Medium-scale cultivation of microalgae in Svalbard

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WANTED

alive only

Suitable strain

- Good growth/high biomass productivity at low temperatures (0-10 °C)
- Tolerance to higher temperatures (above 15 °C)
- Adapted to lower irradiances, but able of photoacclimation to higher ones
- Low nutrient demand
- Easy biomass harvest and processing
- Production of high-value compounds +
- Local origin

❄ Introduction

The adaptation mechanisms of polar microalgae evolved to withstand the harsh polar environment characterized by low temperature, freeze-thaw cycles, desiccation, salinity, and high and variable photosynthetically active and ultraviolet radiation. Hence, polar microalgae developed ecological, physiological, and molecular defensive and adaptive strategies, which include the synthesis of a tremendous diversity of compounds originating from different metabolic pathways which protect them against the above-mentioned stresses. These pathways and metabolites could be prospective for biotechnological applications in low temperatures which could reduce the impacts of human activities on pristine polar environments and provide novel environment-firendly technologies for exploitation of the Polar Regions, namely the Arctic.

Therefore, development of new types of photobioreactors to provide suitable and controlled conditions for microalgal growth and/or biologically active compound production is necessary, especially in medium (tens of liters) and large (hundreds of liters or even more) scales.

❄ Experimental photobioreactor

- **Closed flat panel type** photobioreactor
- Maximum volume of **20 L**
- Aerated by **air + CO_2 mixture**
- **Natural diel light cycle**
- **Sun-oriented** cuvette
- **Out-door** cultivation

