Resource Recovery Potential of Wastewater Treatment: Biopolymers

John Sing-Key.
Department of Civil and Environmental Engineering, South Kensington Campus, Imperial College London

INTRODUCTION

Polyhydroxyalkanoate (PHA) is a type of biopolymer stored inside certain bacteria as granular carbon and energy reserves. These biopolymers can be extracted to produce biodegradable thermoplastics. The biopolymer plastics share similar mechanical properties to typical petroleum-based plastics and can be used for applications in the packaging, agricultural, plastic and medical industries. However, demand for PHA plastics is limited due to the high production costs. The production of biopolymers using wastewater sludge is suggested as a means of reducing PHA biopolymer production costs whilst simultaneously recovering carbon from wastewater treatment and converting it to a high value product.

THE PROCESS OF BIOPOLYMER PRODUCTION

Four processes were identified for the production of PHA biopolymers in wastewater treatment:

1. ENRICHMENT

The microbes which store PHA are found in activated sludge biomass but at insufficient quantities for substantial biopolymer production. The enrichment process applies environmental conditions which favour the growth and survival of these microbes.

2. FERMENTATION

Microbes require a carbon source for PHA production. Although wastewater sludge is rich in carbon, the organic form is not suitable for microbial uptake. Therefore, the wastewater sludge must be fermented under hydrolysis and acidogenesis processes to convert the organic matter into volatile fatty acids, which are a suitable precursor for PHA synthesis.

3. ACCUMULATION

The biomass from enrichment is then transferred to a separate reactor where it can be fed volatile fatty acids from fermentation under controlled conditions to optimise microbial PHA storage.

4. RECOVERY

Once maximum PHA storage in the sludge biomass has been achieved, the biomass is subjected to a series of processes to separate the PHA granules from microbial cell material. The resulting form of the biopolymer is a powder or pellet ready to be used for the manufacture of bioplastic products.

Project aim: Determine the viability of PHA production as an resource recovery option in wastewater treatment.

Project objectives:
- Determine the applications and market for PHA biopolymers
- Investigate technical feasibility of PHA production
- Compare PHA production with standard anaerobic digestion

THEORETICAL ANALYSIS

A theoretical model of a wastewater treatment plant was devised by incorporating the four processes for biopolymer production into a conventional wastewater treatment system; capable of serving a 250,000 population equivalent wastewater flow. A mass balance analysis of the model showed a production capacity of 3.821 kg/day or 1.390 t/year but with the potential for higher capacity by applying optimal conditions for PHA production.

CONTRIBUTION TO GLOBAL PHA PRODUCTION

Potential production capacities show that multiple wastewater treatment plants with PHA production can make significant contributions to global PHA production capacities.

COMPARISON WITH CONVENTIONAL ANAEROBIC DIGESTION

The production of PHA was benchmarked against anaerobic digestion; the standard resource recovery practice by the Water Industry. This was to compare the competitiveness of PHA production as a resource recovery option.

CONCLUSIONS

Recovering biopolymers from wastewater treatment is a technically feasible option. With a few modifications to conventional wastewater treatment plant design, a high value and sustainable product can be produced which contributes to the UK’s bioeconomy and is more economically favourable than standard wastewater resource recovery practices. The process is cost competitive against industrial biopolymer production and has a lower environmental cost compared to petroleum-based plastics. Therefore there is a strong case for PHA biopolymer production to be incorporated into municipal wastewater treatment.

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REFERENCES