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Algal community structure in the backwater "Alte Donau" with special focus on Gloeotaenium

verfasst von | submitted by

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Abstract

Freshwater systems are particularly vulnerable to climate change. Due to rising water temperatures, along with changes in nutrient availability, aquatic community will shift in their composition. Alte Donau, a former side arm of the Danube River, is a shallow urban lake in Vienna, Austria. As a heavily used recreational lake, Alte Donau has been subject to ongoing management and restoration efforts aimed to preserve water quality and ecosystem resilience. Recently, the green algae *Gloeotaenium loitlesbergerianum* Hansgirg was observed in this water body, which is mainly found in warmer regions. Our study aimed to capture seasonal variations in algal communities and associated environmental factors, with a specific focus on *G. loitlesbergerianum*. We conducted weekly samplings from March to October 2024. Besides monitoring environmental variables and analyzing hydrochemical parameters, samples of macrophytes and attached benthos were taken with a grate-sampler, plankton using a plankton net for larger forms, and membrane filtration for picoplankton. In total, 196 algal taxa were identified, with Shannon diversity indices ranging between 3.0 to 3.9 indicating a relatively high and balanced species diversity, with multiple taxa contributing substantially to the overall community composition. Trophic State Index values derived from total phosphorus (35) and chlorophyll-a (44) characterized the backwater as mesotrophic, tending towards oligotrophic conditions. The algal community showed a clear seasonal pattern: spring was marked by blooms of diatoms and Chrysophyceae. In summer, the algal community shifted towards a mixture of Chlorophyta and Streotophyta, Dinophyta, and Cyanobacteria. NMDS showed high variability of spring samples, whereas summer and autumn communities showed increasing similarity. With temperature exceeding 28°C in August, a substantial increase in Cyanobacteria was documented. Water temperature, SiO_4-Si, and alkalinity were the primary environmental factors structuring algal community composition. *G. loitlesbergerianum* was detected during warmer months from May through October across a temperature range of 14°C to 28°C, with peak abundances > 20°C. The ecological balance of Alte Donau is progressively altered by the combined impacts of climate change and anthropogenic stressors. Warmer water and altered nutrient regimes not only stress native macrophytes but also promote the establishment of new species such as *G. loitlesbergerianum,* accelerating community shifts. Sustained monitoring, targeted macrophyte restoration, and effective nutrient management are critical to preserve both water quality and biodiversity.

Keywords

Algal diversity, climate change, urban shallow lake, succession, seasonal variation

Zusammenfassung

Süßwassersysteme sind besonders anfällig für die Auswirkungen des Klimawandels. Steigende Wassertemperaturen in Verbindung mit Veränderungen der Nährstoffverfügbarkeit führen zu Verschiebungen in der Zusammensetzung aquatischer Lebensgemeinschaften. Die Alte Donau, ein ehemaliger Seitenarm der Donau, ist ein flacher, urbaner See in Wien, Österreich. Als stark genutztes Naherholungsgewässer unterliegt die Alte Donau kontinuierlichen Management- und Restaurierungsmaßnahmen, die auf die Erhaltung der Wasserqualität und der ökologischen Resilienz abzielen. Vor vier Jahren wurde in diesem Gewässer die Grünalge *Gloeotaenium loitlesbergerianum* Hansgirg gefunden, die überwiegend in wärmeren Regionen verbreitet ist. Ziel unserer Studie war es, saisonale Veränderungen in den Algengemeinschaften und den damit verbundenen Umweltfaktoren zu erfassen, mit besonderem Fokus auf *G. loitlesbergerianum*. Von März bis Oktober 2024 wurden wöchentliche Probenahmen durchgeführt. Neben der Erfassung von Umweltvariablen und der Analyse hydrochemischer Parameter wurden Makrophyten- und Benthosproben mithilfe eines Rechen entnommen, Plankton mit einem Planktonnetz für größere Formen gesammelt und Picoplankton mittels Membranfiltration gewonnen. Insgesamt wurden 196 Algentaxa identifiziert; die Shannon-Diversitätsindizes lagen zwischen 3,0 und 3,9 und weisen auf eine relativ hohe und ausgewogene Diversität hin, wobei mehrere Taxa maßgeblich zur Gesamtzusammensetzung beitrugen. Die aus Gesamtphosphor (35) und Chlorophyll-a (44) berechneten Trophieindex-Werte klassifizierten das Gewässer als mesotroph, tendierend zu oligotrophen Zuständen. Die Algengemeinschaft zeigte ein deutliches saisonales Muster: Im Frühjahr dominierten Kieselalgen und Chrysophyceae, während im Sommer eine Mischung aus Chlorophyta und Streptophyta, Dinophyta und Cyanobakterien vorherrschte. Die NMDS-Analyse zeigte eine hohe Variabilität der Frühjahrsproben, wohingegen Sommer- und Herbstgemeinschaften zunehmende Ähnlichkeiten aufwiesen. Bei Wassertemperaturen über 28 °C im August wurde ein deutlicher Anstieg der Cyanobakterien dokumentiert. Als wichtigste Umweltfaktoren, die die Zusammensetzung der Algengemeinschaft beeinflussten, wurden Wassertemperatur, SiO_4-Si und Alkalität identifiziert. *G. loitlesbergerianum* wurde in den wärmeren Monaten von Mai bis Oktober nachgewiesen, bei Wassertemperaturen zwischen 14 und 28 °C, mit den höchsten Vorkommen bei über 20 °C. Das ökologische Gleichgewicht der Alten Donau wird zunehmend durch die kombinierten Auswirkungen von Klimawandel und anthropogenen Stressoren beeinflusst. Steigende Temperaturen und veränderte

Nährstoffregime belasten nicht nur die heimischen Makrophyten, sondern begünstigen auch die Etablierung neuer Arten wie *G. loitlesbergerianum* und beschleunigen damit Verschiebungen in der Algengemeinschaft. Eine kontinuierliche Überwachung, gezielte Makrophytenrestaurierung sowie ein wirksames Nährstoffmanagement sind entscheidend, um Wasserqualität wie auch Biodiversität langfristig zu erhalten.

Abbreviations

Variable	Abbreviation
Alkalinity	Alk
Ash mass	AM
Ash-free dry mass	AFDM
Carbon dioxide	CO_2
Chlorophyll-a	Chl-a
Conductivity	Cond
Dry mass	DM
False discovery rate	FDR
Light attenuation	Att. coeff.
Non-metric multidimensional scaling	NMDS
Oxygen	O_2
O_2 saturation	O_2 sat.
Particulate Organic Matter	POM
Principal Component Analysis	PCA
Redundancy Analysis	RDA
Reverse osmosis	RO
Sodium	Na
Standard deviation	SD
Total phosphorus	TP
Variance Inflation Factors	VIF
Water temperature	T

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Introduction

Global mean temperatures impacted by climate change (Crowley, 2000) have risen nearly 1.5°C above pre-industrial levels in recent years (McCulloch et al., 2024). In Austria, observed warming has been substantially higher, with mean temperatures rising by 3.1°C since 1900. Alpine and urban regions experience higher temperature increases compared to lowland and rural areas, reflecting regional variations in climate sensitivity and land-use factors (Huppmann et al., 2025). Aquatic ecosystems are extremely sensitive to environmental shifts in T, pH levels, or nutrient availability (Niinemets et al., 2017). While water temperatures (T) are predicted to rise, this also affects freshwater bodies and organisms therein (Van Vliet et al., 2013; Wanders et al., 2019). Due to their smaller size, freshwater systems are more exposed to climate-induced T fluctuations than marine environments. Even very small environmental changes can threaten these ecosystems and impact organisms (Zhang et al., 2020). Freshwater ecosystems also play a crucial role in global climate regulation and biodiversity maintenance (Johnson et al., 2024). They provide critical habitats for a wide variety of organisms, including fish, amphibians, invertebrates, and aquatic vegetation (Schofield et al., 2018). Beyond their ecological importance, aquatic ecosystems are essential sources of drinking water and food. They also serve as valuable areas for human recreation and provide ecosystem services (Ferreira et al., 2023). Warming of these ecosystems will have dramatic consequences in the future, not only for humans but also for biodiversity (Prakash, 2021). Biodiversity loss and community shifts may trigger ecological imbalances and reduce the resilience of freshwater ecosystems (Tickner et al., 2020).

Among the most sensitive indicators of environmental change in freshwater ecosystems are algae, which can even be used as bioindicators for water quality. Mass occurrences of taxa like *Microcystis* Lemmermann and *Anabaena* Bory ex Bornet & Flahault can act as early signals for pollution (Chandel et al., 2024). As primary producers at the base of the aquatic food web, algae respond rapidly to changes in environmental conditions such as T, light availability, and nutrient concentrations (Reynolds, 2008). Climate-induced alterations in water T and stratification patterns can lead to shifts in algal species composition, seasonal dynamics, and bloom frequencies (Paerl & Paul, 2012). Climate change, along with warming, promotes the proliferation of harmful cyanobacterial blooms in eutrophic waters. Higher T and rising atmospheric carbon dioxide (CO_2) concentrations enhance bloom development by favouring the growth and carbon uptake

efficiency of Cyanobacteria (Visser et al., 2016). This growth can disrupt aquatic ecosystems by blocking sunlight, depleting oxygen (O_2) levels, and producing toxins that harm fish, wildlife, and even humans (Watson et al., 2015). Increased rainfall and extreme weather events lead to greater surface water runoff from agricultural and urban areas, resulting in increasing nutrient levels in aquatic systems. Although nutrients are essential for algal growth, excessive concentration can lead to hyper-eutrophication. This often boosts large-scale algal blooms, particularly of Cyanobacteria, which thrive under such conditions and can disrupt ecological balance (Carpenter et al., 1998). The blooms, however, age and will be decomposed by time, creating dead zones where O_2 levels are too low to support most aquatic life. These changes can trigger cascading effects across higher trophic levels, ultimately altering the structure and functioning of entire ecosystems (Diaz & Rosenberg, 2008).

Seasonal patterns in algal composition reflect adaptations to environmental conditions. In spring and late September, Chrysophyceae and diatoms typically dominate due to their tolerance of cooler T and lower light availability. In addition, cooler water has a higher density and viscosity compared to warm water, thus facilitating buoyancy of heavier phytoplankton. In spring, as water T rises and daylight increases, these groups efficiently utilize all available nutrients, often allowing them to dominate the community (Winder & Sommer, 2012). Dinophyta predominantly thrive during summer and early autumn, coinciding with stratified water columns and limited vertical mixing, and nutrient limitation. In contrast, diatoms dominate during periods of enhanced mixing in spring and autumn, when cooler T and stronger winds disrupt stratification (Winder & Sommer, 2012). Cyanobacteria and Chlorophyta exhibit increased growth at T between 20 and 35°C, with Cyanobacteria capable of forming harmful algal blooms under warmer conditions (Lürling et al., 2013; Lakshmikandan et al., 2024). Many cyanobacterial species regulate their position in the water column through gas vesicles, facilitating optimal light exposure (Salmaso & Tolotti, 2021).

Alte Donau, a former side arm of the Danube River, is a shallow urban lake in Vienna, Austria. Over the years, it has undergone substantial ecological changes, transitioning from a eutrophic to an oligo-mesotrophic state and has been the subject of environmental monitoring since many years (Dokulil et al., 2018). Phytoplankton monitoring in Alte Donau dates back to the 1980s, as indicated by ecological surveys summarized by Löffler in 1988 (Dokulil et al., 2018). Although highly impacted by human activities, Alte Donau

continues to function as an ecologically valuable habitat, sustaining a rich diversity of aquatic life within an urbanized landscape.

Restoration measures in Alte Donau

After huge eutrophication problems in the 1990s, Alte Donau changed into a turbid state dominated by high biomass of filamentous cyanobacteria, mostly *Limnothrix redekei* (Goor) Meffert and *Cylindrospermopsis raciborskii* (Wołoszyńska) Seenayya & Subba Raju. Cyanobacterial blooms reduced water transparency to less than 30 cm, creating an urgent need for comprehensive restoration measures. Macrophyte and charophyte coverage was reduced to minimal, residual growth during this time (Schagerl et al., 1999). A major target was to reduce phosphorus availability to limit phytoplankton growth, while also improving water transparency to enhance overall water quality. The first consideration included stopping the inflow of nutrient-enriched groundwater. Furthermore, water in Alte Donau was exchanged with nutrient-poor water from nearby Neue Donau (this is an artificial channel right to the main river to prevent the city from high-water). However, as these measures did not come to a success, the so-called RIPLOX-method was applied to reduce phosphorus in the water column. In a first step, iron(III)chloride ($FeCl_3$) buffered with limestone was introduced to the system; $FeCl_3$ acts as a barrier against phosphorus release from sediments. This was followed by adding calcium nitrate ($Ca(NO_3)_2$) to the sediments to boost microbial oxidation processes. In addition, macrophytes, primarily *Myriophyllum spicatum* L. were transplanted into Alte Donau to further reduce nutrient concentrations in the water column. The primary advantage of using macrophytes lies in their effectiveness at removing nutrients, resulting in a significant reduction in nutrient load after harvesting the biomass. Each year from March to October, the City of Vienna removes around 2,000 tons of aquatic vegetation from Alte Donau using specialized mowing boats (Stadt Wien, n.d.). These measures transformed the ecosystem into a macrophyte-dominated state characterized by high water clarity. Although the restoration measures have been largely successful, some challenges remain. pH values rise above 9.5 in downstream areas due to intense photosynthesis, decreased buffer capacity caused by biogenic decalcification, and low groundwater inflows. To solve this problem, water from the impoundment Neue Donau is loaded with carbonate and then discharged into Alte Donau. Since the last decade, stable mesotrophic conditions are maintained with mean total phosphorus (TP) values ranging from 12 to 14 $\mu g\, L^{-1}$ and mean chlorophyll-a (Chl-a) values ranging from 3 to 4.5 $\mu g\, L^{-1}$ (Dokulil et al., 2018).

Algal community in Alte Donau

Over the past 30 years, the algal community in Alte Donau has undergone significant changes, primarily driven by restoration efforts and environmental shifts. These alterations have significantly impacted the aquatic ecosystem, influencing algal growth patterns and prompting notable shifts in community composition (Visser et al., 2016; Prakash, 2021). Former hypertrophic conditions favoured the dominance of Cyanobacteria, as such waters are enriched with nutrients like phosphorus and nitrogen that stimulate their growth (Wang et al., 2021). Now, under mesotrophic conditions, the system supports a more balanced and taxonomically diverse assemblage, including Cyanobacteria, diatoms (Bacillariophyceae), green algae (Chlorophyta and Streptophyta) and Chrysophyceae. These circumstances are characterized by moderate nutrient levels, which support a variety of phytoplankton species while preventing the dominance of any single group (Tian et al., 2017). Studies have shown that under mesotrophic conditions, Cyanobacteria exhibit low abundance but high species diversity, similar to observations in large lakes. This diversity is crucial for maintaining ecosystem stability and resilience (Kuczyńska-Kippen et al., 2024). Following the transition, *C. raciborskii* disappeared from Alte Donau, while other Cyanobacteria, such as *Microcystis* and *Aphanocapsa* species, became characteristic of the summer phytoplankton community (Dokulil et al., 2018). Climate change has further influenced algal dynamics, with warmer winters and earlier ice melt leading to earlier onset of thermal stratification and increased light penetration. Consequently, phytoplankton growth initiates earlier in the season, occasionally even under ice cover (Adrian et al., 1999; Horvat et al., 2021; McClish & Bushinsky, 2023). The impacts of climate change, particularly T fluctuations and shifts in precipitation patterns, on phytoplankton dynamics in mesotrophic lakes remain insufficiently understood.

As environmental conditions change, some species will disappear, while others will be introduced. One major change is the expansion of many tropical and subtropical species into temperate regions due to rising water T (Paerl & Huisman, 2009). This applies for algal genera *Limnothrix* M.-E.Meffert and *Cylindrospermopsis* G.Seenayya & N.Subba Raju, which are problematic in nutrient-rich waters and often cause harmful algal blooms (Kosten et al., 2012). Furthermore, alterations in water chemistry resulting from elevated CO_2 concentrations and increased nutrient runoff create conditions that are favourable to the proliferation of these taxa (Verspagen et al., 2014).

Focus on *Gloeotaenium loitlesbergerianum* (Hansgirg, 1890)

Shifts in environmental conditions also allow non-harmful species to extend their ranges into new habitats (Häder & Gao, 2023). Among the new records in Alte Donau is the green algae *Gloeotaenium loitlesbergerianum* Hansgirg. This freshwater species was first described by Hansgirg in 1890 from the region of Bad Ischl, Austria (Transeau, 1913). It is classified within the phylum Chlorophyta (green algae), class Trebouxiophyceae, order Chlorellales, and family Oocystaceae. The genus *Gloeotaenium* was established concurrently by Hansgirg and is recognized by its typical colonies of two to four cells (occasionally up to eight), while solitary cells are rare. The colonies are enclosed within a stratified sheath containing calcite crystals (Komárek, 1983; John et al., 2022). The genus *Gloeotaenium* comprises two species, the very rare *Gloeotaenium minus* Pascher, only found at one location in Austria and the cosmopolitan *G. loitlesbergerianium* which is mainly found in warmer regions (Ramos et al., 2021). The colonies of *G. loitlesbergerianium* are few- celled (2 to 8 cells), oval to elliptical in shape, while two-celled colonies measure up to 60 × 40 µm, and four-celled colonies reaching up to 60 µm in diameter. These colonies are free-floating and surrounded by broad, hyaline mucilaginous envelopes. The cell morphology of *G. loitlesbergerianium* is characterized by broadly asymmetrically oval shapes, ranging from 18–35 × 15–20 µm in size. Furthermore, the cells with colonies are delineated by a hyaline or gray to black stratified layer of the mother cell wall. This layer appears as either a transverse band in two-celled colonies or a diagonal cross in four-celled colonies, with visible calcite crystals on its surface, contributing to the structural framework of the colonies (Hindák & Hindáková, 2008). Microchemical tests and spectroscopic analyses identified calcium carbonate ($CaCO_3$) as the main component of the mineral bands within the cell walls (Devi Prasad & Chowdary, 1982). In addition, they also detected the presence of strontium, magnesium, and barium, likely occurring as carbonates as well (Ramos et al., 2021). According to Hindák & Hindáková, *G. loitlesbergerianum* has been found in the littoral zone of the Čičovské Mŕtve Rameno, an oxbow lake near the Danube River in southern Slovakia (Hindák & Hindáková, 1998; Hindák & Hindáková, 2008). In Alte Donau, however, its presence has only been documented within the past four years (personal observations and communication with Roland Heinz, DWS Hydro-Ökologie GmbH, Vienna).

Hypothesis

The exact cause of the recent occurrence of *G. loitlesbergerianium* remains unclear. However, several potential factors can be hypothesized based on current environmental changes. Rising water T due to climate change may favour the presence of *G. loitlesbergerianium*, as this species is primarily found in warmer waters (Ramos et al., 2021). Additionally, shifts in pH, possibly driven by extensive macrophyte growth, could create favourable conditions for the establishment of this species. Changes in nutrient levels, whether caused by external inputs or internal ecosystem processes, may also promote the proliferation of *G. loitlesbergerianium*. It is likely that interactions between these factors play a significant role in facilitating the growth and spread of this unexpected species. Based on previous observations, we assume that *G. loitlesbergerianium* exhibits a seasonal occurrence pattern, with presence limited to the summer months.

