will present our research aimed to identify cyanobacterial toxins in marine aerosols in the Gulf of Gdańsk region, during the blooms of thecyanobacteria: *Nodularia spumigena*, *Dolichospermum* sp. and *Aphanizomenon flosaquae*. Aerosols were sampled during summer season using a microbial cascade impactor, which allows fractionation of samples by aerosol particle size (ø 0.65-10 µm). Chemical (LC-MS/MS) and molecular (PCR) methods were used to identify and quantify toxic metabolites in aerosol and water samples. Based on LC-MS/MS analyses, the presence of the cyanotoxins: nodularin and microcystins was demonstrated in marine air samples. Toxins were identified in all tested bioaerosol fractions. In contrast, molecular analyses showed trace amounts of eDNA (~10-20 ng/µl), but no genes from the operons encoding microcystins/nodularins (*mcyE*/*ndaF*) were detected in the PCR reaction.These results indicate that marine bioaerosols from the Gulf of Gdańsk region contain and simultaneously transport cyanobacterial hepatotoxins, posing a potential health risk to beachgoers during periods of intense cyanobacterial blooms.

Diversity and seasonal variation of cyanobacterial secondary metabolites in shallow waterbodies

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Cyanobacteria are well-known producers of diverse secondary metabolites, which can vary significantly across different species and under different environmental conditions. Understanding the seasonal dynamics of these metabolites is essential for recognition of their ecological roles and potential impacts on aquatic food web interactions. This study aims to investigate the diversity and seasonal variations in cyanobacterial metabolites across three shallow waterbodies in Southern Poland, annually subjected to cyanobacterial blooms. Metabolite composition was analysed using liquid chromatography coupled with mass spectrometry (LC-MS/MS) in 51 samples, collected in 2022 and 2023. In this study, we found several non-ribosomal oligopeptides belonging to various groups, including anabaenopeptins, aeruginosins, aeruginosamides, microginins, micropeptins, cyanopeptolins, planktocyclins, and microcystins. Metabolite profiles exhibited distinct seasonal patterns, with occurrence starting in May, notable diversity and richness during the warmest months (July and August), but also presence in autumn (September, October). Moreover, significant fluctuations occurred throughout the two-year span, with a decreasing complexity and number of metabolites observed. Furthermore, differences were observed in metabolite profiles among the sampled ponds, suggesting unique metabolic activities of distinct species within each ecosystem. These findings highlight the importance of considering metabolite composition as sensitive indicators of subtle changes in phytoplankton

structure, even at the subpopulation level or in the overall phytoplankton composition. In conclusion, understanding the seasonal dynamics of cyanobacterial secondary metabolites provides valuable insight into the functioning of aquatic ecosystems and the potential risks and benefits associated with proliferation of cyanobacterial blooms.

Year to year fluctuations in the summer phytoplankton of the Płociczna river system in Drawieński National Park (NE Poland)

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The aim of this study was to analyze temporal changes in the state of aquatic ecosystems of Drawieński National Park – one of the protected areas of Poland, created primarily for protection of aquatic ecosystems. This presentation focuses on the phytoplankton communities, their fluctuations and driving forces.

The samples were collected in summer of 2022 and 2023 from the river Płociczna, its inflow, and lakes located on the river.

Phytoplankton communities of the two summers differed immensely. The biomass of the phytoplankton was much higher in 2022 than in 2023 (mean, median and maximum values: 11.5, 7.2, 42.6 mg L^{-1} and 2.7, 1.4 and 11.5, respectively). The highest phytoplankton biomass was noted in both years in the river Cieszynka, inflowing into the park from east. Bloom-forming cyanobacteria (*Dolichospermum planktonicum*, *D. circinale*) dominated the phytoplankton of the river. The biomass of the phytoplankton dropped gradually after the inflow oof Cieszynka to Płociczna river, and with the course of Płociczna, indicating its high self-purification capacities. Phytoplankton of lakes Sitno and Płociczno also differed significantly between the years. Much higher phytoplankton biomass in 2022 was dominated by cyanobacteria (*Planktothrix agardhii*, *Aphanizomenon klebahnii*, *Microcystis areuginosa*), and in 2023 cryptophytes prevailed. Only Lake Ostrowieckie hosted similar phytoplankton community in both years, with similar biomass value and community structure.

Our results point out the huge interannual shifts in phytoplankton communities of the river system of Płociczna. They also show a strong impact of the inflow from outside the Park, that deteriorates ecological conditions of waters within the Park boundaries.

Effects of pH on the cyanobacterium *Synechococcus rubescens* SAG 3.81

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CO_2 uptake of by oceans is a natural process and serves as part of the water buffering system. However, increasing emissions of anthropologic CO_2 leads to an increased concentration of this gas in water. This in turn changes the chemistry of the water and leads to a decline in its pH. Ocean acidification is currently one of the greatest threats to marine ecosystems and microorganisms. The negative effects of acidification include, among others, inhibition of the development and growth of microorganisms by disruption of metabolic functions directly related to the process of photosynthesis, and respiration, as well as changes of the physicochemical properties of the cellular structures.

Thus far, scientific research focused mainly on the effects of ocean acidification on calcifying organisms such as corals, muscles, and oysters. Less attention has been paid to other groups of organisms such as cyanobacteria and algae. Cyanobacteria are the oldest photosynthetic organisms living on Earth. They are an important component of phytoplankton, these microorganisms greatly contribute to the nitrogen and carbon cycles. Additionally, genera such as Synechococcales and Prochlorococcales are most abundant and are responsible for almost 50% of primary production in the world's ocean. Cyanobacteria constitute an important environmental marker and they should not be overlooked.

The aim of this study was to evaluate the effects of pH on *Synechococcus rubescens*. The pigment composition and changes (chlorpphyl-*a*, carotenoids,

and phycobilins) of the tested strain were characterised with the application of chromatographic and spectrofluorimetric methods. To assess the effect of pH on the photosynthetic apparatus, AquaPen handheld fluorometer was used. The organism was very sensitive to the tested factor; significant changes in growth as well as pigment production, and the efficiency of PSII photochemistry were observed between the tested variants.

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Coelastrella vacuolata as a source of microalgal extracellular polymeric substances (EPS)

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Coelastrella sp. is a species that inhabits aerial habitats e.g. soil, rock or tree bark. The wide distribution range of this species, high growth rate, and biochemical profile make *Coelastrella* sp. a promising species for application in biofuel and food production (1). This species was also found to be an effective nutrient removal species from wastewater, with high biomass and lipid production. However, the presence of heavy metals such as Cu or Zn inhibits culture growth, and ammonium and phosphorus removal from wastewater (2). The aim of the presented research was to evaluate the productivity and chemical composition of water-soluble EPS (S-EPS) synthesized in autotrophic and mixotrophic conditions by *Coelastrella vacuolata* culture. *C. vacuolata* was cultivated in autotrophic (air) and mixotrophic (air and glucose) conditions. The water-soluble EPS was then characterized by functional group identification (FTIR). After hydrolysis, the chemical composition was determined using UV-Vis methods. Monosaccharides were identified by thin layer chromatography (TLC) method. The addition of glucose to the culture medium enhances S-EPS productivity [mg L^{-1}]. Specific productivity [mg g^{-1} biomass] also increases indicating a stimulating effect of glucose on *C. vacuolata* metabolism. The addition of glucose resulted in an increase in carbohydrate and reducing sugars content in S-EPS, as well as proteins and phenolic compounds. While the concentration of uronic acids and amino acids – related to sorption properties decreased. The TLC results indicate that the glucose present in the

growth medium was used for S-EPS synthesis. The FTIR spectra showed the reduction in the band intensity in the region of carboxyl groups (1730-1400 cm^{-1}). The results show that glucose present in the growth medium is used for EPS synthesis and affects the chemical composition of EPS, which may consequently lead to a change in their properties.

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Diversity of airborne algae and cyanobacteria from active Mroźna Cave (Tatra Mountains), Poland

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The airborne algae and cyanobacteria found in caves are not yet sufficiently studied. In these extreme environments algae are restricted to illuminated zones, and are to be found at the entrance zones and in the lampenflora communities. However, the number of species is constantly increasing as new species are (continuously) discovered. In this paper, for the first time, we present the airborne algae and cyanobacteria collected in active Mroźna Cave (the Tatra Mountains) in Poland. In total 16 (new) cyanobacteria and 32 algae were found in the cave entrance and lampenflora, based on detailed LM, TEM and SEM observations. Diatoms (Bacillariophyta) were the most frequent, (with as many as) 27 group found, followed by green algae (Chlorophyta), golden-brown algae (Chrysophyta) and the 14 filamentous cyanobacteria (Cyanobacteria). Additionally, five species of mosses and one species of fern were also found. The average temperature in the cave was 5.18ºC and humidity 99.94. Moreover, artificial lighting was removed in 2022, so the research cannot be repeated. However, it is possible to study which species survive and how long after the

removal of artificial lighting.We propose that the airborne algae and cyanobacteria monitoring should be performed regularly in the Mroźna Cave.

Cyanobacterial bloom in a recreational lake, preliminary study before planned restoration

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Lubowidzkie Lake is a valued body of water for recreation, fishing, and water sports. Surveys covered by the State Environmental Monitoring show class 1 purity of this lake (2018 data). However, progressive eutrophication is also making its presence known in this lake. In view of the water bloom phenomena, which have been observed regularly for several years, and the planned restoration measures, an assessment of the current state of this lake's ecosystem was chosen as the goal. The paper presents the biomass and composition of phytoplankton and the identification of the bloom. Lubowidzkie Lake is a medium-sized flowing lake (158 hectares), with a maximum depth of 15.6 m, an average depth of 8 m, with a poorly diversified shoreline. The catchment area is mostly agricultural land. Material for the study was taken during the growing season, i.e. from April to October 2023. Due to the flowing nature, the study in Lubowidzkie Lake was carried out at 4 sites, i.e. at the inflow and outflow of the Węgorza River, in the lake's trough, and in the vicinity of the deep water. The phytoplankton during spring was dominated by diatoms, while in early summer by dinoflagellates. During this period, phytoplankton biomass was very low, characteristic of pure mesotrophic lakes, as phytoplankton biomass did not exceed 2.5 mg/L. However, there was a marked increase in biomass in August. At that time, dinoflagellates continued to dominate, but at the site located in the vicinity of the deep water, an increased proportion of cyanobacteria was clearly evident. A drastic increase in biomass was observed in September, at which time a clear bloom was recorded, and phytoplankton biomass reached an average value of 7.6 mg/L.

A biomass gradient was also observed in the lake, where the highest values occurred at the inflow and successively decreased towards the outflow. The bloom was formed by two species of cyanobacteria. The highest abundance and biomass were *Planktolyngbya limnetica* (Lemmermann) Komárková-Legnerová & Cronberg and *Aphanizomenon flos-aquae* Ralfs ex Bornet & Flahault. Unfortunately, the abundant presence of *Aphanizomenon flos-aquae* is a potential threat, as this species is among the dangerous producers of cyanotoxins.

Cyanobacteria and microalgae assemblages in cryoconite holes (Victoria Land, Antarctica)

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The current melting of glaciers and ice caps is one of the most significant consequences of climate change. Cryoconite holes, supraglacial depressions containing water and microbe-mineral aggregates, are important habitats that can cover up to 10 % of the glacier surface. The autotrophic component of cryoconite plays a central role in reducing the albedo of glaciers and sustaining the entire cryoconite food web. Phototrophic processes associated with the cryosphere are expected to increase in the future, further reducing ice surface albedo caused by biological impurities. Despite the essential role of cryoconite microalgae, the knowledge of these organisms in glacial habitats is incredibly still poor, especially in Antarctica. In this study, we aim to gain insights into the diversity and composition of microalgae and cyanobacteria in different cryoconite holes of the Victoria Land Region, Antarctica. Based on microscopic observations, we provide a highly comprehensive description of the cyanobacteria and microalgae morphotypes in cryoconite holes. Our study revealed that cryoconite holes encompass a high diversity of cyanobacteria and microalgae in terms of taxonomy, biomass, and morphotypes, and underlines the importance of including microalgae morphology in ecological studies of glacier cryoconites.

Ecological implications of *Cladophora glomerata* (L.) Kütz. blooms: Seasonal variability and polyphenolic compounds

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Macroscopic filamentous algae are the main producer of organic matter in aquatic ecosystems. The most common macroalga in freshwater ecosystems is *Cladophora glomerata* (L.) Kütz., which is characterized by: high morphometric variability and phenotypic plasticity, rapid growth of high biomass in a short time, monopolization of the water, colonization of eutrophic water. Excessive growth of *Cladophora* may disturb the ecological balance, affecting, among others: to changes in the structure and functioning of communities of aquatic organisms, including pleustophytes. Although filamentous algae tolerate a wide range of changes in habitat conditions, in response to biotic stress, have the ability to produce increased amounts of polyphenolic compounds. The consequence of this may be an increase in the ecological dominance of *Cladophora* in body of water, causing shading, anaerobic conditions and disruptions in the cycles of nutrients.

