

Joint Master Programmes in Process Engineering and Biotechnology



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Editorial:

Twenty Years of Shaping a Circular Bioeconomy Together

It is our great pleasure to welcome you to the Circular Bioeconomy Symposium at Offenburg University of Applied Sciences. As we gather in Offenburg on October 13 and 14, 2026, we celebrate a remarkable milestone: twenty years of academic partnership between Offenburg University of Applied Sciences and the University of Warmia and Mazury in Olsztyn.

The joint Master's program in Process Engineering was established in 2006 as a flagship of German and Polish cooperation in higher education. Students spend part of their studies in both countries, gaining not only technical expertise but also a genuinely international perspective. In 2018/19, the partnership was expanded to include the joint Master's program in Biotechnology. Throughout these two decades, the Georg and Maria Dietrich Foundation has supported the collaboration with outstanding and lasting commitment, for which we are deeply grateful. We believe that this partnership has shaped the careers of countless engineers and scientists and has grown into a strong binational network in environmental technology and biotechnology.

This symposium is both a reunion and a look ahead. The scientific program reflects the breadth of research carried out across our institutions, ranging from biocatalytic routes to sustainable nutrition and advanced biogas and power to gas technologies, to thermochemical pathways for resource recovery and strategies for monitoring and mitigating environmental pollution. Over two days, the program features 16 oral presentations in four scientific sessions and 28 poster contributions from both universities and their partners. Alongside the scientific sessions, alumni will share their career journeys, a matchmaking workshop will open doors for future joint projects between Olsztyn and Offenburg, and lab tours will offer a look behind the scenes of our current research. This Book of Abstracts provides an overview of all contributions and offers insight into current research trends and future directions in the circular bioeconomy.

We thank our team members and the administration at Offenburg University of Applied Sciences and the University of Warmia and Mazury, whose dedication made this event possible. We also thank all speakers and poster presenters: your contributions are what make this symposium a lively forum for exchange between academia, industry and the next generation of researchers.

We look forward to inspiring presentations, engaging discussions and many reunions with old friends and new colleagues. Welcome to Offenburg, and here's to the next twenty years!

The Symposium Chairs

Institute for Circular Bioeconomy (ICB), Offenburg University of Applied Sciences

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Program Overview

TUESDAY October 13, 2026	
09:00	Opening & Welcoming Remarks
09:10	Welcome of the State Government Baden-Württemberg <i>Dr. Elisabeth Saken-Braunstein and Dr. Andreas Kiesel Ministerium für Umwelt, Klima und Energiewirtschaft BW</i>
09:20	20 Years of Scientific Collaboration – From Environmental Best Practice to Circular Bioeconomy
09:30	Session 1: Biocatalytic Paths to Sustainable Nutrition - Linking Biorefineries and Food Tech
10:40	Poster Session: Biocatalytic Paths to Sustainable Nutrition - Linking Biorefineries and Food Tech
10:50	<i>Coffee Break</i>
11:15	Session 2: Advanced Biogas & Power-to-Gas
12:25	Poster Session: Advanced Biogas & Power-to-Gas
12:35	<i>Lunch Break</i>
14:00	Poster Session: Environmental Pollution From Waste to Wealth
14:30	From Campus to Career: Alumni Insights and Doctoral Opportunities
15:30	<i>Coffee Break</i>
16:00	Celebration Act: 20 Years of Joint Programmes between Offenburg and Olsztyn
17:30	<i>Informal Reception</i>
18:00	<i>Bus Transfer to Evening Location</i>
19:00	Festive Dinner
23:00	<i>Bus Transfer to Offenburg</i>
WEDNESDAY October 14, 2026	
08:45	Session 3: Environmental Pollution: Monitoring, Mitigation and Sustainable Solutions
10:10	<i>Coffee Break</i>
10:25	Parallel Workshops: Matchmaking Didactics (Gamification)
11:25	Session 4: From Waste to Wealth: Thermochemical Pathways for Resource Recovery
12:20	Closing Remarks
12:30	<i>Lunch</i>

Oral Program

TUESDAY October 13, 2026

09:00 Opening & Welcoming Remarks

Prof. Dr. Stephan Trahasch | Rector of Hochschule Offenburg

Prof. Dr. Jerzy A. Przyborowski | Rector of University of Warmia and Mazury

09:10 Welcome of the State Government Baden-Württemberg

Dr. Elisabeth Saken-Braunstein and Dr. Andreas Kiesel | Ministerium für Umwelt, Klima und Energiewirtschaft BW

09:20 20 Years of Scientific Collaboration – From Environmental Best Practice to Circular Bioeconomy

Dr. Andreas Wilke | HSO

09:30 Session 1: Biocatalytic Paths to Sustainable Nutrition - Linking Biorefineries and Food Tech

Moderation: Prof. Dr. Thomas Eisele | HSO

and Prof. Dr. Monika Modzelewska-Kapituła | UWM

09:35 Biorefineries to Precision Fermentation

S1.1

Dr. Daniel Heid (Picea Biosolutions)

09:55 Fully Automated Growth Media Optimization Employing Batch Bayesian Optimization

S1.2

Prof. Dr. Frédéric Lapierre (HSO), Dennis Raith (Labmaite GmbH, University of Freiburg), Pasquale Mattaliano (Labmaite GmbH), Mariela Castillo-Cota (Labmaite GmbH), Jonas Bermeitinger (Labmaite GmbH) and Robert Huber (Hochschule München)

10:10 Optimising *Trichoderma reesei* Cellulase Production for Sustainable Bioprocessing

S1.3

Joanna Łukasiewicz (HSO), Olga Zielińska (HSO), Prof. Dr. Thomas Eisele (HSO) and Dr. Andreas Wilke (HSO)

10:25 Valorisation of Heterogeneous Biowastes via Combined Pretreatment Strategies for Biorefinery Products

S1.4

Olga Zielińska (HSO), Joanna Łukasiewicz (HSO), Prof. Dr. Thomas Eisele (HSO) and Dr. Andreas Wilke (HSO)

10:40 Poster Session: Biocatalytic Paths to Sustainable Nutrition - Linking Biorefineries and Food Tech

Moderation: Sophie Stürmer and Lukas Burger | HSO

See Poster Program for details

10:50 Coffee Break

11:15 Session 2: Advanced Biogas & Power-to-Gas

Moderation: Prof. Dr. Christiane Zell | HSO and Prof. Dr. Katarzyna Bernat | UWM

11:20 How to Plan a Biogas Plant

S2.1

Dr. Simone Besgen (Biogas Besgen GmbH)

11:40 From Renewable Electricity and CO₂ to e-Methane: Low-Cost Water Electrolysis for Carbon Recycling

S2.2

Prof. Dr. Ulrich Hochberg (HSO), Prof. Dr. Christiane Zell (HSO) and Dr. Fabian Haitz (HSO)

11:55 S2.3	From Renewable Electricity and CO₂ to e-Methane: Biological Methanation in a Pilot-Scale Counter-Current Bubble Column Dr. Fabian Haitz (HSO), Stefano Munaretto (HSO), Manuel Scharffenberg (HSO), Aldrin Mattes (Abwasserzweckverband Kinzig- und Harmersbachtal), Prof. Dr. Ulrich Hochberg (HSO) and Prof. Dr. Christiane Zell (HSO)
12:10 S2.4	Load-Dependent Resilience of Jerusalem Artichoke and Cattle Manure Co-Digestion at Short Hydraulic Retention Time Prof. Dr. Tomasz Pokój (UWM), Prof. Dr. Katarzyna Bułkowska (UWM) and Prof. Dr. Bogdan Dubis (UWM)
12:25	Poster Session: Advanced Biogas & Power-to-Gas <i>Moderation: Sophie Stürmer and Lukas Burger HSO</i> <i>See Poster Program for details</i>
12:35	<i>Lunch Break</i>
14:00	Poster Session: Environmental Pollution From Waste to Wealth <i>Moderation: Sophie Stürmer and Lukas Burger HSO</i> <i>See Poster Program for details</i>
14:30	From Campus to Career: Alumni Insights and Doctoral Opportunities Prof. Dr. Christiane Zell; Prof. Dr. Heide Biollaz; Izabela Sosnik; Vera Vanié HSO Prof. Dr. Paweł Brzuzan UWM
15:30	<i>Coffee Break</i>
16:00	Celebration Act: 20 Years of Joint Programmes between Offenburg and Olsztyn <i>Room D001 Prof. Dr. Tobias Hagen HSO</i> <i>Moderation: Kai Wissmann Music accompaniment by the Music School Offenburg-Ortenau</i>
	▶ Panel 1: How it all began ▶ Panel 2: Vision 2025 – the next 20 years ▶ Awarding of the title of “Honorary Senator” to Rector Prof. Dr. Jerzy A. Przyborowski
17:30	<i>Informal Reception</i> <i>Foyer D001</i>
18:00	<i>Bus Transfer to Evening Location</i> <i>by invitation only</i>
19:00	Festive Dinner Schloss Staufenberg, Durbach
23:00	<i>Bus Transfer to Offenburg</i>

WEDNESDAY October 14, 2026			
08:45	Session 3: Environmental Pollution: Monitoring, Mitigation and Sustainable Solutions <i>Moderation: Prof. Dr. Melanie Broszat HSO and Prof. Dr. Katarzyna Bułkowska UWM</i>		
08:50 S3.1	Usage and Design of Bioassays for the Detection of Endocrine-Disrupting Compounds in Environmental Matrices <u>Sophie Stürmer</u> (Goethe University Frankfurt, HSO), Prof. Dr. Henner Hollert (Goethe University Frankfurt, Fraunhofer IME), Prof. Dr. Melanie Broszat (HSO) and Dr. Sabrina Schiwy (Goethe University Frankfurt, Fraunhofer IME)		
09:10 S3.2	Elimination of Antibiotic Resistances and Faecal Indicators in Wastewater Treatment <u>Dr. Claudia Stange</u> (DVGW-Technologiezentrum Wasser), Johannes Ho (DVGW-Technologiezentrum Wasser), Abidelfatah Nasser (Ministry of Health, Israel) and Andreas Tiehm (DVGW-Technologiezentrum Wasser)		
09:25 S3.3	Micropollutant Removal from Municipal Wastewater <u>Mingqing Xu</u> (ProMinent Group)		
09:40 S3.4	Circular, but Safe? Mycotoxin Risk from Kitchen Waste to Compost <u>Prof. Dr. Maciej Woźny</u> (UWM), <u>Dr. Sławomir Kasiński</u> (UWM), Marcin Rudnicki (Municipal Waste Management Plant in Olsztyn) and Prof. Dr. Katarzyna Bułkowska (UWM)		
09:55 S3.5	Aerobic Chloroethene Biodegradation: Stimulation and Molecular Monitoring Andreas Tiehm, <u>Dr. Lara Stelmaszyk</u> , Lena Holl, Johannes Ho and Axel Müller (all DVGW-Technologiezentrum Wasser)		
10:10	<i>Coffee Break</i>		
10:25	Parallel Workshops <table border="0" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> Matchmaking Workshop: Joint Research Alliance — Deepening UWM & HSO Cooperation <i>Dr. Fabian Haitz and Dr. Andreas Wilke HSO</i> </td><td style="width: 50%; vertical-align: top;"> Didactics Workshop: Actionable Gamification for Scientific Communication <i>Lea Wattenberg and Alexander Weigand HSO</i> </td></tr> </table>	Matchmaking Workshop: Joint Research Alliance — Deepening UWM & HSO Cooperation <i>Dr. Fabian Haitz and Dr. Andreas Wilke HSO</i>	Didactics Workshop: Actionable Gamification for Scientific Communication <i>Lea Wattenberg and Alexander Weigand HSO</i>
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11:25	Session 4: From Waste to Wealth: Thermochemical Pathways for Resource Recovery <i>Moderation: Prof. Dr. Heide Biollaz; Prof. Dr. Daniel Kray HSO and Prof. Dr. Mariusz Gusiatin UWM</i>		
11:30 S4.1	Industrial Biochar Production in the Czech Republic: Producers, Technologies, and Characterization <u>Dr. Jaroslav Moško</u> (UCT Prague) and Michael Pohořelý (UCT Prague, Institute of Chemical Process Fundamentals of the CAS)		
11:50 S4.2	Preparing the Pyrolysis Industry for the Future <u>Dr. Leonie Jakob</u> (HSO), Prof. Dr. Daniel Kray (HSO) and Prof. Dr. Heide Biollaz (HSO)		
12:05 S4.3	Co-Pyrolysis of Municipal Sewage Sludge with Lignocellulosic Biomass: Effects on PAH Formation and Heavy Metal Stabilization in Biochar <u>Prof. Dr. Mariusz Gusiatin</u> (UWM)		
12:20	Closing Remarks and Poster Awards Prof. Dr. Thomas Eisele HSO		
12:30	<i>Lunch</i>		

Poster Program

A Biocatalytic Paths to Sustainable Nutrition - Linking Biorefineries and Food Tech

