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Colloid Engineering in Bio-resources

Contents

Keynote Speech

Mark van Loosdrecht is Professor in Environmental Biotechnology at Delft University of Technology, The Netherlands. He was appointed at Delft in 1988 and became Full Professor in 1998. His research is characterized by the combination of scientific understanding of engineered microbial ecosystems and development of new processes. Scientific interests are mainly related to biofilm processes, nutrient conversion processes and the role of storage polymers in microbial ecology. In particular, he has been instrumental in the development of several new commercialized processes related to wastewater treatment and resource recovery. The research has resulted in several processes currently applied on full scale such as the Sharon process, Anammox process and Nereda process. Technologies that are currently in a commercial scale-up (demonstration scale) are production of bioplastics (PHA) from wastewater, production of biopolymers (Kaumera) from waste sludge and recovery of phosphate as vivianite. Mark van Loosdrecht is active member of the International Water Association (IWA – distinguished fellow). He was Editor-in-Chief of Water Research (2009-2019), the #1 journal in the field. He was awarded several prizes for his work, including the Lee Kuan Yew Singapore Water Prize, the Stockholm water prize and the IWA Grand Award. He is member of the Royal Dutch Academy of Arts and Sciences and the Dutch, USA and Chinese Academy of Engineering. He received a honorary doctorate from ETH Zurich and University Gent. He was awarded a knighthood in the order of the Dutch Lion. He has published over 1000 scientific papers, has over 20 patents and has supervised over 100 PhD students.

K-1 - Development of Aerobic Granular Sludge Processes

○Mark C.M. van Loosdrecht

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Abstract: Granular sludge offers great potential for intensifying wastewater treatment plants. Granular sludge was first observed and developed by Prof. Gatze Lettinga for the anaerobic treatment of wastewater. It allowed a strong increase in volumetric conversion and since the 70's of last century upflow anaerobic sludge blanket reactors have become a standard technology especially for industrial wastewater treatment. The success of anaerobic granular sludge induced a search for equivalent system for aerobic wastewater treatment. This turned out difficult. The reason was sought in the unique biology of anaerobic conversion processes, necessitating close cooperation and therefore need to grow close together. Later it was realized that the key for good granulation of compact biofilm formation is in the growth rate of the bacteria. Fast growing (aerobic) bacteria

make a more open and porous structure than slow growing (methanogenic) bacteria. It is possible to select slow growing aerobic bacteria. Not all bacteria compete on growth rate, there is a wide community of bacteria that specializes in storing available substrates and use it when it is absent. These have fast uptake rates, but slow growth rates. Selecting these bacteria allows to also form granular sludge in aerobic wastewater treatment. Based on this principle the Nereda technology was developed. The talk will discuss the development and applications of this rapidly spreading wastewater technology.

Keywords: Aerobic granular sludge; Nereda; Nutrient removal; Wastewater

Yasuhisa Adachi is Professor Emeritus at the University of Tsukuba, specializing in rural environmental engineering and colloid-interface phenomena in soil and water systems. He earned his Ph.D. in Agricultural Science from The University of Tokyo in 1988, and over his extensive career he has developed deep expertise in the behavior of colloids, flocculation, dispersion, and coagulation in both soil and aquatic environments. His research interests center on how humic substances, clays, and polyelectrolytes affect the transport, aggregation, and settling behavior of colloidal materials. Current projects include engineering advances in soil and water environments based on colloid coagulation, motion of colloids in fluid, and predictive control of substance dynamics at environmental interfaces. He has led and contributed to numerous projects funded by the Japan Society for the Promotion of Science, covering topics from fundamental investigations of interface dynamics to applied solutions for environmental interface engineering, including the management of soil and water pollutants. Prof. Adachi is a member of multiple scientific societies, including the Japanese Society of Soil Physics, the Polymer Society of Japan, the International Association of Colloid and Interface Scientists, and others. He is also active in editorial work and professional service, contributing to multiple academic journals and symposia, mentoring younger researchers, and shaping the research agenda in colloid and interface science.

K-2 - Initial Stage Flocculation of Colloidal Particles in the End-over-end Mixing Device Induced by the Deposition of Oppositely Charged Colloids

○Yasuhisa Adachi[*, 1], Marita Wulandari[2, 3], Santanu Saha[1], Yuji Yamashita[1]

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Abstract: The initial stage of flocculation, induced by the mixing of colloidal particles with flocculants, can be regarded as a crucial step in the overall flocculation process. In this study, well-defined experiments on flocculation induced by the deposition of oppositely charged colloidal particles using an end-over-end mixing device were conducted. Thus far, the method has primarily emphasized the enhancement factor associated with the increase in effective collision radius. However, our results qualitatively confirm the validity of predictions based on heteroaggregation, which elucidate the role of ionic strength. The obtained results were further compared across various eco-friendly flocculants, including clay particles, PEG-modified lignin, and ultrafine bubbles (UFBs). The particulate systems revealed that the surface architecture formed on colloidal particles, in conjunction with inter-particle interactions, significantly influences flocculation behavior. In contrast, UFBs-induced flocculation exhibited a distinct trend, with a comparatively lower enhancement factor observed only at elevated KCl concentrations (10 mM). Microscopy and electrophoretic mobility analyses suggest that bridging and charge neutralization are the dominant mechanisms in UFBs-mediated flocculation. The potential activation of chemical interactions by UFBs is also discussed.

Keywords: Initial stage flocculation; End-over-end mixing; Enhancement factor; Hetero-aggregation; Architecture on the colloidal surface

Fabrizio Adani took MsC degree in Agricultural Science on 1988 at University of Milan, Italy, and Ph.D in Environmental Protection on 1994 – at University of Basilicata, Italy. From 1988 to 1999 he worked for private firm on biomass recovery and waste management. From 1994 to 1996 he worked at G. Natta Industrial Chemistry Institute of Politecnico of Milan, Italy. From 1997 till now he worked for the University of Milan, on: soil chemistry, biomass recovery, waste management, biomass chemistry and bioenergy production, bioeconomy. Actually he is a responsible for Gruppo Ricicla labs. within University of Milan, a research team of 12 junior and senior researcher serving as full professor. He is actively involved in 6 H2020 EU project, 2 LIFE-EU project and other national and regional projects. Bibliometric data: Documents = 270; Citation 17229 (Google Scholar); HI = 79 (Google Scholar); Citation = 12325 (Scopus); HI = 69 (Scopus).

K-3 - Renewable Fertilizers from Anaerobic Digestion Promoting Circular Economy in Agriculture

○Fabrizio Adani

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Abstract: The use of mineral fertilizers in agriculture carries a long term negative footprint in the environment. Fertilizer industry production share about 1.6% (748 Tg CO_2 eq.) of the of global GHG emissions (Marquis et al., 2013), and N fertilizers account for 33% of the total annual creation of reactive N, i.e. 170 Tg N y^{-1}. In addition, the production of P and K fertilizers relies to non-renewable and extracted resources, that are depleting and concentrated (e.g. P) in few countries. The consequence of that is the need of new management strategies to reduce the addition of N and P into the ecosystem with particular reference to the agriculture. Circular Economy has been indicated as a new productive paradigm to produce goods and it consists in the re-design of productive processes allowing the successive recovering of wastes for new productive processes avoiding the use of new resources. The application of Circular Economy to fertilizers means the possibility of recovering organic/agricultural wastes producing renewable fertilizers. On the other hand, these renewable fertilizers should be able substituting synthetic mineral fertilizers, reducing environmental impact and promoting a more sustainable agriculture. Renewable fertilizers production, use, performances and impacts will be discussed with the help of real full scale examples.

Keywords: Anaerobic digestion; Circular economy; Environmental impacts; Full scale plants; Renewable fertilizers

Prof. Jonas Baltrusaitis is an associate professor at Lehigh University in Pennsylvania, USA. He started his academic journey at the University of Iowa, where he studied the environmental chemistry of aerosol surfaces. In 2014, he began his independent academic career as an assistant professor and is currently working on sustainable nutrient cycling. He is a coauthor of more than 300 papers and several patents, as well as the editor-in-chief of the IOP Sustainability Science and Technology journal.

K-4 - Resource Recovery from Diverse Biogenic Waste Needs a Focus Shift towards Nitrogen Stabilization

○Jonas Baltrusaitis

Department of Chemical and Biomolecular Engineering, Lehigh University, Bethlehem, Pennsylvania, USA

Abstract: Can N-fertilizer synthesis be decoupled from the need to utilize natural gas as a hydrogen source? Developing a system for harnessing nutrients and producing

advanced new fertilizers derived from manures or other organic residues requires investment not only in technical solutions but also in ag supply chain infrastructure and supporting economic and political policies. Anaerobic Digestion (AD) is a natural process driven by microorganisms that produce biogas and through upgrading, biomethane; two versatile renewable energy carriers that provide electricity, heat and fuel. Importantly, AD can act as a platform process that transforms any biodegradable anthropogenic or agricultural waste into streams of diluted liquid nutrients. It is often overlooked that biogas plants also create another product that is at least as valuable as renewable energy, because of its nutrient and organic matter content: liquid digestate. Thus, as important as biogas technology might be to a sustainable energy future, the industry is pressed to find workable solutions to digestate management. An emerging source of solid nutrient containing materials that can be derived from digestate that contains both solid nitrogen and carbon that does not need equimolar amounts of H_2SO_4 is ammonium bicarbonate (ABC). ABC was one of the main fertilizers used in China some 20 years ago until it gave way to urea. This is due to its poor environmental stability since it readily decomposes back into NH_3 and CO_2 at room temperature. It is excluded from the organic fertilizer register in the US, not allowed as a standalone fertilizer in the EU and is currently used as a fumigant. The methods need to be developed by formulating ABC into solid materials that do not have any negative impacts on the biota (does not function as a fumigant), do not volatilize spontaneously and violently as ABC does and contribute nitrogen to the plant growth. This presentation will focus on designing cost-effective fertilizers possessing the potential to address global nutrient cycling problems. This includes the design of ABC and urea double salts and ionic cocrystals to address waste derived nitrogen environmental stability problems, utilization of recycled or reused macro and micro nutrients from waste to form liquid and solid fertilizers and direct insoluble mineral utilization as a secondary nutrient source. This presentation spans from the fundamental liquid phase equilibria and ionic cocrystal chemistry concepts to the conceptual process design of nutrient recovery for fertilizer synthesis using insoluble minerals. Mechanochemical synthesis methods, as well as the conventional physicochemical characterization of the solid cocrystals, will also be highlighted as emerging solid-solid synthesis methods.

Dr. Caixia "Ellen" Wan is an associate professor in the Department of Chemical and Biomedical Engineering in University of Missouri. She received her B.S. degree in Food Science & Technology and M.S. degree in Fermentation Engineering from Jiangnan University in China. She obtained her Ph.D. degree in Biological Engineering from the Ohio State University. She has extensive experience in bioprocessing especially for bioresource valorization and focuses her research on biorefining and biomanufacturing. Her main research areas include biomass conversion, biopolymer synthesis, and fermentation and biocatalysis. Her research group has been supported through funding

from NSF, DOE, USDA, commodity councils and industries. She has published more than 80 peer-reviewed articles in the field of bioprocess engineering. She is currently serving as an Executive Editor of Bioresource Technology.

K-5 - Functional Materials from Biomass for Sustainability and Environmental Remediation

○Caixia “Ellen” Wan

Department of Chemical and Biomedical Engineering University of Missouri

Abstract: Innovation in biomass conversion technologies is critical for resource recovery into high-value products from biogenic sources or waste streams. Biomass should be valorized to maximize their utilization for diverse industrial applications. This talk covers a few new strategies for biomass valorization with an emphasis on derived materials’ functionality and applications in environmental remediation. One example is simultaneous biomass pretreatment and lignin functionalization for morphology-controlled nanolignin synthesis while yielding dissolving pulp using diol-based deep eutectic solvents. The DES pretreatment provides a new strategy for biorefinery fulfilling both carbohydrate-first and lignin-first priorities. Another example is functionalizing lignocellulosic materials for PFAS remediation. Novel biochar products are also developed and explored for their uses in pollutant removal such as adsorption of heavy metals.

