

THE GREENTREAT PROJECT: MICROALGAE FOR THE TERTIARY TREATMENT OF URBAN EFFLUENTS IN THE ALGARVE, PORTUGAL



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INTRODUCTION

Wastewater treatment is a complex but mandatory process in all European countries, and with potable water supply and municipal budgets under pressure, in particular in countries of the Mediterranean basin, there is an urgent need for the development of cost-effective wastewater treatment plants (WWTPs) able to remove pollutants generated by municipalities, industry and agriculture [1]. Secondary effluents from WWTPs contain high concentrations of nutrients, such as nitrogen and phosphorous compounds, which may lead to eutrophication. In addition, WW may also contain significant amounts of ammonia, endocrine disrupters, personal hygiene products and antibiotics that conventional WWTPs are often unable to remove [2]. Microalgae have demonstrated good ability to remove inorganic compounds (e.g. ammonia, nitrates and phosphates) and organic contaminants (e.g. pharmaceuticals) with removal efficiencies up to 90% - thereby decreasing the toxicity risks of the treated wastewater [3]. Sunlight energy, sequestered carbon and the removed N and P compounds are stored in microbial biomass that can be used as a source of energy: i) lipids may be extracted to produce biodiesel; and ii) the remaining biomass can be anaerobically digested to produce biogas [4]. Biofuels production may thus yield sufficient revenues to lower the cost of wastewater treatment. Finally, reuse of treated wastewater can improve the status of the environment reducing pressure by substituting abstraction, and relieving pressure of discharge from WWTP to sensitive areas, which is is embedded within international and European strategies.

References

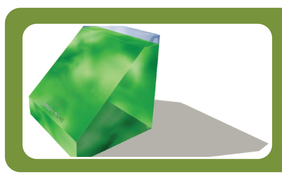
[1] Cai et al, 2013, Renewable and Sustainable Energy Reviews, 19, 360–369.
[2] Pereira et al, 2015, Environmental Research, 136, 108–119.
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[4] Sturm and Lamer, 2011, Applied Energy, 88, 3499–3506.

AIMS

GreenTreat aims to develop a microalgal-based, integrative, sustainable process of tertiary wastewater treatment (WWT) and treated water reuse: a pilot process using microalgae to remove excess nitrogen and phosphorus along with pharmaceutical products, which conventional WWT technologies often fail to eliminate.

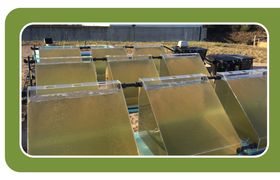
MATERIALS AND METHODS

The GreenTreat project is organized in 7 WorkPackages:



1. Pilot Implementation

- GreenDune photobioreactors (modular units 450 L, 1m^2)
- Designed and patented by Bluemater, SA



2. Pilot Deployment and Optimization of Operational Settings

- Deployment under outdoor conditions in a WWTP
- Influence of HRT, biomass concentration and seasonal variations



3. Removal of Pharmaceuticals

- Characterization of pharmaceuticals present in influent wastewater
- Quantification of the most prevalent pharmaceuticals



4. Monitoring of the Biological Composition

- Monitoring of bacteria by 16S metagenomics
- Monitoring of microalgae by flow cytometry – FACS and 18S metagenomics



5. Biomass Conversion and Upgrade

- Biodiesel production and / or Biogas production from spent biomass



6. Treated Water Re-use Scenarios

- Re-use objectives
- Scenarios for treated water use (on-site recycling and agriculture reuse)
- EU guidelines for water reuse (http://ec.europa.eu/environment/water/reuse-actions.htm)



7. Life-Cycle Assessment and Economical Analysis

RESULTS AND DISCUSSION

Three lines of pilot GreenDune photobioreactors (PBRs) were deployed at WWTP of Quinta do Lago, Algarve, Portugal (Fig. 1). Each line (replicate) is composed of a sequence of 3 PBRs of ~450L (1m^2) totalling 1.35 m^3. PBRs were filled with wastewater (WW) after secondary treatment and native species allowed to develop spontaneously.