Within this study, field and experimental research was conducted. The aim of the field research was: 1) to investigate the seasonal variability of *C.glomerata* biomass as a result of its co-occurrence in the aquatic ecosystem with the pleustophyte community (*Lemna minor* L.); 2) determining changes in physicochemical parameters of water as a result of intensive development of *C.glomerata*; 3) determination of the total content of polyphenols secreted by *C.glomerata* in habitat water. Field research was carried out from May to September in 2021 and 2022 in Lake Oporzyńskie in western Poland, where intense blooms of *Cladophora* and *L.minor* occur during the growing season.

Experimental research included examining the influence of polyphenols secreted by *C.glomerata* in habitat water on changes in the morphological features of *L.minor*. Experiments were carried out using phenolic acids: gallic acid, benzoic acid, quinic acid, coumaric acid at concentrations of 0.01 mg/L; 0.10mg/L; 0.50mg/L; 2.00mg/L; 5.00mg/L. The exposure time of phenolic acids to pleustophyte was: 2 days, 7 days, 14 days.

The conducted research presents one of the possible models for shaping the populations of *L.minor* and *C.glomerata* in the aquatic ecosystem where they occupy the same ecological niche. The presence of macroscopic filamentous algae influences the formation of the pleustophyte community by changing environmental conditions and competition for environmental resources. The consequence of the secretion of excessive amounts of polyphenols by *C.glomerata* may be a gradual weakening of the condition of individuals, reduction of biomass and a decrease in the bioremediation properties of *L.minor* in the aquatic ecosystem.

The rare and poorly-known diatom species (Bacillariophyta) in springs of Eastern Poland

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Diatoms are amongst the most common and abundant algae in urban and forest springs. The aim of the poster is to present the springs as a refuge for freshwater diatoms. Our pioneering studies of diatom communities from Białystok, the big forest complex of Knyszyn Forest Landscape Park (lowland) and Roztocze (upland) documented the presence of many rare and poorly-known species. Among them were: *Achnanthidium lineare* W.Smith, *Cocconeis pseudothumensis* E. Reichardt, *Cymbella hantzschiana* Krammer, *Diploneis burgitensis* Prudent, *D. fontium* Reichardt and Lange-Bertalot, *D. parapetersenii* Lange-Bertalot and Fuhrmann, *Fragilariforma bicapitata* (A.Mayer) D.M.Williams & Round, *F. nitzschioides* (Grunow) Lange-Bertalot, *Gomphonema productum* (Grunow) Lange-Bertalot & E.Reichardt, *Navicula striolata* (Grunow) Lange-Bertalot, *Mayamaea lacunolaciniata* (Lange-Bertalot & Bonik) Lange-Bertalot, *Nitzschia pura* Lange-Bertalot, *Parlibellus protractoides* (Hustedt) Witkowski & Lange-Bertalot, *Psammothidium grischunum* (Wuthrich) Bukht. & Round, *P. lauenburgianum* (Hustedt) Bukhtiyarova & Round, *Staurosira chavauxii* Morales et al., *Stauroneis muriella* J.W.G. Lund, and *S. thermicola* (Petersen) Lund. *Diploneis burgithensis* and *D. parapetersenii*, both rare taxa, are the first recorded for Poland. Our results confirm the important role of the springs in maintaining the biodiversity.

Microalgae as a sustainable source of protein feed

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Microalgal biomass and its cell components were applied in many industrial sectors. Microalgae are used as dietary supplements, in the pharmaceutical and cosmetic industries, in the production of heat and electricity, and for transportation biofuels. Microalgae are used as biofertilizers and biopesticides, so their potential in the agriculture sector is definitely wider.

Microalgal biomass is a source of bioactive compounds, including polyphenols and carotenoids and a range of macro- and micronutrients, as well as polysaccharides, lipids,and proteins. For many of the algal species, the protein concentration can be over 50% of the dry mass. This is a level significantly higher than the content of this component in plants and animal products. The amount of protein in microalgal biomass is a variable value, depending not only on the species but also on the methods of biomass production and environmental factors, including the type of light and its intensity, CO_2 levels, chemical composition of the culture medium, temperature of cell growth, and pH of the growth medium.

Conventional agricultural systems may not support increasing food consumption. Alternative options are required. One such solution could be the production and use of algal biomass, not only as food but also as high-protein animal feed.

A significant barrier to the massive production of microalgal protein is the lack of industrial-scale technologies. Developing such technology and providing high biomass productivity at relatively low cost is a multi-step process. It requires, for example, the selection of microalgae with beneficial physicochemical

parameters, optimization of cultivation conditions, constructions a special technological process line, and analysis of investment costs and costs of exploitation of this system.

The studies are carried out under the project "Development of innovative technology for production of high-protein feed from microalgal biomass"; co-financed by the European Union under Measure M16 "COOPERATION" of the Rural Development Program 2014-2020.

Macrochaete oelandica sp. nov., the second cyanobiont of lichen *Placynthium nigrum* in Europe

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Cyanobacteria, a diverse group of photosynthetic bacteria, act as the primary symbiont in the production of carbohydrates in about 10% of lichenized fungi, referred to as cyanolichens.

In our study, we focused on the effect of two different living conditions on the morphology of filamentous cyanobacterium, in a symbiotic relationship with the lichen *Placynthium nigrum* (Huds.) Gray, i.e., as a cyanobiont vs. a solo cyanobacterium in our isolated culture. We examined the 16S rRNA sequences of this cyanobacterium living in both different forms, fungal mtSSU rDNA and MCM7 using ML analyses. Cyanobacterial sequences 16S-23S ITS were used to examine the structure of DNA helices. While the D1-D1' of the analysed cyanobiont had a similar secondary structure to other *Macrochaete* species (Rivulariaceae), it possessed some unique features. Similarly, the Box B helices showed a unique sequence of the terminal loop 5'-UACUG-3'. Our morphological analyses revealed that genetically identical cyanobacterium derived from the same lichen thallus exhibit different morphological traits depending on their living conditions: incompletely developed traits due to limitations in symbiosis in the lichen thallus versus fully developed morphological traits when cultured.

Based on our results of an integrative taxonomy, we propose a description of the studied cyanobiont as *Macrochaete oelandica* sp.nov.

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Submerged vegetation in Lake Góreckie (Wielkopolski National Park): A case study of charophyte resilience in a eutrophic environment

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Submerged vegetation plays a key role in the functioning of the lake ecosystem, being also an indicator of its water quality. This study aims to analyze the current state and long-term dynamics of submerged plants in the strictly protected Lake Góreckie (Wielkopolski National Park, W Poland) and to indicate potential directions of their further development. Lake Góreckie exhibits a paradox: strict protection coexists with persistent eutrophication. The lake has been characterized by high productivity for decades with phytoplankton blooms dominated by cyanobacteria despite the cut-off of nutrient discharge and the closure of the lake for recreational use. The decrease in water transparency was accompanied by the disappearance of submerged vegetation, including valuable species of macroalgae from the Characeae family (commonly referred to as charophytes and applied as bioindicators of less productive waters). Previously reported from Lake Góreckie representatives of Nitella and the rare *Lychnothamnus barbatus* have vanished, and overall macrophyte species richness has more than halved, with only eutrophic-tolerant taxa remaining at scattered sites. Increased catchment afforestation and lake reclamation efforts (aeration, phosphorus coagulation) have not led to a significant and sustained reduction in eutrophic nitrogen and phosphorus levels. Our study, however, performed in the year the aeration was terminated, i.e. in 2022, evidenced the slight growth of charophyte species in Lake Góreckie. In total, 7 submerged macrophyte species were identified (excluding

filamentous algae) out of which three belonged to the Characeae family. While *Chara contraria* and *C. globularis* were recorded in the past, *Nitellopsis obtusa* occurred in the recent decade as a new species to the vegetation of Lake Góreckie. Unfortunately, charophyte coverage was limited and low. Only *Nitellopsis obtusa* was more abundant, but this was not enough to identify its own community, *Nitellopsidetum obtusae*. The study also showed that the number of macrophyte species increased slightly in the last decade, after the installation of the aerator (December 2009). This evolution was particularly evident in the case of charophytes, which reappeared after a more than 40-year absence. Although a recovery of charophyte species was observed, it is difficult to conclude whether it was a result of aeration, and further study is needed to anticipate the trajectories of the vegetation growth and its relation to the water quality of Lake Góreckie.

Technology for producing algae fertilizer based on phosphorus-containing and lignite-containing waste from the South of Kazakhstan

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Due to the processes of water and wind erosion, waste from the processing of phosphorus and lignite (brown coal) has gradually become a serious environmental problem for the south of Kazakhstan. The mineralogical composition of phosphorus-containing slags, consisting of pseudo-wollastonite (a-$CaO \times SiO_2$), cuspidine ($3CaO \times CaF_2 \times 2SiO_2$), ferrophosphorus Fe_2P, melilite - $Ca_2(Al,MgSi)Si_2O_7$, ackermanite-$Ca_2MgSi_2O_7$, rankinite $3CaO \times 2SiO_2$, fthorapatite – $Ca_5(PO_4)_3F$, whitlockite NaF, fluorite CaF_2, silicocarnotite $5CaO \times P_2O_5 \times SiO_2$. Lignite is represented by minerals such as quartz SiO_2, Gypsum $CaSO_4 \times 2H_2O$, Kaolinite $Al_2Si_2O_5(OH)_4$, Cronstedtite $Fe_3((Si_{0.74}Fe_{0.26})_2O_5)(OH)_4$, Margarite $CaAl_2(Si_2Al_2)O_{10}(OH)_2$, Muscovite $H_2KAl_3(SiO_4)_3$, Calcite $CaCO_3$, Laumontite $CaAl_2Si_4O_{12}(H_2O)_2$, Lead Aluminum Sulfate Hydroxide $Pb_{0.5}Al_3(SO_4)_2(OH)_6$. The presence of a number of metals necessary for phototrophic organisms as sources of growth factors and micronutrient nutrition, such as magnesium, manganese, iron, etc. in lignite-containing waste, indicates the possibility of using these wastes as a component for the industrial cultivation of algae.Phosphorus-containing sludge is constantly in a wet state due to the likelihood of spontaneous combustion. As a result, aqueous solutions are formed around the sludge storage areas, accumulating in concrete-lined tanks of the technological scheme of the former plant. The volume of solutions is constantly maintained due to artificial and natural humidification. Primary algological examination of liquid phosphorus-containing samples revealed the presence of such taxonomic groups of algae as: *Navicula*

sp., Meridion circulare, Oocystis sp., Diatoma sp., Anabaena sp., Chlamydomonas sp., Chlorella vulgaris.A technological scheme for the production of algae fertilizer was developed. In the south of Kazakhstan there is high insolation, which contributes to its practical use. The optimum values for algae cultivation were determined: wavelength indicators when irradiating biomass with red light at a wavelength of 460.0±42.1 nm and blue light at a wavelength of 625.0±5.0 nm; bubbling with parameters per minute of 5.7±0.4 g/l O_2 and 0.09±0.01 g/l CO_2. Solid sediment that accumulates at the bottom of the tanks is collected in sand traps and can be disposed of as filler for building materials.

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Diversity and activity of bacterioplankton in shallow lakes during cyanobacterial blooms

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One of the most serious problems facing the world today is the growing scarcity of drinking, recreational and industrial water, caused by global climate change and ongoing eutrophication. An increase in temperature, deficiency of precipitation and elevated concentrations of pollutants from anthropogenic sources contribute to changes in the biocenosis of waterbodies. Another threat to the ecological balance of these ecosystems comes from cyanobacterial blooms. Since they deplete oxygen and produce highly potent toxins, they may affect the structure of bacterial communities that play a key role in the transformation and mineralization of organic matter. Therefore, the aim of the study was to assess the functional and structural diversity of bacterioplankton in three eutrophic lakes during cyanobacterial blooms. Water samples were collected at monthly intervals in summer (July-September 2020). Microbial communities were examined using high-throughput sequencing of the 16S rRNA gene. The abundance and activity of bacterioplankton populations were determined with the use of fluorescent markers. The results indicate the predominance of dead bacterial cells in the investigated lakes. Taxonomic analysis showed the dominance of the following phyla: Cyanobacteria, Proteobacteria, Bacterioidetes, Actinobacteria and Verrucomicrobia. In addition, the structure of bacterial communities (β-diversity) differed significantly between the investigated lakes, but did not depend on the season. No significant impact of abiotic factors on the structural and functional diversity of bacterioplankton was observed. Our research demonstrates that, regardless of cyanobacterial dominance, the structure of the microbial community remains specifically related to the type of the lake. Further analysis is needed to better understand factors influencing this structure.