Day 1, 10:40 | Moderation: Sophie Stürmer and Lukas Burger, HSO

- P01** **Effects of Pulsed Electric Field (PEF) Preservation on the Quality of Bovine Colostrum**
Dr. Adriana Łobacz (UWM), Cezary Domasiewicz (UWM), Katarzyna Staniewska (UWM) and Prof. Dr. Justyna Żulewska (UWM)
- P02** **The Influence of the Homogenization Method on the Quality and Stability of the Emulsion**
Dr. Józef Warechowski (UWM) and Prof. Dr. Fabian Dajnowiec (UWM)
- P03** **Development of Copper-Binding Artificial Metalloenzymes Based on β -Helix Mimicking Peptides for Biocatalysis**
Nele Schulte (University of Strasbourg), Nico Bruns (TU Darmstadt), Ivano Eberini (University of Milan), Prof. Dr. Peter Faller (University of Strasbourg), Dr. Vincent Lebrun (University of Strasbourg) and Dr. Maxime Naudé (University of Strasbourg)
- P04** **Evaluation of Different Engineering Strategies for the Successful Expression of Precision Fermentation Targets in *Trichoderma reesei***
Samuel Zuber (HSO, Picea Biosolutions), Prof. Dr. Melanie Broszat (HSO), Prof. Dr. Thomas Eisele (HSO) and Tobias Stadelmann (Picea Biosolutions)
- P05** **Recombinant Expression of β -fructofuranosidases in *T. reesei* for the Production of Fructooligosaccharides**
Christian Peter (HSO, Picea Biosolutions), Prof. Dr. Melanie Broszat (HSO), Prof. Dr. Thomas Eisele (HSO) and Tobias Stadelmann (Picea Biosolutions)
- P06** **Investigation of the Possibility of *Listeria monocytogenes* Growth in Nitrite-Free Frankfurters**
Prof. Dr. Monika Modzelewska-Kapituła (UWM), Prof. Dr. Katarzyna Tkacz (UWM) and Prof. Dr. Anna Zadernowska (UWM)
- P07** **Sporulation of *Trichoderma reesei* in Fermentations; Early Detection and Countermeasures**
Paul Wiesenthal (HSO), Joanna Łukasiewicz (HSO), Patricia Semke (HSO), Olga Zielińska (HSO) and Dr. Andreas Wilke (HSO)
- P08** **Gamification-Based Study Promotion for Environmental Technology**
Lea Wattenberg (HSO), Alexander Weigand (HSO) and Prof. Dr. Susanne Gleißle (HSO)

B Advanced Biogas & Power-to-Gas

Day 1, 12:25 | Moderation: Sophie Stürmer and Lukas Burger, HSO

- P09** **Anaerobic Digestion of Hemp and Sorghum Silages**
Prof. Dr. Katarzyna Bułkowska (UWM), Prof. Dr. Tomasz Pokój (UWM), Prof. Dr. Cezary Purwin (UWM) and Prof. Dr. Bogdan Dubis (UWM)
- P10** **Biogas Production from Municipal Sewage Sludge in a Microbiogas Plant at a Small Wastewater Treatment Plant: A Circular Economy Approach**
Prof. Dr. Katarzyna Bernat (UWM), Prof. Dr. Magdalena Zaborowska (UWM), Prof. Dr. Mariusz Gusiatin (UWM) and Prof. Dr. Dorota Kulikowska (UWM)

B Advanced Biogas & Power-to-Gas

Day 1, 12:25 | Moderation: Sophie Stürmer and Lukas Burger, HSO

- P11 Two Stage Anaerobic Digestion of Marine Macroalgae: Implementation of Herbst Loop Reactor®**
Harivignesh Senthilkumar (HSO, UWM)
- P12 Development of a Parallelized Test Rig with a Circulating Gas Flow System for Biological Methanation**
Irina Knosp (Hochschule Esslingen)
- P13 Development of an Assay to Assess Specific Methanogenic Activity in Biological Methanation Reactors**
Saskia Elbert (HSO), Katharina Röttele (HSO) and Prof. Dr. Christiane Zell (HSO)
- P14 Microbiological Quality of Tvarog Cheeses in Relation to Their Packaging**
Prof. Dr. Jarosław Kowalik (UWM), Dr. Anna Lis (UWM) and Prof. Dr. Justyna Żulewska (UWM)

C Environmental Pollution | From Waste to Wealth

Day 1, 14:00 | Moderation: Sophie Stürmer and Lukas Burger, HSO

- P15 Tire-Derived Microparticles Drive Microbial Selection and Functional Adaptation in Aerobic Granular Sludge**
Prof. Dr. Agnieszka Cydzik-Kwiatkowska (UWM) and Dr. Piotr Jachimowicz (VSB-Technical University of Ostrava)
- P16 Changes in the Mechanical Properties and Surface Topography of PLA Carriers Used as Supports for Nitrogen Removal from Reject Water in SBR**
Prof. Dr. Magdalena Zaborowska (UWM), Dr. Bartosz Pszczółkowski (UWM), Prof. Dr. Dorota Kulikowska (UWM), Prof. Dr. Mariusz Gusiatin (UWM) and Prof. Dr. Katarzyna Bernat (UWM)
- P17 Improving the Extremophile Species Growth by Manipulating the Growth Conditions and Exploring the Accumulation of R-PC and EPS**
Tarek Hamdoudi (Blue2) and Dr. Andreas Wilke (HSO)
- P18 Phosphorus Recovery from Hydrothermally Carbonized Sewage Sludge by Acid Leaching**
Ann Maria Bobby (HSO, blueFLUX Energy AG), Andreas Bechter (blueFLUX Energy AG) and Prof. Dr. Melanie Broszat (HSO)
- P19 Standardization of the Planar Yeast Estrogen Screen (pYES) for the Detection of Estrogenic Activity in Environmental Samples**
Amerisa Corovic (HSO), Sophie Stürmer (Goethe University Frankfurt, HSO) and Prof. Dr. Melanie Broszat (HSO)
- P20 Elimination of Phosphonates and Phosphorus Speciation in Municipal Wastewater by Different Treatment Strategies**
Tim Meier (HSO), Johanna Neef (HOLINGER GmbH), Regina Brämer (HSO) and Prof. Dr. Melanie Broszat (HSO)
- P21 Integrating HPTLC Fingerprinting, Effect-Directed Analysis and Machine Learning for the Characterization of Complex Environmental Matrices**
Lara Gutscher (HSO), Barbara Anders (HSO) and Prof. Dr. Melanie Broszat (HSO)
- P22 Prediction of PAH Degradation in Bioremediation Research: A Rule-Based Cheminformatics Analysis**
Ahmet Yazicioğlu (UWM) and Prof. Dr. Sławomir Ciesielski (UWM)

C Environmental Pollution | From Waste to Wealth
Day 1, 14:00 | Moderation: Sophie Stürmer and Lukas Burger, HSO

-
- P23** **Optimizing Biochar Selection for Heavy Metal Immobilization Using Multi-Criteria Decision Analysis Across Contrasting Soils**
Michael Biney (UWM), Prof. Dr. Mariusz Gusiatin (UWM) and Prof. Dr. Lukáš Trakal (University of Life Sciences Prague)
-
- P24** **Agronomic Evaluation of Biochar from Secondary Agricultural Biomass: The BC-LOOKUP Database**
Vishal Satheesh (HSO), Dr. Nikolas Hagemann (Ithaka Institute), Prof. Dr. Heide Biollaz (HSO) and Prof. Dr. Daniel Kray (HSO)
-
- P25** **Substrate-Specific Optimization of Macronutrient Ratios for *Trichoderma reesei* Cultivation**
Elisa Guerin (HSO), Joanna Łukasiewicz (HSO), Mark Oppong-Gyamfi (HSO), Patricia Semke (HSO), Olga Zielińska (HSO) and Dr. Andreas Wilke (HSO)
-
- P26** **ISO 10993-5/-12-Guided Cytotoxicity Evaluation of Molybdenum and Reference Materials for the Development of Novel Implants**
Vanessa Curtaz (HSO)
-
- P27** **Establishment of a Measurement Method to Determine Cell Growth Under Micromovements**
Kristina Pudiel (HSO)
-
- P28** **Comparison of the Effectiveness of Microbiological Consortia and Bacterial Monocultures in Reducing Selected Synthetic Human Faeces Parameters – Chemical Oxygen Demand (COD), Total Nitrogen (Nt)**
Jolanta Maczugin (UWM), Emna Bahrouni (UWM) and Prof. Dr. Sławomir Ciesielski (UWM)
-

Scientific Committee

Circular Bioeconomy Symposium Scientific Committee

Prof. Dr. Katarzyna Bernat

University of Warmia and Mazury in Olsztyn

Prof. Dr. Heide Biollaz

Institute for Circular Bioeconomy (ICB)
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Hochschule Offenburg

Prof. Dr. Melanie Broszat

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Dr. Andreas Wilke

Institute for Circular Bioeconomy (ICB)
Hochschule Offenburg

Prof. Dr. Christiane Zell

Institute for Circular Bioeconomy (ICB)
Hochschule Offenburg

Conference Venue

Offenburg University of Applied Sciences (Hochschule Offenburg)

Badstraße 24 | 77652 Offenburg | Germany

www.hs-offenburg.de

Celebration Act & Informal Reception

Room D001 and Foyer D001, Hochschule Offenburg

Festive Dinner (by invitation only)

Schloss Staufenberg, Durbach

Bus transfer from Offenburg at 18:00, return to Offenburg at 23:00

Abstracts for Oral Contributions



Session 1: Biocatalytic Paths to Sustainable
Nutrition - Linking Biorefineries and Food Tech

S1.1: Biorefineries to Precision Fermentation

Daniel Heid

Picea Biosolutions

The transition towards more sustainable food systems requires more than alternative protein sources alone. It requires integrated value chains that connect renewable carbon utilization, advanced bioprocessing, and the production of functional food ingredients.

Agricultural residues, lignocellulosic biomass, and industrial side streams represent largely underutilized carbon resources. Through enzymatic biomass conversion, these feedstocks can be transformed into fermentable sugars and other platform molecules, creating alternatives to conventional sugar and starch crops while reducing dependence on dedicated agricultural land. As such, biorefineries play an important role in establishing circular and resource-efficient bioeconomy concepts.

Building on these renewable carbon streams, precision fermentation enables the production of a broad range of food-relevant molecules, including enzymes, dairy proteins, egg proteins, sweet proteins, and other functional ingredients. Recent advances in systems biology, omics technologies, strain engineering, automation, and bioprocess development have significantly expanded the capabilities of microbial production platforms. At the same time, strain performance, process efficiency, and scalability remain critical determinants of commercial viability and large-scale implementation.

Connecting biomass valorization with microbial manufacturing creates new opportunities to decouple food ingredient production from conventional agricultural supply chains. The combination of biocatalysis, renewable feedstocks, and precision fermentation therefore represents a promising pathway towards scalable, resource-efficient, and economically sustainable nutrition solutions within a circular bioeconomy.

S1.2: Fully Automated Growth Media Optimization Employing Batch Bayesian Optimization

Frédéric Lapierre¹, Dennis Raith^{2,3}, Pasquale Mattaliano², Mariela Castillo-Cota²,
Jonas Bermeitinger² and Robert Huber⁴

¹*Offenburg University of Applied Sciences*

²*Labmaite GmbH*

³*University of Freiburg*

⁴*Hochschule München*

Bioprocessing plays a crucial role in producing specialized products like antibiotics and enzymes. Selecting the right microbial strains and optimizing culture conditions are essential for economic success. A key challenge in this process is developing a fermentation medium that meets the nutritional needs of the strain, a task that is often time-consuming and complex. Traditionally, Design of Experiments (DoE) methods have been the standard for growth media development. Although they reduce the number of necessary cultivation experiments, these methods have limitations, particularly with nonlinear systems. Moreover, two-stage DoE methods may overlook significant parameters in the initial screening that become crucial in later optimization stages. Batch Bayesian Optimization (BBO) emerges as a promising, more efficient alternative.

S1.3: Optimising *Trichoderma reesei* Cellulase Production for Sustainable Bioprocessing

Joanna Łukasiewicz, Olga Zielińska, Thomas Eisele and Andreas Wilke

Offenburg University of Applied Sciences

Trichoderma reesei is the primary industrial producer of cellulases, which are essential for converting lignocellulosic biomass into second-generation (2G) biofuels. Despite its high secretory capacity, the cost of enzyme production remains a significant economic bottleneck. Within the framework of the MoDe_ProBio project, the development of resource-efficient bioprocesses utilising 2G waste-derived streams is prioritised to enhance industrial sustainability. However, due to the inherent heterogeneity of waste materials, current optimisation is performed on standardised laboratory media.

To address the limitations of traditional optimisation, strategies have transitioned from "one factor at a time" (OFAT) methods, which are often slow, costly, and fail to identify synergistic effects, to statistical Design of Experiments (DoE) and Response Surface Methodology (RSM). These methodologies allow for the simultaneous evaluation of multiple variables, identifying optimal operating ranges with a minimal number of experimental runs. Based on the Luedeking-Piret kinetic model, which correlates specific protein productivity with biomass growth dynamics, the initial substrate concentration and specific feed rate were identified as the critical parameters governing enzyme biosynthesis. As these factors are frequently analysed in isolation in existing literature, current research focuses on capturing their complex, non-linear interactions. By deriving a mathematical regression equation through these statistical tools, the study aims to identify the production optimum and establish a robust quantitative description of their combined effect on the secretory capacity of *T. reesei*.

