B-PLAS DEMO: creating bioplastics from industrial organic waste

PROJECT DETAILS

Name: B-PLAS DEMO
Website: site.unibo.it/b-plas/en/mission
Sector(s): Chemicals - industrial bio-materials / plastics
Project Partners: University of Bologna, Caviro Extra S.P.A., Pannon Pro Innovation Services Ltd., AIJU, Ferrovial.
Project Duration: 2018 – 2021
Location: Bologna, Italy

Key messages

- B-PLAS DEMO – an EIT Climate-KIC demonstrator project led by the University of Bologna, Italy – is developing an automated industrial-scale plant that can transform sludge, food waste, and other organic waste residues into polyhydroxyalkanoate (PHA), a biodegradable bioplastic.
- Using a raw material like sludge – that suppliers have to pay to dispose of – has the potential to make PHA price-comparable with traditional plastics and bioplastics.
- Circular innovation is not always confined to the commercialisation of new technologies. B-PLAS DEMO is a novel combination of existing technologies with new processes implemented through an open-innovation business model.
- Innovative business models, however, cannot transform existing production systems alone; they need support from system elements to succeed (e.g. policy, finance).

Introduction

We utilise large amounts of plastic in our daily lives, putting pressure on the planet and its resources. By 2050 it is estimated that the oceans will contain more plastic than fish (by weight), and that plastic production will be responsible for a vastly increased share of the world's oil usage and greenhouse gas emissions (1).

An alternative to fossil fuel-based plastics are bio-based plastics: plastics produced using renewable raw materials, such as agricultural crops or waste organic residues. Some bio-based plastics are also biodegradable, making them safer for the environment. These materials have a crucial role to play in the transition towards a more circular economy (2). The circular economy refers to a restorative economic model, which seeks to extend the life of products, components and materials by keeping these in use within the economy for as long as possible. Circular strategies include, but are not limited to: eco-design, re-use, repair, refurbishment, remanufacturing, product-service systems and recycling.

The way our economy currently operates produces two main flows of organic waste: food waste and sludge (residue left behind from wastewater treatment processes and anaerobic digesters). In the European Union, an estimated 88 million tonnes of food waste (3) and another 10 million tonnes of this sludge (4) are produced on an annual basis.

The disposal of these waste streams is often complicated, costly and not environmentally friendly. In the case of sludge, it is currently disposed of in the EU via land application (spreading on fields as a low-grade fertiliser), incineration (after drying it) or sending it to landfill (5). These disposal methods contribute to greenhouse gas emissions. For example, according to B-PLAS's own estimates, the incineration process generates around 1 kg of CO2 per kilo of sludge. Furthermore, sludge disposal is not cost-free; on the contrary, companies producing sludge need to pay increasingly higher fees, due to stringent regulations at both the EU and national levels (6) – in addition to the costs and CO2 incurred when transporting sludge for disposal.

Transforming sludge into an industrial feedstock for bioplastics is an ideal solution for both economic and environmental reasons. By re-using a waste material as a feedstock, it becomes a revenue source instead of a cost, while also reducing pressure on other virgin resources (e.g. fossil fuel, raw agricultural resources) for (bio) plastics production (7).

B-PLAS DEMO, a three-year demonstrator project initiated by EIT Climate-KIC partners in 2018, seeks to design and build an