Industrial Property Office
Utility model No. 36383

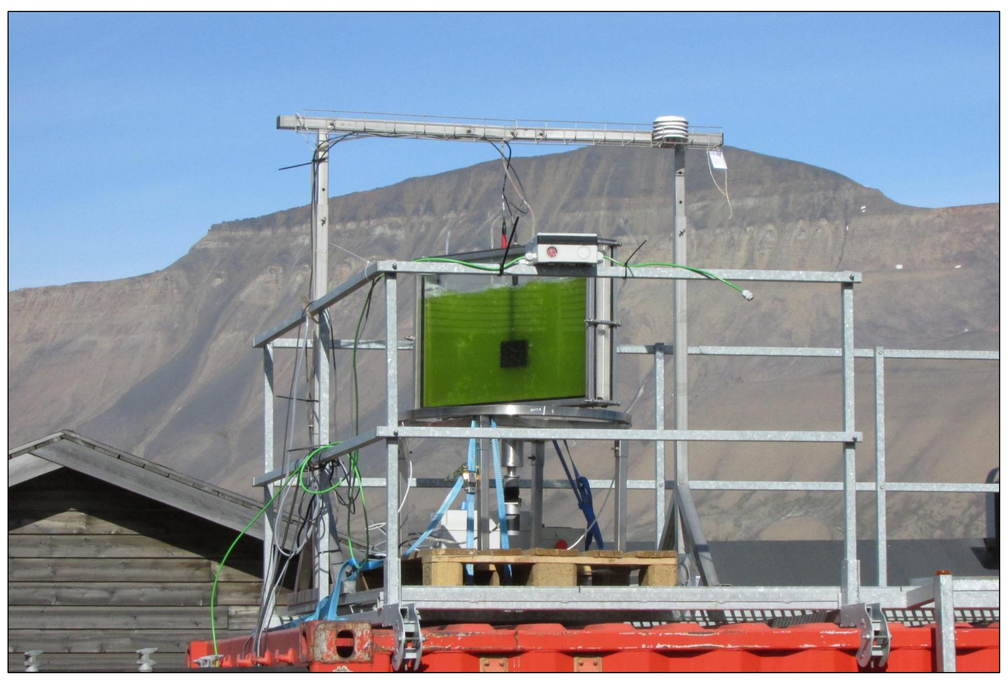


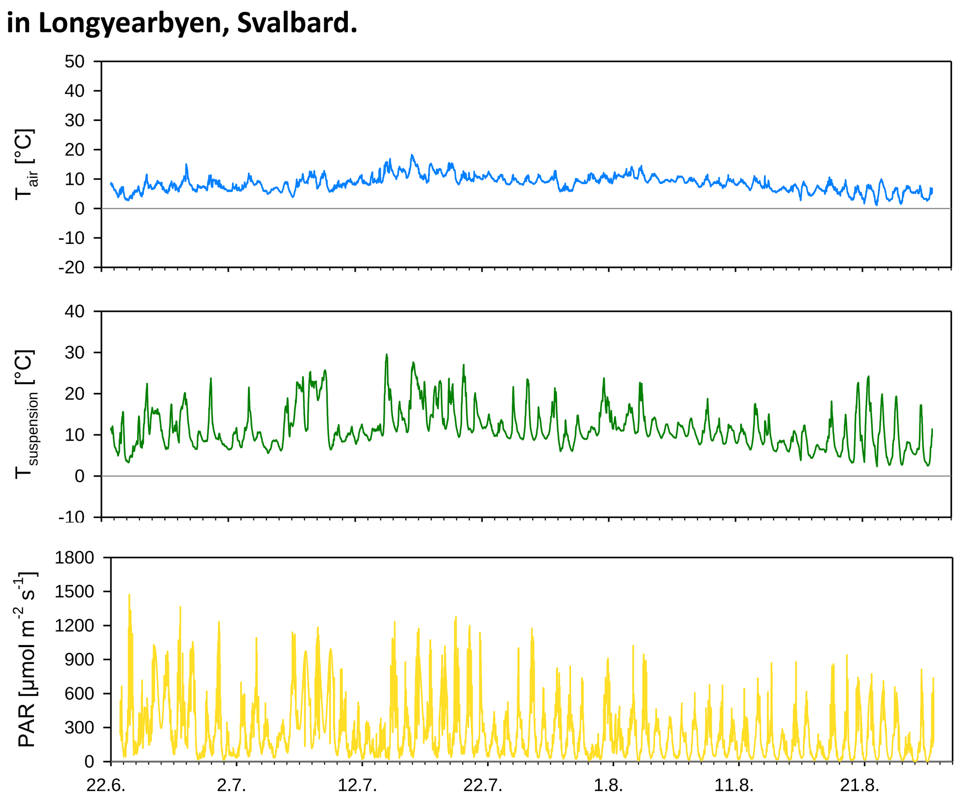
Fig. 1. Medium-scale (20L) photobioreactor in CARS USB in Longyearbyen, Svalbard.

❄ Cultivation conditions

Table 1. The summary statistics of environmental variables during summer cultivation in Svalbard.

	Cultivation (total)	Batch 1	Batch 2
Cultivation start (CET)	22.6.2022 17:30	22.6.2022 17:30	23.7.2022 7:54
Cultivation end (CET)	26.8.2022 12:10	22.7.2022 14:00	26.8.2022 12:10
Cultivation duration (days)	65	30	34
n (max)	*9329*	*4300*	*4922*
Air temperature			
Mean (°C)	**8.5 ± 2.6**	**8.9 ± 2.8**	**8.0 ± 2.4**
Median (°C)	8.6	8.6	8.4
Minimum (°C)	1.0	2.6	1
Maximum (°C)	18.3	18.3	14.6
Suspension temperature			
Mean (°C)	**11.6 ± 4.8**	**12.9 ± 5.3**	**10.4 ± 4.0**
Median (°C)	10.6	11.4	10.1
Minimum (°C)	2.3	3.3	2.3
Maximum (°C)	29.6	29.6	24.2
Irradiance (PAR)			
Mean (µmol m^{-2} s^{-1})	**262 ± 244**	**337 ± 282**	**199 ± 185**
Median (µmol m^{-2} s^{-1})	179	251	138
Minimum (µmol m^{-2} s^{-1})	1	12	1
Maximum (µmol m^{-2} s^{-1})	1473	1473	1175
Diel sum of radiation (PAR)			
Mean (MJ m^{-2} d^{-1})	**4.86 ± 2.53**	**6.13 ± 2.96**	**3.67 ± 1.35**
Median (MJ m^{-2} d^{-1})	4.13	6.25	3.39
Minimum (MJ m^{-2} d^{-1})	1.21	1.21	1.29
Maximum (MJ m^{-2} d^{-1})	11.61	11.61	6.91
Total sum of radiation (PAR) (MJ m^{-2})	**320.54**	**190.26**	**128.51**

