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HRAP retrofitting for the production of polyhydroxyalkanoates using bacterial photosynthetic mixed cultures treating domestic wastewater and agricultural wastes

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Introduction

Polyhydroxyalkanoates (PHAs) are biopolymers that can be synthetized and internally accumulated by several microorganisms. These biopolymers are precursors for bioplastics production which have reduced carbon footprint and improved biodegradability, representing a sustainable alternative to synthetic plastics. A new PHA producing system has been proposed, consisting in operating photosynthetic mixed cultures (PMC) and enriching them in PHA-producing photosynthetic bacteria. This system yields promising results since aeration can be eliminated (decrease in operating costs) because photosynthetic bacteria are able to obtain energy from light.

PHA accumulation levels up to 30% and 60% (Fradinho et al., 2013 and 2016) have been achieved using feast and famine and permanent feast, respectively. Using permanent feast, organisms are selected for their capability of internally regulating the cell's reducing power through PHA formation, while under permanent presence of external carbon. The main advantages of this regime are process simplification and decrease in operation costs: only one reactor is used for simultaneous selection, growth and accumulation.

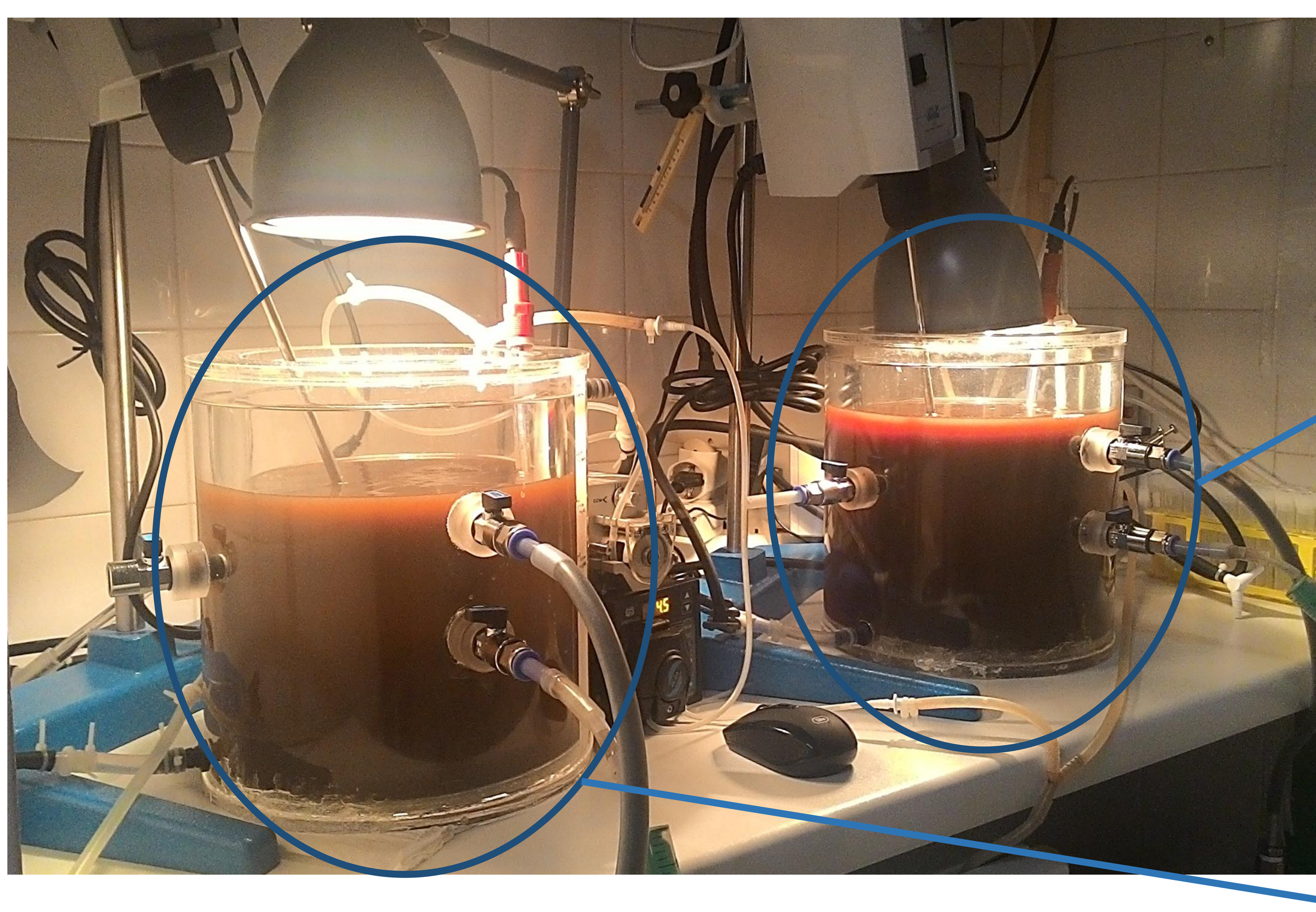
Currently, studies with PHA-producing PMCs are occurring under a Horizon 2020 European project:

- **INCOVER** aims the retrofitting of already existing algae ponds facilities used for domestic wastewater treatment, adapting their operation for PHA production;

GOAL: To develop sustainable plastic production systems that comprise the utilization of renewable feedstocks and a cost-effective production of biodegradable plastics, under the circular economy perspective.

