Forschungszentrum-Jülich algal turf scrubbing pilot 2018

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21 March, 2019

Introduction

Here we provide **cleaned data, in the form of csv files**, from the 2018 ATS pilot at Forschungszentrum-Jülich conducted by the Institute for Bio- and Geosciences's Plant Sciences: Alternative Biomass department. Biomass composition data were obtained by standard analyses and recorded in the spreadsheet `Analysen ZEA-3.xlsx`. Biomass productivity data were recorded manually in the spreadsheet `ATS Treatment.xlsx`. Temperature and irradiance data were obtained from HOBO data loggers and exported as csv files. Data was cleaned by knitting `FZJAP2018.Rmd`, which, using functions defined in `FZJAP2018.R` rearranges, renames, or or discards cells or observations. Four csv files are created, recording biomass composition and productivity, logged temperature and irradiance, and water chemistry.

Methods

Floway Configuration. A 0.54 m × 2.5 m algal turf scrubber (ATS) floway and headworks was assembled from local home improvement store materials (Bauhaus, Belp, Switzerland; Hornbach Baumarkt AG, Bornheim, Germany) and lined with surplus growth substratum originally used for a thin layer algae spray reactor (Schreiber et al. 2017). The floway was operated at the Forschungszentrum-Jülich (FZ-J) campus wastewater treatment plant (WWTP) from August 15th to October 22nd, 2018. Influent was recirculated in batch mode from a 1 m^3 IBC tank filled to 0.5 m^3 from the secondary treatment clarifier tank at the FZ-J WWTP. Water was exchanged by completely draining the IBC tank into a prior treatment tank then refilling with 0.5 m^3 of influent. The inner walls and bottom of the IBC tank were scrubbed during water exchange to reduce algal growth within the tank. Water exchange was performed Mondays through Thursdays, except for Wednesday, October 3. Commercially available centrifugal sump pumps were used to recirculate the water to the floway at a rate of 37 L min^{-1} with a pulsing interval of 15-20 s, provided by a tipping bucket at the headworks.

Harvesting and Biomass Processing. Harvesting was performed weekly by turning off the pumps, allowing the floway to drain for approximately 15 min, then manually scraping biomass from the base and walls of the lower 1.6 m of the floway, comprising a total harvested area of 0.99 m^2. The remainder of the biomass was left to facilitate re-colonization of the harvested area during the following growth interval. Scraped biomass was collected into a tared jar and weighed to determine the fresh weight of the harvested material. The biomass was dried by in an oven at 60°C for 24 hours and weighed. Dried biomass was homogenized by grinding with a mortar and pestle. Weighed samples were frozen at -20° in airtight plastic bags.

Environmental Observations. Floway water temperature and irradiance were logged once per minute using a HOBO data logger and downloaded as csv files using proprietary software (Onset Computer Corporation, Bourne, MA).

Water Chemistry. One water sample (15 mL) was taken from the tailworks of the floway before and one after water exchange. These were either analyzed within six hours or frozen for later analysis. Prior to analysis, samples were centrifuged at room temperature for 10 minutes at a relative centrifugal force of 3,007 g. Soluble phosphate (PO_4-P) and Total nitrogen (TN) were determined using a DR 5000 UV-Vis spectrophotometer after processing the samples with Hach LCK 349 (PO_4-P) and LCK 138 (TN) kits. (All: Hach Lange GmBH, Düsseldorf).

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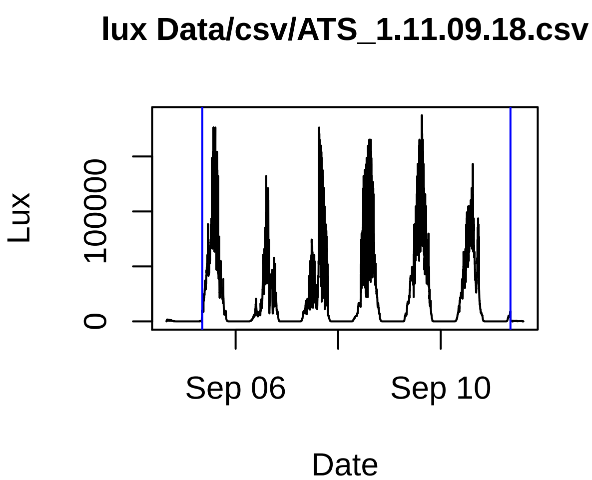
Biomass Composition. Two 50 mg aliquots of each dried biomass sample, each with 2 mL HNO_3 and 1 mL H_2O_2 were placed in closed Xpress containers (CEM Corporation, Matthews, NC, USA) and digested in a MARS 5 microwave digestion oven (CEM Corporation, Matthews, NC, USA) by heating to 160°C within 20 minutes and kept at this temperature for 15 minutes. The containers were then filled to 14 mL with deionized water. Two aliquots of each sample solution obtained were diluted, one at 1:20 and one at 1:50, and analyzed. Each dilution was assayed with ICP-OES (iCAP 6500, Thermo Scientific). Reference material NIST1515 (SRM1515, 2017) was included as control. Recovery for K was 101%, Ca 94%, Mg 94%, Mn 83% and P 90%. Measurements reflect the mean of two determinations. Standard deviation for two observations, recorded originally as "< 0,1" are set to NA in the cleaned data.