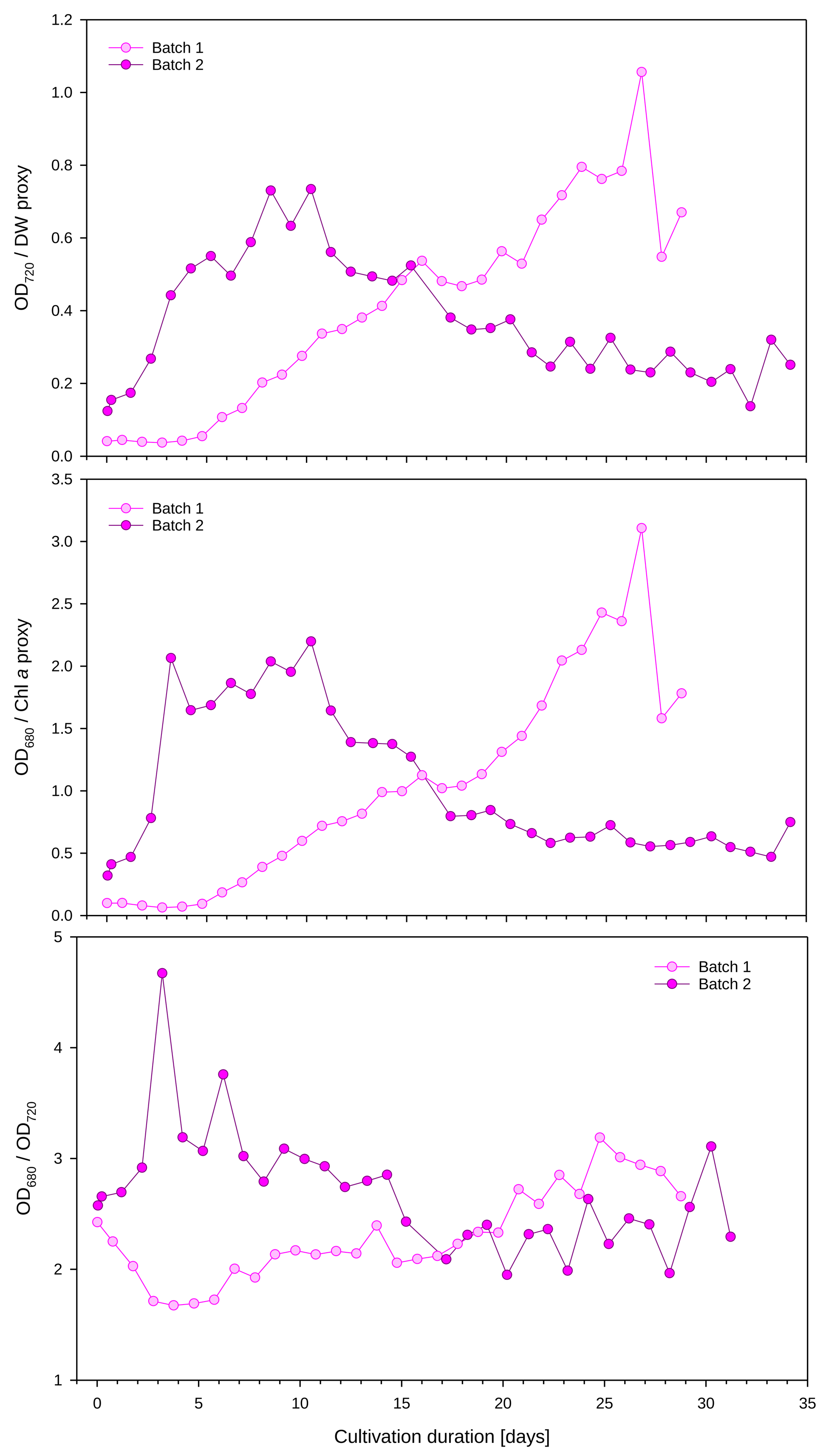
Fig. 2. The courses of environmental variables during summer cultivation in Longyearbyen, Svalbard.



