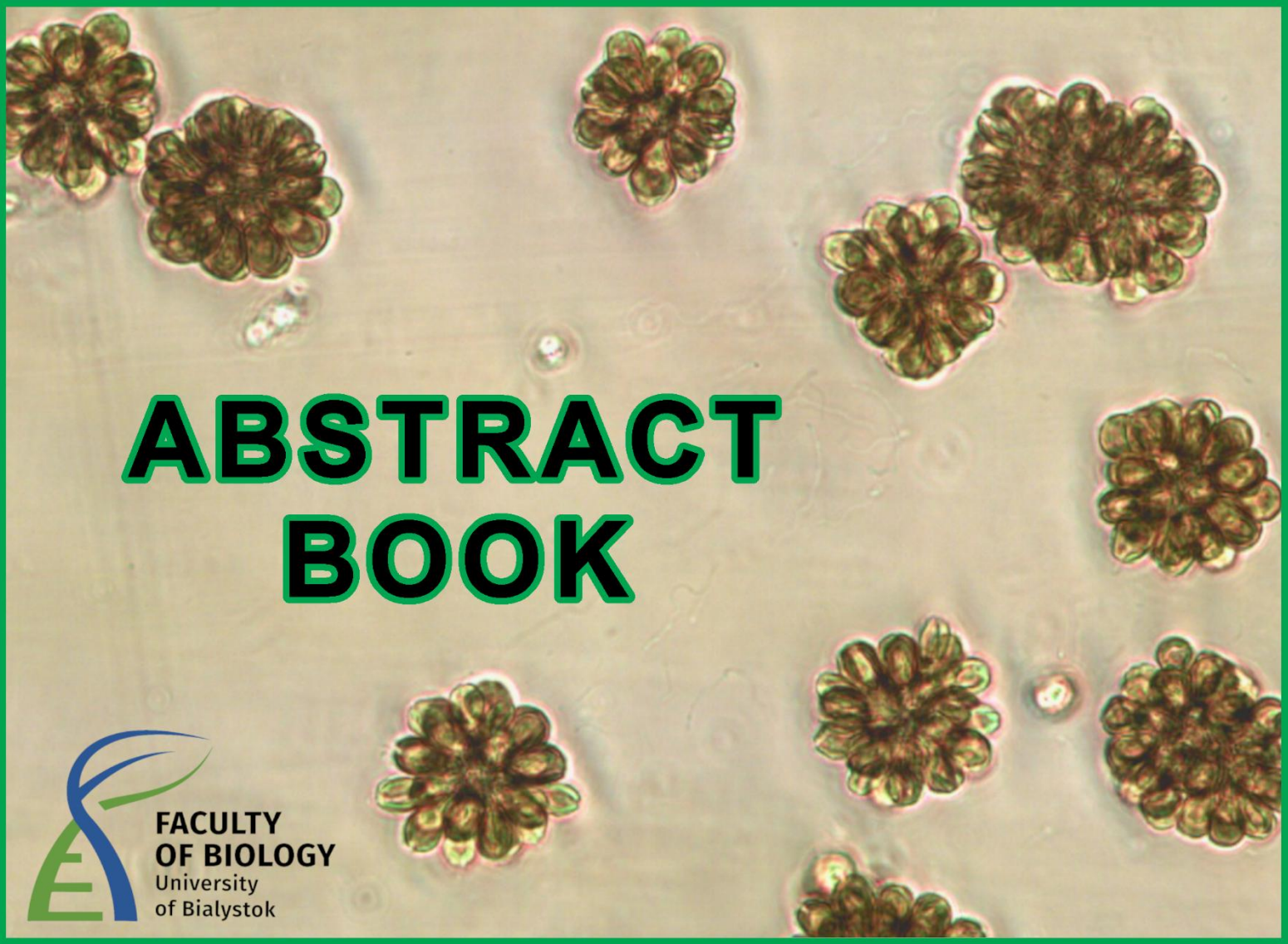
# 42nd International Conference of the Polish Phycological Society

*Vast potential of algae and cyanobacteria – – from diversity to application*



# ABSTRACT BOOK

FACULTY OF BIOLOGY
University of Bialystok

**May 27th - 30th, 2025 Bialystok - Tykocin, NE Poland**

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# 42nd International Conference of the Polish Phycological Society

## *Vast potential of algae and cyanobacteria – – from diversity to application*

May 27th -30th, 2025 in Białystok - Tykocin, NE Poland

**THE CONFERENCE WAS ORGANIZED BY**

Polish Phycological Society

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**CONTENTS:**

# PLENARY LECTURES

# The impact of *Prymnesium parvum* on the river ecosystem – insights from the ecological catastrophe on the Odra River in 2022 and beyond

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In the summer of 2022, the Odra River experienced what is probably the largest ecological disaster linked to a harmful algal bloom in inland waters. A mass die-off of fish and other gill-breathing organisms occurred due to an initially unknown cause. The losses were estimated to be around 60% of the fish population from before the disaster and between 80% and 90% of bivalves and snails. Information about other affected organisms remains limited. The direct cause of the disaster was identified as the bloom of *Prymnesium parvum,* a euryhaline haptophyte found on five continents, leading to recurrent harmful blooms in these areas. *P. parvum* produces highly potent toxins called prymnesins, which exhibit cytotoxic, hemolytic, neurotoxic, and ichthyotoxic effects on fish and other gill-breathing organisms. Recent findings indicate that they also negatively affect human cell lines. During the disaster in the Odra River, three toxin variants from the prymnesin-B group were identified.

*P. parvum* has not previously been recorded in Polish waters, let alone in blooms. Nevertheless, conditions favorable for its growth, such as elevated salinity, high nutrient content, low water levels, and slow water flow, have existed in the Odra River for decades, possibly for over a century. This raises the question of why *P. parvum* has only recently emerged, and what has caused the bloom in 2022? Following the disaster, *P. parvum* has continued to be part of the phytoplankton community in the Odra River, its tributaries, and the connected water reservoirs. Notably, this toxic alga has been predominant in the salty Gliwice Canal for the most prolonged duration.

However, studies on the occurrence of *P. parvum* in 2022, 2023, 2024, and spring 2025 do not yet allow for the identification of its occurrence pattern, dynamics, and toxicity of *P. parvum*. It is known, however, that this harmful species has invaded saline inland waters in Poland, raising concerns about the next potential massive bloom and ecological disaster. Meanwhile, various methods are being tested in laboratory and field experiments to combat the haptophyte.

# Unveiling the chemical diversity of cyanobacteria through mass spectrometry-based metabolomics

Triantafyllos Kaloudis[1,2], Sevasti-Kiriaki Zervou[2], Sofia Iliakopoulou[1,2], Angelika-Ioanna Gialleli[1], Anastasia Hiskia[2]

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Freshwater cyanobacterial blooms are increasingly recognized as a major threat to aquatic ecosystems and human health due to their production of a wide range of secondary metabolites, including potent toxins. While current guidelines and regulations focus on only a limited number of cyanotoxins, over 3,000 cyano-metabolites have been documented in the literature to date, with the majority containing at least one peptide bond. Targeted chemical analysis often fails to capture the range of this diverse chemical space, potentially overlooking compounds with significant ecological functions, ecosystem-level impacts, or health risks. Complicating this issue further is the complex composition of phytoplankton communities in environmental samples, along with the presence of anthropogenic pollutants and xenobiotics. To address these challenges, our group employs an "aquatic metabolomics" approach, using non-targeted analytical workflows that integrate high-resolution mass spectrometry (HRMS) with advanced computational tools. These workflows typically involve data-dependent acquisition (DDA), data preprocessing in MZmine, feature-based molecular networking (FBMN) in GNPS2, compound- and class-level annotations using SIRIUS and the CMMC workflow to gain insights into co-occurring microbial communities. We demonstrate the application of these workflows in analysing metabolites from cyanobacterial cultures, bloom events, and lake water samples, including investigations into cyanobacterial stress responses and the transformation pathways of cyano-metabolites, both naturally and during advanced water treatment processes. Our non-targeted workflows significantly expand the detectable and annotatable chemical space of cyano-metabolites, enabling the discovery of novel congeners within known metabolite classes. Importantly, by relying exclusively on openly accessible and free computational platforms, these workflows facilitate collaborative (including virtual) efforts and promote community-driven data sharing and exploration.

*We are grateful to the developers of the MS computational platforms and tools (MZmine, GNPS/GNPS2, Sirius, CyanoMetDB, MetFrag, Cytoscape), which are freely offered to the research community.*

# Hot stories: diversity, ecology and biogeography of thermal cyanobacteria

Jan Kaštovský, Jan Pokorný, Jeffrey R. Johansen

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Cyanobacteria from thermal springs are probably the second most studied ecological group of cyanobacteria, after the species forming the water bloom. his is primarily because, at high temperatures of approximately 70–55°C, cyanobacteria dominate as the sole group of phototrophs. As a result, ecological studies in these environments are simplified, focusing on a single group of organisms and a key limiting factor – temperature – though water chemistry also influences cyanobacterial community composition. The current temperature record holder among cyanobacteria is the genus *Thermosynechococcus*, which can sustain metabolic processes, including photosynthesis, at up to 73°C. Examples of studies in these types of habitats are numerous works in Yellowstone NP, USA.

Another reason for the abundance of research – some dating back to the 19th century – is the high attraction of these sites to humans. However, anthropogenic influences, particularly in spa localities, have led to degradation. Despite this, cyanobacteria persist in refugia here, as demonstrated in our studies of the iconic species *Mastigocladus laminosus* and *Phormidium lucidum* from Karlovy Vary, Czech Republic.

Less attention has been given to so-called warm springs, where temperatures are lower – generally around 40°C or below, though definitions vary. In these environments, diatoms and green algae coexist with cyanobacteria, yet cyanobacteria remain a crucial component of the community. Their species diversity is often surprisingly high, and many taxa appear to be previously unidentified, as our studies in Albania and Utah suggest. Thermal springs are found worldwide, and their ecological uniformity offers an ideal platform for studying not only phylogeny and species diversity but also broader biogeographic questions about microbial distribution on Earth.

# Advantages and bottlenecks in applied phycology: an example of environmental algal biomass

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Applied phycology has gained significant attention due to its potential to address global challenges such as climate change, resource scarcity, and sustainable development. Algae and cyanobacteria efficiently convert sunlight, $CO_2$, and nutrients into biomass yielding high biomass per unit area. Moreover, they produce a wide range of valuable compounds – including lipids, proteins, carbohydrates, pigments, and bioactive molecules – and can therefore contribute significantly to sustainable development across various industries (e.g., energy, health, agriculture, and environmental management). Despite substantial progress over the past decades, scaling up algal production while maintaining consistent yields, managing capital investment, and ensuring proper maintenance of cultivation systems remains a significant challenge. As a result, many algal-based products are still not cost-competitive with conventional alternatives without financial support or subsidies.

To overcome these bottlenecks, a circular economy approach can be employed by harvesting excess environmental biomass from ecosystems affected by eutrophication, where algae act as natural filters by capturing released nutrients. Implementing this solution requires the development of specialized machinery along with dewatering technologies for further biomass processing. The harvested biomass could serve as a low-cost renewable resource for bioproducts, improving the economic sustainability. However, the use of environmental biomass for bioproducts presents several limitations.

Variability in biomass composition – due to species shifts or compound variation linked to environmental factors – complicates downstream processing and compromises product consistency. Additionally, environmental biomass falls into a grey area between waste and resource, creating regulatory ambiguity as different end uses of algal biomass (e.g., food, feed, biofuels, chemicals) are governed by distinct EU regulatory frameworks. Also, ensuring the safety of bioproducts derived from harvested biomass remains a critical challenge. Many cyanobacteria produce toxic compounds, leading to strict EU regulations. Quality control is particularly difficult with wild-harvested algae, which limits the potential applications of environmental biomass.

Nonetheless, discussions on overcoming these challenges through technological advancements, integrated biorefineries, and supportive policies are both essential and timely. They are key to improving the economic viability and sustainability of algae-based bioproducts.

