REEgain: Using Algae for Industrial Waste Recycling

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„REEgain“ INTERREG PROJECT

Austria-Czech Republic

“Sustainable biological recycling of ecologically problematic compounds (REEs) from electronic waste and water“

- Recycling of REEs using microorganisms (algae, extremophills)
- Co-cultivation (bacteria)

Interreg Österreich-Tschechische Republik
Europäischer Fonds für regionale Entwicklung
EUROPÄISCHE UNION

2018-2022

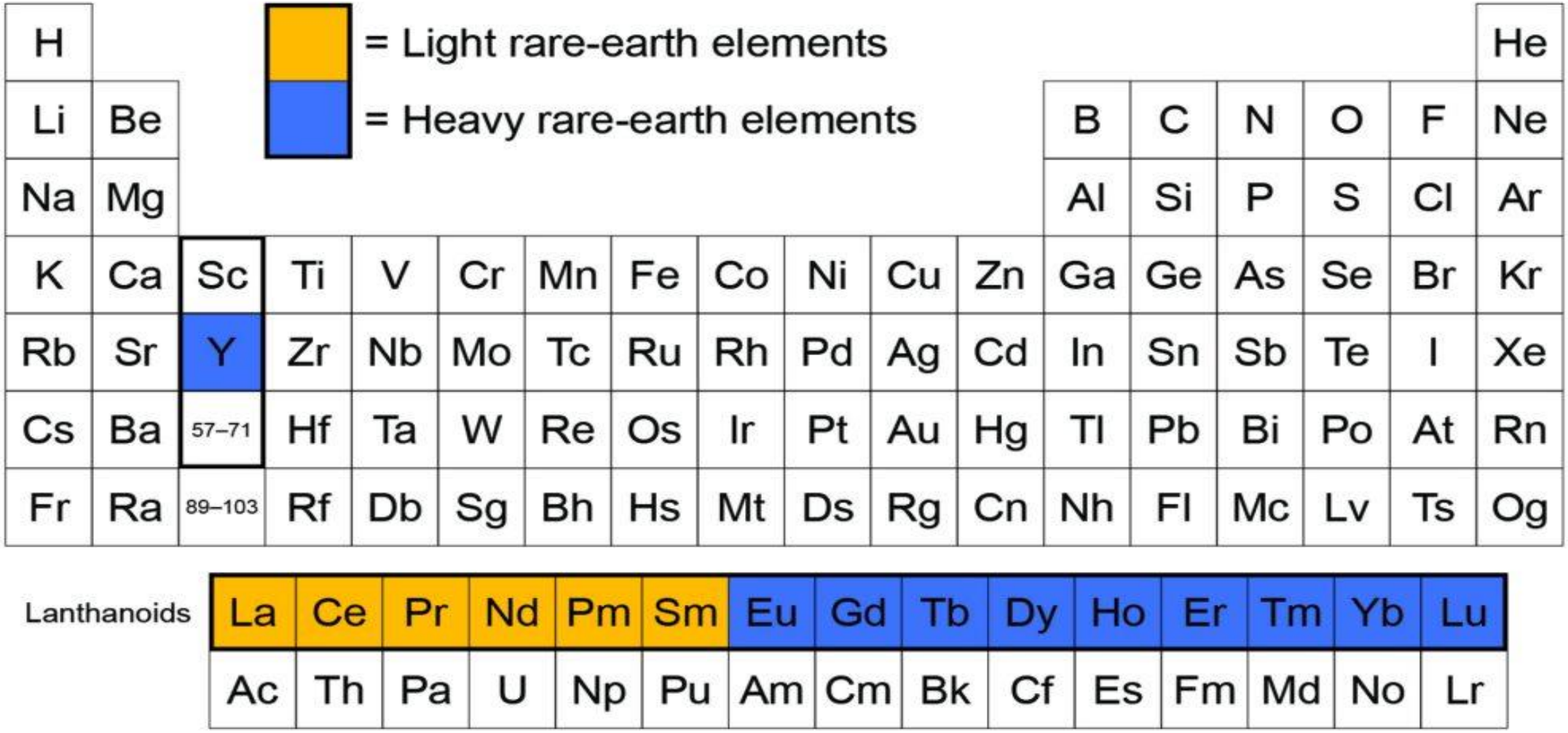
ALGATECH

imc FH KREMS UNIVERSITY OF APPLIED SCIENCES / AUSTRIA

DONAU UNIVERSITÄT KREMS

KARL LANDSTEINER PRIVATUNIVERSITÄT FÜR GESUNDHEITSWISSENSCHAFTEN

RARE EARTH ELEMENTs



WHY ARE THE RARE EARTH ELEMENTS IMPORTANT?

Magnetics

Nd | Tb, Dy | Pr

Computer Hard Drives
Disk Drive Motors
Anti-Lock Brakes
Automotive Parts
Frictionless Bearings
Magnetic Refrigeration
Microwave Power Tubes
Power Generation
Microphones & Speakers
Communication Systems
MRI

Phosphors

Nd, Eu, Tb, Y | Er, Gd | Ce, Pr

Display phosphors - CRT, LPD, LCD
Fluorescent Lighting
Medical Imaging
Lasers
Fibre Optics

Metal Alloys

Nd, Y | La, Ce, Pr

NimH Batteries
Fuel Cells
Steel
Super Alloys
Aluminium / Magnesium

Catalysts

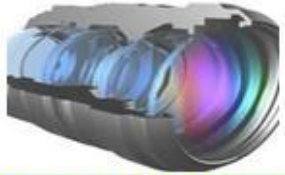
Nd | La, Ce, Pr

Petroleum Refining
Catalytic Converter
Fuel Additives
Chemical Processing
Air Pollution Controls

Ceramics

Nd, Y, Eu | Gd, Lu, Dy | La, Ce, Pr

Capacitors
Sensors
Colorants
Scintillators
Refractories



Glass & Polishing

Nd | Gd, Er, Ho | La, Ce, Pr

Polishing Compounds
Pigments & Coatings
UV Resistant Glass
Photo-Optical Glass
X-Ray Imaging

Defense

Nd, Eu, Tb, Dy, Y | Lu, Sm | Pr, La

Satellite Communications
Guidance Systems
Aircraft Structures
Fly-by-Wire
Smart Missiles

CREOs
HREOs
LREOs

WHY BIO-REMOVAL OF REEs IS BENEFICIAL?