- **No freezing temperatures during cultivation**
- **Large diel suspension temperature and PAR variation**
- **Significant diel temperature and light cycles**

❄ Algal growth

Fig 3. The comparison of algal growth in individual batches expressed as OD_{720}, OD_{680} and OD_{680}:OD_{720} ratio.



- **Low biomass yield (light and/or CO_2 limitation?)**
- **Different growth caused by growth conditions and initial innoculum concentratios**
- **Peaks of OD_{680}:OD_{720} close to the inflection point of the growth curve**

❄ Cultivation

- **Longyearbyen, Svalbard (RiS ID 11978), 22.6. – 26.8.2022**
- ***Neocystis* sp.** (Chlorophyceae), **2 batches**

❄ Measurements

10 min interval
- Suspension and air temperatures
- Photosynthetically active radiation (PAR)
- pH
- OD_{720} (biomass proxy)
- OD_{680} (chlorophyll a proxy)
- OD_{680}:OD_{720} ratio
- Effective quantum yield (Φ_{PSII})

Daily (local noon)
- OD_{720} (biomass proxy)
- OD_{680} (chlorophyll *a* proxy)
- OD_{680}:OD_{720} ratio
- Maximum quantum yield (F_V/F_M)
- OJIP transient

Weekly
(during stationary phase only)
- Bulk sample of 2 L for detailed biochemical analyses of lipid and photosynthetic pigment composition
- » centrifugation
- » frozen supernatant and pellet

❄ Algal physiology

Fig. 4. The course of the maximum quantum yield (F_V/F_M) during individual batches.