# ORAL PRESENTATIONS

# A critical assessment of the diatom test of rib bone marrow as a supporting procedure in the case of drowning

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Diatoms (*Bacillariophyta*), being single-celled photosynthetic organisms, are widely distributed in aquatic ecosystems around the globe. Their exoskeletons are resistant to most environmental factors as well as chemical reagents in laboratory settings. Moreover, the ornamentation featured on exoskeletons can be used to identify individual diatomaceous species. As a result, the detection of diatoms in the internal organs, and especially rib marrow, of corpses found in water can serve as an important tool for diagnosing drowning as the cause of death as long as passive postmortem penetration of diatoms into those organs is excluded.
Thus, the objective of this work is to verify the usefulness of the diatom test for the diagnosis of drowning cases with corpses devoid of soft tissue by answering the question of whether or not diatoms can passively penetrate the bone marrow of ribs remaining in water for a long time. For this purpose, experiments were conducted in which pig ribs were submerged in aquatic environments for different time intervals. The use of pig ribs was motivated by the fact that their density and mechanical parameters are the same as those of human bones, and procedures for examining animal carcasses correspond to those applied in forensic medicine.
In the environmental experiments which had been conducted, diatoms were detected in rib marrow only when contamination resulted from a mechanical breach of bone integrity and structure, irrespective of the residence time of bone material in the aquatic environment.
Our research suggests that the presence of diatoms in the rib marrow may be the gold standard in the diagnosis of drowning in the future. Our animal model research dispels one of the doubts, such as the possibility of passive penetration of diatoms into the bone marrow which is still under discussion in the forensic medicine community.

# Baltic cyanobacterium *Pseudanabaena galeata* a source of anticancer agents

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Cyanobacteria are a prolific source of bioactive metabolites. These compounds, most commonly exhibit cytotoxic, antibacterial and enzyme inhibitory activities, and some of them have already been developed into drugs. It has always been believed that tropical regions are the richest source of biotechnologically relevant organisms; however, temperate regions such as the Baltic Sea, even with limited resources, harbour microorganisms with equally promising potential. Our screening studies performed with cellular extracts from various Baltic cyanobacterial strains allowed us to select *Pseudanabaena galeata* CCNP1313 as a source of potent anticancer compounds. In the first step, of the current study, the activity of the cellular extracts from CCNP1313 against cervical (HeLa, SiHa, C33-A, CaSki), lung (A549), prostate (PC3), and breast (T47D) cancer cells was tested. Promising results encouraged us to fractionate the samples using flash chromatography, and test the fractions against the same cell lines. Activities varied between fractions, however, the effects against cancer cells were strong and dose-dependent. Chemical analyses (LCMS/MS) were also employed to characterise the contents of the fractions. Analyses revealed the presence of peptides, unfortunately, we were not able to assign the activity to any of them. This study shows that Baltic *Pseudanabaena galeata* CCNP1313 produces strong anticancer agents. However, further attempts need to be made in order to determine the active agents, and to understand the mechanisms of their action.

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# River phytoplankton and its importance in environmental assessment

Ewa A. Dembowska

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Phytoplankton plays an important role as an indicator of aquatic environmental characteristics. It is mainly used for monitoring the lake environment, although in recent decades it has won its rightful place in assessing the environment of flowing waters. A number of indicators unifying this assessment have been developed in European Union countries, including Poland. Algae in the water column of smaller rivers are more in the nature of tychoplankton, but in large slow-flowing rivers, due to the long retention time and large volume of water, they show characteristics of euplankton. The prolongation of low periods in rivers promotes the slowing down of the river current and the development of true plankton. In the present study, the phytoplankton of Poland's largest river, the Vistula, in its middle and lower reaches, as well as two medium-sized rivers, the Brda and the Pilica, and canals, the Bydgoszcz Canal and the Górnonotecki Canal, were evaluated. In the Vistula and Pilica, centric diatoms were dominant in abundance and biomass, with an increase in the proportion of chlorococcales green algae in summer. Smaller watercourses were dominated by small cryptophytes and chrysophytes, and the filamentous cyanobacteria in the spring in the canals. The presentation will show the results of water quality assessment based on indicators used to study river phytoplankton.

# No stress, no life: cyanobacterial response to stress factors; the case of *Raphidiopsis raciborskii*

Dariusz Dziga

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Cyanobacteria are recognized as organisms capable of inhabiting and dominating new ecosystems due to their high flexibility, adaptive potential, ability to acquire nutrients efficiently and production of multiple secondary metabolites. Such a unique set of features allows effective stress management and fast response to changing environment. In this presentation several advanced mechanisms of *Raphidiopsis raciborskii* plasticity and response to biotic and abiotic stress factors is discussed. The described physiological traits related to the functioning of the photosynthetic apparatus indicate that this species may adopt various strategies to cope with changing environmental conditions, particularly the accumulation of specific photoprotectants (xanthophylls), energy dissipation and operational efficiency of PSII as key processes involved in the distinct capacities for growth under variable light and temperature conditions, e.g. chill/light stress.. Thus, our findings suggest that the intraspecific physiological plasticity of genetically similar *R. raciborskii* strains may explain its ability to thrive successful expansion in diverse environments. Furthermore, the hypothesized role of toxin cylindrospermopsin in the response to chill/light has been considered. The subtle change of gene expression and toxin content might reflect a stress-related metabolic shift and redirection of metabolic resources toward increased cyanotoxin synthesis.

The presence of cyanophages that may infect or modulate the proliferative success and viability of *R. raciborskii* strains is another unique and complex process that has not been investigated comprehensively. Our findings reveal that cyanophages trigger host strain-specific responses in photosynthetic performance, population size and toxin production, even among non-permissive hosts. These non-lytic effects suggest indirect impacts on co-existing cyanobacteria, increasing the overall complexity and variance in many ecologically relevant cyanobacterial traits.

# Revision and expansion of the genus *Spirirestis* (Tolypothricaceae, Cyanobacteria)

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Recent phylogenetic analyses of members of the Tolypothrichaceae (Nostocales, Cyanobacteria) based on 16S rRNA sequence data demonstrate that the soil inhabiting members of the family belong to a clade separate from the aquatic and subaerial members of the family. The soil-inhabiting species clade includes *Spirirestis*, a monophyletic taxon originally defined by its tight spiral coiling. Most of the soil-inhabiting species have been identified in the past as belonging either to *Hassallia* or *Tolypothrix*, which are subaerial and aquatic taxa, respectively. A comprehensive study of the terrestrial Tolypothrichaceae led us to conclude that all terrestrial Tolypothrichaceae should be included in the genus *Spirirestis*, even though most of those isolates lack the spiral coiling diagnostic of the genus. Using a polyphasic approach, we recognize seven distinct clades in *Spirirestis*, which we split into seven species: *S. rafaelensis* (the generitype), *S. californica* comb. prov., *S. pseudoramosissima* comb. prov., *S. lignicolor* sp. prov., *S. williamsae* sp. prov., *S. hydroterrestris* sp. prov., and *S. atacamensis* sp. prov. *S. rafaelensis* and *S. californica* are represented by multiple isolates, and we postulate that with time and further taxon sampling some of the strains we include in these two species may be recognized as additional species. As study of soil cyanobacteria continues, additional species of *Spirirestis* will likely be discovered and described.

# Toxigenic blooms composed of *Microcystis*, *Aphanizomenon* or *Planktothrix* and related bacteria – potential ecophysiological interaction

Joanna Mankiewicz-Boczek[1], Arnoldo Font Nájera[2], Magdalena Kluska[2], Francisco Josué López Hun[1,3], Milena Skóra[4], Michał Seweryn[4], Rebecca Gorney[5], Jerome Wai Kit Kok[6], Shu Harn Te[6], Mikołaj Kokociński[7], Jennifer Graham[5], Karina Yew-Hoong Gin[6], Dominik Strapagiel[4]

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This study aimed to increase our knowledge of bacterial community diversity and its potential role influencing the development of cyanobacterial blooms of various morphotypes, including coccoidal *Microcystis* and filamentous *Aphanizomenon* or *Planktothrix*. Water bodies are in the USA (The Lake in Central Park), Poland (Raczyńskie Lake and Sulejów Reservoir), and a reservoir in Singapore. The study focused on four factors: i) cyanobacterial toxigenicity, ii) diversity of associated bacterial taxa, iii) presence of pathogenic bacteria, and iv) abundance of bacterial nutrient-cycling genes. Such elements help elucidate the potential ecophysiological roles of bacteria and the relations among cyanobacteria and their attached consortia. Blooms comprised of a mix of coccoidal, and filamentous cyanobacteria could increase the potential for cyanotoxin production, because filamentous cyanobacteria can produce several types of cyanotoxins, including hepato- and neurotoxins. Amplicon sequencing (16S rRNA gene) was used to describe bacterioplankton communities, and shotgun-metagenomics to describe cyanotoxin genes and nutrient-cycling genes involved in nitrogen (N) and phosphorus (P) transforming processes. Bacterial diversity was the highest in a water body where *Microcystis* blooms dominated. Bacterial diversity was lower when filamentous cyanobacteria dominated the blooms. Regarding cyanobacterial morphology, *Microcystis*-dominated blooms had higher diversity of attached bacteria, which was attributed to thicker and richer extracellular polysaccharide mucilages compared to filamentous cyanobacteria. *Microcystis* blooms showed high abundance of potentially pathogenic bacteria belonging to *Roseomonas*, while *Planktothrix* blooms showed strong co-dominance with the potential pathogen *Flavobacterium*. Blooms dominated by non-diazotrophic cyanobacteria (*Microcystis* or *Planktothrix*) showed higher dependencies with their attached consortia than blooms dominated by diazotrophic cyanobacteria (*Aphanizomenon*). N degradation and assimilatory genes were detected most

often in consortia associated with non-diazotrophic cyanobacteria, allowing these taxa to obtain nutrients in N-limited environments. In contrast, high abundances of N fixing genes in blooms dominated by *Aphanizomenon* suggested less dependency of diazotrophic cyanobacteria on their attached consortia. Study results highlight the importance of knowing the diversity of bacterial communities and genes associated with toxic cyanobacterial blooms and understanding potential ecophysiological interactions in diverse ecosystems worldwide.

*Research funding: NSC 2022/47/NZ8/00689 "CyMiBiom" Intercontinental comparison of bacterial and archaeal communities associated with the cosmopolitan cyanobacterium Microcystis - unveiling their ecological roles in anthropopressure and climate change.*

# Periphyton patterns in ponds: forest vs. field catchment type influence

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The catchment area conditions, whether a small water body is surrounded by field or forest, can significantly affect pond water quality and the structure of periphytic communities (in terms of both species richness and biomass). This can be an effect of nutrient enrichment as well as other abiotic and biotic interactions. We have assumed that forest-dominated ponds, despite their lower nutrient input, provide enhanced light availability and more stable substrate conditions, creating favorable environments for periphyton development.

The study, conducted on 24 field (36 sites within elodeids and helophytes) and 21 forest ponds (31 sites), showed that the type of pond catchment impacted epiphytic communities. Field ponds with significantly higher values of conductivity and trophic state parameters (TRP, NO2, NO3, hardness and trophic state index, TSI) were characterised by generally lower species diversity and biomass compared with ponds within the forest catchment. Higher periphyton occurrence in forest ponds may reflect their adaptation to low-nutrient conditions, including mutualisms with bacteria that help local nutrient recycling.

Analysis of the qualitative structure of periphytic algal communities revealed 116 taxa found exclusively in field ponds and 58 in forest ponds. In both pond types, the most numerous exclusive species belonged to green algae (43 taxa in field ponds; 22 in forest ponds), cyanobacteria (22 taxa in each), diatoms (14 in field ponds; 7 in forest ponds), and euglenids (20 and 6, respectively). Regardless of the type of pond and the analysed habitat, several species of periphyton diatoms were found with 100% frequency: *Achnanthidium minutissimum*, *Encyonema minutum*, *Gomphonella olivacea*, *Cocconeis placentula* and *Epithemia gibba*. These species of epiphytic diatoms seem to be a constant component of the qualitative and quantitative structure of the periphyton communities of ponds, irrespective of the analysed type.

