ERA CoBioTech

BioTech Research & Innovation Hack

2021

ERA CoBioTech Funded Projects at A Glance: SYNBIOGAS

Synthetic landfill microbiomes for enhanced anaerobic digestion to biogas

PART OF
EUROPEAN BIOTECH WEEK
INNOVATION IS IN OUR GENES

SYNBIOGAS

Synthetic landfill microbiomes for enhanced anaerobic digestion to biogas

The SYNBIOGAS project harnesses biomass degrading microorganisms and enzymes from landfill sites to enhance anaerobic digestion processes and transform waste biomass residues into biogas and value-added products as a key enabling technology for a sustainable bioeconomy.

Project coordinator:

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Consortium

Bangor University, (United Kingdom)

Helmholtz-Centre for Environmental Research, (Germany)

CNRS and Aix-Marseille, (France)

Project duration:

01 January 2020 -
31 December 2022

Total budget: 1.2 M€

Enhancing waste biomass conversion to biogas with landfill microorganisms

Lignocellulosic plant biomass is the most abundant waste product generated by society, agriculture and industry. By 2025, global cities will generate approximately 2.2 billion tonnes of solid waste per year, with significant impacts on health and the economy at local and global scales. Natural communities of microorganisms (microbiomes) convert waste biomass to methane-rich biogas that can be used as a sustainable green-energy source to generate electricity, heat and power, biomethane for injection into the national gas grid, and production of transport fuels. Anaerobic digestion (AD) plants and landfill sites are engineered environments where microbial processes are harnessed for waste decomposition and biogas production. The EU is the largest global producer of biogas from biomass, with >17,000 AD plants; consequently, microbial conversion of solid waste residues to biogas in AD plants and landfills presents an unprecedented opportunity to leverage key enabling technologies for a sustainable bio-based economy for green-energy production. In turn, conversion of waste biomass to biomethane mitigates the escalating environmental and social impacts of waste residues. However, the metabolism of microorganisms responsible for anaerobic digestion is poorly understood. One of the major bottlenecks to industrial application of microorganisms for biomass-conversion is low substrate specificity, low temperature tolerance, and an inability to perform optimally under reaction conditions. Natural microorganisms found in landfill sites represent an unexplored repository of biomass-degrading enzyme diversity with the potential to enhance existing industrial biomass-conversion processes. Landfill microorganisms are already adapted to engineered environments, decompose diverse solid waste types, produce methane-rich biogas, and are therefore good candidates for the bioaugmentation of anaerobic digestion processes.

The SYNBIOGAS consortium is an academic-industry partnership that will integrate diverse and cutting-edge technological, analytical, engineering and computational approaches for characterisation of the landfill biomass-degrading microbiome. Microbial isolations, DNA sequencing, enzyme characterisation and computational modelling of landfill microbial biomass-conversion processes will inform the design and validation of optimised synthetic landfill microbiomes (SLMs) for enhanced waste biomass-conversion in AD plants and landfill sites, and to develop applications of the SLM that can be readily adopted by industry. Engineering biomass-degrading microbiomes is a new research frontier with many novel applications, including bioaugmentation and optimisation of biomass conversion in AD and landfill systems towards an enhanced bio-based economy for waste management, environmental protection, and sustainable intensification of renewable energy generation. The SYNBIOGAS consortium brings together world-leading academic researchers from three funded EU partners (UK, Germany, France) and non-funded EU industry partners (UK, Germany) to develop biotechnological approaches for waste biomass conversion and biogas production as a key enabling technology (KET) for a sustainable bioeconomy. In doing so, the consortium tackles key 21st-century societal challenges; (i) to address the burgeoning production of municipal, industrial and agricultural solid waste biomass and its health and economic effects, and (ii) to utilise waste biomass as feedstock for green-energy generation to reduce our reliance on fossil feedstocks for energy production.

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No [722361]

This will be achieved through a multidisciplinary collaboration between researchers in the fields of microbial ecology, anaerobic decomposition, computational biology, enzyme biochemistry, network modelling, social sciences, and industry partners (engineers, policy advisors and plant operators).

Current results

So far, we have completed landfill bioreactor experiments (see WP1 in the Figure) and analysed physicochemical parameters, biogas production and composition and microbial community composition in the bioreactors at 5 timepoints. Over 500 microbial isolates associated with biomass degradation have been obtained from the bioreactors; many of these are new species and currently undergoing formal taxonomic description and genome sequencing. In WP2, computational enzyme discovery in microbial DNA sequences from the bioreactors datasets has been completed to identify carbohydrate-active enzymes. To improve enzyme predictions, a literature review and a method for the creation of enzyme subfamilies has been developed. A manuscript presenting an objective criterion to select optimal thresholds in sequence similarity networks has been written and will soon be submitted. This work will provide subfamilies for 3 glycoside hydrolase families, while only 5 families have benefited from such detailed analysis in the past 15 years. For WP3, network modelling and synthetic microbiome design, a computational pipeline for the reconstruction of high-quality metabolic models has been developed and is available as a web application for the curation and comparison of metabolic models. The tool identifies essential reactions and maps them to KEGG and BIGG pathways, and is available online. Ultimately, we will develop biotechnological approaches to utilise our synthetic landfill microbiome to transform waste biomass residues into biogas and value-added products in a sustainable manner. In addition, we incorporate stakeholder engagement, knowledge transfer, Life Cycle Assessment (LCA) and Cost Benefit Analysis (CBA) within our proposal to ensure consideration of social, political, and economic implications of the approach, and generate a roadmap for technology adoption.