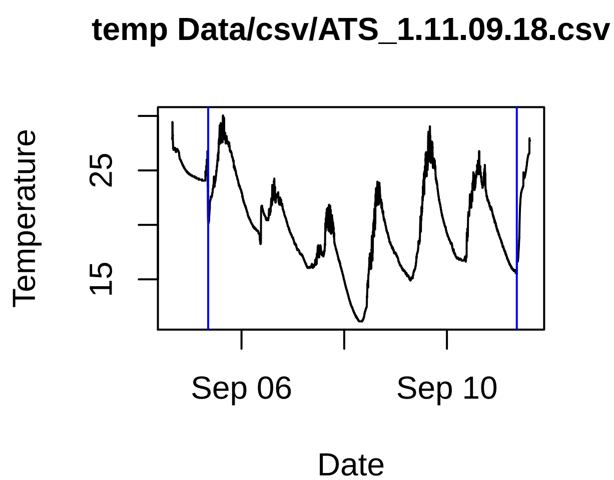
Data Cleaning

To clean the water quality and biomass data, spreadsheets were loaded and reshaped into a tidier schema before being saved as csv. Some columns of `ATS Treatment.xlsx` ("Dilution PO4-P", "PO4-P", "reduction", "Dilution TNb", "TNb", "remark"), were not retained in the cleaned data, while others (unnamed column with "before/after", "commend") were converted from character to logical for improved utility. All columns of `Analysen ZEA-3.xlsx` were retained. Temperature and irradiance logs (`ATS_<#.dd.mm.yy>.hobo`) were converted to csv using proprietary software (`*.hproj` contain metadata about the `*.hobo` and were not processed). Because the data loggers were either initialized in an office before being transported to the floway for installation, or downloaded after being removed from the floway and taken to an office, the initial and final observations of each file were discarded. Figures 1-7 and the code that generated them show which observations were discarded. Selected observations were combined into a single data frame and saved as a csv file.

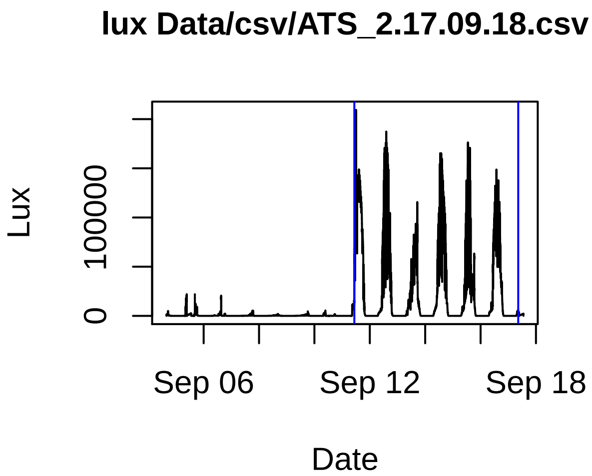
HOBO Data.