Our results show that periphyton thrives in forest ponds, where clear water and stable substrates create good growth conditions, even under nutrient-poor environments. In contrast, nutrient-rich field ponds often support phytoplankton blooms, increasing turbidity and reducing light for macrophyte habitats. These findings underline the important role of catchment land use and light availability in shaping primary producer communities in small freshwater ecosystems.

# Exploring genome evolution of the green alga, *Desmodesmus*

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Genomic analysis is a technique used to discover the function of the DNA and RNA, the identity of proteins and the activity of chloroplasts and mitochondria. *Desmodesmus* has a basic biology, multicellularity, and unicellularity. Why do they change between multi-cells and uni-cells? There are not many genomic resources available (and very little information on genome content/structure/architecture/genome variation) for any microalga in the family, Scenedesmaceae, particularly *Desmodesmus*, so we intend to build on, and use, what genomic resources/data are available and undertake novel research to determine the following:
> To investigate these phenomena, we have developed a novel DNA and RNA extraction protocol utilising liquid nitrogen, and bead beating, etc.
> Which genes are dictating multicellularity vs unicellularity, and which are being differentially expressed in multi-cells/colonies? We are conducting transcriptomic analysis and RNA-seq from uni- and multi-cell colonies to identify the genes of interest.
> We have conducted whole genome sequencing (WGS) using short- and long-read technologies, and assembled complete, high-quality mitochondrial and chloroplast genomes using a hybrid assembly approach. We hope to also assemble a full nuclear genome and then conduct gene prediction and annotation of these genomes (we have already done this gene prediction and annotation for the mitochondrial and chloroplast genomes).
> Investigate how *Desmodemus* mitochondrial and chloroplast genomes differ between members of the family, Scenedesmaceae, and how microalgae have evolved, based on variation in gene content, structure, size, and arrangements.
> Conduct phylogenomic analysis using whole mitochondrial and chloroplast genomes to improve on Scenedesmaceae taxonomy and systematic resolution (to our knowledge, only individual barcoding gene phylogenetics have been undertaken to date).

# Not only lectures and laboratories: the research of the Włodzimierz Chętnicki Biological Science Club

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The Włodzimierz Chętnicki Biological Science Club at the Faculty of Biology of the University of Białystok (Poland) is an association of students who want to expand their biological passion beyond regular studies' curriculum. Since 1978 it has been an opportunity to put the theory learned during lectures and laboratories into practice already during the early years of the bachelor's degree. The Biological Science Club enables students to participate in both field and laboratory research, as well as in science popularizing events organized e.g. in schools. Currently the most prominent branches of our studies are actions devoted to ornithology, herpetology and arachnology. We were the first organization in Poland to implement the use of the protective UV-foil in order to prevent birds' collisions with glass surfaces on our University's buildings, and our projects received several grants from the Polish ECO-Bank (BOŚ). Our long-term (over 12 years) actions aimed at the active conservation of migrating amphibians were part of the LIFE Program and made a significant contribution to the construction of underpasses in the Narew National Park (NE Poland). We are also involved in research on ecology of wolf spiders (Lycosidae), which expands knowledge about habitat requirements of rare and endangered species such as *Pardosa paludicola*.

# Recent advancements in emerging physical processing technologies for sustainable algae biomass utilization

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Synergistic plasma-PEF treatment enhances algal cell disruption efficiency compared to PEF alone. Plasma-generated radicals oxidize algal membrane lipids, compromising structural integrity and enabling more effective PEF-induced electroporation. Recent work demonstrates 20-35% increases in lipid yields from *Chlorella* and *Nannochloropsis* strains using hybrid plasma-PEF pretreatment versus standalone PEF. Despite these advances, there is still a lack of research on the combined effects of plasma and PEF on microalgae and the extraction of their valuable compounds. Our study focused on *Chlorella vulgaris* microalgae, investigating the effects of the combined treatment on cell membrane permeability, wall integrity and the release of intracellular compounds. To achieve our objectives, we used sliding arc discharge plasma and PEF technologies. The plasma discharge was generated using compressed air (distance between electrode and suspension: 30 mm, exposure time: 300 s, source input voltage: 50-250 V, frequency: 270 kHz). Immediately after plasma treatment, the algae were exposed to PEF (exponential pulses: 10 µs, 1-10 pulses, repetition rate: 1 Hz, electric field strength: 25 kV/cm).

The results showed that $NO_2^-$, $NO_3^-$ and $H_2O_2$ radicals were formed in the algae suspension after plasma treatment and their concentration increased with increasing plasma voltage. In contrast, PEF treatment did not produce such effects. Plasma treatment alone caused permeabilisation of the cell membrane and changes in the cell wall only when the plasma generator was operated at voltages higher than 210 V. In contrast, PEF treatment alone increased membrane permeability in proportion to the number of pulses applied. Furthermore, the assessment of cell permeability after 24 hours showed that PEF treatment induced the release of DNA into the environment, which is one of the main signs of programmed cell death. However, the same effect was not observed in the permeabilised algal population after plasma treatment alone. The effects on algal cells observed in this study after combined plasma and PEF treatment are novel and not previously described. Therefore, additional studies are needed to fully understand the mechanisms of the combined effect before further applications can be explored.

# Autochthonous algae in post-mining waters

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Intensive exploitation of hard coal deposits often brings significant threats to the environment through the discharge of so-called drainage waters contaminated with heavy metal and chloride compounds into surface and ground waters. The first symptom of this is the decrease in the number and biodiversity of organisms inhabiting these waters. Considering the fact that algae communities are adapted to the bioaccumulation of heavy metals contained in water, search for them was started in two degraded ditches carrying post-mining waters. They both have increased values of conductivity but differ in the level of organic pollution, heavy metals and silica. It was assumed that an increase in the population size of autochthonous species would cause the settlement and development of other taxa, what would enable an increase in the gene pool of algae resources in degraded ditches and also accelerate the self-purification process.
In the studied ditches, ca. 15 taxa of algae were recognized, among them diatoms, green algae, yellow-green algae, and cyanobacteria. In order to obtain rich inoculum from the aforementioned isolates, individual aerated cultures were established. As a supplement to autochthonous species, selected *Tribonema* sp. (Xanthophyceae), *Stigeoclonium* sp. and *Scenedesmus* sp. (Chlorophyceae) allochthonous taxa known as very good bioaccumulators of heavy metals, were used. Laboratory experiments were carried out on them in the environment of two-phase media using post-mining waters as a liquid substrate and stone shales as a solid substrate being the basis of "biological starters". In parallel to the experiments, a multi parameter electronic sonde/sampler equipped with an analyzer of various photosynthetic algal pigments is being developed and constructed to study the course of development of algal communities and their diversity. The conducted observations confirmed that the fouling species (epilithic and epiphytic) have high physiological resistance to the variability of environmental conditions.

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# Legal protection of inland surface waters. A case study of an ecological disaster in the Oder River

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The study analyses the legal status of protection of inland surface waters, legal instruments of management and remedial actions in the context of ecological disaster of the Oder River. After this event, in order to improve the effectiveness of the water management and protection system, especially in the event of a natural disaster in water reservoirs, amendments to the Water Act of 2017 were necessary in the range of monitoring, control, the information system and the authorities' tasks. It was also necessary to establish appropriate procedures that would contribute to a faster response in such cases and more effective preventive and remedial measures. To remedy this, GIOŚ has established procedures for monitoring water conditions for the risk of golden algae occurrence and a system for reporting information. In addition, the list of reasons for withdrawing or restricting a water permit has been extended. The Odra River Revitalisation Act of 2023 has also been adopted, but it only deals with activities related to the development of the river and does not address the fundamental issues of the river's revitalisation. In addition, the law should clarify issues related to the conceptual framework, information system and impact analysis of investments carried out on the river. In conclusion, in order to effectively restore the Oder River ecosystem, the procedures already established by the GIOŚ, as well as the provisions of the Revitalisation Act, should be implemented and continued, but with a view to supplementing them and clarifying the above-mentioned issues.

# ORAL PRESENTATION COMPETITION

# Floristic insights into marine diatoms of the Gulf of Tomini, Indonesia

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The Indonesian seas are in the centre of the Coral Triangle. This region is known globally for its rich marine biodiversity. The Gulf of Tomini is the largest gulf in Indonesia and is located along the coast of Sulawesi Island. It covers an area of about 137,700 km$^2$. Several studies have been conducted on fish in the Gulf of Tomini. However, research on marine diatom communities is still insufficiently studied. This study aimed to investigate the biodiversity of marine diatoms observed from the Gulf of Tomini, Indonesia. Sampling was carried out in 2022 and 2023. Samples were collected from various substrates, including epiphytic microalgae, rocks, sediments, seagrass, and mangrove roots. This study listed 365 taxa representing 45 families and 89 genera, with supporting identification references and dimension measurements. However, several taxa could only be identified at the genus level. Biraphid diatoms were the most frequently encountered group during the identification process, with a total of 242 taxa recorded. Among the biraphid diatoms, the *Mastogloia* genus was the most observed, with a total of 46 taxa documented, followed by *Nitzschia* (29 taxa), *Diploneis* (23 taxa) and *Navicula* (22 taxa). The results highlight that the marine environment of the Gulf of Tomini is high biodiversity among diatoms, with a chance to find diatom species that have not been described in scientific studies.

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# Phytoplankton under pressure - the role of environmental drivers in parasitism

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Fungal parasitism is attracting growing attention in phytoplankton ecology because of its outstanding importance for aquatic food webs and energy cycling. However, relatively few studies have addressed baseline data on occurrence and environmental factors associated with chytrid parasite infections in natural ecosystems. This work provides insights into occurrence, prevalence, and dynamics of parasitic infections by studying three shallow, freshwater bodies during the growing season over a period of six years. Data were collected each year from April to October, monthly or fortnightly from a central point of each waterbody from 2019 to 2024. Chytrids were detected in each of the studied waterbodies, infecting species of green algae, diatoms, and cyanobacteria. General linear model (GLM) indicated that major factors driving the occurrence of chytrid infections were water temperature, nitrates, phosphates and pH. However, recurring and prevalent infections were observed in only one waterbody, which is classified as a natural, undisturbed aquatic ecosystem. The recorded infection prevalence (IPC) ranged between 0% and 20%, while the mean infection severity remained low throughout the study. Infections were highest in summer (June-August) and were most prominent during cyanobacterial blooms, although the most infected group of phytoplankton was green algae (*Desmodesmus* spp.). GLM revealed a significantly positive correlation between IPC and water temperature, precipitation and cyanobacterial bloom. Overall, our results demonstrate that a combination of abiotic and biotic parameters drives the occurrence of parasitic infection more than just indicated by the magnitude of the prevalence alone.

# Antioxidant, antimicrobial and cytotoxic activities of the freshwater alga *Spirogyra* sp. from Algerian Desert

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Algeria, a large African country, is characterized by a remarkable diversity of flora and fauna across various ecosystems, ranging from the Mediterranean coastline to the Sahara Desert, which occupies approximately four-fifths of the country's territory. Despite this ecological diversity, the algal diversity and their potential applications in these environments remain largely unexplored. To the best of our knowledge, there have been no studies investigating the biotechnological potential of algae from the Sahara region, either within Algeria or across Africa. In this context, the primary objective of the present study was to evaluate the antioxidant, antimicrobial, and anticancer properties of *Spirogyra* sp. isolated from the Algerian Sahara. Species of *Spirogyra* (Family Zygnemataceae), a filamentous freshwater green alga, hold considerable significance due to their various applications in agriculture, medicine, nutrition, and environmental management. The genetic analyses the algae collected from an oasis in the Sahara region demonstrated the genetic distinctiveness of the Algerian *Spirogyra* strain from other species within the genus. The extract from the alga was chromatographically separated, analyzed by LC-MS/MS and tested in antioxidant, antibacterial and anticancer assays. The results highlighted the most significant antioxidant and antibacterial potential of metabolites present in fraction F5, which included gallotannins. Additionally, potent cytotoxic effects against a panel of cancer cell lines were observed; however, the same fractions were also cytotoxic to normal human dermal fibroblast (HDF) cells. These findings enhance the understanding of *Spirogyra* diversity in North Africa and emphasize its potential as a valuable natural source of antioxidant compounds. Continued research is required to characterize the bioactive molecules responsible for these effects and to explore their potential applications across various industries.

