Closing the loop: Can biodegradable plastics enhance energy production from food waste anaerobic digestion?

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Problem statement

Since the first commercial plastic was developed in the 1920's, 8.3 billion tons of plastic were produced[1] – but recycling is still lagging behind, particularly for food packaging. Meanwhile, households in the UK alone generate 10.2 million tons of food waste every year[2]. This linear model threatens the integrity of our ecosystems while creating an unprecedented waste management crisis.

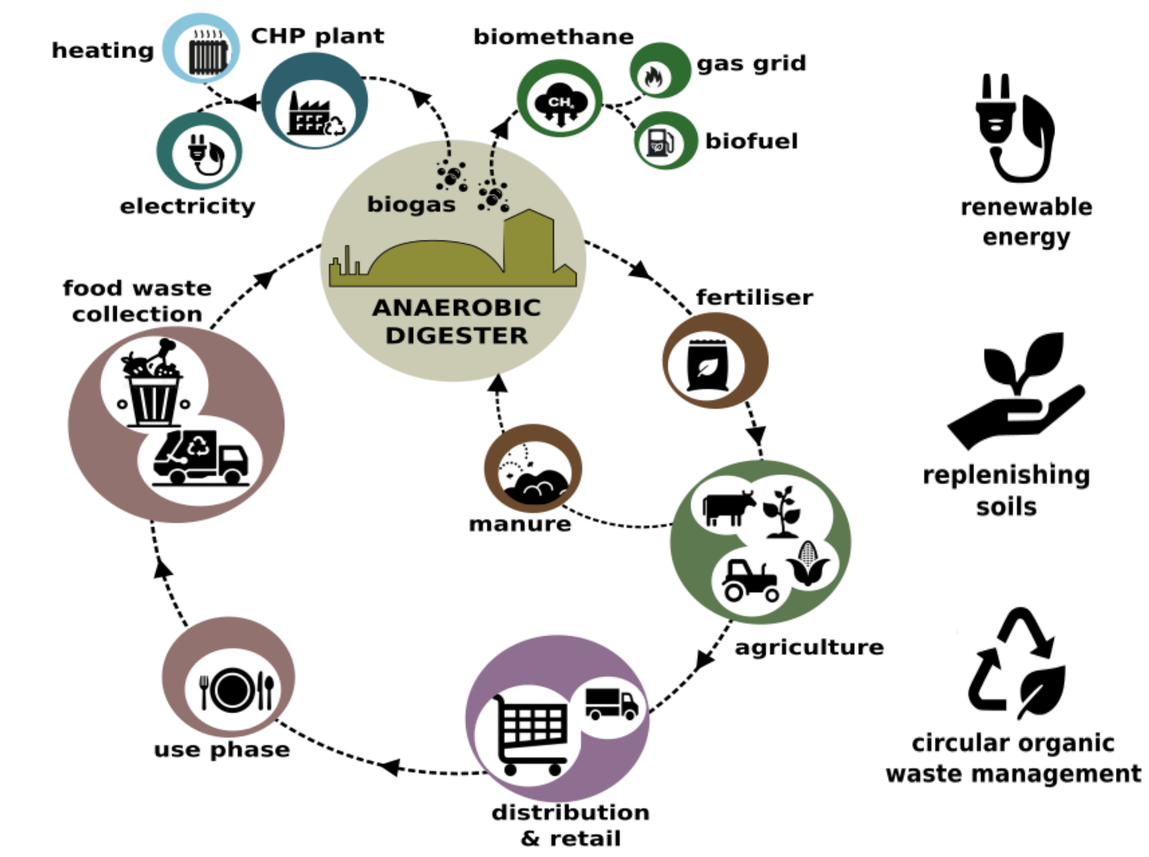
Bioplastics have been identified as a promising solution to 'close the loop' while shifting to a bio-based economy. The majority of studies have investigated the process of bioplastic biodegradation in composting environments. More recently, anaerobic digestion has emerged as more valuable end-of-life scenario, as it has the potential to generate renewable energy through biogas production. This thesis addresses the feasibility of food waste and bioplastics co-treatment in industrial anaerobic digestion within a circular economy framework at the UK and EU level.

What are biodegradable bioplastics?

Bioplastics are plastic materials made from renewable biomass, such as vegetable oils, corn starch or even wood chips and lobster shells[3]. **Biodegradable bioplastics (BBPs)** have the additional properties of being biodegradable under certain controlled environments, which means they can be treated alongside food waste for composting or anaerobic digestion (see below).

What is anaerobic digestion?

Anaerobic digestion (AD) refers to the degradation of biowaste by microorganisms in the absence of oxygen (i.e. anaerobically)[4]. As it mitigates greenhouse gas emissions, recycles nutrients and organic matter and generates renewable energy, AD represents a circular waste management strategy and plays a key role in the **bioeconomy and circular economy[5].**