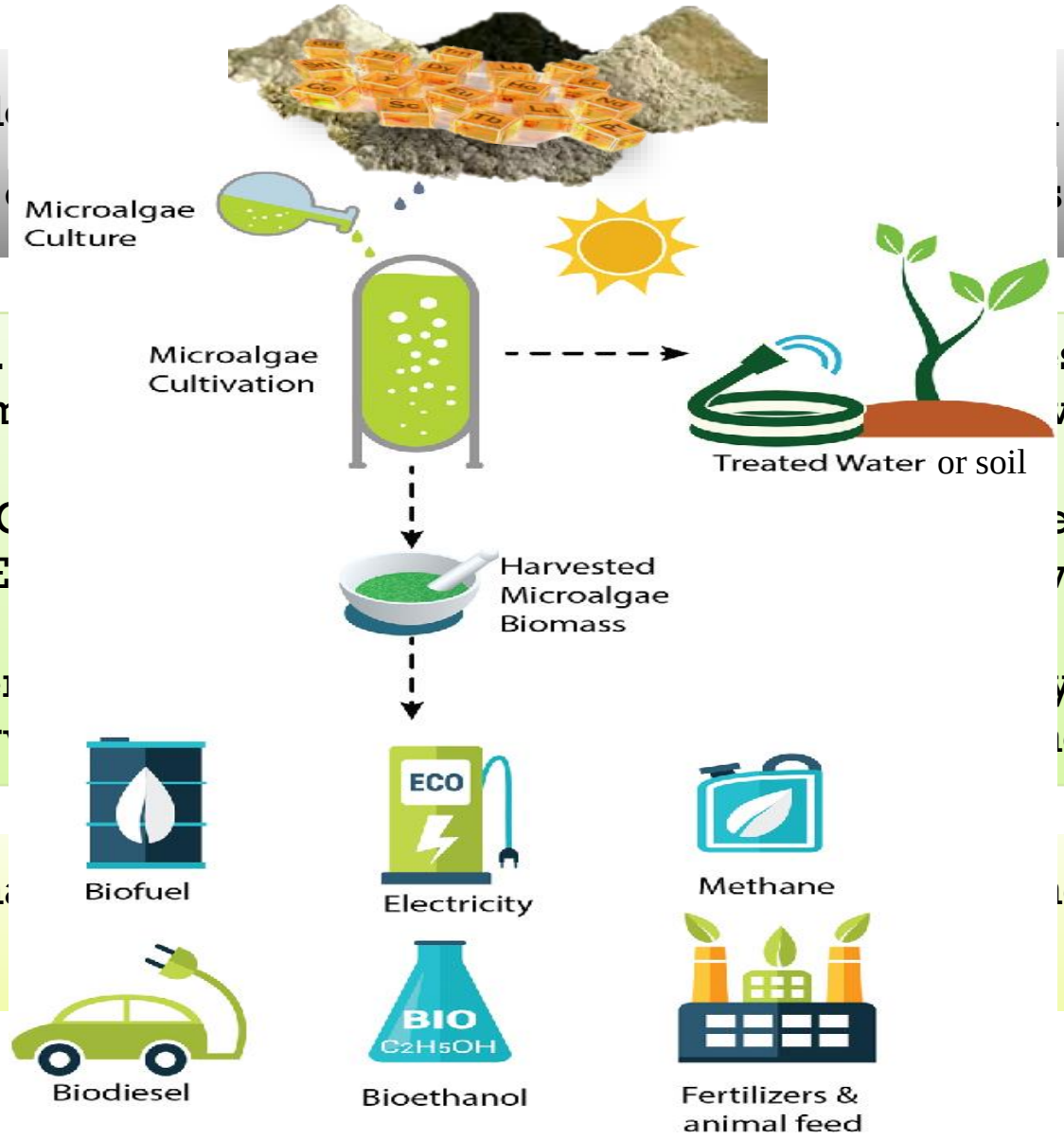
Demands - Increased d alternate resources like

Environment Protection s → release of REE into the environm vironment

while RE es
vironment

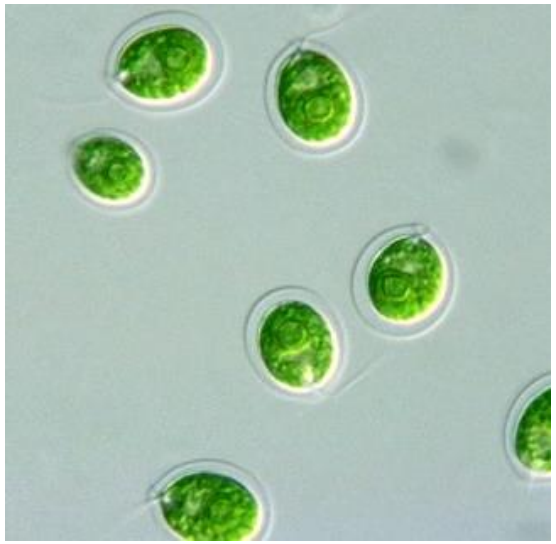
Soil, water or e-waste re y clean-up soil, water and har omy