Sampling was conducted a total of 25 times weekly from March to October 2024. During this period, pronounced shifts in algae species composition were expected. During cold seasons, we expected a dominance of Chrysophyceae. Additionally, diatoms should be common especially during cooler periods. During summer, the algal community was predicted to consist of a mixture of green algae, Dinophyta and Cyanobacteria. Especially, during warmer periods, with water T exceeding 25°C, a substantial increase in the proportion of Cyanobacteria was expected.

Material & Methods

Study site

Alte Donau is a shallow lake located in the city of Vienna (Austria) within the geological region known as the Vienna Basin (Wiener Becken) (Fig. 1). It originated as a former side arm of the Danube River and was formed during the river regulation phase between 1870 and 1875 (Donabaum et al., 1999). Today, Alte Donau serves amongst the most important recreational areas in Vienna. It is divided into two distinct basins, the upper basin, which spans 0.55 km² and has a volume of 1.34×10^6 m³, and the larger lower basin, with a surface area of 0.88 km² and a volume of 2.20×10^6 m³. Alte Donau has an average depth of 2.5 m, with a maximum depth of 7.0 m occurring in a single depression located in the northern basin. The remaining backwater lies at an elevation of 157 m above sea level (Adriatic reference) and has no natural surface inflow or outflow. As a result, its water balance is maintained by groundwater inflow and precipitation (Dokulil et al., 2018).

Urban lakes, like Alte Donau, are particularly vulnerable to pollution and eutrophication due to intensive recreational use and high shoreline development, which reduces their resilience (Birch & McCaskie, 1999; Naselli-Flores, 2008). Alte Donau is characterized by a temperate continental climate, with a mean annual T of 10.9°C (Climate-Data.org, 2025). Annual precipitation varies between 607 mm and 717 mm, distributed relatively evenly throughout the year with a slight peak in early summer (Climate.top, n.d.; Weather-and-Climate.com, n.d.).

The sample site was located at the upper basin at Alte Donau in the 22 district of Vienna at the Hofbauer boat rental facility (48°14'26"N 16°25'35"E).

Figure 1. Map of study site. The inset map displays the location of Vienna within Austria, marked by a red dot. The main map provides a detailed view of Alte Donau in Vienna. To the left, the main branch of the Danube River (Donau) and the Neue Donau are shown. To the right, the Alte Donau is depicted, divided into the upper and lower basins. The red mark indicates the specific sampling site within the study area.

Field sampling and *in situ* measurements

Samples were collected once a week at a fixed location from March to October, resulting in a total of 25 sampling events. At the research site, sample collection entailed gathering macrophytes and attached benthos with the assistance of a grate sampler. Macrophytes were then carefully transferred into vessels containing site water. Plankton was subsequently sampled using a plankton net with a mesh size of 40 µm and transferred to vessels for storage. For the chemical analysis and filtration processes conducted in the laboratory, site water was gathered in bottles. Following field measurements were performed on site: O_2 concentration (Multiparameter Taschenmessgerät MultiLine® Multi 3510 IDS), pH value and T (WTW pH 3310 pH-Messgerät pH-Wert, Temperatur), and specific conductivity (Cond) (WTW pH/Cond 340i), light intensity both at the surface and 0.75 meters depth, for calculation of light attenuation coefficient µ (SKYE Instruments LTD, UVA UVB sensor):

$$\mu = \frac{\ln\left(\frac{I0}{I}\right)}{x}$$

(I_0, Initial intensity at surface; I, Intensity after passing through medium (0.75m); x, Path length through medium (0.75m))

Dry mass, ash mass, chlorophyll-a

To determine dry mass (DM), glass microfiber filters (Whatman GF/C; particle retention: 1.2 µm) were pre-combusted and pre-weighed. Then, a defined volume of water sample was filtered using vacuum filtration. The filters were dried at 80°C for 24 hours and reweighed. DM was calculated using the following formula:

$$\text{DM (mgL}^{-1}\text{)} = \text{(filter incl. material (mg) – empty filter (mg)) / filtered volume (L)}$$

For ash mass (AM) determination, the filters were then combusted at 450°C for 2.5 hours and reweighed. The particulate organic component of the biomass (POM, or ash-free dry mass (AFDM)), was determined by subtracting AM from DM.

Spectrophotometric chlorophyll-a (Chl-a) analysis for estimating algal biomass was performed while a defined sample volume was filtrated on a glass fiber filter (Whatman GF/C; particle retention: 1.2 µm). The filter was stored at -20°C at least one day to assist algal cell bursts. Frozen filters were cut and ground in 5 ml 90% cold acetone and homogenized using an ultrasonication (Branson Sonifier 250). Pigment extraction

followed by storage in the dark at 4°C for twelve hours. Extracts were centrifuged for 10 minutes (Eppendorf, Centrifuge 5810 R), and the clear supernatant was measured with a V-1200 spectrophotometer (VWR) at a wavelength of 663 nm. Chl-a concentration was calculated using the following formula (Lorenzen, 1967):

$$\text{Chl-a } (\mu g L^{-1}) = 11.40 \times E663 \times v \times V^{-1} \times d^{-1}$$

(E663 absorbance at 663 nm; v, volume of the extract in ml; V, sample volume in L; d, cuvette path length in cm).

Water chemistry

Total alkalinity (carbonate hardness HCO_3^-) was determined titrimetrically using unfiltered water (Carbonate Hardness Test MQuant® 108048). Cations Sodium (Na^+), Kalium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}) (OENORM DIN EN ISO 14911) and anions Chloride (Cl^-), Sulfate (SO_4^{2-}), Nitrate (NO_3^-) (DIN EN ISO 10304-1) were analyzed from filtered samples with ion chromatography (IC) using a Metrohm 761 Compact IC (Cation column: Metrohm Metrosep C2; Anion column: Metrohm Metrosep A Supp 5) of filtrated samples (0.45 µm filters, Whatman Puradisc, UK). Total phosphors (TP) was determined after wet combustion of unfiltered samples (OENORM DIN EN ISO 6878) using a spectrophotometer at 890 nm (Hach-Lange DR 2800). Soluble reactive phosphorus (PO_4-P), nitrite-N (NO_2^--N), ammonium-N (NH_4^+-N) and silicate (SiO_4-Si) were measured in filtrates obtained by filtering (0.45 µm filters, Whatman Puradisc, UK). The analyses were carried out using photometric methods as follows: PO_4^{3-} with α-phosphomolybdenum blue at 890 nm (OENORM DIN EN ISO 6878), NO_2^--N via diazotization as a violet-red azo dye at 542 nm (DIN EN ISO 26777). NH_4^+-N was quantified photometrically using the indophenol-blue (IPB) method at 655 nm (DIN38406-5, OENORM ISO 7150-1). SiO_4-Si was measured using the photometric unreduced silicomolybdic acid method as yellow β- silicomolybdic acid at 400 nm (DIN38405-21). For calculating an ion balance, major cations Na^+; K^+; Ca^{2+}; Mg^{2+}, and anions (HCO_3^-, Cl^-; SO_4^{2-}) for anions were transformed to meq L^{-1}. Next all cations and all anions were summed up separately. For ion balance calculations, anions were subtracted from cations, with the resulting value ideally approaching zero to ensure a balanced ratio.

Trophic state index

Trophic State Index values, calculated from the mean values of TP (8.4 µg L^{-1}) and Chl-a (4 µg L^{-1}) were approximately 35 for TP and 44 for Chl-a, placing the backwater in the mesotrophic range, close to oligotrophic conditions. According to the classification criteria of Forsberg and Ryding (1980), most samples fell within the transitional zone between oligotrophic and mesotrophic states (Fig. 2).

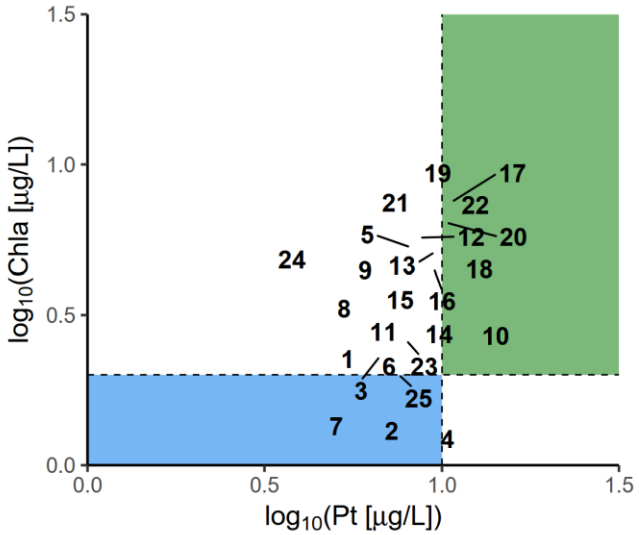

Figure 2. A log-log transformed trophic diagram showing the trophic levels of the sample IDs with trophic status thresholds according to Forsberg & Ryding (1980). Background colors indicate trophic categories: blue = oligotrophic, green = mesotrophic.

Algae identification and diversity

Light microscopy (Leica DM500; Leica DM 2000 Led, camera: Leica ICC50 W) was performed with both live and preserved material for species identification to the lowest possible taxonomic level (John et al., 2022; Lange-Bertalot et al., 2017; Linne von Berg et al., 2004; Streble & Krauter, 1973; Wehr et al., 2015). Identified taxa were verified with valid species names in algaebase (Guiry and Guiry, 2025). To obtain a comprehensive overview of algal biodiversity, three different methods were used for identification: (i) identifying phytoplankton gathered through a 40 µm net: (ii) gathered macrophytes and phytobenthos; (iii) through vacuum filtration (membrane filters, pore size 0.45µm, Sartorius) to also consider picophytoplankton. Samples were stored at 4°C until analysis. In addition, part of the samples was preserved with a few drops of formaldehyde for later identification (final concentration around 0.25%; the low concentration was used to keep cell structures intact). For diatom identification, the heat

combustion method was used to prepare permanent microscopic slides (Krammer & Lange-Bertalot, 2007). First 1mL was applied onto a coverslip which was then transferred to a Ceran plate. The plate was carefully heated to speed up drying. Next, heating was turned to maximum for combusting organic substances (only the inorganic part remains). During this process, colour switches from brown as organic material was incinerated over black to grey. Washing the slide followed with hydrochloric acid (5% HCl) and subsequently with reverse osmosis (RO) water (MilliQ) to remove carbonate precipitation. The coverslip was heated again to dryness. A drop of Naphrax® was placed onto a microscope slide, and the coverslip was immediately carefully positioned with the material side facing downward to ensure proper embedding of the diatoms. The microscope slide was promptly placed on the heated Ceran plate until solvent bubbles occurred very slowly, which ensured evaporation of toluene. Finally, the coverslip was pressed carefully onto the slide. After the Naphrax® has hardened, the permanent microscopic slides can be used at any time to identify diatoms.

Algal abundance was assessed using a semiquantitative scale ranging from 0 to 5, originally developed by Korde (1956), and has since been widely applied in various water monitoring programs (0 = not present, 1 = very rare/sporadic, 2 = rare, 3 = moderate, 4 = high, 5 = very high abundance) (Alster et al., 2024).

Statistics

All statistical analyses were conducted using RStudio (version 2024.12.1, Build 563). A Mantel test revealed a significant positive correlation between benthic and planktonic community dissimilarity matrices ($r = 0.62$, $p = 0.001$). Benthic and planktonic species data were therefore aggregated into a single dataset to represent the overall aquatic community composition. Seasonal data was categorized as follows: Spring: March to May, Summer: June to August, Autum: September to October.

Trophic state index

Trophic State Index values were first calculated from measured TP and Chl-a concentrations according to Carlson (1977). Subsequently, TP and Chl-a values were $\log_{10}$-transformed to generate a trophic diagram.

Environment

Mean values and SD of key limnological parameters were calculated for the period from March to October. It should be noted that the number of samples varied each month, as

follows: 1 sample in March; 2 samples in April and October; 3 samples in September; 4 samples in May, June, and August; and 5 samples in July. Principal Component Analysis (PCA) was performed to identify the main environmental factors driving variation within the dataset. The PCA was computed in R using the psych package (principal), extracting two components. A Varimax rotation was applied to enhance interpretability by producing a clearer loading structure while maintaining orthogonality. A loading cutoff of 0.30 was used for interpretation.

Algal community

Two-dimensional non-metric multidimensional scaling (NMDS) from the vegan package was performed using the metaMDS() function with Bray-Curtis distances to explore the structure of the algal community dataset. Sampling days were labeled with their corresponding day numbers, while seasons were represented by different colours. To assess seasonal differences in algal community composition, a PERMANOVA (Permutational Multivariate Analysis of Variance) analysis was conducted based on Bray-Curtis dissimilarities (999 permutations). To further evaluate the degree of separation between seasons, an ANOSIM (Analysis of Similarities) analysis (9999 permutations) was performed. Additionally, a one-way analysis of multivariate homogeneity of group dispersions (betadisper) followed by ANOVA was applied to assess potential differences in within-group variability across seasons.

Chl-a was utilized as an indicator for algal biomass. Raw Chl-a data were log-transformed to meet assumptions of normality and homoscedasticity (Shapiro-Wilk $P = 0.2654$; Constant Variance Test $P = 0.7935$) and all predictors were standardized prior to analysis. A backward stepwise multiple linear regression was conducted to identify a linear combination of predictor variables for Chl-a, using a significance threshold of $p < 0.05$.

A total of 25 sample days were analyzed. Species abundance data included 196 taxa identified to the genus or species level. This served as the basis for diversity and community structure analyses, including the calculation of Shannon diversity and Evenness. For calculating, relative abundances were ^3 transformed to consider the natural relations of taxa within the community.

Gloeotaenium loitlesbergerianum

To investigate the potential ecological niche of *G. loitlesbergerianum* a non-parametric multiplicative regression (NPMR) approach was employed using HyperNiche software

(version 2.30). The response matrix consisted of a single binary variable indicating the presence or absence of *G. loitlesbergerianum* across 25 sampling sites. The predictor matrix included three environmental variables, pH, T and light attenuation. T emerged as the strongest individual predictor, particularly when combined with light attenuation. The best model overall model included T (tolerance = 2.55) and light attenuation (tolerance = 0.17) with logB = 3.110.

Environment and algal community

To explore the relationship between environmental factors and the algal community, we performed a direct gradient analysis. First, a Detrended Correspondence Analysis (DCA) was conducted to estimate the gradient length in our dataset. With a gradient length of 1.6 standard deviation units, Redundancy Analysis (RDA) was performed as direct gradient analysis, while species data were Hellinger-transformed, and environmental variables were standardized. Variance Inflation Factors (VIF) were calculated to first assess and then minimize multicollinearity, and only variables with VIF values below 5 were included in the model. P-values were adjusted for multiple testing using the false discovery rate (FDR) correction (Benjamini and Hochberg 1995). A triplot was generated showing the environmental variables and the 20 species with the highest goodness-of-fit values.

Image Processing

The photographs of the algae were processed using ImageJ (Fiji distribution), version 1.54p.

Cartographic Data and Map Design

The map was created using OpenStreetMap for base data, Adobe Illustrator (version 29.6.1) for vector design and Adobe Photoshop (version 26.8.1) for image editing.

Results

Environmental conditions

Figure 3 presents the monthly mean values and standard deviations (SD) of key limnological parameters recorded. Notable seasonal variations were observed for some of the variables. TP concentrations nearly doubled, increasing from 6 $\mu g\ L^{-1}$ in March to 11 $\mu g\ L^{-1}$ in August (Fig. 3A). SiO_4-Si concentrations were lowest in May (0.01 mgL^{-1}) and increased to 0.8 mgL^{-1} by September (Fig. 3B). The pH fluctuated consistently

between 8.5 and 9.0 throughout the observation period (Fig. 3C). T strongly increased from 11.4°C in March to a peak of 28.4°C in August, followed by a decline to 15°C in October (Fig. 3D). Cond decreased from approximately 360 μScm^{-1} to a minimum of 275 μScm^{-1} in July, then increased again to 340 μScm^{-1} in autumn (Fig. 3E). O_2 saturation reached a maximum of 125% between April and May, then gradually declined to 100% by October (Fig. 3F). Light attenuation increased during the summer months from 0.4 m^{-1} in March to a maximum of 1.75 m^{-1} in August (Fig. 3G). Alkalinity declined from 2.2 $mmolL^{-1}$ in April to a minimum of 1.8 $mmolL^{-1}$ in May and slightly increased to a maximum in October (Fig. 3H).

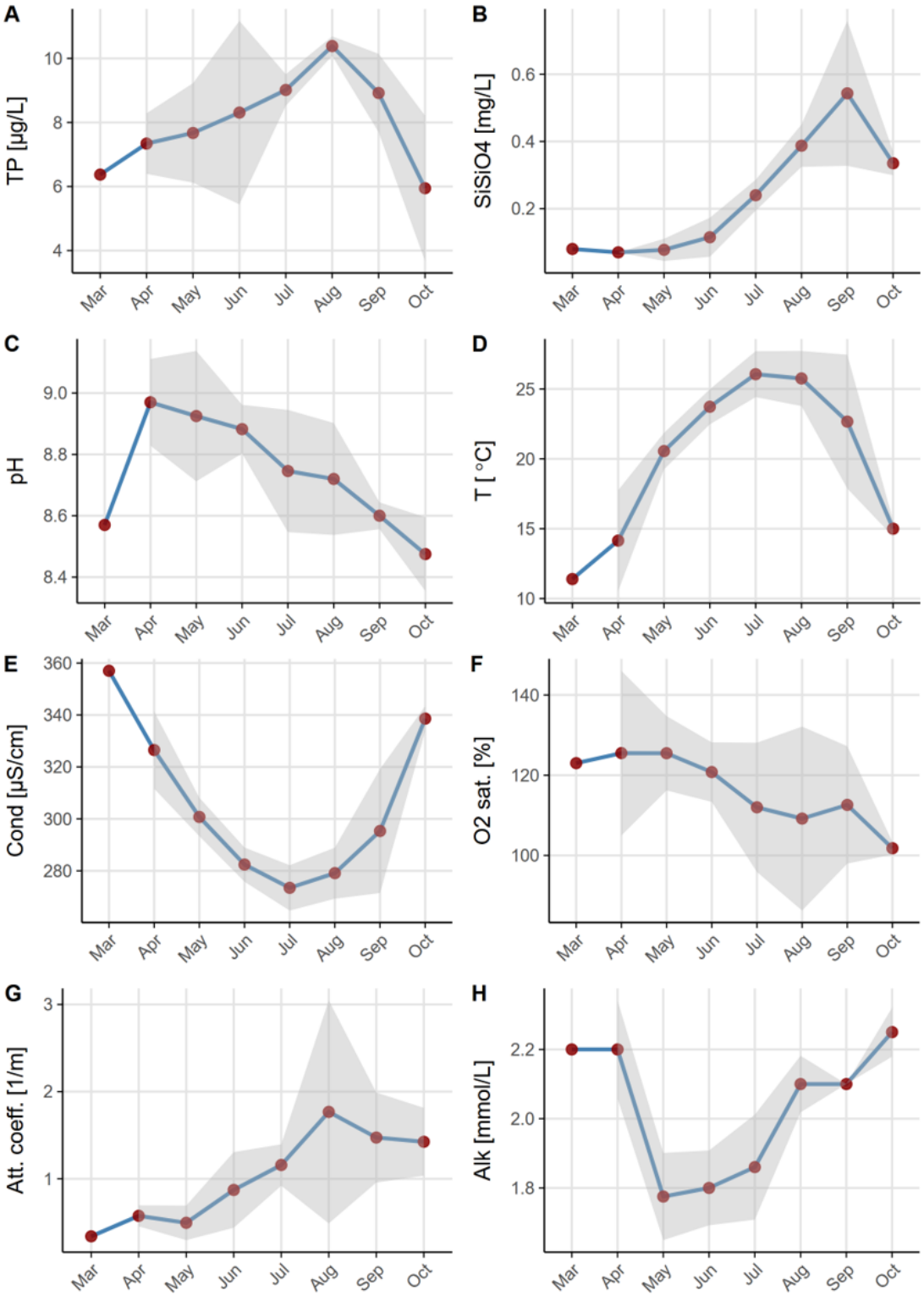

Figure 3. Mean values and standard deviation (light grey) of characteristic limnological parameters from March until October. Abbreviations: TP, total phosphorus; T, temperature; Cond, conductivity; O2 sat., O_2 saturation; Att. coeff., light attenuation; Alk, alkalinity.