Horizon 2020 project: current perspectives and future developments

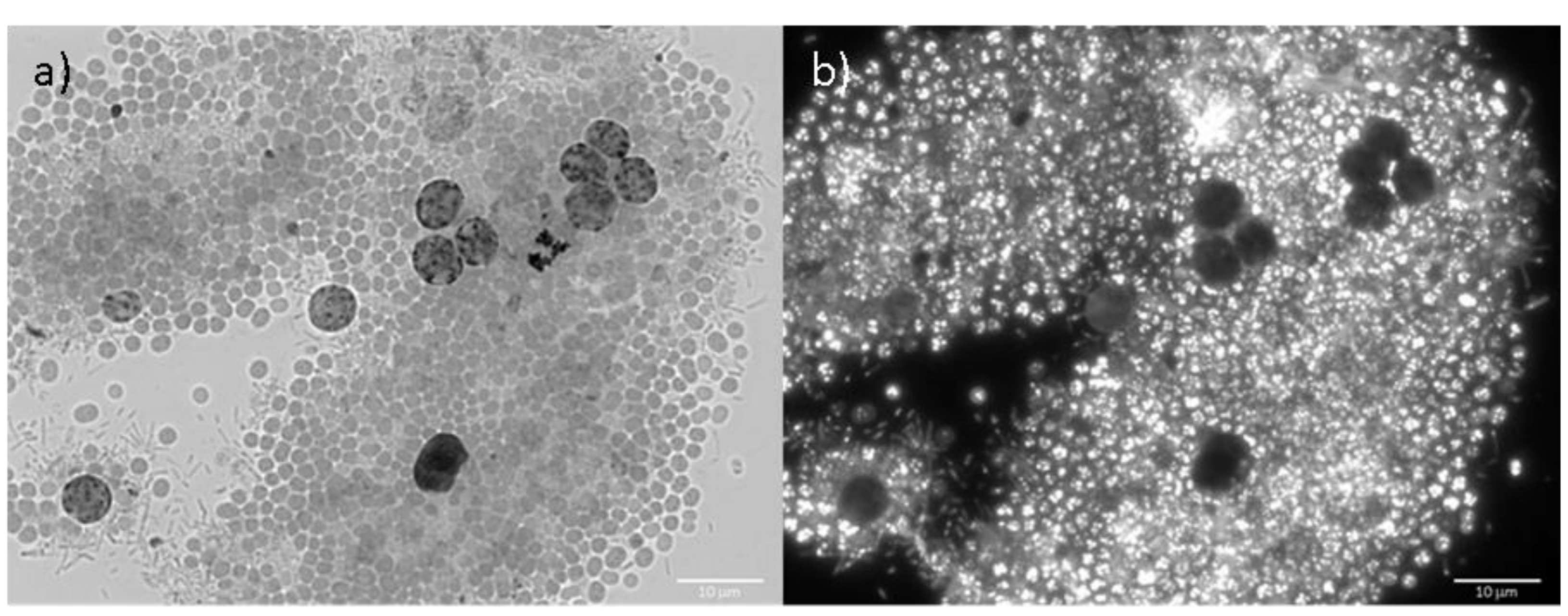
INCOVER aims the optimization of existing algae production infrastructure for PHA production from wastewater using microalgae/bacteria consortia. The potential of using already installed facilities and replacing the currently used algae communities by PHA-producing photosynthetic bacterial communities in terms of carbon and nutrients removal capacity from wastewater, as well as the possible economic revenue obtained from PHA commercialization, is being evaluated.



PMC reactors for the INCOVER project using different feeding strategies. Left: permanent feast, simulating a jet mixed algae pond with low sun exposure and anaerobic conditions. Right: feast and famine, simulating a paddle wheel algae pond with higher light availability and aeration.

Paddle wheel pond

Jet mixed pond



Microscopic image of the PMC under feast and famine fed with real fermented wastewater (simulating paddle wheel pond). a) Bright field; b) Fluorescence image of Nile blue staining indicating PHA granules.

Conclusions

Photosynthetic PHA accumulating bacteria have been successfully selected with bioplastic storage levels up to 10 – 20 % of mass content in the enrichment reactors. Ongoing experiments will continue to assess the maximum PHA accumulating capacity of the enriched cultures.

Operational conditions and impact of different substrate profiles on bioplastic yield will provide valuable data for the economic and scale-up evaluation of the process.

References: J.C. Fradinho, A. Oehmen, M.A.M. Reis, "Effect of dark/light periods on the polyhydroxyalkanoate production of a photosynthetic mixed culture", *Bioresource Technology*, vol. 148, pp. 474-479, 2013. J.C. Fradinho, M.A.M. Reis, A. Oehmen, "Beyond feast and famine: Selecting a PHA accumulating photosynthetic mixed culture in a permanent feast regime", *Water Research* vol. 105, pp. 421-428, 2016.

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