# Ecology of free-living freshwater heterotrophic euglenoids: are there any (aut-)ecological phenomena among heterotrophic euglenoids?

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Heterotrophic (= 'colourless') euglenoids represent very diverse, common and abundant group of protists. Together with ciliates, cryptomonads and amoebae, phagotrophic euglenoids are one of the most important group of bacteria grazers in freshwater and marine environments. On the other hand, osmotrophic euglenoids are still very poorly studied and their role in nutrient cycle and ecosystem remain unknown in general. Despite abundance and importance of phagotrophic and osmotrophic euglenoids, their ecological traits and phenomena, as well as autecological features, have never been studied. This contribution presents results of our two published and two ongoing projects focusing on diversity and ecology of heterotrophic euglenoids in the Czech Republic. In conclusion, there are five main points that were figured out: 1) heterotrophic euglenoids are truly inseparable group of protists in freshwater benthic communities – they can reach the largest diversity, abundance and biomass among all heterotrophs; 2) their greatest species diversity was found in biotopes with well-developed macrovegetation; 3) the ratio of osmotrophs to phagotrophs decreases with pH and osmotrophs are the dominant group in acidic sites, sometimes massively dominant; 4) the key diversity of phagotrophs is found in polytrophic habitats, but many very interesting taxa, such as *Calycimonas*, inhabit peatbogs; 5) there is a cluster of possible bioindicators of certain types of habitats, but larger dataset is necessary.

# Diatom diversity in spring ecosystems of the Western Bieszczady Mountains

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Natural springs, untouched by human activity, provide stable thermal and chemical water conditions, as well as the availability of diverse microhabitats. As a result, they create unique and valuable ecosystems that support diatom species diversity. These habitats serve as refuges for sensitive species with high water quality requirements. Springs that remain on the far side of direct human influence or where human impact is minimized are often located within protected areas, such as national parks. Research on diatom microflora diversity was conducted in three spring ecosystems in the Western Bieszczady Mountains. Eliza Spring and the Spring at Goprowska Pass—are located directly in the Bieszczady National Park. In contrast, the spring in the village of Dwerniczek is situated in the park's buffer zone and serves as an example of an ecosystem affected by human activity. The study results present a list of taxa found in the springs of the Western Bieszczady and allow for a comparison of recorded species in each spring with reference to their recognition level in Poland. A total of 303 taxa were recorded across the three springs. Each spring was characterized by the presence of species that were only observed in one of the three springs. Furthermore, many poorly known, rare and even endangered species, according to the German Red List, were observed. Examples of species rarely recorded in Poland include *Cymbopleura austriaca* (Grun.) Krammer, *Geissleria gereckei* Cantonati & Lange-Bert., *Diatomella balfouriana* Greville, and *Neidium alpinum* Hust.

# SHORT COMMUNICATIONS

# Airborne cyanotoxins – preliminary studies on inland transport of aerosolized toxins

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Cyanobacteria synthesize a range of bioactive compounds, including a diverse array of toxic metabolites. Some of them (nodularin and microcystins) are considered to be initiators of cancer development, as well as inducers of apoptosis and necrosis in cells. Toxic cyanobacterial metabolites can be transferred from water to the atmosphere, becoming part of bioaerosols, and simultaneously posing a source of exposure for people engaging in water sports and relaxing on beaches. These studies are a continuation of research aimed at identifying cyanobacterial toxins in marine aerosols in the Gulf of Gdańsk region. During the summer of 2025, coinciding with *Nodularia spumigena* blooms, we conducted pilot studies investigating the landward transport of cyanotoxins via bioaerosols. In this study, a transect was established by placing air samplers at two locations, beginning at the beach and extending 400 meters inland. Aerosols were sampled using a microbial cascade impactor, which allows for the fractionation of samples by aerosol particle size (ø 0.65-10 μm). Chemical methods (LC-MS/MS) were used to identify and quantify toxic metabolites in both aerosol and water samples. Our research revealed the presence of cyanotoxins, nodularin and microcystins, in marine air samples collected both at the beach and at an inland site. The study also considered the impact of meteorological factors such as temperature, wind speed, wind direction, precipitation. This presentation constitutes the first report on the inland transport of airborne marine cyanotoxins in Poland.

# Cyanobacterial blooms as potential hotspots for antibiotic resistance genes – an intercontinental comparative study

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Harmful cyanobacteria blooms (HCBs) provide potential environments for the attachment of bacteria harbouring antibiotic resistance genes (ARGs); antibiotics are emerging contaminants detected in environments impacted by anthropogenic pressure. In this study, we compared the population of ARGs in HCBs dominated by different morphotypes of cyanobacteria: coccoidal *Microcystis*, and filamentous *Aphanizomenon* or *Planktothrix*. The study was conducted during 2023 in freshwater bodies located in two geographical zones: The Lake in Central Park in the USA (TL) and Raczyńskie Lake (RA) and Sulejów Reservoir (SU) in Poland (temperate zone), and a reservoir (SP) in Singapore (tropical zone). A shotgun metagenomic approach was used to predict ARG composition. Cyanobacterial communities were dominated by *Microcystis* in TL (33 %), and a mixed composition containing *Microcystis*, *Aphanizomenon* and *Snowella* in RA (23, 19 and 12 %, respectively). Blooms were dominated by *Aphanizomenon* (38 %) in SU and *Planktothrix* in SP (18 %). ARGs were detected in all systems, although abundance was relatively low compared to total bacterial 16S rRNA abundances (<0.1%). Nevertheless, ARG types of global concern were detected, including those conferring resistance to tetracyclines, beta-lactams, macrolides, aminoglycosides and multidrug resistance. Relative abundance and composition of ARGs was higher in blooms dominated by filamentous forms of cyanobacteria in SP (*Planktothrix*) and SU (*Aphanizomenon*). ARG composition decreased in freshwater bodies that had the highest toxigenic potential. Both TL and RA had high detection rates of the microcystin synthetase gene (*mcy*E), and RA also had detections of cylindrospermopsin, anatoxin and saxitoxin synthetase genes (*cyr*J, *ana*C, and *sxt*A, respectively). These observations suggest that both the cyanobacterial morphotype and toxigenic potential influence the composition of ARGs in HCBs. Our study design was repeated with samples collected during 2024 and includes two additional systems (the Daecheong Reservoir in the Republic of

Korea and the Amatitlán Lake in Guatemala). Understanding harmful compounds that can be associated with the development of HCBs is essential to revealing the potential danger of ARG hotspots in blooms dominated by different morphotypes.

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# Transfer efficiency of carbon, nutrients, and polyunsaturated fatty acids in planktonic food webs under different environmental conditions

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Trophic transfer efficiency (TTE) reflects how effectively energy and nutrients move through food webs and is a key metric of ecosystem functioning. We investigated the transfer of essential substances (carbon, nutrients, and polyunsaturated fatty acids) from phytoplankton to zooplankton in more than 30 Polish lakes with different trophic status in the middle of summer. We have found a significant mismatch between the elemental and biochemical composition of zooplankton and phytoplankton during summer stagnation, suggesting possible accumulation of certain compounds. The average TTE of C, N, P, and the polyunsaturated fatty acids were 6.55%, 9.82%, 15.82%, and 20.90%, respectively. Importantly, TTEs were highest in oligotrophic lakes and lowest in eutrophic and dystrophic systems, indicating that both eutrophication and dystrophication can disrupt energy and nutrient flow in aquatic food webs. The main cause of low TTE was the presence of filamentous and colonial cyanobacteria in eutrophic lakes, as well as large algal species such as *Gonyostomum semen* in dystrophic lakes. Nevertheless, we found that the mass development of high-nutritional algae such as *Botryococcus braunii* in dystrophic lakes could favor the intense development of omnivorous *Asplanchna priodonta*, which could feed on a wide range of particles and benefit from these high-nutritional food resources. Under these conditions, zooplankton successfully controlled phytoplankton development, which led to a switch to the effective transfer of matter and energy in the planktonic food web.

# The sensitivity of haptophytes and cyanobacteria to the application of hydrogen peroxide in riverine experiment conditions

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*Prymnesium parvum* N.Carter 1937, is a planktonic haptophyte, which during mass reproduction releases a number of metabolites into the water, causing many biological effects, including neurotoxic, cytotoxic, hepatotoxic and hemolytic effects on gill-breathed organisms. This alga has been identified as the direct cause of mass fish kills in the Odra River in 2022. This event is regarded as the most significant ecological disaster in the world resulting from a bloom of *P. parvum*. In the summer of 2024, as the *P. parvum* bloomed in the Gliwice Canal and the Dzierżno Duże Reservoir, a field experiment was conducted to prevent the influx of toxic algae into the Odra River via the Kłodnica River. This experiment took place around the Small Hydroelectric Plant in Pławniowice. Hydrogen peroxide, a compound applied to control algal blooms, particularly those caused by cyanobacteria, was used in this study. Over the course of the 22-day study, water samples were collected from six locations at least twice daily, two control sites located upstream of the hydrogen peroxide dosing area and four research sites situated downstream. *P. parvum* showed exceptional sensitivity to hydrogen peroxide compared to other algae groups. At the sites located on the river course below the dosing place, a very large decrease (over 90%) in the number of cells was observed. The presentation will illustrate the changes in the population of *P. parvum* during the experiment, as well as the impact of hydrogen peroxide on other taxa of the phytoplankton, particularly cyanobacteria.

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# SHORT COMMUNICATION COMPETITION

# Year-on-year observations of invasive cyanobacterial dynamics and water quality assessments based on the environmental parameters in post-glacial temperate lakes in Northeastern Poland

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Freshwater resources are essential for ecosystems but are increasingly impacted by natural and human-driven factors. Industrialization, especially in developing countries, has caused widespread pollution, degrading water quality. Eutrophication, primarily driven by agricultural runoff, population growth, and rising temperatures, further threatens these resources by promoting excessive algal growth. Invasive species, often spread through ballast water, human activities, and waterfowl migration, disrupt ecosystem stability. Climate change and hydrological shifts alter species distributions and affect water chemistry and temperature, accelerating the growth of harmful algal blooms. Monitoring water quality is crucial to ensuring water remains safe for drinking, irrigation, and aquatic life. Among tropical invasive species in temperate Europe, *Raphidiopsis raciborskii*, *Chrysosporum bergii*, and *Sphaerospermopsis aphanizomenoides* are major threats. *R. raciborskii* is especially concerning, as it is already highly invasive in Western Poland. This study examined their presence in the Masurian and Suwałki Lakelands, phytoplankton composition, and environmental impacts on water quality. The study was conducted across twenty-five lakes in July 2023 and fourteen lakes in August 2024, spanning a geographical gradient from central to northeastern Poland. The analyses revealed *R. raciborskii* in five lakes in 2023 and six in 2024, *C. bergii* in three lakes in 2023 and four in 2024, and *S. aphanizomenoides* in one lake in 2023 and three in 2024. Biovolume rates of these invaders showed significant differences between the two years. Alpha diversity analyses (H′, J′, and RDA), along with beta diversity analysis (Bray-Curtis index), were used to interpret the ecological data and examine the relationships between abiotic variables and invasive cyanobacterial species. Polymerase chain reaction (PCR) was performed to identify specific toxic genes based on e-DNA, and water quality analyses, including WAWQI, CPI, and TSI, assessed the trophic statuses of the lakes. In conclusion, invasive cyanobacterial species were found in several lakes in Northeastern Poland, with variations in abundance and biomass. Water quality and phytoplankton community structure differed between the two years.