In spite of th d is currently



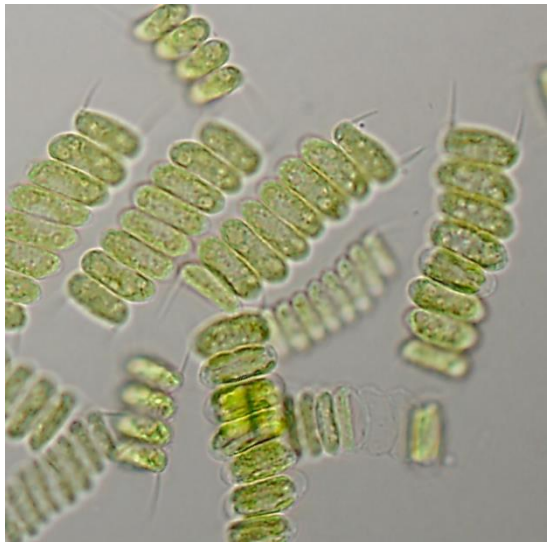
MODEL ORGANISMS

Green algae



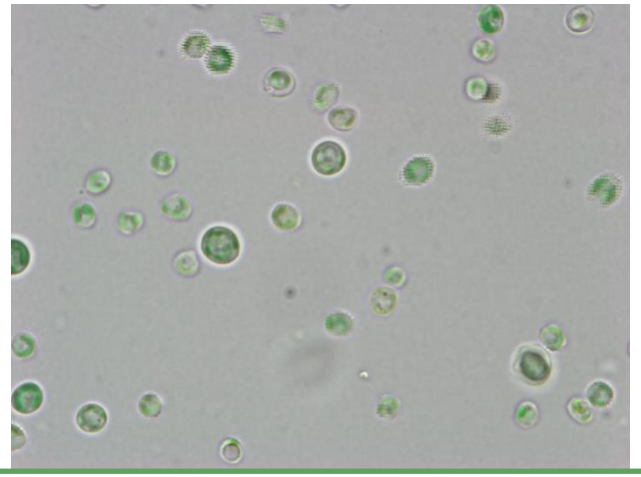
Chlamydomonas reinhardtii

Parachlorella kessleri



Desmodesmus quadricauda

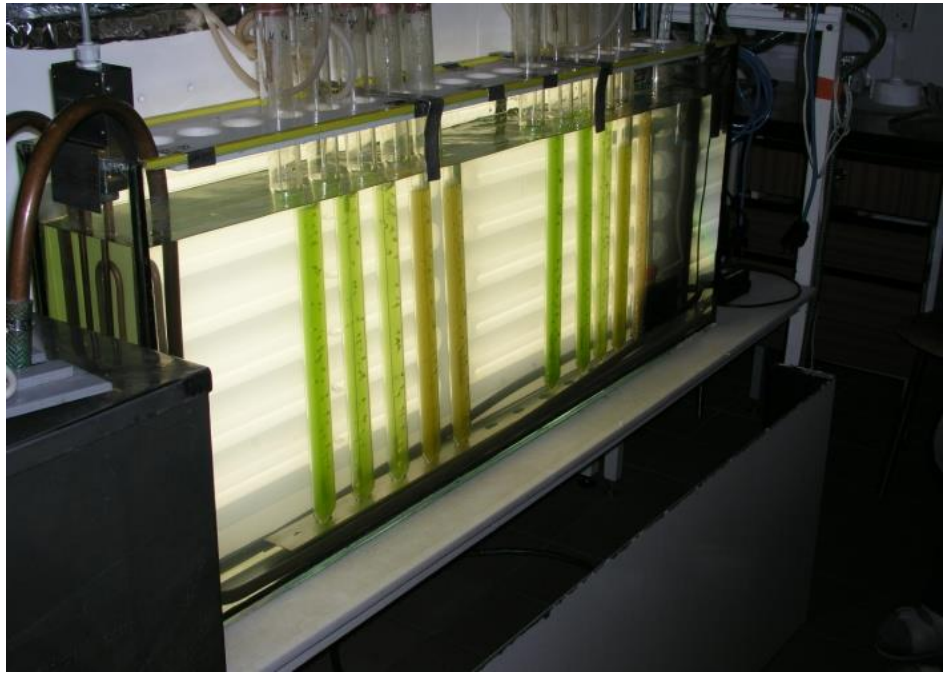
Red algae

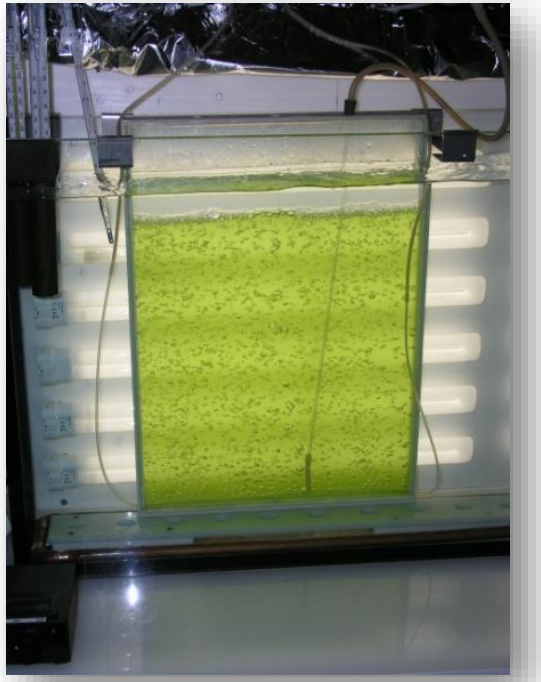


Galdieria sulphuraria (*pflegrea*)

- unicellular eukaryotes
- photosynthetic organisms
- thermo-acidophilic growth
- up to **56 °C,** pH between **0** and **4**
- highly tolerant of **high salt** and of **toxic metals**

PHOTOBIOREACTORS





30°C, pH 7-8
40°C, pH 3

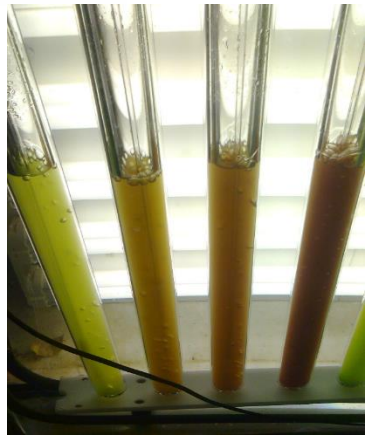
500 $\mu mol.m^{-2}.s^{-1}$
2% (v/v) CO_2 in air

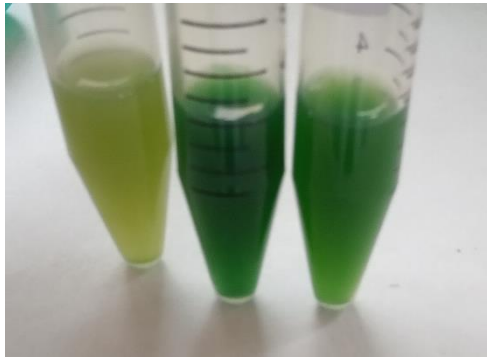
Study of algal growth responses and the ability to uptake REEs from 2 types of waste material:

