DEEP PURPLE

2023

URBAN BIOREFINERIES FOR A CIRCULAR BIOECONOMY

The urban biorefinery concept came up to promote the recovery of energy and value resources contained in urban waste to be used as a raw and secondary materials to create new value chains. This Workshop deals with the last innovative developments on the re-use and re-cycling of urban waste into high added-value products for a sustainable the society.

ecoSTP2023
6th IWA International Conference on eco-Technologies for Wastewater Treatment

Circular Bio-based Europe Joint Undertaking

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AGENDA

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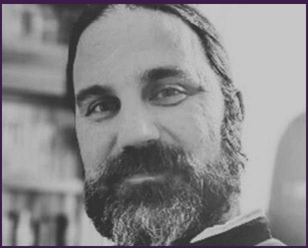
08:55	Presentation of the Deep Purple Project (Victor Monsalvo, Aqualia)
09:40	Advances from Deep Purple Project
9:40 – 10:00	Development of purple bacteria-based wastewater treatment technology (Daniel Puyol, URJC and Patricia Zamora, AQUALIA)
10:00 – 10:15	Research line on organic fertilizers production (Elise Rethore, Agro Innovation)
10:15 – 10:30	Research line on ectoine production (Raul Muñoz, University of Valladolid)
10:30 – 10:45	Research line on construction materials production (Mizi Fan, Brunel University)
10:45 – 11:00	Research line on biopolymers production (Daniele Turati, Novamont)
11:00	Coffee Break
11:40	Invited Keynote Speaker: Ana Soares, Cranfield University
12:10	Open Session I: Novel Processes and Technologies in Urban Biorefineries
12:10 – 12:35	Invited speaker: Joan Garcia, Polytechnic University of Catalonia
12:35 – 12:45	*Impact of Polyethylene terephthalate (PET) degradation products on Mixed Purple Phototrophic Bacteria (PPB) metabolism.* Miguel Palhas, D. Puyol, J. Fradinho and M.A.M Reis
12:45 – 12:55	*Assessing the potential of purple bacteria culture for resource recovery from the vegetal beverage industry by-products.* Laura Foix, P.M. Binder, A. Pabón, S. Ponsá
12:55 – 13:05	*Granular biofilm growth of purple phototrophic bacteria.* Sam J. Stegman, T. Hülsen, P. D. Jensen, D. J. Batstone
13:05 – 13:15	*Alginate Biopolymer Stabilized Pickering Emulsion Liquid Membrane for Methylene Blue Extraction from Aqueous Solution.* K. Bidkar, M. Jerold.
13:15	Lunch Break
14:20	Open Session II: Sustainability, Marketability and Industrialization of Urban Biorefineries
14:20 – 14:45	Invited speaker: Martín Santos. REPSOL S.A.
14:45 – 14:55	*Shaping a Greener Future for Biopolymers: Environmental Footprint of Polyhydroxyalkanoates Production by Purple Phototrophic Bacteria Mixed Cultures.* Mario Martín-Gamboa, L. D. Allegue, D. Puyol, J. A. Melero and J. Dufour.
14:55 – 15:05	*Advanced demand & response: application of power forecasting to a real-scale plant for costs optimization.* Marco Vian, M. Di Iorio, F. Polesel, M. Flauto, M. Muzzatti, D. Villa and G. Andreottola
15:05 – 15:15	*Carboxylate platform based on chain elongation - evaluation of the feedstock composition and process configuration on production efficiency.* F. Brodowski, R. Zagrodnik, N. Gutowska, A. Duber, H. Prusak, M. Szczygielda, M. Lezyk, Piotr Oleskowicz-Popiel
15:15 – 15:25	*Integrated Resource Recovery from Aerobic Granular Sludge Plants.* Nouran T. Bahgat, P. Wilfert, L. Korving, M.C.M. van Loosdrecht.
15:25	Round Table: Opportunities and Challenges for creating new value chains in urban biorefineries Moderators: Daniel Puyol and Victor Monsalvo Participants: Martín Santos, REPSOL S.A. Lucia Gusmaroli, Catalan Water Partnership Joan García, Polytechnic University of Catalonia Javier Mena, Clamber biorefinery Nouran Bahgat, Wetsus, European centre of excellence for sustainable water technology
16:30	Closure

PRE-CONFERENCE WORKSHOP URBAN BIOREFINERIES FOR A CIRCULAR BIOECONOMY

The urban biorefinery concept came up to promote the recovery of energy and value resources contained in urban waste to be used as a raw and secondary materials to create new value chains. This Workshop deals with the last innovative developments on the re-use and re-cycling of urban waste into high added-value products for a sustainable the society. Urban waste includes Municipal Solid Waste, Green Waste, Wastewater, and Sewage Sludge. The Workshop aims to be a contact point between Scientific, Academia, Industry, and Administration to share, discuss, and promote initiatives over the last developments in European cities within the European Green Deal over the base of the Horizon 2030. The Workshop is promoted in the framework of the European Project H2020.JTI.BBI DEEP PURPLE and shows last advances in a dedicated Session, and over the general subject through two consecutive Open Sessions where the most relevant novelties will be presented and discussed in a Round Table with relevant representatives from Academia, Industry and Administration. The intended audience includes junior and senior researchers and technologists aiming to enlarge their knowledge on Urban Biorefineries.