To demonstrate the potential impact, a grey-box (hybrid) model is being developed that combines mechanistic kinetic equations with data-driven statistical models. This hybrid approach aims to predict performance under variable feeding conditions more accurately, serving as the core of a digital twin that can streamline bioprocess development, reduce costs, and accelerate the deployment of sustainable industrial bioprocesses.

S1.4: Valorisation of Heterogeneous Biowastes via Combined Pretreatment Strategies for Biorefinery Products

Olga Zielińska, Joanna Łukasiewicz, Thomas Eisele and Andreas Wilke

Offenburg University of Applied Sciences

The accelerating annual accumulation of heterogeneous biowastes - including municipal organic waste, agricultural residues and processing by-products - presents a severe environmental disposal challenge while contributing to global greenhouse gas emissions. Within a circular bioeconomy framework, these abundant, carbon-rich waste streams represent vast, untapped feedstocks with immense potential for sustainable biorefinery operations. However, realizing their full utility requires effective upstream conversion strategies that unlock their biochemical constituents for biological platforms.

To address this challenge, this study explores a fractionated biorefinery framework utilizing targeted, multi-step pretreatment strategies to transform complex agricultural and municipal waste matrices into functional, value-added processing streams. An initial stage of mechanical pretreatment increased the accessible surface area of the wastes to enhance subsequent enzymatic hydrolysis, with the resulting hydrolysate analysed for monomeric sugar content. Rather than relying on synthetic growth media, the nutrient-rich liquid streams were evaluated as low-cost, sustainable substrates for microbial cultivation. Specifically, the converted liquid fractions served a dual biological purpose: providing essential nutrients to support robust microbial biomass proliferation, while simultaneously functioning as a carbon-rich inducing substrate to drive cellulolytic enzyme expression using *Trichoderma reesei*.

Experimental proof of concept confirmed that pretreated heterogeneous agricultural biowastes - including wheat straw, sugar beet, and sugar beet pulp - can effectively replace traditional, high-cost inputs across distinct cultivation roles, supporting fungal biomass proliferation and cellulolytic enzyme expression. Ultimately, utilizing converted biowastes as targeted functional media highlights the feasibility of integrating complex organic waste streams into circular bioeconomy models while helping alleviate environmental disposal challenges.

Abstracts for Oral Contributions



Session 2: Advanced Biogas & Power-to-Gas

S2.1: How to Plan a Biogas Plant

Simone Besgen

Biogas Besgen GmbH

This keynote shows a practical start to finish overview of how to plan a biogas plant, from the basic planning to commissioning. The central design principle is that the plant must be built based on the feedstock availability and the location. Seasonality, dry matter content, contaminants (such as nitrogen or struvite from chicken manure), logistics and long-term supply determine everything that follows. Decision between CHP (Combined Heat and Power) and biomethane or a combination of both for the energy consumption of the plant is a basic planning. If a heat sink is nearby, amine scrubbing for biomethane production can be a sensible option, particularly in the case of a co-digestion plant with a pasteurization. Waste treatment, nutrient recycling, and the reduction of greenhouse gas (GHG) emissions are also key components of the initial plant design.

The feedstock determines the early decisions. The first is the gas potential calculation, covering biogas yield, methane content, annual biomethane output and gas storage needs. The third is the GHG quota under the European RED III directive, where manure, the heating system and process efficiency matter more than biological waste or transport distance. The second is the selection of the most efficient energy concept: combined CHP versus biomethane for grid injection, Bio-CNG or Bio-LNG, depending on the local energy market and demands.

The technical part addresses the design of the biological process:

- digester volume
- retention time
- organic loading rate
- pasteurization
- temperature
- mixing
- feeding digestate, transport

Gas treatment:

- H₂S removal
- Drying
- activated carbon
- CO₂ removal and ideally process for reusing in the food market (PSA)
- Siloxanes
- Compression
- Injection
- Grid injection stations need 2-3 years of development in Germany

After achieving the initial design it turns to project realization: soil survey, insurance, safety, permitting, logistics, economics (CAPEX/OPEX, CO₂ cap and trade) and the EPC (Engineering, Procurement & Construction) phases from feasibility study through basic and detailed engineering to construction, commissioning and performance testing. These are the five major points: feedstock first, analysis of the substrates, design for the biology, define the energy concept early, treat safety and reliability as part of the design, and recognize that the business case matters as much as the technology. A successful plant is not the one that produces the most gas, but the one that creates the highest sustainable value from its feedstock.

S2.2: From Renewable Electricity and CO₂ to e-Methane: Low-Cost Water Electrolysis for Carbon Recycling

Ulrich Hochberg, Christiane Zell and Fabian Haitz

Offenburg University of Applied Sciences

The increasing share of wind and solar power requires flexible technologies that balance fluctuating renewable electricity generation and support grid stability. At the tens-of-terawatt-hour scale required for seasonal energy storage, the conversion of electricity into chemical energy carriers becomes essential. Hydrogen is therefore expected to play a key role in future energy systems.

However, despite extensive technological development, green hydrogen has not yet achieved broad commercial deployment. Its economic viability remains challenging, mainly because renewable electricity for electrolysis is costly compared with hydrogen produced from natural gas. One approach is to operate electrolyzers predominantly during periods of low electricity prices, implying only about 1,500–2,000 operating hours per year and consequently requiring substantially lower electrolyser investment costs.

A second challenge is hydrogen utilisation. Major industrial consumers require a largely continuous hydrogen supply, while large-scale hydrogen transport and storage infrastructure is still under development. Converting intermittently produced hydrogen into an energy carrier compatible with existing infrastructure can overcome this mismatch.

Biogas provides a particularly promising interface. Biogenic CO₂ released during biogas production and upgrading can be combined with renewable hydrogen through biological methanation to produce e-methane. CO₂ from unavoidable point sources, such as cement production, can likewise be utilised. This enables the use of established technologies and existing natural-gas infrastructure for transport, storage and utilisation. Beyond energy storage, e-methane provides a pathway towards recycling biogenic CO₂ and establishing renewable carbon cycles.

Our research therefore focuses on alkaline water electrolyzers specifically designed for this operating concept. Simplified stack architectures, cost-efficient materials and scalable manufacturing are investigated with the objective of achieving low investment costs despite limited annual operating hours, thereby enabling grid-supportive e-methane production at biogas plants.

S2.3: From Renewable Electricity and CO₂ to e-Methane: Biological Methanation in a Pilot-Scale Counter-Current Bubble Column

Fabian Haitz¹, Stefano Munaretto¹, Manuel Scharffenberg¹, Aldrin Mattes²,
Ulrich Hochberg¹ and Christiane Zell¹

¹*Offenburg University of Applied Sciences*

²*Abwasserzweckverband Kinzig- und Harmersbachtal, Biberach*

A promising approach for carbon dioxide (CO₂) valorization and storing excess electricity is the biological methanation of hydrogen and carbon dioxide to e-Methane. The primary challenge here is to supply sufficient quantities of dissolved hydrogen.

To meet this challenge, a newly designed innovative pilot reactor in the form of a counter-current bubble column with a total volume of 1.1 m³ was constructed. The counter-current bubble column consists of two coupled reactor columns, each 10 m high. This configuration enables effective use of hydrostatic pressure differences to promote dissolution of the feed gas and degassing of the product gas, respectively. The reactor design can thus be kept simple and cost-effective, requiring only a small amount of operating energy.

By circulating the liquid and the resulting pressure changes, degassing of the gas component that is oversaturated relative to atmospheric pressure is enabled on the degassing-reactor side. Circulating the liquid through the two columns also achieves spatial separation of the feed-gas inlet and the product-gas outlet.

The reactor prototype was relocated to a digester-gas facility at the wastewater treatment plant of the regional wastewater association Kinzig- & Harmersbachtal for further optimization and demonstration of operation in a relevant application environment. Currently, the biological methanation of CO₂-containing digester gas is being investigated. In the next development step, the methanation plant is planned to be combined with the low-cost water electrolysis system being developed in parallel.

S2.4: Load-Dependent Resilience of Jerusalem Artichoke and Cattle Manure Co-Digestion at Short Hydraulic Retention Time

Tomasz Pokój, Katarzyna Bułkowska and Bogdan Dubis

University of Warmia and Mazury in Olsztyn

Jerusalem artichoke aboveground biomass is a potentially valuable feedstock for anaerobic digestion, but its high fermentability may increase the risk of acidification under short hydraulic retention times. This study evaluated the effect of cattle manure addition and organic loading rate (OLR) on the performance and stability of continuous co-digestion. Four feed mixtures containing 0, 6.25, 12.5, and 25 % cattle manure on a volatile solids basis were digested at 39 °C in 6 dm³ reactors operated at a hydraulic retention time of 10 days. The reactors were initially operated at an OLR of 5 g VS·dm⁻³·d⁻¹ (days 1–29), followed by 8 g VS·dm⁻³·d⁻¹ (days 30–53).

At the lower OLR, mono-digestion of Jerusalem artichoke remained acidified, with low pH and methane production, whereas all co-digestion variants showed improved methanogenic performance. After increasing the OLR, reactors containing 6.25 and 12.5 % manure exhibited a temporary rise in volumetric biogas production, followed after approximately one hydraulic retention time by VFA accumulation, pH decline, and reductions in methane yield of 78 and 87 %, respectively. In contrast, the reactor containing 25% manure maintained a pH of approximately 6.7, increased volumetric biogas production from 0.66 to 1.65 dm³·dm⁻³·d⁻¹, and maintained methane yield at approximately 0.1 dm³ CH₄·g⁻¹ VS. Its VFA profile was dominated by propionate, while acetate and butyrate remained comparatively low.

The results show that the proportion of cattle manure required to maintain process performance increased with organic loading rate. Low manure addition was sufficient at moderate loading, whereas, among the tested mixtures, only 25 % manure maintained short-term methanogenic resilience after the OLR increase.

Abstracts for Oral Contributions

Session 3: Environmental Pollution: Monitoring,
Mitigation and Sustainable Solutions

S3.1: Usage and Design of Bioassays for the Detection of Endocrine-Disrupting Compounds in Environmental Matrices

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¹*Goethe University Frankfurt*

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³*Fraunhofer Institute for Molecular Biology and Applied Ecology (IME)*

Anthropogenic activity introduces a wide range of chemical stressors into aquatic environments, including endocrine-disrupting compounds (EDCs) such as synthetic hormones, pharmaceuticals, and per- and polyfluoroalkyl substances (PFAS). These substances are routinely detected in wastewater and surface waters, where they can interfere with hormonal signaling pathways, including estrogen and androgen receptor activity, and contribute to reproductive disorders and hormonal dysregulation in wildlife and humans.

Conventional chemical analytics can identify and quantify individual target compounds with high precision, but remain limited for complex environmental mixtures, where unknown or unmonitored substances, transformation products, and combined mixture effects often escape detection. Effect-based bioassays address this gap by measuring the aggregate biological activity of a sample, making them a valuable complement to chemical analysis within effect-directed analysis (EDA) workflows.

At the Institute for Circular Bioeconomy (Hochschule Offenburg), the Yeast Estrogen Screen (YES) and its planar, HPTLC-coupled format (pYES) are currently used to detect estrogenic activity in environmental samples. While well established, yeast-based systems can underestimate hormonal activity due to metabolic differences from human cells. To overcome this limitation, we are currently establishing a dual-receptor bioassay in a human cell line, designed to simultaneously detect estrogenic and androgenic activity in complex environmental matrices using two parallel reporter systems.

By integrating both receptor systems into one assay, this approach will enable parallel screening of agonistic and antagonistic effects, increasing throughput and biological relevance compared to yeast-based single-receptor assays, and will provide a sensitive, humans-relevant tool for prioritizing hormonally active contaminants within EDA workflows.

S3.2: Elimination of Antibiotic Resistances and Faecal Indicators in Wastewater Treatment

Claudia Stange¹, Johannes Ho¹, Abidelfatah Nasser² and Andreas Tiehm¹

¹*DVGW-Technologiezentrum Wasser*

²*Water Quality Research Laboratory, Ministry of Health, Israel*

Minimising the release of biological contaminants from wastewater treatment plants (WWTPs) is important for protecting surface waters and enabling safe water reuse. Within the ELARIA project, reliable data were generated on the effectiveness of advanced treatment processes in removing antibiotic-resistant bacteria (ARB), antibiotic resistance genes (ARGs), and microbial indicators.

Studies combined sampling from full-scale WWTPs in Israel and Germany with controlled bench-scale experiments. In Israel, samples were collected along a treatment train including primary sedimentation, activated sludge, sand filtration, and either chlorination or UV irradiation. In Germany, three WWTPs employing ozonation as an advanced treatment step were investigated. A broad spectrum of microbiological parameters was analysed, including faecal indicator bacteria, bacteriophages, ESBL-producing *E. coli*, and ARGs.

High concentrations of microbial indicators, ARB, and ARGs were detected in raw effluents. Chlorination (1–2 mg/L) achieved higher reductions of bacterial and viral indicators than UV irradiation (40 mW/cm²), while ARG reduction was negligible under UV but reached $\geq 2 \log_{10}$ with chlorine. Ozonation in German plants resulted in 1–2 $\log_{10}$ reductions of culturable microorganisms. However, ARGs quantified by short-amplicon qPCR showed only limited reduction compared to microbial indicators. Bench-scale experiments demonstrated that targeting longer gene fragments resulted in higher observed reductions, indicating that long-amplicon PCR provides a more realistic assessment of nucleic acid damage and potential risk (see figure).