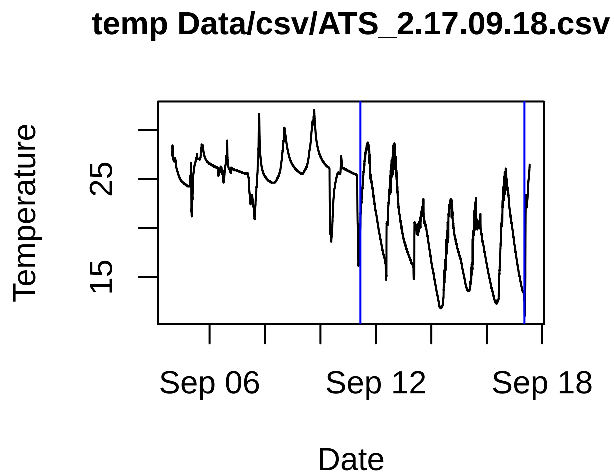
Week 1 (ATS_1)



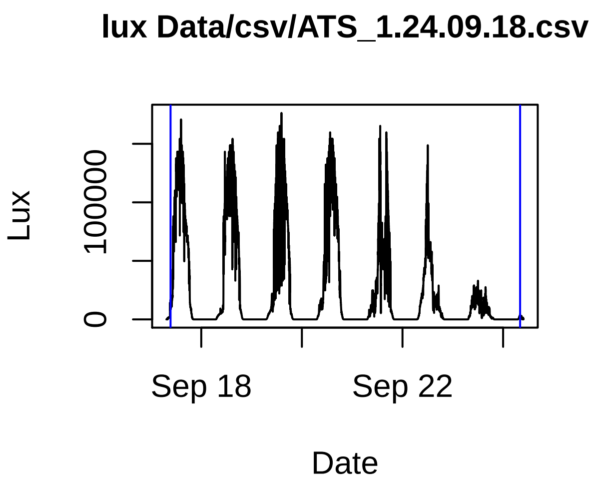


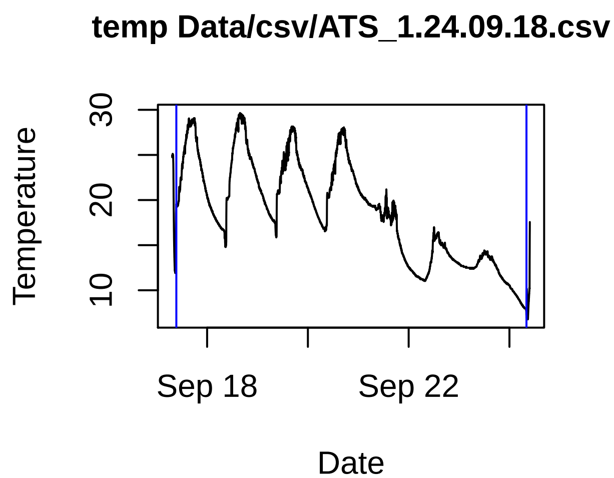
Week 2 (ATS_2)



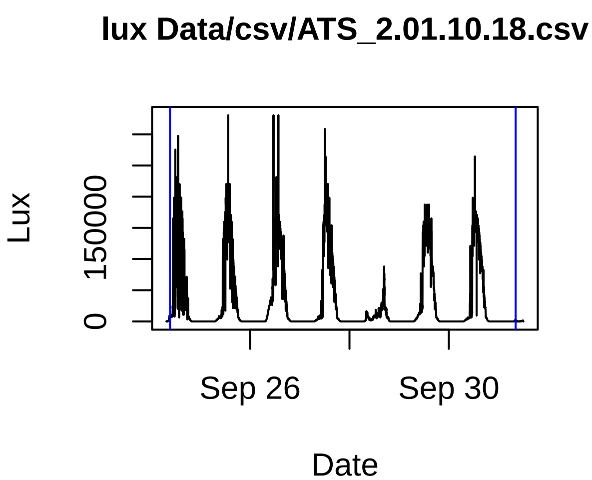


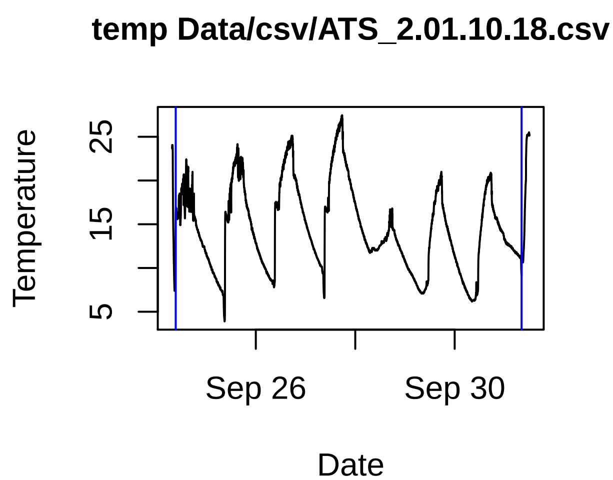
Week 3 (ATS_1)