Dr. Daniel Puyol

Senior Researcher, Department of Chemical and Environmental Technology
University Rey Juan Carlos

Expert on environmental biotechnology processes for resource recovery from waste

Dr. Victor Monsalvo

Head of Eco-efficiency Area, Innovation and Technology Department
Aqualia

Expert on innovative technologies for the efficient use of water and resources

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ABSTRACT SESSION I

Impact of Polyethylene terephthalate (PET) degradation products on Mixed Purple Phototrophic Bacteria (PPB) metabolism

M. Palhas, D. Puyol, J. Fradinho and M.A.M Reis

Plastics and their degradation products are almost everywhere nowadays, even in traditional waste streams. These streams can be treated by multiple technologies, such as purple phototrophic bacteria (PPB). Current knowledge on PPB and plastic interaction is scarce. The study aimed to investigate the impact of plastic degradation compounds (PDCs) on the metabolism of PPB. Batch tests were performed on 100mL flasks under an irradiance of 160 ± 10 W/m2 in the presence of butyric acid at different concentrations of PDCs (1, 2.5, and 5 gCOD/L), composed of half ethylene glycol and half terephthalic acid. Results indicate that PPB can tolerate PDCs concentrations of up to 5 gCOD/L without significant adverse effects on growth and activity but with a slight lag phase at higher concentrations simultaneously with EG consumption. Further research is needed to understand the upper tolerance limit for PDCs and their long-term effects on the bacteria.

ABSTRACT
SESSION I

Assessing the potential of purple bacteria culture for resource recovery from the vegetal beverage industry by-products

L. Foix, P.M. Binder, A. Pabón and Sergio Ponsá

A rise in the consumption of fruit & vegetable juices, changes in consumer tastes, adoption of healthier diets, and the advent of cold-pressed juices are the major factors accelerating the growth of this global market. As this production grows, so does the generation of by-products and waste streams. Purple phototrophic bacteria (PPB) are highly adaptable organisms possessing a unique metabolism, enabling them to thrive in various environments, even in some of the most complex waste streams. Recent reports show that PPB biomass can be used as a single-cell protein with high protein concentration. This work presents the outcome of culturing PPB (Rhodobacter sphaeroides) using the resulting material after the cold pressing of rice, soybean, and oat as substrate. Results show that PPB was not able to grow solely over these by-products, but growth was enabled when adding an external source of simple sugars. The growth was sustained in batch mode, and PPB was able to produce a biomass with remarkable high contents of high-quality proteins. Positive control (commercial growing medium) achieved a biomass with 5% (dw) of proteins, while the addition of soybean/oat by-products enhanced the protein content reaching up to 67% (dw). These results provide initial evidence on the feasibility of producing high-value biomass from a relevant by-product which deems suitable for its potential downstream valorization as animal feed ingredients.

ABSTRACT
OPEN SESSION I

Granular biofilm growth of purple phototrophic bacteria

S. J. Stegman, T. Hülsen, P. D. Jensen, D. B. Batstone

Aerobic, anaerobic, and anammox bacteria in the form of granular sludge is an applied biotechnology for wastewater remediation. There is substantial motivation to further apply this technology towards resource and energy recovery. For example, some aerobic granular sludge treatment technologies (Nereda) are beginning to generate added resources such as alginate like polymers. One such biological wastewater treatment technology which has also gained interest for its use in resource recovery (e.g. microbial protein, biopolymers, carotenoids) is purple phototrophic bacteria (PPB). However, PPB has primarily been used in suspended systems, with research into biofilms limited, and research into granulation non-existent. If successful, granular PPB – with the associated excellent settling properties – could form the basis for future resource recovery platforms. PPB granules were grown in 50 d from a non-flocculent PPB inoculum and the reactors were operated for over 200 days. Importantly, the granular PPB were large (up to 3 mm), had excellent settling capabilities (SVI30 ~10 mL g-1), high levels of extracellular polymeric substances (EPS) of ~300 mgEPS gbiomass-1 and crude protein levels comparable to other PPB technology (40–60 %), and were dominated by PPB genera (predominately Rhodopseudomonas, Rhodobacter, Allochromatium, and Blastochloris) at average relative abundances of ~50 % and up to 90 %. Using fluorescent in-situ hybridisation (FISH), organisms responding to PPB specific probes were found at the outside of the granule, but were found in lower abundance throughout the whole granule. Unlike other granular technologies, the suspended fraction remained functionally and fractionally high, and could not be eliminated through size selection methods, rapidly regrowing. The biomass was able to remove the majority (60-100 %) of the wastewater organics (acetic acid-COD).