I. Red Mud

II. E-waste

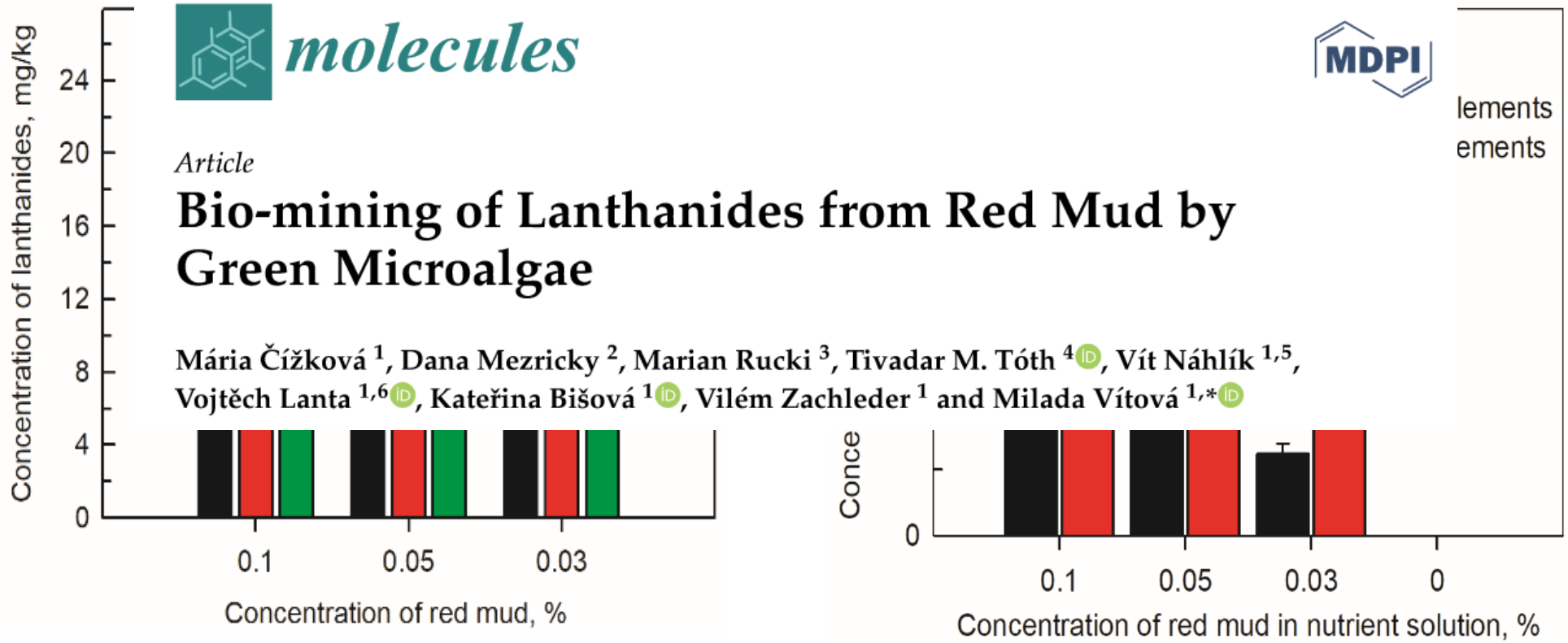
powder/ acidic extract





REEs UPTAKE vs MEDIA COMPOSITION

Desmodesmus quadricauda - nutrient medium without microelements

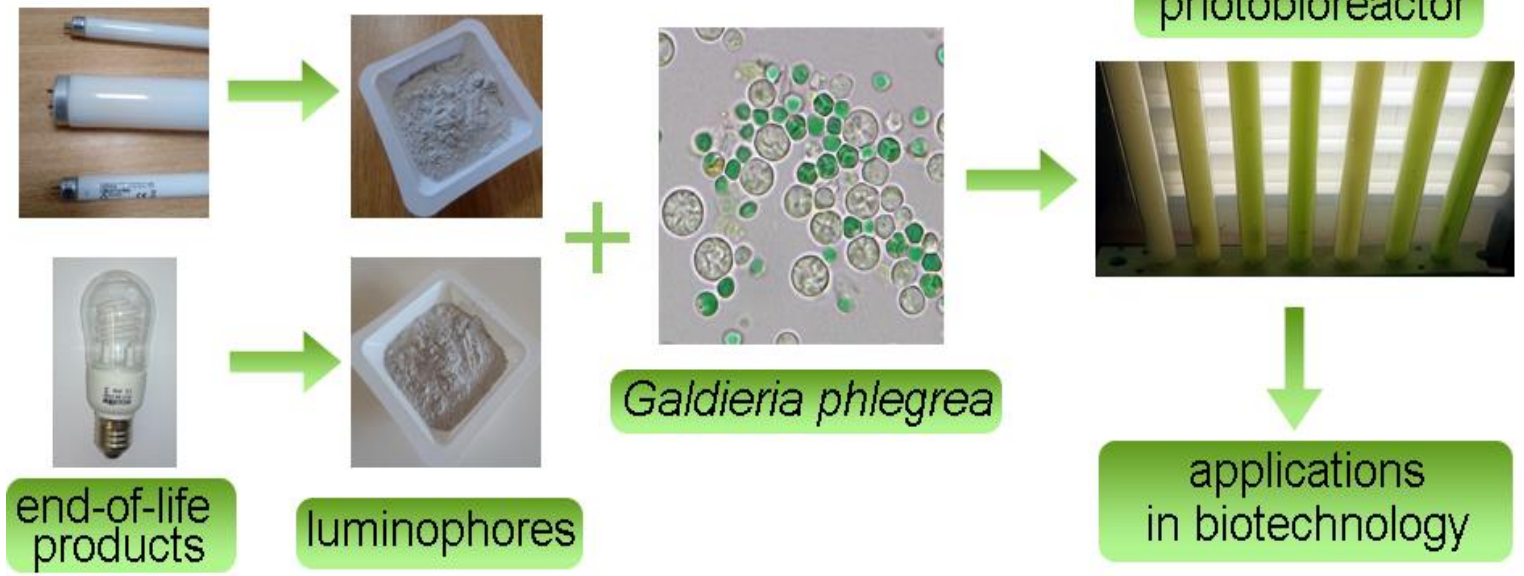


Content of individual REEs

Content of total REEs

Waste and Biomass Valorization (2021) 12:3137–3146
https://doi.org/10.1007/s12649-020-01182-3

ORIGINAL PAPER



- Luminophore powder shedding the light availability to algae.
- Powder was not completely soluble, settle down in bottom.
- Hard to separate the CFL powder and algal biomass for further analysis.