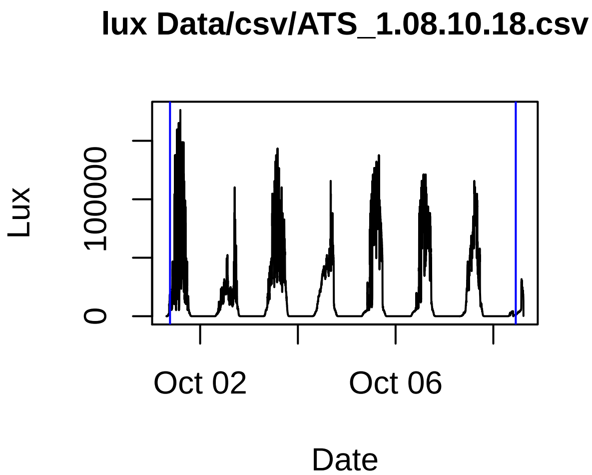


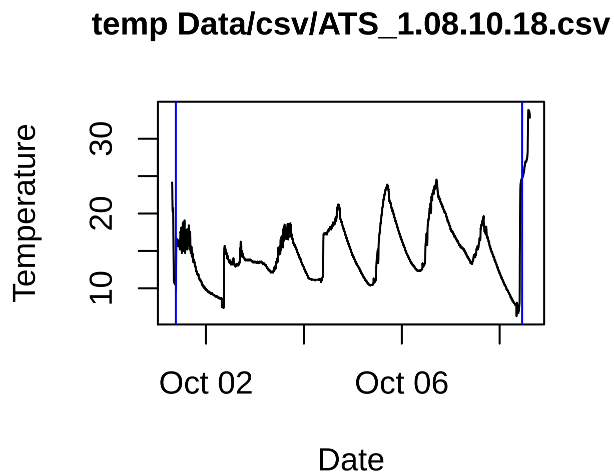
Week 4 (ATS_2)



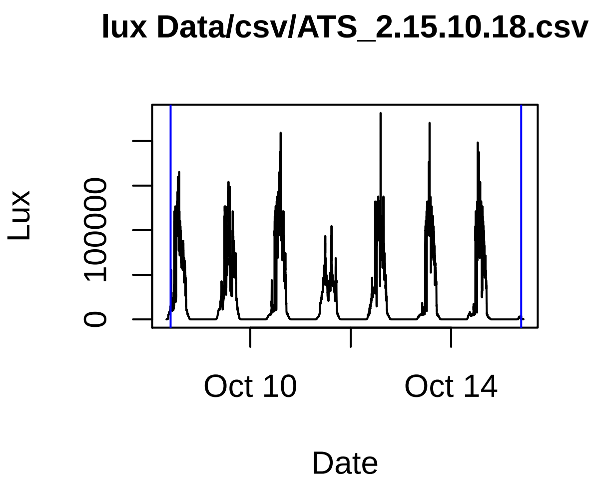


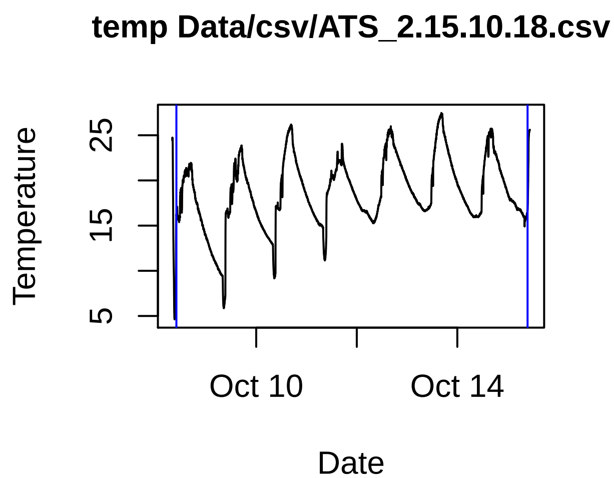
Week 5 (ATS_1)