# Around brassinosteroids in microalgae

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Microalgae are a diverse group of autotrophic microorganisms that play an important role in environmental sustainability and offer numerous biotechnological applications, including biofuel production and wastewater treatment. Brassinosteroids (BRs) are a class of steroidal phytohormones known to promote cell division, enhance photosynthetic activity, and increase stress resistance. As a relatively recent discovery among phytohormones, the biosynthesis pathways of BRs in microalgae remain poorly understood, and techniques for their detection and analysis are still evolving. Notably, BRs have been shown to positively influence microalgal metabolism and growth, especially under abiotic stress conditions such as salinity, heavy metal exposure, and temperature fluctuations. These findings suggest promising future application of BRs in enhancing microalgal biomass production, which could be valuable for biofuel generation, pharmaceutical development, and phycoremediation. However, further research is essential to optimize BRs concentrations for different microalgal species and to fully elucidate their biochemical effects.

# POSTERS

# The planned Lower Odra Valley National Park – what do diatoms "say" about it?

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For several years, actions have been taken to establish the first national park in Poland in almost a quarter of a century in Międzyodrze. Extensive discussions are based on two approaches – the first, assuming that because the area of the future park is of strongly anthropogenic origin, it is not so valuable in terms of nature to be covered by the highest form of protection and the second, stating that despite its anthropogenic origin, the area has been naturalized and presents very valuable natural values, predisposing it to be covered by the highest form of protection. Among the various groups of organisms that have been studied in Międzyodrze in recent years, there were diatoms, which are known for their bioindicative properties. Samples for the studies were collected in 2017, 2024 and 2025 from various types of channels – large and small, flow-through and blind-ended, and lake-type reservoirs. The identified species of diatoms were quite numerous – over 130 taxa were found, which well characterized the ecological state of the waters and reflected the nature of the habitats. What do diatoms „say" about Międzyodrze? This is an area with diverse habitats, with different ecological status of waters depending on the size of channels and flows. Diatoms typical of highly eutrophic and polluted waters, indicating bad or poor ecological status were found mainly in small and blind channels or with obstructed flow. Diatoms characterizing better environmental conditions occurred in large channels with relatively free flow and in lake-type reservoirs. Despite the dominance of the same species that occur in both arms of the Odra, in the Międzyodrze area several species from the Red List of Algae in Poland were also identified, with categories including rare and endangered. This proves the diversity of habitats offered by the area of the planned national park, which makes it a unique natural, landscape and cultural mosaic.

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# Biological activity of cyanobacterial biomass collected during blooms in Lithuanian inland waters

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Harmful blooms pose a serious threat to fresh and brackish water ecosystems as they produce toxic compounds and have other negative effects. However, in addition to harmful effects, cyanobacterial secondary metabolites, also exhibit antiviral, antibacterial, and anticancer activities, making them interesting for medical applications. The aim of this study was to assess the cytotoxic activities of bloom samples from Lithuanian inland waters. Cyanobacterial biomass was collected manually or using specialised prototypes (AS-L, AS-LAND) from Kaunas Reservoir, Lake Simnas and Lake Gineitiškės between 2019 and 2023. Species composition was assessed using an inverted microscope. *Microcystis* spp. was the predominant genus, while *Aphanizomenon flos-aquae* and *Dolichospermum* spp. also contributed to some samples. The activity of intracellular metabolites against human cancer cell lines (A549, T47D, PC3, CaSki, SiHa, HeLa, C33-A), healthy cells (HDFa) and *Oncorhynchus mykiss* gill cells (RTgill-W1) was assessed with the application of the MTT assays. The most potent effects were observed against C33-A and SiHa cells. The samples had no effect on the RTgill-W1 cells, but unfortunately, most of them hampered the proliferation of HDFa cells. However, because cellular extracts are so complex, it is possible that the observed effects can be attributed to different compounds. To gain some insight into the cyanometabolites present in the bloom material, chemical analyses (LC-MS/MS) were also employed.

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# Algae and cyanobacteria adapting to the cave habitats – green puzzles in the environmental jigsaw in the Mroźna Cave (Tatra Mountains, Poland)

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Aerophytic microorganisms colonizers of different cave (particularly in caves visited by tourists) habitats are in not sufficiently investigated and studied. The Mroźna Cave is one of the most frequently visited caves by tourists in the Polish Tatra. The data shows (number of tickets sold) that over 650 thousand tourists visited the cave between 2015 and 2020. Our research conducted in 2022, based on detailed LM and SEM microscopic observations, shows that diversity of algae (52 species) and cyanobacteria (26 species) was high in the Mroźna Cave. Green algae (27 filamentous species) were dominant in cave and were followed by diatoms (18 species) and cyanobacteria (coccoid forms prevailing). Additionally, five species of mosses such as: *Amblystegium juratzkanum* Schimp., *Cratoneuron filicinum* (Hedw.) Spruce, *Fissidens taxifolius* Hedw., *Hygrohypnum luridum* (Hedw.) Jenn., *Rhynchostegium murale* (Hedw.) Schimp. and one species of fern (*Asplenium viride* Huds.) were also found. It was observed that diatoms species were positively correlated with light intensity and sites where seeping water was present, and cyanobacteria with water content in habitat and air humidity. Higher diversity of aerophytic microorganisms was found in May and June, and lower in September. The average temperature in the cave was 5.18ºC and humidity 99.94.

# Changes in the trophic state of Lake Suchar II in Wigry National Park over the past 12 000 years – a subfossil algae proxy

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The long-term development of a humic lake Suchar II in Poland was investigated via palaeoecological analyses of age-dated sediment cores. Peat and lacustrine deposit records spanning approximately 12000 years of lake history were analysed with regard to different proxies (palynomorphs, plant macrofossils, degree of peat decomposition, Cladocera and geochemistry). Between non-pollen palynomorphs algae were recognised, as well as between plant macroremains. Our study of the palaeoecology of the humic lake suggested three primary shifts in its trophic status: from oligotrophy to mesotrophy (the first shift; Allerød-Boreal), to eutrophy (the second shift; Atlantic), and to humotrophy (the third shift; from the Subboreal to the present). During the first shift abundant charophyte oospores indicated that the lake was overgrown by charophytes and could be oligotrophic. Their presence suggests that the depth of this lake basin may have ranged from only tens of cm to more than 10 m. In this water, only *Tetraedron minimum* and algae of species *Botryococcus* occurred. The second shift – to eutrophication was indicated by high proportions of chlorophytes *Tetraedron minimum*, *Coelastrum reticulatum* and *Pediastrum*. The third shift in the trophic state of studied lake was connected with the decline in *Botrycoccus* and near total absence of the other algae. The results indicated that shifts in the trophic status occurred in response to climatic changes and factors linked to the catchment. The transformation from a clearwater lake of high trophic status to a humic lake was possible, such that the latter may originate not only from an oligotrophic lake. We determined that a humic water body may even develop due to transformation of a eutrophic lake.

# The effect of high-density polyethylene on oxidative stress and antioxidant response in two green algae *Chlorella vulgaris* and *Scenedesmus quadricauda*

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The presence of microplastics in the environment represents a significant threat to aquatic ecosystems. High-density polyethylene (HDPE) is one of the most frequently identified polymers, characterised by durability, hydrophobicity, and resistance to degradation under environmental conditions. Its ubiquity contributes to its prolonged persistence in aquatic systems, where it can interact with autotrophic organisms. Understanding the impact of such micropollutants on green algae, key primary producers in aquatic food webs, is therefore essential. The objective of the present study was to evaluate the impact of exposure to HDPE microparticles on selected physiological and biochemical parameters in two species of green algae: *Chlorella vulgaris* and *Scenedesmus quadricauda*. The analysis included the determination of cell number, lipid peroxidation (measured as malondialdehyde, MDA), hydrogen peroxide concentration, ascorbate content, antioxidant enzyme activities, and the levels of photosynthetic pigments. Exposure to microplastics led to oxidative stress, as indicated by increased hydrogen peroxide levels and enhanced lipid peroxidation. This was accompanied by elevated antioxidant enzyme activity, changes in ascorbate content, and alterations in pigment composition. The results indicate that HDPE microplastics have a negative impact on algal physiology, inducing oxidative stress and triggering antioxidant responses. The observed biochemical shifts reflect a cellular reaction to microplastic-related environmental stress. The research was conducted as part of the OPUS grant no. 2023/51/B/ST10/00157, entitled "Evaluation of the usefulness of advanced oxidation methods (AOP) and phytoremediation for removal of microplastics from waters”.

# Algal diversity in urban water bodies of Uzbekistan as an ecological status indicator

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Biodiversity in aquatic ecosystems plays a crucial role in maintaining their stability, functionality, and resilience. A diverse biological structure enhances resistance to environmental disturbances, supports nutrient cycling, and improves water quality. Algae, as primary producers, are especially important due to their sensitivity to environmental changes and foundational role in the aquatic food web. The diversity of algae in urban ponds of Uzbekistan serves as an important indicator of the ecological status of these aquatic ecosystems and reflects the impact of anthropogenic activities on the environment. This study presents a review and analysis of the taxonomic composition and structure of phytoplankton in selected urban ponds in Tashkent, Samarkand, and Bukhara from the spring period of 2025.

In the ponds of the Bukhara region, 54 species of diatoms, 31 species of green algae, and 15 species of cyanobacteria were identified, with dominance of Planktolyngbya and Leptolyngbya among cyanobacteria and Fragilaria, Navicula, Nitzschia among diatoms. In the ponds of the Samarkand and Taskhent region, 116 and 99 species of algae were identified, respectively, indicating high algal biodiversity in these water bodies. Representatives of major algal groups were identified, including green algae (Chlorophyta), diatoms (Bacillariophyta), and cyanobacteria (Cyanophyta), with the dominance of specific species often correlating with levels of pollution and eutrophication. The results indicate that urban water bodies are exposed to significant fluctuations in physicochemical conditions, which influence the variation in algal community composition. The collected data can support the development of strategies for water quality monitoring and biodiversity conservation in urbanized environments. The findings highlight the need for sustainable water resource management in the context of Uzbekistan's town rapid urbanization.

# Influence of temperature and pH on the stability of food-grade phycocyanin extracted from wild cyanobacteria *Aphanizomenon flos-aquae* biomass

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Cyanobacteria are unique microorganisms capable of producing a variety of biologically active compounds, including phycobiliproteins such as phycocyanin. This water-soluble protein complex is highly valued for its antioxidant, anti-inflammatory, anti-cancer, and other properties. Due to its bioactive characteristics, phycocyanin offers unique properties that have applications in various fields, such as the food, pharmaceutical and cosmetic industries, where it is used as a natural colorant and additive. The extraction of phycocyanin is mainly focused on cultivated cyanobacteria, while wild freshwater cyanobacteria biomass remains an under-explored source for the sustainable production of bioactive compounds. One of the promising sources of phycobiliproteins is the wild harvested cyanobacterial biomass dominated by *Aphanizomenon flos-aquae* which stands out as a candidate for phycocyanin production due to its non-toxic nature, abundance, easy of biomass collection, rich biochemical composition, and sustainability. This study investigated the stability of food-grade phycocyanin (purity of 1.56) extracted from harvested cyanobacteria biomass dominated by *Aphanizomenon flos-aquae* from the fish ponds of Simnas (Lithuania) under different temperature and pH conditions. The effect of temperatures between 25°C and 80°C (in 5 °C intervals) and pH values between 5 and 8 (in 0.5-unit intervals) at different time points (1, 5, 10, 20 and 30 minutes) were analysed. Phycocyanin stability was assessed based on pigment degradation patterns: degradation rate constant, pigment concentration, and purity index by absorption ratio $A_{620}/A_{280}$. The data showed that temperature and pH have an important influence on the stability of phycocyanin. The highest stability was observed at temperatures between 25°C and 45°C and at a pH between 6.5 and 7.0, where the phycocyanin maintained its purity and concentration. These results demonstrate the thermostability of phycocyanin extracted from the wild biomass of *A. flos-aquae* and suggest that it could serve as a promising alternative to natural blue colorant.

# Accumulation potential of phycobiliproteins in bloom-forming cyanobacteria: effects of temperature and light intensity

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Cyanobacteria are highly diverse and widely distributed photosynthetic prokaryotic organisms that serve as valuable natural resources in biotechnology due to their ability to produce a wide range of biologically active compounds. They synthesize pigments, peptides, polysaccharides, fatty acids and other metabolites, making them important for biotechnological applications in numerous fields. Their unique pigments, phycobiliproteins, are particularly valuable due to their antioxidant, anti-cancer, and anti-inflammatory properties and are of increasing industrial interest in the food, cosmetics and pharmaceutical industries.