Waste disposal of CFL and FL lights

Powder of CFL and FL lights

Acid solution containing CFL powder

HNO_3

Filtered acid extract

Direct addition of powder were insoluble and settle down

ICP-MS

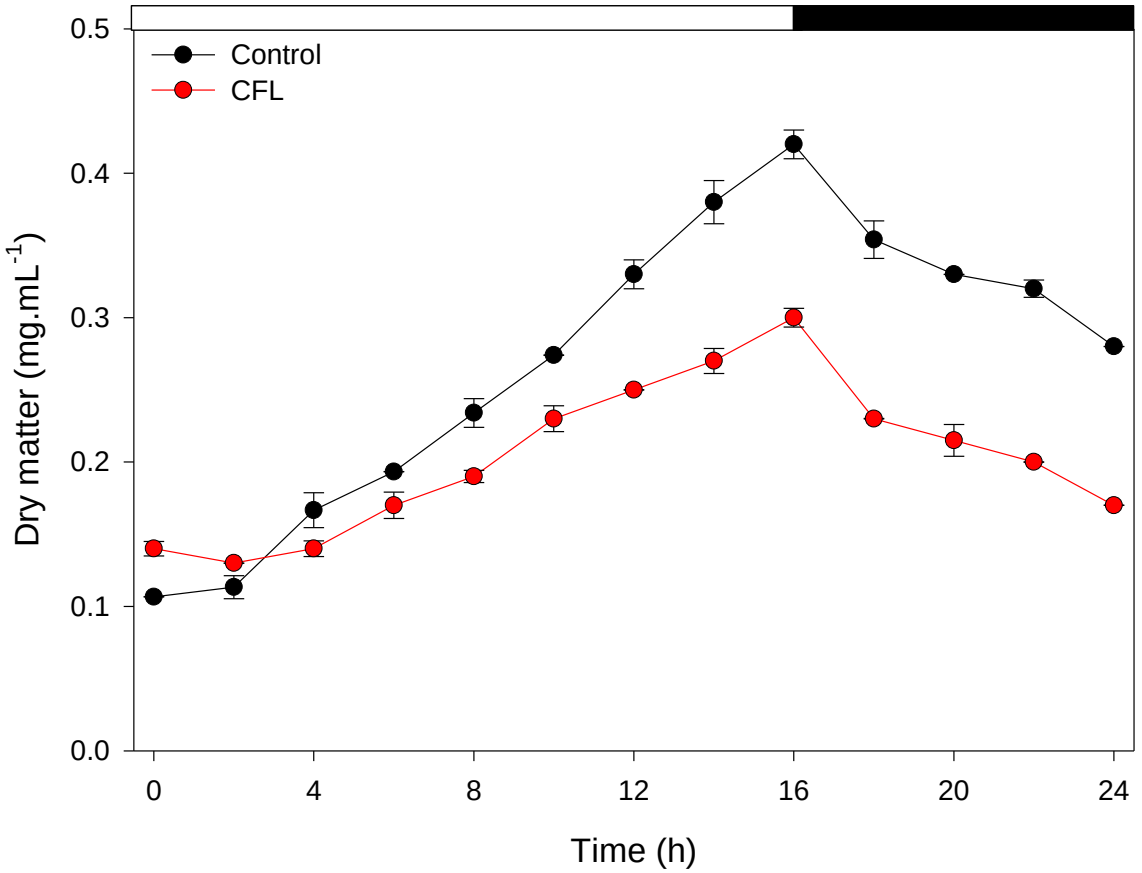
Bio-accumulation of REEs were analysed by ICP-MS

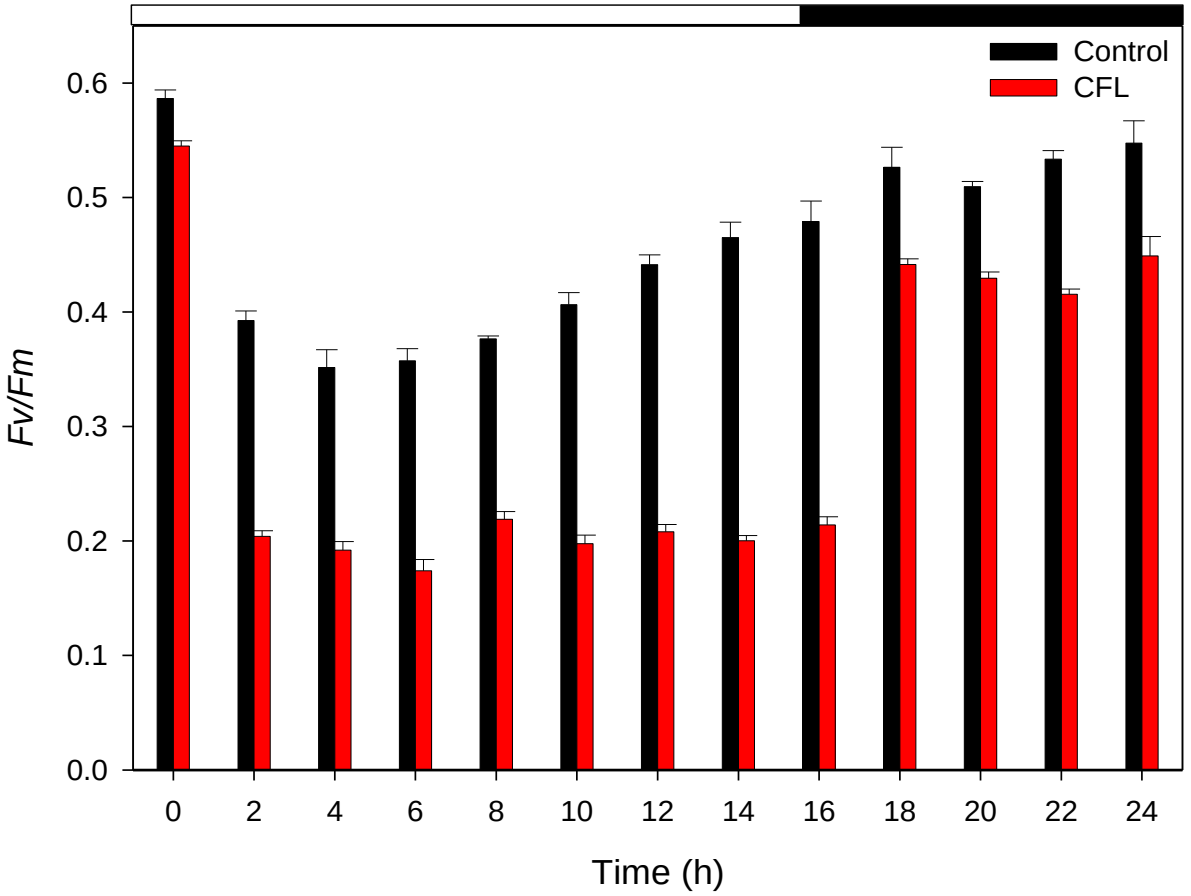
Algal sample were processed for pigments, protein, DNA, RNA, starch and microscopic analysis to check their response to REEs