PCA was performed to identify the main environmental drivers of variation in the dataset. The rotated two-component solution accounted for 72.9% of the total variance (RC1: 41.6%, RC2: 31.3%). The first component (RC1) represents a productivity/eutrophication gradient, characterized by strong loadings of algal indicators (Chl-a, Cl^-), T, TP and SiO_4-Si. The second component (RC2) reflects a chemical buffering gradient, primarily defined by alkalinity and light attenuation (Tab. 1). Together, these two components capture the main environmental gradients shaping community structure in the system.

Table 1. Summary table of rotated PCA loadings for RC1 and RC2. Abbreviations of variables: TP, total phosphorus; T, temperature; Att, light attenuation, Alk, alkalinity; Cl^-, chloride.

Variable	RC1	RC2
TP	0.744	-0.716
SiO_4-Si	0.698	0.598
T	0.84	-0.339
Att	0.509	0.518
Alk	-0.15	0.895
Cl^-	0.827	0.408
Chl-a	0.782	0.283

A two-dimensional NMDS analysis (Stress: 0.07) was conducted to search for potential patterns in the algal community composition (Fig. 4). Samples collected in spring exhibited greater dispersion, whereas those from summer and autumn were more tightly grouped. PERMANOVA analysis revealed significant differences in algal community composition across seasons ($p = 0.001$), with the grouping explaining approximately 39% of the variation. ANOSIM showed a strong and significant separation of algal community composition between the seasons (9999 permutations, sample statistics $R = 0.558$, $p = 0.001$). The distances between groups (median = 191.0) were clearly larger than the within-group distances (Spring = 142.0). ANOVA also indicated significant differences in community dispersion among seasons ($F = 3.9434$, $p = 0.03439$).

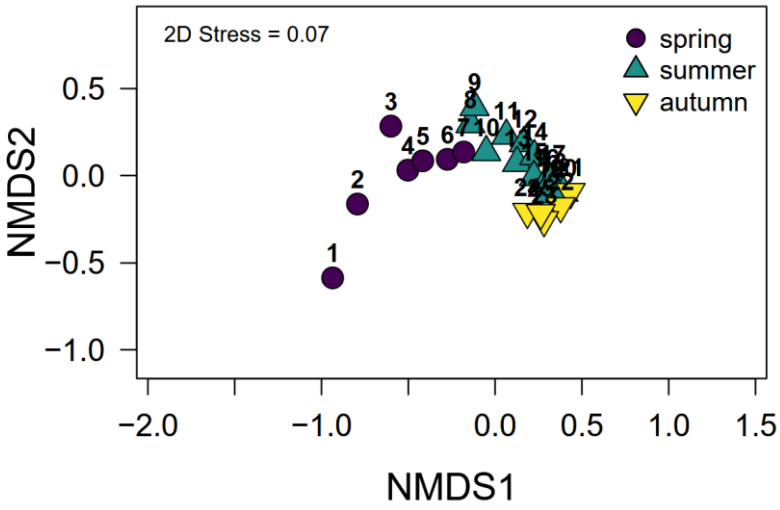

Figure 4. Two-dimensional NMDS plot showing seasonal patterns in algal community composition. The plot is based on species data with sampling days labeled from 1 to 25. Seasonal differences are represented by distinct colors, as indicated in the legend.

Environment and algal biomass

Figure 5 shows mean values and SD of Chl-a and POM concentrations during the sampling period. Chl-a (Fig. 5A) showed a minimum of 0.8 µg L^{-1} in April and a maximum of 6.7 µg L^{-1} in August. POM (Fig. 5B) concentrations were lowest in March (0.3 mg L^{-1}) and peaked in September at 1.5 mg L^{-1}. Chl-a was taken as proxy for algal biomass and showed significant differences during seasons (Kruskal-Wallis test p = 0.013, n = 25) with a significant increase from spring to summer (Dunn test p = 0.0057*). There was no significant difference between summer and autumn and neither between spring and autumn.

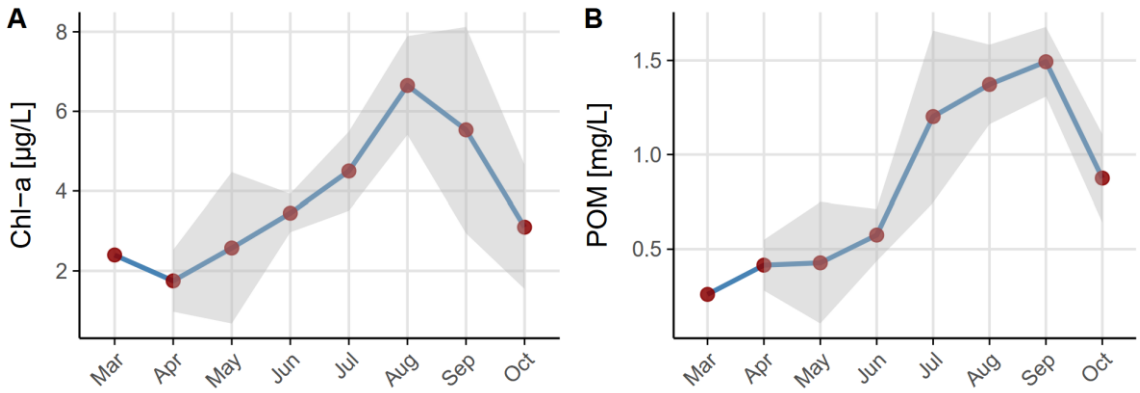

Figure 5. Mean values and standard deviation of Chl-a and POM concentrations in the time period from March until October. Abbreviations: POM, Particulate Organic Matter.

A significant positive correlation was found between Chl-a and POM (r = 0.59, p = 0.002). Based on a Chl-a-to-biomass conversion factor of 2 %, the estimated algal contribution to POM ranged from 6.1 % to 60.0 % (median: 20.8 %).

A multiple regression analysis was performed to get a more detailed insight into the parameters influencing Chl-a. In a preliminary model, nine independent variables which affect growth of microalgae were chosen. Cl^-, NO_3^-, PO_4^{3-}, pH, T and light attenuation had no statistically significant effect in the model and were excluded. The final model (Fig. 6) explained approximately 59% of the variance (p = 0.021). Cond emerged as the most important predictor, with higher values associated with lower Chl-a concentrations (p = 0.0027), and was statistically significant. SiO_4-Si showed a positive trend (p = 0.079), while pH showed a negative trend (p = 0.080); both were marginally significant.

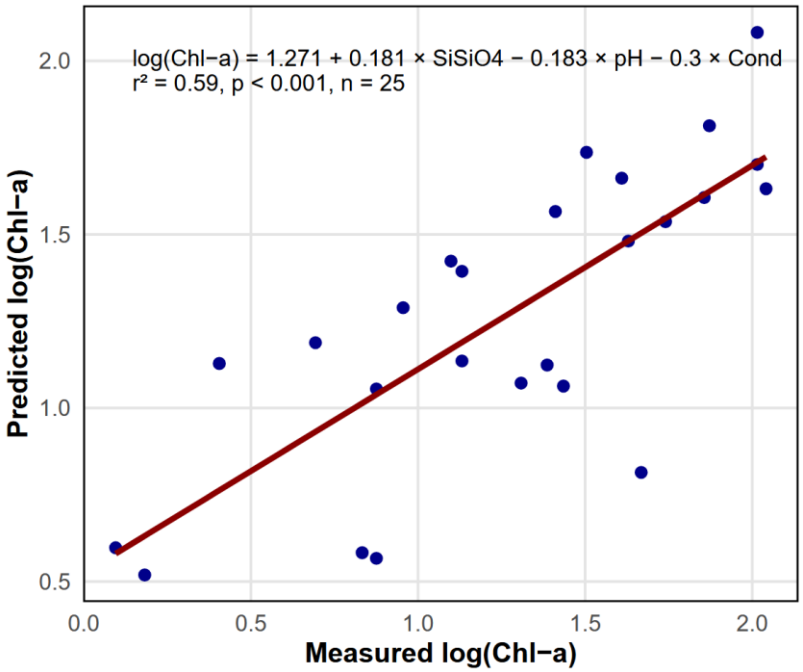

Figure 6. Correlation diagram of measured logChl-a versus predicted logChl-a computed by backward stepwise regression (r = 0.59, n =25).

Algal diversity

In total, 196 algal taxa were identified. Green algae (102) had the highest taxa number, followed by Cyanobacteria (40), Bacillariophyceae (33), Euglenophyta (9), Chrysophyceae (5), Dinophyta (4), Cryptophyta (2) and Rhodophyta (1).

Lowest mean values for Shannon diversity index (Fig. 7A) and Evenness (Fig. 7B) were calculated for spring (Average: H' = 3.0; E = 0.75). This followed a significant increase

during summer (Average: *H'* = 3.8; *E* = 0.83). In autumn, the values were comparable to summer (Average: *H'* = 3.9; *E* = 0.86). Taxa number (Fig. 6C) was found to be highest in the summer months. Highest diversity and evenness could be obtained in July (101 taxa, *H'* = 4.0; *E* = 0.88), while lowest values were observed in March (31 taxa, *H'* = 2.7; *E* = 0.8).

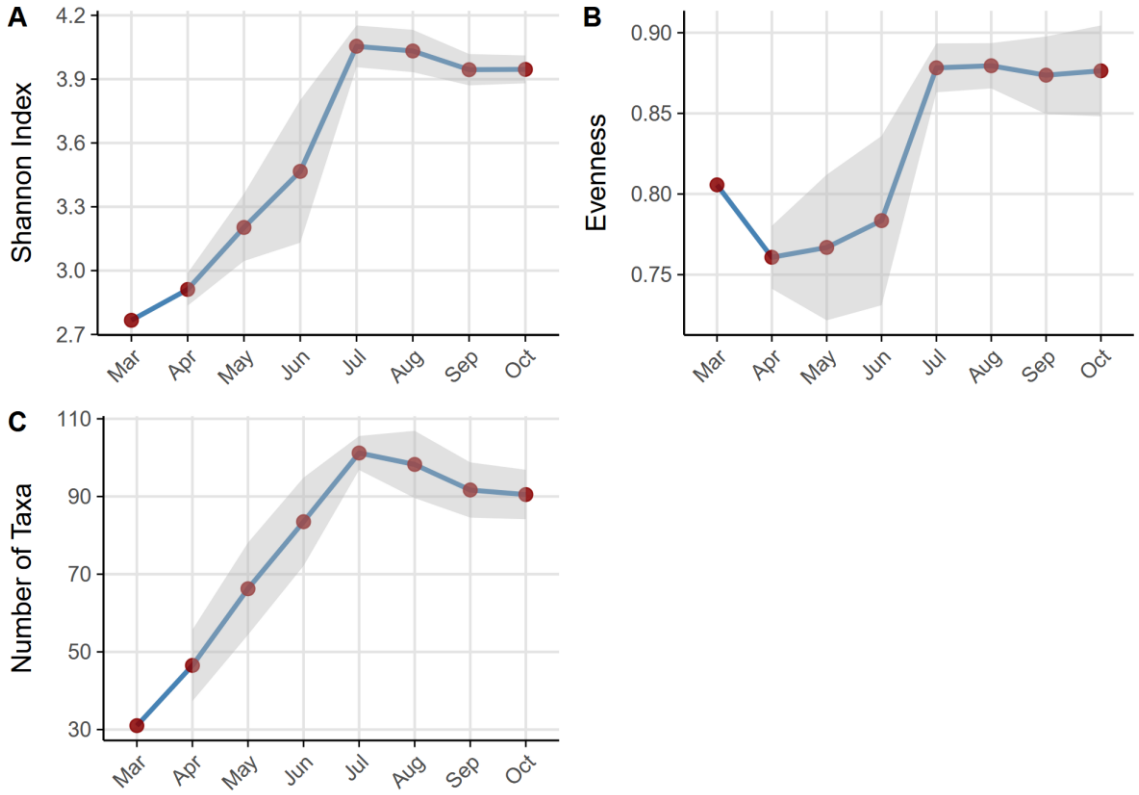

Figure 7. Mean values and standard deviation of Shannon Index, Evenness and number of taxa in the time period from March until October.

A special focus on *Gloeotaenium loitlesbergerianum*

G. loitlesbergerianum was first recorded in a benthic sample on May 13th (5th sampling) and was present at all following sampling days. A relative abundance level of 2 was recorded on sampling days 6, 8, 9, and 16. The species was mainly found in benthic samples, in planktonic samples, it was observed on sampling days 13 and 20. Hyperniche model with T and light attenuation provided the best fit (Fig. 8). T increased from 10°C in April to 20°C in May, coinciding with the first recorded occurrence of *G. loitlesbergerianum* at 19°C. The species was observed across a T range of 14°C to 28°C, with peak abundances occurring between 20°C and 25°C. Notably, it remained present in October when T fell below 20°C. Furthermore, *G. loitlesbergerianum* was recorded on

sampling days with light attenuation values ranging from μ = 0.27 in May and 3.67 in August.

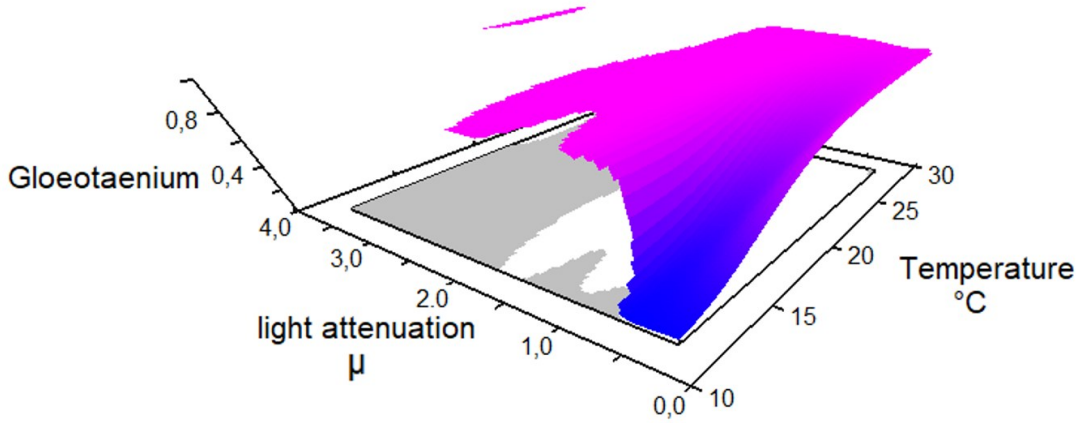

Figure 8. Ecological niche for *G. loitlesbergerianum* based on environmental factors, temperature (°C) and light attenuation (μ). The model uses three color codes: blue indicates absence of *G. loitlesbergerianum*, pink indicates presence, and grey indicates no available data.

Representative morphological stages of *G. loitlesbergerianum* are shown in Figure 9, including unicellular and multi-celled forms as observed under light microscopy.

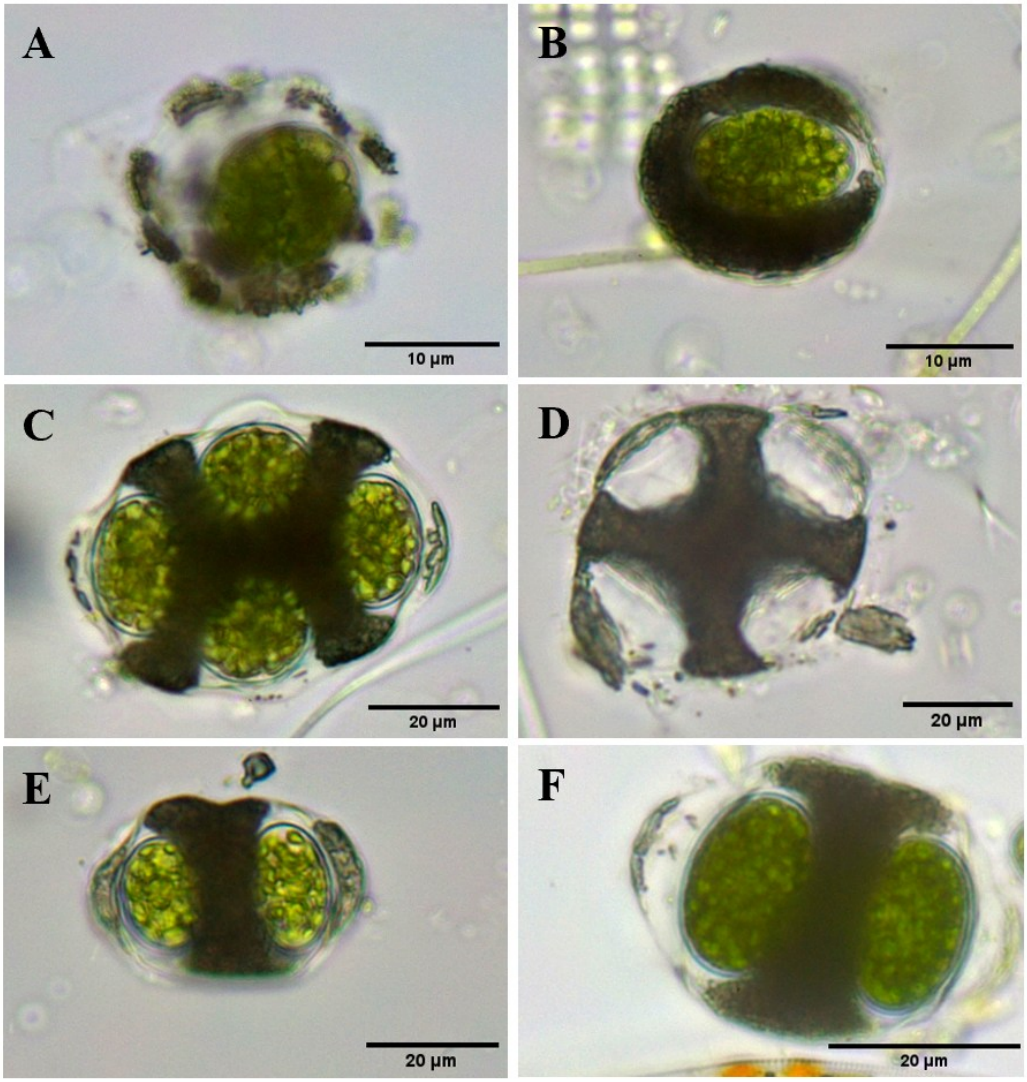

Figure 9. Light microscopy images of *G. loitlesbergerianum*. A–B: Mature unicellular individuals; **C:** Four-celled family, front view; **D:** Four-celled family, front view, empty; **E:** Four-celled family, lateral view; **F:** Two-celled family, lateral view. Own material, processed using ImageJ (Schneider et al., 2012).