Professor Jo-Shu Chang is the Chair Professor and Vice President of Tunghai University, and also serves as an Honorary Chair Professor at National Cheng Kung University (NCKU) in Taiwan. He obtained his Ph.D. from the University of California, Irvine in 1993. In 2019-2021, he was recognized as a Highly Cited Researcher by the Web of Science Group. He was also included in the World's top 2% scientist list by Stanford University Group from 2020 to 2024. Additionally, Professor Chang ranked No.1 in Taiwan's Biology and Biochemistry category, according to Research.com, for the period from 2021 to 2025. He was also selected in Stanford University's List of the World's Top 2% Scientists from 2020 to 2024. Professor Chang's research interests cover biochemical engineering, environmental biotechnology, and applied microbiology, with a recent focus on utilizing microalgae for CO_2 capture and conversion into biofuels and biorefineries. In 2009, he established the world’s first microalgae-based carbon capture and utilization pilot plant at China Steel Co. (CSC), capturing flue gas from the blast furnace of the CSC factory. He also built a microalgae cultivation and biorefinery plant at NCKU, which features large-scale cultivation systems and showcases cutting-edge microalgae technologies from upstream to downstream. His

publication in the category of microalgae ranked No. 1 in the world (WoS). He held the position of President of Taiwan's Society of Biotechnology and Biochemical Engineering (BEST) from 2019 to 2022. Furthermore, he is the principal investigator of Taiwan's National Energy Project, where he has built a world-leading team specializing in microalgae biorefinery and bio-based CO_2 utilization. He also leads the Negative Carbon Technology and Biomass Energy task groups for Taiwan's 2050 Net Zero Pathway Task Forces. Professor Chang has earned numerous prestigious domestic and international academic awards, including three Distinguished Research Awards from Taiwan's National Science and Technology Council. He has been recognized as a Fellow of the American Institute of Medical and Biological Engineering (AIMBE) since 2015 and a Fellow of the International Forum of Industrial Bioprocessing (IFIBiop) since 2018. He has also contributed to the field by serving as the Editor/Associate Editor for five renowned international journals and as an editorial board member for nearly 10 SCI-indexed journals. Professor Chang's academic contributions are reflected in his extensive publication records, comprising over 800 SCI-indexed journal papers, with a total citation count of 52,452 (WoS), 63,490 (Scopus), and 83,026 (Google Scholar). His h-index stands at an impressive 113 (WoS), 129 (Scopus), and 152 (Google Scholar). In addition to his research publications, he has authored 15 book chapters, holds nearly 50 patents, and has over 10 technical transfers. Several of his research findings have been effectively applied in the industry and commercialized. He also owns a venture company focused on microalgae-based biofuels and biorefineries that has received significant investment from Taiwan’s Formosa Group.

K-6 - Microalgae-driven Negative Carbon and CO_2 to X Technologies

○Jo-Shu Chang

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Abstract: Microalgae absorb CO_2 via photosynthesis, fixing carbon 20–100 times faster than terrestrial plants. They can capture CO_2 directly from the air and industrial sources, such as flue gas, biogas, and fermentation off-gas, making them valuable for Carbon Capture and Utilization (CCU) and achieving net-zero targets by 2050. The biomass contains compounds for biofuels, chemicals, nutraceuticals, feed, fertilizers, and pharmaceuticals. From 2009 to 2012, our team built the world’s first ton-scale demonstration plant, utilizing blast furnace gas from China Steel Corporation to cultivate microalgae for biodiesel production. Microalgae also remove nitrogen and phosphorus from wastewater; we have developed a microalgae-bacteria symbiotic system to treat wastewater from livestock, petrochemical, and electroplating industries, advancing the circular bioeconomy. Commercialization faces challenges, including high cultivation and

harvesting costs, slower CO_2 uptake than physicochemical methods, and large land needs. This talk will discuss using diverse CO_2 sources and sustainable nutrients, addressing technical and economic barriers, and innovative strategies, such as combining chemical absorption with biological fixation, to boost CCU efficiency and product value.

Keywords: Bio-based chemicals; Biofuels; Biorefinery; Circular bioeconomy; Microalgae-bacteria consortium; Microalgae-driven carbon capture and utilization

Dr. Cheng-Di Dong is a Chair Professor in the Department of Marine Environmental Engineering and Dean of the International College at the National Kaohsiung University of Science and Technology (NKUST), Taiwan. His research focuses on waste-to-resource recovery technologies, biotechnology, nanotechnology, and the development of novel catalytic materials and biochar for environmental applications. Dr. Dong has published over 600 peer-reviewed articles in leading international journals, contributed 7 book chapters, and edited 6 special issues in various scientific journals. He has an h-index of 79, with more than 22,277 citations according to Google Scholar. He has received numerous awards and honors from various academic institutions and has been recognized in the 'World's Top 2% Scientists' list by Stanford University for Environmental Sciences (2021–2024). Dr. Dong is a Fellow of the International Bioprocessing Association, serves as Editor of *Sustainable Environment Research*, and is a member of the Editorial Board of *Bioresource Technology*.

K-7 - Integrating Biochar and Advanced Oxidation for Effective Removal of Emerging Contaminants from Waste Activated Sludge

○Chang-Mao Hung[1], Chiu-Wen Chen[2], Cheng-Di Dong[*, 2]

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Abstract: The excessive production of waste activated sludge (WAS) remains a major engineering challenge in biological wastewater treatment. WAS is characterized by unstable organic matter and the presence of emerging organic contaminants (EOCs). Biochar (BC), readily produced from lignocellulosic biomass residues *via* thermochemical conversion under oxygen-limited conditions, possesses unique

physicochemical properties such as biocompatibility, a highly graphitized porous structure, and abundant surface functional groups. These features enable BC to activate oxidants and generate stable free radicals. However, the mechanisms and performance of BC-based pretreatment for WAS containing EOCs have rarely been investigated. The integration of BC with oxidants represents a sustainable catalytic strategy to transform EOCs into more degradable organics, thereby enhancing subsequent biological processes while improving the overall efficiency and cost-effectiveness of WAS treatment. This study provides new insights into the chemical and biological pathways through which BC facilitates EOC biodegradation in WAS via radical-driven, carbon-based advanced oxidation processes.

Keywords: Advanced oxidation process; Biochar; Emerging organic contaminants; Waste activated sludge

Chul Park is a Professor in the Department of Civil and Environmental Engineering at the University of Massachusetts (Amherst, MA, USA). He received BS in Environmental Engineering at Yeungnam University (South Korea). He obtained MS in Environmental Engineering and PhD in Civil Engineering at Virginia Tech (USA). Park's research areas reside in environmental bioprocesses for both built and natural systems. He is particularly interested in microbial aggregation, especially from the aspect of molecular microbial physiology, and its application for engineering systems. Park has carried out numerous research projects sponsored by a variety of funding agencies, including the U.S. National Science Foundation. He is the recipient of 2013 Paul L. Busch Award presented by the Water Research Foundation for his research on oxygenic photogranules (OPGs). While his research on OPG for sustainable wastewater treatment continues he also recently started deeper investigation into other microbial granular processes. In prior years, he was a visiting scholar at INRAE-LBE (France) in 2014, UNIST (South Korea) in 2019, Chiba University (Japan) and Kyoto University (Japan) in 2020. Park enjoys conducting experiments and discussions in the laboratory, which continued during these visiting opportunities, and multi- and interdisciplinary collaborations play a big part in his research endeavors.

K-8 - Microbial Granulation and Lessons from Oxygenic Photogranules (OPGs)

○Chul Park[*, 1], Joseph G. Gikonyo[1], Yasu S. Morita[2]

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Abstract: Microorganisms occasionally form dense, spherical aggregates commonly known as granules. Microbial granulation is observed in diverse environments, from wastewater treatment to glaciers. In recent years, research endeavors on photogranulation have greatly increased. OPGs, in which photosynthetic oxygenation is incorporated into granules, present potential for sustainable wastewater treatment but also motif for reevaluating granulation mechanisms, as they are generated in varying environments that defy traditional selection pressures. OPGs are formed in hydrostatic batches without shear, repetitive feast/famine cycles, or hydraulic-selection pressure (HSP). Similarly, OPGs are formed in hydrodynamic batches that involve shear but lack HSP and feast/famine cycles. Success in operating OPGs in continuous-flow CSTR challenges the convention that CSTRs are unsuitable for granulation. Cryoconites from glaciers and OPGs, despite growing in vastly different environments, share striking similarities in their characteristics. These suggest a range of causal relationships with substitutability of selection pressures, akin to a 'Goldilocks zone' of granulation. Prior OPG research and literature review encouraged us to develop a hypothesis that a universal biological switch exists for granulation, and this switch can be turned on under varying suites of environments. We will present ongoing studies examining this hypothesis, including culturing genetically-altered model bacteria and chemical augmentation to enhance granulation.

Keywords: Granulation enhancement; Microbial granulation; Oxygenic photogranules (OPGs); Selection pressure; Wastewater Treatment

Guangtao Fu is Professor of Water Intelligence at the University of Exeter, UK. His work lies at the forefront of artificial intelligence and water research, where he develops and applies advanced computer models, big data analytics, and AI tools to tackle some of the most pressing challenges in water management—from flooding and pollution to the creation of sustainable urban water systems. He is currently a Fellow of the International Water Association (IWA) and has previously held prestigious roles as a Royal Society Industry Fellow and a Turing Fellow.

K-9 - Data-centric Water Engineering for Sustainable Urban Wastewater Management

○Guangtao Fu

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Abstract: Urban water infrastructure (UWI) is fundamental in providing essential water and wastewater services and supporting the prosperity of cities. However, UWI is now facing a wide range of chronic and acute threats such as increasing demands, stringent regulations, ageing, lack of investment, climate change and extreme weather events. A key approach to tackling these threats is provided through capitalising on the advances in artificial intelligence (AI). AI technologies have long been applied to UWI planning and management, however, there is a critical research gap in understanding how AI will transform the way UWI systems are planned, designed, operated and maintained during their lifetime.

This study calls for the development of data-centric water engineering to tackle water challenges in a changing world. Building on the historical evolution of water engineering from empirical and theoretical paradigms to the current computational paradigm, it is envisioned that a fourth paradigm, i.e., data-centric water engineering, is emerging driven by recent AI advances. Here a new framework is defined for data-centric water engineering in which data are transformed into knowledge and insight through a data pipeline powered by AI technologies. Examples will be provided to demonstrate how the framework works. It is proposed that data-centric water engineering embraces three principles – data-first, integration and decision making. The development of data-centric water engineering needs an interdisciplinary research community, a shift in mindset and culture in the academia and water industry, and an ethical and risk framework to guide the development and application of AI.

Keywords: Artificial intelligence; Automation; Data centric; Digital water; Wastewater management

Dr. Wenshan Guo is a Professor in School of Civil and Environmental Engineering, University of Technology Sydney. Her current research focuses on innovative wastewater treatment and reuse technologies, green technologies for resource and energy recovery, water-waste-energy nexus, and climate change mitigation. She has authored 6 books, 53 book chapters, and > 480 peer-reviewed journal papers. She is an Editor, Chemical Engineering Journal & Bioresource Technology Report (Elsevier), Section Editor, Journal of Water Process Engineering (Elsevier), Associate Editor, Journal of Hazardous, Toxic & Radioactive Waste (ASCE) & Frontiers in Bioengineering and Biotechnology (Frontiers), and Academic Editor, Journal of Chemistry (Wiley). She has been recognized as Highly Cited Researcher in 3 Categories from 2019 to 2022 by Clarivate Analytics, Web of Science Group, as well as the Winner of Excellence in Women in Research Award, Scopus Researcher of the Year Award 2022. She has also been named as one of the Top 40 Research Superstars in Australia (2020 and 2021, Environmental Science).