Taxonomical checklist of southern African photosynthetic and heterotrophic euglenoids: preparation launched

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Formation and development of southern African algal checklists is a primary priority in algal systematic research, which stimulates research initiatives aimed at addressing taxonomic challenges. As an initial step towards realizing this objective, we have initiated the compilation of a taxonomic checklist including both photosynthetic and heterotrophic euglenoids found in the freshwater ecosystems of southern Africa (South Africa, the Kingdoms of Eswatini and Lesotho, Namibia, Botswana, Zimbabwe, and Mozambique). This checklist aims to consolidate all known records from scientific literature for this region, dating back to Gottlob Ludwig Rabenhorst's work on South African algae in 1855.

Our preliminary data indicate the documentation of 151 species, classified into 15 genera. In total there are 201 intraspecific taxa (including types). Five genera, namely *Lepocinclis*, *Euglena*, *Phacus*, *Strombomonas* and *Trachelomonas* account for 89% of the species diversity observed. The remaining 10 genera are poorly presented in terms of species number, particularly with regards to osmotrophic and heterotrophic euglenoids, which remain largely unexplored within southern African water bodies. The majority of species have been recorded from dams (reservoirs), rivers, pools, vleis, and swamps in South Africa and Mozambique. Limited information exists regarding euglenoids in Botswana, Zimbabwe, and Lesotho, while those of Namibia and Eswatini

remains entirely unknown. The level of endemism within the southern African euglenoid flora is estimated at 7.5%, indicating relatively low endemism compared to other algal groups within the region. All records will be documented, providing detailed geographical and ecological information of the sampling sites.

Despite the rich biodiversity of algae in Africa, algal research in many African countries remains limited, with numerous species yet to be documented. The lack of phycologists conducting research on the continent intensifies this issue, resulting in significant gaps in our understanding of algal biodiversity on the continent. We therefore agree with the statement expressed by Karl Henrik Oppegaard Printz (1921): "With regard to algae, South Africa - as well as the entirety of this continent - remains rather incompletely known".

The potential threat assessment of phytoplankton blooms for the isoetids range in a mid-forest lobelia lake

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Gonyostomum semen (Ehr.) Diesing has been recorded in Poland since the 1980s and occurs in humic waters with various degrees of humification. It is believed that the expansion of the species is related to climate change and human impact, which are leading to disturbances in the hydrological and hydrochemical cycles of lakes. The aim of the study was to assess the threat to isoetids, the indicator species of the lobelia lakes, from phytoplankton blooms occurrence with particular emphasis on *G. semen*. Studies were carried out in the context of the limitation of photosynthetically active radiation (PAR) at the intensity that guarantees the undisturbed functioning of rooted hydrophytes.The object of the study was a drainless mid-forest lake with a small area (11.8 ha) and low maximum depth (9.6 m). The lakes waters are subject to accelerated humification due to the drainage of a drainless depression filled by a large raised bog (about 5 ha), carried out at the end of the last century. It caused disturbances in the lake's biotope (increased abundance of organic and mineral nutrients), as well as in the biocenosis, particularly concerning the depth range of isoetids. The amount of available light at the depth range of isoetids is crucial for *Isoëtes lacustris* L., which overgrows the bottom at the greatest depths. The study included analysis of phytoplankton (species composition, organisms abundance and biomass of *G. semen*) in the thermal layers of the lake from May to October 2023 and parallel measurements of the actual depth of PAR penetration using a quantum meter (LI-1400) with a spherical sensor (LI-193SA,

LI-COR Biosciences).Overall, 65 taxa from 8 phytoplankton groups were determined. The highest species diversity was represented by Chlorophyta (31 taxa, with the most abundant *Raphidocelis danubiana* (Hindák) Marvan et al.) and Chrysophyceae (10, with Chromulina sp.), and less Cyanoprokaryota (6, with *Merismopedia tenuissima* Lemm.), Bacillariophyceae (5, with *Nitzschia acicularis* var. *closterioides* Grunow), Euglenophyta (4, with *Lepocinclis acus* (O.F.Müller) B.Marin & Melkonian) and Cryptophyta (4, with *Cryptomonas erosa* Ehrenberg and *Plagioselmis nannoplanctica* (Skuja) G. Novarino et al.). From class Raphidophyceae 2 species were determined – *G. semen* and *Vacuolaria virescens* Cienk. It should be noted that flagellates were represented by a total of 23 taxa (e.g. *Chrysochromulina parva*, *C. erosa*, *L. acus*, *G. semen*). Assuming that a chlorophyll-a concentration of ≥20 μg/dm^3 indicates a phytoplankton bloom, no blooms occurred in the lake. In the case of *G. semen*, the fresh biomass concentration >1.4 mg/dm^3, is considered as a bloom. This concentration was noted in the lake during summer (July: meta- and hypolimnion, August: epilimnion) and autumn. In the light zone of the lake's waters (as the PAR concentration guaranteeing undisturbed functioning of rooted submerged plants), the share of Raphidophyceae in the total phytoplankton abundance was low in spring and summer (<1%) and higher in autumn (5%). PAR measurements indicated that the development of isoetids in spring, during the growth initiation period, was possible up to 2.4 m, deeper than they currently occur (2.0 m). Moreover, during the period of *G. semen* blooms in summer and autumn, the PAR range guaranteed the isoetids functioning at a depth of no less than 3 m.

The spatial changes of summer phytoplankton against the PAR availability in Biezdruchowskie Lake

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Studies of the composition of phytoplankton communities in eutrophic lakes in the summer are common, but not while simultaneously examining the availability of photosynthetically active radiation (PAR). In the summer period in the ecology of eutrophic lakes, the shallow subsurface layer with usually the highest concentration of phytoplankton biomass is decisive for PAR availability for phytoplankton. The aim of the study was to assess the influence of phytoplankton on light conditions, and especially the effect of a self-shading phenomenon on its vertical structure. The research object was the flow-through Biezdruchowskie Lake, located within the city boundaries of Pobiedziska (western Poland). It is a relatively small reservoir (48.8 ha) with a significant maximum and average depth (17.7 m and 5.4 m, respectively). A specific feature of the lake is the unusual flow pattern of the feeder river (Główna River), which flows only through a small bay protruding to the northwest.The research included the analysis of phytoplankton (species composition and abundance of organisms) in the lake's light layers (euphotic, disphotic and aphotic) at the peak of the summer season. In the lake, in a transect of two stations (littoral at depth 4.6 m and profundal at 17.5 m), the vertical profiles of photosynthetically active radiation (PAR) were mapped. For the solar radiation, spectral measurements were made from water samples and PAR-band (400-700 nm) in situ scalar irradiance measurements were made using a quantum meter (LI-1400) with a spherical sensor (LI-193SA, LI-COR Biosciences).

The concentrations of optically active substances (yellow substances, turbidity, suspended solids) and trophic parameters were analysed in the water.During the research, the lake was eutrophic (mean TSI 51.3), and the chlorophyll-a concentration indicated low phytoplankton bloom (20.4 µg/dm^3). The weather conditions on the sampling day were very good (cloudless and windless). The range of the euphotic zone was 3.5 m, and the disphotic zone was 1.2 m, which meant that ¾ of the depth of the water column was deprived of PAR access. The magnitude of the self-shading phenomenon is best demonstrated by the fact that the PAR penetration through the sub-surface layer with a thickness of 1.0 m (with the highest concentration of phytoplankton) was 20% of the value penetrating into the water.Overall, 24 taxa from 4 phytoplankton groups were determined. The abundance of organisms was very high, but qualitative differentiation was very low. The highest species diversity was represented by Chlorophyta (16 taxa, with the most abundant *Coleastrum microporum* Nägeli), Bacillariophyceae (4, with Fragilaria sp.) and Cyanoprokaryota (3, with *Lyngbya limnetica* Lemmermann). In the vertical profile, the dominance of cyanobacteria in the euphotic layer was noted (co-dominance of *L. limnetica* and *Planktothrix agardhii* (Gomont) Anagnostidis & Komárek 1988). In deeper water zones, the dominance structure was different: in the dysphotic zone, Chlorophyta (with *C. microporum*), dominated, and in the aphotic zone Bacillariophyceae (with *Fragilaria crotonensis* Kitton).

Application of algae to reduce toxicity of hexavalent chromium in surface waters with its conversion to non-toxic trivalent chromium

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Pollution of Ilek River with hexavalent chromium in the Aktobe industrial zone is associated with the ingress of chromium into the aquifer due to leaks of technological solutions from the territory of the chromium compounds plant, as well as the filtration of waste from sludge ponds and their further wedging out into the Ilek River. Experiments carried out on the reagent treatment of an aqueous solution of iron sulfate ($FeSO_4$) with the conversion of Cr^{6+} to Cr^{3+} showed a one-time effect. Currently, the presence of chromium (6+) in Ilek is regularly recorded. Recent experiments with a species of Gram-negative sulfate-reducing bacteria in the family Desulfovibrionacea indicate that this anaerobic sulfate-reducing bacterium is an important organism involved in the bioremediation of heavy metals in aquatic environments. Research has also established that Desulfovibrio species are capable of reducing heavy metals and represent well-studied systems for understanding the fate and transport of metals in anaerobic environments. When sulfate levels were increased in the presence of Cr(VI), cellular responses were improved, as evidenced by shorter growth lag times. The results indicate that the temperature-resource relationship significantly influences the degree of Cr(VI) toxicity, Cr(VI) reduction and subsequent cellular health through Cr(VI) influx and overall metabolic rate.

Bioactive metabolites in wild cyanobacterial biomass from the Kaunas Reservoir (Lithuania)

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Cyanobacteria produce a large number of metabolites with a wide range of bioactivities due to their unique biosynthetic capacity. These natural products are mainly derived from marine cyanobacteria, belonging to 14 genera, and they are considered to be the most promising candidates for the production of valuable compounds and advances in biotechnology. However, there are still many challenges to overcome before cyanobacteria can be used for industrial applications. One of these is that they are mainly researched using pure cultures, which are expensive to grow on an industrial scale. Therefore, this work was chosen to assess the potential for the use of wild cyanobacterial biomass collected from bloom waters in biotechnology.The composition of biologically active substances in the biomass of wild cyanobacteria harvested from the Kaunas Reservoir during the period of water bloom in 2019–2021 was analysed. The predominant genera of cyanobacteria were identified and the amounts of pigments (chlorophyll a, carotenoids, phycobiliproteins), phenolic compounds, toxins as well as antioxidant, antibacterial and antifungal activity in the collected biomass were determined. *Aphanizomenon* cyanobacteria dominated in 2019 and *Microcystis* spp. Prevailed in 2020 and 2021 in the different locations of the Kaunas Reservoir. Freeze-dried biomass had the highest chlorophyll-a and carotenoid content compared to dried biomass. The highest amounts of 10.82 mg/g and 3.26 mg/g, respectively, were found in *Aphanizomenon* biomass. Phycocyanin was the predominant cyanobacterial phycobiloprotein, accounting for 87% of the total phycobiloprotein in the biomass of *Aphanizomenon*. The maximum total phenolic compounds expressed as gallic acid equivalents (GAE) (9.26 mg GAE/g extract) were determined

in *Microcystis* dried biomass using the Folin-Ciocalteu method. The strongest antioxidant activity was evaluated by the DPPH assay reaching 3.46 mg GAE /g extract in *Aphanizomenon* extracts, and by ABTS assay, expressed as Trolox Equivalent (TE) per g extract - in 2021 m. *Microcystis* biomass extract (8.09 mg TE /g extract). All cyanobacterial biomass samples, regardless of the method used to disrupt the cells and prepare the extracts, showed antimicrobial activity against Gram+ *Staphylococcus aureus*, Gram–*Escherichia coli* and east *Candida albicans*. Minimum inhibitory concentrations against E. coli and C. albicans ranged from 250 µg/ml to 62.5 µg/ml, and against *S. aureus* from 250 µg/ml to 7.8 µg/ml. The amount and activity of biocomponents in the wild cyanobacterial biomass varied depending on the dominant cyanobacteria causing blooms in Kaunas Reservoir and the methods used to disrupt cells and prepare biomass extracts for research.