Environment and algal community

RDA explained a total of 57.3% of total variation. The first two RDA axes were statistically significant accounting for 59.0% of the explained fitted variance (Tab. 2). The subsequent axes were not considered relevant for model interpretation, as they did not contribute significantly to the explained variance.

Table 2. Summary of RDA results based on Hellinger-transformed taxa abundances. The table displays eigenvalues, cumulative explained variation, pseudo-canonical correlations, and the cumulative explained fitted variation for axis 1 and 2. P-values indicate the statistical significance of their contribution to the explained variation in relation to the environmental variables.

Statistics	Axis 1	Axis 2
Eigenvalues	0.08189	0.03309
Explained variation (cum.)	24.06%	33.15%
Pseudo-canonical correlation	0.69	0.42
Explained fitted variation (cum.)	41.98%	58.95%
P value	0.001	0.002

The first RDA axis was primarily related to Chl-a, SiO_4-Si and light attenuation. The second axis reflected mostly T and Na^+, while alkalinity had a negative influence. The most influential and statistically significant variables were SiO_4-Si, T and alkalinity (Tab. 3). TP and SO_4^{-3} did not show a significant influence.

Table 3. Summary table of significant explanatory variables to the RDA model, including VIF, R^2 and p values. Abbreviations of variables: T, temperature; Att, light attenuation, Alk, alkalinity; Na; sodium.

Variable	RDA1	RDA2	VIF	R^2	p value
SiO_4-Si	0.976	-0.216	3.97	0.7502	0.001 ***
pH	-0.948	0.317	2.5	0.4112	0.005 **
T	0.646	0.763	2.7	0.6362	0.001 ***
Att	0.999	-0.035	1.66	0.4229	0.001 ***
Alk	0.498	-0.867	2.8	0.5606	0.001 ***
Chl-a	0.989	0.147	2.93	0.4629	0.002 **
Na	-0.739	0.674	2.17	0.3858	0.003 **

Conditional effects analysis indicated that SiO_4-Si, T and TP had significant independent effects on species composition (Tab. 4). Alkalinity, SO_4^{-3}, and Na^+ exhibited marginal significant effects in both the simple and conditional tests.

Table 4. Contribution of SiO_4-Si, temperature, and total phosphorus to the explained variation based on conditional effects. The table reports the Pseudo-F statistic, unadjusted p-values, and false discovery rate (FDR)-adjusted p-values. Abbreviations of variables: T, temperature; TP, total phosphorus.

Variable	Pseudo-F	p	p (adj., FDR)
SiO_4-Si	5.76	0.001	0.009
T	3.22	0.004	0.016
TP	2.41	0.002	0.014

To gain insight into the relative contribution of algal groups to the overall taxa number, percentage based on presence data of diatoms, green algae, Cyanobacteria,

Chrysophyceae and Euglenophyta were analyzed for each sampling day (Fig. 10). The category "remain" comprises all other algae groups, Cryptophyta, Dinophyta and Rhodophyta. Benthic and planktonic algal taxa were analyzed as combined data, because no significant compositional dissimilarity was observed (Mantel test: $r = 0.62$, $p = 0.001$). Algal group composition was almost constant during seasons, with only minor changes observed. In spring, diatoms had the highest taxa number, contributing 22% to the community, while in summer and early autumn, they only accounted for 10–15%. Green algae consistently exhibited the highest taxa number across all sampling days (55-65%). However, during summer, taxa richness increased dramatically for green algae, leading to greater algal diversity. Chrysophyceae made up about 5% of the algal taxa in spring and autumn and were nearly absent during summer months. The algal taxa of Cyanobacteria nearly doubled from around 10% in spring to around 20% in summer and autumn. Euglenophyta were present in early summer (2%), but their algal taxa increased towards the end of summer and autumn to 2-4%.

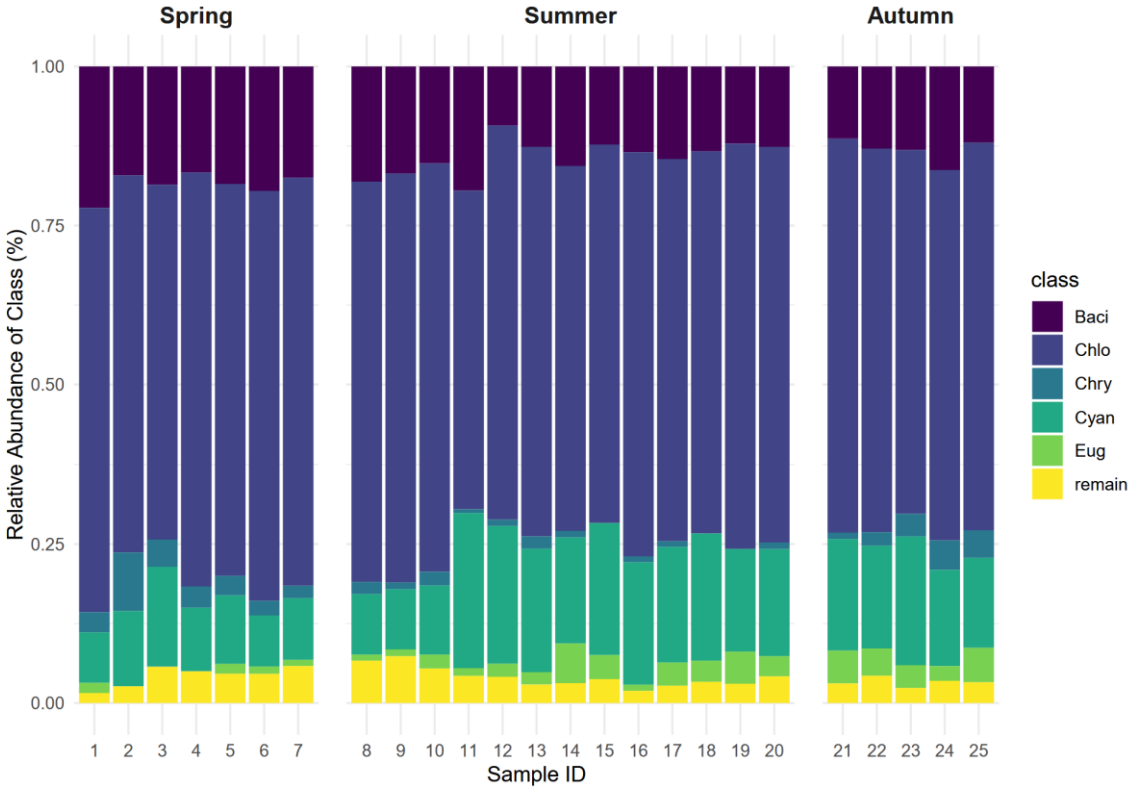

Figure 10. Composition of algal groups across sampling days. The x-axis represents sample days, with distinct segments for each season (Spring: 1–7, Summer: 8–20, Autumn: 21–25), illustrating seasonal variations in algal group composition. The y-axis depicts number of taxa of each class in percentage. Each class is distinguished by a different color, as indicated in the legend. Abbreviations: Baci, Bacillariophyta (Diatoms); Chlo, Chloro- & Streptophyta; Chry, Chrysophyceae; Cyan, Cyanobacteria; Eug, Euglenophyta; "remain": Cryptophyceae, Dinophyta and Rhodophyta.

The algal community displayed seasonal patterns across major algal groups, including diatoms, green algae, Cyanobacteria, and several smaller taxonomic groups. Figure 11 displays light microscopy images of several representative species. In spring, diatoms were dominated by benthic or tychoplanktic species such as *Cymbella* spp., *Navicula* spp., and especially *Epithemia sorex* (Kützing) and *Staurosira construens* (Ehrenberg). During early summer, the community included *E. sorex* and *Epithemia turgida* (Ehrenberg) Kützing, along with *Amphipleura pellucida* (Kützing) Kützing (Fig. 11E), Navicula spp., *Epithemia gibba* (Ehrenberg) Kützing, and *Nitzschia* spp. In late summer, more planktic taxa occurred, *Fragilaria crotonensis* (Kitton) and *S. construens* were particularly common. By autumn, *F. crotonensis* and *S. construens, Navicula* spp., and *Nitzschia* spp. continued to be moderately abundant.

The spring assemblage of Chloro- & Streptophyta comprised benthic species, including *Oedogonium* sp., *Spirogyra* sp., *Cosmarium reniforme* (Ralfs) W.Archer, and also planktic taxa like *Neglectella solitaria* (Wittrock) Stenclová & Kaštovský, *Pseudopediastrum boryanum* (Turpin) E.Hegewald, and *Botryococcus braunii* (Kützing). Early summer brought a more diverse composition in green algae like *Coelastrum microporum* (Nägeli), *Willea rectangularis* (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko, *Staurastrum manfeldtii* (Delponte), *Cosmarium neodepressum* (G.J.P.Ramos & C.W.N.Moura). Also, the very special desmid *Micrasterias crux-melitensis* (Ralfs), was documented on July 1st a species commonly found in peat bogs. In late summer, the community included more planktic taxa *B. braunii, Desmodesmus armatus* (Chodat) E.H.Hegewald, *Lacunastrum gracillimum* (West & G.S.West) H.A.McManus, *Cosmarium moniliforme* (Ralfs), *Heimansia pusilla* (L.Hilse) Coesel, and *Staurastrum teliferum var. gladiosum* (W.B.Turner) Coesel & Meesters. In autumn, a mixture of species from *Staurastrum tetracerum* (Ralfs ex Ralfs), *Euastrum bidentatum* (Nägeli) (Fig. 11B)*, Scenedesmus obtusus* (Meyen) and *Cosmarium reniforme* (Ralfs) W.Archer was noted. *Cosmarium* and *Scenedesmus* taxa were primarily observed in benthic samples, but were also detected in the plankton.

Cyanobacteria observations in spring included *Aphanocapsa* sp. and *Chroococcus limneticus* (Lemmermann). In early summer, cyanobacterial diversity increased with *Anabaena* sp., *Dolichospermum* sp. (Fig. 11D), *Aphanothece clathrata* (West & G.S.West), *C. limneticus, Merismopedia* sp., *Microcystis* sp., *Planktolyngbya limnetica* (Lemmermann) Komárková-Legnerová & Cronberg, and *Snowella lacustris* (Chodat) Komárek & Hindák. In late summer, the assemblage was additionally characterized by

Pseudanabaena sp., and *Chroococcus* sp. In autumn, *Aphanocapsa conferta* (West & G.S.West) Komárková-Legnerová & Cronberg, *P. limnetica*, and *S. lacustris* persisted.

In spring, planktonic Chrysophyceae like *Uroglenopsis americana* (G.N.Calkins) Lemmermann and a high abundance of *Dinobryon sertularia* (Ehrenberg) was recorded. In autumn, *Dinobryon divergens* (O.E.Imhof), *U. americana*, *D. sertularia* and *Synura* sp. were present again.

Within Dinophyta, spring marked the appearance of *Ceratium hirundinella* (O.F.Müller) Dujardin (Fig. 11F) which bloomed in May and was rare the following weeks. *Peridinium willei* (Huitfeldt-Kaas) was documented in the end of May and in early summer.

Euglenophyta observations included a few *Euglena* sp. in spring. *Phacus pleuronectes* (O.F.Müller) Nitzsch ex Dujardin (Fig. 11G) was observed in early summer. In late summer, *Phacus salinus* (F.E.Fritsch) E.W.Linton & Karnkowska and *Euglena sanguinea* (Ehrenberg) appeared. Both *P. pleuronectes* and *P. salinus* remained present in autumn.

Also rare Rhodophyta *Kyliniella latvica* (Skuja) was detected on July 1st during early summer.

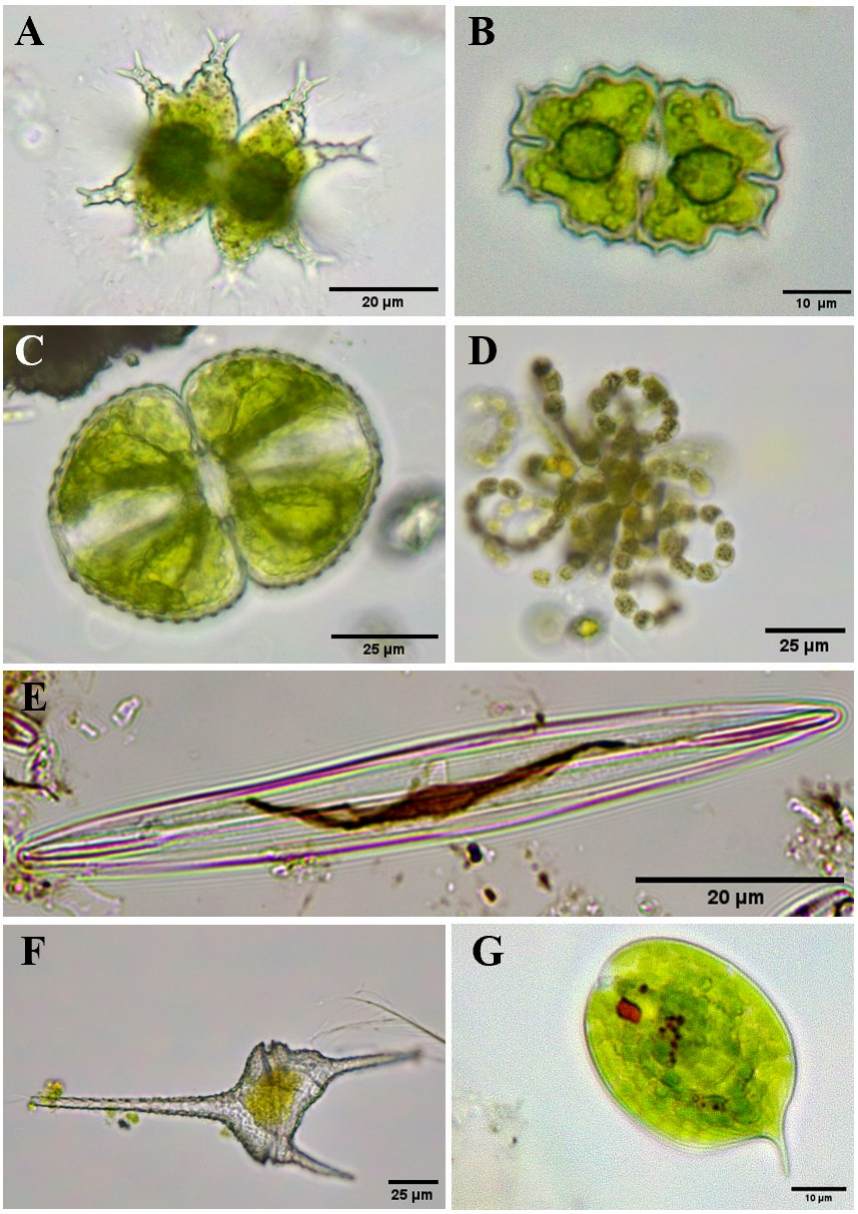

Figure 11. Light microscopy images of algae. A: *Staurastrum furcigerum* (Brébisson) W.Archer**, B:** *Euastrum bidentatum* Nägeli, **C:** *Cosmarium botrytis* Meneghini ex Ralfs, **D:** *Dolichospermum lemmermannii (Richter) P.Wacklin, L.Hoffmann & J.Komárek,* **E:** *Amphipleura pellucida* (Kützing) Kützing, **F:** *Ceratium hirundinella* (O.F.Müller) Dujardin, **G:** *Phacus pleuronectes (O.F.Müller)* Nitzsch ex Dujardin. Own material, processed using ImageJ (Schneider et al., 2012).

An RDA biplot was generated to display environmental variables with the 20 algal taxa with best fit to the model and all nine environmental variables (Fig. 12). *Cosmarium reniforme* (Ralfs) W.Archer was related to higher sulfate concentration. *Staurastrum tetracerum* (Ralfs ex Ralfs) showed positive associations with Chl-a. *Phacus salinus* (F.E.Fritsch) E.W.Linton & Karnkowska and *Dinobryon sociale* (Ehrenberg) Ehrenberg were present with higher alkalinity. Several green algae, including *Cosmarium*

moniliforme (Ralfs), *Pandorina morum* (O.F.Müller) Bory and *Tetraeëdron caudatum* (Corda) Hansgirg showed a preference for higher T. In contrast, *Dinobryon sertularia* Ehrenberg and *Staurosira venter* (Ehrenberg) Cleve & J.D.Möller were predominantly found at lower T. *Closterium leibleinii* (Kützing ex Ralfs) was observed at lower pH values. *Heimansia pusilla* (L.Hilse) Coesel and *Lacunastrum gracillimum* (West & G.S.West) H.A.McManus were associated with low Na^+ concentrations. Finally, *Lyngbya* sp. C.Agardh ex Gomont, 1892 and *Kirchneriella obesa* (West) West & G.S.West 1894 were present at higher TP concentrations.

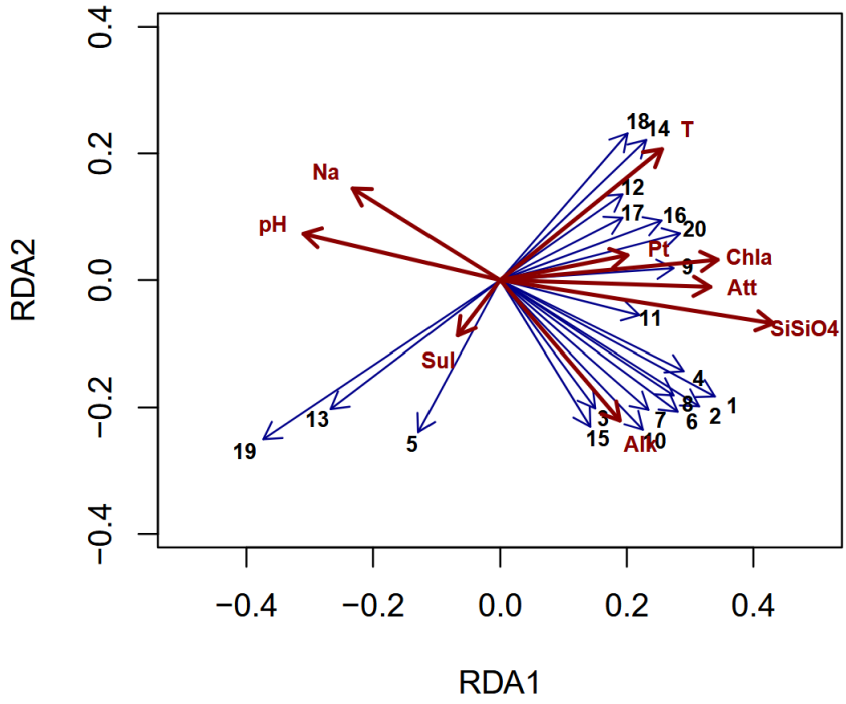

Figure 12. Biplot of RDA with environmental variables and 20 algae species fittest to the RDA model. Species names are presented as number (for explanation see supplementary table A2). Abbreviations of variables: T, temperature; Alk, alkalinity; Pt, total phosphorus; Na, sodium; Sul, sulfate; Att, light attenuation.