K-10 - Recent Advances in Conversion of Biowaste to Value-added Products and Their Applications

○Wenshan Guo

Centre for Technology in Water and Wastewater, School of Civil and Environmental Engineering, University of Technology Sydney, Sydney, NSW 2007, Australia

Abstract: Biofuel production has attracted increasing attention, especially given the global concerns about fast-growing energy demand and emissions of greenhouse gases that threaten the planet. Converting biowaste into green and sustainable biofuel, which can enhance the bioeconomy and contribute to sustainable economic development goals. Various biowaste sources such as food waste, textile waste, microalgal waste, agricultural waste and sewage sludge have been treated as potential and renewable feedstocks for producing biofuels and value-added products. Meanwhile, biofuel production technologies, including thermochemical processing, anaerobic digestion, fermentation and bioelectrochemical systems, have been extensively studied and reported, which can achieve waste valorization through producing biofuels and re-utilizing wastes. In addition, to enhance circular bioeconomy, further perspectives on possible integrated approaches to maximizing waste utilization for valuable products production are discussed.

Keywords: Biowaste; Waste valorization; Circular bioeconomy Bioelectrochemical systems; Thermochemical technologies

Taira Hidaka

Education:

•PhD, Department of Environmental Engineering, Kyoto University, Japan, 2002

Experience:

-April 2024 to present, Associate Professor in Department of Global Ecology, Kyoto University, Japan

-April 2015 to March 2024, Assistant, Junior Associate and Associate Professor in Department of Environmental Engineering, Kyoto University, Japan

-November 2011 to March 2015, Senior Researcher, in Materials and Resources Research Group, Public Works Research Institute, Japan

-March 2010 to February 2011, Visiting Scholar in Department of Civil and Environmental Engineering, University of Cincinnati, USA

-April 2002 to October 2011, Assistant Professor, in Department of Environmental Engineering, Kyoto University, Japan

Research Projects:

-Promoting resource and energy recovery from wastewater and waste through sunlight-driven microbial reactions, JSPS Grants-in-Aid for Scientific Research(B)25K03320

(2025.04-2029.03, PI)

Recent Publications:

-Goto M, Hidaka T*, Nomura Y, Fujiwara T, Park C: Effect of solids retention time on wastewater treatment and methane recovery by oxygenic photogranules, *Bioresource Technology Reports*, **31**, 102246, 2025.

-Hidaka T*, Nguyen TH, Togari T, Takashima M, Shigemura H: A review of sewage sludge digestion technologies in Japan: from technological evolution to global perspectives, *Journal of Material Cycles and Waste Management*, 2025. https://doi.org/10.1007/s10163-025-02281-w

Award:

-WET Excellent Paper Award in Japan Society on Water Environment, 2024 (corresponding author)

K-11 - Resource and Energy Recovery from Wastewater and Organic Waste Using Anaerobic Digestion with Sunlight-driven Phototrophic Microorganisms

○Taira Hidaka

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Abstract: Wastewater and organic waste management is shifting from simple disposal to the recovery of valuable resources, such as clean water, fertilizers, and various forms of energy, including electricity, fuel, and heat. The anaerobic digestion (AD) of sewage sludge and organic waste is a promising technology for achieving both energy and resource recovery.

Bacteria–microalgae consortia forming oxygenic photogranules offer a feasible approach for wastewater treatment because of their good settleability and energy efficiency, particularly through self-aeration. The anaerobic co-digestion of sewage sludge with cultivated photogranules further enhances energy recovery, as carbon dioxide supplied through biogas from AD is captured in the algal biomass.

Sunlight can also support the cultivation of photosynthetic bacteria using digestates, thereby improving fertilizer quality. The growth of Rhodospirillaceae, a well-known group of photosynthetic bacteria, is observed when filtered digestate liquor from AD of sewage sludge with an organic substrate is exposed to light.

These two types of sunlight-driven phototrophic microorganisms, derived from activated sludge but grown under different conditions, can synergistically enhance resource and energy recovery from wastewater and organic waste via anaerobic digestion.

Keywords: Biogas; Fertilizer; Methane; Microalgae; Photogranule; Renewable energy

Huu Hao (Hao) NGO is currently a Distinguished Professor of Environmental Engineering at the University of Technology Sydney (UTS), where he serves as Deputy Director of the Centre for Technology in Water and Wastewater and Co-Director of the Joint Research Centre for Environmental Green Bioprocess at the School of Civil and Environmental Engineering, Faculty of Engineering and IT (FEIT). He is also the Founder and Executive Coordinator of the Australasia Practical Net Zero Emissions Society (APZES). From 2021 to 2024, he served as President of the International Bioprocessing Association and currently holds the titles of Distinguished Fellow of the Association (D-FIBA) and Fellow of the International Water Association (FIWA).

Hao's research expertise lies in Environmental Biotechnology, with a strong focus on advanced biological waste and wastewater treatment, circular economy-driven green technologies (such as algae-based systems), resource recovery, bioenergy production, waste minimization, net-zero emissions strategies, membrane technologies, alternative water sources, and environmental impact assessment.

Hao was recognized as a Highly Cited Researcher by Clarivate Analytics (2019-2022). The AUSTRALIAN Scholar Rankings named him a National Leader in 2 areas of Biotechnology and Environmental Science.

Hao has authored over 800 publications, including 16 books and 54 book chapters, with over 66,000 citations and an h-index of 127 (Google Scholar, August 2025). Hao is frequently invited to deliver plenary and keynote lectures at prestigious universities and major international conferences.

K-12 - Harnessing Algae for Enhanced Performance in Membrane Bioreactors

○Huu Hao Ngo

Centre for Technology in Water and Wastewater, School of Civil and Environmental Engineering, University of Technology Sydney, Sydney, NSW 2007, Australia

Abstract: The integration of algae into membrane bioreactors (MBRs) represents a novel and sustainable approach for wastewater treatment. Algae–MBR systems provide several benefits, including enhanced nutrient removal, in situ oxygen production through photosynthesis, reduced aeration energy demand, and the possibility of valorizing algal biomass into biofuels or other bioproducts. These synergies can improve both treatment efficiency and environmental performance compared to conventional MBRs. However, practical implementation faces challenges such as membrane fouling from algal extracellular polymeric substances, limited light penetration, and instability of algal–bacterial consortia under varying conditions. Current research focuses on solutions such as anti-fouling membranes, optimized photobioreactor designs, and genetically improved

algal strains. Future directions include system integration, life cycle assessment, and techno-economic analysis to enable scale-up. Advancing algae–MBR technology could significantly contribute to energy-efficient, resource-recovering wastewater management and support the goals of a circular bioeconomy.

Brendan Higgins is an Associate Professor in Biosystems Engineering at Auburn University. His research group's mission is to investigate processes that utilize algae and bacteria for waste remediation, water quality, plant production, and high-value product synthesis. We seek to understand underlying mechanisms that contribute to system performance, with a particular focus on organism interaction. He holds a BS degree in Civil Engineering from Northwestern University, an MS in Transportation Technology & Policy from UC Davis, and a PhD in Biological Systems Engineering from UC Davis. He is the principal investigator on over $13 million in competitive extramural funding and has published 58 peer reviewed articles.

K-13 - Cultivation of Microalgae on Thermal Hydrolysate from Rendering of Poultry Dissolved Air Flotation (DAF) Solids

○Brendan T. Higgins[*, 1], Edward T. Drabold[1], Melissa Boersma[2]

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Abstract: Dissolved air flotation (DAF) solids from poultry processing facilities are land-applied, resulting in extreme foul odors (rotting meat). Rendering of DAF solids is not widely practiced, due to their high water content (>70%). Thermal hydrolysis at 120-130 C is a common rendering technique which sterilizes the material and generates a solid fatty phase and an aqueous phase known as "stick water." Here we valorized the stick water as medium to cultivate nutraceutical microalgae. We tested thermal hydrolysis of DAF solids at 7% solids content and 25% solids content. Interestingly, *Chlorella sorokinana* and *Auxenochlorella protothecoides* grew well (> 2 g/L in 5 days) on full strength stick water from the 7% loading but were completely suppressed on stick water from the 25% loading. This suppression could not be undone with even 8x dilution suggesting that solids loading substantially changes the reaction chemistry during thermal hydrolysis. We investigated the differences in the stick water chemistry generated from 7% versus 25% solids loading by using LCMS/MS in combination with dose response testing of promising molecules. We found that certain aldehydes, such as *pthalaldehyde*, were present at much higher concentrations in the 25% stick water and that these aldehydes were toxic to algae.

Keywords: Aldehydes; Algae; Aqueous phase; Meat byproducts; Nutraceutical; Toxicity

Dr. Bin-Le Lin is a Chief Senior Scientist at the National Institute of Advanced Industrial Science and Technology (AIST), Japan, and Affiliated Professor at the University of Tsukuba. She earned her B.S. in Biology (1987) and M.S. in Microbial Biochemistry (1990) from Fujian Normal University, and her Ph.D. in Engineering of Materials and Biology from Tokyo University of Agriculture and Technology (1998). Following a postdoctoral fellowship at the Institute of Industrial Science, University of Tokyo (1998–2001), she joined AIST in 2001, where she also led the Ecological Risk Assessment Group (2003–2008). Her research centers on ecological risk and risk–tradeoff assessment of chemicals and emerging energy technologies associated with the nitrogen cycle, including biomass and ammonia–hydrogen systems. She has developed a global nitrogen cycle model and the ecological risk assessment platform AIST-MeRAM, and has authored several books and numerous peer-reviewed publications that have informed national policies on chemical safety and sustainable energy. Dr. Lin has been recognized with the AIST President's Award for Excellence in Research (2009) and the U.S. Environmental Protection Agency's Scientific and Technological Achievement Award (2015). She currently serves as Asia-Pacific Chair of the Global Advisory Group on Ecological Risk Assessment of SETAC and as a founding member of the International Board of Environmental Risk Assessors (IBERA).

K-14 - Nitrogen and Phosphorus Recovery Potential from Japan's Food Loss and Waste: Implications for Resource Circularity and Carbon Neutrality

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Abstract: This study presents the first comprehensive quantitative assessment of nitrogen (N) and phosphorus (P) recovery potential from food loss and waste across Japan's entire food supply chain. Through systematic analysis of 29 representative food items using official government databases, we estimated total food loss at 16.25 million tons/year (production-supply stage) and food waste at 11.07 million tons/year (consumption stage) for 2022. Our findings revealed substantial nutrient recovery potential: 708,671 tons

N/year and 150,266 tons P/year through composting (100% recovery rate), and 432,289 tons N/year and 91,662 tons P/year through composting (61% recovery rate), representing 200% and 107% substitutions (maximum potential), and 122% and 65% substitutions (average potential) of Japan's current agricultural N and P usages, respectively. This nutrient recovery could reduce CO_2 emissions by 3,061,630 tons (maximum potential) and 1,867,600 tons (reasonable potential) CO_2-equivalent annually. The research revealed significant disparities in the implementation of food recycling across food supply chain sectors, with recovery rates ranging from 22% in the food service sector to 79% in the food manufacturing sector. These findings provide critical baseline data for developing sustainable nutrient management policies and advancing Japan's objectives for a circular economy and carbon neutrality.

