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Producing biopolymers for the bioplastic and chemical industries

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Motivation

Activated sludge (AS) is normally produced as a waste by-product in biological wastewater treatment plants (WWTP) and its production, and subsequently disposal, contributes significantly to the operational costs of the WWTP. Within regionally based circular economies, AS does not necessarily need to be a waste by-product. It can be considered as a resource for the production of renewable products, for instance, polyhydroxyalkanoates (PHAs). PHAs are polyesters with attractive properties: renewable and biodegradable. Surplus AS can be a raw material input for a PHA production process if a volatile fatty acid (VFA) stream can be made sufficiently available as feedstock[1].

Technological challenge

The use of AS has been demonstrated for PHA accumulation[2] or as inoculum for a biomass enrichment by feast and famine cycles[3]. At the same time, municipal biomass, from full-scale treatment systems without previous enrichment have demonstrated potential to produce already significant amounts of high quality polymer[1] (Fig. 1). However, there is a **lack of fundamental understanding in methods that can ensure for reproducibility and consistent efficiencies** in the production process when a municipal AS is supplied directly into a PHA production process.
Moreover, strategies that address needs in both productivity and polymer quality are essential towards establishing regional economies with surplus AS as an abundantly available raw material for biopolymer value chains. Fundamental insights leading to innovative process methods are anticipated to come from steering the biomass condition prior accumulation (physiological state), control and exploitation of flanking metabolic activity and reactor configuration with its process control (Fig. 2).

Fig 1. Business card holder made during the PHARIO project using municipal activated sludge[1].

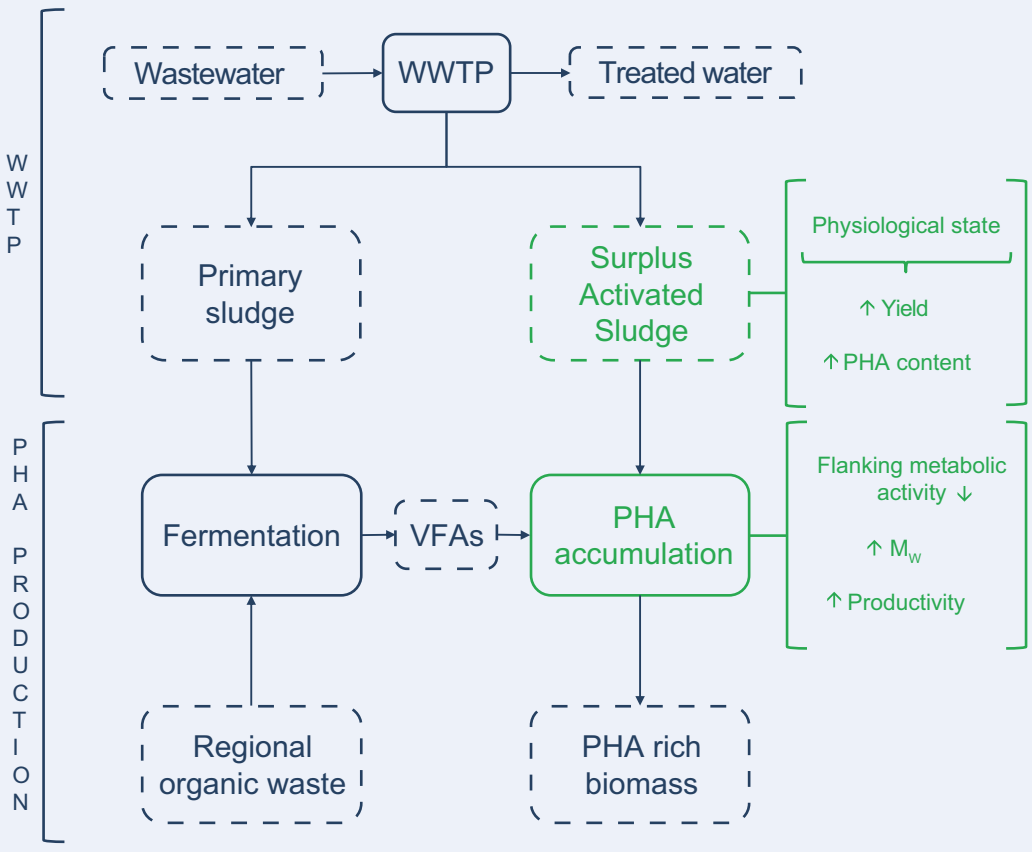

Fig 2. Research strategy of the project: steering the biomass condition prior accumulation (physiological state), control and exploitation of flanking metabolic activity and reactor configuration with its process control.

Research goals

The objective of this project is to **establish robust and optimal bioprocess engineering design principles for mixed culture PHA accumulation** (Fig. 2). The approach will be with fundamental evaluations of biomass physiological state, respiration response, and polymer molecular weight control, while developing monitoring strategies to ensure that:

- biomass condition before accumulation is primed for maximum PHA content and yield,
- process operations are selective and controlled for high polymer molecular mass (M_w),
- bioprocess methods are generic for varied biomass sources and feedstocks,
- control strategies give selective advantage to the PHA storing phenotype in the biomass, and
- process configuration and design are optimized for productivity and economy

References
[1] Bengtsson et al (2017) PHARIO report. STOWA (April), 93.
[2] Cavaille et al. (2013) Bioresource Technology, 149, 301–309.
[3] Tamis et al. (2014) Journal of Biotechnology, (Part A), 161–169.

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