Overall, advanced treatment processes significantly reduced indicator organisms and ARB, but did not eliminate them completely. The findings highlight the importance of method selection for ARG analysis and demonstrate that combining treatment

technologies with suitable monitoring approaches improves risk assessment and supports optimisation of treatment performance.

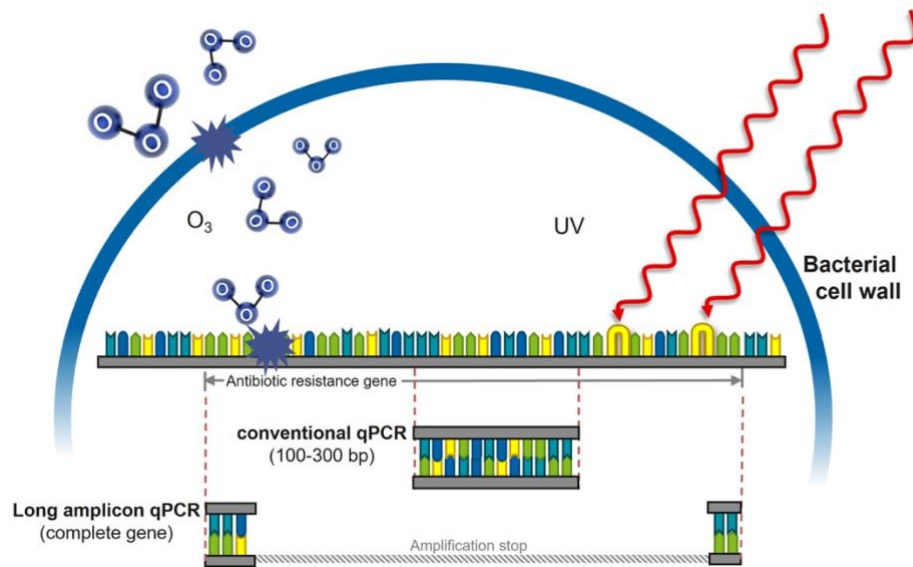


Figure: Comparison of short and long PCR for (A) 16S rRNA and (B) *vanA* across ozone doses; error bars show standard deviations.

The ELARIA project was funded within the German–Israeli Cooperation in Water Technology Research by BMBF and MOST.

S3.3: Micropollutant Removal from Municipal Wastewater

Mingqing Xu

ProMinent Group

- Micropollutants overview
- EU regulations
- Main processes and ProMinent scope ozone and powdered activated carbon
- Installation pictures of a ozone unit at a WWTP
- Q&A



S3.4: Circular, but Safe? Mycotoxin Risk from Kitchen Waste to Compost

Maciej Woźny¹, Sławomir Kasiński¹, Marcin Rudnicki² and Katarzyna Bułkowska¹

¹*University of Warmia and Mazury in Olsztyn*

²*Municipal Waste Management Plant in Olsztyn*

A circular bioeconomy begins with a change in perspective: kitchen and garden waste is not an endpoint, but a reservoir of carbon and nutrients that composting can return to soil. However, the moist, nutrient-rich material that makes biowaste so valuable also supports fungal growth. This raises an overlooked question: could mycotoxins (i.e., harmful fungal metabolites) travel through, or even arise within, the biowaste-to-compost chain?

Mycotoxins are generally discussed as food and feed contaminants, yet toxigenic fungi and mycotoxins have been detected in food waste, compost bioaerosols, and compost piles. Studies are scarce and difficult to compare. It remains unclear whether risk arises during household storage, source-separated collection, small-scale or poorly controlled composting, or in the final product. The aim of this presentation is to synthesise current evidence and our recent findings on mycotoxin occurrence in biowaste and compost, identify key knowledge gaps, and outline priorities for further research. Our pilot-scale study tracked eight mycotoxins over 45 days of composting kitchen and garden waste in a 550-L passively aerated bioreactor. The process reached 62.6 °C and stabilised the composting material. Only trace amounts of mycotoxins were detected in a few samples; commercial composts also showed low or non-detectable contamination. These reassuring findings address only the chain's final part.

The next step is to investigate the chain upstream of composting. A new project will test how waste composition, storage time, season, housing type, collection in bags or bins, and composting scale influence mycotoxin occurrence. Chemical analysis will be combined with fungal community profiling and controlled composting experiments to distinguish feedstock contamination from patterns shaped by process conditions. The objective is not to portray compost as unsafe, but to identify where risk may arise and which controls are needed to keep organic recycling circular and safe.

S3.5: Aerobic Chloroethene Biodegradation: Stimulation and Molecular Monitoring

Andreas Tiehm, Lara Stelmaszyk, Lena Holl, Johannes Ho and Axel Müller

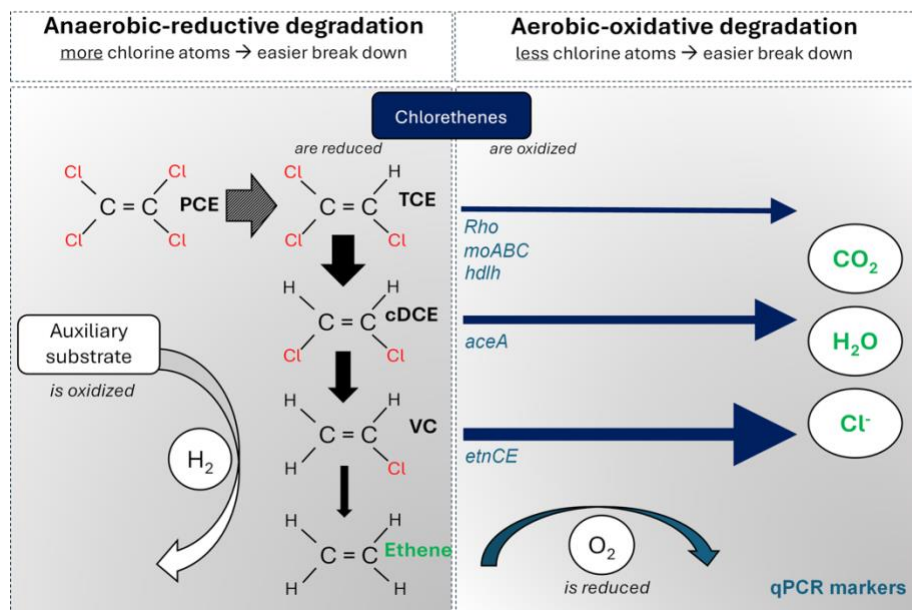
DVGW-Technologiezentrum Wasser

Chlorinated hydrocarbons are among the most common groundwater contaminants and for decades, assessment and remediation focused on anaerobic reductive dechlorination. Depending on site conditions, this process can have major limitations: degradation is often incomplete, leading to the accumulation of dichloroethene (cDCE) and the carcinogenic vinyl chloride (VC). It also requires highly reduced conditions and organic substrates, which promote side reactions such as methane formation and hydrogen sulfide production.

While the primary substance trichloroethene (TCE) was long thought to be degradable only cometabolically under aerobic conditions, the aerobic metabolic degradation of TCE was demonstrated in 2014. In this process, microorganisms use TCE directly as an energy and carbon source. It is more efficient than cometabolism and results in complete mineralization to CO₂ and chloride without toxic intermediates. cDCE and VC can also be oxidized directly under aerobic conditions.

Bacteria of the *Rhodocyclaceae* family have been identified as key organisms in this pathway, with enzymes such as monooxygenases and hydrolases playing central roles. The process is reproducible, stable, and can be enhanced through oxygen supply or bioaugmentation.

Based on these findings, molecular biomarkers have been developed that allow detection, quantification, and activity assessment of aerobic degradation in the field. qPCR-based methods, available for aerobic TCE, cDCE and VC degradation (Figure 1), thus provide an effective tool for monitoring and optimizing remediation strategies.



Because slightly aerobic conditions occur in many aquifers, this pathway is more widespread than previously assumed. At a long-term monitored site, new biomarkers recently revealed that aerobic TCE degradation occurs alongside previously assumed anaerobic processes. These findings were evidenced by the latest batch tests measuring activity at various monitoring points on the site.

In conclusion, for the evaluation of suitable remediation strategies, we recommend to investigate whether these processes play a role at contaminated sites and could be stimulated.

Abstracts for Oral Contributions

Session 4: From Waste to Wealth:
Thermochemical Pathways for Resource
Recovery

S4.1: Industrial Biochar Production in the Czech Republic: Producers, Technologies, and Characterization

Jaroslav Moško¹ and Michael Pohořelý^{1,2}

¹*University of Chemistry and Technology, Prague*

²*Institute of Chemical Process Fundamentals of the CAS, Prague*

Biochar has emerged as a crucial component of the circular bioeconomy, offering solutions for carbon sequestration and waste valorization. While the theoretical benefits of biochar are well-documented, understanding the regional industrial landscape and the material quality variations driven by different feedstocks and operational technologies is essential for successful market integration. This presentation provides a comprehensive overview of the current industrial biochar status in the Czech Republic by mapping the existing production facilities, detailing their operational setups, and comparing the physicochemical properties of the generated biochars. The analysis covers all four current industrial-scale producers in the country, highlighting their distinct technological paths and feedstock choices. This includes two facilities utilizing pyrolysis for sewage sludge valorization, one facility operating pyrolysis for agricultural post-harvest residues, and one facility using gasification technology focused on softwood from single-use pallets. The presentation details the geographical distribution, technological parameters, and functional frameworks of these sites, followed by a comparative analysis of the resulting biochars, focusing on key properties. By contrasting these different waste streams and thermal conversion methods, this study highlights how technology and feedstock dictate final biochar quality, offering practical insights into the viability of the Czech biochar market.

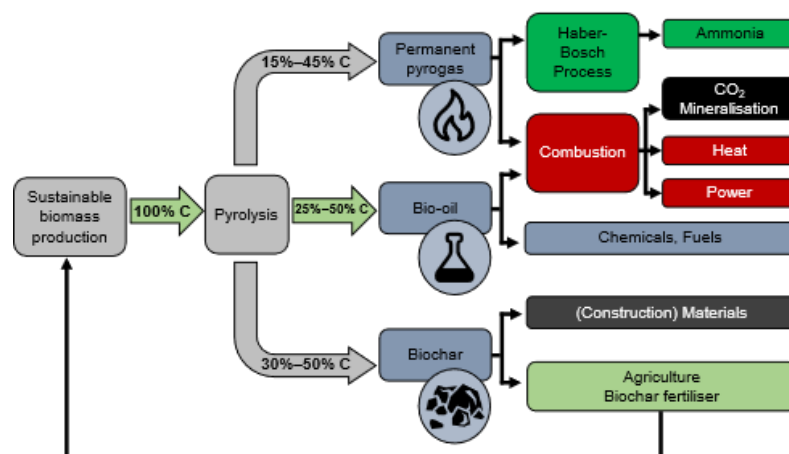
S4.2: Preparing the Pyrolysis Industry for the Future

Leonie Jakob, Daniel Kray and Heide Biollaz
Offenburg University of Applied Sciences

Pyrolysis converts biomass to biochar, bio-oil and pyro-gas by thermal treatment (ca. 500 – 800 °C) in the absence of oxygen. The biochar is mainly used in agricultural applications and is sold as a carbon sink. The bio-oil and the pyro-gas are combusted and used as heat and electricity sources. Currently, the pyrolysis industry grows exponentially. However, in the near future, the use of the produced heat and electricity is no longer economically feasible and the produced amount of biochar will exceed the agricultural demand. Therefore, alternative pathways for the application of the pyrolysis products must be identified. This is the objective of our research project PyCCS-2050.

We aim to achieve these goals by several different approaches. We plan to facilitate the broader agricultural use of biochar by developing granulated or pelletized fertilizers, which enable an easier application without additional effort for the farmers. Additionally, we investigate how the mixing of biochars from different feedstocks and production sites influences the properties. A better understanding of the behavior of mixed biochar eases the application of biochar in fields like plastics, asphalt or concrete, which require large quantities of homogeneous biochar exceeding the production capacities of single pyrolysis plants.

In addition, we also investigate alternative uses of the liquid and gaseous products, which would additionally increase the carbon dioxide removal efficiency. One approach aims to capture the CO₂ resulting from the combustion via an alkalinity reactor in the form of solid and stable carbonates. Alternatively, applications of the bio-oil for the production of basic chemicals are investigated and possible post-processing strategies of the pyro-gas e.g., for the production of ammonia via the Haber-Bosch process are studied and simulated.



S4.3: Co-Pyrolysis of Municipal Sewage Sludge with Lignocellulosic Biomass: Effects on PAH Formation and Heavy Metal Stabilization in Biochar

Mariusz Gusiatin

University of Warmia and Mazury in Olsztyn

Municipal sewage sludge (MSS) is a promising feedstock for biochar production; however, its environmental application is limited by polycyclic aromatic hydrocarbons (PAHs) and heavy metals (HMs). Co-pyrolysis with lignocellulosic biomass can reduce PAH formation and modify HM speciation. This study investigated the effects of biomass type, biomass proportion and pyrolysis temperature on PAH and HM content, and HM mobility in MSS-derived biochars.