Wild cyanobacterium *Aphanizomenon flos-aquae* biomass: potential source for phycobiliproteins extraction and purification

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The proliferation of cyanobacteria in freshwaters has become a pressing concern, exacerbated by eutrophication and the resulting formation of harmful algal blooms. These blooms not only threaten aquatic ecosystems by depleting oxygen levels, blocking sunlight from reaching submerged vegetation but also pose a significant risk to human health due to the release of cyanotoxins. Despite their negative effects, cyanobacteria are also important for various industries due to their ability to produce a wide range of bioactive compounds. One of the most remarkable products derived from cyanobacteria are phycobiliproteins. These water-soluble pigments, such as phycocyanin, allophycocyanin, and phycoerythrin, offer unique properties and a diverse range of applications, from scientific research to consumer products, driving innovation across industries. One of the promising sources of phycobiliproteins can be wild cyanobacterial biomass. Cyanobacteria biomass dominated by *Aphanizomenon flos-aquae* can be a suitable candidate for the production of phycobiliprotein due to its non-toxic nature and rich biochemical composition. The aim of the study was to evaluate phycobiliproteins diversity in harvested cyanobacteria biomass dominated by *A. flos-aquae* and to assess the biomass as a potential feedstock for phycocyanin extraction and purification. The study revealed that the harvested biomass of *A. flos-aquae* was rich in phycobiliproteins, notably phycocyanin (PC) and allophycocyanin (APC), which accounted up to 7.8% of dry

biomass. The total phycobiliproteins content was similar to that in commercial *Spirulina*, highlighting the potential of *A. flos-aquae* biomass as a source of phycobiliproteins. The most important natural pigment among them is phycocyanin, which serves as a strong antioxidant and exhibits anti-inflammatory properties, making it valuable in food colouring, cosmetics, and potential therapeutic interventions. However, the extraction and purification of PC from the wild biomass is crucial to obtain the desired quality, yield and purity of PC. Various extraction and purification techniques such as freeze-thawing, ultrasonication, ultrafiltration, ammonium sulphate precipitation, gel chromatography, and ion exchange chromatography were used to purify PC. Depending on the techniques used, the PC purity, which was assessed by the absorbance ratio A620/A280, varied from 1.5 for use as a colorant in food and cosmetics to 4.1 for use in the pharmaceutical industry. The pigment obtained with different purity possessed significant antioxidant properties (more 85% of ABTS scavenging activity). This study confirms the potential of *A. flos-aquae* as a valuable source for phycocyanin extraction, which has implications for its biotechnological application.

To survive or not to survive – benthic diatoms in lowland intermittent streams?

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Extreme weather events such as droughts and flash floods can put significant pressure on aquatic communities. Small watercourses are particularly vulnerable to these extremes, and there has been a growing interest in their role in shaping communities in recent years. Reservoirs can mitigate the negative effects of changes in water levels caused by drying or flash flooding of small watercourses. We investigated the taxonomic and trait distributions of benthic diatom communities in four small lowland watercourses, two with reservoirs and two without reservoirs. The watercourses were categorized based onthe probability of receiving water (high or low) in the presence of a reservoir and the probability of drying up (high or low) in the absence of a reservoir. We hypothesised that there would be significant differences in the species- and trait-based community composition between watercourses with and without reservoirs. Significant differences in community structure between the watercourses were also expected based on the probability of the reservoirs receiving water and the probability of the watercourses drying up. Our hypotheses were only partially supported by our results: While significant differences in taxa-composition were found, the results did not indicate trait-based separation. Our study clearly demonstrated the significant impact of reservoirs on the composition of benthic diatom assemblages and the aquatic ecosystem as a whole. Our findings aid in the creation of responsible water management plans that are adapted to the predicted changes in temperature

and precipitation distribution. These plans should also comply with nature conservation regulations, such as the preservation of diversity.

The structure of freshwater diatom assemblages in the vicinity of the Antarctic research station

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Diatoms (Bacillariophyta) are one of the most abundant algal groups in Antarctic inland waters and terrestrial environments showing a high level of endemism. Numerous studies report the presence of rather species-rich Antarctic diatom assemblages controlled by several environmental parameters such as salinity, pH and nutrient content. The freshwater diatom assemblages developing in the vicinity of the Polish Antarctic *Arctowski* Station (King George Island, South Shetland Islands, Maritime Antarctic Region) have been investigated.

Both sediment samples and scrapings from submerged stones were collected from various pools and small waterbodies during Antarctic Expeditions in 1992, 1996 and 2015. Physicochemical parameters including: water temperature, pH and conductivity were measured in situ. A total of 110 diatom taxa (including 13 taxa with a marine origin), belonging to 37 genera have been observed. Among them 23 taxa, reaching ≥ 5% of share, were considered as dominants. Based on the biogeographical distribution the observed diatom flora shows an interesting mixture. The largest group (more than 50% of all observed species) consists of species with a restricted Antarctic distribution. On the other hand, taxa considered as a cosmopolitan reached 19% with an additional 10% of taxa with unknown or not confirmed distribution. Within the last group quite

numerous populations were formed by species that have not been recorded from this region so far. The obtained results were compared with previous research from the same area.

The extensive taxonomic revision of diatoms in the Antarctic Region have been conducted for over 20 years. Our observations indicate, however, that despite numerous studies, there are still areas requiring more detailed research. These include especially zones directly adjacent to research stations, which are exposed to the presence and diverse human activity affecting Antarctic ecosystems.

Benthic communities as a tool for assessing the ecological status of a flysch stream

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Benthic communities are a key element of biocenoses in flowing waters. The most important groups of benthos found in mountain streams include algae (mainly diatoms) and macroinvertebrates (e.g. aquatic insects, crustaceans, oligochaetes). In the Bieszczady Mountains, the only part of the Eastern Carpathians in Poland, the dominant abiotic type of running waters is a flysch stream. Diatoms (Bacillariophyta), developing in nutrient-poor flysch streams, are less important food source compared to allochthonous matter, reaching the stream from the ecotone zone. This matter is incorporated into aquatic food webs by macroinvertebrates, mainly shredders (functional feeding group), using coarse particulate organic matter (CPOM). The natural balance of processes taking place in the stream may be disturbed by increasing inputs of nutrients. Water pollution also applies to areas considered to have been only slightly affected by human, such as the Bieszczady Mountains. With the increasing tourist pressure in the Bieszczady National Park and its buffer zone, the problem of municipal pollution is becoming more and more important. Many tourist facilities do not have efficient sewage treatment plants. Additionally, the peak of tourist activity in the summer months coincides with low discharges. The combination of low water levels and large amounts of sewage increases the threats to aquatic biocenoses. The aim of the study was to assess the ecological status of the flysch stream, in the section downstream the effluent input from the treatment plant, based on the analysis of water physicochemical parameters as well as diatom communities and macrozoobenthos. The aquatic ecosystems of the Bieszczady Mountains are characterised by the presence of many rare or protected diatom and invertebrate species. Moreover the natural

character of the streams allows the designation of sites which may constitute a reference for many other Carpathian streams.

Toxicity of prymnesins produced by *Prymnesium parvum* from the Odra River

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Prymnesium parvum, a type of haptophyte algae, is known to be highly detrimental, often causing significant environmental and socio-economic damage when it proliferates extensively. In Poland, the first occurrence of a *P. parvum* bloom was observed in the summer of 2022, leading to severe consequences for the ecosystem of the Odra River. During the peak of this bloom in 2022, the density of *P. parvum* exceeded 600 million cells per liter. Fish mortality events were documented in both 2022 and 2023, coinciding with population densities of 20-30 million cells per liter.

LC-MS/MS analysis confirmed the production of three type-B variants of these ichthyotoxins. Variations in the PRMs profile were observed across different locations and seasons, indicating non-clonality within the population.

In order to examine the differences in toxicity among specific PRM variants, three type-B prymnesins were isolated and tested *in vitro* using a fish gill cell line.

Given the anticipated continuous presence of *P. parvum* in Polish water bodies, the insights gained regarding its dynamics, diversity, and toxicity can contribute to the development of effective strategies for managing harmful algal blooms.

Environmental variables relationship to subfossil diatoms assemblages in coastal lakes under the marine impact: examples from southern Newfoundland (Burin Peninsula)

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Coastal lakes are ecosystems frequently subjected to marine inundations, such as storm surges and tsunamis. They exhibit profundal ecological impacts both immediately after events and over longer timescales being marked within the surrounding area. Between paleo proxies, the diatoms, a microalgae presenting thousands of species, serve as an suitable indicator of the lake ecosystem due to their sensitivity to environmental factors such as salinity, tidal exposure, substrate, vegetation, pH, nutrient supply, and temperature (Dura et al., 2016). The aim of this study was to examine the relationship between the environmental factors and the subfossil diatoms community structure. The investigated area, Burin Peninsula, a southern part of Newfoundland island, Canada, whose climate is heavily influenced by the ocean, experiences marine inundations every year, with a described tsunami event in 1929 (Ruffman 1996). We examined diatoms community structure in 50 lakes, differing in surface area and distance to the sea. The following environmental characteristics were

analysed: water chemical parameters (total phosphorus, nitrogen, silica concentration, dissolved organic carbon, conductivity, pH, dissolved oxygen), and the morphometric parameters (lake depth, area, distance to the sea, geographical position). The results revealed, that the lakes are grouped into smaller, nutrient-rich and deeper, oligotrophic ones. Both surface sediment samples and lake sediment cores were most abundantly represented by small benthic representatives: *Stauroforma exiguiformis*, *Pseudostaurosira elliptica*, *Achnanthes petersenii*. The benthic and marine individuals were also found, being represented mostly by *Cocconeis scutellum*, *Navicula hanseatica*, *Navicula meniscus*. Among the environmental variables, distance to the sea turned out to influence the diatom communities the most, followed by nitrogen concentration and salinity. Among the species, *Aulacoseira canadensis*, a centric, planktonic representative, considered to be an extinct taxon was identified. The Variety of diatom community structure among the lakes was determined. Similarly to previous studies, a diatoms response to marine inundations was noticeable, but rather subtle.

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Phytoplankton community composition of urban Swarzędzkie Lake

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Swarzędzkie Lake is a shallow, flow-through lake located on the border of Poznań, west Poland. It's surface covers 93.7 ha and mean depth is 7.2 m. It has been hypertrophic lake with cyanobacterial water blooms, owing to a high load of nutrients from the main tributary, the River Cybina. The procedure of simultaneous three complementary methods of so-called sustainable restoration were held in the years 2012–2014. During this period, water quality improved and no cyanobacterial blooms were recorded. In the following years, the restoration procedure was limited to the only one method - the oxygenation of water overlying the bottom sediments using a wind-driven aerator.The main objective of the study was to analyze the phytoplankton structure in the period of 2023/2024 and comparing the results with the one noted during sustainable restoration.Phytoplankton samples were collected four times (in mid and late summer, autumn 2023 and spring 2024) from the bridge localized on south part of the lake. For quantitative and qualitative analyses, samples were collected from beneath the surface at a depth of approximately 0.50 m. Sampled material was preserved with Lugol's solution. Living material without fixation, thickened with a plankton net, was also analyzed. The counting units were single cells, colonies, and trichomes with length of 100 µm. Phytoplankton abundance was determined according to the Utermöhl method using an Olympus microscope. The biomass of algae was determined using the volumetric method.During the period of this research, intense cyanobacteria blooms were observed both in summer and autumn. The phytoplankton composition was dominated by *Pseudanabaena limnetica* (Lemmermann) Komárek, *Planktolyngbya limnetica* (Lemmermann) Komarkova-Legnerova et Cronberg,

Aphanizomenon gracile Lemmermann, *Raphidiopsis raciborskii* (Woloszynska) Aguilera, Berrendero Gómez, Kastovsky, Echenique & Salerno. In spring, diatoms such as *Ulnaria acus* (Kützing) Aboal, chrysophytes *Chrysochromulina parva* Lackey and cryptophytes *Rhodomonas lacustris* Pascher et Ruttner were the most abundant species recorded. Compared to the sustainable restoration period, the abundance and share of other taxonomic phytoplankton groups, especially chlorophytes, was significantly lower.

Biomass production, lipid accumulation and fatty acid profile of *Eustigmatos calaminaris* under phytohormone supplementation and nutrient stress

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The growth rate, carbohydrate and lipid content and fatty acid profile of unicellular algae depend on physical and chemical factors. Stress factors occurring in the environment cause changes in growth and metabolism of algal cells. Cell response to growth conditions may vary even within the same microbial strain.This study shows the effect of different nitrogen levels and the addition of indole-3-acetic acid (IAA) on biomass production, biochemical composition and fatty acid accumulation in *Eustigmatos calaminaris*.The specific growth rate was determined spectrophotometrically by measuring the optical density of algal samples. Biomass productivity and biomass yield were determined with the gravimetric method. Lipids were extracted using a modified Bligh and Dyer method. Carbohydrate content was determined using the the anthrone colorimetric method. Fatty acid methyl ester content was determined using a Trace GC Ultra chromatograph coupled with an ITQ 1100 mass spectrometer (Thermo Scientific). The results showed that supplementation of of indole-3-acetic acid under nitrogen limitation plays a role in the growth and metabolic processes of *Eustigmatos calaminaris*. The nitrogen limitation to 25% and the addition of IAA resulted in the highest growth rate, the shortest biomass doubling time as well as and the highest lipid content and daily lipid productivity of *E. calaminaris*.