Particle of REEs adsorb or accumulated by alga

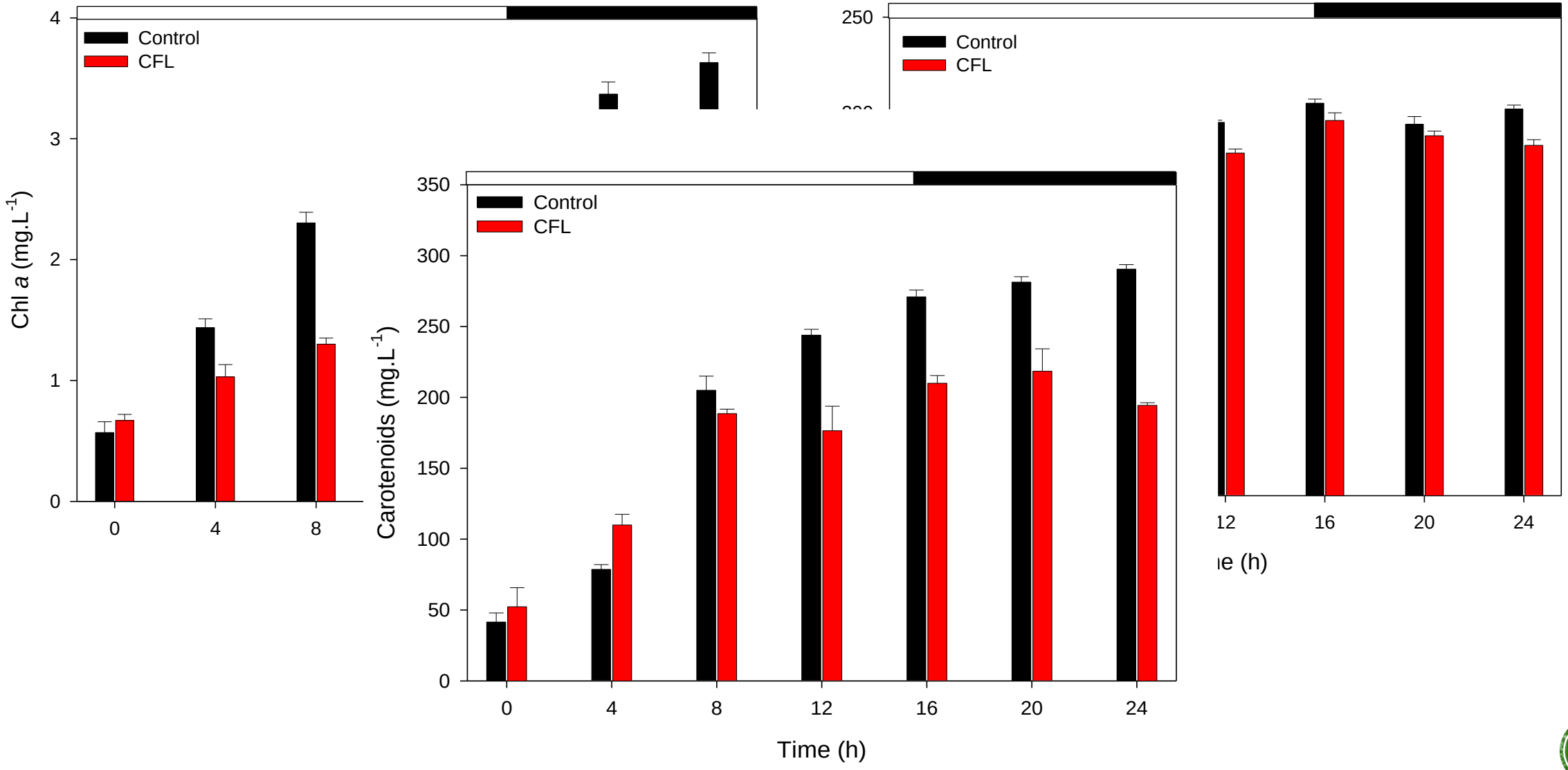
Algae with acid extract

DRY MATTER AND QUANTUM YIELD

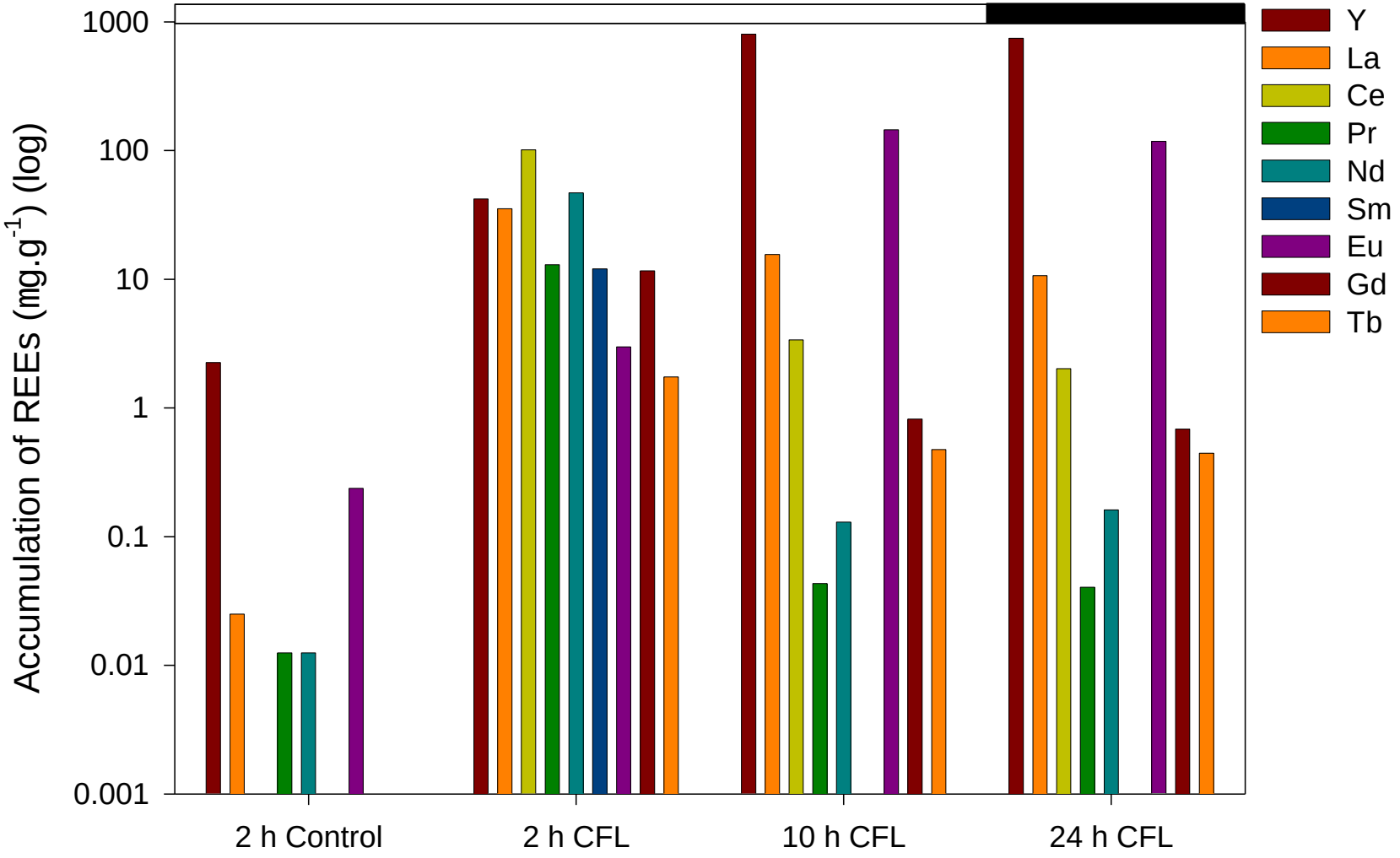




EFFECTS OF CFL ON PHOTOSYNTHETIC PIGMENTS



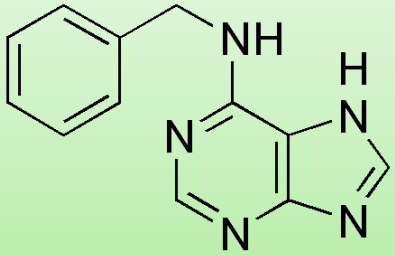