MSS was co-pyrolyzed with Jerusalem artichoke stalks (SS) and pine sawdust (PS) at mass ratios of 50:50 and 25:75 in a tubular furnace at 500 and 700 °C (2 h, 1 L N₂/min). The EPA priority PAHs were analyzed by LC-MS/MS. HM fractionation and environmental risk were assessed using the modified BCR procedure and RAC index, respectively.

Among the PAHs, acenaphthylene, fluoranthene, benzo[a]pyrene, benzo[ghi]perylene and indeno[1,2,3-cd]pyrene were detected. Pyrolysis of MSS reduced the total PAH concentration from 785 to 627 ng/g, whereas the lowest value after co-pyrolysis (589 ng/g) was obtained for MSS:SS (25:75) at 700 °C. Compared with biochars produced from MSS alone, the greatest reductions in total HM concentrations occurred at the 25:75 biomass ratio, reaching 98 % for Pb, 76 % for Ni, 68 % for Cu and 67 % for Zn. HM stabilization was metal-specific. Cu and Cd exhibited the greatest stabilization, evidenced by increased residual fractions and very low RAC values. Ni showed a reduction in environmental risk despite moderate changes in the residual fraction, whereas Zn remained the most mobile metal and Pb was almost associated with the residual fraction. Cr showed treatment-dependent responses. All biochars complied with the EBC and WBC limits for PAHs and the WBC limits for HMs. Co-pyrolysis improved environmental quality by reducing PAH formation and HM concentrations, while HM stabilization depended on biomass type, biomass proportion and pyrolysis temperature.

This research was funded in whole by National Science Centre, Poland (Grant number 2024/55/B/NZ9/01278).

Abstracts for Poster Contributions

A. Biocatalytic Paths to Sustainable Nutrition -
Linking Biorefineries and Food Tech

P01: Effects of Pulsed Electric Field (PEF) Preservation on the Quality of Bovine Colostrum

Adriana Łobacz, Cezary Domasiewicz, Katarzyna Staniewska and Justyna Żulewska

University of Warmia and Mazury in Olsztyn

Conventional preservation methods for bovine colostrum, including thermal pasteurization and drying, may reduce the stability of bioactive components, particularly immunoglobulins. Pulsed Electric Field (PEF) processing has emerged as a promising non-thermal alternative capable of improving microbial safety while preserving nutritional and functional quality. This study evaluated the effects of PEF treatment on the physicochemical composition, microbiological quality, and immunoglobulin G (IgG) content of raw bovine colostrum. Colostrum samples were processed under two PEF conditions: (i) pulse width of 50 μ s, 10 pulses, pulse repetition times ranging from 10 to 10,000 ms, and a treatment time of 10 min; and (ii) pulse width of 99 μ s, 10 pulses, a pulse repetition time of 1000 ms, and treatment durations of 10, 20, or 30 min. Chemical composition was determined using a MilkoScan™ FT3 (Foss), total viable count was assessed on CASO agar (Merck), bacterial isolates were identified by MALDI-TOF mass spectrometry, and IgG concentration was quantified using a bovine IgG ELISA kit (Bethyl Laboratories). PEF treatment caused a slight reduction in solids-not-fat (SNF), which may be attributed to electrochemical deposition of charged constituents on the electrodes and localized heating during processing. However, no significant changes in IgG concentration were observed, indicating preservation of the major bioactive protein fraction. Moreover, shorter pulse repetition times (higher pulse frequencies within the investigated range) resulted in lower residual bacterial counts, demonstrating that microbial inactivation depended on the applied PEF parameters. These findings indicate that appropriately optimized PEF processing can improve the microbiological quality of bovine colostrum while preserving its chemical composition and immunological value. Further studies are required to optimize processing conditions and maximize preservation efficiency without inducing undesirable thermal effects.

P02: The Influence of the Homogenization Method on the Quality and Stability of the Emulsion

Józef Warechowski and Fabian Dajnowiec

University of Warmia and Mazury in Olsztyn

Many intermediates and products in the chemical and food processing industries require a homogeneous form for both process and application reasons. Various homogenization methods are used for liquid and semi-liquid mixtures.

This paper presents the results of research on various homogenization techniques for a model emulsion prepared from distilled water and rapeseed oil, using WPC80 as the emulsifier.

First, WPC80 was dissolved in water while stirring with a disc stirrer driven by an IKA EUROSTAR 60. It was then standardized to pH 7.0 with NaOH solution. Rapeseed oil was added to the resulting solution while stirring with a Unidrive X1000D device with a T10 working unit – the S/R homogenization system.

The resulting pre-emulsion was then subjected to the actual homogenization process using one of three techniques: two-stage pressure homogenization (PH - 1000/200 bar), microfluidization (MF - 1000 bar), and two-stage ultrasonic homogenization in a flow cell (US - P = 200 W; f = 20 kHz; Q = 1.5 ml/s).

The emulsions were analyzed using DLS for fat globule size distribution and degree of homogenization. Rheological properties were measured to measure viscosity and yield stress, and stability was measured using a TSI measurement using a Turbiscan Classic 2 device.

The resulting emulsions exhibited yield stresses ranging from 53 to 267 Pa, with the lowest being the US emulsion and the highest being the MF method. The highest stability after 60 min was demonstrated by emulsions obtained using the MF technique (TSI = 0.477), and the lowest by PH and US emulsions (TSI = 0.277-0.301). The highest degree of homogenization was obtained using the MF technique (95 %) and the lowest by US (44.6 %). The smallest fat globules were obtained using the MF method ($D(90) = 0.663 \mu\text{m}$), and the largest by US - $D(90) = 4.099 \mu\text{m}$.

P03: Development of Copper-Binding Artificial Metalloenzymes Based on β -Helix Mimicking Peptides for Biocatalysis

Nele Schulte¹, Nico Bruns², Ivano Eberini³, Peter Faller¹, Vincent Lebrun¹
and Maxime Naudé¹

¹*University of Strasbourg*

²*TU Darmstadt*

³*University of Milan*

Artificial metalloenzymes (ArMs) offer a promising strategy for expanding the catalytic repertoire of biomolecules by integrating metal centers into designed peptide and protein scaffolds. In this work we focus on developing β -helix mimicking peptides as structurally defined platforms for Cu-catalyzed C-C-bond forming reactions. Building on previously designed metal-free self-assembling β -helix peptides [0], rational sequence modifications were introduced to incorporate tailored copper-binding sites while maintaining structural integrity. The structural stability of the β -helix fold is complemented by metal binding sites. A small library of peptides was generated, systematically varying the coordination environment, metal positioning, and local scaffold properties to optimize catalytic efficiency. The peptides ability to self-assemble into fibrillar architectures is aimed to facilitate both catalytic function and recyclability. The peptides were synthesized using solid-phase peptide synthesis (SPPS), purified, and characterized using electron microscopy to confirm the peptides' ability to assemble into fibers. Their catalytic activity was confirmed. During the first tests for catalytic activity, the Cu(II)-coordinating peptides proved to be stereoselective and an advantageous platform for heterogeneous reactions. The metal-free peptide scaffolds were compared to the metalated peptides (either Cu(II) or Zn(II), and free Cu²⁺ or Zn²⁺). This work contributes to advancing the design of bioinspired catalysts, demonstrating how rationally engineered self-assembling peptide scaffolds can provide efficient, potentially recyclable ArMs for C-C bond-forming transformations, with potential applications in sustainable catalysis and green chemistry.

[0] Naudé, M., Lebrun, V., Faller, P. (2023). A closer look at Type I left-handed β -helices provides a better understanding in their sequence-structure relationship: towards their rational design. BioRxiv (Cold Spring Harbor Laboratory). <https://doi.org/10.1101/2023.06.27.546660>

P04: Evaluation of Different Engineering Strategies for the Successful Expression of Precision Fermentation Targets in *Trichoderma reesei*

Samuel Zuber^{1,2}, Melanie Broszat¹, Thomas Eisele¹ and Tobias Stadelmann²

¹*Offenburg University of Applied Sciences*

²*Picea Biosolutions*

Precision fermentation (PF) has emerged as an important technology in the alternative-protein market, providing a sustainable and scalable approach to meeting future global protein demands without requiring further increases in agricultural production. Although the filamentous fungus *Trichoderma reesei* (*T. reesei*) has already been successfully utilized for heterologous protein production, its competitive application remains hindered by several genetic limitations. This study investigates two different genetic engineering strategies for improving the suitability of *T. reesei* for PF applications. The approaches were based on the deletion of transcription factors to reduce undesired homologous protein expression or their overexpression to potentially increase overall protein titers. The generated strains were characterized using the model expression of bovine β -lactoglobulin (BLG) and hen egg ovalbumin (OVA). Expression of both PF targets remained undetectable in the transcription factor deletion strains. In contrast, some transcription factor overexpression strains exhibited increased expression potential, although the effects were strongly target-dependent. Individual transformants displayed up to threefold higher BLG expression than the reference strain, whereas OVA expression remained substantially lower in the same genetic background. A second modification showed comparatively consistent expression behavior for both target proteins, although improvements in titer were more moderate, with median increases of 22.0 % and 7.5 % for BLG and OVA, respectively, compared to the reference strain. Investigations of extracellular proteolytic activity further indicated that target stability remained a relevant limitation. BLG degradation varied across the different genetic backgrounds, whereas no additional degradation of OVA occurred throughout the time-course experiment despite its characteristic banding pattern associated with proteolytic degradation.

Overall, this work provides new insights into strategies for improving *T. reesei* for PF. The findings demonstrate the importance of understanding the interaction between the genetic background and the expressed target protein and emphasize the need for target-specific evaluation when developing engineered *T. reesei* expression systems.

P05: Recombinant Expression of β -fructofuranosidases in *T. reesei* for the Production of Fructooligosaccharides

Christian Peter^{1,2}, Melanie Broszat¹, Thomas Eisele¹ and Tobias Stadelmann²

¹*Offenburg University of Applied Sciences*

²*Picea Biosolutions*

Industrial production of fructooligosaccharides (FOS) is dependent on the availability and specific activities of β -fructofuranosidases used for enzymatic sucrose conversion. In this work, six β -fructofuranosidases from various fungal sources were recombinantly expressed in *Trichoderma reesei* and represented the predominant secreted proteins within the cellulase background. Four enzymes were identified as fructosyltransferases with high transfructosylating activity. All four fructosyltransferases exhibited highly similar biochemical properties, with optimal activity at 50 °C and pH 6 and temperature stability up to 40 °C. In addition, these enzymes produced similar FOS yields of up to 55 % relative to the total sugar content, comparable to those obtained with a commercial benchmark enzyme. FOS yield and composition could be controlled by adjusting incubation time and enzyme dosage, with extended incubation combined with high enzyme concentrations leading to an increased degree of polymerization (DP) in the resulting FOS, reaching up to DP7. Moreover, *in situ* FOS production in fruit based beverages achieved FOS yields as high as 20 % of total sugar content through the conversion of natively present sucrose. These results demonstrate the suitability of *Trichoderma reesei* as an industrial host for fungal β -fructofuranosidases and highlight their potential for both industrial FOS production and *in situ* food applications.

P06: Investigation of the Possibility of *Listeria monocytogenes* Growth in Nitrite-Free Frankfurters

Monika Modzelewska-Kapituła, Katarzyna Tkacz and Anna Zadernowska

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Listeria monocytogenes is a Gram-positive pathogenic bacterium. It is a cause of listeriosis, which is characterised by a high mortality. The bacteria can grow under refrigerated conditions in contaminated, after thermal treatment, ready-to-eat meat products during storage. The European Commission set limits for *L. monocytogenes* numbers in food individually for products in which it can and cannot grow [1]. To determine the growth potential of *L. monocytogenes*, a challenge test should be conducted. This applies to freshly introduced food products such as sausages produced without traditional nitrite curing. Therefore, the study aimed to investigate the possibility of *L. monocytogenes* growth in frankfurters produced without the nitrite addition.

The frankfurters produced without the use of nitrite addition were inoculated with a mix of three *Listeria monocytogenes* strains (0.1 ml on the surface of each sausage with the mixture containing $6.0 \log_{10}$ CFU/ml). Products were vacuum-packed and stored for 10 days at 6 °C and sampled using ALOA media (Merck). A growth potential (δ) was calculated using the equation: $\delta = \log_{10}$ CFU/g at the end of the test - $\log_{10}$ CFU/g at the beginning of the test.

The frankfurters showed a relatively high value of growth potential ($\delta = 0.63$), which indicates that there is a possibility of the pathogen growth on the surface of nitrite-free products. The δ value higher than $0.5 \log_{10}$ CFU/g obliges the producer to classify the product as one in which the growth of *L. monocytogenes* is possible.

References

[1] Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs, Official Journal of the European Union, L 338/1.

P07: Sporulation of *Trichoderma reesei* in Fermentations; Early Detection and Countermeasures

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Trichoderma reesei serves as an essential organism for cellulase production and plays a significant role in industry. However, fermentations are time-consuming and costly endeavors. While sporulation is a normal aspect of the production cycle, excessive sporulation renders the fermentation non-productive, necessitating its cessation and resulting in substantial loss of time and financial resources.

This project centered on understanding sporulation, focusing on when and how it can be detected and what methods could be developed to prevent excessive sporulation. To achieve this, we concentrated on pinpointing the critical factors within the fermentation process and analyzing the specific build-up of spores under conditions of active stress.