The aim of the study was to investigate the diversity and accumulation of phycobiliproteins in six bloom-forming cyanobacterial species (*Sphaerospermopsis aphanizomenoides, Aphanizomenon gracile, Microcystis aeruginosa, M. wesenbergii, Planktothrix agardhii, P. rubescens*) and to assess their potential for phycobiliprotein storage under different temperature and light intensity conditions. Of all phycobiliproteins, phycocyanin and allophycocyanin were dominant in all tested cyanobacterial strains. *S. aphanizomenoides* and *A. gracile* had the highest content of phycocyanin and allophycocyanin, while *P. rubescens* was the richest in phycoerythrin. The synthesis of phycocyanin was influenced by both temperature and light intensity, while the production of allophycocyanin and phycoerythrin was only affected by illumination. The effect of these factors on phycobiliprotein production varied between strains, indicating a strain-dependent response. The results demonstrate the influence of environmental conditions on phycobiliprotein production and suggest that strain-specific responses should be considered when optimizing cyanobacterial cultivation for biotechnological applications.

# Mechanical/physical disruption of *Microcystis* cell wall for biocomponent extraction

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Due to the eutrophication of water bodies, cyanobacteria proliferate rapidly in aquatic ecosystems worldwide, leading to water blooms. Harvested cyanobacteria during bloom periods are an attractive natural source of specialized metabolites with diverse bioactivities. This research aimed to investigate the yields of specific biocomponents in the natural biomass of *Microcystis* collected from Kaunas Reservoir, Lithuania, depending on the method of cell wall disruption. Mechanical-physical methods, including ultrasonication and homogenization using two types of beads of various diameters, were applied to disrupt lyophilized and dried *Microcystis* biomass. These methods involved exposure to 4 and 8 cycles of 30 seconds each. Different solvents were used to extract the desired biomaterials. In lyophilized *Microcystis* biomass processed via ultrasonication and homogenization, chlorophyll *a* (maximum value: 11.09 ± 1.46 mg/g) and phycobiliproteins (maximum value: 44.4 mg/g) were found at concentrations up to three times higher than in dried biomass. In contrast, carotenoids were up to four times higher (2.17 ± 0.11 mg/g) in dried cyanobacterial biomass. The carbohydrate content was also higher in freeze-dried *Microcystis* biomass compared to dried biomass, measuring 28.13 ± 0.84 mg/g and 20.94 ± 0.80 mg/g, respectively. Additionally, extracts from dried biomass subjected to ultrasonication and homogenization contained up to eight times higher levels of phenolic compounds (maximum value: 83.86 ± 17.8 GRE μg/g) and up to 1.5 times higher levels of protein (maximum value: 318.6 ± 9.6 mg/g) compared to freeze-dried biomass samples. The results indicate that the yield of biocomponents in natural cyanobacterial biomass is influenced by the biomass preparation method, the cell disruption technique, the number of homogenization cycles, and the diameter of the zirconium-silica and metal beads used for cell wall disruption.

# Diversity changes in the phytoplankton composition in the final part of the Cybina River

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Cybina is a small 41-km long river, flowing within the borders of the Wielkopolska voivodeship. The area of the waters feeding Cybina covers an area of about 200 km² and is mostly agricultural land. The aim of the study is to compare the taxonomic composition of the phytoplankton of the Cybina River from 2 research sites, i.e. above the dam site and below the dam site located at the final section of the river. As a result of damming the river, a reservoir was created, which serves recreational and sports functions and is regularly restored. Water samples were analysed from spring to winter 2024, the specific floristic composition and phytoplankton abundance were determined, as well as the impact of the reservoir/dam on the taxonomic diversity of algae. Shannon-Wiener diversity index (H') was analysed. Samples for the phycological analyses were taken three times: in spring, summer and autumn, and once in winter, from above the dam site and below the dam site. In the analysed period, 189 phytoplankton taxa were recorded, of which 166 at the upstream site and 144 at the downstream site. At both sites, the highest number of taxa were chlorophyceae (45% upstream site and 38% downstream site). Nearly 65% of the taxa were common to both sites, 24% of all identified taxa were found only at the upstream site, and nearly 12% of the taxa were found only at the downstream site. Among exclusively noted species, the highest share in the upstream site was recorded by green algae (14% of all taxa), while in the downstream by Bacillariophyceae (4%). Shannon-Wiener diversity index varied from 1.55 to 3.65, while the average value was higher in the upstream site. Phytoplankton abundance varied from $3.1 \times 10^6$ ind./ml to $1.95 \times 10^7$ ind./ml and was on average lower downstream site ($1.03 \times 10^7$ ind./ml). compared to the upstream site density ($1.22 \times 10^7$ ind./ml). The reservoir created because of damming river water and restoration procedures have a significant impact on the taxonomic composition diversity and abundance of phytoplankton.

# Evaluation of the influence of bacterial exopolymers on microalgal cells

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Microalgae and bacteria coexist in natural environments and industrial processes. Microalgal-bacterial interactions influence the physiological and metabolic processes of both organisms. These interactions also affect the ecological functions of these consortia and the diversity of microorganisms. Interactions between microalgae and bacteria stimulate the secretion of extracellular polymeric substances (EPS). Extracellular polymeric substances are mainly composed of polysaccharides, proteins, nucleic acids, and lipids. Studies show that the composition of extracellular polymeric substances seems to be the basis for the specific interactions among bacterial and algal cells.

The aim of the study was to determine the effect of the presence of bacterial exopolymers in the culture medium on the growth processes and metabolite accumulation of unicellular green algae. Microalgal cells were grown in batch culture. Microalgal growth was measured by measuring changes in optical density using UV/vis spectrophotometry. The protein content was quantified with the Bratford method. Carbohydrate accumulation in the biomass was determined colorimetrically using the anthrone method. Chlorophyll content was measured spectrophotometrically. The lipid content was determined using a modified Bligh and Dyer method. The results showed that supplementation of bacterial extracellular polymeric substances supported the growth rate and biomass productivity of microalgal cells. The presence of the bacterial exopolymer in the culture medium induced changes in the chlorophyll, carbohydrate, protein and lipid contents of the green microalgae studied.

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# Effects of water colour on phytoplankton diversity and biomass in boreal lakes

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Many factors influence the phytoplankton community in the aquatic environment. These include biological factors such as competition from aquatic macrophytes, grazing by zooplankton, but also changes in abiotic factors such as water temperature, light availability, and nutrient content. One important abiotic factor is water browning, which has been observed in many European lakes. This process is related to the increased loading of dissolved organic carbon to the waters, which is caused by climate change influencing increased air temperatures, precipitation and intense run-off from catchments. Brownification has a significant impact on phytoplankton, by diminishing the penetration of irradiance into the water column, thus decreasing the thickness of the productive layer. Brownification also affects the spectral composition of light in water, which influences the content of photosynthetic pigments, chlorophyll *a* and *b* in the phytoplankton cells. In our study, we investigated the variability of the phytoplankton community expressed by its biomass, chlorophyll *a* and *b* content in lakes of southern Finland. The study was conducted in 2024 in eight lakes along a gradient of water colour intensity, from 22.3 to 319.2 mg Pt $L^{-1}$. Water colour was shown to have a significant effect on the absorption of different parts of the light spectrum, with the highest attenuation of short-wavelength blue light and the weakest attenuation of long-wavelength red light, which affected the phytoplankton community. On the basis of the results obtained, the existence of a unimodal response of phytoplankton to water browning was showed. The highest values of cyanobacteria, diatoms and total phytoplankton biomass, species richness and diversity, as well as, chlorophyll *a* concentration and chlorophyll *a*:*b* ratio were recorded in lakes with medium colour, while the lowest values were recorded in lakes with low and high water colour. However, there were phytoplankton groups whose biomass increased, i.e. Cryptophyceae or decreased, i.e. Raphidophyceae with increasing water colour. Our results suggested that phytoplankton content of chlorophyll *b* and ratio of chlorophyll *b*:biomass, is elevated with increasing water colour that it could be considered as potential phytoplankton-based indicator of lake browning.

# Anticancer potential of two Baltic filamentous cyanobacteria – *Limnoraphis* sp. CCNP1424 and *Spirulina subsalsa* CCNP1310

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Cyanobacteria, are the oldest photosynthesising organisms on Earth, and during their long history, they developed effective mechanisms of metabolic adaptation, which allowed them to survive in even the most unfavourable conditions. As a consequence of their evolution, cyanobacteria, synthesise a wide array of bioactive secondary metabolites. Primarily, the scientific community focused on the toxic properties of cyanometabolites, and their harmful effects on humans and the environment. However, compounds produced by cyanobacteria also exhibit antiviral, antibacterial, and cytotoxic activities, making cyanometabolites promising drug candidates. In our study, the activity of metabolites produced by two Baltic cyanobactera, *Limnoraphis* sp. CCNP1324, and *Spirulina subsalsa* CCNP1310, was explored. The strains were grown for biomass in culture, and harvested at the exponential phase of growth. Intracellular metabolites were extracted, and separated using solid phase extraction (SPE). The activity of the fractions was tested against cancer cell lines (A549, T47D, PC3, CaSki, SiHa, HeLa, C33-A) and healthy cells (HDFa). In the MTT assays, selective, dose-dependent antiproliferative activity of the samples was observed. Furthermore, LC-MS/MS analyses of the samples revealed the presence of peptides in the active fractions. The obtained results show that both, *Limnoraphis* sp. CCNP1324, and *Spirulina subsalsa* CCNP1310 have biotechnological potential, however, further studies are needed to identify the active agents.

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# Ecological shifts in algal communities following *Cladophora glomerata* biomass removal in an eutrophic freshwater lake

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This study explores the positive ecological outcomes of the removal of several tons of macroscopic algae from a freshwater Lake Oporzynskie, focusing on the subsequent increase in biodiversity within both benthic and planktonic algal communities. The removal of excessive algal biomass, primarily dominated by large macroscopic filamentous green algae species, led to a significant improvement in water clarity and less nutrient availability, thereby facilitating the growth and diversification of smaller, often overlooked algal species. Benthic communities experienced a notable increase in species richness, particularly within diatom assemblages in the surface layer of sediments, where previously suppressed species flourished and inhabited new niches in the lake's substrate. Similarly, the planktonic communities showed a marked shift, with a significant increase in the proportion of green algae (Chlorophyta) within the phytoplankton. This change highlights a positive response of this group to the altered nutrient dynamics and enhanced light availability. The reduction in macroscopic algal dominance also contributed to improved oxygen levels in water, benefiting the overall ecosystem health and promoting the return of various aquatic organisms. This study underscores the importance of controlled algal removal as a potential management tool for enhancing biodiversity and restoring ecological function in eutrophic freshwater systems.

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# Submerged macrophytes as microplastics trap in lowland river

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Microplastic (MP) pollution is an emerging environmental issue that poses a significant threat to aquatic ecosystems. In this study, we investigated the presence and accumulation of MPs on different macrophyte species in the Narew River, Poland. Macrophytes play a crucial role in aquatic habitats, serving as primary producers, a food source for many herbivorous organisms, and providing shelter and developmental habitats for various aquatic animals. They also contribute significantly to the self-purification processes of rivers through the activity of biofilms that cover their surfaces. Furthermore, macrophytes serve as important bioindicators of water quality. Recent studies suggest that submerged macrophytes may also act as traps and potential reservoirs for MP contamination. We collected in the growing season of 2024 samples of selected macrophyte species from various locations along the Narew River and analyzed them for MP presence. Representative species such as yellow water lily (*Nuphar lutea*), Canadian waterweed (*Elodea canadensis*), rigid hornwort (*Ceratophyllum demersum*), and arrowhead (*Sagittaria sagittifolia*) were selected. Microscopic observations were conducted to count and visually inspect the particles' shape, color, and size. The quantitative value was expressed as the number of particles per gram of wet matter. The results revealed differences in MP accumulation among macrophytes species. The most frequently detected MP included fibers and fragments. MP particles were predominantly observed in blue, black, and red hues. Most MP particles fell within the size range of 50–1000 μm, indicating a dominance of small to medium-sized fragments. The average MP content was determined to be 1 particle per gram of wet biomass. Our findings highlight the role of macrophytes in MP retention and emphasize the need for further research on the implications of MP pollution for aquatic organisms and ecosystem health.