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Cyanobacteria response to habitat and catchment conditions

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Cyanobacteria play a crucial role in aquatic ecosystems, yet their response to environmental factors in different habitats and catchment area conditions of small water bodies remains unclear. We investigated ponds from two types of surroundings (field vs. forest) to understand cyanobacteria distribution triggers and their habitat preferences, analysing two distinct types of habitats (open water and macrophyte-dominated zones). To evaluate the importance of the presence or absence of particular cyanobacteria species, that can be considered as indicators of certain characteristics of habitat and catchment conditions, we have evaluated the interactions of microalgae species in reference to specific environmental gradients in 53 ponds.Unlike other algae, cyanobacteria exhibit distinct reactions to varying habitat and catchment area conditions. Through comprehensive analysis, it was observed that in small water bodies, cyanobacteria distribution correlates significantly with pH levels, as well as the presence of NO3 and NH_4. Furthermore, our research highlights the preference of pond cyanobacteria for macrophyte-dominated sites over open water environments. From among dominating species there were two (*Oscillatoria splendida*, *Dolichospermum circinale*) that exclusively occurred in the open water area, while in the case of macrophytes two other species (*Oscillatoria limosa*, *Lyngbya birgei*) were only found in this habitat. Comparative studies between field ponds and forest ponds revealed noteworthy differences, with field ponds exhibiting higher cyanobacteria density and lower diversity than their the forest water bodies. Three species among dominants (*Oscillatoria limosa,*

O. sancta, Dolichospermum circinale) occurred exclusively in field ponds and seven species only in forest ponds (*Oscillatoria splendida, Lyngbya kützingii, Phormidium pavlovskoense, Phormidium mucicola, Calothrix scytonemicola, Dolichospermum mendotae, Aphanocapsa parasitica*). Additionally, filamentous forms of cyanobacteria (e.g. *Planktothrix agardhii, Aphanizomenon flos-aquae, A. gracile, Limnothrix redekei, Phormidium amphibium*) emerged as dominant, particularly within field ponds and among macrophyte habitats. The study also revealed variability in the significance of both biotic (filtrators and macrophytes) and abiotic (physicochemical parameters of water) factors influencing cyanobacterial development across different habitat types and catchment areas.These findings underscore the importance of considering both habitat characteristics and catchment area conditions in understanding and managing cyanobacteria populations within small water bodies, thereby informing effective strategies for their conservation and management. Thus, cyanobacteria may serve as efficient bioindicators due to their ability to reflect ecosystem conditions, including pollution in agricultural ponds, while also contributing to increased landscape biodiversity through their diversity in macrophyte-rich environments.

Screening for algae effective in removal of plastic additives from wastewater

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Despite successive bans on using plastic products in Europe, pollution with plastics, microplastics and their additives is still raising serious concerns. DBP (dibutyl phthalate) and DINP (diisononyl phthalate) are one of the organic chemicals commonly used as these additives. They can be found in e.g., building materials, children toys, clothes and food related accessories. Phthalates are oily liquids that easily migrate from plastics to environment, contaminating water, soil and air. Besides their harmful effect on human health, phthalates also threaten other organisms, including algae. Whereas lower molecular weight phthalates, like DBP, are toxic to aquatic organisms, higher molecular weight phthalates, e.g. DINP, are considered safe. Our research is focused on searching for algae suitable for removing of phthalates from wastewater. It includes two stages: (i) screening for algae resistant to DBP and DINP, (ii) studying accumulation and reduction of the phthalates in a few most resistant species. In our preliminary study we measured the biomass of selected green algae and diatoms isolated from secondary sewage settling tanks and cultured under laboratory conditions at a few concentrations of the phthalates up to 5 mg dm^{-3}. Additionally, we tested other indicators of phthalate impact, including population growth, cell ultrastructures and absorption spectrum of visible light in living algae.

Insights into macrophyte and algae competition: *Ceratophyllum demersum* as a source of anticancer agents

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Primary producers in aquatic environments are constantly competing for resources. The consequence in shallow lakes is existence of two main alternative states: clear-water state dominated by submerged macrophytes, and a turbid one dominated by phytoplankton. Competition between the two groups is manifested by the presence of species with high ecological plasticity capable of producing secondary metabolites that, when released into the water, may inhibit the growth of other species. This study analyzed the dominance of the macrophyte *Ceratophyllum demersum* over phytoplankton in a specific shallow subsidence reservoir (Nadrybie, E Poland) formed by coal mine activities. The study presents secondary metabolites found in *C. demersum* that limited the development of cyanobacteria, however, did not affect the development of mixotrophic flagellates. The phytoplankton community in vegetation season was composed by cryptomonads, i.e., *Plagioselmis nannoplanctica*, *Cryptomonas marssonii, Cryptomonas curvata*, and dinophytes, i.e., *Peridinium gutwinskii* and

Parvodinium inconspicuum. Phytochemical analysis of ethanolic extracts from *C. demersum* revealed a high content of phenolic compounds ca. 18.5 mg/g (mainly flavonoids), i.e. protocatechuic acid, 4-hydroxybenzoic acid, syringic acid, known as cyanobacterial inhibitors, and apigenin, apigenin-7-O-glucoside, isoquercetin including isorhamnetin, sakuranetin, taxifolin, and eriodictyol, not yet determined for this species. Such rich flavonoid content is most likely responsible for the anticancer activity of the *C. demersum* extract, which was targeted especially at neoplastic cells of gastrointestinal tract origin. The flow cytometry analysis of treated cells showed an increased percentage of late apoptotic and necrotic cells. The fish embryo toxicity test showed safety of the extract toward Danio rerio fish up to the concentration of 225 µg/ml. Studies concerning the competition between macrophytes and phytoplankton in a shallow subsidence reservoir provided to discover a new properties of secondary metabolites derived from *C. demersum* as a source of anticancer agents.

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Day to night shift – vertical changes in structure of phytoplankton communities due to light intensity in Lake Durowskie

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Ecosystems are strongly dependent on natural light-dark cycles, i.e., diurnal, annual and lunar cycles. In the age of ubiquitous electricity, it is becoming more difficult to identify a night sky unpolluted by light. The phenomenon of light pollution may carry with it changes in the biorhythm of species. It can affect dynamic processes in aquatic ecosystems, including interactions between species, leading to disruption of the entire trophic network (harmful algae blooms).Planktonic algae, thanks to their physiological abilities, respond very quickly to changes in environmental conditions. The structure of phytoplankton in any lake reflects the many physical and chemical episodes of the water. The biomass of planktonic algae changes in successive hours of the diurnal and nocturnal cycle, which makes them suitable for short-term experiments. According to previous studies, it can be noted that water temperature, light intensity and nutrient concentration are key environmental conditions that affect the vertical distribution of phytoplankton. So the following hypotheses were put forward:

1 – Artificial light induces the active movement of selected groups of algae (dinoflagellates, cryptophytes, flagellate green algae) and selected taxa towards the light or movement deeper into the water column, avoiding the light (e.g. cyanobacteria).

2 – With the source of light pollution, the proportion of flagellate taxa in the phytoplankton community structure increases.

The aim of this study was to determine the variation in the population stability structure of the dominant groups and species of microalgae in phytoplankton communities in relation to the heterogeneity of the aquatic environment (physico-chemical parameters of water, absence or intense light pollution). It was assumed that as light intensity increases, the phytoplankton biomass in the water reservoir will decrease. The study of vertical changes of the phytoplankton community in relations to the light intensity in water was carried out in two sites (artificially illuminated at night versus completely immersed in darkness) of Lake Durowskie on 6th September 2023 at 5 hours intervals. In Lake Durowskie the most frequent species with large biomass were *Coelastrum reticulatum, Cryptopmonas erosa, Oocystis lacustris, Cyclotella radiosa, Phacotus lenticularis, Ceratium hirundinella*. Preliminary research results from the field experiment were analysed in terms of the possibility of determining the groups or taxa of light-avoiding and light-following algae, including flagellates.

Short-term changes of phytoplankton assemblages after sodium percarbonate treatment in a small reservoir

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Eutrophication is an increasing problem nowadays. It is well known that high nutrient content favors the mass proliferation of cyanobacteria. In addition, higher temperatures associated with global climate change, characteristic of increasingly longer periods of the year, also lead to the formation and persistence of cyanobacterial water blooms for longer and longer periods of time. Based on the ever-expanding knowledge of the negative effects of toxic cyanobacteria on aquatic and even indirectly terrestrial communities, mitigation, regulation and, if possible, prevention of cyanobacterial water blooms are among the most urgent tasks of the future. Regardless of, or in addition to nutrient load reduction, the use of algaecides is a common method to control cyanobacterial blooms, as it offers a relatively cost-effective and quick solution to the problem. One of the most effective and cyanobacteria-selective methods is treatment with hydrogen peroxide. However, since handling of concentrated hydrogen peroxide is complicated, it may be advisable to use compounds that release hydrogen peroxide during their dissolution. Such is sodium percarbonate, which is already successfully used in practice for water disinfection purposes. In the course of our work, we treated a cyanobacterial water bloom occurred in a fire water reservoir by applying solid sodium percarbonate to reach 5 mg/l final

concentration of produced hydrogen peroxide. As a result of the treatment, conductivity, oxygen content and pH showed a slight increase, and the bicarbonate concentration also increased. The concentration of nitrogen-containing compounds released from the biomass collapsing as a result of the treatment reached the highest value on the 2nd day, the nitrogen was released as ammonium ions within a week, and the nitrite and nitrate concentrations also increased in parallel, indicating rapid nitrification processes. Similarly, the concentration of organic phosphorus compounds also reached its maximum on the 2nd day after the treatment. The total number of phytoplankton individuals decreased immediately after the treatment, the number of cyanobacteria decreased below the value measured at the start of the experiment. The number of eukaryotic algae showed a slight increase after the treatment. The regeneration of the number of cyanobacteria started already 48 hours after the treatment, however, the initial high density was not reached until the end of the first week. The diversity did not change significantly, slight increases both in total, cyanobacteria, and eukaryotic algae diversity were observed. Overall, it can be said that the sodium percarbonate required to reach a 5 mg/l hydrogen peroxide concentration caused slight water chemistry changes and effectively reduced the cyanobacterial density within a short term period. However, higher amount of the chemical, or frequently repeated treatments would be required to completely eliminate the water bloom. Based on these preliminary results, sodium percarbonate seems to be a promising treatment possibility, especially as preventive treatment before the appearance of the huge cyanobacterial biomass.

Algal biodiversity in ephemeral water pool in the cultivated field

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The temporary water bodies in agricultural fields, known as water pools (ponds), exhibit considerable variability in terms of surface area, depth, type of cultivation (winter crops, fallow), and duration of existence (fluctuation of water level). Characterized by their transient nature, these water bodies lack repeatability, as each occurrence is associated with a unique set of physical and chemical habitat factors. The main aim of the study was to determine the biodiversity of algae in a short-term (6-week) field water pool taking into account the ecological characteristics of dominant taxa.

The studied water body (N 52.75142, E 17.226226, the Wielkopolska region), with an area of 200 m^2 and a depth of 0.70 m, formed at the end of February and persisted until April 2024. Micro- and macroalgae samples were collected in the first week of its formation, at the end of the third to fourth week, and in the sixth week. Basic measurements of physicochemical water parameters were conducted each time. Samples intended for phycological analysis were collected directly from the water using a 0.5 l container without using any plankton net, then they were preserved in 4% Lugol's solution. Unpreserved samples were used for detailed taxonomic analyses.

The water pool turned out to be a reservoir with a high taxa diversity of algae (a total of 95 taxa), despite its brief existence. During the initial phase, several taxa of unicellular flagellated algae were observed, predominantly from the green algae group (*Chlamydomonas*), Haptophyta (*Chrysochromulina*) and Heterokontophyta (*Chrysococcus, Chromulina*). After 3 weeks, the algal

community encompassed not only microscopic algae (cyanobacteria, green algae, diatoms) but also numerous populations of macroscopic algae representatives (*Ulothrix, Tribonema, Cladophora*). As the water pool diminished (decrease in depth, increase in water turbidity), the proportion of diatoms in the structure of the microscopic algal community increased. An interesting aspect of the research was the formation of stable microalgal communities and the appearance of representatives from the desmid group (*Cosmarium meneghinii*, *Closterium venus*, *Euastrum binale*) within their composition.

It is not clear in this study if microalgae became dominant because of high nutrient loading form soil or lack of control of algae by grazers. Ongoing are further detailed studies on the succession of algal communities in such short-existed water bodies.

Differences and similarities in the functioning of *Cladophora glomerata* in a lake and a river

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Cladophora glomerata (L.) Kutz. is a very common freshwater alga, which grew very intensively on various substrates and plays a crucial ecological role in aquatic ecosystems. This study aimed to investigate the differences and similarities in the functioning of *Cladophora glomerata* between a lake and a river ecosystem. Field surveys were conducted in both water ecosystems (Lake Oporzynskie, Nielba River) to assess the abundance, biomass, and morphological characteristics of *Cladophora* populations. Physicochemical parameters such as nutrient concentrations, light availability, and flow dynamics were also measured to evaluate their influence on *Cladophora* growth and distribution.