Discussion

Due to their pivotal role as primary producers at the base of the aquatic food web, algae serve as valuable indicators of environmental change (Haque et al., 2021; Li et al., 2022). Nutrient levels, T, and light conditions vary throughout the year and play a crucial role in shaping the algal community structure (Mesquita et al., 2020). As we assumed, a clear seasonal pattern in the composition of the algal community was observed. While Chrysophyceae were dominant in spring and September, diatoms were abundant in

spring. In summer, the algal community was characterized by a mixture of green algae, Dinophyta and Cyanobacteria. With T exceeding 25°C in August, a substantial increase in Cyanobacteria was documented. The seasonal occurrence of *G. loitlesbergerianum* in Alte Donau aligns with the initial hypothesis that its presence is influenced by rising T and shifting environmental conditions. This species was detected during warmer months, from May through early October, and was absent in early spring.

In total, 196 algal taxa were identified, and Shannon diversity indices ranged between 3.0 and 3.9 indicating a relatively high and balanced species diversity, with multiple taxa contributing substantially to the overall community composition. Chl-a concentrations varied between a minimum of 0.8 µg L^{-1} in April and a maximum of 6.7 µg L^{-1} in August, which was similar to previous observations in Alte Donau (Dokulil et al., 2018). The pronounced increase in Chl-a from June to July indicated summer phytoplankton development, likely driven by elevated T and increased light conditions (Dokulil et al., 2018). Furthermore, TP values ranged between 6 µg L^{-1} in March and 11 µg L^{-1} in August. Based on these findings and in accordance with Austrian standards (ÖNORM M6231:2001), Alte Donau was classified as mesotrophic close to oligotrophic, consistent with the classification reported by Dokulil et al. (2018). Chl-a is commonly used to estimate algal biomass because it is the primary photosynthetic pigment in all O_2 producing photosynthetic organisms (Ramaraj et al., 2015). Measured Chl-a reflected only phytoplankton and excluded macrophytes and benthic algae, which can contain substantial Chl-a. Roughly estimating this fraction would increase the total Chl-a and provide a more complete view of the system's trophic state. POM is a complex and dynamic component in lakes that includes both living and nonliving matter from within the lake and external sources. It plays a key role in influencing lake productivity, food web dynamics, and the behaviour of trace contaminants (Xu et al., 2019). The observed increase in POM towards autumn further supports the notion of accumulating organic material, reflecting both production and decay processes. A significant positive correlation was found between Chl-a and POM, indicating that algal biomass plays a major role in POM concentrations. These values showed that algae were an important component of POM, but also other planktic organisms and organic material like detritus significantly contributed to POM (Xu et al., 2019).

Shallow lakes benefit from a clear macrophyte-dominated state, as submerged aquatic vegetation plays a key role in enhancing water transparency by stabilizing sediments and reducing nutrient availability for algae (Scheffer, 1998). Moreover, the presence of

macrophytes is associated with lower algal biomass, as reflected in reduced Chl-a concentrations (Takamura et al., 2003). This reinforces the significant benefits of restoring Alte Donau through implementing macrophytes.

Seasonal Pattern

NMDS analysis showed that spring algal communities were more variable within the season, while summer and autumn communities were more stable and similar to each other, reflecting a gradual seasonal transition. These findings reflect a broader pattern in temperate lakes, where seasonality can be divided into two principal phases, a cold season (winter to spring) and a warm season (summer to autumn). Major shifts in species composition typically occur during the transitional periods between these phases (Teubner, 2000). The ability of algae to repeatedly acclimate to seasonal conditions over time promotes community stability, as certain taxonomic groups consistently dominate during specific seasons (Anneville et al., 2018; Dokulil & Teubner, 2024). Spring was characterized by higher heterogeneity in environmental conditions and species composition, likely driven by spring blooms, variable T and light availability, and changing stratification patterns. Fast growing r-strategists rapidly exploit the high resource availability in the cooler, well-mixed water column (Salmaso et al., 2015). In contrast, summer and autumn conditions appeared more stable, favouring the development of more homogeneous algal assemblages. Early summer was more dominated by K-strategists, which can be tolerant to fewer resources (Salmaso et al., 2015). This seasonal pattern aligns with previous studies that observed an influence of seasonal variations on the algal community structure and β-diversity (Tang et al., 2025). The production phase in spring is often marked by high primary productivity, which supports the development of a mature, high-biomass community by summer. In contrast, the diversification phase in autumn is characterized by a notable increase in species diversity as environmental conditions become more variable (Martí et al., 2005).

Algal diversity

Algal species composition closely resembled previous reports in Alte Donau (Dokulil et al., 2018). Several dominant species were identified, each displaying distinct seasonal patterns. Lowest diversity occurred in spring, suggesting a community structure co-dominated by fewer, more competitive taxa. Certain species rapidly take advantage of increasing light and nutrient availability after winter, like the Chrysophyceae *U. americana*, which formed blooms on the surface water in late spring. It can maintain

continuous growth even under extended periods of low-nutrient conditions, and has been linked to changes in taste and odor in many oligotrophic and mesotrophic systems during spring and autumn (Green & Hufhines, 2017). Another characteristic spring species was *Dinobryon* spp*.,* which is typically found in oligo- to mesotrophic waters. With pH levels in Alte Donau approaching 9, the presence of *Dinobryon divergens* is consistent with its known occurrence in environments where pH exceeds 8.7 (Lehman, 1976). Diatoms were most abundant in spring, coinciding with their preference for lower T. The benthic diatom *Epithemia sorex* typically thrives in oligo-mesotrophic freshwater environments, while it can also occur in brackish waters (Vishnyakov et al., 2014; Chiba et al., 2023). In our study, we observed a significant increase in the number of taxa from summer through autumn. During summer, higher T, increased stratification and macrophyte harvesting likely promoted the coexistence of a greater number of taxa in particular Cyanobacteria and green algae (Maberly et al., 2022). Aquatic macrophytes also play a crucial role in maintaining overall water quality and a clear-water state, which in turn supports a diverse and balanced phytoplankton community (Swe et al., 2021). Furthermore, dense macrophyte beds provide habitat and refuge for various microorganisms and zooplankton, helping to regulate nutrient cycling and limit the dominance of bloom forming algae (Amorim et al., 2025). An increase in Cyanobacteria like *Snowella lacustris* and *Planktolyngbya limnetica*, which is characteristic for shallow lakes in temperate regions was observed (Nõges et al., 2003; Dokulil et al., 2018). Potentially harmful species like *Dolichospermum* sp. and *Microcystis* sp*.,* known for bloom formation and toxin production (Paerl & Otten, 2013; Hobbs et al., 2021), were recorded only sporadically. Their ability to fix nitrogen and store phosphorus enables them to thrive in both nutrient-poor and nutrient-rich environments (Bryant, 2006). Additionally, some species achieve optimal growth at higher T, contributing to their abundance during the summer months (Paerl & Otten, 2013). As climate change progresses, these traits are likely to give Cyanobacteria a competitive advantage, potentially leading to increased dominance in aquatic ecosystems in the future. On the other hand, the rare species, *Micrasterias crux-melitensis*, was present in early summer. It is commonly found in the phytobenthos of mesotrophic, slightly acidic wetlands (Neustupa et al., 2010), thus highlighting the ecological richness of Alte Donau. The continued high diversity into early autumn indicated that environmental conditions remained favourable for a wide range of taxa. *P. pleuronectes* and *P. salinus* favoured warmer T and were particularly abundant in autumn. Euglenophyta thrive under elevated nutrient availability and are often used as

bioindicators of organic pollution (Sultana et al., 2024). A flood event, close to Vienna in September 2024 caused by heavy rainfall, likely contributed to increased nutrient inflow.

The occurrence of benthic taxa like various species of *Cosmarium*, *Closterium*, and *Spirogyra* in the water column suggested their temporary integration into the plankton. This may result from hydrodynamic mixing or wind-induced resuspension, processes commonly observed in shallow lake systems (Reynolds, 2006). Another reason could be the macrophyte harvesting which occurred frequently during summer in Alte Donau or heavy boat traffic. This may be the reason why there was no clear difference between benthic and planktonic samples.

A special focus on *Gloeotaenium loitlesbergerianum*

Although no single environmental variable was identified as a significant predictor for the presence of *G. loitlesbergerianum,* T appeared to play a potentially important role in shaping its distribution. This species was observed during the warmer months, from May through October, and was absent in early spring. It occurred across a relatively broad T range (14 – 28 °C), with peak abundances recorded between 20 °C and 25 °C. These findings are consistent with previous observations from tropical and subtropical regions, such as Brazil, where *G. loitlesbergerianum* was reported in waters with an annual average T of 24 °C (Ramos et al., 2021). Interestingly, in our study, the species remained detectable even in October when T dropped below 20 °C, indicating a certain degree of cold tolerance. This suggests that it can persist under cooler transitional conditions. Also light attenuation values ranged from 0.27 m^{-1} in late spring to 3.67 m^{-1} in late summer. The higher light attenuation observed in August coincided with elevated T, potentially creating synergistic conditions that favoured growth (Singh & Singh, 2015). Another possible factor contributing to the occurrence of *G. loitlesbergerianum* in Alte Donau may be the elevated pH levels in the system. The identification of $CaCO_3$ as the principal component of the observed band suggests potential calcification (Prasad & Chowdary, 1981). While $CaCO_3$ deposition is common among marine algae, it is considered relatively rare in freshwater taxa (Lewin, 1962). However, the exceptionally high pH conditions (>8.6) in Alte Donau, could create a chemical environment that favours precipitation of $CaCO_3$ (Dokulil et al., 2018). Therefore, the altered carbonate chemistry of the system may represent a previously underappreciated ecological driver behind the occurrence and persistence of *G. loitlesbergerianum*. However, given the lack of strong statistical associations, it is likely that other factors such as hydrological regime or

competition may also influence its occurrence and should be further explored in future studies.

Influence of environmental variables

The strong influence of SiO_4-Si, T and Chl-a indicated that spring dynamics were linked to diatom activity and bloom development, followed by reduced uptake and nutrient accumulation post-bloom. Warmer water has lower density and viscosity, which accelerates the sinking of particles (Zhang et al., 2023). At 4 °C, water has a density of approximately 0.99997 g/cm³ and a dynamic viscosity of 1.792 mPa·s. At 25 °C, the density decreases slightly to 0.99705 g/cm³ and the viscosity drops to 0.894 mPa·s, which facilitates faster sinking of particles in warmer water (Lange, 1999). These T dependent physical properties are often neglected in ecological studies, despite their potential influence on particle dynamics. In diatoms, sinking speed also depends on their physiological state. Larger diatoms tend to sink more rapidly, which can limit their productivity. However, by producing thinner frustules, they can slow their descent, extend the period available for photosynthesis, and reduce the energetic cost of buoyancy regulation, ultimately enhancing their fitness (Miklasz & Denny, 2010). Studies revealed that under light *Coscinodiscus wailesii* Gran & Angst 1931 exhibited a much wider range of sinking speeds when nutrients were depleted compared to when they were abundant (Du Clos et al., 2019). Alkalinity and light attenuation, representing a secondary environmental gradient, appeared to influence community structure during the warmer seasons

T emerged as one of the key environmental influences on algal communities, especially promoting the proliferation of green algae and several cyanobacterial species during summer (Rasconi et al., 2017). Particularly the increase in TP and T resulted in a higher algal biomass, as reflected in Chl-a concentrations. After all it should be mentioned that TP levels around 1990 were considerably higher, ranging between 50 and 70 μgL^{-1} (Dokulil et al., 2018), while highest TP concentrations in our study were 12 μgL^{-1}. This aligns with previous findings showing that warm T, pH and elevated nutrient levels enhance primary production of Cyanobacteria in shallow lakes (Havens & Paerl, 2015), which can have significant shifts in algal biodiversity (Frenken et al., 2023). In summer, calm weather and higher T can lead to temporary thermal stratification in Alte Donau, but it is typically unstable and breaks down with wind or weather changes (Dokulil et al.,

2018). Such instability is disadvantageous for organisms denser than water, as they cannot remain in the upper, light-rich layers (Miklasz & Denny, 2010).

Multiple species from the desmid genera *Cosmarium*, *Staurastrum*, and *Closterium* were observed, with their species richness increasing notably during the summer months. This pattern corresponds with previous research in other habitats, which identifies stratification as a key driver of growth and succession for these taxa (Reynolds et al., 2002; Souza et al., 2008; Padisák et al., 2009). Many desmid species are favoured under oligotrophic conditions (Huszar et al., 1998) in combination with partial atelomixis (Barbosa & Padisák, 2002). Although this is usually observed in tropical lakes, elevated T in Alte Donau, reaching nearly 30°C, may create similar conditions to this phenomenon.

In our study, the green algae *Cosmarium moniliforme*, *Pandorina morum* and *Tetraeëdron caudatum* showed a clear preference for higher T. This aligns with other findings (Rasconi et al., 2017), who reported a shift toward the dominance of algal taxa which thrive under warmer and more variable thermal conditions. Particularly *P. morum* is common in nutrient rich water bodies (Reynolds et al., 2002; Maileht et al., 2013). The presence of *Dinobryon sertularia* and *Staurosira venter* at lower T indicated that Chrysophyceae and diatoms are well adapted to cooler conditions, while warmer T may negatively affect the presence and abundance of diatoms (Mesquita et al., 2020).

The role of SiO_4-Si was equally prominent, especially in structuring diatom communities during spring. The seasonal dominance of tychoplanktonic and benthic diatoms in early samples mirrors past findings linking early spring diatom blooms to higher silica availability (Sommer, 1986). During spring, rapid diatom growth typically depletes the available silicic acid in the water to build their siliceous cell walls (frustules). As concentrations fall below critical thresholds, diatom growth becomes limited, leading to a decline in their abundance (Krause et al., 2019). The observed peak in SiO_4-Si concentrations during late summer is likely linked to low abundances in the pelagial caused by the high sinking velocities of heavy diatoms (Miklasz & Denny, 2010); in autumn diatoms are becoming more abundant again.

Alkalinity also had a major influence on the algal community, which was indicated in recent studies (Maileht et al., 2013). Another study demonstrated that alkalinity plays a central, yet previously underestimated role in the carbon cycle of freshwater lakes throughout the entire year (Perolo et al., 2023). In our studies, *Phacus salinus* and *Dinobryon sociale* were associated with higher alkalinity.

A distinct decrease in Cond was observed during the summer months, coinciding with a notable reduction in alkalinity in June. These parallel trends likely reflect enhanced photosynthetic activity of macrophytes, which reduce both ion concentrations and dissolved CO_2 in the water (Kahara & Vermaat, 2003). Macrophytes can only compete effectively with phytoplankton if they receive sufficient light to sustain photosynthesis (Xie et al., 2013). By altering nutrient ratios, reducing ionic stress, and stabilizing water chemistry, macrophytes create favourable conditions for certain algal groups, particularly r-strategists (Lv et al., 2019). Thanks to past macrophyte restoration efforts, Alte Donau maintains positive mesotrophic conditions, highlighting the crucial role of macrophytes as ecosystem engineers in shaping algal biomass and community composition.

Rising T is a significant threat to freshwater ecosystems. Already reaching 28 °C in summer, Alte Donau may face increased risks of cyanobacterial dominance under continued climate warming (Baker & Geider, 2021; Capon et al., 2021). Combined with higher nutrient availability, these shifts could further promote bloom formation and disrupt ecological balance (Kosten et al., 2012; Visser et al., 2016). Nevertheless, some macrophyte species are better able to tolerate high phytoplankton biomass, and those capable of enduring shading can maintain dominance, supporting overall ecosystem stability (Xie et al., 2013).

Conclusions

Our study aimed to investigate seasonal dynamics of algal communities in Alte Donau and to identify the key environmental drivers influencing these trends. Algal communities exhibited distinct seasonal patterns. Spring was dominated by diatoms and occasional blooms of Chrysophyceae, which can be interpreted as r-strategists taking advantage of abundant nutrients and favourable light conditions. These fast-growing species rapidly exploit the high resource availability in the cooler, well-mixed water column. In early summer, species richness was higher, reflecting a more diverse community dominated by K-strategists, like a desmid green algae *Cosmarium* and *Closterium*. Late summer and early autumn showed a pronounced increase in Cyanobacteria, which often behave as r-strategists. The shifts between r- and K-strategists reflect not only seasonal changes in T and light but also alterations in nutrient dynamics and physical water structure. This also indicates a transition toward algal communities that thrive under warmer T and altered nutrient regimes. Key environmental drivers identified in our study included SiO_4-Si, TP, pH, and alkalinity all of which influence community composition.

The occurrence of *G. loitlesbergerianum* during warmer months suggests that rising T and elevated pH may play a critical role in shaping its distribution and potential dominance. This – together with other findings – highlight the increasing sensitivity of Alte Donau to climate change and anthropogenic stressors.

Recent restoration measures in Alte Donau have successfully reduced nutrient loads, improving water quality and partially mitigating local pollution. These positive outcomes demonstrate that local management can restore ecosystem balance and reduce the dominance of harmful algae. However, climate change remains a pervasive threat, with rising T, altered stratification, and extreme weather events potentially destabilizing algal dynamics even in nutrient-improved waters. While local interventions (macrophyte restoration, nutrient control, pollution mitigation) can buffer the system, their effectiveness is limited under global-scale pressures, highlighting the need to integrate local restoration with broader climate action. Maintaining ecosystem services such as biodiversity, water quality, and recreational value will therefore require continued monitoring and adaptive management, alongside global efforts to combat climate change.

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Appendix

Table A1. Overview of Instrument Usage.

Parameter / Step	Manufacturer/ Model
Centrifugation of extracts	Eppendorf Centrifuge 5810 R – Germany
Conductivity	WTW pH/Cond 340i - Germany
Light intensity (surface & 0.75 m)	SKYE Instruments LTD, UVA UVB sensor, UK
Light Microscopy	Leica DM500, Leica DM 2000 Led, camera: Leica ICC50 W - Swiss
Oxygen concentration	Multiparameter Taschenmessgerät MultiLine® Multi 3510 IDS, WTW - Germany
pH and temperature	WTW pH 3310 pH-Messgerät pH-Wert, Temperatur - Germany
Pigment extraction	Branson Sonifier 250 - USA
Spectrophotometric measurement	VWR V-1200 Spectrophotometer - USA

Table A2. Full taxonomic names corresponding to the numbering in the RDA biplot.

Number	Taxon
1	*Heimansia pusilla* (L.Hilse) Coesel 1993
2	*Pseudanabaena* sp. Lauterborn, 1915
3	*Dinobryon sociale* (Ehrenberg) Ehrenberg 1834
4	*Lacunastrum gracillimum* (West & G.S.West) H.A.McManus 2011
5	*Cosmarium reniforme* (Ralfs) W.Archer 1874
6	*Scenedesmus quadricauda* (Turpin) Brébisson 1835
7	*Phacus salinus* (F.E.Fritsch) E.W.Linton & Karnkowska 2010
8	*Staurastrum cyrtocerum* Brébisson 1848
9	*Staurastrum tetracerum* Ralfs ex Ralfs 1848
10	*Scenedesmus obtusus* Meyen 1829
11	*Closterium leibleinii* Kützing ex Ralfs 1848
12	*Tetraëedron caudatum (Corda) Hansgirg 1888*
13	*Staurosira venter* (Ehrenberg) Cleve & J.D.Möller 1879
14	*Cosmarium moniliforme* Ralfs 1848
15	*Sorastrum spinulosum* Nägeli 1849
16	*Kirchneriella obesa* (West) West & G.S.West 1894
17	*Merismopedia* sp. Myen, 1839
18	*Pandorina morum* (O.F.Müller) Bory 1826
19	*Dinobryon sertularia* Ehrenberg 1834
20	*Lyngbya* sp. C.Agardh ex Gomont, 1892, nom. et typ. cons.