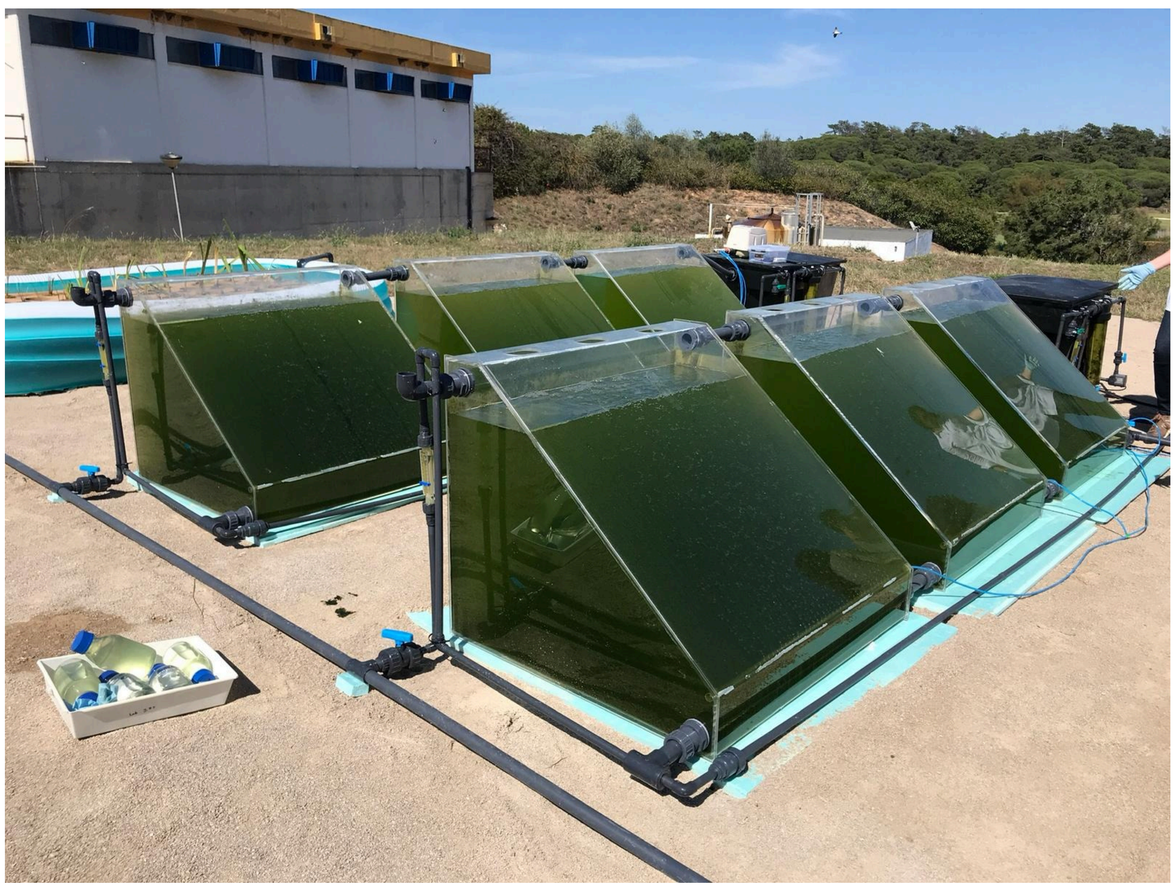


Fig. 1: Pilot GreenDune PBRs deployment at WWTP of Quinta do Lago, Algarve, Portugal.

Spontaneously growing strains belonged mainly to the classes *Cyanophyceae*, *Chlorophyceae* and *Bacillariophyceae.* Several strains were isolated by flow cytometry coupled with fluorescence activated cell sorting: *Desmodesmus abundans* GTM1, *Scenedesmus* sp. GTM2, *Scenedesmus* sp. GT3, *Chlorella* sp. GT4 and *Chlorella* sp. GT5 (Fig. 2).

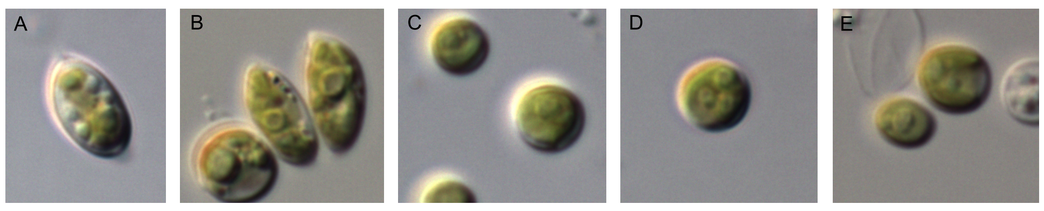


Fig. 2: Strains isolated from the pilot PBRs. A – *Scenedesmus* sp. GTM2; B - *Desmodesmus abundans* GTM11; C - *Desmodesmus* sp. GT7; D – *Chlorella* sp. GTM4; E – *Chlorella* sp. GTM 5.

WW was continuously fed to the PBRs maintaining an **hydraulic retention time of 2 days**. Part of the biomass produced in the PBRs was recirculated in a **bioaugmentation scheme**. In an experiment conducted during October 2019, the pH ranged from 9.24 to 10.64 and the biomass concentration varied between 55 and 258 mg/L (no CO_2 was added to the PBRs). Removal of nutrients (NH_4-N and P) was followed; the PBRs were efficient at removing these nutrients to below legislated values (Fig. 3).

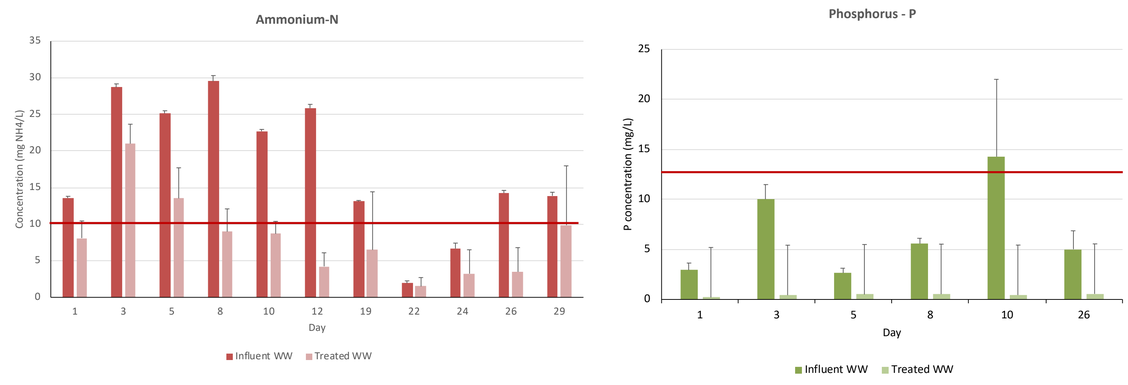


Fig. 3: Ammonium-N and phosphorus-P removal from wastewater.

CONCLUSIONS

An innovative design of microalgal photobioreactors – GreenDune – was successfully deployed in a real case scenario in a wastewater treatment plant located in the Algarve, South Portugal, to perform tertiary treatment of urban wastewater. Using a bioaugmentation scheme, and without any CO_2 supplementation to keep costs low, it was possible to reduce nutrient emissions at an hydraulic retention time of 2 days, under Autumn conditions.

ACKNOLEGMENTS

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