Keywords: Food Waste; Food Loss; Nutrient Recovery; Circular Economy; Nitrogen; Phosphorus; Sustainable Agriculture

Fan Lyu is a distinguished Chinese scientist specializing in environmental microbiology and environmental engineering. He is a professor at Tongji University and an academician of the Chinese Academy of Engineering. His research primarily focuses on microbial ecology in wastewater treatment, mechanisms of pollutant degradation, and sustainable water environment management. Professor Lyu has made pioneering contributions to understanding microbial community dynamics in biological wastewater treatment processes, promoting the development of advanced treatment technologies for urban and industrial wastewater. He has published numerous influential papers in leading international journals and has been recognized with multiple prestigious awards for his achievements. As a key figure in China's environmental science and engineering community, Professor Lyu has also played an important role in advancing interdisciplinary research and training future talent in environmental protection. His work has significantly contributed to improving China's water environment governance and enhancing international collaboration in sustainable environmental management.

K-15 - Liquid Digestate: Characterization, Resource Recovery and Treatment

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Abstract: Anaerobic digestion is the main technology to recovery bioenergy from biowaste. Unfortunately, it is a big challenge to beneficially utilize digestate, especially liquid digestate, by land application in urban areas. Although liquid digestate is rich in plant nutrients, there is lack of cost-effective resource utilization method. At the same time, on one hand, high concentration of inhibitors like acids and ammonia in the liquid digestate often leads to the problems of unstable methanogenesis process, and low methane production and utilization rate during anaerobic digestion. On the other hand, using anaerobic bioprocess to produce higher-value and more widely used carboxylate products is receiving increased attention. However, these inhibitors or high-value nutrient elements and carboxylate products are highly water-soluble and mixed in the complex digestate. How to economically and technically separate them from liquid digestate for downstream processing has been a major challenge in this field. Regarding the concerns about inhibitors and new contaminants potentially involved in the liquid digestate, this study firstly characterized the liquid digestate using ultra-high performance liquid chromatography and hybrid quadrupole Orbitrap mass spectrometry. Then, given the potential of membrane technology for achieving continuous production and in-situ recovery, this study explored the application of ion exchange membrane-based electrochemical methods for the separation and recovery of high-value products from liquid digestate. The investigated issues include the migration patterns of inorganic salt ions and organic acids in fresh and mature digestate through traditional electrodialysis, the migration and membrane fouling behaviour of organic matter in digestate during electrodialysis, and finally an acids continuous production and in-situ separation platform. To the last, for the purpose of end-of-pipe treatment, a Fenton-based treatment on each category of organics in liquid digestated was investigated on molecular level, with the aim to targeted effect and low derivation.

Keywords: Humus; Microplastics; Heavy metals; Volatile fatty acids; Lactic acid

Shu-Yuan Pan is an Associate Professor in the Department of Bioenvironmental Systems Engineering, College of Bioresources and Agriculture, at National Taiwan University (NTU). He also serves as the Chief Executive Officer of the Agricultural Net Zero Technology and Management Innovation Research Center at NTU. Dr. Pan has made significant contributions to circular bioeconomy technology R&D in support of a net-zero future, pioneering new possibilities and opportunities. His interdisciplinary research spans green chemistry, materials synthesis, reactor design, and environmental systems engineering, advancing both scientific understanding and real-world implementation of circular and net-zero solutions. Dr. Pan received his B.S. in Geography from NTU in 2009, followed by his M.S. and Ph.D. from the Graduate Institute of Environmental Engineering at NTU in 2011 and 2016, respectively. During his Ph.D.

studies, he was a visiting student at the Institute of Technical Thermodynamics, RWTH Aachen University (2014), and at the Energy Systems Division, Argonne National Laboratory (2015–2016). He later conducted postdoctoral research at the Energy Technologies Area, Lawrence Berkeley National Laboratory (2018–2019). In 2019, Dr. Pan joined NTU as a tenure-track Assistant Professor and was promoted to Associate Professor in 2023. More information about his research group can be found at https://homepage.ntu.edu.tw/~sypan/Default.html

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K-16 - Circular Carbon Chemistry for Net-zero Bioeconomy

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Abstract: Carbon chemistry, e.g., CO_2, CH_4, carbonates, and carbon-based fuels and chemicals, is fundamental to achieving a net-zero future. This presentation will explore the concept of carbon chemistry through the lens of the circular bioeconomy and net-zero strategies. Notable examples will include recent research and advancements at National Taiwan University in biomass conversion technologies, electrochemical processes, and life cycle assessment. The chemistry of carbon–nitrogen coupling also plays a crucial role in both agriculture and industry. Several case studies, such as the manufacturing of green fertilizers and sustainable chemicals, will be highlighted. As a tutorial presentation, this study will offer insights into the principles for identifying optimal circular technologies across diverse feedstocks, end products, and regional contexts.

Keywords: Thermodynamics; Kinetics; Biomass; Electrochemical processes; Life cycle assessment; Green fertilizer

Name: Duu-Jong Lee
Title: Chair Professor
Organization: City University of Hong Kong

Prof. Duu-Jong Lee's research portfolio comprehensively explores sustainable energy solutions and environmental engineering, demonstrating depth and breadth across multiple disciplines. He has won total research funding of over HKD 65 million, published over 1,300 peer-reviewed journal papers, thirty-one book chapters, nine edited books, and fourteen patents. His publication has received over 74,000 citations by Google

Scholar, giving an h-index of 131. Beyond publications, Professor Lee's team developed processes with industrial practice. A novel process for simultaneously removing carbon, sulfur, and nitrogen from industrial wastewater was established from fundamental studies, successfully handling over 60,000 cubic meters daily in China's pharmaceutical and chemical industries to meet the updated environmental standards. Prof. Lee has gained worldwide recognition for his exemplary service to the academic community. He was elected in 2012 as President of the Taiwan Institute of Chemical Engineers. He was the Chair of the International Bioprocessing Association from 2013-2019. Prof. Lee was elected as a Fellow of the Taiwan Institute of Chemical Engineers, the Royal Society of Chemistry, the International Bioprocessing Association, and the International Academy of Drying Science and Technology. He was also elected as a Corresponding member of the International Academy of Engineering of Russia.

K-17 - Facultative Sulfide-oxidizing Heterotrophic Denitrification for Enhanced Nitrogen and Sulfide Removal

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Abstract: Facultative sulfide-oxidizing heterotrophic denitrification is an innovative biological process that integrates sulfide oxidation and denitrification, providing an effective solution for wastewater treatment. This process employs specific heterotrophic bacteria that can oxidize sulfides while simultaneously reducing nitrates, thereby removing both sulfide and nitrogen compounds from wastewater. The facultative nature of these bacteria allows them to adapt to varying oxygen levels, enhancing the process's flexibility and efficiency. While heterotrophic denitrifiers are crucial for global carbon and nitrogen cycling, their inability to oxidize sulfide can lead to increased greenhouse gas emissions by inhibiting nitrous oxide (N_2O) reduction. Research utilizing microcosm incubations, stable-isotope probing, and metagenomics has shown that these denitrifiers can enhance denitrification by using sulfur as an alternative electron source, significantly reducing N_2O emissions across different environments. This presentation emphasizes the ecological importance of heterotrophic denitrifiers in sulfur cycling and their potential role in mitigating climate change. Additionally, it will address the limitations of this process and explore future research prospects to optimize its application in wastewater treatment and environmental sustainability.

Keywords: Denitrification; Heterotrophic; Nitrous oxide; Sulfide; Sulfur cycling; Wastewater treatment

Dr. Yue-Qin Tang earned her doctoral degree from Kumamoto University in Japan. She served as an Assistant Professor at Kumamoto University from 2006 to 2008, then as a Professor at Peking University from 2008 to 2012. Since 2012, she has been a Professor at Sichuan University. She is also the Director of the Key Laboratory of Organic Waste Valorization for Environmental Protection in Sichuan Province, a Standing Director of the Microbiology Society of Sichuan Province, and a member of the Archaea Committee of the Chinese Society for Microbiology. Her research focuses on the valorization of waste biomass for the production of biofuels, biochemicals, and biofertilizers, as well as microbial breeding and environmental microbial ecology. Dr. Tang has developed extensive expertise, particularly in technologies for producing fuel ethanol and biochemicals from lignocellulosic biomass waste, the construction of superior fermentation strains, anaerobic fermentation for methane production, and the underlying microbiological mechanisms. She has published over 250 research papers and holds more than 30 authorized patents.

K-18 - Structure of Phage Communities and Their Interaction with Prokaryotic Microbiome in Anaerobic Digesters

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Abstract: Anaerobic digestion (AD) is an effective technology for the treatment and resource recovery of organic waste. At its core is a complex microbial process in which diverse functional groups of microorganisms synergistically degrade organic matter and produce methane. In addition to bacterial and archaeal prokaryotes, bacteriophages (phages) are increasingly recognized as key components of AD systems. However, the structural features of phage communities and their interactions with prokaryotic microbiomes in AD systems remain insufficiently characterized. In this study, meta-omics approaches were applied to investigate the composition and structure of phage communities in AD systems and their associations with prokaryotic hosts. The dynamic succession patterns of both phage and prokaryotic microbial communities were analyzed, and in situ phage–host interaction features were explored. Moreover, the mechanisms by which ammonia stress influences phage–host interactions were elucidated. The findings reveal the potential roles of phages in shaping microbial community structure and regulating metabolic pathways in AD. These insights contribute to a better understanding of the ecological functions of phages in engineered microbial ecosystems and provide a theoretical basis for optimizing microbial community regulation in biogas production systems.

Keywords: Ammonia stress; Anaerobic digestion; Meta-omics; Microbiome; Phage community

Suyun Xu is an Associate Professor in the Department of Environmental Science and Technology in the School of Environment and Architecture at the University of Shanghai for Science and Technology, China. She received her Master degree from Tongji University in 2009, and obtained the Ph. D degree from Hong Kong Baptist University in 2012. Her research interests mainly focus on the fields of biowaste treatment, bioenergy conversion, biological treatment of wastewater and bioelectrochemical system development. She is dedicated to turning energy and resource recovery from biowaste and wastewater, including the biogas upgrading, nutrients recovery from the source-separated sewage, and the high-value products from various biowaste. She has published over 100 peer-reviewed papers and serves as the editorial boards of several international journals.

K-19 - Substrate Dependent Response to Exogenous CO_2 Injection in Anaerobic Digestion

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Abstract: The efficiency of anaerobic digestion (AD) in treating high-load, complex substrates is often constrained by process instability and suboptimal methane conversion. Here, we demonstrate that exogenous CO_2 injection can substantially enhance AD performance, with its effects strongly dependent on substrate composition and organic loading rate. Using semi-continuous reactors fed with varying food waste-to-sludge ratios and operated at three loadings, we show that CO_2 mediation not only boosts methane yield but also reshapes microbial metabolism. Optimal performance occurred at a 3:1 food waste-to-sludge ratio, where CO_2 injection mitigated acidification risk, promoted acetate accumulation, and reduced propionate build-up, favoring the acetoclastic pathway. Microbial community analysis revealed CO_2-induced enrichment of hydrolytic *Bacteroidota* and methanogenic *Methanobacterium* and *Methanosarcina*, enhancing both hydrogenotrophic and acetoclastic methanogenesis. In contrast, CO_2-deficient systems favored fermentative taxa, indicating less efficient methane conversion. These results elucidate the substrate-dependent bioconversion mechanisms of CO_2 mediation and provide guidance for optimizing co-digestion strategies to improve methane productivity and load resistance in AD.

Keywords: CO_2 injection; Methane production; Organic loading rate; Substrate ratio; Volatile fatty acids

Professor Tong Yen Wah joined the Department of Chemical and Biomolecular Engineering at the National University of Singapore (NUS) in 2001 after graduating from the University of Toronto with a PhD in Chemical Engineering. His expertise is in biomaterials research for tissue engineering and in bioenergy from food wastes and biomass wastes, with over 280 publications and 180000 citations. His recent works in food wastes management has been successfully commercialized with distributed anaerobic digesters that can be effectively used in cities through a spin-off company from NUS.