Table A3. Taxonomic list of plankton identified in Samples 1–25. This table presents the plankton taxa recorded across 25 samples, organized by major algal and zooplankton groups. For each taxon, abundance is scored on a semi-quantitative scale from 1 to 5, where 1 indicates rare occurrence and 5 indicates very high abundance.

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Bacillariophyceae																									
Asterionella formosa Hassall 1850	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Aulacoseira granulata (Ehrenberg) Simonsen 1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Aulacoseira sp. Thwaites, 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-
Cymbella sp. C.Agardh, 1830, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1
Epithemia sp. Kützing, 1844	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fragilaria crotonensis Kitton 1869	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Gomphosphaeria aponina Kützing 1836	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	-	1	-	-	1	-	-	1	-
Gyrosigma acuminatum (Kützing) Rabenhorst 1853	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Navicula oblonga (Kützing) Kützing 1844	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Navicula sp. Bory, 1822	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Nitzschia sp. Hassall, 1845, nom. cons.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Staurosira construens Ehrenberg 1843	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Chlorophyta & Streptophyta																									
Botryococcus braunii Kützing 1849	3	3	1	2	1	1	1	2	1	1	-	2	1	2	2	2	2	3	3	2	2	2	2	2	2
Bulbochaete sp. C.Agardh, 1817	-	-	1	1	-	-	1	-	1	-	1	-	-	1	1	1	-	-	-	1	-	-	-	-	1
Chlamydomonas sp. Ehrenberg, 1833, nom. et typ. cons.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Closterium acerosum Ehrenberg ex Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	1	-	-	1	-	1	-
Closterium aciculare T.West 1860	-	1	2	3	1	2	2	1	-	1	1	1	1	1	1	1	1	1	1	-	-	-	-	1	-
Closterium dianae Ehrenberg ex Ralfs 1848	-	-	-	-	1	1	1	-	1	1	1	1	1	1	1	-	2	1	1	1	-	-	-	1	1
Closterium incurvum Brébisson 1856	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Closterium leibleinii Kützing ex Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Closterium navicula (Brébisson) Lütkemüller 1905	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Closterium sp. Nitzsch ex Ralfs, 1848	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coelastrum astroideum De Notaris 1867	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	1	-	-	-	1
Coelastrum microporum Nägeli 1855	-	-	-	-	-	-	1	-	-	-	-	1	-	1	1	2	-	2	-	-	1	1	-	1	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Coelastrum pulchrum Schmidle 1892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Coenochloris fottii (Hindák) P.M.Tsarenko 1990	-	-	-	-	-	-	-	-	-	-	-	1	-	3	3	-	-	-	1	-	-	-	-	-	1
Comasiella arcuata (Lemmermann) E.Hegewald, M.Wolf, Al.Keller, Friedl & Krienitz 2010	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Cosmarium botrytis Meneghini ex Ralfs 1848	2	-	-	2	1	1	1	1	1	-	1	1	2	1	1	2	-	1	1	1	1	-	-	1	1
Cosmarium granatum Brébisson ex Ralfs 1848	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-
Cosmarium humile Nordstedt ex De Toni 1889	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cosmarium moniliforme Ralfs 1848	-	-	-	-	-	1	1	2	1	2	2	2	2	2	2	2	3	2	3	3	3	2	2	2	2
Cosmarium neodepressum G.J.P.Ramos & C.W.N.Moura 2020	-	-	-	2	1	1	1	-	1	2	2	2	2	2	2	2	2	2	2	1	2	2	-	2	1
Cosmarium reniforme (Ralfs) W.Archer 1874	2	2	2	-	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	2	2	2	-	2	1
Cosmarium sportella var. *subnudum* West & G.S.West 1908	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cosmarium turpinii Brébisson 1856	-	-	1	-	-	-	-	-	-	-	1	1	1	1	-	-	-	1	-	-	1	1	-	-	-
Cosmarium venustum var. *excavatum* (B.Eichler & Gutwinski) West & G.S.West 1895	-	-	-	1	-	-	-	1	-	-	-	-	1	-	-	2	1	-	1	-	-	-	-	-	-
Desmodesmus brasiliensis (Bohlin) E.Hegewald 2000	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Desmodesmus magnus (Meyen) P.M.Tsarenko 2000	-	-	-	-	-	-	1	-	-	1	-	1	1	1	1	-	1	1	-	-	1	2	-	2	1
Desmodesmus opoliensis (P.G.Richter) E.Hegewald 2000	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Dictyosphaerium ehrenbergianum Nägeli 1849	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dictyosphaerium Nägeli, 1849	1	-	1	1	1	1	-	1	-	1	1	1	2	2	1	1	2	1	2	2	2	2	-	2	2
Euastrum bidentatum Nägeli 1849	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-
Euastrum germanicum (Schmidle) Willi Krieger 1937	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	1	-	-	-	-
Euastrum sp. Ehrenberg ex Ralfs, 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Eudorina elegans Ehrenberg 1832	-	-	-	-	1	1	1	1	1	1	1	1	1	-	1	1	-	-	-	-	-	-	-	-	-
Geminella interrupta Turpin 1828	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Geminella Turpin, 1828	-	-	-	-	-	-	1	1	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Gloeotaenium loitlesbergerianum Hansgirg 1890	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-
Hariotina polychorda (Korshikov) E.Hegewald 2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-
Hariotina reticulata P.A.Dangeard 1889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	2	1	-	1	-	1	2
Heimansia pusilla (L.Hilse) Coesel 1993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	2

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Hindakia tetrachotoma (Printz) C.Bock, Pröschold & Krienitz 2010	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kirchneriella dianae (Bohlin) Comas 1980	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1
Kirchneriella obesa (West) West & G.S.West 1894	-	-	-	-	-	-	-	1	-	1	1	2	2	2	2	2	2	2	2	2	3	3	-	2	1
Klebsormidium sp. P.C.Silva, Mattox & W.H.Blackwell, 1972	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lacunastrum gracillimum (West & G.S.West) H.A.McManus 2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	3	2	2	3	2	1	1	1	1
Monoraphidium sp. Komárková-Legnerová, 1969	-	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mougeotia sp. C.Agardh, 1824, nom. cons.	2	2	-	1	1	-	1	1	-	1	-	-	1	1	1	1	1	1	2	1	2	1	1	1	-
Neglectella solitaria (Wittrock) Stenclová & Kaštovský 2017	-	-	-	1	1	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oedogonium sp. Link ex Hirn, 1900	1	-	-	2	1	1	1	1	1	-	1	-	-	-	1	1	-	-	1	2	2	-	-	-	2
Oocystis borgei J.W.Snow 1903	-	-	-	-	-	-	1	1	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oocystis sp. Nägeli ex A.Braun, 1855	-	2	-	-	-	-	1	-	-	-	1	-	-	-	-	-	2	-	-	2	2	2	-	-	-
Pandorina morum (O.F.Müller) Bory 1826	-	-	-	-	-	-	-	-	-	1	1	2	2	2	2	2	1	2	2	1	1	2	-	-	-
Pectodictyon cubicum Taft 1945	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	1	1	-	-	-	-	-	-
Pediastrum duplex Meyen 1829	-	-	-	-	-	1	1	2	1	1	1	1	1	1	-	-	-	-	-	-	-	1	-	2	2
Pleurotaenium ehrenbergii (Ralfs) De Bary 1858	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	1	-
Pleurotaenium trabecula Nägeli 1849	2	-	1	1	1	1	1	1	1	1	1	1	2	2	1	2	1	-	-	1	1	1	-	-	2
Pseudopediastrum boryanum (Turpin) E.Hegewald 2005	3	-	-	2	-	1	1	1	1	1	1	2	2	2	2	2	2	2	3	2	2	2	-	2	2
Pseudopediastrum boryanum var. *longicorne* (Reinsch) P.M.Tsarenko 2011	-	1	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudopediastrum cornutum (Raciborski) Lenarczyk 2020	-	-	2	2	1	1	-	-	-	-	1	2	2	2	1	1	2	2	2	2	2	2	-	2	2
Pseudopediastrum integrum (Nägeli) M.Jena & C.Bock 2014	-	-	1	-	-	-	-	-	-	1	-	-	-	-	2	2	1	1	1	2	1	-	-	-	-
Pseudopediastrum subgranulatum (Raciborski) Lenarczyk 2020	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Pseudostaurastrum enorme (Ralfs) Chodat 1921	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Quadricoccus sp. Fott, 1948	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radiofilum conjunctivum Schmidle 1894	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-
Scenedesmus obtusus Meyen 1829	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	2	-	-
Scenedesmus quadricauda (Turpin) Brébisson 1835	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	2	1	2	2	-	-	1	2
Scenedesmus semipulcher Hortobágyi 1960	-	-	-	-	-	-	-	1	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Scenedesmus sp. Meyen, 1829	1	-	-	-	1	1	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Spirogyra sp. Link, 1820, nom. cons.	-	-	-	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	2	2	2	2
Spirogyra spp. Link, 1820, nom. cons.	1	2	1	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum anatinum Cooke & Wills 1881	2	2	1	2	1	-	-	1	1	2	2	1	1	2	2	2	2	2	1	1	2	1	-	1	1
Staurastrum avicula Brébisson 1848	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum furcigerum (Brébisson) W.Archer 1861	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum lapponicum (Schmidle) Grönblad 1926	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Staurastrum manfeldtii Delponte 1878	-	-	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	2	2	1	1	-	1	1
Staurastrum sp. Meyen ex Ralfs, 1848	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum teliferum Ralfs 1848	-	-	-	-	-	-	-	1	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum teliferum var. *gladiosum* (W.B.Turner) Coesel & Meesters 2013	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	2	2	2	2	1	2	1	-	1	-
Staurastrum tetracerum Ralfs ex Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	2	-	-	-	1	-	-	-
Stauridium tetras (Ehrenberg) E.Hegewald 2005	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurodesmus cuspidatus (Brébisson) Teiling 1967	1	1	1	-	1	2	2	1	1	2	2	2	2	2	2	2	1	2	2	1	2	2	-	1	1
Tetraëdriella limbata Pascher 1938	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko 2014	-	2	2	2	1	1	2	2	1	2	1	2	2	2	2	2	2	2	2	1	2	2	-	2	-
Zygnema sp. C.Agardh, 1817, nom. et typ. cons.	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	-	-	-	-	-	-	-
Chrysophyceae																									
Dinobryon divergens O.E.Imhof 1887	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3
Dinobryon sertularia Ehrenberg 1834	1	3	1	1	4	4	1	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Dinobryon sociale (Ehrenberg) Ehrenberg 1834	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	2	2	2
Synura Ehrenberg, 1834	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Uroglenopsis americana (G.N.Calkins) Lemmermann 1899	-	4	4	3	3	3	2	1	1	2	1	2	2	1	-	2	2	-	-	-	-	1	2	3	4
Cryptophyceae																									
Cryptomonas sp. Ehrenberg, 1831	-	-	-	-	-	-	-	1	1	1	2	1	-	-	-	-	-	-	-	-	1	1	-	-	-
Rhodomonas sp. G.Karsten, 1898	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanobacteria																									
Anabaena sp. Bory ex Bornet & Flahault, 1886, nom. cons.	2	-	-	1	1	-	1	1	1	1	1	3	2	3	2	2	1	2	1	-	2	1	-	1	2

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Anathece clathrata (West & G.S.West) Komárek, Kaštovský & Jezberová 2011	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphanocapsa conferta (West & G.S.West) Komárková-Legnerová & Cronberg 1994	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphanocapsa delicatissima West & G.S.West 1912	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2	-	-	2	2
Aphanocapsa sp. Nägeli, 1849	1	-	-	1	1	-	1	2	-	1	-	-	2	2	-	-	1	-	2	2	2	-	-	2	2
Aphanothece sp. Nägeli, 1849, nom. cons.	-	-	-	-	-	-	-	-	-	-	-	3	2	2	1	-	-	-	1	-	2	-	-	2	2
Aphanothece stagnina (Sprengel) A.Braun 1863	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
Calothrix sp. C.Agardh ex Bornet & Flahault, 1886	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	1
Chroococcus sp. Nägeli, 1849	-	1	-	-	-	-	-	-	-	-	-	-	2	-	2	2	-	-	2	-	-	-	-	-	-
Chroococcus turgidus (Kützing) Nägeli 1849	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-	1	1	-	-	-	-	1
Coelosphaerium sp. Nägeli, 1849	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Cyanodictyon sp. Pascher, 1914	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-
Cylindrospermum sp. Kützing ex Bornet & Flahault, 1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Dolichospermum lemmermannii (Richter) P.Wacklin, L.Hoffmann & J.Komárek 2009	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
Dolichospermum sp. (Ralfs ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek, 2009	-	-	-	-	-	-	-	1	1	3	3	2	2	-	-	-	-	-	-	-	-	-	-	-	2
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová 2010	-	-	2	1	2	1	1	2	-	2	2	2	2	2	2	2	2	2	3	2	3	2	-	2	2
Lyngbya C.Agardh ex Gomont, 1892, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	1	2	2	2	2	-	-	1
Merismopedia sp. Meyen, 1839	-	-	-	-	-	-	-	-	-	1	1	1	1	2	2	1	2	2	2	2	2	2	-	-	-
Microcystis aeruginosa (Kützing) Kützing 1846	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Microcystis sp. Lemmermann, 1907, nom. et typ. cons.	-	1	1	1	1	2	1	2	1	1	1	2	2	-	2	2	2	2	2	2	-	2	2	2	1
Microcystis wesenbergii (Komárek) Komárek ex Komárek 2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Oscillatoria sp. Vaucher ex Gomont, 1892	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	2	-	-	2	1	2	-	-	1	-
Pannus sp. Hickel, 1991	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Phormidium sp. Kützing ex Gomont, 1892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg 1992	-	-	-	-	-	-	-	-	1	-	-	2	2	1	2	3	3	3	3	2	2	3	-	2	2

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pseudanabaena sp. Lauterborn, 1915	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Radiocystis geminata Skuja 1948	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-
Snowella lacustris (Chodat) Komárek & Hindák 1988	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	-	-	-	-	2	2	-	-	-	-
Tolypothrix sp. Kützing ex Bornet & Flahault, 1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Trichodesmium sp. Ehrenberg ex Gomont, 1892, nom. cons.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	1	-	1	-	-	-	-
Woronichinia naegeliana (Unger) Elenkin 1933	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dinophyta																									
Ceratium hirundinella (O.F.Müller) Dujardin 1841	1	1	2	3	2	3	4	4	4	2	3	3	3	2	2	2	3	2	2	3	3	3	2	2	2
Peridinium sp. Ehrenberg, 1830	-	1	1	1	1	3	4	-	-	-	-	-	2	2	2	2	2	2	1	1	2	2	-	2	2
Peridinium willei Huitfeldt-Kaas 1900	-	-	-	-	-	-	-	4	2	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Euglenophyta																									
Euglena ehrenbergii G.A.Klebs 1883	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Euglena sanguinea Ehrenberg 1832	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1	-
Euglena sp. Ehrenberg, 1830	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-
Lepocinclis acus (O.F.Müller) B.Marin & Melkonian 2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-
Phacus pleuronectes (O.F.Müller) Nitzsch ex Dujardin 1841	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	2	1	-	2	-	-	-
Phacus salinus (F.E.Fritsch) E.W.Linton & Karnkowska 2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	3	1	-	2	-	1	-

Table A4. Taxonomic list of benthos identified in Samples 1–25. This table presents the benthic taxa recorded across 25 samples, organized by major algal and zooplankton groups. For each taxon, abundance is scored on a semi-quantitative scale from 1 to 5, where 1 indicates rare occurrence and 5 indicates very high abundance.

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Bacillariophyceae																									
Amphipleura pellucida (Kützing) Kützing 1844	1	1	1	-	1	1	1	-	1	2	1	-	1	1	1	1	1	1	2	1	-	-	2	2	2
Amphora ovalis (Kützing) Kützing 1844	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aulacoseira granulata (Ehrenberg) Simonsen 1979	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Aulacoseira sp. Thwaites, 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-
Cyclotella sp. (Kützing) Brébisson, 1838, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1
Cymbella lanceolata C.Agardh 1830	-	-	-	1	2	2	2	1	-	2	-	2	3	3	1	-	2	-	2	-	-	1	-	2	-
Cymbella sp. C.Agardh, 1830, nom. et typ. cons.	1	1	1	1	2	2	2	2	1	1	2	1	2	2	1	1	1	2	-	-	-	-	-	-	-
Diatoma sp. Bory, 1824, nom. et typ. cons.	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Encyonema triangulum (Ehrenberg) Kützing 1849	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	-	1	-	1	-	-	-	-	-	-
Epithemia gibba (Ehrenberg) Kützing 1844	-	-	-	-	1	1	1	-	-	-	-	-	-	-	1	2	1	1	-	2	1	2	-	2	2
Epithemia sorex Kützing 1844	1	1	1	2	2	2	2	3	3	3	3	-	3	1	2	2	2	-	2	2	2	-	2	2	2
Epithemia sp. Kützing, 1844	1	1	2	2	-	-	3	2	-	2	3	2	2	2	-	-	2	2	-	-	-	-	-	-	-
Epithemia turgida (Ehrenberg) Kützing 1844	-	-	-	-	1	1	1	2	1	1	2	-	2	-	1	1	1	1	1	-	1	-	1	1	-
Fragilaria crotonensis Kitton 1869	-	1	1	2	1	2	-	1	1	2	2	-	2	2	1	2	2	2	2	2	2	2	2	2	2
Fragilaria sp. Lyngbye, 1819	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gomphosphaeria aponina Kützing 1836	-	-	1	-	-	1	-	-	1	1	1	-	-	-	1	1	1	1	1	1	2	1	1	1	1
Gyrosigma acuminatum (Kützing) Rabenhorst 1853	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mastogloia sp. Thwaites ex W.Smith, 1856	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	1	1	1	2	-
Meridion circulare (Greville) C.Agardh 1831	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Navicula oblonga (Kützing) Kützing 1844	1	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
Navicula sp. Bory, 1822	1	2	2	3	3	2	2	2	2	4	3	2	3	3	2	2	3	3	3	3	4	3	3	4	4
Navicula tripunctata (O.F.Müller) Bory 1822	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1
Nitzschia acicularis (Kützing) W.Smith 1853	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitzschia sigmoidea (Nitzsch) W.Smith 1853	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-
Nitzschia sp. Hassall, 1845, nom. cons.	1	-	-	-	2	1	1	-	1	3	2	2	2	2	2	2	2	2	2	2	3	2	3	3	4