Study findings reveal distinct patterns in *Cladophora* developments between the lake and river systems. In the lake environment, Cladophora exhibited higher biomass and growth rates, likely attributed to elevated nutrient concentrations and reduced flow velocities promoting filament entanglement and mat formation. Conversely, in the river ecosystem, *Cladophora* populations displayed lower biomass but higher filament lengths, indicative of adaptations to strong water currents and fluctuating nutrient availability. Moreover, comparative analyses of nutrient availability and photosynthetic efficiency suggest differential strategies employed by *Cladophora* in response to varying environmental conditions. While both habitats support *Cladophora* proliferation, their functional roles and ecological impacts differ significantly. In lakes, *Cladophora*

may contribute to eutrophication and alter water quality, whereas in rivers, it rather serves as a vital component of benthic habitats, providing habitat and food for diverse aquatic organisms.

Understanding the differences in *Cladophora* development between lake and river ecosystems is essential for effective water resource management and ecosystem conservation. This research underscores the need for tailored management strategies that account for habitat-specific factors influencing *Cladophora* rapid development and ecological consequences for ecosystem. Further investigations incorporating long-term monitoring are warranted to elucidate the complex interactions driving *Cladophora* mat formation in freshwater ecosystems.

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Diatoms biodiversity of Świna strait and Pomeranian Bay

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Diatoms (Bacillariophyta) are single-celled, photosynthetic organisms found in almost all water types. In many environments, diatoms form the basis of the food chain, are one of the major producers of atmospheric oxygen and find applications in paleoclimatic reconstructions, biomonitoring and industry.

This poster presents preliminary results of biodiversity analysis at the mouth of the Świna strait (Świnoujście, West Pomerania, Poland) in relation to seasonal variability. This area is characterized by the mixing of freshwater (Odra river), brackish waters (Pomeranian Bay) and marine waters (seasonal inflows from the North Sea) as well as a high influence of anthropogenic factors (e.g., presence of large seaports and intense ship traffic), which could potentially affect the formation of specific biocenoses in this area. Samples used for the study were collected on both sides of the Świna mouth (Uznam and Wolind islands) and were analyzed using a light microscope.

The diatom flora shows moderate species richness. The most abundant genera were *Tabularia*, *Gedaniella* and *Pseudostaurosira*. Analysis of ecological preferences, particularly salinity preferences of individual species, reflects a mixture of factors shaping the area of the Oder river estuarine system, as brackish, marine and freshwater species occurred in various proportions within diatom assemblages. Marine currents in the bay were also evident, with brackish and marine species prevailing on the western side of the Świna mouth

(Uznam Island), while freshwater species were more numerous on the eastern side (Wolin Island), reflecting the dominant direction of the water movement from west to east

Expansion potential of yellow-green alga *Heterococcus caespitosus* over building materials in the temperate climate zone

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In soil algal communities of Antarctica or other cold regions, yellow-green microalgae from *Heterococcus* genus (Xanthophyceae) can be often found. Representatives of this genus in agar cultures show very high plasticity in morphology regarding cell sizes, formation of branches with different patterns or the number of chloroplasts. In fresh environmental samples or aquatic cultures, they create unicellular coccoid biofilms that without additional molecular studies may be mistaken for other coccoid-type xanthophytes or even green algae, like *Desmococcus*.

While investigating the diversity of green biofilm colonizing walls of a newly constructed residential building in Central Poland we have isolated the coccoid yellow-green algae, which in culture had features similar to the morphological description of the *Heterococcus* genus. Molecular analysis of the 18S rRNA and rbcL markers showed a close relationship in phylogeny to *H. caespitosus* 835-9 SAG strain and confirmed the taxonomic position of the isolate PNK067.

The *H. caespitosus* PNK067 was collected from plaster surface in the spring season when the average of daily temperatures during the seven days preceding the field survey was ca. 16°C. In lab culture, it adapted well to BG-11 agar medium and grew fast at 22°C and moderate insolation of 3900 Lux.

To check whether this yellow-green alga may also develop and colonize artificial substrates in the temperate climate zone at higher temperatures than

in cold regions we transferred the strain directly to experimental substrates of building materials. After 3 months of incubation, *H. casepitosus* successfully adapted to a brick surface and formed a coccoid-type biofilm. At the plaster surface, the adaptation phase lasted a bit longer than in the previous type of substrate, but after 5 months the biofilms were equal on both types of building materials.

Laboratory ammonium treatments to suppress blooms of *Prymnesium parvum* - effects on phytoplankton community

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In summer 2022, the ichthyotoxic microalga *Prymnesium parvum* caused massive fish and other branchiate animals kills in Odra River, leading to a large-scale ecological disaster. Since then, *P. parvum* has been a permanent component of the phytoplankton community of the Odra River and some of its tributaries, posing a risk of harmful effects on the ecosystem. Hence, researchers and water managers continue to make efforts to mitigate the risk of harmful blooms by inhibiting the development of this taxa. One control measure is the addition of ammonium salts, as *P. parvum* is particularly sensitive to free ammonia. The susceptibility of algae to ammonia depends strongly on local environmental factors such as temperature, pH and salinity. In our research, ammonium sulfate (doses in the research trials: 0.5; 2.5 and 5.0 mgN NH_4^+/L) additions were tested in laboratory experiments for their ability to suppress *P. parvum* blooms (the initial abundance 60 000 × 10^3 cells/L) in prior experiment conditions: temperature 24.6°C, pH 9.26 and conductivity 1138 µS/cm. Water samples used for tests were taken from the Czernica Reservoir (an oxbow lake directly connected to the main Odra riverbed) on August 23, 2023. During 19-day experiment, the composition of phytoplankton was examined on days 1, 2, 5, 12 and 19. Ammonium resulted in the elimination of *P. parvum* after the first 24 h. The effectiveness of this process at the doses mentioned above was 18%, 98% and 99%, respectively. On the contrary, in the control group, a 67% increase in the number of this species was observed. Low abundance of *P. parvum* (approx. 130-500 × 10^3 cells/L) remained in trials with

higher concentrations of ammonium nitrogen (2.5 and 5.0 mgN NH_4^+/L) until the 12th day of the experiment. Simultaneously, an increase of the dominant cyanobacteria species *Planktothrix aghardii* was observed, especially high in the "5.0" trial, the number of its filaments increased by 86% between the first and 12th day of testing. Contrary, in the control sample, there was an 83% decrease in the density of this cyanobacteria in this time. During the experiment, the concentration of ammonium nitrogen gradually decreased, reaching at the end of the study a level that was 7% of the initial level for the "2.5" trial and 48% for the "5.0" trial, which was accompanied by a slight increase in the number of *P. parvum* cells (max. 5,133.17× 10^3 cells/L).

The research was carried out as part of the project "Scientific and research studies on the Odra River - pilot of a continuous river monitoring system" financed by National Fund for Environmental Protection and Water Management, Poland.

First report on adverse effects of cyanobacterial anabaenopeptins, aeruginosins, microginin and their mixtures with microcystin and cylindrospermopsin on aquatic plant physiology

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Cyanobacteria produce a variety of oligopeptides beyond microcystins and other metabolites. Their biological activities are not fully recognized especially to aquatic plants. Acute toxicity tests on *Spirodela polyrhiza* and *Lemna minor* exposed to a range of concentrations of different cyanobacterial metabolites: anabaenopeptins (ANA-A, ANA-B), aeruginosins 98 (Aer-A, Aer-B), microginin-FR1 (MG-FR1), microcystin-LR (MC-LR) and cylindrospermopsin (Cyl) were carried out to compare their influence on plant physiology. Effects of their binary mixtures were determined by isobole approach and calculation of the combination index (CI) that indicates a type of metabolites' interaction. Cyclic oligopeptides microcystin-LR and anabaenopeptin-A revealed the strongest inhibition of S. polyrhiza growth while other metabolites appeared less toxic. Oxygen evolution was inhibited by Cyl, MC-LR, ANA-A, ANA-B, while both variants of aeruginosins and MG-FR1 did not affect this process. Photosynthetic pigments' contents decreased in *S. polyrhiza* exposed to ANA-A and Cyl, while MC-LR and Aer-A caused their slight increase. 96 h-EC50 values showed that the growth of *L. minor* was more sensitive to MC-LR, ANA-A, MG-FR1 and Cyl than the growth of *S. polyrhiza*. In *S. polyrhiza* synergistic effects of all the binary mixtures of peptides with MC-LR on oxygen evolution were observed, while antagonistic one on the growth of S. polyrhiza exposed to the mixtures with aeruginosins and ANA-A. The mixtures of MC-LR and MG-FR1 with

cylindrospermopsin revealed synergistic effects on the growth but antagonistic one to the O_2 evolution. Quadruple mixtures (ANA-A+MC-LR+MG-FR1+Cyl) did not reveal any inhibitive effect on the plant growth and very slight on the oxygen evolution, irrespectively of their total concentrations. Various effects caused by ANA-A and ANA-B suggest the importance of molecule structures of metabolites for their toxicity. Specific composition of the mixtures of cyanobacterial metabolites was essential for the observed effects.

Response of freshwater periphytic diatoms to elevated cadmium concentrations: results of the experimental study

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The study is carried out with an understanding of the importance of biological monitoring using diatoms as bioindicators in freshwater ecosystems. Biological observation has many advantages in assessing of ecosystem quality and is considered a valuable tool for both ecological and human health care. The development and application of biological monitoring provide a better knowledge of the effects of chemical contaminants and anthropogenic pressures on living organisms, while at the same time ensuring better protection of public health and the environment. The aim of the study was to determinate the impact of cadmium on diatoms biodiversity, community structure and evaluate application of diatoms as cadmium bioindicators. Diatoms communities for the experiments were collected from River Šimša (Lithuania) after five weeks of cultivation on glass plates and transferred to experimental containers with growing media and different concentrations of cadmium. The experiment was carried out for six weeks. Diatoms species diversity was found to decrease with increasing cadmium concentration in the treatments: 85 taxa of diatoms were identified in the control without cadmium, and species richness decreased with changing cadmium concentration, from 59 species at 0.01 mg/l cadmium to 52 at 0.1 mg/l. After calculating the Shannon-Weiner Diversity Index for each sample, it was observed that the diversity index was inversely proportional (rs=-

0.584, $p<0.001$) to the concentration of cadmium. The higher concentrations of cadmium were reliably indicated by decreasing proportion of *Navicula lanceolata* (C. Agardh) Ehrenberg, *N. gregaria* Dokin and *N. rostellata* Kutzing in the treatments. Meanwhile, proportion of diatoms from *Achnanthidium* and *Fragilaria* genera increased with increasing cadmium concentration. An effect of cadmium on morphological changes of diatom frustules was also observed. The frequency of deformations of frustule and only striaes increased at higher cadmium concentrations: at 0.01 mg/l cadmium more than 8% of diatom cells become deformed, and at 0.04 mg/l – 12%. It was determined that *Navicula rostellata* was the most prone to deformation, therefore, from the bio-indicative point of view, it was the most sensitive species among studied diatoms to cadmium exposure.

Algae and environmental policy: catastrophic fishkill in the Odra River as a case of meandring water management in Poland

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Thirty years after joing European Union and adopting its environmental regulations (including implementation of the Water Framework Directive) Polish system of enviromental, water and crisis management seem to be still far from effective functioning. Water bloom caused by *Prymnesium parvum* (Haptophyta) which occured in the Odra River in summer 2022 resulted not only in the massive fishkill (~1,650 tons) and high economical loss (stilll not estimated, probably billions euro) but also focused strong media attention as well as caused a kind of political turmoil in Poland. This ecological disaster seems to brought together long lasting neglection in water management, showed the ineffective structure of environmental institutions, the incompetence of officials and decission-makers as well as the lack of preparation of the state to manage environmental crises, especially those related to the changing climate.

First record of loricated euglenoids in mountain lakes of Lori Province, Armenia

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Lori Province is a part of mid-northern Armenia bordering Georgia. It is a mountainous region. The highest point of the province is Mount Achkasar of the Javakheti range with a height of 3196 m. Lori Region has a relatively humid climate. In the middle and high regions, the climate is characterized by long and cold winters. Summers are warm and humid. The main water resource of the province is the Debed River with its tributaries Dzoraget, Pambak, and Martsaget. Lori Region is rich in natural lakes. In a study launched in 2023 in the lakes of Lori Province, the quantitative structure of phytoplankton and its diversity were determined. In Horse Liman, Clear Liman, and Urasar lakes dominated depending on the season by green algae (early summer), diatoms (early summer and summer), and cyanobacteria (autumn), many species belonging to euglenoids were determined. Among them, representatives of the genus *Trachelomonas* were the most abundant. Overall, the abundance of euglenoids was up to even 204×10^3 cells L^{-1}, and the biomass value of 2.66 mg L^{-1} in the summer period. Altogether, we found over 30 taxa belonging to the *Trachelomonas* genus. The genus was mainly represented by cosmopolitan species such as *T. hispida* and *T. intermedia*. However, less common species such as *T. compacta, T. mirabilis, T. rotunda*, or *T. sydneyensis* were also identified. *Trachelomonas acanthostoma* and *T. lemmermannii*, although not very common worldwide, were abundant in our samples.