K-20 - Upcyling of Food Waste Digestate into Solid Fertilizer with Biochar and Encapsulation

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Abstract: A novel, facile, and cost-effective upcycling treatment of food waste digestate was developed in this study. Food waste digestate after anaerobic digestion was able to be transformed into value-added solid fertilizer using one-step gelation method. Sodium alginate (SA) was used as the main encapsulating material, and the K-rich biochar made from wood chips was used as the core material. The suspension mixture of food waste digestate, SA, and biochar could be simply made into solid beads under gelation in the calcium chloride solution. The nutrient recovery rates from the digestate were low (< 60% for phosphate, < 15% for ammonia or potassium) by using biochar only, while large amount of K^+ was released. However, by using SA as coating, over 90% of phosphate, 38.9% of ammonia, and 38.3% of potassium could be recovered from the food waste digestate. Moreover, large amount of Na+ occurring in the food waste digestate was not able to be absorbed, which would also be beneficial to the utilization of this developed solid fertilizer in the crop cultivation application.

Keywords: Biochar; Food Waste; Gelation; Fertilizer

Masanori Toyofuku completed the doctoral program at the Graduate School of Life and Environmental Sciences, University of Tsukuba in 2009, earning a Ph.D. in Agricultural Science. After serving as a researcher at the University of Zurich and as Group Leader and Assistant Research Supervisor for the ERATO Nomura Microbial Community Control Project, he has been an Associate Professor in the Faculty of Life and Environmental Sciences at the University of Tsukuba since 2019. He has received numerous awards, including the Japan Prize in Agricultural Sciences, Achievement Award for Young Scientists (2021), the Nomoto Prize from the Federation of Microbiological Societies of Japan (2021), Bioindustry Research Award (2025). Since 2021, he has been a Fellow of the Suntory SunRiSE Program. His expertise lies in bacterial interactions, and he has made significant contributions to the discovery of novel membrane vesicle formation pathways, including explosive cell lysis and bubbling cell death. He also coined the concepts of binary signaling and quantal secretion in bacteria. His review paper on this topic has become one of the most cited works in the field.

K-21 - Towards Controlling the Microbial Community

○M. Toyofuku[*, 1, 2]

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Abstract: Understanding bacterial interactions is one of the keys in studying the development of microbial communities. However, how bacteria regulate energy conservation within these communities remains unclear. One possible mechanism is cell-to-cell communication, also known as quorum sensing. Our research focuses on how such communication influences respiration and growth, mainly using Pseudomonas aeruginosa as a model organism. This widespread bacterium also used as a model organism for denitrification, a key process in wastewater treatment for nitrogen treatment, regulates numerous genes through signaling molecules. We found that bacterial communication regulates denitrification in P. aeruginosa through distinct pathways. To further explore bacterial interactions, we analyzed the extracellular matrix of P. aeruginosa biofilms. Proteomic analysis revealed an abundance of proteins derived from membrane vesicles (MVs), suggesting a functional role for MVs in biofilm structure and communication. More recently, we have investigated the formation and function of MVs, which MVs appear to be promising tools for regulating bacterial communities. I would like to introduce our basic research findings which may open new avenues for applications.

Keywords: Bacterial Communication; Biofilm; Denitrification; Membrane Vesicles.

Dr. Qiyong Xu is an Associate Professor and the Vice Dean of the School of Environment and Engineering at Peking University Shenzhen Graduate School. He earned his Ph.D. in Environmental Engineering from the University of Florida in 2005. He has worked as a professional engineer at an environmental consulting firm in the U.S. for four years. Dr. Xu serves as an Associate Editor for the journal *Waste Management* (Elsevier). He is also the Director of the Shenzhen Engineering Laboratory for Recycled Composite Materials. His research focuses on critical areas of environmental sustainability, including municipal solid waste management, food waste treatment, bioreactor landfill technologies, leachate treatment, and anaerobic digestion. He has published over **190 papers** in peer-reviewed journals and holds **11 patents** (**10** in China and **1** in the U.S.).

K-22 - Integrated Resource Recovery from Food Waste: Biogas Generation and Carbon Source Production

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Abstract: Food waste (FW) constitutes a significant fraction of municipal solid waste and presents both environmental challenges and bioenergy recovery opportunities. This study presents a dual-pathway valorization strategy targeting both energy and material recovery from FW via (1) two-stage anaerobic digestion (AD) for biogas production and (2) controlled fermentation for short-chain carbon source generation. In the AD route, a combination of conductive materials—biochar, zero-valent iron (ZVI), iron oxide, and iron–carbon micro-electrolysis—was applied to enhance hydrolysis, acidogenesis, and methanogenesis. These additives significantly improved methane production across both batch and continuous systems. In two-stage configurations, methane yield increased by approximately 20% to 160%, depending on material type and reactor condition. The use of iron-based additives promoted favorable fermentation pathways, while effluent recirculation further enhanced system resilience and conversion efficiency. In parallel, a pilot-scale fermentation system (2.25 m^3) operated under mildly acidic pH (3.8–4.2), with NaOH dosing and biochar supplementation, achieved substantial yields of acetate (up to 18.4 g/L), along with elevated production of n-propanol and ethanol. Enhanced degradation of organic matter and fermentation kinetics were observed, driven by

improved physicochemical conditions and metabolic activity. The system demonstrates a practical route to generate low-cost, renewable carbon sources under real operational conditions. This integrated framework bridges energy and material recovery from FW, providing scientific and technical support for sustainable solutions in urban organic waste management.

Keywords: Food waste; Anaerobic digestion; Methane; Biochar; Carbon source.

Keiko Yamaji is a full professor at the Institute of Life and Environmental Sciences, University of Tsukuba, Japan. Her research focuses on environmental chemical ecology, especially the clarification of plant–microbe symbiosis under environmental stresses such as heavy metals in addition to field investigations with chemical analysis. Prof. Yamaji has published more than 80 peer-reviewed papers, who is actively engaged in research projects supported by Japan Society for the Promotion of Science (JSPS), including recent studies on endophytic fungi and their roles in vegetation succession at mining sites and on siderophore-mediated iron plaque formation in reed root systems. Her scientific work contributes to a deeper understanding of how plants interact with microbes and adapt to environmental stresses. Prof. Yamaji also has extensive leadership experience, who has been serving as Chair of Master's Program in Environmental Sciences (2020–2022; 2024–present) and Chair of Doctoral Program in Environmental Studies (2022–2024).

K-23 - *Miscanthus Sinensis* Andersson at Mine Sites; the Metal Tolerant Mechanism, the Symbiosis with Functional Root Endophytes, and the Important Ecological Roles as Pioneer Herb

○Keiko Yamaji[*, 1], Toshikatsu Haruma[2], Kohei Doyama[1], Xingyan Lu[1], Yuta Matsushiro[1], Mitsuki Yachi[1]

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Abstract: In the world, there are about 300,000 mines, where ecological conservation is needed due to SDGs and nature positive. Mine soil contains high concentrations of metals, which are toxic to plants; therefore, generally, plants cannot survive there because of the oxidative damage. On the contrary, plants, which are tolerant to metal stress, can grow naturally at mine sites without any symptoms, even though these plants accumulated metals. According to vegetation succession, we have examined many kinds of plant species, such as pioneer herbs, pioneer trees and late-succession trees, which were naturally growing at mine sites in Japan. *Miscanthus sinensis* is one of pioneer herbs

found at several mine sites and we have clarified that *M. sinensis* 1) highly accumulates metals in the roots, 2) shows the metal-tolerant mechanism via production of antioxidant, chlorogenic acid, and 3) forms symbiotic relationships with functional root endophytes, which can enhance metal tolerance of plants. Because *M. sinensis* can survive severe environments at mine sites, this plant plays important ecological roles, such as soil development and the promotion of tree establishment. Therefore, we consider that *M. sinensis* would be suitable plant species for greening at mine sites, especially in early vegetation succession.

Keywords: Metal tolerance; Mine site; *M. sinensis*, Native plants; Root endophytes

Dr. Xiaoyuan Zhang is an Associate Professor at the School of Environmental Science and Engineering, Nankai University. She received her Ph.D. in Municipal Engineering from Tianjin University in June 2019 and completed joint doctoral and postdoctoral research at Nanyang Technological University in Singapore from December 2017 to January 2023.Dr. Zhang obtained her Bachelor degree in the Department of Environment Science and Engineering, Fudan University, in 2002, before pursuing her graduate study with Nanyang Technological University, Singapore. In School of Civil and Environmental Engineering, she focused her research on the treatment of toxic industrial wastewaters via novel biological processes, i.e. aerobic granular sludge systems. She started working as a project officer in 2006, in the Institute of Environmental Science and Engineering, where she expanded her expertise into areas such as ballast water treatment, bunker fuel and clean energy. After being awarded her Doctoral degree, she joined her alma mater as a lecturer, and later became Associate Professor. Her research interests, though centering on, are not limited to environmental engineering and wastewater treatment. Dr. Zhang believes the solution to mankind's environmental problems requires interdisciplinary collaboration and holistic mindset. Therefore, her present research involves the interconnection of resource reclamation from waste streams, new materials and renewable energy, as well as social aspects and human values. Dr. Zhang's research focuses on low-carbon green wastewater reuse and resource recovery, as well as the control of heavy metal and radioactive contamination. She leads a research team centered on a 'Low-Carbon Non-Conventional Water Resource Recovery and Water Quality Assurance Technology Platform,' integrating environmental biotechnology, environmental chemistry, and functional materials to advance water pollution treatment and resource recycling. She has published over 60 peer-reviewed articles in leading environmental and water treatment journals, with an h-index of 17. Her work has been supported by multiple national and international research projects, including the National Natural Science Foundation of China and the Singapore Ministry of Education. Dr. Zhang is actively involved in academic service as a youth editorial board member for several journals and serves as a reviewer for numerous environmental science publications.

K-24 - Mechanistic Insights into the Role of Tannic Acid-modified Iron-Biochar Composites for Enhanced Methane Production in Anaerobic Process

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Abstract: Anaerobic process, such as anaerobic digestion, has been widely recognized as a sustainable approach for energy recovery in the form of methane from wastewater and sludge digestion. However, methane production in anaerobic process could be significantly hindered by the limited interspecies electron transfer. The application of conductive materials in anaerobic processes has attracted increasing attention to improve electron transport and facilitate interspecies electron transfer (IET) between syntrophic partners. In this study, a novel tannic acid (TA)-modified iron-biochar composite (Fe-TAC) with a high electron transfer capacity of 18.6 μmol e^-/g and a specific capacitance of 1.14 F/g was developed. The Fe-TA-C composite promoted redox-active quinone groups and Fe(II)/Fe(III) redox cycle, which accelerated the establishment of energy-conserving pathways associated with IET during the anaerobic process. Furthermore, a dosage-dependent modulation of electron transfer pathways was observed. At lower Fe-TA-C dosages, direct interspecies electron transfer (DIET) was enhanced, facilitating syntrophic interactions among anaerobic microbes. However, with increasing Fe-TA-C dosage, a shift towards mediated interspecies electron transfer (MIET) was observed, possibly due to the excessive enrichment of exogenous quinone-like functional groups (C=O) in Fe-TA-C, which function as electron shuttles and may further stimulate endogenous quinone pools, thereby reinforcing MIET between bacteria and methanogens. This observed DIET-to-MIET shift in electron transfer pathways provides new mechanistic insights into the dosage-dependent behavior of conductive materials, offering a strategy to optimize methane production in anaerobic process. Consequently, this work highlights the role of Fe-TA-C as a conductive material for dual DIET-MIET mechanisms and demonstrates a dosage-responsive strategy using conductive material to fine-tune electron transfer pathways for improving methane production in anaerobic process.