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pinnularia sp. Ehrenberg, 1843, nom. et typ. cons.	1	1	-	-	-	-	-	1	1	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	-
Staurosira construens Ehrenberg 1843	-	1	2	-	-	-	2	1	1	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
Staurosira venter (Ehrenberg) Cleve & J.D.Möller 1879	-	1	1	2	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surirella librile (Ehrenberg) Ehrenberg 1845	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Surirella sp. Turpin, 1828	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Tabellaria sp. Ehrenberg ex Kützing, 1844	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Ulnaria ulna (Nitzsch) Compère 2001	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
Chlorophyta & Streptophyta																									
Ankistrodesmus falcatus (Corda) Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ankistrodesmus fusiformis Corda 183	1	-	1	1	1	1	1	1	-	1	1	1	1	-	1	-	-	-	-	-	-	-	-	1	-
Ankistrodesmus spiralis (W.B.Turner) Lemmermann 1908	-	-	-	-	1	1	-	-	-	1	-	-	1	1	1	1	1	-	-	1	1	1	1	-	1
Ankyra judayi (G.M.Smith) Fott 1957	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-
Botryococcus braunii Kützing 1849	2	-	1	2	1	-	1	-	1	1	1	2	1	1	2	2	2	2	2	2	2	3	2	2	2
Bulbochaete sp. C.Agardh, 1817	-	-	-	-	1	1	1	1	1	1	1	1	1	-	1	1	2	-	1	-	-	-	-	-	-
Chlamydocapsa sp. Fott, 1972	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Chlamydomonas sp. Ehrenberg, 1833, nom. et typ. cons.	-	-	-	-	-	1	-	1	-	1	1	1	1	-	1	2	1	2	2	-	-	2	-	-	-
Closterium acerosum Ehrenberg ex Ralfs 1848	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	-	-	-	-	-	1	1	-	1
Closterium aciculare T.West 1860	-	-	-	-	-	1	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-
Closterium dianae Ehrenberg ex Ralfs 1848	-	-	-	-	-	-	1	1	1	1	1	1	2	2	2	2	-	2	1	1	1	1	1	-	1
Closterium leibleinii Kützing ex Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	1	1	1	1	1	1	1	1	1	1
Closterium navicula (Brébisson) Lütkemüller 1905	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1	1	2	1	1	-
Closterium sp. Nitzsch ex Ralfs, 1848	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coelastrum astroideum De Notaris 1867	-	-	-	-	-	-	-	-	1	1	1	1	1	-	-	-	1	2	2	2	2	1	-	1	-
Coelastrum microporum Nägeli 1855	-	1	1	1	1	1	-	1	1	1	1	1	2	2	1	1	1	-	1	2	-	1	1	2	2
Coelastrum pulchrum Schmidle 1892	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Coenochloris fottii (Hindák) P.M.Tsarenko 1990	-	-	-	-	-	-	-	-	-	-	2	2	2	-	-	2	2	-	-	2	2	-	-	-	-
Comasiella arcuata (Lemmermann) E.Hegewald, M.Wolf, Al.Keller, Friedl & Krienitz 2010	-	-	-	-	-	1	1	-	1	1	1	1	1	-	-	-	-	-	-	2	2	2	2	-	2
Cosmarium botrytis Meneghini ex Ralfs 1848	-	2	-	-	-	1	1	1	1	1	1	-	1	1	1	1	1	-	1	1	1	-	1	-	1
Cosmarium crenulatum Nägeli 1849	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	1	1	1	-	-	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Cosmarium granatum Brébisson ex Ralfs 1848	-	-	-	-	-	-	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	-	-	1
Cosmarium humile Nordstedt ex De Toni 1889	-	-	1	2	2	1	2	-	2	2	1	2	2	2	1	2	2	2	2	2	1	2	2	2	2
Cosmarium moniliforme Ralfs 1848	-	-	-	-	-	-	2	1	-	-	1	1	1	1	1	2	2	2	2	2	2	-	-	2	2
Cosmarium neodepressum G.J.P.Ramos & C.W.N.Moura 2020	2	-	-	1	-	1	1	-	-	1	1	2	1	2	1	3	3	2	2	2	2	2	1	2	2
Cosmarium reniforme (Ralfs) W.Archer 1874	-	2	3	2	2	1	1	1	1	1	1	1	1	1	-	2	2	2	2	1	2	1	2	2	2
Cosmarium sp. Corda ex Ralfs, 1848	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cosmarium sportella var. *subnudum* West & G.S.West 1908	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cosmarium turpinii Brébisson 1856	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	-	-	-
Cosmarium venustum var. *excavatum* (B.Eichler & Gutwinski) West & G.S.West 1895	-	-	2	1	1	1	1	-	2	1	1	1	2	1	1	2	2	2	2	2	2	2	2	2	2
Desmodesmus armatus (Chodat) E.H.Hegewald 2000	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-
Desmodesmus brasiliensis (Bohlin) E.Hegewald 2000	-	-	-	-	-	1	1	1	1	2	1	2	1	2	-	2	3	2	1	-	2	-	-	2	1
Desmodesmus magnus (Meyen) P.M.Tsarenko 2000	-	-	1	-	-	1	-	-	1	1	1	1	2	1	1	1	2	1	1	-	1	2	1	2	2
Desmodesmus opoliensis (P.G.Richter) E.Hegewald 2000	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	2	-	-	-	-	-	-	-	-
Desmodesmus subspicatus (Chodat) E.Hegewald & A.W.F.Schmidt 2000	-	-	-	-	-	1	1	1	1	1	1	1	-	-	2	2	2	-	1	2	2	-	-	-	2
Dictyosphaerium ehrenbergianum Nägeli 1849	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dictyosphaerium Nägeli, 1849	2	-	-	-	-	-	-	-	-	-	-	-	1	2	1	2	-	2	2	2	2	1	2	-	2
Euastrum bidentatum Nägeli 1849	-	1	-	-	-	1	1	1	1	-	1	1	1	2	1	1	2	1	1	1	-	2	2	1	2
Euastrum germanicum (Schmidle) Willi Krieger 1937	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	-	1	1	-	1
Euastrum sp. Ehrenberg ex Ralfs, 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eudorina elegans Ehrenberg 1832	-	-	1	1	-	1	1	-	-	-	-	1	-	-	1	1	2	1	-	1	-	-	1	1	-
Geminella Turpin, 1828	-	-	-	-	-	-	1	-	1	1	-	1	1	1	-	1	1	-	-	-	1	-	-	-	1
Gloeotaenium loitlesbergerianum Hansgirg 1890	-	-	-	-	1	2	1	2	2	1	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Hariotina polychorda (Korshikov) E.Hegewald 2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-
Hariotina reticulata P.A.Dangeard 1889	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	2	1	-	-	2	1	-	1
Heimansia pusilla (L.Hilse) Coesel 1993	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	2	2	2	2	3	2	4	3	2	3
Kirchneriella obesa (West) West & G.S.West 1894	-	-	-	-	-	1	1	-	-	-	-	1	-	-	-	1	2	2	2	2	2	2	2	-	2
Klebsormidium sp. P.C.Silva, Mattox & W.H.Blackwell, 1972	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Lacunastrum gracillimum (West & G.S.West) H.A.McManus 2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	2	2	1	1	1	-	-
Lagerheimia genevensis (Chodat) Chodat 1895	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2	-	-	-	-
Micrasterias crux-melitensis Ralfs 1848	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Mougeotia sp. C.Agardh, 1824, nom. cons.	-	1	-	-	1	1	1	1	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-
Neglectella solitaria (Wittrock) Stenclová & Kaštovský 2017	-	-	1	2	1	-	2	-	2	2	2	2	2	2	-	-	2	-	-	-	-	-	-	-	1
Oedogonium sp. Link ex Hirn, 1900	3	-	1	1	1	-	2	1	1	2	2	2	2	2	1	1	1	1	1	1	1	1	2	2	2
Oocystis sp. Nägeli ex A.Braun, 1855	-	2	-	-	-	-	-	3	3	-	2	2	2	3	1	2	2	2	2	-	2	2	-	-	2
Pectodictyon cubicum Taft 1945	-	-	-	-	-	-	-	-	-	-	-	1	2	1	-	2	2	2	-	2	-	1	1	2	1
Pediastrum duplex Meyen 1829	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phacotus lenticularis (Ehrenberg) Diesing 1866	-	-	-	1	-	-	1	1	1	1	1	1	1	2	1	2	1	1	-	2	2	2	1	-	2
Pleurotaenium ehrenbergii (Ralfs) De Bary 1858	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1	-	-
Pleurotaenium trabecula Nägeli 1849	1	1	1	-	1	1	2	1	1	1	1	2	2	1	1	1	-	-	1	-	-	1	1	1	1
Pseudopediastrum boryanum (Turpin) E.Hegewald 2005	2	2	-	-	1	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Pseudopediastrum boryanum var. *longicorne* (Reinsch) P.M.Tsarenko 2011	-	-	-	-	-	-	2	-	1	1	1	-	1	1	1	1	1	-	2	-	-	-	1	-	1
Pseudopediastrum cornutum (Raciborski) Lenarczyk 2020	-	2	2	1	-	1	-	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	-	2
Pseudopediastrum integrum (Nägeli) M.Jena & C.Bock 2014	-	-	-	-	-	-	-	-	1	1	1	1	-	1	1	1	1	-	-	-	-	-	-	-	-
Pseudopediastrum subgranulatum (Raciborski) Lenarczyk 2020	-	-	1	-	-	-	-	-	1	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-
Pseudostaurastrum enorme (Ralfs) Chodat 1921	-	-	1	-	1	-	1	-	1	2	1	-	1	1	1	1	1	1	1	2	1	2	2	2	2
Quadricoccus sp. Fott, 1948	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Radiofilum conjunctivum Schmidle 1894	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	2	2	1	1	2	2
Scenedesmus obtusus Meyen 1829	-	-	-	-	1	1	1	-	-	-	-	-	-	-	2	1	2	2	2	2	2	2	2	2	2
Scenedesmus quadricauda (Turpin) Brébisson 1835	-	-	-	-	-	1	1	-	-	-	-	-	-	-	2	2	3	2	2	2	3	2	2	2	2
Scenedesmus semipulcher Hortobágyi 1960	-	-	-	-	-	-	-	1	1	1	1	1	2	2	-	-	-	-	-	-	-	-	-	-	-
Scenedesmus sp. Meyen, 1829	2	1	1	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sorastrum spinulosum Nägeli 1849	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	2	3
Spirogyra sp. Link, 1820, nom. cons.	-	-	-	1	1	1	1	1	1	2	1	1	1	1	2	1	2	-	1	-	2	2	2	-	1
Spirogyra spp. Link, 1820, nom. cons.	2	1	1	3	-	-	1	1	2	-	1	-	1	-	1	-	-	-	2	-	-	-	1	-	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Spondylosium ellipticum West & G.S.West 1902	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Staurastrum anatinum Cooke & Wills 1881	1	-	1	1	1	-	1	-	1	1	1	1	1	-	1	1	-	1	2	2	-	2	-	-	1
Staurastrum cyrtocerum Brébisson 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2	2	2	2	2	2	-	2
Staurastrum furcigerum (Brébisson) W.Archer 1861	-	-	-	-	-	-	-	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum lapponicum (Schmidle) Grönblad 1926	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	-	1	1	2	1	2	2	2	-
Staurastrum manfeldtii Delponte 1878	-	-	-	1	-	-	1	1	1	-	-	-	1	1	1	1	1	-	1	1	-	-	-	-	1
Staurastrum punctulatum Brébisson 1848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Staurastrum sp. Meyen ex Ralfs, 1848	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum teliferum Ralfs 1848	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Staurastrum teliferum var. *gladiosum* (W.B.Turner) Coesel & Meesters 2013	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	2	2	1	-	-	1	-	-	1
Staurastrum tetracerum Ralfs ex Ralfs 1848	-	-	-	-	-	-	-	-	-	1	1	1	2	1	1	2	2	2	1	2	2	2	2	2	2
Stauridium tetras (Ehrenberg) E.Hegewald 2005	-	1	1	-	1	1	1	-	1	1	1	1	1	1	2	2	1	1	2	2	2	1	1	2	2
Staurodesmus cuspidatus (Brébisson) Teiling 1967	1	-	1	1	-	1	1	2	1	1	1	1	2	2	2	2	1	1	2	2	2	2	2	2	2
Tetraëdriella limbata Pascher 1938	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	-
Tetraëdron caudatum (Corda) Hansgirg 1888	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	1	2	2	2
Tetraëdron minimum (A.Braun) Hansgirg 1889	-	-	-	1	1	1	1	1	1	1	1	2	1	2	2	2	2	2	1	2	1	1	2	-	-
Tetraëdron triangulare Korshikov 1953	-	-	-	-	-	1	1	1	-	-	1	1	2	1	2	1	1	1	1	2	1	-	1	1	-
Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko 2014	-	-	-	1	-	1	-	1	1	1	1	1	1	2	1	1	-	-	1	1	-	-	-	-	-
Zygnema sp. C.Agardh, 1817, nom. et typ. cons.	-	2	1	1	1	1	2	1	1	1	1	1	1	1	1	-	1	1	1	1	-	1	-	-	2
Rhodomonas sp. G.Karsten, 1898	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanobacteria																									
Anabaena sp. Bory ex Bornet & Flahault, 1886, nom. cons.	-	2	1	1	-	1	2	1	1	2	3	1	3	3	2	2	2	2	2	2	2	2	2	2	2
Anathece clathrata (West & G.S.West) Komárek, Kaštovský & Jezberová 2011	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Anathece smithii (Komárková-Legnerová & Cronberg) Komárek, Kaštovský & Jezberová 2011	-	-	-	-	-	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphanocapsa conferta (West & G.S.West) Komárková-Legnerová & Cronberg 1994	-	-	-	-	-	-	-	-	1	-	2	2	2	2	1	-	-	-	-	-	-	-	3	2	-

Taxon	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Aphanocapsa delicatissima West & G.S.West 1912	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	-	-
Aphanocapsa holsatica (Lemmermann) G.Cronberg & Komárek 1994	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Aphanocapsa incerta (Lemmermann) G.Cronberg & Komárek 1994	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphanocapsa sp. Nägeli, 1849	-	2	1	1	-	1	2	-	-	1	2	2	3	2	2	2	3	3	3	2	3	3	2	-	2
Aphanothece sp. Nägeli, 1849, nom. cons.	1	1	-	-	-	-	-	-	-	1	-	-	2	2	2	2	3	3	3	2	2	2	2	2	2
Aphanothece stagnina (Sprengel) A.Braun 1863	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	2	2	-	2	-	2	-	-
Calothrix sp. C.Agardh ex Bornet & Flahault, 1886	-	-	-	-	-	-	1	1	1	1	2	2	1	2	1	1	2	-	-	2	1	1	1	-	-
Chroococcus sp. Nägeli, 1849	1	-	2	-	-	-	1	-	-	-	2	2	1	2	2	3	3	3	-	-	-	3	-	-	2
Chroococcus turgidus (Kützing) Nägeli 1849	-	-	2	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	2	1	2	1	-	-
Coelosphaerium sp. Nägeli, 1849	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichospermum lemmermannii (Richter) P.Wacklin, L.Hoffmann & J.Komárek 2009	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichospermum sp. (Ralfs ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek, 2009	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
***Gloeotrichia natans* Rabenhorst ex Bornet & Flahault 1886**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1	1	-	-	-	-	-	-
Leptolyngbya Anagnostidis & Komárek, 1988, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnococcus limneticus (Lemmermann) Komárková, Jezberová, O.Komárek & Zapomelová 2010	-	2	2	1	1	-	-	-	1	1	2	2	2	2	2	2	3	2	2	2	2	3	2	2	2
Lyngbya C.Agardh ex Gomont, 1892, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	1	-	-	2	2	3	-	2	2	2	2	2	2	-	1
Merismopedia sp. Meyen, 1839	-	-	-	1	1	1	1	1	1	1	1	1	3	2	1	3	3	3	2	3	3	4	3	2	2
Microcystis sp. Lemmermann, 1907, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	1	-	-	-	-	-	-	-	-	-
Nostoc sp. Vaucher ex Bornet & Flahault, 1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
Oscillatoria sp. Vaucher ex Gomont, 1892	-	-	1	1	-	1	1	1	-	1	1	1	1	2	2	2	2	-	2	2	2	1	2	1	1
Pannus sp. Hickel, 1991	-	-	-	-	-	-	-	-	-	-	2	1	1	1	-	-	2	2	-	2	-	2	2	-	2
Phormidium sp. Kützing ex Gomont, 1892	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Planktolyngbya limnetica (Lemmermann) Komárková-Legnerová & Cronberg 1992	-	-	-	-	-	-	-	-	-	-	-	3	4	4	3	3	4	4	3	3	3	3	2	3	3
Planktolyngbya sp. Anagnostidis & Komárek, 1988	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Taxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Pseudanabaena catenata Lauterborn 1915	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Pseudanabaena limnetica (Lemmermann) Komárek 1974	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Pseudanabaena sp. Lauterborn, 1915	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3	3	2	3	2	2	2	2	-
Radiocystis geminata Skuja 1948	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	2	3	2	-	2	-	2	-	-	-
Snowella lacustris (Chodat) Komárek & Hindák 1988	-	-	-	-	1	-	-	-	-	-	1	3	3	2	2	4	4	4	3	4	3	-	-	-	-
Tolypothrix sp. Kützing ex Bornet & Flahault, 1886	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Dinophyta																									
Ceratium hirundinella (O.F.Müller) Dujardin 1841	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1	-	-	1	-	-	-	-	-	-
Parvodinium umbonatum (F.Stein) Carty 2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Peridinium sp. Ehrenberg, 1830	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	1	-	-	-	-	-
Peridinium willei Huitfeldt-Kaas 1900	-	-	-	-	-	-	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Euglenophyta																									
Trachelomonas sp. Ehrenberg, 1834	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-
Lepocinclis acus (O.F.Müller) B.Marin & Melkonian 2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	1
Euglena sp. Ehrenberg, 1830	-	-	-	-	1	1	1	1	1	1	1	1	1	2	1	1	-	-	-	-	-	-	-	-	-
Euglena sanguinea Ehrenberg 1832	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1	1	1	1	1	-	1
Euglena ehrenbergii G.A.Klebs 1883	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Phacus pleuronectes (O.F.Müller) Nitzsch ex Dujardin 1841	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	1	1	-	1	-	1	-	1
Monomorphina pyrum (Ehrenberg) Mereschkowsky 1877	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1
Phacus salinus (F.E.Fritsch) E.W.Linton & Karnkowska 2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	1
Phacus sp. Dujardin, 1841, nom. et typ. cons.	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	-	1	-	-	-	-
Rhodophyta																									
Kyliniella latvica Skuja 1926	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A5. List of chemical parameters measured in Samples 1–25, with corresponding sampling dates.