The anticipated outcomes from the evaluation of pre-existing fermentations identified measurable stress factors, like a glucose deficit or difficulties to maintain a constant pH, which occurred during the preculture phase and in the transition from batch to the fed-batch. To assess the status of *T. reesei* at these points, experiments were executed to examine spores.

For calculating the spore-count, we utilized the Thoma-counting-chamber method, blending the resulting spore-density with the dry biomass from the shaking-flasks or fermentation samples to determine the specific spore-count.

Furthermore, we conducted HPTLC (High-Performance Thin-Layer Chromatography) and full wavelength scans of the supernatant from 300 to 780 nm to correlate the presence of orange pigments with the specific spore-count.

In instances of excessive sporulation, the specific spore count is, unlike the initial hypothesis, significantly lower compared to the typical operating conditions. Meanwhile, HPTLC and spectroscopy show a presence of orange pigments at 310 and 365 nm in sporulated samples.

The analysis of the condition from the preculture before inoculation into the fermenter is vital to secure a successful fermentation process. If the culture is heavily sporulated it can put additional strain on the early and later phases of the fermentation process.

P08: Gamification-Based Study Promotion for Environmental Technology

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Engineering programmes in Germany have experienced a substantial decline in first-year student enrolment. Between 2013/14 and 2023/24, enrolment decreased by 13 %, with mechanical and process engineering declining by around 45 % [1]. At Hochschule Offenburg (HSO), this challenge is also relevant to the related field of Environmental Technology. Active promotion of the degree programme is therefore used as one approach to attracting prospective students. However, communicating the content and relevance of engineering programmes to school students can be challenging when programme content appears abstract or disconnected from students' everyday experiences.

In this project, a low-resource concept for active study promotion based on a gamified learning entry point was developed. The concept consists of: (1) a gamified entry, (2) subject-specific deepening, and (3) study information. In the first phase, students collaboratively explore a tangible topic related to Environmental Technology through a game designed around selected Core Drives of the Octalysis Framework [2] to foster motivation, curiosity, social interaction, and active participation.

The concept follows a constructivist learning approach. Students first build experiences and activate existing knowledge through the game. Relevant subject-specific concepts are then introduced and connected to these experiences before the Environmental Technology degree programme is presented. Thus, study information is provided only after students have established an initial understanding of the underlying topic.

Initial testing showed positive responses in terms of students' attention, participation, and engagement. Regarding the balance between gaming and learning, 76.6 % of participants considered the concept well balanced. Furthermore, 91.5 % expressed a desire to learn and work more frequently with gamified methods. Compared to other information and study-orientation events, 74.5 % of participants rated the gamified format more positively. The concept illustrates how gamification and constructivist learning principles can be combined to create engaging, accessible, and flexible approaches to engineering study promotion.

Abstracts for Poster Contributions

B. Advanced Biogas & Power-to-Gas

P09: Anaerobic Digestion of Hemp and Sorghum Silages

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Anaerobic digestion converts plant biomass into renewable energy, but process efficiency depends on feedstock composition and biodegradability. This study compared hemp (*Cannabis sativa* L.) silage and sorghum (*Sorghum bicolor* cv. *Kallisto*) silage as substrates for biogas production.

The experiments were conducted in laboratory-scale continuously stirred tank reactors operated in semi-continuous mode at 39 °C. Each reactor had a working volume of 6 L. The hydraulic retention time was 45 days, and the organic loading rate was approximately 2.0 g VS/L·d. Process performance was evaluated using daily biogas production, methane content, pH, alkalinity, volatile fatty acids, chemical oxygen demand, and solids concentration in the digestate.

Both reactors operated under stable conditions. Digestate pH remained at approximately 7.0–7.2, and volatile fatty acid concentrations were about 640 mg/L in both variants. *Kallisto* sorghum produced 3.8 L of biogas per day, compared with 1.6 L/d for hemp, corresponding to an approximately 2.4-fold higher production. Methane content was similar for both substrates and remained at approximately 50–52 %. The digestate from the sorghum reactor contained less residual organic matter: volatile solids were 23.6 g/kg and chemical oxygen demand was 2.06 g/L, compared with 32.2 g/kg and 5.35 g/L for hemp.

The results indicate that sorghum silage was converted into biogas more efficiently than hemp silage under the applied operating conditions. The lower performance of hemp may reflect its lower biodegradability, potentially associated with slowly degradable lignocellulosic compounds.

P10: Biogas Production from Municipal Sewage Sludge in a Microbiogas Plant at a Small Wastewater Treatment Plant: A Circular Economy Approach

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A pilot-scale microbiogas plant for the anaerobic digestion (AD) of sewage sludge at a small wastewater treatment plant (WWTP) (<10,000 PE) in Rybno (Warmian-Masurian Voivodeship, Poland) was commissioned in December 2025. The plant consists of a horizontal mesophilic (37 °C) digester with a working volume of 67 m³, equipped with mechanical mixing. The objective of the study is to evaluate the efficiency of AD, reactor stability, and the physicochemical characteristics of the resulting digestate. During start-up, the reactor was inoculated with anaerobic sludge from a full-scale mesophilic digestion facility. Winter temperature control was improved by additional digester insulation, stabilizing the process at approximately 37 °C from mid-April 2026. This resulted in methane concentrations of up to 67 %. At the same time, the pH in the digester remained stable between 6.8 and 7.5. The organic loading rate (OLR) was gradually increased by feeding dewatered excess sludge with a total solids (TS) content of 10.7 % and a volatile solids (VS) content exceeding 85 % of TS. The OLR was increased from 0.27 to a maximum of 4.12 kg VS/(m³·d) and was subsequently maintained at 2.7 kg VS/(m³·d), corresponding to a hydraulic retention time (HRT) of 33 days. During the last month of operation, the average biogas production reached approximately 0.7 m³/(m³·d), with methane concentrations of up to 65 %. Digestate analyses confirmed stable AD performance. The pH remained within the range of 7.58–8.29, while an increase in alkalinity to approximately 248 meq/L indicated good buffering capacity of the system. As the OLR increased, the concentration of volatile fatty acids (VFA) temporarily rose to approximately 6000 mg/L before decreasing to 1200–1500 mg/L, confirming microbial adaptation and the restoration of process stability. The obtained results demonstrate that a microbiogas plant integrated with a small WWTP can effectively stabilize sewage sludge while ensuring stable operation and producing methane-rich biogas.

P11: Two Stage Anaerobic Digestion of Marine Macroalgae: Implementation of Herbst Loop Reactor®

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Ulva lactuca (U), a green marine macroalgae naturally growing in coastal ocean waters worldwide, grows rapidly without occupying ashore farmland, making it promising feedback for sustainable biogas production. Despite its potential, the anaerobic digestion of *Ulva lactuca* is not without significant limitations. Its naturally low carbon-to-nitrogen (C: N) ratio of around 8.6, high salt content, and tough cell-wall results in process instability and reduce methane yields in standard anaerobic digestion systems (Bruhn et al., 2011; FitzGerald et al., 2015).

This study takes a step-by-step approach to tackling these challenges. The biochemical methane potential (BMP) of *Ulva lactuca* was evaluated both alone and in combination with sugar beet pulp silage (S) and sugar beet pulp pellets (P) as fresh mixtures and as co-ensilaged substrate prepared at a target C: N ratio of 22:1. Co-ensilage was carried out over 23 days with a lactic acid bacteria (LAB) extract, and pH monitoring confirmed the successful fermentation in both U+S (pH 3.65) and U+P (3.75). BMP testing following (VDI 4630) showed a clear progression: *Ulva lactuca* alone produced only a partial methane yield of 112.41 NL CH₄/kgVS, while co-ensilaged U+P achieved the highest methane yield of 330.08 NL CH₄/kgVS and biogas yield of 707.88 NL/kgVS, demonstrating the ensiling actively improves its digestibility beyond simple preservation (Herrmann et al., 2015).

Based on these results, co-ensilaged U+P was selected for the continuous digestion in the Herbst Loop Reactor®, a novel two-stage system developed by Herbst Umwelttechnik GmbH, comprising, a mesophilic reactor (45 °C, HRT 30 days) with a thermophilic reactor (65 °C, HRT 3 days). Two approaches were investigated: sole digestion of *Ulva lactuca* at three organic loading rates (OLR) (0.5, 1.0, 1,5 g VS/L·d), and digestion of co-ensilaged U+P at different mixing ratios. Preliminary results including biogas yield, methane concentration, process stability indicators, are presented and discussed.

P12: Development of a Parallelized Test Rig with a Circulating Gas Flow System for Biological Methanation

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The usage of renewable energy is often limited due to the fact, it cannot be scheduled, and often there is a large amount of electricity available at times when electricity consumption is low, while during peak consumption periods, only very little electricity is produced from renewable sources. Therefore, ways are being sought to store electricity for longer periods of time. One way to store excess electricity is to convert water through electrolysis in hydrogen gas for storage. However, the storage, transport, and consumption of hydrogen present major technical challenges. By biologically converting H_2 and CO_2 into methane, it is possible to leverage the already established technology and infrastructure of the natural gas network. For the technical implementation of the biological methanation, this poster describes the development and commissioning of a parallelized laboratory-scale test rig with a circulating gas flow system. The development of the test rig, as well as the production of methane up to 80 % through biological methanation, was successfully carried out.

P13: Development of an Assay to Assess Specific Methanogenic Activity in Biological Methanation Reactors

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Against the backdrop of the energy transition, chemical energy storage systems are being developed to store surplus electricity from renewable energy sources and supply power during periods of low energy generation. One such method is methanation. Hydrogen and Carbon dioxide are fed into reactors, where methanogenic archaea in sewage sludge can utilise the gas to catalyse methane production. To monitor the biological processes in the reactor, a rapid activity test using glass syringes has been developed to determine the specific methanogenic activity (SMA) of hydrogenotrophic archaea.

The assay relies on the reaction equation $\text{CO}_2 + 4 \text{H}_2 \rightarrow \text{CH}_4 + 2 \text{H}_2\text{O}$; the conversion of substrate gas to methane results in a volume reduction, which is directly quantified by plunger displacement. The biomass is drawn into syringes, along with substrate gas. The syringes are then incubated and the volume change in each syringe is recorded over the duration of incubation. Additionally, assuming biological activity decreases proportionally, sludge dilutions were prepared, to simulate varying biomass concentrations.

The gas uptake per day is calculated by determining the slope of each curve. Dividing the gas uptake by four gives the methane production rate, and normalising these rates against the biomass dry weight yields the SMA.

During testing, biological replicates showed variations in volume reduction, some up to an hour slower than their respective replicates. However, despite the individual volume changes among the syringes, biological replicates exhibited consistent methanogenic rates, demonstrating the reproducibility of the optimised assay. The assumption that biological activity decreases in the same proportion as dilution could not be confirmed. The activity dropped disproportionately in diluted samples depending on the solution or buffer used for dilution, posing further inquiries on how the buffer/solution affects metabolism or mass transfer and solubility.

P14: Microbiological Quality of Tvarog Cheeses in Relation to Their Packaging

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The aim of this study was to evaluate the effect of two packaging methods ("hot packaging" and "cold packaging") on the microbiological quality, physicochemical properties, and sensory characteristics of semi-fat tvarog cheese during 28 days of refrigerated storage. The analyses included the enumeration of psychrotrophic bacteria, *Enterobacteriaceae*, yeasts, and molds, as well as the determination of the basic chemical composition and sensory evaluation of the products.

The results demonstrated that the packaging method affected the microbiological stability of the cheeses. Samples packaged using the hot packaging method showed lower counts of *Enterobacteriaceae*, yeasts, and molds after storage, together with more favorable microbiological changes than cheeses packaged using the cold packaging method, in which an increase in psychrotrophic bacteria was observed. The packaging method did not significantly affect the chemical composition of the products.

Sensory evaluation indicated that cheeses packaged using the hot packaging method retained superior quality attributes, including greater firmness, lower whey separation, and higher aroma scores. The obtained results suggest that hot packaging may improve the microbiological stability and sensory quality of semi-fat curd cheese during refrigerated storage.

Abstracts for Poster Contributions

C. Environmental Pollution | From Waste to
Wealth

P15: Tire-Derived Microparticles Drive Microbial Selection and Functional Adaptation in Aerobic Granular Sludge

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Tire-derived microplastics (TMPs) are abundant in urban runoff and introduce physical and chemical stressors to wastewater biocenoses. In this study, aerobic granular sludge (AGS) in sequencing batch reactors was exposed to TMPs, and microbial structure was quantified by RNA sequencing-based metatranscriptomic profiling. Exposure of AGS to TMPs induced shifts in microbial community composition and function. While *Proteobacteria* remained dominant (>90 %) in both control and TMP-exposed systems, other phyla exhibited changes. *Chloroflexi* abundance increased from 0.5 % to 1.6 %, suggesting filamentous bacterial proliferation under TMP stress. In contrast, *Planctomycetes* decreased from 3.0 % to 1.6 % and *Acidobacteria* from 1.1 % to 0.7 %, potentially affecting nitrogen cycling. At the genus level, TMP exposure led to the enrichment of key functional genera such as *Azoarcus* (3.63 %→4.62 %), *Micavibrio* (0.75 % → 2.83 %), *Pseudomonas* (1.14%→2.33%), *Accumulibacter* (0.02 %→1.38 %), *Zoogloea* (0.09 %→1.13 %), *Nitrosomonas* (0.19%→0.66%), and *Nitrotoga* (0.00 %→0.45 %). These taxa are associated with xenobiotic degradation, nitrogen cycling, EPS production, and phosphorus removal. The rise in facultative anaerobes in the presence of TMP suggests that it impairs oxygen diffusion within granules. At the same time, TMP exposure caused a decline in sensitive genera such as *Azospirillum*, *Delftia*, *Alicyclophilus*, and *Leadbetterella*, indicating selective pressure and potential disruption of organic matter transformation. The results indicate that TMP exposure imposes strong selective pressure on the AGS microbial community, decreasing microbial diversity, altering key nitrogen transformation pathways and promoting the enrichment of stress-tolerant taxa capable of adapting to TMP-induced environmental changes. These findings provide new insights into how TMPs reshape microbial diversity in engineered wastewater treatment bioreactors.

