Plastic is fantastic: polyhydroxyalkanoate production on real fermented wastewater

Keywords: PHA production in a chemostat, mixed microbial cultures, Phosphorus (P)-limitation.

Background

The wastewater treatment plants (WWTP) of the future is a net source of energy and valuable products, i.e., a water resource recovery facilities (WRRF). While conventional WWTPs only focus on the removal of organic substrates and nutrients, WRRFs will also aim at converting pollutants into valuable end-products. The current project aims at evaluating the conversion of organic carbon from municipal wastewater (WW) into bioplastics, i.e., poly-hydroxalkanoates (PHA). PHAs are biodegradable intracellular polymers produced by storing-microorganisms as carbon and energy sources. PHAs represent, to a certain extent, a relevant alternative to plastics produced by petro-chemical industry.

The production of PHA from municipal WW is usually performed in a 2-steps approach (Valentino et al., 2015). In step #1 PHA-storing micro-organisms are selected in sequencing-batch reactors, i.e., by imposing a feast-famine regime. In step #2 the accumulation of PHA by these specialized micro-organisms is maximized in a separate fed-batch reactor. Such 2-steps approach has strong limitations (different influent compositions are required for the enrichment and accumulation steps, complex operation, etc.). Recent research efforts thus aimed at evaluating to what extent PHA can be produced from municipal WW using a single reactor operated in continuous mode (Brison et al., 2022; Brison et al., 2023).This research highlighted that nutrient limitations, e.g., phosphorus, can be modulated to trigger the production of PHA and that storing-microorganisms with a high PHA content (> 70% w/w) can be cultivated on real fermented municipal WW. However **the exact nutrient limitation responsible for the PHA storage response** during treatment of fermented municipal wastewaters, **as well as the microbial mechanisms associated to this nutrient limitation, was not identified**.

Objectives and scientific research questions

The main goal of the proposed master thesis is **to gain fundamental understanding of how environmental growth conditions** (nature and extent of the nutrient-limitation, composition of the carbon sources) **influence the selection of storing micro-organisms** during treatment of real fermented municipal WW **and ultimately their storage response** (substrate to PHA conversion yield and type of monomers produced). The proposed master thesis project will especially aim at:

- characterizing the detailed composition of fermented municipal WW in terms of nutrients (nitrogen, phosphorus, iron, sulfur, etc.) in order to anticipate the nutrient limitations responsible for the storage-response.
- Assessing that PHA production during treatment of fermented WW is triggered by the identified nutrient, via:
    - long-term PHA production experiments using the same fermentate (mass balanced on nutrients),
    - short-term PHA accumulation using synthetic or real fermented WW doped with selected nutrients.

Requirements
Knowledge and interest in biological wastewater treatment. (e.g., Process Engineering 1a course or equivalent, anaerobic processes). Interest in biotechnology applied to resource recovery and circular economy.

Specific Information
The master thesis will be performed in the Process Engineering department of Eawag. This is part of a collaboration between the Process Engineering dpt of Eawag (Nicolas Derlon) and the laboratory of microbal physiology and resource biorecovery of EPFL (Ass. Prof. Wenyu Gu). Office space with computer and access to the existing experimental facility will be provided.

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References – Recommended Literature
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