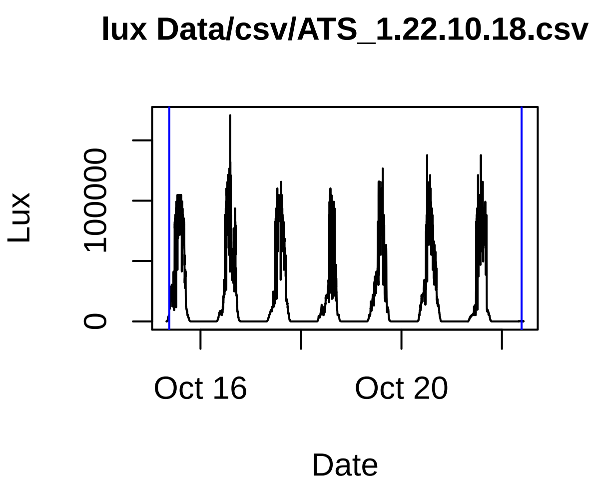


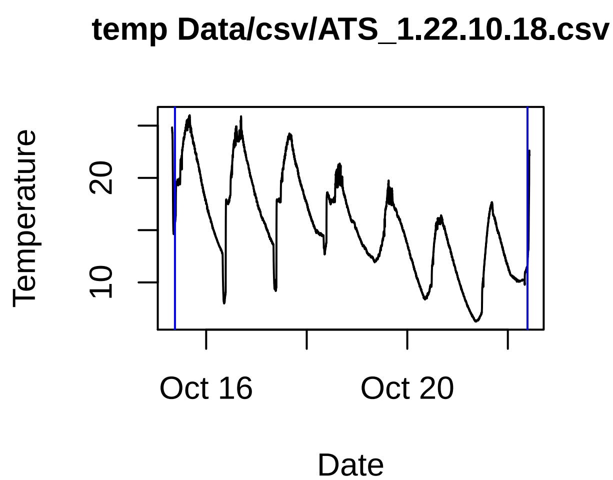
Week 6 (ATS_2)





Week 7 (ATS_1)