P16: Changes in the Mechanical Properties and Surface Topography of PLA Carriers Used as Supports for Nitrogen Removal from Reject Water in SBR

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Three-dimensional (3D)-printed polylactide (PLA) carriers were used as biomass support media in sequencing batch reactors (SBRs) treating reject water from sewage sludge dewatering. Due to their biodegradable nature, they may also serve as an additional carbon source for denitrifying bacteria. As the material is potentially subject to degradation, it is essential to evaluate the changes occurring in the material during SBR operation. Therefore, monitoring both the extent of carrier degradation and its mechanical properties without significant deterioration is crucial. The aim of this study was to evaluate changes in the surface topography and mechanical properties of PLA carriers. The study was conducted over seven months in SBRs with different carrier filling ratios (20, 25, and 30 % of the reactor working volume). During the experiment, carriers were periodically collected for surface topography analysis (digital microscopy) and compression tests.

Surface topography analysis revealed progressive material degradation. Minor changes in the arithmetic average roughness (R_a) suggest that there were no substantial changes in surface roughness. The R_a value increased from 10 μm (initial) to 14 μm . Greater variability in the total height of the roughness profile (R_t) and the maximum profile valley depth (R_v) indicates the localized and heterogeneous nature of the observed changes. The R_t value increased from 64 μm to 74 μm , whereas the R_v value decreased from 34 μm to 19 μm . Macroscopic observations confirmed gradual surface modification of the carriers, manifested by discoloration and the disappearance of the layer-by-layer structure characteristic for fused deposition modelling (FDM), while maintaining material integrity. Regardless of the residence time of the carriers in the SBR, the compressive load required to cause carrier failure remained nearly constant at approximately 5000 N. The results indicate that degradation of the PLA carriers was limited to the surface and did not reduce their resistance to compression.

P17: Improving the Extremophile Species Growth by Manipulating the Growth Conditions and Exploring the Accumulation of R-PC and EPS

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Rising atmospheric CO₂ concentrations and increasing environmental pollution have intensified the search for sustainable biotechnological solutions capable of reducing greenhouse gas emissions while producing high-value bioproducts. Microalgae represent a promising platform for CO₂ valorization, converting carbon dioxide into biomass through photosynthesis while generating compounds of commercial interest. Among these, R-phycocyanin is a natural blue pigment widely sought after by the food, cosmetic, and pharmaceutical industries due to its coloring properties and biological activities.

Our study aimed to optimize the culture medium of a novel extremophilic red microalgal strain to enhance biomass production and R-phycocyanin accumulation. Laboratory-scale cultivation experiments were conducted to evaluate the effect of different medium formulations and different culture conditions on microalgal growth. Cell growth was monitored by optical density and cell counting, while pH was measured throughout cultivation. R-phycocyanin was extracted from harvested biomass and quantified spectrophotometrically. The optimized medium was subsequently validated in a 25 L airlift photobioreactor to assess process scalability.

Culture medium optimization resulted in a threefold increase in biomass production compared with the initial conditions. Furthermore, R-phycocyanin content reached approximately 11 % of the dry biomass. The successful scale-up demonstrated the feasibility of cultivating this extremophilic strain under controlled photobioreactor conditions.

These findings demonstrate the potential of this novel microalga as a sustainable cell factory for simultaneously valorizing CO₂ and producing high-value natural pigments, contributing to the development of environmentally friendly bioprocesses within a circular bioeconomy.

P18: Phosphorus Recovery from Hydrothermally Carbonized Sewage Sludge by Acid Leaching

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Phosphorus is an essential nutrient for agricultural production and indispensable to global food security. However, phosphate rock, the primary source of phosphorus, is finite and geographically concentrated. Consequently, phosphorus recovery from secondary resources has gained increasing attention as a means of improving resource security and supporting the transition towards a circular bioeconomy. Municipal sewage sludge represents one of the most promising secondary phosphorus resources, as most of the phosphorus entering wastewater treatment plants is retained within the sludge.

This study investigates the recovery of phosphorus from hydrothermally carbonized sewage sludge through acid leaching as a sustainable approach to resource recovery. Hydrothermal carbonization is used as a thermochemical pretreatment to convert wet sewage sludge into a phosphorus-enriched hydrochar while improving its physicochemical properties for subsequent processing. Different phosphorus extraction strategies based on sulfuric acid and citric acid, including single-stage and sequential leaching, are investigated to evaluate their influence on phosphorus dissolution. Process performance is assessed through photometric determination of phosphorus concentrations in leachates, wash waters, and residual solids, supported by phosphorus mass balance calculations. Beyond this mass balance, elemental characterization by ICP-OES is used to assess the influence of co-dissolved metal cations on the phosphorus concentration in solution.

The study aims to identify process conditions that maximize phosphorus recovery while improving the understanding of phosphorus behaviour during hydrothermal carbonization and subsequent acid leaching. The outcomes of this study are expected to contribute to the development of more efficient and environmentally sustainable phosphorus recovery strategies from sewage sludge, supporting the implementation of circular resource management in the wastewater sector.

P19: Standardization of the Planar Yeast Estrogen Screen (pYES) for the Detection of Estrogenic Activity in Environmental Samples

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The increasing contamination of aquatic ecosystems with endocrine disrupting compounds (EDCs) represents a central challenge for modern environmental analytics. The planar Yeast Estrogen Screen (pYES) combines High-Performance Thin-Layer Chromatography (HPTLC) with an on-plate yeast-based bioassay, enabling estrogenic activity detection directly within separated sample fractions. As a bioanalytical method, it is gaining importance for environmental sample analysis, requiring careful optimization for robust and reproducible results.

The pYES was systematically optimized and standardized. An environmentally friendly developing solvent (ethyl acetate/n-heptane) was established in line with Green Analytical Chemistry, providing separation sufficient for effective screening. Stability of five reference standards (estrone, 17 β -estradiol, estriol, 17 α -ethinylestradiol, bisphenol A) was confirmed in solution and chromatography. To prevent silica gel degradation, immediate plate development after sample application and 10 minutes drying in the Automatic Developing Chamber 2 was necessary. Adjusting the standard concentration and introducing a methanol pretreatment of the plates substantially reduced background fluorescence and artifact formation. Evaluation of assay homogeneity revealed pronounced edge effects, recommending central sample application within a migration range of 30 to 50 mm. Finally, calibration of 17 β -estradiol (0.65 to 2.0 pg) achieved high quality ($R = 0.998$, $CV = 3.01\%$), providing a validated basis for future quantification of environmental samples.

Despite these improvements, artifact formation could not be fully eliminated, and reproducibility remains a limiting factor that requires further investigation, alongside the establishment of a robust sample enrichment method. As a complementary approach to increase biological relevance, a human cell based dual receptor bioassay for the simultaneous detection of estrogenic and androgenic activity is currently being established at the Institute for Circular Bioeconomy at Hochschule Offenburg, offering a promising extension of the effect-based toolbox for future environmental monitoring.

P20: Elimination of Phosphonates and Phosphorus Speciation in Municipal Wastewater by Different Treatment Strategies

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Phosphonates are organophosphorus complexing agents widely used in industrial and domestic applications. Due to their exceptional hydrolytic stability and high mobility, they bypass conventional multi-barrier wastewater treatment and accumulate in aquatic systems as a persistent, slowly degrading internal phosphorus source.

An ion chromatography coupled to ICP-OES (IC-ICP-OES) method was established and validated for the direct speciation and quantification of the phosphonates HEDP and ATMP alongside ortho-phosphate in complex aqueous matrices. Using this method, ozone-based oxidation was evaluated as a removal strategy: ATMP was degraded below the detection limit within 16 minutes, with ortho-phosphate, readily removable by chemical precipitation, identified as the main degradation product. HEDP proved considerably more resistant, reaching only 16 % degradation under identical conditions. The developed method also enabled the detection of HEDP in real municipal wastewater samples, confirming its applicability to complex environmental matrices.

Building on this established analytical and oxidative toolbox, the current project extends the approach to hydrothermal carbonization (HTC) of digested sludge. A design of experiments (DoE) approach is applied to systematically investigate the influence of varying process conditions on the resulting process water composition. Subsequent phosphorus balancing and speciation analysis, including the quantification of phosphonates, will characterize the fate of phosphorus during carbonization and provide a basis for assessing recovery potential.

Future work will extend the analytical and elimination framework to trifluoroacetic acid (TFA), a further class of highly persistent and mobile micropollutants, aiming toward integrated removal strategies for both phosphonates and TFA across wastewater and HTC process streams.

P21: Integrating HPTLC Fingerprinting, Effect-Directed Analysis and Machine Learning for the Characterization of Complex Environmental Matrices

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Complex environmental matrices, such as wastewater and organic waste, contain mixtures of known and unknown compounds with diverse physicochemical properties and biological activities. Their comprehensive characterization requires both chemical and effect-based approaches, since targeted analytical methods rely on predefined analytes and therefore fail to capture the full chemical complexity of a sample, often overlook unknown or unexpected constituents, and do not account for the combined biological effects of the mixture as a whole. This project aims to develop an integrated analytical workflow combining high-performance thin-layer chromatography (HPTLC), effect-directed analysis (EDA), and machine learning, based on the hypothesis that combining chemical and effect-based fingerprints enables a more comprehensive classification of sample groups than either approach alone. A broadly applicable sample-preparation strategy for solid environmental matrices has already been established, and chemical fingerprints are generated by HPTLC, complemented by effect-based fingerprints obtained through a panel of on-plate bioassays. First results already show characteristic features in the fingerprints that allow conclusions to be drawn about the biomass used. After data preprocessing, normalization and feature extraction, chemometric and machine-learning methods will be applied to classify samples, identify similarities between sample groups, and explore associations between chemical patterns and biological responses. Organic waste materials and their corresponding products from hydrothermal carbonization (HTC) will serve as an application case for the developed workflow, allowing the chemical and effect-based changes caused by the conversion process to be investigated. Overall, the proposed workflow is intended to support the comprehensive characterization of complex environmental matrices and to contribute to the development of data-driven approaches for assessing waste-derived value-added products.

P22: Prediction of PAH Degradation in Bioremediation Research: A Rule-Based Cheminformatics Analysis

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In silico biotransformation predictions aim to identify initial enzymatic attacks, intermediates, and degrading organisms for bioremediation. Polycyclic aromatic hydrocarbons (PAHs) pose structural challenges for these methods. Rule-based cheminformatic engines and public pathway annotation are therefore both used to propose degradation routes and candidate organisms. However, how far either approach actually reaches for this compound class has not been measured. This study quantifies the limitations of these predictive approaches.

Using 16 PAHs, handwritten reaction transformation rules (SMIRKS- a reaction transform language) were developed in software toolkit for cheminformatics (RDKit) to predict initial bacterial oxidation (targeting dihydrodiol, catechol, phenol, and quinone families). Predictions were validated against documented metabolic routes in the literature and cross-checked with publicly available biodegradation pathway database and prediction system (EAWAG-BBD/enviPath). Annotation coverage was evaluated using Kyoto Encyclopedia of Genes and Genomes (KEGG) maps and orthology records, benchmarked against more than 650 microorganism's species used in pure cultures experiment.

The rule engine successfully reproduced 50 of 53 reference bacterial metabolites, showing high class-based recovery (phenol 8/8, dihydrodiol 22/23, catechol 16/17, quinone 4/5). The three failures all involved compounds containing a five-member acenaphthene/acenaphthylene ring. In terms of annotation, only 6 of the 16 PAHs appeared as KEGG substrates. Enzyme and orthology mapping was sparse; four compounds shared the exact enzyme number, while pyrene lacked orthology annotations entirely. Additionally, up to 13 of the 66 benchmark genera (predominantly white rot fungi and algae) were missing from the KEGG genome list.

Predictive accuracy is hindered by rule engines being restricted to specific structural families and the fact that ligninolytic enzymes are not PAH-specific. Incorporating a distinct fungal layer with separate relationship semantics could address this gap. Rather than condensing these diverse evidence sources into a single score, future approaches should evaluate them as separate, mutually controlling relationships within a graph-based framework.

P23: Optimizing Biochar Selection for Heavy Metal Immobilization Using Multi-Criteria Decision Analysis Across Contrasting Soils

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Heavy metal contamination of soils poses a threat to ecosystem health and food safety. Biochar has emerged as a sustainable amendment for soil remediation by immobilizing contaminants and improving soil physicochemical properties. However, identifying the most suitable biochar for different contaminated soils remains challenging because remediation performance depends on multiple performance criteria. This study evaluated and ranked tailored biochars for three contrasting heavy metal-contaminated soils collected from a battery recycling site in Poland (S1) and non-ferrous metal smelter sites in Poland (S2) and the Czech Republic (S3).