We have generated 90 DNA sequencing datasets from bioreactors with 6 different feedstock treatments. Over 500 microbial isolates with many new species have been identified. Three manuscripts on new species descriptions are currently in preparation. A manuscript describing optimised methods for carbohydrate active enzyme subfamily prediction is in preparation and will facilitate extensive analysis of three key enzyme families in this project. Our team at UFZ Helmholtz have developed a computational pipeline for the reconstruction of metabolic models and developed a web application for the curation and comparison of metabolic models. The tool identifies essential reactions and maps them to KEGG and BIGG pathways, and facilitates the automatic inclusion and deletion of reactions according to the pathway in which they are present. The tool is available online *sbmlcomp.bioinf.uni-leipzig.de*

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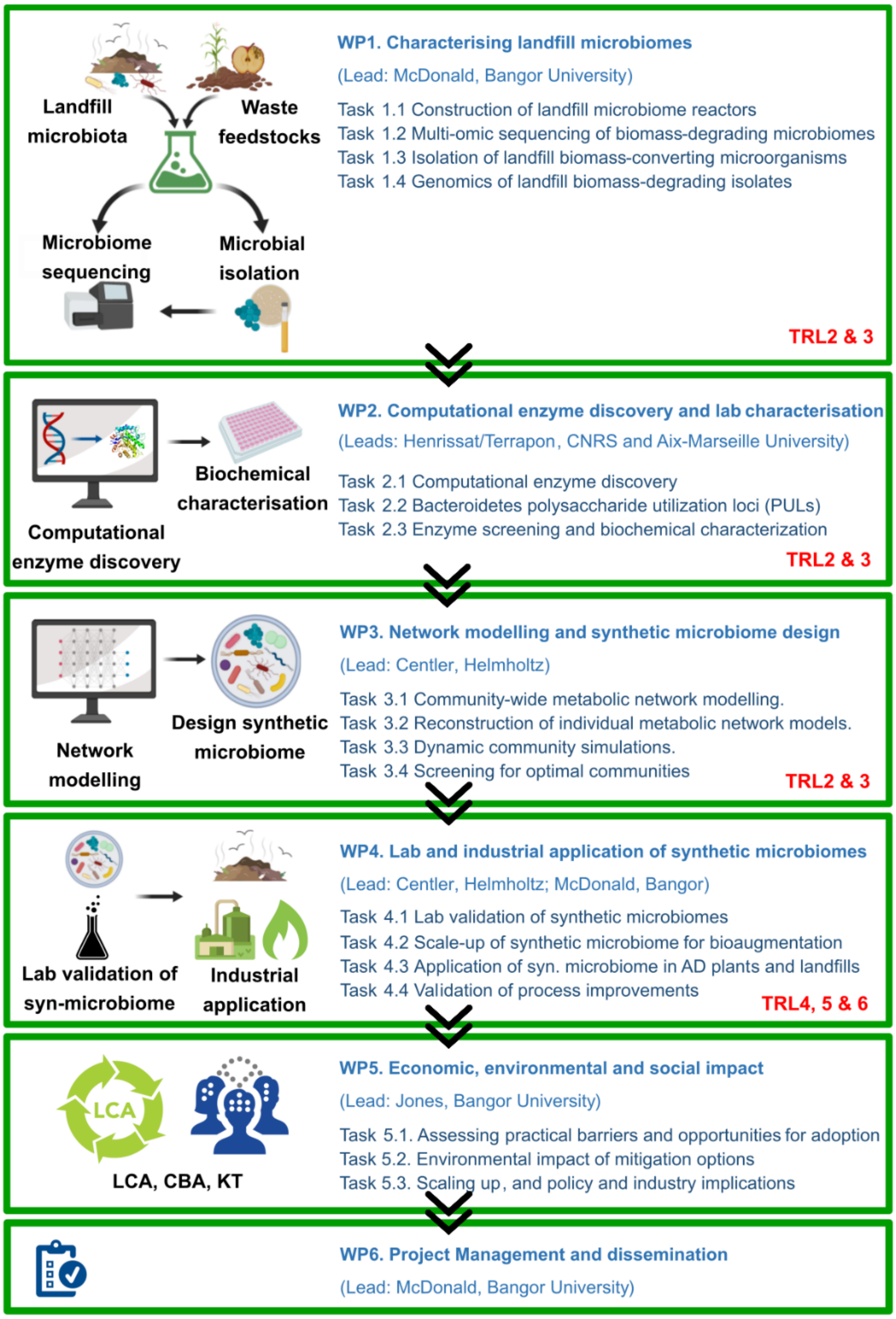

Figure 2: Overview of the SYNBIOGAS project
Summary of project work packages and tasks, experimental approaches and Technology readiness levels (TLR)

Project website: www.synbiogas.com
Twitter: @synbiogas

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