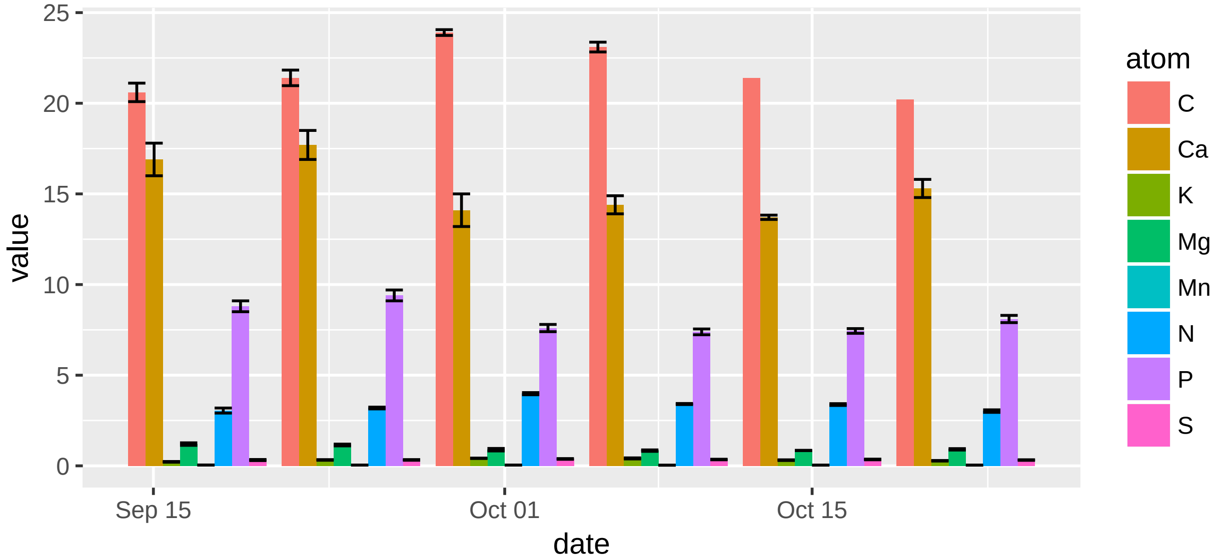
Floway Chemistry & Biomass Productivity

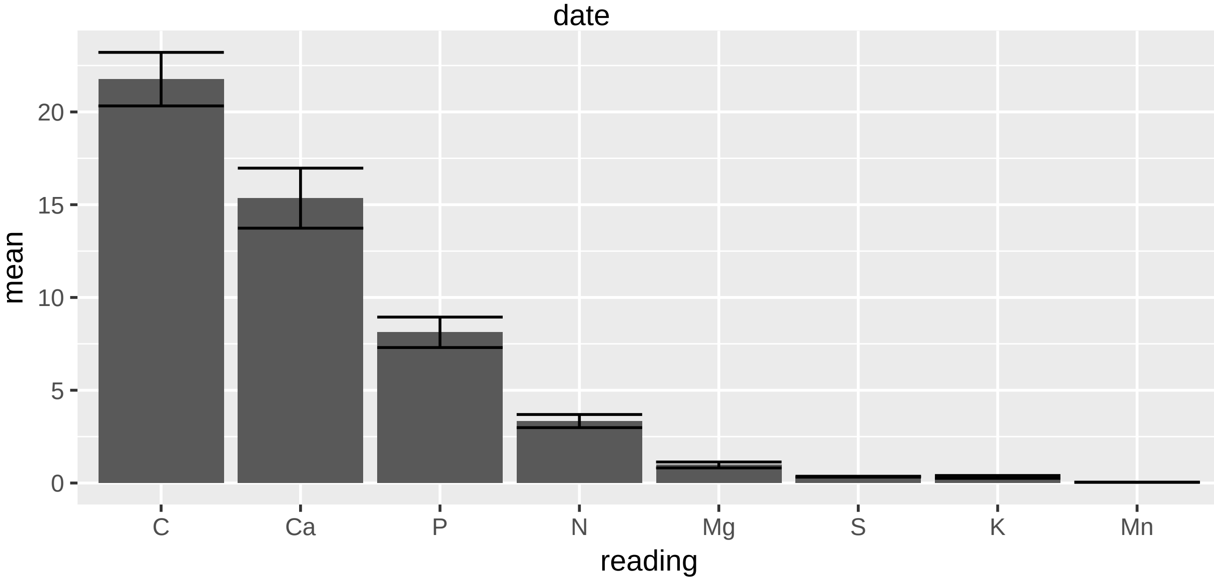
On two occasions, samples were assayed both on the day they were taken and after freezing (Table 1). As the absolute differences between the readings for frozen and unfrozen samples was small, less than 5% except for two measurements, it was decided to freeze and accumulate samples for collective analysis rather than assay each sample on the day it was collected.

Table 1: Differences among fresh and frozen samples

before	PO4Pdelta	TNdelta	PO4Ppct	TNpct
FALSE	0.40	0.29	5.4869684	3.2842582
TRUE	-0.10	0.10	-0.9615385	1.0764263
FALSE	-0.27	0.47	-4.1284404	5.6085919
TRUE	-0.17	0.02	-1.7119839	0.2051282

Biomass Composition Data





Data Dictionaries

Table 2: Data/csv/FZJAP2018 Biomass Composition.csv

Column	Description
id	Observation ID
date	Harvest date
atom	Element assayed
wtprop	Mass proportion of element in sample
wtpropsd	Standard deviation of proportion with n = 2

Table 3: Data/csv/FZJAP2018 Biomass Productivity.csv

Column	Description
wet_biomass	Mass of total fresh biomass harvested
dry_biomass	Mass of total dried biomass
obsdate	Harvest date

Table 4: Data/csv/FZJAP2018 Temperature and Irradiance.csv

Column	Description
datetime	Date and time of observation
temp	Temperature (°C)
lux	Irradiance (lux)
week	Week index

Table 5: Data/csv/FZJAP2018 Water Chemistry.csv

Column	Description
datetime	Date and time of observation
before	Was this sample taken before or after water exchange?
PO4P	Soluble PO4, mg L-1
TN	Total N, mg L-1
pH	ph
frozen	Was this sample frozen?
assaydate	Date sample was assayed
obsdate	Observation date

Acknowledgement

This work was supported by the German Federal Ministry of Education and Research (BMBF) within the project Algnutrient-UrBioSol, Bioeconomy International FKZ031B0453A.

References

Schreiber, Christina, Dominik Behrendt, Gregor Huber, Christian Pfaff, Janka Widzgowski, Bärbel Ackermann, Andreas Müller, Vilém Zachleder, Šárka Moudríková, and Peter Mojzeš. 2017. "Growth of Algal Biomass in Laboratory and in Large-Scale Algal Photobioreactors in the Temperate Climate of Western Germany." *Bioresource Technology* 234 (June): 140–49. https://doi.org/10.1016/j.biortech.2017.03.028.