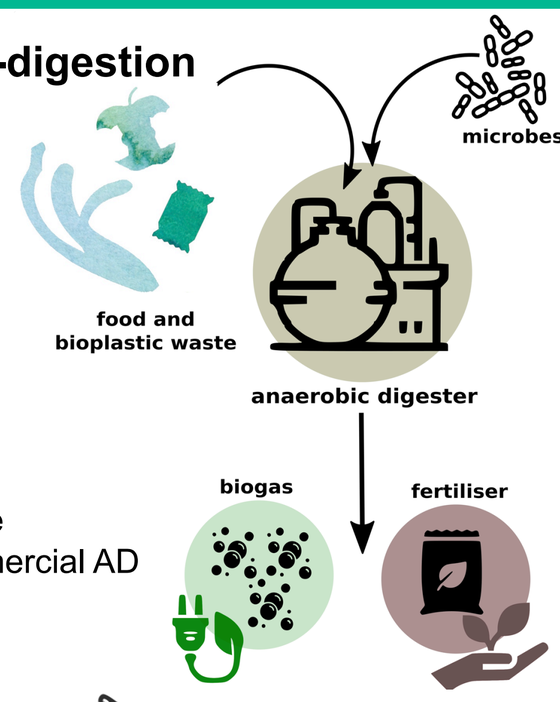


Methodology

① Lab-based anaerobic co-digestion

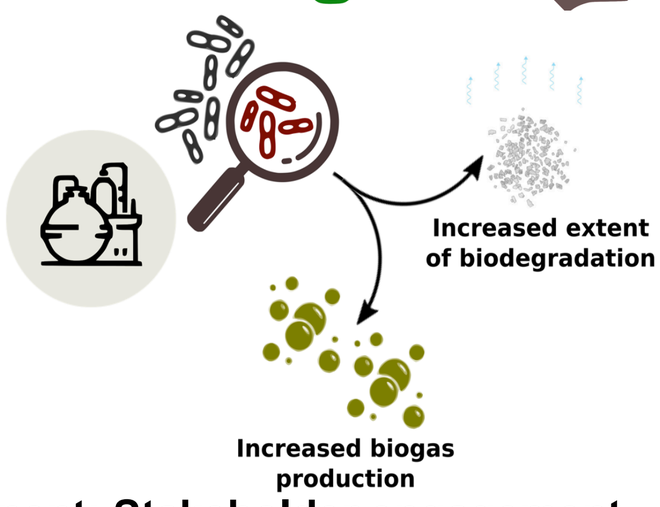
<u>Fermentation</u> of food waste with different BBPs and different concentrations and measuring biogas production as well as the quality of the digestate

Experimental design:
- 250 ml glass bottles (batch)
- Mesophilic (37°C) incubator
- 1x1 cm^2 plastic film size
- 'Homemade' food waste puree
- Microbial inoculum from commercial AD plant



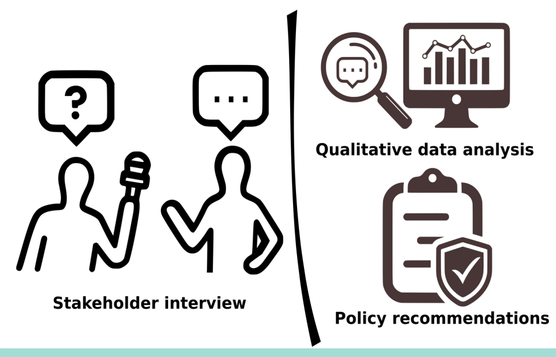
② Microbiology

Characterisation of microbial community structure and function through <u>metagenomics sequencing</u> to identify potential species that could optimise the AD process and increase biodegradation of BBPs



③ Qualitative component: Stakeholder engagement

<u>Semi-structured interviews</u> with stakeholders in the waste management, bioplastic manufacturing, non-for-profit and policy sectors



Results so far

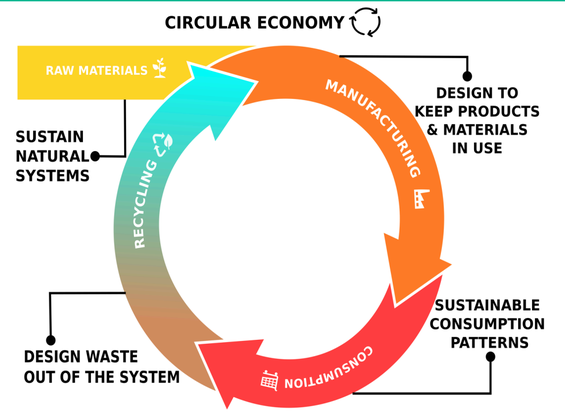
- Design of a synthetic food waste recipe to reflect the typical food waste bin of a UK household

- Literature review suggests most study designs for BBP digestion do not reflect industrial conditions

What next?

- Further AD co-digestion experiments
- Stakeholder engagement: interview analysis with NVivo software
- Microbiology: screening for potential candidates in AD co-digestion
- Case study: UC Davis on-site organic waste processing

Ultimate ambitions



Research aims

① Investigate the contribution of BBPs to biogas production in AD;
② Explore the interaction between microbial communities, bioplastic material type and biogas production;
③ Investigate the current and projected waste management infrastructure for BBP packaging waste in industrial AD facilities; and
④ Evaluate the advantages and limitations of BBPs from a circular economy perspective.

References & Acknowledgments

[1] Geyer, R., Jambeck, J. R. & Law, K. L. (2017) Production, use, and fate of all plastics ever made. *Science Advances*. 3 (7), e1700782.
[2] Gillick, S. & Quested, T. (2018) *Household food waste: restated data for 2007-2015*. Oxon, WRAP
[3] European Bioplastics. (2016) *What are bioplastics? Material types, terminology, and labels: an introduction*. Berlin, European Bioplastics.
[4] Trabold, T. & Babbitt, C.W. (eds.). (2018) *Sustainable food waste-to-energy systems*. Academic Press.
[5] ADBA. (2020) *Biomethane – the pathway to 2030 report*. London, ADBA

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