# Phytoplankton communities in six reservoirs of coal mining-subsidance genesis (Polesie Zachodnie, eastern Poland) at different stages of succession

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Coal mining activity affect both landscapes and ecosystems in various ways, among others, by a formation of subsidence troughs. In the areas in which groundwater aquifiers are situated shallowly they became fulfilled with water, thus creating new water bodies and new ecosystems in the landscape. The development of new mining reservoirs may give a unique opportunity to study the early stages of colonization by various freshwater communities, including phytoplankton. In this communication we present preliminary results from six antropogenic water bodies situated in the nearby of coal mine Bogdanka near Łęczna (Lublin Coal Basin). All water bodies are shallow (max depth ~2m), small area (<60 ha) and have been appearing since 90'of the 20th century. Phytoplankton was sampled in various time periods after the development of the reservoirs: from one year (Kobyłki) through 20 years (Uciekajka I, Uciekajka II) up to 30 years (Nadrybie I, Nadrybie II, Szczecin). Phytoplankton was dominated (in terms of species richness, abundance and biomass) by chlorophytes and cyanobacteria with strong presence of euglenids but was highly variable among sites. In the presentation we discuss this variability against reservoirs characteristics such as: age of the reservoir, land use structure before the subsidence process, nutrient level and reservoir morphometry.

# Taxonomic significance of the *Trachelomonas hispida* lorica – study under laboratory and environmental conditions

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Among euglenoids, there are three genera whose representatives form a solid structure that serves as a type of test for the monad living inside. *Trachelomonas* produces a lorica of various shapes, which can be smooth on the surface or covered with spines/wart-like projections. In the genus *Strombomonas*, the lorica has a wrinkled surface and may be coated with inorganic or organic matter, while in *Ascoglena*, the lorica has a very wide apical opening, and the cells themselves lead a sessile lifestyle. Other microorganisms, such as diatoms, dinoflagellates, testate amoebae, foraminifera, or radiolarians, also produce similar structures. The function of the lorica is not yet fully understood. The rigid test allows the cells to interact with the external environment while keeping their genetic material protected. The *Trachelomonas* lorica may serve as protection against grazing; however, small forms are readily consumed by zooplankton. It may also be a site where the cell divides, but in many cases, cell division occurs after the monad leaves the lorica. Currently, in the taxonomy of this genus, the lorica is the main criterion for determining species affinity. However, is it a structure with sufficiently stable characteristics to serve as a reliable basis for identification? In our study, we focused on analysing the morphology of the lorica in *Trachelomonas hispida* specimens from both natural environments (ponds and lakes in eastern Poland and southern Czechia) and culture collections (CCAP 1283/8, Culture Collection of Algae & Protozoa, Oban, Scotland, UK). We considered features such as lorica size and shape, its coloration, the presence or absence of spines on the surface, the size and number of pores, and the structure surrounding the apical opening. The results indicate a remarkable variability in all analysed features of the *T. hispida* lorica. The lorica may completely lack spines, exhibit different shapes, have variably developed structures around the apical opening, and display a range of colours—from light green-red to dark red-brown. This suggests the necessity for further research and the development of a revised classification system within the species and the genus as a whole.

# Diatoms as bioindicators of water quality in the hyporheic zone of urban springs

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Diatoms are a key component of periphyton in spring ecosystems, playing a crucial role in self-purification processes and serving as sensitive indicators of trophic changes. This study aimed to assess the relationship between water quality in the hyporheic zone and the structure of diatom assemblages in spring niches subjected to varying degrees of anthropogenic impact. Research was conducted at two springs within the Horodnianka and Jaroszówka river catchments (northeastern Poland). Phytobenthic material was collected from spring outflows and receiving streams fed by shallow groundwater. Interstitial and surface water samples were collected periodically during the 2019 vegetation season and analyzed for selected physicochemical parameters, including electrical conductivity (EC), dissolved organic carbon (DOC), total oxidized nitrogen (TON), ammonium ($NH_4^+$), nitrate ($NO_3^-$), total phosphorus (TP), and redox potential. Diatoms were isolated from epilithon and identified to the species level. A total of 78 diatom taxa were identified, predominantly from the genera Navicula, Nitzschia, Amphora, and Planothidium. The diatom index (IO), calculated based on the presence and abundance of indicator species, was used to assess ecological status. Assemblage structure varied significantly between sites and was closely related to water chemistry. The more natural spring (Horodnianka catchment) supported oligotrophic and mesotrophic species, including boreal-montane taxa, and exhibited lower EC and nitrate concentrations alongside greater taxonomic diversity. In contrast, the spring under stronger anthropogenic pressure (Jaroszówka catchment) exhibited higher nutrient levels and a simplified assemblage dominated by eutrophic-tolerant taxa. IO values indicated good ecological status for both springs, though the Horodnianka River was classified as moderate. These findings confirm the effectiveness of diatom assemblages as bioindicators of hyporheic water quality and their utility in monitoring anthropogenically impacted spring ecosystems.

# The importance of microalgae in wastewater treatment processes using natural substrate

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The study pertains to the use of microalgae assemblages in biological sewage treatment. The analyses were conducted in two ways: 1. they compared the laser diffraction method and microscopic observation when examining flocs of activated sludge occurring in sewage; 2. they examined the possibility of using readily available, natural materials as substrates for the immobilization of microalgal biomass (biofilm) during wastewater treatment. In wastewater treatment processes, microorganisms together with organic and mineral matter - create specific activated sludge flocs characterized by different strength, density, and porosity. These specific properties determine their sedimentation and flotation. Size and spatial structure are not the only important parameters in assessing the properties of flocs - it is also their composition. The analysis of the species structure of activated sludge flocs revealed another observation. Over time, algae with a spatially developed structure and the ability to create large aggregates subject to flotation and sedimentation appeared in the treated sewage (e.g. *Klebsormidium*, *Tribonema*, *Ulothrix tenerrima*, *Microthamnion kuetzingianum*). During the study, it was found that the size analysis of activated sludge flocs using the laser diffraction method is consistent with their microscopic observation. This confirms that both methods should be used to estimate the dynamics of changes in algae growth in sewage. Taxonomic identification of microalgae allows researchers to assess their ability to remove minerals from sewage, i.e. their impact on the quality of treatment. At the same time, the study focused on selecting an appropriate separation method resulting from the accumulation of biomass flocs. Pine bark was used as a substrate for the immobilization of microalgae biomass. After 42 days, abundant biofilm growth was observed on the surface of pine bark. The main components were: *Chlorella*, *Oocystis*, *Scenedesmus obliqus*, *Ulothrix tenerrima*, *Microspora quadrata*, *Tribonema minus*, and epiphytic green algae growing on filamentous forms. During biomass production, an improvement in the quality of treated sewage was observed. The amount of mineral components decreased (total nitrogen by 64–81%; total phosphorus by 97–99%), and wastewater turbidity (90% reduction in the concentration of suspended solids). The study confirmed that the use of a solid substrate for the development of biofilm containing microalgae is an effective solution for reducing the costs of this cultivation. Algae forming activated sludge flocs in wastewater treatment processes can be used to produce biomass on an industrial scale.

# Cultivation of green microalgae on phosphorus-containing wastewater

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To cultivate the composition of microalgae strains *Chlorella vulgaris* ASLI-1, *Chlorella vulgaris* ASLI-2, *Oocystis borgei* APR for the production of algal fertilizers on an industrial scale, it is possible to use phosphorus-containing wastewater with the introduction of additional biogenic elements, aeration using an air mixture with 2% carbon dioxide content, a daylight length of 12 hours and a temperature of +23+270C. At the same time, the titer of microalgae in the culture fluid reaches: *C. vulgaris* ASLI-1-(8,7±0,8)×$10^9$ CFU/ml, *C. vulgaris* ASLI-2 – (7,9±0,5)×$10^9$ CFU/ml, *O. borgei* ATP – (8.2±0.5)×$10^9$ CFU/ml. It has been established that phosphorus solubilization by the developed fertilizer occurs in the following order: ammonium sulfate→ potassium nitrate→ sodium nitrate→ ammonium nitrate. A negative correlation was found between solubilized phosphorus and pH values, i.e., with an increase in the amount of released phosphorus, pH values decreased, while the degree of acidification occurred in the following order: ammonium sulfate→ potassium nitrate→ sodium nitrate→ ammonium nitrate. The rate of phosphorus solubilization from the sludge was 0.1±0.01 SI/day, which is 0.02±0.00 SI/day higher than in the case of using phosphorus-containing slag.

# Summer phytoplankton of shallow freshwater lakes, West Spitsbergen

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Small freshwater lakes of Spitsbergen during the summer period are characterised by unique physicochemical parameters, shaped by the harsh Arctic climate as well as local geological and hydrological conditions. Despite extreme environmental stresses, these water bodies serve as habitats for cyanobacteria and algae. The aim of this study was to identify the taxonomic composition and abundance of summer phytoplankton in shallow lakes of Western Spitsbergen, in the Bellsund region. Water samples were collected in 2022 from six water bodies (two lakes located in the tundra zone, three in the moraine area, and one on a sandur). Analyses of phytoplankton abundance and biomass were conducted, along with measurements of the physicochemical parameters of the water. Additionally, the relationships between phytoplankton abundance and biomass of taxonomic groups and environmental variables were examined. The species composition, abundance, and biomass of phytoplankton were highly variable. The number of recorded taxa in individual water bodies was relatively low, ranging from a few (min. 4) to several (max. 14) species. The highest number of identified taxa belonged to green algae. Considerable differences in total abundance and biomass were observed across the studied lakes, yet in both cases, the dominant group was chlorophytes (*Oocystis submarina*, *Monoraphidium contortum*). Other groups showing significant growth in terms of abundance and biomass included flagellates (dinoflagellates and cryptophytes). A distinct dominance of chlorophytes was recorded in lakes located closest to the fjord shoreline, whereas in lakes situated farther inland, dinoflagellates and cryptophytes were the dominant groups. A mass development of green algae, reaching biomass levels typical of eutrophic water bodies in the temperate zone, was recorded in a landlocked lake located in the tundra zone, surrounded by peat formations, and frequented by birds and other animals. The higher share of *Chlorophyta* in lakes closer to the sea may be linked to an increased inflow of nutrients transported by rainfall and surface runoff from the land. However, a key factor influencing the composition and abundance of phytoplankton in the studied lakes appears to be bird activity. Birds play a crucial role in enriching the lakes with nitrogen and phosphorus from their droppings, leading to an increased rate of primary production.

# POSTER COMPETITION

# The effect of salicylate treatment and light duration on the growth and biosynthesis of valuable metabolites within green microalga *Chlorella sorokiniana*

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Microalgae are photosynthetic microorganisms that efficiently utilize solar energy and carbon dioxide for their growth and biomass production. They are potent organisms that can be used to solve different contemporary ecological issues. On the other hand, microalgae produce valuable metabolites such as carotenoids, phenolic compounds, vitamins, fatty acids, and proteins. Thus, they are sustainable sources of food ingredients, cosmetics, pharmaceuticals, and renewable energy. Particularly, high amounts of these substances are produced under abiotic stress conditions, such as intensive light and nutrient depletion, or after exposure to plant hormones, such as salicylates – salicylic acid (SA) and methyl salicylate (MS). In our studies, we have determined the effect of two concentrations of salicylates (0,1 and 10 μM) and different light periods (16:8 and 24:0) on the growth and biosynthesis of carotenoids, chlorophylls, phenolic compounds, and flavonoids of green alga *Chlorella sorokiniana*. Continuous illumination caused an increase in algal cell diameter compared to the cells grown in optimal light photoperiod conditions, and salicylate treatment further modulated algal growth. Constant irradiance induced stress conditions within microalgal cultures and caused a decrease in the levels of carotenoids, total chlorophylls, and flavonoids. In contrast, the treatment with salicylic acid and methyl salicylate has significantly increased the content of carotenoids and chlorophylls within microalgae subjected to light stress. It was found that zeaxanthin was a predominant carotenoid within *C. sorokiniana* cells, and its content increased after the treatment with salicylates in both light regimes. Additionally, the application of salicylic acid and methyl salicylate stimulated the production of flavonoids, and the highest flavonoid levels were observed within the cells cultivated in continuous light with 0,1 μM methyl salicylate treatment.