ACCUMULATION OF REEs

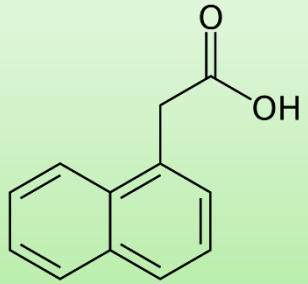


EFFECT OF PLANT HORMONES ON REEs ACCUMULATION

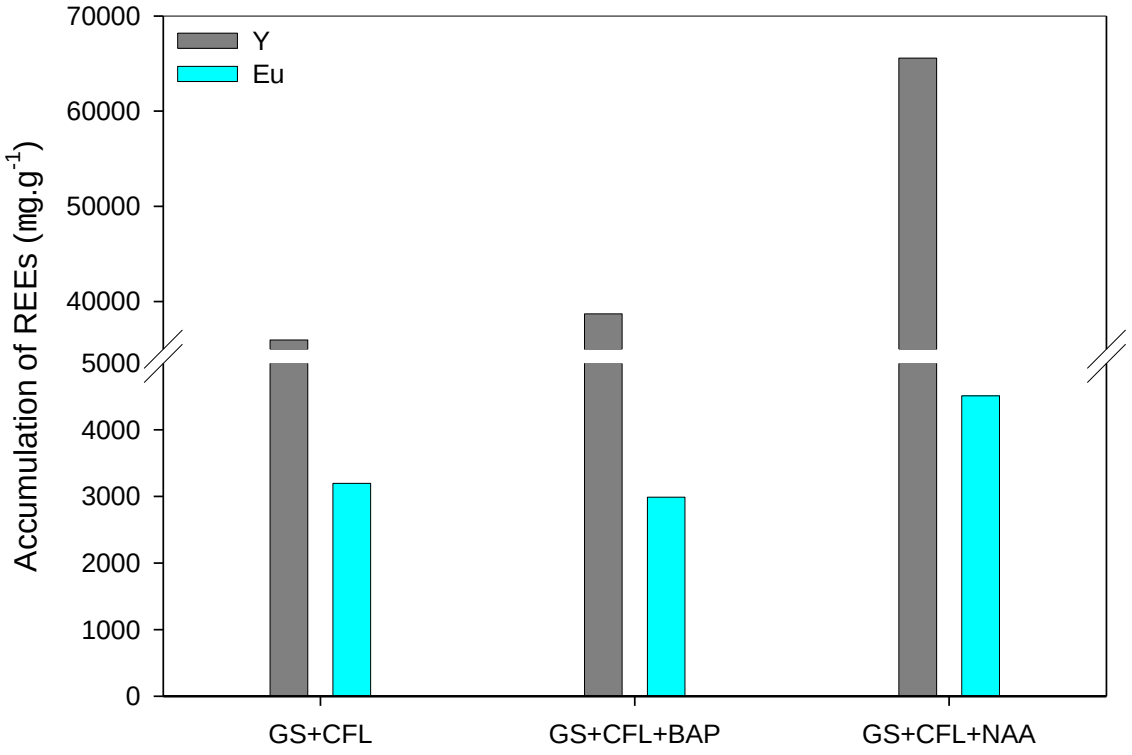
Concentration of 6-Benzylaminopurine (BAP) and 1-Naphthaleneacetic acid (NAA) – 5 mg/L