Keywords: Anaerobic process; Conductive material; Dosage-dependent; Electron transfer; Fe-TA-C; Methane production

Dr. Zhang Yi obtained her Bachelor degree in the Department of Environment Science and Engineering, Fudan University, in 2002, before pursuing her graduate study with Nanyang Technological University, Singapore. In School of Civil and Environmental Engineering, she focused her research on the treatment of toxic industrial wastewaters via novel biological processes, i.e. aerobic granular sludge systems. She started working as a project officer in 2006, in the Institute of Environmental Science and Engineering, where she expanded her expertise into areas such as ballast water treatment, bunker fuel and clean energy. After being awarded her Doctoral degree, she joined her alma mater as a lecturer, and later became Associate Professor. Her research interests, though centering on, are not limited to environmental engineering and wastewater treatment. Dr. Zhang believes the solution to mankind's environmental problems requires interdisciplinary collaboration and holistic mindset. Therefore, her present research involves the interconnection of resource reclamation from waste streams, new materials and renewable energy, as well as social aspects and human values.

K-25 - Scaling up of Polyhydroxyalkanoates (PHA) Production from Toxic Feedstock: Influence of Operational Modes

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Abstract: Polyhydroxyalkanoates (PHA) are biodegradable intracellular polymers, and a renewable alternative to fossil fuel based plastics. To reduce PHA's cost, this study applied an unconventional, toxic carbon source, i.e. phenol, to an acclimated consortium, to develop scalable PHA production processes by exploring various operational modes. Batch, fed-batch, and continuous feeding modes were systematically compared for their resultant process performance. Phenol toxicity led to inhibition under batch mode, reducing the PHA synthesis rate but resulting in a high PHA content in cells (PHA% > 50%). Fed-batch feeding alleviated such inhibition, facilitating a high PHA titer and yield from the substrate. Using a continuous mode also reduced phenol toxicity, but saw the

synthesis of more non-PHA cellular materials (NPCM). Comparing all 14 conditions under the three modes, feeding phenol more gradually tended to channel substrate away from PHA to NPCM synthesis. The volumetric productivity generally ranged from 3 to 12 mg L^{-1} min^{-1}, while the biomass productivity was between 2 and 11 mg/g initial CDW^{-1} min^{-1}. A 3-stage, production-harvest and starvation production process was then designed to simulate industrialized manufacturing. Fed batch mode again performed the best, as it fixed 1/3 of phenol's organic carbon in PHA product, suggesting high potential for future application.

Keywords: Batch; Continuous; Fed-batch; Phenol; Polyhydroxyalkanoate (PHA); Productivity

Oral Presentation

Theme I: Biological waste/wastewater treatment

O-A-1 - Electrodialysis-based Approaches for Simultaneous Water Reclamation and Resource Reuse from Brackish Wastewater

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Abstract: Compared with conventional wastewater treatment, which primarily focuses on pollution mitigation, electrodialytic-based processes have emerged as innovative approaches that integrate wastewater treatment, water reclamation, and sustainable resource management. These technologies offer remarkable advantages, such as ion selectivity, energy efficiency, and chemical-free operation. This study develops a sandwich-type bipolar membrane electrodeionization (BMEDI) module to recycle organic acids from wastewater. Within process, water splitting is a critical step, providing H^+ and OH^- ions that help stabilize overall conductivity and current. Preliminary experiments were therefore conducted to evaluate water-splitting performance. The voltage applied to the stack is consumed through Ohmic drop, concentration polarization, and reaction overpotential. Experimental results indicate that, the total voltage loss is proportional to the applied voltage (10-20 V), providing a fundamental basis for future scale-up designs. In the application for recovering formic acid (HCOOH), the combined action of the electric field and ion-exchange membranes facilitates the transport of formate ions ($HCOO^-$) from waste stream (dilute chamber) to the concentrate chamber, enabling the recovery of purified HCOOH. Given the variability in module configurations and operating parameters, identifying key performance indicators, such as energy consumption, recovery rate, and energy efficiency, is essential for evaluating and optimizing process performance.

Keywords: Electrodialytic-based processes; BMEDI; Resource recovery; Module scale-up; Optimization

O-A-2 - Performance of a Pilot-scale Sand Moving Bed Biofilm Reactor for Nitrogen Removal in a Seawater Recirculating Aquaculture System

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Abstract: The biological filtration and purification units are the core component of seawater recirculating aquaculture systems (sRAS), and selecting the appropriate reactor type is crucial for removing pollutants from aquaculture water and ensuring the safety of cultured organisms. In this study, a sand moving bed bioreactor (SMBBR) characterized by low energy consumption, high circulation capacity, and stable oxygen levels was designed and constructed. The reactor achieved rapid startup, with the nitrosification process starting in 15 days and the nitrification process starting in 34 days. After 68 days of operation, the SMBBR achieved ammonia and nitrite oxidation rates of 5.7 mg N/L/h and 7.5 mg N/L/h, respectively. Once stabilized, the reactor achieved an ammonia nitrogen load of 396.0 g N/d and a nitrite nitrogen load of 283.2 g N/d. The theoretical carrying capacity of cultured organisms (fish) in the sRAS was 302.6 kg, equivalent to a stocking density of 75.7 kg/m³. The dominant ammonia-oxidizing and nitrite-oxidizing bacteria were identified as *Nitrosomonas* and *Nitrospina* in the sand carrier. The SMBBR effectively filtered without clogging, facilitating robust biological nitrification processes and promising significant applications in safeguarding water quality in sRAS.

Keywords: Biological filters; Aquaculture wastewater treatment; Ammonia-oxidizing bacteria (AOB); Nitrite-oxidizing bacteria (NOB); Heterotrophic nitrifying-aerobic denitrifying bacteria (HN-ADB)

O-A-3 - New Insights into How Carbon Substrates Shape Nutrient Removal and Microbial Community Assembly Mechanisms in an Integrated Simultaneous Methanogenesis-Feammox-denitrification System

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Abstract: A limited understanding of microbial community assembly and metabolic

mechanisms in an integrated simultaneous methanogenesis-Feammox-denitrification (SMFD) system, particularly with different substrates, has hampered the optimization and development. In this study, SMFD reactors fed with distinct carbon substrates (sodium acetate, R_{NaAC}; glucose, R_{GLU}; methanol, R_{MeOH}; and their mixture, R_{Mix}) were constructed to investigate the nutrient removal efficiency, microbial assembly, and metabolic mechanisms for treating aquaculture wastewater. R_{Mix} exhibited higher methane yield by 39.2%, 6.1%, and 23.9%, respectively, compared to R_{NaAC}, R_{GLU}, and R_{MeOH}. The results indicated that acetate preferentially stimulated dissimilatory iron reduction, thereby limiting methanogenesis through substrate competition. Notably, the dominant iron reducing bacteria (IRBs) shifted from *Anaerolinea* in single-substrate systems to *Chloracidobacterium* in R_{Mix}, alleviating competition between Feammox and DIR for Fe(III) resources, thus enhancing ammonia nitrogen removal rates by 41.6%-53.4%. The analysis of microbial community and metabolic pathways revealed that mixed carbon substrates helped autotropic microbes resist the competitive pressure from heterotrophic bacteria, improving the balance between IRBs, denitrifiers, and methanogens. These results contributed to our understanding of how substrates shape distinct microcosms in SMFD systems, providing valuable insights for guiding the future construction and management of SMFD systems.

Keywords: Aquaculture wastewater; Methane production; Nitrogen removal; Metagenomic analysis

O-A-4 - Development and Application of a Three-loop Recirculating Freshwater Aquaculture System

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Abstract: A pilot intensive three-loop recirculating freshwater aquaculture system (RAS) was developed in Qionghai, Hainan province, China. Backwashing water from a microfilter was used as the carbon source for the denitrification process. An operation mode is established to ensure the water quality and fish sludge to comply with the requirements for fish growth and pollution control. Tilapia *(Oreochromis mossambicus*) was cultured in the RAS for 121 days. The results showed that the tilapia had a survival rate of 100%, with the stocking density and the feed conversion ratio (FCR) being 107.7 $kg \cdot m^{-3}$ and 1.74 respectively. The average concentrations of total ammonia, nitrite and nitrate were 0.95, 0.15 and 43.01 $mg \cdot L^{-1}$ respectively. The volume for daily water drainage was 2.66% of the total water volume, and 6.67% of the water volume in the fish

tank. No fish sludge was discharged throughout the experiment, and only a small amount of sludge existed in the anaerobic digestion unit. Microbial community analysis showed that a total of 21 genera of microorganism were involved in nitrogen metabolism, including *Rhodobacte*, *Flavobacterium* and *Azospira*. These results implicated that the RAS provides a potentially sustainable and ecological aquaculture mode for freshwater fish.

Keywords: Recirculating aquaculture system; Three-loop treatment; Denitrification; Carbon source; Anaerobic digestion

O-A-5 - Partial Nitritation and Anammox for Saline Sewage Treatment

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Abstract: Large amounts of saline municipal wastewater are often generated in global coastal areas due to the application of seawater toilet flushing and/or occasional seawater incursion into municipal wastewater treatment plants (WWTPs). Mainstream anammox has been rated as the best nitrogen removal technology to enable the upgrade of existing WWTPs from energy-intensive to energy-positive. Application of anammox for saline municipal wastewater treatment is yet to be explored. In this talk, two case studies on the application of partial nitritation and anammox (PN/A) for treating saline sewage will be shared. Our lab-scale PN/A exhibited resilience to recurrent seawater incursions, gaining stable nitrogen removal of 150.0 ± 8.0 and 78.5 ± 12.1 g $N/m^3/d$ on freshwater and saline sewage, respectively, with producing high quality effluent of < 3 mg NH_4^+−N/L and < 10 mg TN/L. Microbial community analysis indicated that *Nitrosomonas* (2.1%), *Brocadia* (11.3%) and *Kuenenia* (20.4%) mainly responded to the nitrogen removal. Nitrate-to nitrite reducers, e.g., *Diaphorobacter*, *Aridibacter*, and *Quisquiliibacterium*, in total accounting for 0.9%−6.2%, was observed to offset Nitrospira's activity by turning nitrate to nitrite so as to underpin the metabolism of anammox bacteria given the persistence of *Nitrospira* (~2.3%). Our pilot-scale PN/A, started from saline anaerobic digestion sludge, achieved comparable nitrogen removal of ~78.3 g $N/m^3/d$ treating saline sewage at 3.2 m^3/d. Excluding *Scalindua*, common-freshwater-observed *Kuenenia* proliferated in biofilms, representing 1.2 ± 0.1%. Metagenomic sequencing analysis indicated the C-N-S synergy of nitritation, anammox, sulfate reduction, and mixotrophic denitrification in the system. Together, our work certified that PN/A is competent to treat saline sewage for stringent nitrogen discharge and displays stably high-rate nitrogen removal comparable to that of the conventional activated sludge process. Knowledge gleaned from our studies could serve as a strong technical base for the extension of anammox to saline wastewater treatment.

Keywords: Anammox; *Kuenenia*; Nitrite-oxidizing bacteria; Saline sewage; Salinity

O-A-6 - Biogas-driven Denitrification Efficiency and Mechanisms in Membrane Biofilm Reactors

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Abstract: Conventional biological nitrogen removal relies on external organic carbon, while biogas from sludge anaerobic digestion contains CH_4, CO_2, and trace H_2S that, if unused, cause resource loss and greenhouse gas emissions. This study investigated a novel methane-driven denitrification process in membrane biofilm reactors (MBfRs) using simulated biogas mixtures and different electron acceptors (NO_3^-, NO_2^-). Long term operation achieved stable and complete nitrogen removal (up to 100%), with trace H_2S markedly enhancing removal rates and short-chain fatty acids (SCFAs) accumulation. Batch tests confirmed SCFAs as essential intermediates linking gaseous carbon to aqueous denitrification. Microbial and metagenomic analyses revealed a shift from heterotrophic dominance to a C-N-S cycling network involving methane oxidizers (*Methylocystis*), CO_2-fixing acidogenic bacteria (*Desulforhabdus*), and multifunctional denitrifiers (*Paracoccus*). Functional genes indicated coexisting incomplete methane oxidation and CO_2 reduction via the Wood-Ljungdahl pathway, converging at acetyl CoA for acetate synthesis. Stable isotope labeling showed CH_4 and CO_2 contributed directly to acetate formation. These findings uncover a dual-carbon-source, SCFA centered denitrification mechanism, providing a theoretical basis for biogas resource recovery and low-carbon wastewater treatment.