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ABSTRACT
OPEN SESSION I

Alginate Biopolymer Stabilized Pickering Emulsion Liquid Membrane for Methylene Blue Extraction from Aqueous Solution

Kasturi Bidkar and M. Jerold

In the present investigation, alginate biopolymer stabilized Pickering emulsion liquid membrane (PELM) was employed for the extraction of Methylene blue (MB) from aqueous solution. The novel PELM composed of aliquat 336 as a carrier, potassium hydroxide (KOH) as a stripping agent, and waste cooking oil (WCO) as the green diluent. WCO is a non-toxic organic solvent was used as substitution of petroleum based organic solvent in the preparation of PELM. The optimum conditions for the maximum removal of MB were: Emulsifier concentration – 2.3 (v/v %), Carrier concentration – 5.6 (v/v%), Treat ratio – 12, internal phase concentration – 0.92 M, initial external feed phase concentration – 100 ppm, O/A ratio – 1. The mechanism of MB extraction was also presented. At optimized condition, the maximum extraction of 98.8% was recorded. Kinetic analysis shows that the MB extraction by PELM follows first-order reaction. Furthermore, the thermodynamic analysis reveals that the extraction process was an endothermic, and spontaneous in nature.

ABSTRACT
OPEN SESSION II

Shaping a Greener Future for Biopolymers: Environmental Footprint of Polyhydroxyalkanoates Production by Purple Phototrophic Bacteria Mixed Cultures

M. Martín-Gamboa, L. D. Allegue, D. Puyol, J. A. Melero and J. Dufour

Bioplastics are a promising and sustainable alternative to traditional plastics derived from petroleum. Particularly, polyhydroxyalkanoates (PHA) produced from purple phototrophic bacteria (PPB) and low-value substrates have gained attention as a viable option. However, concerns remain about the scalability and environmental feasibility of this production method. This study focuses on quantitatively assessing the environmental implications of PHA production and the simultaneous management of organic waste from municipal solid waste (OFMSW). A novel photobiorefinery system utilizing mixed cultures of PPB is modelled. The environmental impacts are compared to those of fossil-based plastics like low-density polyethylene (LDPE), polyethylene terephthalate (PET), and polyurethane (PU). The photobiorefinery stage is found to have the most significant contribution to environmental impacts, particularly due to direct emissions, electricity consumption, and the use of extractive chemical agents. When comparing PHA production to conventional plastics, particularly PET and PU, the environmental implications vary depending on the specific indicator evaluated, with potential savings in terms of carbon footprint and less favourable performance in the case of eutrophication. Exploring alternative scenarios, such as utilizing renewable electricity or environmentally friendly extraction agents, leads to significant reductions in environmental impacts. Therefore, implementing feasible improvement measures in the short term can position PHA produced by PPB mixed cultures as a sustainable substitute for petroleum-based plastics.

Advanced demand & response: application of power forecasting to a real-scale plant for costs optimization

M. Vian, M. Di Iorio, F. Polesel, M. Flauto, M. Muzzatti, D. Villa and G. Andreottola

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OPEN SESSION II

Carboxylate platform based on chain elongation - evaluation of the feedstock composition and process configuration on production efficiency

F. Brodowski, R. Zagrodnik, N. Gutowska, A. Duber, H. Prusak, M. Szczygielda, M. Lezyk and P. Oleskowicz-Popiel

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ABSTRACT
OPEN SESSION II

Integrated Resource Recovery from Aerobic Granular Sludge Plants

Nouran T. Bahgat, Philipp Wilfert, Leon Korvinga and Mark C.M. van Loosdrecht

This study evaluated the combined phosphorus, nitrogen, methane, and extracellular polymeric substances (EPS) recovery from aerobic granular sludge wastewater treatment plants. The study showed that 30% of sludge organics are recovered as EPS, and 25-30% can be recovered through integrated alkaline anaerobic digestion (AD) producing ≈260 ml methane/g VS. It also showed that 20% of excess sludge total phosphorus (TP) ends in the EPS, 20-30% in the acidic liquid by-product stream (≈600 mg PO4-P/L), and 15% in the AD liquid effluent (≈800 mg PO4-P/L) which can be recovered through an integrated chemical precipitation unit. Ammonium recovery from the alkaline high-temperature liquid stream is attractive but it is not feasible for existing large-scale established technologies because of low concentrations. However, ammonium concentration in AD liquid effluent was calculated to be 2600 mg NH4-N/L and ≈20% of total nitrogen in sludge, making it feasible for recovery. The methodology used in this study consisted of three main steps. The first step was developing a laboratory protocol mimicking large-scale EPS extraction conditions. The second step was establishing mass balances over EPS extraction on laboratory and demonstration scales within a full-scale AGS WWTP. Finally, the feasibility of resource recovery was evaluated based on concentrations, loads, and integration of existing technologies for resource recovery.

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