Biopolymer production from wastewater treatment by experimental and modelling approaches

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Wastewater resource recovery

Motivation

Sewage sludge is generally produced by wastewater treatment plant (WWTPs) and represents a waste byproduct. The management and disposal of sewage sludge, highly contributes to WWTPs operational costs.

In a circular economy context, the sewage sludge may become a resource for the production of various renewable products, for instance, polyhydroxyalkanoates (PHAs) [1].

PHAs are polyesters with attractive properties: renewable and biodegradable. Surplus sludge can be a raw material input for an inexpensive PHA production process thus favoring their use in substitution of traditional petroleum-based plastics that poses many concerns regarding their disposal, environmental contamination, toxicity to the ecosystem and human health [2].

Challenges

The use of sewage sludge for PHA production, both as feedstock and as inoculum for biomass enrichment by feast and famine cycles, has been already demonstrated in the literature. However, there is still a lack of overall cost effectiveness in the process and consistency in the property of the obtained polymer. Strategies that address needs in both productivity and polymer quality are essential towards establishing regional economies with surplus sewage sludge as an abundantly available raw material for biopolymer value chains [3].

Fundamental insights leading to innovative process methods are anticipated to come from:

- The optimization of sludge acidogenic fermentation step in order to obtain a stream with high VFA/RBCOD ratio and low nutrient concentration.
- The optimization of mixed-microbial-culture enrichment and PHA accumulation in order to achieve high PHA cell contents
- Innovative downstream processing methods to recover the polymer maintaining its properties.
- Modeling of the biological system, and proper bioreactor design.

Research objectives

The objective of the PhD project is to establish optimal engineering design and operational principles for mixed culture PHA production and to model the overall bioprocess (Figure 1). The experimental approach will be based on batch tests and pilot plants treating real wastewater.

The first pilot plant will be located at the university campus and fed with wastewater from university dormitory and canteen. Different plant layout will be tested to optimize the process. A second pilot plant (Figure 2) will be located at Marineo's WWTP and will test the process with real wastewater composition and variability.
The activities are part of the Horizon2020 project - Wider-Uptake [1].