Importantly, this is the first record of the occurrence of loricated euglenoids in this mountainous area and Armenia in general. What is additionally very interesting is that the vast majority of the loricae (envelopes) smooth on the surface that we examined for elemental composition showed high concentrations of iron ions and negligible or no concentrations of manganese. On the other hand, in loricae that were covered with spines, regardless of species, in addition to high iron content, we also found high or fairly high manganese content as the main mineralizing elements of trachelomonad lorica. The detailed elemental composition of loricae is the subject of our further research, since the lakes of Lori Province, although located in a pristine area, are under the influence of copper, molybdenum, and gold mines located in Lori Province, with the high risk of heavy metal contamination of waters and soils, as has already been proven in other studies.

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Shedding new light on the bioindicative potential of *Hildenbrandia rivularis* (Liebmann) J. Agardh 1851 (Rhodophyta)

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Recently, it was shown that *Hildenbrandia rivularis* is not an obvious bioindicator for oligotrophic and fast-flowing water ecosystems of European countries, such as Poland, Germany, France, and the United Kingdom. Currently, in Poland, this red alga is mainly correlated with eu- and hypertrophic waters of rivers, streams, and lakes instead of clean, well-oxygenated, and calcareous waters as historically described. Because *H. rivularis* is rather a weak indicator of the good ecological status of waters, however, some researchers are unaware of the change in its status, this topic needs further detailed studies. Moreover, another observed change is an expansion of this species into the lowland with the simultaneous disappearance in the mountain and upland areas. Based on the riverine population of *H. rivularis* from the Greater Poland, our project aims to carry out different *ex situ* metabolic analyses focusing on *H. rivularis* survival and resistance under different biotic and abiotic factors. Our preliminary studies (unpublished data) are in line with the proposal that the ecological status of *H. rivularis* must be revised, and this information should be urgently updated in environmental monitoring protocols.

Comparative analysis of diatom epiphytic community diversity associated with green macroalgal substrates

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Newest research conducted on water bodies in the Wielkopolska region shows the development of macroalgae from the *Cladophora* genus in water ecosystems takes place from April to October, with its optimum in the summer period. Macroalgal communities can vary in accordance to the structure of mats (dense, sparse) and their surface area (small, large). Size and durability of filamentous green algae mats can influence the development of thalli and changes in its community structure of epiphytic diatoms (quality and quantity). The aim of the study was to specify the extent of the diversification of the biotic structure of epiphytic diatoms and the size of their populations in accordance with thalli density and structure as created by *Cladophora* (*C. glomerata, C. fracta, C. rivularis*) in water ecosystems.

The study was conducted during summer 2022 and 2023 in different water bodies located in western Poland, including Lake Oporzynskie and Nielba River. Samples of macroalgal filaments were collected from the surface mats. In parallel, studies measuring basic parameters of the habitat were conducted. In study were included environmental performance of diatoms species, diversity index of Shannon-Weaver and Jaccard similarity index.

The total number of taxa identified in all samples studies was 167 diatoms, whereof on *Cladophora glomerata* was observed 102 taxa, on *Cladophora fracta* – 52 and on *Cladophora rivularis* – 74. The highest numbers of taxa were observed within the genera *Navicula, Nitzschia, Cymbella, Cyclotella* and *Gomphonema*.

Dominant taxa were, among others, *Cocconeis placentula, Achnanthidium minutissimum, Gomphonema parvulum, Amphora ovalis, Cymatopleura elliptica, Epithemia* spp., *Navicula cryptocephala*. Epiphytic communities colonizing various *Cladophora* species exhibit significant diversity; certain diatom taxa display preferences for specific substrate types. Diverse in diatom communities was observed both at the level of dominant species as well as the density of the component species.

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The spring Dwerniczek is an example of an oligotrophic ecosystem under human pressure

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Springs are ecotonal habitats that are formed by the exposure of groundwater at the Earth's surface. The uniqueness of these oligotrophic ecosystems makes them perceived as hotspots of biological diversity for many species, including diatoms. They are considered to be important ecosystems for water cycle and biodiversity conservation, but they are also considered to be globally threatened due to direct and indirect human impact. The spring Dwerniczek is located in the buffer zone of the Bieszczady National Park. It is the ecosystem that has been hydromorphological transformed by a human. Diatoms sampling was carried out from 2011 to 2023, from available microhabitats – sand (surface sediment) and mosses (bryophytes). Due to hydromorphological transformation, the epilithic (stones or rock) microhabitat was lost. A total of 153 diatom species were recorded in all samples. Number of species on the available substrates was as follows: surface sediment – 136 taxa, bryophytes – 109 taxa.Many of the diatom taxa showed preferences for certain types of substratum. In the spring Dwerniczek diversity quantified with the Shannon Diversity Index was higher for surface sediment (average from all samples = 4,01) than for bryophytes (average from all samples = 2,89). A number of species that occurred only in one microhabitat was also higher for sand (44 taxa) than for mosses (17 taxa). Bryophytes are considered to be important microhabitats for diatoms in spring ecosystems distinguished by a high species diversity and the presence of rare and even threatened species. The lower diversity and number of recorded species on mosses substratum in the spring Dwerniczek could be caused by human impact. Nevertheless, the proportion of diatom species included in the Red Lists of diatoms was higher for species that showed preferences for mosses

substrate than species connected with sand surface. Among 17 species that occurred only in mosses, 11 were included in at least one of three analyzed Red Lists of diatoms (Lange-Bertalot 1996; Siemińska et al. 2006; Hofmann et al. 2018). Examples of species that rarely occurred in Poland and are included in Red Lists are: *Eunotia kruegeri* Lange-Bertalot, *Navicula notha* Wallace and *Nitzschia alpina* Hustedt.

Fluctuations of the phytoplankton in annual cycle in the context of selected environmental factors - a case study of Lake Strzeszyńskie (Poland)

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In the pelagial of lakes, at the level of primary producers, several generations of organisms appear during the growing season. Thus, identifying the specifics of their biomass and species composition requires multiple water sampling throughout the year. The aim of this study was to assess changes in structure of phytoplankton in eutrophic Lake Strzeszyńskie (surface area 35 ha, max. depth 17.8 m) located in the Wielkopolska Lakeland (mid-western Poland) from January to December 2021. Water samples were collected from the lake surface 1-3 times per month (23 dates). Phytoplankton was analyzed under an inverted microscope after sedimentation in 14-ml chambers and the biomass was estimated from microscopic measurements. Environmental parameters were measured in situ (water temperature, pH, dissolved oxygen, conductivity) and in the laboratory (mineral forms of phosphorus and nitrogen, chlorophyll-a and total suspended solids). Phytoplankton included prokaryotic and eukaryotic cells representing eight groups of algae. Its biomass ranged between 0.211 mg l^{-1} and 4.258 mg l^{-1}. The maximum biomass was found in March and subsequent peaks occurring in late July, August and October were lower and lower. The size of total phytoplankton biomass was most influenced by diatoms, cryptophytes and green algae. In March and April, diatoms dominated (36%-81%). Their share in biomass was also high in late July and August (67% and 53%). Green algae were the most significant group in February (72%) and June (40-45%), while cryptophytes in January and May (62% and 49.3%) and October-November (44-47%). The share of cyanobacteria in the biomass exceeded 10% only three times: in early August (24.2%) and September (24%, 27%). The seasonal variation

in biomass and dominant phytoplankton taxonomic groups presented for 2021, due to the diatom biomass peak in summer and the lack of an autumn phytoplankton biomass peak, differs from the typical succession in eutrophic lakes of the temperate climate zone. A high quantitative variations in phosphorus and nitrogen forms distribution were observed. The concentration of mineral nitrogen varied from 0.466 to 1.072 mg N l^{-1} (mean 0.672 mg N l^{-1}), dissolved phosphate from 0.022 to 0.108 mg PO_4 l^{-1} (mean 0.041 mg PO_4 l^{-1}). The appearance of only few significant correlations between total phytoplankton biomass and mineral forms of nitrogen and orthophosphates supports the hypothesis that energy-related factors may be more important than nutrients in predicting phytoplankton growth. In addition, the model of phytoplankton changes emerging from our study indicates the importance of early spring for the lakes functioning, which may have implications for managing its water quality and protection.

A light and electron microscope study of *Lindavia antiqua* (Bacillariophyceae) from high arctic pond, Svalbard

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Lindavia antiqua (W. Smith) Nakov, Guillory, M.L. Julius, E.C. Theriot & A.J. Alverson, 2015, a diatom of the family Stephanodiscaceae, has been reported from near-shore habitats of lakes or pools, e.g. in Finland, Norway, Sweden, Scotland, Canada, the United States. In Poland, this species is known from reservoirs in the Tatra Mountains and has been reported as characteristic in fossil sediments mainly for late glacial lakes, especially during Dryas periods. The species can be found in the scientific literature under several names, including: *Cyclotella antiqua* W. Smith, 1853; *Orthosira antiqua* (W. Smith) Lagerstedt, 1873; *Cyclotella operculata* var. *antiqua* (W. Smith) Brun, 1880; *Cyclotella operculata* var. *antiqua* Héribaud; *Handmannia antiqua* (W. Smith) Kociolek & Khursevich, 2012. Here we present a population of the centric diatom *L. antiqua* from a small pond (surface 0.1 ha, depth 0.7 m) located on Adventdalen Valley, central Svalbard (78°12'N, 15°49'E). Water and algal samples were taken from open water in August 2023. Phytoplankton were identified by microscopic observation of specimens preserved with Lugol solution and counted under an inverted microscope after sedimentation in 14 ml chambers. The photographic documentation and measurements were made at the Department of Water Protection of Adam Mickiewicz University, Poznań using image analysis in a light microscope and at the Laboratory of Electron and Confocal Microscopy of the Faculty of Biology of the same University in a scanning electron microscope. The studied reservoir was characterized with low nutrient concentrations (total phosphorus <0.05 mg P/L, total nitrogen 0.4 mg N/L). During sampling, water temperature, pH and conductivity were:

10°C, 8.19 and 902 µS cm^{-1} respectively. *L. antiqua* was characterized by low abundance (8.6 cells/mL) and cell diameters varied between 10.1 µm and 21.2 µm. More numerous than diatoms in the phytoplankton were mixotrophic cryptophytes and chrysophytes. The density of centric diatom and its relative abundance to other groups of algae, especially pennate diatoms, may prove to be a valuable biostratigraph - an indicator of the climate changes taking place and the reconstruction of the environment.

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Impact of salinization on invasion success of bloom-forming cyanobacterium *Sphaerospermopsis aphanizomenoides*

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In recent decades, freshwater ecosystems have been increasingly affected by salinization, often resulting from anthropogenic activities such as road salt use for de-icing, fertilizers in agriculture, and mining. Freshwater salinization can induce shifts in the biodiversity of phytoplankton communities and increase their susceptibility to invasion by halotolerant species. Our research focused on the halotolerance and invasive potential of the bloom-forming cyanobacterium *Sphaerospermopsis aphanizomenoides*. Positive growth rates were recorded for the four strains of cyanobacterium in monoculture experiments across a range of salinity levels (0, 1, 2.5, 5, and

10 g/L NaCl). Subsequently, a mesocosm experiment was conducted to examine the ability of *S. aphanizomenoides* to establish in native phytoplankton community under salinity stress. Additionally, we analysed the combined effects of salinization and phosphorus enrichment on the invasion success of *S. aphanizomenoides*, recognized as a highly nutrient demanding species. Contrary to its monoculture performance, in the mesocosms experiment net development rate of *S. aphanizomenoides* was inhibited at higher salinity (5 g/L NaCl), however, the native community could sustain its biomass under all salinity levels. *S. aphanizomenoides* showed positive rates at lower salinity levels (0.2 and 1 g/L NaCl) but not in a non-saline environment, indicating better performance under mild salinity stress. Additionally, the phosphorus level had a positive effect on *S. aphanizomenoides* proliferation. These results highlight the importance of abiotic stressors in establishment of newly arrived harmful algal species within the native phytoplankton communities and underscore the ability of complex natural systems to develop a resistance to invasions.