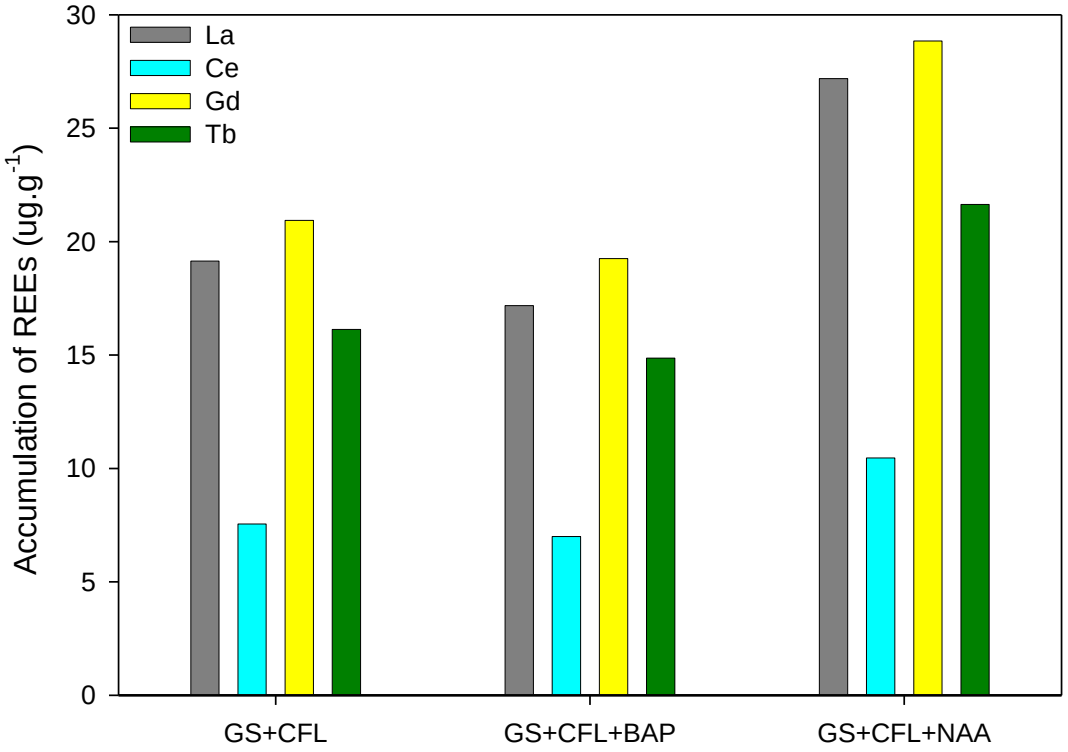
Cytokinin





Auxin





CONCLUSIONS

Galdieria sulphuraria - able to grow in presence of the acidic extract of CFL in the medium.
The growth was slightly affected as compared to the untreated culture.

The content of photosynthetic pigments decreased under the CFL treatment.
The Fv/Fm ratio lowered most probably by the CFL stress.

The most accumulated REEs in the algal biomass were Y, Eu, Ce, La and Nd, respectively.

NAA and BAP increased 60- and 30-fold of Y accumulation, respectively.

FUTURE PROSPECTS

- Electrical & electronic waste - potential secondary source of scarce REEs.

- Further research required to investigate the mechanism behind the bio-absorption/accumulation of REEs by algae.

- Need to develop eco-friendly and economical methods for REEs recovery from algal biomass.

LABORATORY OF CELL CYCLES OF ALGAE

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Kamila Ondrejmišková

Klára Kochtová

ARTICLES

molecules

MDPI

Article

Bio-mining of Lanthanides from Red Mud by Green Microalgae

Mária Čížková [1], Dana Mezricky [2], Marian Rucki [3], Tivadar M. Tóth [4], Vít Náhlík [1,5], Vojtěch Lanta [1,6], Kateřina Bišová [1], Vilém Zachleder [1] and Milada Vítová [1,*]

biomolecules

MDPI

Article

Growth under Different Trophic Regimes and Synchronization of the Red Microalga *Galdieria sulphuraria*

Vít Náhlík [1,2,†], Vilém Zachleder [1,†], Mária Čížková [1], Kateřina Bišová [1], Anjali Singh [1], Dana Mezricky [3], Tomáš Řezanka [4] and Milada Vítová [1,*]

Waste and Biomass Valorization
https://doi.org/10.1007/s12649-020-01182-3

ORIGINAL PAPER

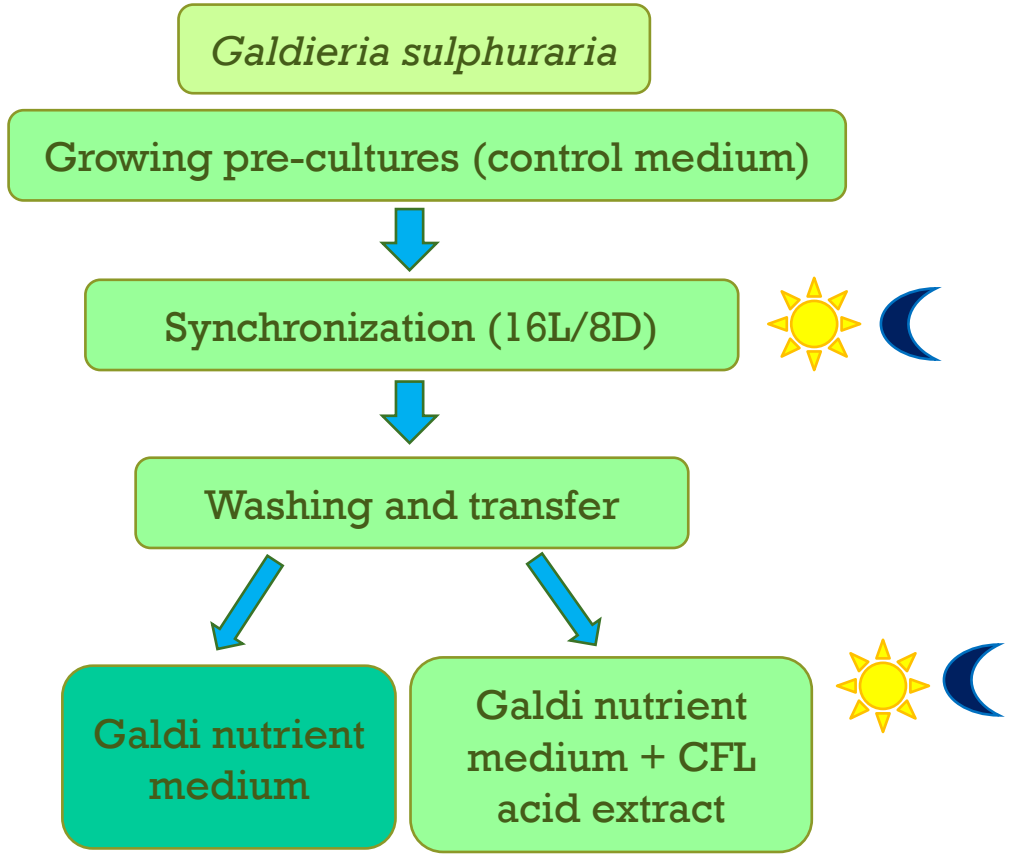
Bioaccumulation of Rare Earth Elements from Waste Luminophores in the Red Algae, *Galdieria phlegrea*

Mária Čížková[1] · Pauline Mezricky[2] · Dana Mezricky[2] · Marian Rucki[3] · Vilém Zachleder[1] · Milada Vítová[1]

Received: 28 February 2020 / Accepted: 20 July 2020

EXPERIMENTAL DESIGN

- Organism *Galdieria sulphuraria*
- 24 hours duration – sampling every 2 hours
- Synchronous (16L/8D) → permanent light
- Medium → Control and with CFL extract
- Final concentration of CFL – 2g/L
- Light - 350 µmol photons m^{-2} s^{-1}
- Temperature - 40°C



Monitored parameters:

Biomass composition – DM, RNA, DNA, protein, starch

Cell cycle observation – confocal microscopy, DAPI

REEs accumulation – ICP-MS

CONFOCAL MICROSCOPY

Control

CFL - Treated