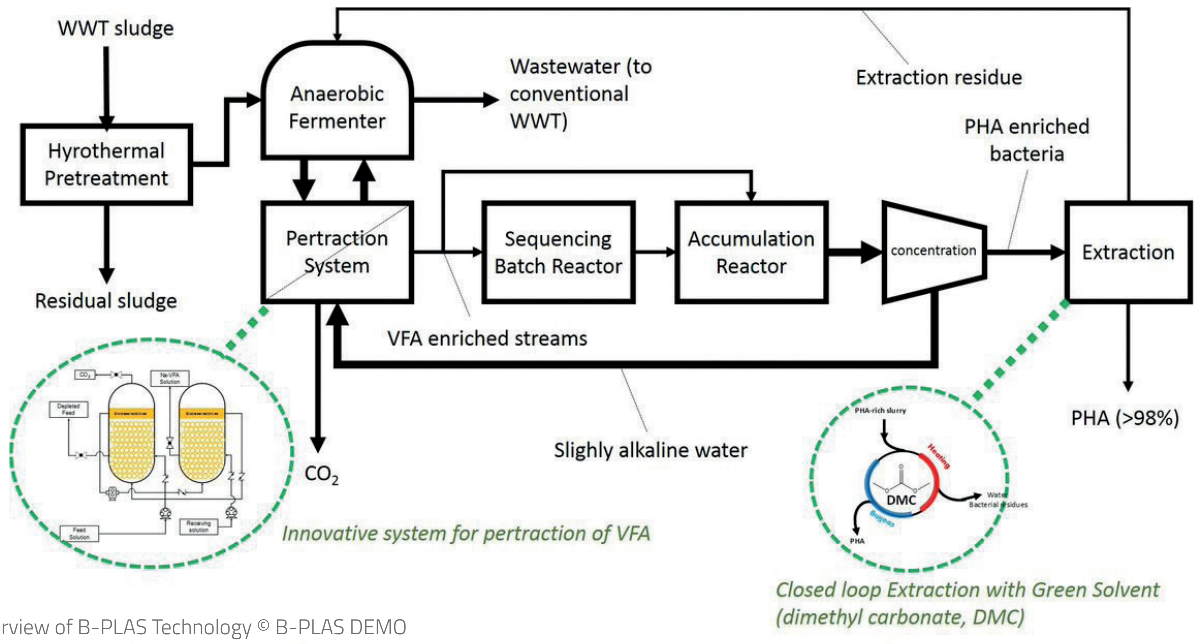

Figure 1: Overview of B-PLAS Technology © B-PLAS DEMO

automated industrial-scale plant that utilises multiple microbial cultures (MMC) (bacteria) to transform sludge, food waste, and other organic waste residues into polyhydroxyalkanoate (PHA), a biodegradable bioplastic.

The process innovation at the heart of this project, utilising MMC, was originally developed at the University of Bologna's (UNIBO) Chemistry Department in 2014, funded by a range of organisations including EIT Climate-KIC (8). The main advantage of MMC, in comparison to single strain bacteria used in traditional bioplastics production, is that it does not require a sterile environment. This in turn lowers production costs (see Figure 1 for an overview).The first lab-based prototype had the capacity to convert around one kilogram of organic waste per hour into biodegradable plastics.

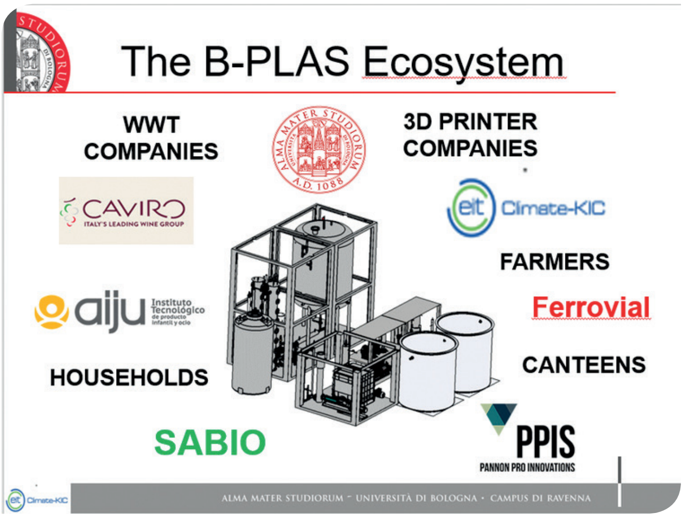

Figure 2: B-PLAS DEMO Consortium and wider ecosystem. © B-PLAS DEMO

B-PLAS DEMO, a consortium of academic and industrial partners led by UNIBO (see Figure 2 for an overview), aims to scale this circular solution by operationalising an industrial-scale module that can convert 10,000 tonnes of organic materials a year into a significant amount of cost-competitive PHA through an open-innovation business model.

B-PLAS DEMO's business Model

Using bacteria to convert sludge from wastewater treatment and anaerobic digestion into PHA is not new. The innovative aspect of the B-PLAS DEMO consortium's business model is that it is based on combing existing technologies (e.g. anaerobic digestors and an extraction plant running B-PLAS's

Scale of Sludge Generation (tonnes)	Investment required by Partners	Infrastructure Installed	Benefits to Partners	Benefits to B-PLAS
> 3,000 -10,000 t/y	~ € 1,000,000	• Onsite digester and one extraction plant running B-PLAS's process	• Zero sludge disposal costs • B-PLAS maintains and operates the plant	• Free source of feedstock • Generation of revenue from selling the plant • Generation of revenue from selling the PHA
>10 t/y	~ € 100,000	• Onsite digester with PHA extraction processed at a centralised plant offsite.	• Zero sludge disposal costs • B-PLAS collects sludge residue	• Free source of feedstock • Generation of revenue from selling the plant • Generation of revenues from selling the PHA

Table 1: Business Model options dependent on scale of sludge produced

process) with a new process that utilises multiple microbial cultures (MMC) and is underpinned by what the team refers to as an 'open knowledge' approach. Streams of data generated by the sludge-conversion process – collected by autonomous sensors installed in each plant – will be collated in a central repository. This repository will be kept open for research (9), but B-PLAS DEMO's own analysis of the data – its recipe for the most efficient feeding cycles for the multiple bacterial cultures – remains proprietary.

The consortium has developed two distinct business models for their clients - whom they consider as partners - dependent on the scale of organic waste residue produced (See Table 1 for an overview). In both cases, B-PLAS DEMO saves on the capital expenditure to operationalise their plants and gains access to a free feedstock, which underpins their core revenue streams derived from the sales of the resulting biodegradable bioplastic and the sale of the plant itself. Sludge-derived PHA has several potential applications, including 3D printing, textiles and industrial packaging (its biological origin, however, makes it unsuitable for medical or food-based applications).