ID	Date	Sodium	Potassium	Calcium	Magnesium	Chloride	Nitrate	Sulfate	PO_4^{3-}	Pt	NO_2^-	NH_4^+	SiO_4-Si
		mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	µg L^{-1}	µg L^{-1}	µg L^{-1}	µg L^{-1}	mg L^{-1}
1	21/03/24	19.46	2.55	27.83	12.51	19.4	0.03	26.02	0.37	6.37	0.53	8.55	0.08
2	08/04/24	17.85	2.38	22.98	12.37	22.88	0.03	26.51	0.1	8.01	0.33	13	0.07
3	23/04/24	21.4	2.69	16.98	14.97	21.79	0.03	28.18	0.22	6.67	0.4	8.45	0.07
4	06/05/24	20.36	2.9	15.69	14.11	23.54	0.03	27.7	0.22	9.31	0.67	8.07	0.1
5	13/05/24	19.34	2.74	18.17	14.1	22.73	0.03	28.15	0.22	8.14	0.47	6.36	0.06
6	21/05/24	16.25	2.77	19.98	13.96	22.84	0.03	27.17	0.59	7.65	0.27	6.82	0.04
7	27/05/24	19.18	3.18	18.75	14.27	25.03	0.03	27.01	0.88	5.59	0.6	27.91	0.11
8	03/06/24	20.09	3.02	17.89	14.75	24.82	0.03	26.56	0.59	5.88	0.27	10.64	0.09
9	10/06/24	18.88	2.95	15.47	14.33	23.5	0.03	25.69	0.29	6.76	0.27	9.2	0.07
10	18/06/24	17.61	3.03	15.28	14.27	23.67	0.03	25.54	0.2	12.35	0.2	10	0.1
11	25/06/24	19.65	2.9	16.96	13.92	25.55	0.03	25.97	0.2	8.24	0.87	31.18	0.2
12	01/07/24	20.62	3.02	17.17	14.55	25.81	0.03	25.58	0.88	8.65	0.67	27.55	0.27
13	08/07/24	20.07	2.89	16.92	13.81	25.59	0.03	27.24	0.29	9.53	0.4	11.18	0.29
14	16/07/24	18.78	2.99	14.63	14.28	25.42	0.03	26	0.44	8.43	0.29	13.27	0.17
15	22/07/24	19.48	3.18	16.36	14.51	26.66	0.03	27.39	0.15	8.97	0.29	12.82	0.24
16	30/07/24	22.08	3.7	17.01	16.25	26.04	0.03	26.85	0.29	9.49	0.33	20.82	0.23
17	06/08/24	21.23	3.42	19.46	16.39	26.69	0.03	27.53	0.29	10.66	0.4	16.27	0.3
18	16/08/24	15.7	2.49	19.79	16.19	31.45	0.03	27.16	0.49	10.59	0.4	15.09	0.4
19	20/08/24	15.88	2.36	19.68	16.01	30.93	0.03	26.88	0.49	10	0.47	16.45	0.4
20	27/08/24	16.4	2.46	21.69	16.15	30.93	0.04	27.38	0.49	10.29	0.53	22.36	0.45
21	02/09/24	16.13	2.48	22.52	16.17	30.68	0.03	27.13	0.49	8.53	0.33	13.73	0.45
22	09/09/24	16.18	2.75	23.05	16.23	30.9	0.02	27.39	0.49	10.29	0.47	20.09	0.79

23	24/09/24	13.38	2.38	25.45	14.91	26.13	0.02	24.76	0.49	7.94	0.57	17.09	0.39
24	01/10/24	12.72	2.48	26.07	15.09	26.08	0.02	25.49	0.59	4.34	0.37	35	0.31
25	09/10/24	12.46	2.48	27.85	15.08	28.19	0.04	25.5	0.59	7.55	0.47	15.45	0.36

Table A6. List of environmental factors measured in Samples 1–25, with corresponding sampling dates.

ID	Date	DM	AM	OM	Chl-a	pH	T	Cond	O2	O2	light	light (0.75m)	Light attenuation	Alka-linity
		mg L^{-1}	mg L^{-1}	mg L^{-1}	µgL^{-1}		°C	µS cm^{-1}	mg L^{-1}	%	µmol x m-2 x S^{-1}	µmol x m-2 x S^{-1}	m	mmol L^{-1}
1	21/03/24	0.354	0.094	0.26	2.4	8.57	11.4	357	13.33	123	660	510	0.34	2.2
2	08/04/24	0.632	0.12	0.512	1.2	8.87	16.7	337	13.41	140	870	530	0.66	2.3
3	23/04/24	0.454	0.134	0.32	2.3	9.07	11.6	316	11.96	111	940	650	0.49	2.1
4	06/05/24	1,293	0.393	0.9	1.1	9.23	19.8	305	12.25	136.9	450	280	0.63	1.6
5	13/05/24	0.65	0.4	0.25	5.3	8.9	19.2	308.4	10.6	115.7	1150	860	0.39	1.8
6	21/05/24	0.4	0.2	0.2	2.4	8.75	21.1	297.6	10.58	120.8	930	760	0.27	1.8
7	27/05/24	0.52	0.16	0.36	1.5	8.82	22.1	292	11.1	128.5	420	250	0.69	1.9
8	03/06/24	0.805	0.268	0.537	3.7	8.86	22	292	10.4	116.6	780	380	0.96	1.95
9	10/06/24	0.86	0.22	0.64	4	8.95	24.3	278.8	10.5	128.4	320	110	1.42	1.8
10	18/06/24	0.6	0.2	0.4	3.1	8.94	23.7	281.2	10.49	125.5	1003	750	0.39	1.75
11	25/06/24	1,031	0.313	0.719	3	8.78	24.9	277.6	9.2	112.6	930	540	0.72	1.7
12	01/07/24	0.7	0.2	0.5	5.7	8.8	26	272.4	8.41	105.5	850	330	1.26	1.8
13	08/07/24	1,250	0.05	1,200	5.1	8.74	23.8	283.6	9.19	110.1	1110	450	1.2	1.8
14	16/07/24	1,286	0.071	1,214	3.1	8.98	28	262	10.5	137.1	1100	620	0.76	1.7
15	22/07/24	1,829	0.057	1,771	4.1	8.78	27.2	268.8	8.92	114.2	680	240	1.39	1.9
16	30/07/24	1,450	0.125	1,325	4.5	8.43	25.3	280.4	7.59	93.1	1020	420	1.18	2.1
17	06/08/24	1,457	0.343	1,114	7.5	8.46	24.3	287.2	7.89	95	1037	450	1.11	2.2
18	16/08/24	1,725	0.425	1,300	5	8.88	28.4	266.8	11.06	143.4	880	430	0.95	2.1
19	20/08/24	1,625	0.125	1,500	7.7	8.8	26.1	275.6	7.81	97.8	490	180	1.34	2
20	27/08/24	1,710	0.129	1,581	6.4	8.74	24.2	286.8	8.39	100.6	360	23	3.67	2.1
21	02/09/24	1,667	0.067	1,600	6.5	8.65	26.5	276	9.89	122.5	630	320	0.9	2.1

22	09/09/24	1,720	0.12	1,600	7.5	8.58	24.2	288	7.84	95.8	270	80	1.62	2.1
23	24/09/24	1,400	0.12	1,280	2.6	8.57	17.3	322	11.47	119.5	250	60	1.9	2.1
24	01/10/24	1,200	0.16	1,040	4.2	8.56	15.4	335.2	9.95	100.7	260	110	1.15	2.2
25	09/10/24	0.771	0.057	0.714	2	8.39	14.6	342	10.23	102.9	350	98	1.7	2.3

SEM Images

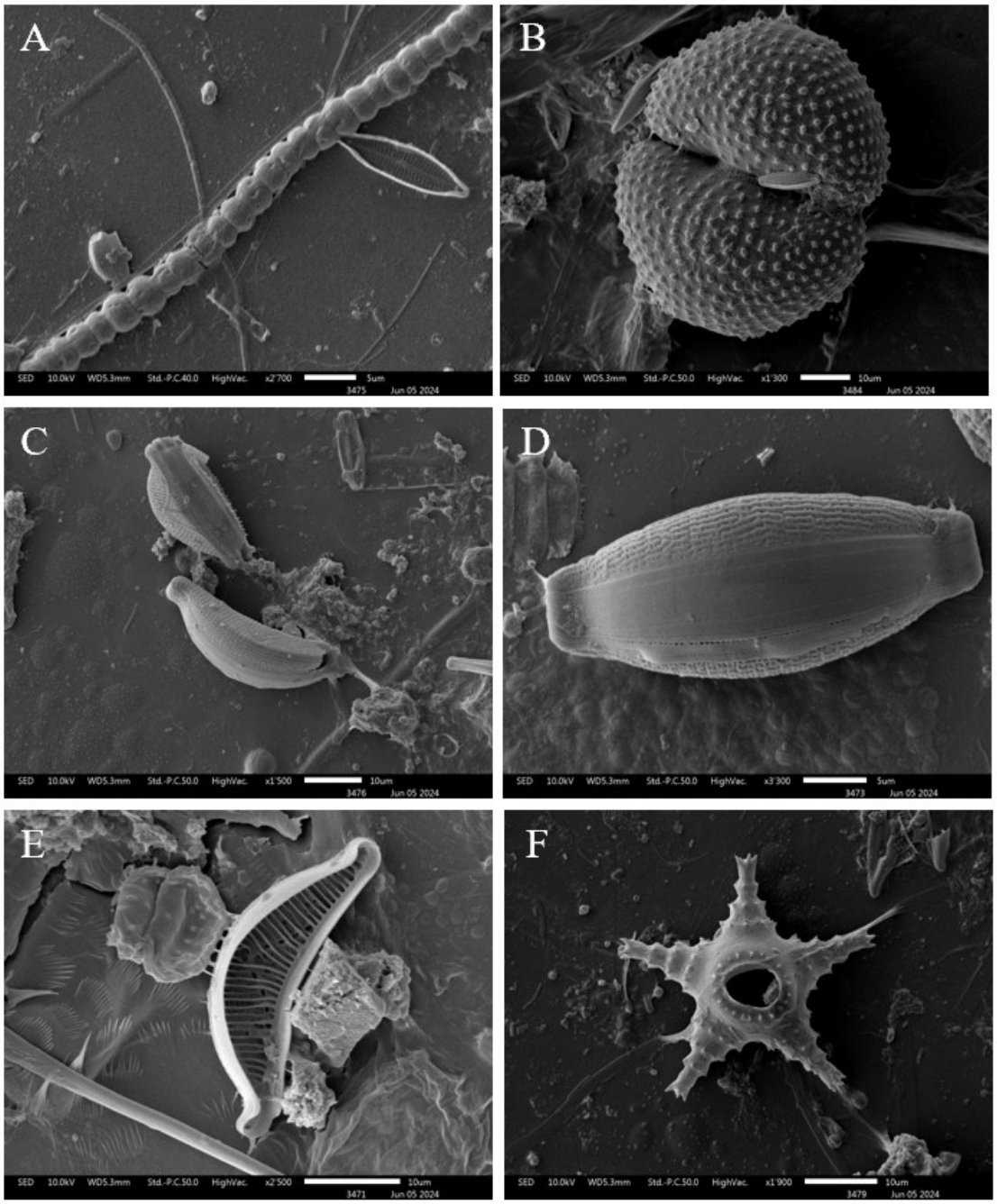


Figure A1. SEM images of representative algal taxa. A: *Anabaena* sp., **B:** *Cosmarium* sp., **C:** *Epithemia* sp. – external, **D:** *Epithemia* sp. – dorsal, **E:** *Epithemia* sp. – internal, **F:** *Staurastrum* sp.

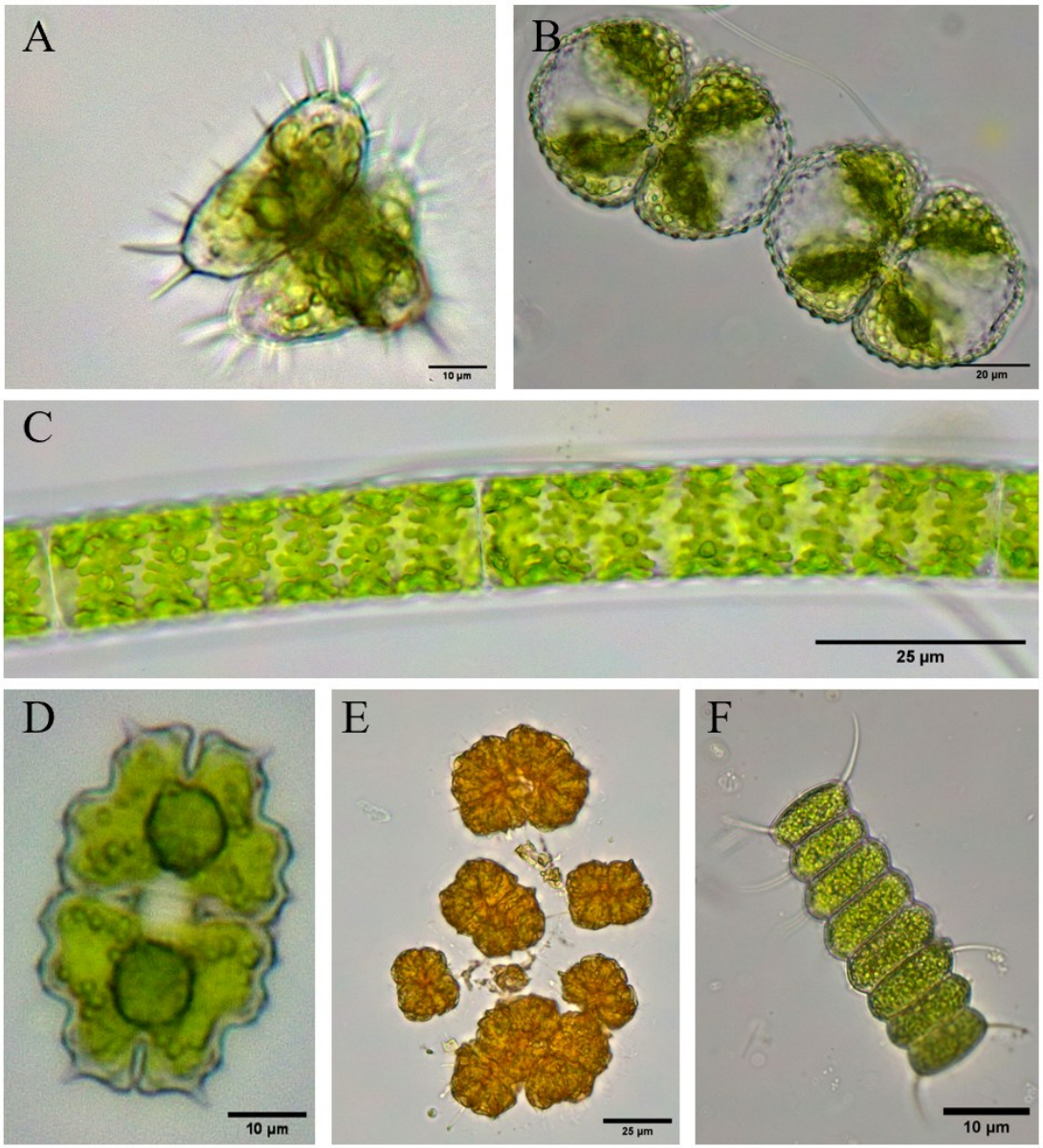


Figure A2. Light micrographs of representative algal taxa. A: *Staurastrum teliferum* Ralfs, **B:** *Cosmarium botrytis* Meneghini ex Ralfs, **C:** *Spirogyra* Link, **D:** *Euastrum bidentatum* Nägeli, **E:** *Botryococcus braunii* Kützing, **F:** *Scenedesmus* sp.

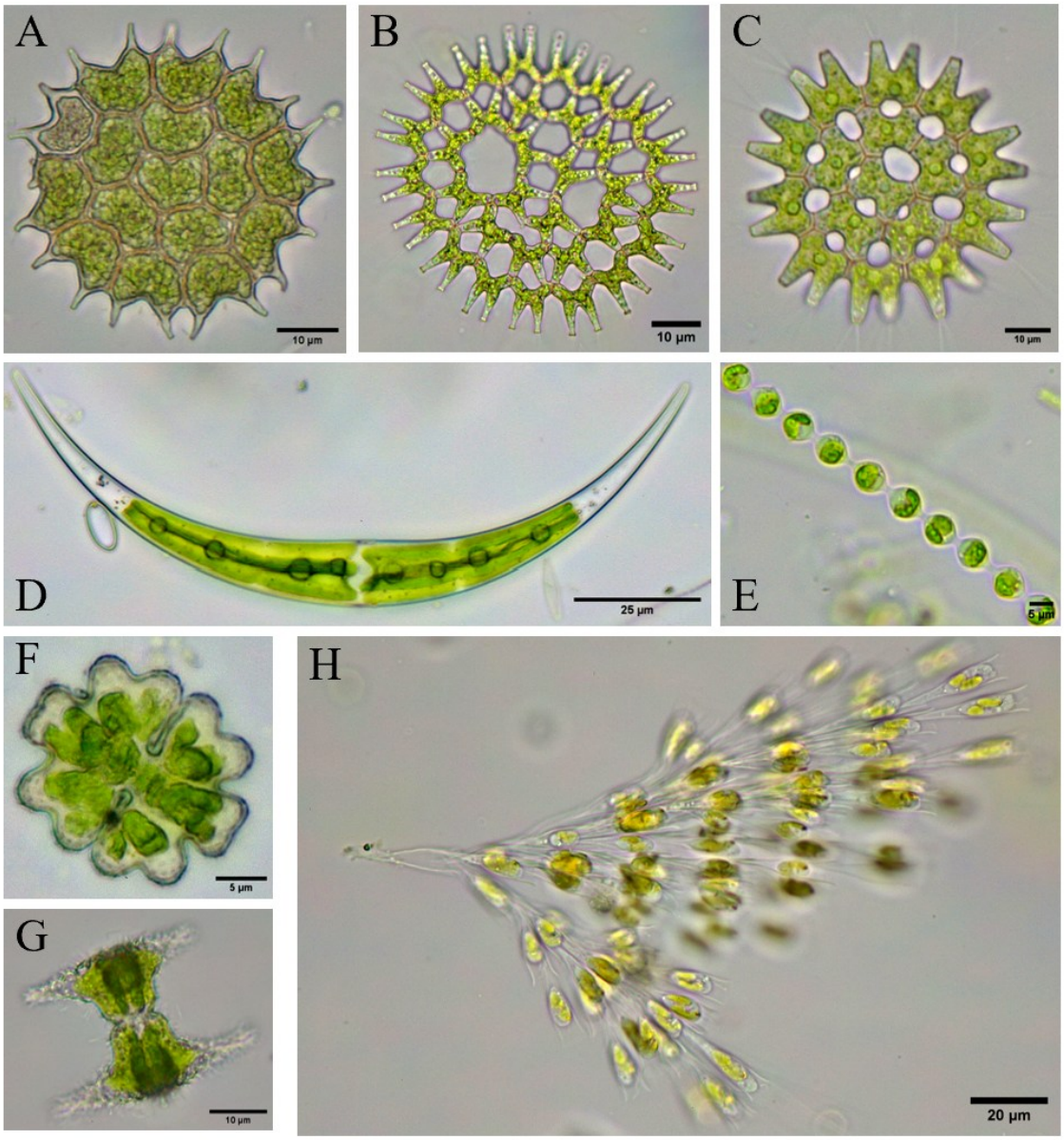
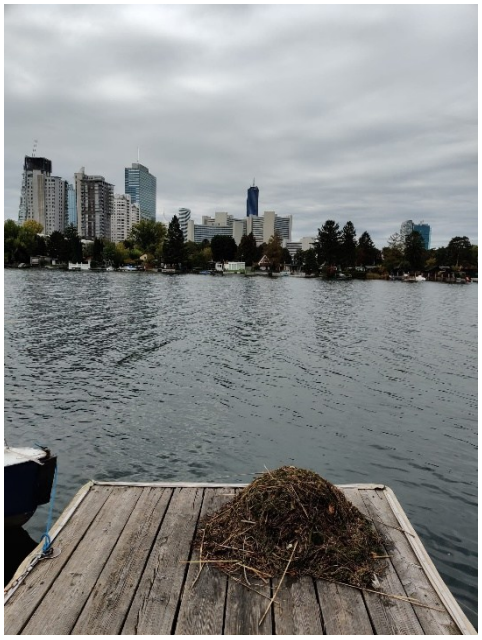


Figure A3. Light micrographs of representative algal taxa. A: *Pseudopediastrum boryanum* (Turpin) E.Hegewald, **B:** *Lacunastrum gracillimum* (West & G.S.West) H.A.McManus, **C:** *Pediastrum duplex* Meyen, **D:** *Closterium dianae* Ehrenberg ex Ralfs, **E**: *Radiofilum conjunctivum* Schmidle, **F:** *Euastrum germanicum* (Schmidle) Willi Krieger, **G:** *Staurastrum manfeldtii* Delponte, **H:** *Dinobryon sertularia* Ehrenberg.

Photographic documentation

Study Site Photography



Laboratory Photography