# Bioremediation potential of extracellular polymers produced by unicellular microalgae in mixotrophic growth conditions

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Given the growing awarness of the environmental pollution resulting from the use of synthetic polymers in sorption and flocculation processes, the search of new, natural materials is increasingly important. Extracellular polymers (EPS) are high molecular weight compounds that can be bound to the surface of microalgal cells or secreted by these cells into the environment. They are mainly composed of saccharides, uronic acids, proteins and amino acids, and therefore have various properties. Due to the presence of numerous functional groups and high molecular weight, EPS can remove heavy metals from environment. The sorption process is highly dependent on the pH value of the environment. The aim of this study was to investigate the influence of the pH value of the system on the sorption properties of EPS released by unicellular algae cultivated in mixotrophic conditions. EPS were extracted from cell-free post-culture medium. Purified EPS after freeze-drying were used in this study. For the sorption experiment Pb(II) was used in the form of lead nitrate (V) at a concentration 100 mg $L^{-1}$. The sorption properties were studied in various pH (4, 5, 6) and contact time (5 min, 30 min, 60 min). The concentration of Pb(II) was measured by the optical emission spectroscopy inductively coupled plasma (ICP-OES). To investigate the mechanism of heavy metal sorption by the microalgal EPS the interactions between Pb(II) ions and EPS were investigated using Fourier transform infrared spectroscopy (FTIR). The results showed species-specific sorption properties of the produced EPS. The modification of pH of the studied EPS led to the protonation of carboxyl groups at pH 4. The highest sorption potential was found for *C. vulgaris* EPS after 5 min at pH 5. FTIR spectroscopy showed the participation of carboxyl and hydroxyl groups in the Pb(II) with EPS. The pH value determines the availability of functional groups, their protonation or dissociation.

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# Can diatoms adapt to human-altered conditions? A model of an urban park pond

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May 3rd Park in Łódź (Poland) is a remnant of city's primeval forest. In 1928, the park was enriched by two artificial ponds divided by a levee but connected through a culvert running beneath it. With concrete beds, the ponds are isolated from other bodies of water and rely solely on rainfall and surface run-off to maintain a suitable water level for fauna and flora, including diatoms. Small, urban ponds of anthropogenic origin are generally believed to not support high biodiversity levels. Therefore, one of the aims of this research was to recognise the diatom communities formed in both ponds. A total of 185 diatom taxa were identified, mostly from the genera *Nitzschia* and *Gomphonema*. Both genera belong to the pennate diatoms, a group known for its adaptive mechanisms to unfavourable environmental conditions, including very low water levels such as those observed during the periodic droughts that have recently affected the studied ponds. The taxonomic analysis, along with the assessment of the ecological preferences of diatoms identified in 50 diatom preparations, fulfilled the second aim of this research – the identification of factors potentially differentiating the two ponds. The two main physical properties of water that separated the reservoirs were pH and organic matter content. These differences led to the creation of distinct environmental conditions and, consequently, the formation of two separate diatom communities. The diatoms inhabiting these specific ponds must exhibit adaptive mechanisms for coping with low water levels as well as high levels of illumination and associated high temperatures. The taxa colonising the second pond must also display adaptations to lower water quality compared to the first pond.

# Initial characterization of acetolysis-resistant polymers from algae cell walls with scanning and transmission electron microscopy

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Unicellular green algae express considerable differences in the structure and chemical composition of their cell walls. In particular, some algal strains are able to accumulate sporopollenin-like polymers (algaenans). Algaenans are non-hydrolyzable, acetolysis-resistant materials found in the cell walls of *Chlorophyta*. They consist long (C22–C34) fatty acids and their derivatives, cross-linked via ester and ether bonds into a rigid polymeric network. Its accumulation leads to the formation of a specific trilaminar cell wall structure. Although algaenans were identified as intrinsic components of cell walls in many green algae, the current knowledge about their chemical nature, biological function and the diversity among algal species remains limited. Herein, an acetolysis-resistant material from 10 *Chlorophyta* strains previously assigned as accumulating algaenans (A+ strains) or not accumulating algaenan ($A^-$ strains) has been purified using a modified method, where the sequential elimination of most cellular pigments and lipids preceded an acetolysis stage. Subsequently, structural properties of acetolysis-resistant polymeric fractions have been examined with TEM and SEM. The chemical properties of these fractions were studied using fluorescence microscopy following primuline staining. SEM images of algaenan fractions revealed the well-preserved cell- shaped structures in all $A^+$ strains after acetolysis. The whole cell shells and/or long compressed algaenan mats can be observed. Contrary to this, in $A^-$ strains, no organized structure was visible, except the residual amorphous material. TEM imaging revealed consistent algaenan structures with high electron density in cross-section and low electron density in longitudinal section in all A+ strains. In contrast, the images of A- strains showed shredded material with irregular structure or shape. Fluorescence was observed after primuline staining only in A+ strains. Our results indicate that, although all tested strains are able to accumulate acetolysis-resistant polymers, their chemical and structural properties differ substantially between A+ and A- strains. In particular, the preservation of cell shells and the structural arrangement indicates a significant both chemical and mechanical resistance of algaenan layer in strains within multilayered cell wall. The positive staining of algaenan fractions with primuline proves the similarity of its structure to plants sporopollenin in A+ strains. In summary, our results provide an evidence of structural and functional diversity of acetolysis-resistant polymers in cell walls of unicellular green algae.

## Seasonal changes of diatom communities in urban springs

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Diatoms are the most numerous groups of algae inhabiting springs. They are excellent organisms for assessing the quality of the environment, as they respond very quickly to different types of anthropopressure. The first aim of the study was to identify and compare the diatom communities of two lowland springs Jaroszówka Duże and Pietrasze, which are located in forested areas in Białystok. The second aim was to assess the ecological status of the spring waters based on the Polish Multimetric Diatom Index, which take into account levels of trophy, saprobity and the proportion of reference species. Epilithic samples from four seasons were collected in 2021, 2024 and 2025. Preliminary qualitative and quantitative analyses showed high taxonomic similarities of diatom communities in both springs. Among the permanently recorded species were: *Achnanthidium minutissimum* var. *minutissimum, Amphora pediculus*, *Planothidium frequentissimum*, *P. lanceolatum* and *Staurosirella pinnata*. However, taxonomic differences were found between seasons. In the Pietrasze spring, species such as *Diploneis fontanella*, *D. krammeri*, *Halamphora normanii*, and *Stauroneis kriegeri* were recorded in autumn, but were absent in summer. Similarly, in the Jaroszówka Duże spring, species such as *Cocconeis placentula* var. *klinoraphis*, *Diploneis krammeri*, *Neidium binodeforme* were recorded in autumn and did not occur in summer. Our preliminary results indicate very good ecological status of the spring waters in all seasons.

# Effect of graphene oxide (GO) on diatom *Nitzschia palea*

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Graphene oxide (GO) is a promising nanomaterial utilized in various fields due to its unique properties. However, its growing use raises environmental concerns, as GO can infiltrate aquatic ecosystems and interact with biota leading to adverse biological and ecological effects on aquatic organisms. Therefore, it is crucial to not only explore the benefits of GO but also to assess its environmental fate and impact to ensure its safe and sustainable development. This study focuses on the effects of graphene oxide (GO) on diatom species with high ecological plasticity commonly found in freshwater ecosystems under various ecological conditions. Due to their low sensitivity, these species serve as valuable model organisms for exploring resistance mechanisms to GO exposure and assessing the long-term ecological impact of pollutants. The aim of this study was to examine the effects of GO on the morphological and physiological traits of the diatom *Nitzschia palea*. In the experiment, *N. palea* was exposed to different concentrations of GO (0.1–80 mg/L) for a duration of 4 days. Slight deformations of the valves were found. No significant differences in growth rate were observed, however, chlorophyll-a and carotenoid levels significantly decreased at 20 mg/L GO, likely due to shadowing effect of GO, marking this concentration as a threshold for photosynthesis. Lipid peroxidation level and antioxidant activity showed similar trends. These tested physiological responses may serve as sensitive indicators of GO effects on *N. palea*. The findings of this study provide new insights into the response mechanisms of *N. palea* to graphene oxide (GO) in aquatic ecosystems.

# The key role of springs in diatom biodiversity conservation

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Decline in species diversity is one of the greatest threats caused by global climate change. An equally significant factor negatively impacting biodiversity is direct human activity. Climate change and intense anthropogenic pressure affect not only terrestrial ecosystems but also aquatic ecosystems, leading to their degradation or disappearing. Currently springs, unique and highly sensitive ecosystems are recommended for monitoring environmental changes. These ecosystems serve as refuges for diatoms with high environmental quality requirements. Springs are exceptional ecosystems characterized by stable thermal and chemical water conditions, determined by the groundwater sources and the type of geological substrate. Additionally, these ecosystems often feature diverse microhabitats (benthos, epilithon, bryophyton). Particularly valuable are those springs located in protected areas, where remain outside direct human influence. However, knowledge of diatom microflora diversity in the spring ecosystems of the Bieszczady National Park remains limited. Diatomological studies conducted in this area aim to identify taxa present in the springs and assess whether diatom communities have undergone or are undergoing changes indicative of environmental degradation, including water quality deterioration. Published research from these areas indicate that different springs host distinct diatom assemblages. Each spring contributes new taxa to the overall species pool, not only for this region but also on a broader scale, highlighting their role in preserving and enhancing biodiversity. Furthermore, diatoms often exhibit substrate preferences, leading to taxonomic diversity even within a single ecosystem, depending on the microhabitat from which samples were collected. The presence not only of rare, poorly known, endangered, but also species that were observed in one, specified microhabitat emphasize the ecological value of springs as entire ecosystems and the need for their protection.

# Impact of salinization on cyanobacterium *Sphaerospermopsis aphanizomenoides* invasion in freshwater ecosystems

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*Sphaerospermopsis aphanizomenoides* is a halotolerant cyanobacterium of subtropical origin that has spread to European waters. The establishment of alien cyanobacteria in non-native ecosystems may be driven by changing environmental factors, including warming climate and freshwater salinization. Salinization of freshwater ecosystems, driven by human activities, leads to changes in biodiversity and creates conditions for the establishment of halotolerant alien cyanobacteria, which can alter the structure of the local community. The aim of this study was to determine the influence of freshwater salinization on the establishment of *S. aphanizomenoides* and the structural changes of the native phytoplankton community. A microcosm experiment was conducted under controlled laboratory conditions that lasted for thirteen days. Two treatment groups were formed: one containing the native phytoplankton community and the other with the addition of *S. aphanizomenoides*. Each group was subjected to four salinity levels (0, 0.2, 1 and 5 g/L NaCl). The establishment of *S. aphanizomenoides* was observed at both the beginning and end of the experiment, alongside measurements of the phytoplankton community's taxonomic composition and biomass, which were assessed through microscopy. Seven different taxonomic groups were identified: Bacillariophytina, Charophyta, Chlorophyta, Cyanobacteria, Coscinodiscophytina, Dinoflagellata, Ochrophytina. Native phytoplankton community showed low sensitivity to salinization due to halotolerance of the dominant Chlorophyta group, which developed stable biomass at all salinity levels. In the invaded community, *S. aphanizomenoides* accounted for the largest part of the biomass and its biomass increased at higher salinity levels. If freshwater salinization increases, it may provide an opportunity for the establishment of new halotolerant species in aquatic ecosystems.

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