"Right now, bioplastics are not competitive in price with conventional plastics," says Cristian Torri, Chemistry Professor at the University of Bologna and B-PLAS DEMO team member. "We want to compete on a level-playing field as conventional petroleum-derived plastic, when it comes to price. And because we are starting with a feedstock considered as waste, we can achieve this."

For sludge producing partners, the key benefit is that their sludge disposal costs will be significantly reduced. According to B-PLAS DEMO, the disposal costs for sludge vary across Europe from between €30-€120 per tonne, depending on the location and the method of disposal. The team estimates that sludge producers who invest in B-PLAS DEMO's equipment will save around 90% of their sludge disposal costs over the long-term and hedge against the potential risk of more stringent regulations for sludge disposal being introduced in the future. B-PLAS's preliminary projections suggest short payback periods for all involved ranging from between 3-5 years. Moreover, an additional motivation for partner engagement in B-PLAS DEMO is the reputational benefits they gain from reducing their environmental impact.

System Conditions

With climate change requiring urgent and concerted action, there is a need to reconfigure and transform our economies and societies. Innovative business models alone will not live up to the mark as they are not guaranteed access to market; it is often the surrounding environment that proves decisive on whether an innovation will flourish or perish. This is because the innovation is a part of a wider system and influenced by key system elements, such as: Policy, Skills, Behaviour, Market Structures, Information Flows, Organisational Governance and Finance. Innovation needs to happen on all these fronts ('systems innovation') in order to achieve substantial system transformation.

B-PLAS DEMO: Enablers

Policy

Sludge treatment and disposal is regulated at the EU level and to varying degrees by member states, and represents a considerable cost to sludge producers. Costs vary anywhere between €30-€120 per tonne depending on the member country in question and, in some instances, this can account for an estimated 50% of sludge producers' operating costs (10).

In B-PLAS DEMO's case, the cost of sludge disposal incentivises sludge producers to invest in the necessary infrastructure and equipment, because it will save producers money in the long run. The additional benefit for B-PLAS DEMO is that it secures a free raw material stream. This illustrates how mandatory waste disposal regulations and associated costs can support market creation for circular products that utilise waste.

Organisational Governance

The transition to a circular economy will require increased collaboration among value chain actors. The B-PLAS DEMO consortium aims to show how an open innovation business model can work in practice and that partners from across the organic waste value network can share the financial value generated by this project when operating at a commercial scale.

As this demonstrator project is relatively young, B-PLAS DEMO's financial projections are based on the data gathered from their lab-scale prototype, and the assumption that the results will scale up. The consortium's industrial-scale plant is expected to become operational in 2019, providing more reliable data to underpin the project's further financial projections and shape their future value distribution strategy.

B-PLAS DEMO: Challenges

Skills & Information Flows

Taking projects out of research labs and into commercial reality requires bringing business and project management skills together. In the case of B-PLAS, Prof. Matteo Mura joined the project from the University of Bologna's Department of Management to help formulate the business model and business plans. Initially, he says, it took time for the team's members to understand each other: "We spoke different languages." Moreover, there is a disconnect between the academic and commercial worlds, he adds, yet for commercial projects to succeed, these different perspectives need to be reconciled.

For B-PLAS, this took time. Key to the process, Mura says, was physical proximity: getting UNIBO's B-PLAS DEMO team and the wider project consortium of partners into the same room as often as possible was crucial – as was communication in a spirit of openness.

Conclusion and lessons learnt

The B-PLAS DEMO consortium is designing and building an automated industrial scale plant that can transform organic waste into polyhydroxyalkanoate (PHA), a bio-degradable bioplastic.

Central to B-PLAS DEMO's success thus far has been the consortium's development of strong partnerships and its careful progress towards commercialisation.

Key observations from this experience are:

- **Policy instruments can play a crucial role in enabling or hindering circular business models.** Waste disposal regulations are a good example as they can support market creation for circular products. Mandatory disposal imposes costs on businesses, which in turn incentivises them to engage with more cost-effective circular solutions. However, policies that fail to recognise the potential of waste streams as raw material inputs can hamper circular economy efforts, too.

- **Organisational innovation has a key role to play in the circular economy.** Circular innovation is not always confined to new technologies but rather novel combinations of existing technologies with new processes that are implemented through innovative business models. B-PLAS DEMO's open-innovation business model is centred on co-creating value with ecosystem partners by commercialising a process innovation, in this case utilising multiple microbial cultures (MMC) (bacteria) to transform organic waste into plastic.

B-PLAS DEMO's business model innovation has the potential to deliver a price-competitive biodegradable alternative to traditionally produced bioplastics. It enables the valorisation of what has until now been a problematic waste stream and contributes to reducing our dependence on fossil fuel-based plastics.

About

EIT Climate-KIC is Europe's largest public-private partnership addressing climate change through innovation to build a net zero carbon economy. The Climate Innovation Insights are one of the most knowledge sharing prominent formats of EIT Climate-KIC since 2016. Building on innovation endeavours of EIT Climate-KIC start-ups and partner institutions, the Insights are intended to share learnings and provide a platform for reflection and discussion.

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Endnotes:

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