A 60-day incubation and leaching experiment was conducted using biochar at a dosage of 5 % (w/w). Fourteen biochars were produced from municipal sewage sludge (MSS) alone or co-pyrolyzed with oak bark (OB) or hemp hurd (HH) at biomass ratios of 25:75, 50:50, and 75:25 and pyrolysis temperatures of 400 °C and 700 °C. Biochar performance was evaluated using a Multi-Criteria Decision Analysis (MCDA) framework. Mean values from three replicates were used in the MCDA, integrating heavy metal (Cd, Pb, and Zn) leaching in H₂O, CaCl₂, and CH₃COOH extracts, root length, soil pH, electrical conductivity, cation exchange capacity (CEC), soil organic matter, and biochar CEC. Performance was expressed as the percentage reduction relative to the untreated control, normalized to a 0–1 scale, weighted, and combined into a final MCDA score.

The MCDA ranking (Fig. 1) demonstrated that soil type strongly influenced biochar performance, although trends were observed. Co-pyrolyzed MSS-OB biochars generally ranked high across the three soils. The best-performing treatments were MSS+HH 25:75 (700 °C), MSS+OB 25:75 (400 °C), and MSS+OB 25:75 (700 °C) in S1, S2, and S3, respectively. MSS-HH biochars generally ranked lower, except in S1. These findings demonstrate that MCDA is an effective decision-support tool for optimizing site-specific biochar selection and promoting sustainable remediation of heavy metal-contaminated soils.

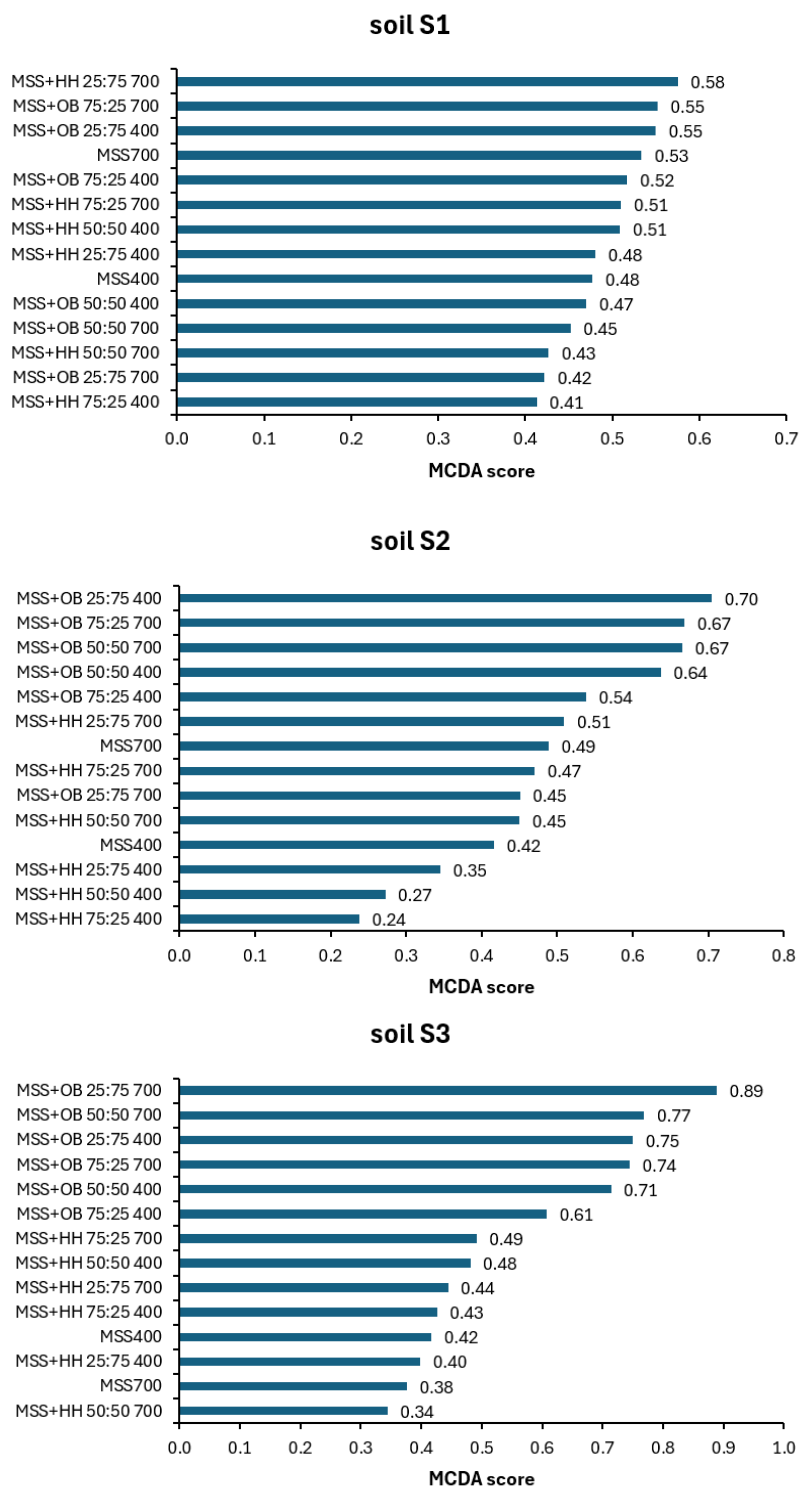


Figure 1. MCDA scores and ranking of biochar treatments for the three contaminated soils (S1–S3).

P24: Agronomic Evaluation of Biochar from Secondary Agricultural Biomass: The BC-LOOKUP Database

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Pyrogenic Carbon Capture and Storage (PyCCS) via the agricultural application of biochar represents a promising negative-emission technology. While the biochar industry predominantly relies on woody feedstocks, long-term availability limits its scalability. Conversely, biochars derived from high-ash agricultural secondary biomasses—such as cereal straw, hedge trimmings, and biogas digestate—often demonstrate superior agronomic performance, such as enhanced crop productivity. However, robust empirical data regarding the industrial-scale production, physicochemical characterization, and agronomic impacts of non-woody biochars remain limited.

The BC-LOOKUP project addresses these critical knowledge gaps by establishing a comprehensive database of biochar properties derived from secondary agricultural feedstocks. Experimental pyrolysis trials are conducted using a pilot-scale reactor alongside various industrial-scale facilities to capture process variability across distinct operation conditions. The database is developed as a publicly accessible online tool that allows farmers to estimate potential biochar yields based on site-specific inputs, such as acreage and crop type.

To evaluate agronomic efficacy, a series of greenhouse pot trials are being conducted across diverse crops, soil types, and technology-specific biochars. Furthermore, a long-term study focuses on the pyrolysis of straw and digestate—two major agricultural side-streams. This study evaluates the capacity of non-woody biochars to enhance soil organic carbon (SOC) stocks compared to traditional management practices, including straw mulching, straw removal, and biochar co-composting.

P25: Substrate-Specific Optimization of Macronutrient Ratios for *Trichoderma reesei* Cultivation

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Lignocellulosic waste is an abundant and renewable resource with strong potential for the sustainable production of biofuels and biochemicals. In this context, *Trichoderma reesei* is widely used for its high cellulase production capacity, making it a key organism in processes using second-generation (2G) substrates. However, its performance is highly dependent on the composition of the growth medium, particularly the balance of essential macronutrients such as carbon, nitrogen, phosphorus, and sulfur.

This study investigated the influence of medium composition on *Trichoderma reesei* growth using wheat straw and sugar beet hydrolysates. The objectives were to assess the valorization potential of these agricultural residues and determine the optimal C:N:P:S ratios for fungal growth.

Wheat straw and sugar beet dried and powderized waste streams were pretreated with NaOH, followed by enzymatic hydrolysis with cellulase for both and pectinase for sugar beet. The resulting liquid hydrolysates were supplemented with synthetic salts to obtain different C:N:P:S ratios and cultivated with *Trichoderma reesei* in microtiter plates. A Box–Behnken design generated with JMP® was used to model the effects of macronutrient concentrations on fungal growth. Fungal growth was monitored via optical density measurements at 600 nm and using a spiral measurement across the whole well diameter.

Response Surface Methodology (RSM) revealed distinct optimal C:N:P:S ratios for each growth substrate. With a fixed N mass of 1, the optimal ratio is (13:1:1.7:1.5) for the wheat straw hydrolysate while it is (8.5:1:0.4:0.1) in case of the sugar beat hydrolysate. These findings highlight the importance of substrate-specific nutrient balancing to enhance microbial performance on 2G-substrates.

These findings demonstrate that agricultural residues can be efficiently valorized for fungal cultivation through tailored nutrient optimization, supporting the development of sustainable bioprocesses within a circular bioeconomy framework.

P26: ISO 10993-5/-12-Guided Cytotoxicity Evaluation of Molybdenum and Reference Materials for the Development of Novel Implants

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Molybdenum (Mo) has emerged as a promising bioresorbable metallic material for bone regeneration and implant applications. Its high mechanical stability, controlled degradation and favorable corrosion behavior make it a potential alternative to conventional implant metals. To evaluate its biological safety, cytotoxicity testing according to ISO 10993-5/-12 was performed. In this study, the cytotoxicity of molybdenum was assessed using osteoblasts (hFOB1.19) in extract based and direct contact assays. Standard reference materials RM-A (Polyurethane +0.1 % ZDEC, strongly cytotoxic), RM-B (Polyurethane +0.25 % ZDBC, mildly cytotoxic) and RM-C (Polyurethane, non-cytotoxic) were included for comparison. Cell viability was determined by XTT and Neutral Red Uptake assays after 24 h exposure. Cells exposed to molybdenum extracts showed overall high viability with only minor reductions at the highest extract concentration (100 %). As expected, RM-A and RM-B induced concentration dependent cytotoxicity, while RM-A exhibited reduced toxicity after gamma sterilization. These results also emphasize that sterilization conditions can influence reference material behavior, while Mo retained its cytocompatibility across all treatments.

P27: Establishment of a Measurement Method to Determine Cell Growth Under Micromovements

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The titanium alloy Ti-6Al-4V is frequently used for orthopedic implants. Such implants can be inserted after a bone fracture to support the healing process. Titanium offers the advantage of osseointegration, meaning that osteoblasts can attach directly to the implant. Mechanical stress in the form of compressive loading stimulates cell proliferation. To develop a future *in vitro* loading model, measurement methods must first be established, for example, to determine cell viability or enzyme activity.

This study aimed to lay the groundwork for a measurement method to study the growth of osteoblasts on structured titanium samples under compressive loading. To this end, a modified medium composition was investigated to enable cultivation without CO₂ and to minimize the risk of contamination in non-sterile environments. In addition to the standard medium components, 100 mM HEPES proved effective for buffering the pH, while 0.25 µg/mL amphotericin B was added as an antifungal agent against yeasts and multicellular fungi.

In the first experiment, five titanium samples seeded with osteoblasts were cultured for six days, and two of these samples were used on the sixth day to determine viability, which was $65.24 \pm 0.62 \%$.

The initial results provide a foundation for the further development of the experimental setup. Full establishment of the method requires further optimization of the culture conditions and additional studies under defined mechanical loads.

P28: Comparison of the Effectiveness of Microbiological Consortia and Bacterial Monocultures in Reducing Selected Synthetic Human Faeces Parameters – Chemical Oxygen Demand (COD), Total Nitrogen (Nt)

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Portable toilets generate highly concentrated waste, placing a significant load on wastewater treatment plants. Waste collected from tanks is characterized by elevated chemical oxygen demand (COD), total nitrogen (Nt), ammonium nitrogen and total phosphorus, reducing downstream treatment efficiency. One strategy to lower parameters of waste is adding selected microorganisms directly to the tank. Recent studies indicate that microbial consortia, through synergistic interspecies interactions, reduces parameters more effectively than monocultures. This work therefore compared bacterial monocultures versus consortia in reducing COD and Nt.

Using a local microorganism library, single bacterial strains and consortia were assessed for their ability to reduce COD and Nt in synthetic human faeces. Physicochemical parameters were determined using cuvette test kits based on colorimetric reactions, with absorbance read by spectrophotometer, consistent with ISO/DIN determination principles.

Both monocultures and bacterial consortia achieved a similar maximum COD reduction of 56 %. However, they differed in the stability of the results obtained. Monocultures exhibited COD reduction ranging from 38.3 to 56 %, whereas consortia reduced COD in a narrower range (41 to 56 %). Notably, even the weakest-performing consortium outperformed the weakest monoculture. More pronounced advantage of consortia was observed for Nt removal. The mean reduction of Nt values achieved by monocultures was 35.7 % (ranging from 30.7 to 40.7 %), compared to 44.5 % for consortia (ranging from 27 to 57 %). The best-performing consortium reached a removal of Nt values efficiency of 57%, exceeding the best-performing monoculture (40.7 %).

These findings demonstrate that bacterial consortia achieve higher and more stable parameters reduction than monocultures, particularly for total nitrogen removal probably as an effect attributable to synergistic strain cooperation exceeding the sum of individual potentials. These results justify the development of a bioproduct for use in portable toilets, aimed at the preliminary reduction of selected parameters prior to further treatment.