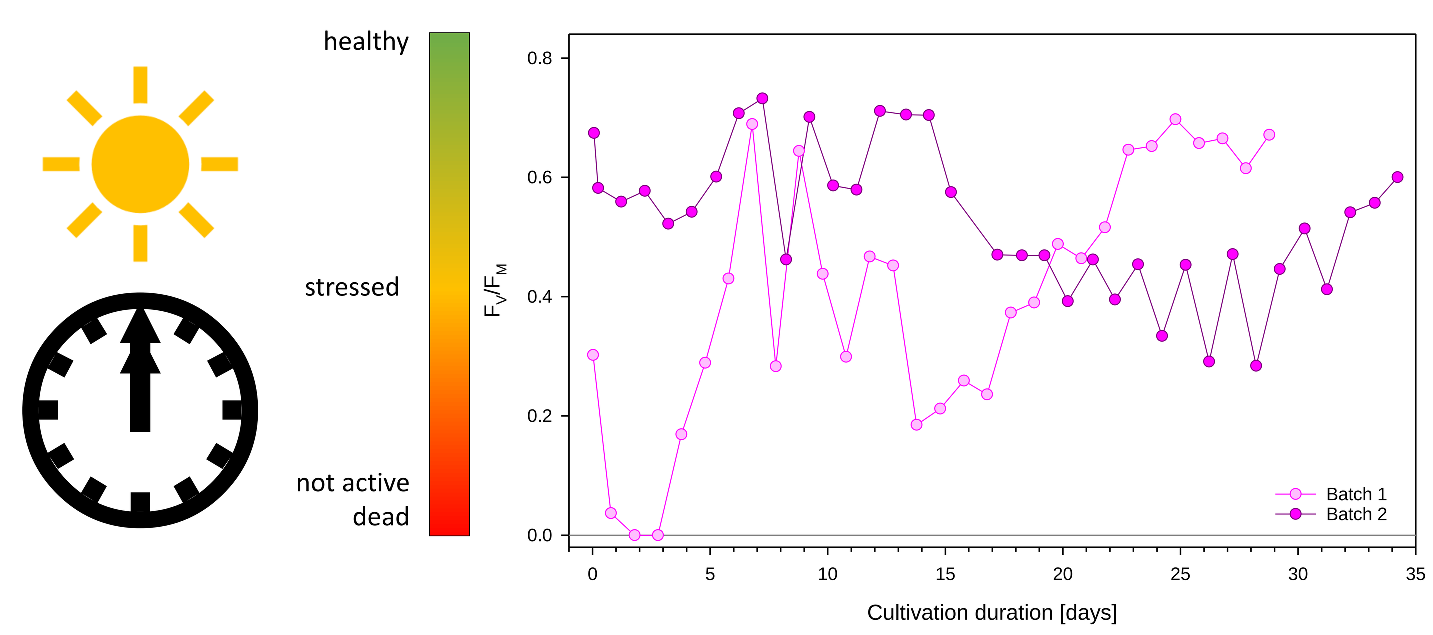
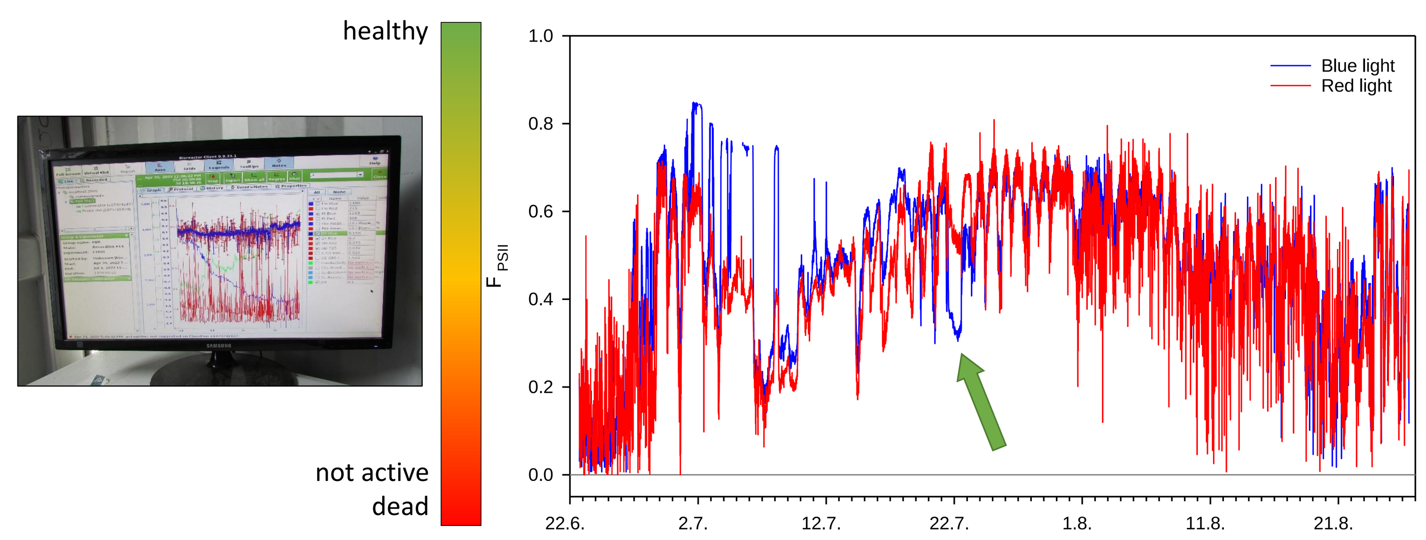


Fig. 5. The course of the effective quantum yield (Φ_{PSII}) during individual batches measured by red and blue excitation lights. The green arrow indicates start of the Batch 2. Insert: The photobioreactor control unit.



- **Stressing conditions during cultivation in Svalbard**
  - **High light + low temperature, especialy during initial phases of Batch 1**
- **Large variability during continuous monitoring » detailed data analysis needed**
- **Diel cycles of the photosynthetic activity**
- **Both spectrophotometric and variable fluorescence data necessary to estimate the growth and physiological state of the culture**

References
Šnokhous K, Bělohlav V, Jirout T, Krátky L, Elster J, Kvíderová J, Liška J, Lukavský J, Nedbalová L (2022) Rotary plate reactor, especially for cultivating microalgae. Industrial Property Office, Utility model No. 36383, 19p.

Acknowledgement: The work was supported by projects GAČR 22-08680L (GAČR), LTAIN 19139 (MŠMT), TN01000048 (TAČR) and RVO 67985939 (AV ČR).