Keywords: Biogas utilization; Methane oxidation coupled denitrification; Microbial metabolism; Short-chain fatty acids; Stable isotope labeling

O-A-7 - The Treatment Efficiency and Mechanism Analysis of Activated Sludge in a Slightly Bulking State for Wastewater with Different Carbon-to-Nitrogen Ratios (C/N)

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Abstract: Sequencing batch reactor (SBR) was used to treat domestic wastewater, and the start-up conditions of slightly bulking activated sludge process was investigated under the combined effects of low dissolved oxygen (DO) and low sludge loading (N_s). Additionally, different influent COD/NH_4^+-N (C/N) ratios (C/N) were designed to examine their impact on nitrogen and phosphorus removal efficiency. The results indicated that, under conditions of DO ranging from 0.5 to 0.8 mg/L and Ns between 0.10-0.12 kg COD/(kg MLSS d), the slightly bulking activated sludge process could be successfully initiated, with the sludge volume index (SVI) stabilizing at about 262 mL/g. As the influent C/N ratio increased, the number and size of mycelial clumps within the system gradually increased, leading to significant changes in the microbial community, with the abundance of *Thiothrix* increasing from 30.21% to 54.41%. The influent C/N ratio had a minor impact on COD and NH_4^+-N removal efficiencies, with COD removal rates reaching 97.21% and NH_4^+-N removal rates exceeding 98%. But it significantly affected TN and TP removal efficiencies. When the influent C/N ratios were 4, 6, and 11, the average TN removal efficiencies of the system were 37.15%, 52.65%, and 77.94%, respectively, and the average TP removal efficiencies were 36.82%, 45.71%, and 64.30%.

Keywords: Slightly bulking activated sludge; Nitrogen and phosphorus removal; Low dissolved oxygen; Sludge loading; *Thiothrix*; Domestic wastewater

O-A-8 - Role of *Comammox Nitrospira* in an Oxygen-limited DHS Reactor

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Abstract: Complete ammonia oxidation (Comammox) is a promising pathway for nitrogen removal in municipal wastewater treatment. This study investigated the enrichment of *Comammox Nitrospira* and its role in nitrogen transformation under oxygen-limited conditions in a down-flow hanging sponge (DHS) reactor. The reactor was operated for 335 days with 30 mg-N L^{-1} ammonium, a hydraulic retention time of

7.0 hours, and a loading rate of 0.10 kg-N m^{-3} day^{-1}. From days 209 to 359, dissolved oxygen was maintained below 2 mg/L, and ammonia removal averaged 80 ± 11% (Fig. 1.). 16S rRNA gene sequencing on day 224 revealed that *Nitrospira* spp. and *Nitrosomonas* spp. accounted for 27.6 ± 8.3% and 4.5 ± 2.8% of the microbial community, respectively. Planctomycetes, which include Anammox bacteria, were also detected at a relative abundance of 5.7 ± 1.8%. Despite the dominance of *Nitrospira*, 43% of the input nitrogen remained as nitrite, indicating incomplete nitrification. Metagenomic analysis conducted on day 224 confirmed *Candidatus Nitrospira* nitrificans; however, high-quality metagenome-assembled genomes for other *Nitrospira* spp. could not be reconstructed. These findings suggest that *Comammox Nitrospira* contributed to partial nitrification under oxygen-limited conditions and likely facilitated the coexistence of Comammox and Anammox bacteria within DHS reactors.

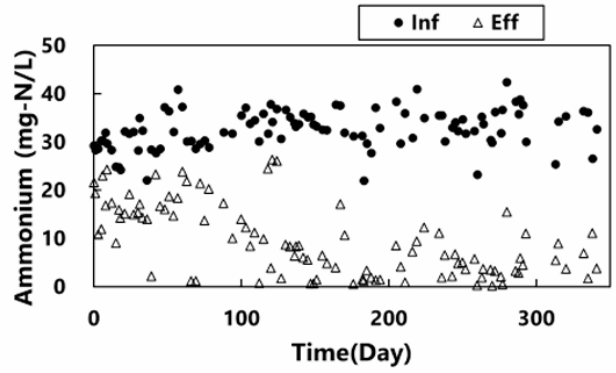

Fig. 1. Ammonia removal performance

Keywords: Comammox; Nitrification; Trickling filter

O-A-9 - Phosphorus Recovery and Microcystin Degradation from Water Blooms by the Sediment-based Biofilm Treatment System

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Abstract: Phosphorus is an essential substance used as a fertilizer in agriculture. However, its production is declining, and export restrictions worldwide are leading to increased prices. In eutrophic lakes, harmful algal blooms, primarily caused by Microcystis, produce the toxic substance microcystin (MC). Some species of Microcystis have also been found to accumulate phosphorus in their cells. This study aims to develop

a reactor capable of degrading MC and recovering phosphorus from algal blooms while examining the optimal operation conditions. Two mother reactors were constructed for culturing biofilm on the polyethylene (Kaldnes K1) and sponge carrier. Biofilm carriers containing MC degrading bacteria and polyphosphate-accumulating organisms (PAOs), which uptake and release phosphorus under specific conditions, were cultured from lake sediments. The cultured biofilm carriers were applied to the batch experiments in the test reactor under three conditions: high MC concentration, high sodium acetate concentration, and high air flow rate. The performance of the reactor was compared across these different conditions, which were used to determine the optimal conditions for novel reactor design and development.

Keywords: Biofilm reactor; Eutrophic lakes; Microcystin; Microcystis; Phosphorus; Polyphosphate-accumulating organisms

O-A-10 - Advanced High-rate Wastewater Treatment: Key Insights from Anammox-HAP in IC Reactor

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Abstract: This research conducted a comprehensive evaluation of nitrogen removal and phosphorus recovery performance of the high-rate anaerobic ammonium oxidation-hydroxyapatite (Anammox-HAP) in an internal circulation (IC) reactor. Under dual-circulation strategy, the system achieved a nitrogen removal rate of 23.3 g N/L/d and a phosphorus recovery rate of 0.79 g P/L/d. During the long-term operation, co-enrichment of biomass and inorganic in Anammox-HAP granules significantly enhanced their mechanical strength and settling performance. Microbial community analysis demonstrated that elevating influent total nitrogen concentration effectively phased out heterotrophic nitrifying aerobic denitrifying bacteria (*Acinetobacter* and *Exiguobacterium*), establishing dominance of anaerobic ammonia oxidation bacteria (*Ca. Kuenenia*) and denitrifying bacteria (*OLB13*, *SJA-28*, and *Denitratisoma*). Comparatively, reducing hydraulic retention time proved more effective in enhancing specific anammox activity. A novel "rupture-recycle-restart" strategy enabled recovery of HAP cores from over-mineralized granules and achieved rapid restart-up of the reactor and regranulation of broken sludge within 11 days. These results demonstrate the viability of IC-Anammox-HAP systems for high-load wastewater treatment, concurrently providing insights into optimizing granular stability and resource recovery.

Keywords: Anammox; Hydroxyapatite; Internal circulation reactor; Operational strategy

O-A-11 - The Enhanced Degradation Mechanism of 17 α-Ethynylestradiol by Group Induction in Microbial Electrochemical Systems

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Abstract: This study examined the enhancement of the endocrine disruptor 17α-ethinylestradiol (EE2) degradation in microbial electrochemical systems (MES) via quorum sensing (QS) activation by externally adding acyl-homoserine lactones (AHLs). QS activation significantly improved EE2 removal efficiency (37.12–42.49%), reduced internal resistance (4.81–85.71%), and markedly increased maximum power density (26.20–519.05%). Component analysis of extracellular polymeric substances (EPS) in the anodic biofilm revealed that QS induction significantly increased the protein content in EPS by 216.99%–293.60%. Microbial community analysis indicated a notable enhancement in the relative abundance of electrochemically active microorganisms and key degradative genera following the addition of AHLs. Combined with the analysis of EE2 degradation products, it was demonstrated that the introduction of signaling molecules altered EPS composition and increased the relative abundance of electrochemically active microorganisms, thereby enhancing extracellular electron transfer efficiency. This effectively promoted the redox processes of EE2, resulting in improved EE2 removal efficiency.

Keywords: Bioelectrochemistry; Ethinylestradiol; Microbial electrochemical system; Quorum sensing; Signaling molecule

O-A-12 - Recirculating Aquaculture Systems under Artificial Intelligence Control for High-density Cultivation: A Case Study of *Litopenaeus vannamei*

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Abstract: Driven by rising demand for high-quality protein and sustainable development goals, recirculating aquaculture system (RAS) is emerging as a key solution for sustainably producing high-value species like *Litopenaeus vannamei*, with reduced water and energy consumption. Combining with artificial intelligence and automatic control, RAS has a high potential for an intensive cultivation of *Litopenaeus vannamei*. In this study, an image recognition model trained by manually annotated datasets achieved over 98% accuracy in shrimp identification along with functions of counting, estimating body length and weight, while uneaten feed and mortality can also be monitored. Automatic control enables precise control of aeration (maintaining DO > 5 mg/L), water circulation (50% of total volume per hour), water replenishment (maintaining a 1 m depth), sewage return device (solid-liquid separation), and pH adjustment (maintaining pH 7.6–8.2). The AI-dominated system is used to manage all data in shrimp farming operation, allowing farm operators to manage the entire RAS system through simple communication interaction. Overall, the intelligent RAS reached 10 kg of *Litopenaeus vannamei* per ton of water combined by utilizing efficient water treatment and saving more than 95% water usage than conventional RAS, demonstrating its potential for sustainable and efficient aquaculture.

Keywords: Smart farming; Recirculating aquaculture system (RAS); Artificial intelligence (AI); Smart farming; Water-efficient aquaculture

O-A-13 - Construction of Stable Niches for Denitrifiers Using 3D Bioprinting for Efficient Nitrogen Removal

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Abstract: The denitrification process is the core of biological nitrogen removal technology, but its efficacy is limited by the fragile ecological niches of denitrifying bacteria. This study successfully created three-dimensional (3D) denitrification living materials by the controllable and biocompatible 3D bioprinting technology, enabling the construction of artificial 3D microscale structures that facilitate microenvironments for the efficient dynamic reactions of denitrifying bacteria. By developing the double network structure of sodium alginate–gelatin, the bioink with easy extrusion and robust mechanical properties was obtained. Subsequently, the denitrifying bacteria were arranged in three dimensions through a 3D bioprinting platform, and the living materials characterized by precisely controlled three-dimensional morphology and excellent dynamic metabolism were created. The results further indicated that the stable denitrifying bacterial niches were successfully established within 3D living materials,

resulting in a significant improvement in the denitrification performance. Additionally, the 3D living materials still maintained high bacterial activity at the low temperatures, showing their potential for repeated use and tolerance to adverse conditions. This study demonstrated the potential of 3D bioprinting technology in constructing living materials with ideal bacterial niches for efficient wastewater treatment, thereby offering novel avenues for addressing the water pollution concerns.