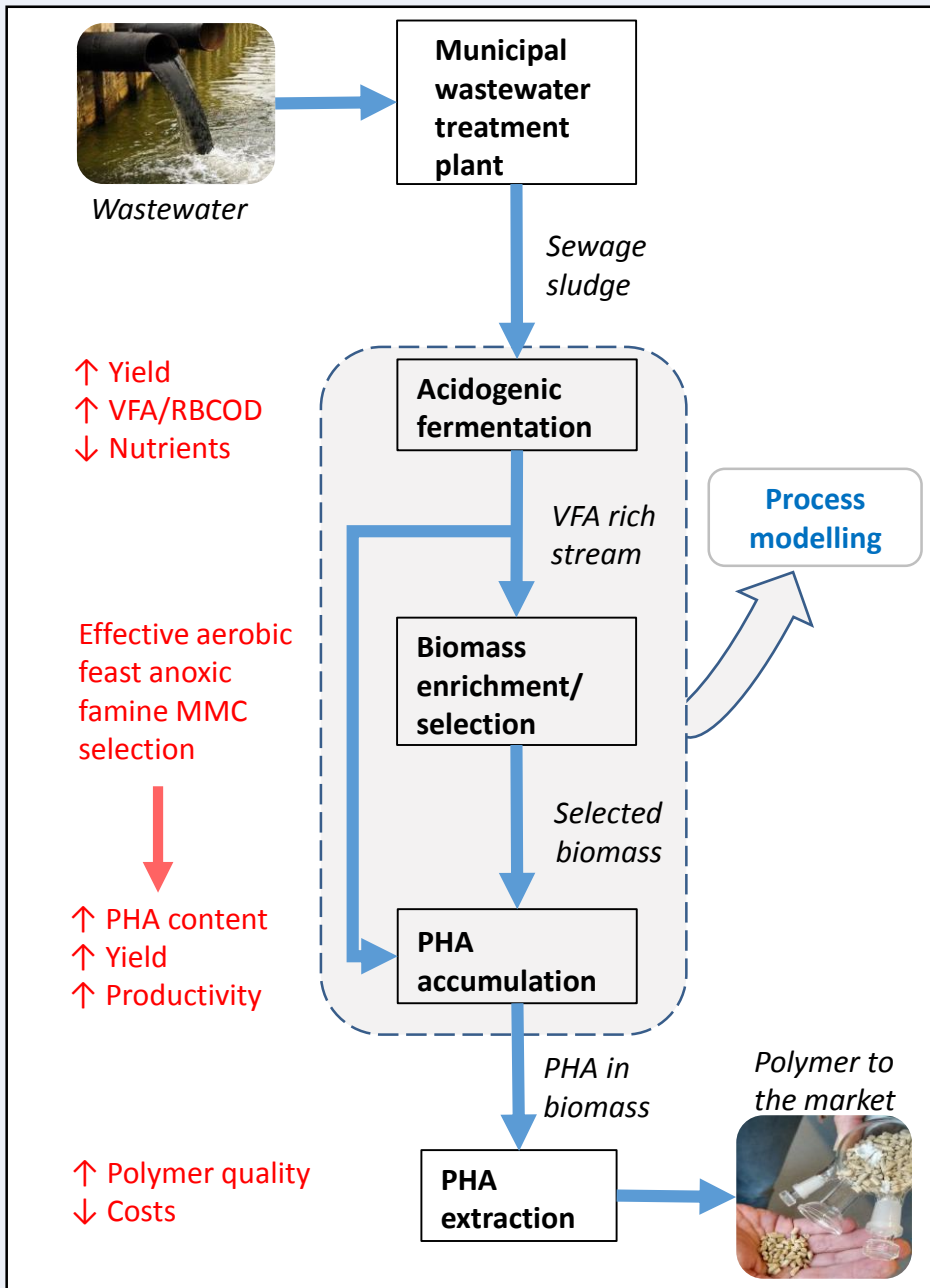

Figure 1 – Research strategy of the project

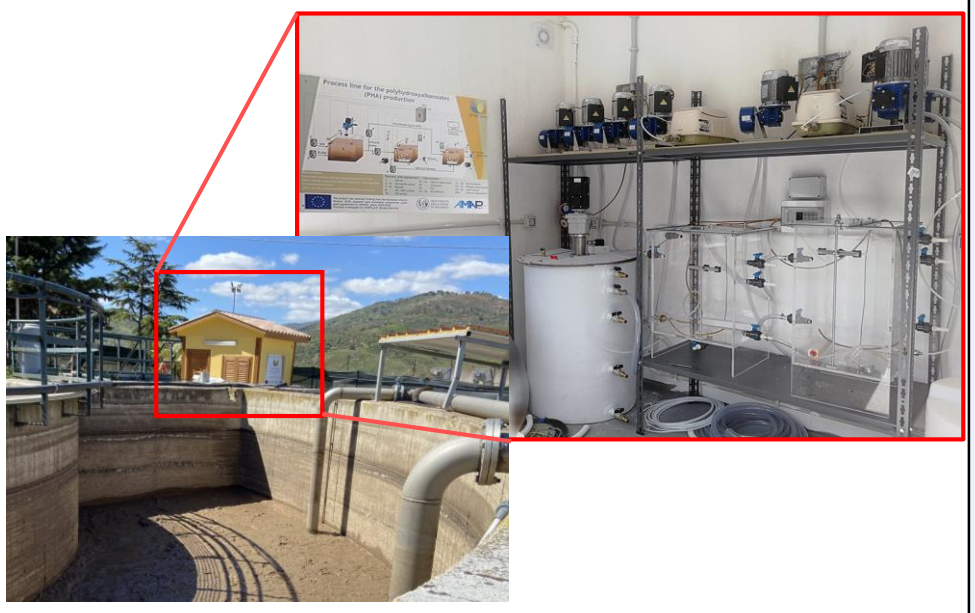

Figure 2 – PHA pilot plant located in Marineo WWTP

[1] Mannina et al. (2021), Water 13(7), 946
[2] Mannina et al. (2020), Bioresource Technology 297 122478
[3] Estevez-Alonso et al. (2021), Bioresource Technology 327 124790