Selection of the composition of the fertilizer and optimal factors for the cultivation of green microalgae on phosphorus-containing waste in the South of Kazakhstan

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Rational use of natural resources involves waste-free production without negative impact on the environment. Often, biotechnological methods are the most effective in solving waste disposal problems, due to the fact that they are based on the natural mechanisms of self-healing of disturbed ecosystems. The purpose of the study was to isolate and study the properties of new strains of green microalgae cultivated in residual phosphorus-containing waters, promising for the production of biofertilizers.Analysis of the taxonomic structure of phytoplankton in small rivers of the Turkestan region showed that the algocenosis of water bodies is represented by wrinkles of the departments Chlorophyta by 47.0±4.5%, Cyanophyta -27.2±2.5%, Diatomophyta -26.1±2.1%. The main widespread groups of freshwaters are Naviculaceae, Fragillariaceae, Anabaeaceae, Nitzschiaceae, Oscillatoriaceae. The widest range of character diversity for the genera *Cocconeis*, *Navicula*, *Nitzschia*, *Synedra*, *Scenedesmus*, *Tetraedron*. From samples of water from small rivers in the south of Kazakhstan, 68 isolates of green microalgae were isolated, from which 20 strains of microalgae were isolated using the method of serial dilution and screening according to the criterion of the rate of biomass accumulation. Preliminary taxonomic analysis showed that they belong to the genera *Chlorella, Botryococcus, Scenedesmus, Desmodesmus, Chlamydomonas, Oocystis*,

and *Parachlorella*. Based on the study of algal flora from natural reservoirs and wastewater in the south of Kazakhstan, strains of green microalgae *Chlorella vulgaris* ASLI-1, *Chlorella vulgaris* ASLI-2, *Oocystis borgei* ATP, capable of consuming phosphate phosphorus and ammonium nitrogen from residual waters in places of storage of solid phosphorus-containing waste, were isolated.

These studies were carried out within the framework of a grant from the Ministry of Higher Education and Science of the Republic of Kazakhstan: "Technology for the production of organic fertilizers based on the utilization of phosphorus-containing and carbon-containing waste to increase the yield of vegetable crops in the Turkestan region" (2022- 2024).

Cyanobacterial bloom extracts caused changes in the structure of the phytoplankton community from a hypertrophic, *Planktothrix*-dominated lake

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Blooms of the toxigenic cyanobacterium *Planktothrix agardhii* (Gom.) Anagn. et Kom., occurring worldwide in shallow and eutrophic waterbodies, can significantly affect freshwater biocenoses. This work aimed to study the effects of two extracts from *P. agardhii*-predominated bloom samples on the phytoplankton community of the hypertrophic *P. agardhii*-dominated Lake Syczyńskie (Eastern Poland). The tested samples (Pa-A and Pa-B) were collected in two different lakes and differed in the admixture of other cyanobacteria. Also, the composition and concentrations of MCs, other oligopeptides, and nutrients (P-PO4 and N-NO3) were different. In general, aeruginosins (AERs), cyanopeptolins (CPs), and anabaenopeptins (APs) were the most numerous peptides, but only 16% of oligopeptides were common to both extracts. The qualitative and quantitative phytoplankton composition was analyzed after a 7-day exposure to the extracts. The addition of the extracts caused a decrease in the total number of algal and cyanobacterial taxa. The share of Bacillariophyceae and Dinophyceae in the total number of taxa decreased, whereas the share of Euglenophyceae taxa increased. Exposure to rising concentrations of Pa-A extract led to a slight increase in the proportion of Zygnematophyceae and Cyanobacteria taxa. The lowest species similarity of eukaryotic taxa was recorded between the control samples (Pa-B and Pa-A)

and the highest concentration of the Pa-B extract (J = 0.25 and 0.28, respectively), whereas the highest similarity was found between control samples (J = 0.49) and between samples with the highest concentrations of extracts (J = 0.49-0.51). The extracts showed a positive effect on the proliferation of cyanobacteria and the total abundance of algae. Both extracts had a positive effect on the growth of Chrysophyceae and Euglenophyceae, and a negative influence on the Bacillariophyceae and Dinophyceae abundance decreasing with the increasing concentration of cyanobacterial metabolites. In general, the abundance of coccoid green algae (Chlorophyceae), Cryptophyceae, and Zygnematophyceae did not undergo significant alterations. The highest concentrations of extracts increased the abundance of Ulvophyceae. To summarize, exposure to both extracts elicited similar changes in the structure of phytoplankton in terms of both quantitative and qualitative aspects. The results suggest that biogenic compounds played a positive role in the development of golden algae and euglenins, while MCs and other oligopeptides may have had a detrimental effect on diatoms and dinoflagellates. The implications of our findings are significant in understanding the response of eukaryotic phytoplankton communities to cyanobacterial blooms and their metabolites.

The role of cyanobacteria in the formation of cryoconite granules - key biogenic microstructures darkening glaciers in polar regions

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The dark sediment on the glacier surface called cryoconite often aggregate into oval or irregular granules. These structures are one of the organic matter sources on glaciers and play an important role for the biogeochemical function of the glacier surface, darkening the surface ice and triggering warming of the glacial surface. They also shape the dynamic of microbial communities, sustain biodiversity hotspots and serve as refuges and feeders for microorganisms on glaciers. It has been hypothesized that cryoconite granules are formed owing the microbial activity in the cryoconite, especially those microorganisms that

produces and secret extracellular polymeric substances (EPS) which acts as a gluing agent. In this study, we tested whether Arctic filamentous cyanobacteria (three strains of *Phormidesmis priestleyi* and one strain of *Microcoleus autumnalis*) isolated directly from cryoconite sediments can be responsible for cryoconite granulation under low nutrient levels and at low temperatures reflecting cryoconite habitat. In addition, we conducted staining of the cyanobacterial strains with Alcian blue to understand whether they produce and secrete EPSs into the environment. Incubation of Greenlandic, Svalbard, and Scandinavian strains of cyanobacteria in different low-nutrient availability and substrata for strain growth (dH_2O, dH_2O with quartz powder, furnaced cryoconite without organic matter, or powdered rocks from glacial catchment) revealed binding mineral particles into granules by cyanobacteria. Forming structures in the presence of cyanobacteria during the experiment resembled those commonly observed in cryoconite holes in nature. Alcian blue staining and scanning electron microscopy imaging revealed that studied strains were able to produce EPSs. Our results are empirical evidence that EPS-producing oscillatorialean cyanobacteria, obtained from the diverse microbial communities inhabiting cryoconite on different glaciers, can form granules from mineral substrate. Moreover, the presence of mineral substrate increases the probability that these complex biogeochemical microstructures are formed on glaciers.

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Current state of art on the harmful haptophyte *Prymnesium parvum* s.l.

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Prymnesium parvum N. Carter is a protist species that can form highly toxic aquatic blooms that are deadly to fish and molluscs all over the world. Although this species was described in 1937 in a brackish pond in Bembridge, Isle of Wight, England, it is still enigmatic. According to AlgaeBase, more than 20 species of *Prymnesium* are known to science, but the one species, *Prymnesium parvum*, is considered to be the most harmful. On the other hand, recent studies of its genome show that it is not necessarily a single species, but a morphospecies with some cryptic species. *P. parvum* is a cosmopolitan species and has been found on all continents except Antarctica. Since the 1980s, the blooms of *P. parvum* has been spreading in the USA, especially in the southern and mid-south. Its blooms have been known also from Europe earlier and more recently (e.g. in Denmark in September 1938, in Finland in June 1990, in Germany in 1909 and April 1990, in the Netherlands in March 1920 and November-December 1990, in Norway in August 1989 and in Poland in August 2022).It is a euryhyaline, eurythermal species associated with brackish or saline habitats and capable of acquiring resources through both phototrophy and mixotrophy, using bacteria, other protists, fish tissue or dissolved organic matter as food sources.The aim of our presentation is to discuss the current state of knowledge about Prymnesium parvum and its ecology, because in a changing world with increasing temperatures, pollution, anthropogenic pressure and decreasing water levels, deadly *Prymnesium* blooms may become more common.

Unusual high abundant occurrence of diatom species of genus *Anomoeoneis* in Lake Van, the largest soda lake in the world

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Lake Van, located in the eastern Anatolian region of Turkey, is the world's largest soda lakes. It is notable not only for this but also for its saline water composition. Situated at an average altitude of 1648 meters above sea level, the lake has an average depth of 171 meters, with its deepest point plunging to 460 meters. The perimeter of the lake is characterized by volcanic rocks to the north and west, metamorphic rocks to the south, and predominantly sedimentary rocks to the east. his study investigates the remarkable prevalence of diatom species belonging to the genus *Anomoeoneis* in Lake Van, recognized as the largest soda lake globally. The abundance and ecological significance of these distinct diatoms within Lake Van are explored. Utilizing a combination of morphological analyses conducted through light microscopy (LM) and scanning electron microscopy (SEM), this research provides detailed insights into the structural characteristics of *Anomoeoneis* species thriving in the lake. Furthermore, molecular investigations employing specific genetic markers enhance our understanding of the taxonomic composition, phylogenetic relationships, and genetic diversity of *Anomoeoneis* diatoms in this unique ecosystem.

Use of soil macro and microelements to increase the biological values of *Chlorella vulgaris*

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Chlorella vulgaris is recommended for livestock and poultry farming as highly effective dietary supplements and feed additives. The main problem in the development of microalgae biotechnology is the high cost of heterotrophic cultivation, mainly due to the fact that the growth and density of the microalgae culture is limited by the light transmission of the medium and the cost of chemical elements for the nutrient medium.In this regard, a technology was developed for obtaining macro and microelements from soil using the electrohydraulic effect, as a result of which more than 40 chemical elements and their compounds included in these soils are transferred into water in large quantities in the form of soluble compounds. To compensate for the macronutrient deficiency of nitrogen, potassium, phosphorus and magnesium, they were introduced in the form of various salts into the soil suspension. As a result of 12-day cultivation of algae on an experimental medium, the number of *C. vulgaris* AsLi1 cells increased to 37.6 x 10^8 cells/ml, compared to cultivation on traditional Tamiya medium, where the number was 8.6 x 10^4 cells/ml. Cultivation of *Chlorella* in a medium enriched with soil microelements significantly increases the level of such valuable microelements as boron by 3 to 137%, vanadium by 79%, lithium by 142% and cobalt by 137% compared to the control. Interest in boron has increased significantly in recent years due to the

emergence of new data on the hypolipidemic, anti-inflammatory and antitumor properties of its compounds, such as aminocarboxyboranes. Regarding vanadium, it has been shown that in the human body this compound can increase the sensitivity of cells to injected insulin and this explains its potential in the treatment of diabetes. Lithium is actively used in the treatment of cancer and in dermatology. Cobalt is a coenzyme for a number of enzymes and is necessary primarily for hematopoiesis of bone marrow tissue, nervous tissue and for stimulating the formation of red blood cells. Economic calculations have shown the advantages of the electrohydraulic method of enriching the nutrient medium with necessary elements from soils due to the reduction in the cost of the obtained algae biomass. *Chlorella* suspension is recommended as a dietary supplement in preventive medicine and agro-industrial sectors.

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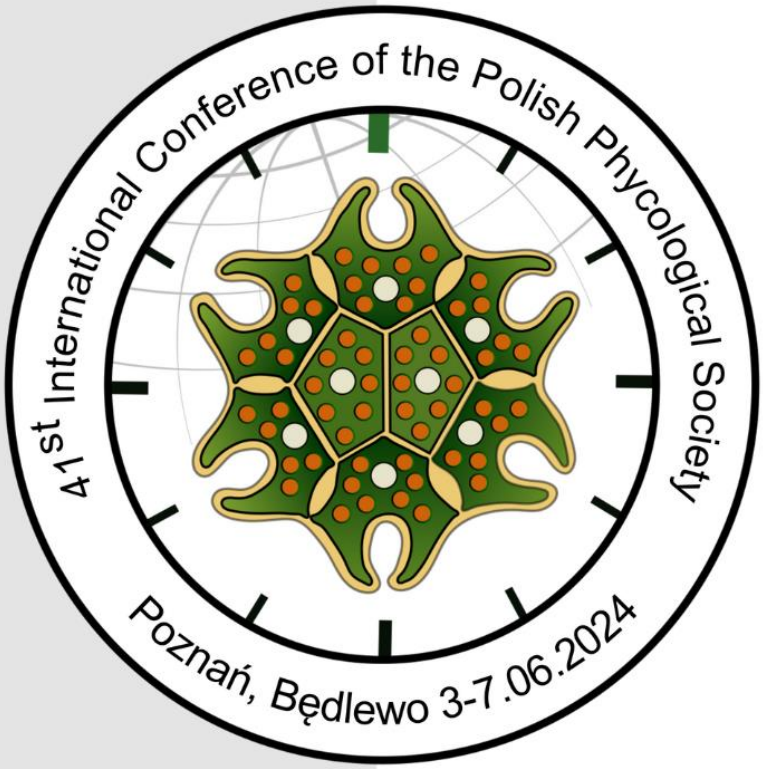
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