Keywords: 3D bioprinting; Denitrification niche; High bacterial activity; Living materials; Wastewater treatment

O-A-14 - Regulation of Microcurrent on Carbon and Nitrogen Metabolism in Denitrification under Low Carbon-to-nitrogen Ratio: Optimizing Carbon Flux Distribution

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Abstract: Synergy of autotrophic and heterotrophic denitrification can achieve low-carbon and high-efficient nitrogen removal. However, it remains unclear how microcurrent dominating hydrogen autotrophic denitrification regulates carbon flux distribution (nitrogen reduction, poly-β-hydroxyalkanoate (PHA) storage, and cell growth) in heterotrophic denitrification. This work compared biofilm reactor (BR) with biofilm electrode reactor (BER) under different carbon-to-nitrogen (C/N) ratios (10 - 3). In contrast to sufficient carbon sources (C/N ratios of 10 and 5), microcurrent accelerated nitrate reduction rate by 0.35 mg/L·min and reduced nitrite accumulation by 10.29 mg/L at C/N ratio of 3, thus decreasing nitrogen reduction proportion by 11.21%. While PHA storage proportion and cell growth proportion increased by 0.03% and 11.18%. PHA storage demonstrated to be initially formed and then utilized for nicotinamide adenine dinucleotide (NADH) and energy. Limited carbon sources were preferentially used for cell growth to maintain system stability. Moreover, less NADH production and downregulated complex I expression proved the decreased nitrogen reduction proportion under microcurrent simulation. Increased abundance of hydrogen autotrophic denitrifiers, heterotrophic denitrifiers, and PHA storage bacteria confirmed optimization of microcurrent on carbon flux distribution. These findings advanced the understanding of microcurrent regulation on carbon flux.

Keywords: Nitrogen reduction; Poly-β-hydroxyalkanoate (PHA) storage; Cell growth; Electron behaviors; Microbial community

O-A-15 - Co-cultivation of *Cyclotella* and a Filamentous Fungus for Effective Treatment of Palm Oil Mill Effluent

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Abstract: Palm Oil Mill Effluent (POME) is a high-risk environmental pollutant from the palm oil industry due to its high nutrient load and pigmentation. In a previous study, a co-culture experiment was set-up to investigate the potential of a bacterial–algal consortia of *Cyclotella* sp. and photosynthetic bacteria (PSB) in POME treatment. During the experiment, the spontaneous formation of a stable floc composed of the diatom *Cyclotella* sp. and an unidentified filamentous fungus was observed. The fungus formed a visible structural matrix, resulting in a distinct microalgal floc. This colony floc was isolated and cultivated in artificial POME to evaluate its treatment efficiency. The results demonstrated an effective reduction in chemical oxygen demand (COD), nitrogen, and phosphorus levels. In addition, the discoloration capacity of the effluent was notable, as the chroma of the solution was reduced markedly, indicating effective pigment removement. Preliminary morphological analysis suggested that the fungus may belong to the species of *Aspergillus* sp., due to its white-translucent septate hyphae exhibiting dichotomous branching and globose conidial heads. These results highlighted the potential of the naturally formed fungal–algal consortia as a sustainable and efficient approach for POME treatment.

Keywords: POME treatment; Fungal-algal consortia; Discoloration; Nutrient removement

O-A-16 - Multidimensional Insights into the Impact Mechanisms of Toxicant Stress on Anammox System

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Abstract: Anaerobic ammonium oxidation (anammox) is efficient and cost-effective for

treating high-strength ammonia wastewater, but the toxicant (such as heavy metals and organics) in wastewater will affect its stability. To address this challenge, it is crucial to gain a deep understanding of the inhibitory effects and mechanisms of toxicant stress on anammox bacteria. The work provided a comprehensive classification of organics and evaluated their effects on the anammox system according to their respective characteristics, and re-evaluated the heavy metals toxicity from the inhibition effects and the inhibition recovery. Based on the micro to macro perspective, the "molecule-cell ecology" inhibitory mechanism of toxicant stress on anammox bacteria was proposed. The molecular observation summarized the binding process and action sites of toxicant with anammox bacteria. At the cellular observation, the mechanisms of toxicant effects on extracellular polymeric substances, membranes, and anammoxosome were expounded. At the ecological observation, the dynamic changes in coexisting populations and their role in toxicant transformation were discussed. Inhibition mitigation strategies such as bio-accelerators, bio-augmentation and spatial engineering of microbial community were suggested to enhance anammox system resilience. This work offered a multidimensional understanding of the toxicant inhibitory mechanism of anammox bacteria and provided a theoretical foundation for anammox systems.

Keywords: Anammox; Inhibition; Inhibition mitigation strategies; Mechanism; Multidimensional perspectives; Toxicant

O-A-17 - Delineation of Microbial Nitrogen-metabolic Network in an Anammox Driven Full-scale Wastewater Treatment Plant

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Abstract: Microbial-driven nitrogen removal is the crucial step in full-scale wastewater treatment plants (WWTPs), a better understanding of the overall nitrogen cycling networks is therefore a prerequisite for the further enhancement and optimization of wastewater treatment processes. In this study, metagenomics and metatranscriptomics were used to elucidate the microbial nitrogen removal processes in an ammonium-enriched full-scale WWTP, which was configured as an anaerobic-anoxic-anaerobic-oxic system for efficient nitrogen removal (99.63%) on a duck breeding farm. A typical simultaneous nitrification-anammox-denitrification (SNAD) process was established in each tank of this WWTP. Ammonia was oxidized by ammonia-oxidizing bacteria (AOB), archaea (AOA), and nitrite-oxidizing bacteria (NOB), and the produced nitrite and nitrate were further reduced to dinitrogen gas (N_2) by anammox and denitrifying bacteria. Visible red anammox biofilms were formed successfully on the sponge carriers submerged in the

anoxic tank, and the nitrogen removal rate by anammox reaction was 4.85 times higher than that by denitrification based on ^{15}N isotope labeling and analysis. This supports the significant accumulation of anammox bacteria on the carriers responsible for efficient nitrogen removal. Two distinct anammox bacteria, named '*Ca*. Brocadia sp. PF01' and '*Ca*. Jettenia sp. PF02', were identified from the biofilm in this investigation. By recovering their genomic features and their metabolic capabilities, our results indicate that the highly active core anammox process found in PF01, suggests extending its niche within the plant. With the possible contribution of the dissimilatory nitrate reduction to ammonium (DNRA) reaction, enrichment of PF02 within the biofilm may also be warranted. Collectively, this study highlights the effective design strategies of a full-scale WWTP with enrichment of anammox bacteria on the carrier materials for N removal and therefore the biochemical reaction mechanisms of the contributing members.

Keywords: Anammox; Biofilm; Nitrogen cycle; ^{15}N isotope labeling; SNAD

O-A-18 - PAC-enhanced MBCR for Rural Wastewater Treatment in Warm Climates: Achieving Superior Nutrient Removal and Membrane Fouling Mitigation

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Abstract: Decentralized wastewater treatment in rural areas posed critical challenges under warm climate conditions, particularly in achieving effective nutrient removal and mitigating membrane fouling from low-carbon source influents. This study evaluated a modified biofilm membrane bioreactor (MBCR) integrated with polymeric aluminum chloride (PAC) and polymeric ferric sulfate (PFS) as inorganic flocculants. Simulated rural domestic wastewater (C/N ≈ 6:1) containing glucose, NH_4^+-N, and phosphate was treated under steady-state conditions. The MBCR system consistently achieved ~95% removal of COD, NH_4^+-N, and TN, while TP removal ranged from 63.3% to 65.4%. Notably, PAC addition elevated TN removal to 60% and enhanced TP elimination to 99%, outperforming conventional MBR systems. Although COD and NH_4^+-N removal remained largely unaffected, PAC significantly reduced membrane fouling, as confirmed by scanning electron microscopy. Compared with PFS, PAC formed smaller flocs that alleviated pore blockage and preserved membrane permeability. These findings demonstrated the synergistic effect of PAC-enhanced flocculation and biofilm-based retention in improving membrane stability and nutrient separation. The PAC-assisted MBCR provided a cost-effective and robust solution for rural wastewater treatment, especially under high-temperature conditions. This work offered a promising foundation

for developing sustainable sanitation strategies in decentralized and thermally stressed regions.

Keywords: MBCR; PAC; Nutrient removal; Membrane fouling; Rural wastewater; Warm climate

Theme II: Bioenergy and Resource Recovery

O-B-1 - Mechanistic Insights into C-S-Fe-P Transformations in Anaerobic Co-digestion of Iron–phosphorus Compounds Containing Sludge with Sulfur Containing Biomass

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Abstract: Anaerobic co-digestion of sulfur-containing biomass with waste activated sludge containing iron–phosphorus compounds (FePs) is an environment-friendly strategy to promote phosphate release, energy recovery, and hydrogen sulfide (H2S) control. Nevertheless, the concurrent transformation of carbon, sulfur, iron, and phosphorus within this system remains unclear. To address this knowledge gap, methionine, a typical hydrolysis product of sulfur-containing biomass, and five FePs prevalent in sludge (ferric-phosphate tetrahydrate ($FePO_4{\cdot}4H_2O$), ferric-phosphate dihydrate ($FePO_4{\cdot}2H_2O$), vivianite ($Fe_3(PO_4)_2{\cdot}8H_2O$), phosphate coprecipitated with Fe(III) (COP-P), and phosphate adsorption on hydrous ferric oxide (HFO-P)) were selected to elucidate C-S-Fe-P transformations in this study. The results showed that the H_2S and methyl mercaptan productions decreased by > 96% and > 99%, respectively, while the methane production rate increased by 51.60–103.9% in the presence of FePs. The reaction between FePs and sulfide promoted the transformation of gaseous H_2S and aqueous S^{2-} to solid sulfur species, while simultaneously promoting the release of PO_4^{3-} from FePs. The formation of Fe(II) species derived from both abiotic sulfide-driven reduction and microbial-mediated iron reduction processes. The reduction rates of $FePO_4$ were higher than those of COP-P and HFO-P, owing to their higher thermodynamic favorability. A negative correlation was observed between the Fe/P molar ratio and PO_4^{3-} release efficiency. $FePO_4$ with the lowest Fe/P molar ratio achieved the highest P release efficiency. Metagenomics analysis revealed that the gene related to the degradation of methanethiol to sulfide was upregulated by 21.12–51.72% in the presence of FePs, and the genes involved in propionate metabolism, methylotrophic, and hydrogenotrophic methanogenesis were up-regulated concurrently. This study provides an in-depth understanding of C-S-Fe-P interactions and transformations during the anaerobic co

digestion systems, facilitating both methane production and the phosphorus recovery.

Keywords: Anaerobic co-digestion; C-S-Fe-P interaction; Iron-phosphorus compounds; Phosphate release; Sulfur-containing biomass; Waste activated sludge

O-B-2 - Odorous Gas Generated during Food Waste Biotreatment: Emission Characteristics, Health Risks, and Treatments

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Abstract: Food waste management is an important global issue for sustainable development, and biotreatment is a favourable technology for reducing and recycling food waste. However, odorants are generated during food waste biotreatment, and have caused considerable public complaints. To solve this problem, we collected the gas samples from different food waste biotreatment plants, including three anaerobic digestion (AD) plants and an insect-based bioconversion plant, analyzed the odorant emission characteristics, and evaluated the health risks of the odorants to identify the major odor and health risk contributors. In addition, the odor control performances and secondary pollution problem of chemical scrubbing and biotrickling were investigated in a food waste AD plant. It was found that odor nuisance and health risks existed in different areas of the food waste biotreatment plants. Methanethiol, propanethiol, H_2S, and acetaldehyde were identified as the major odor contributors, and acetaldehyde was identified as the underestimated major carcinogenin in AD plants, while trimethylamine and acetaldehyde were the key odorant and carcinogen, respectively in the breeding area of the insect-based bioconversion plant. Moreover, it was notable that the secondary pollutants, such as acetaldehyde, sulfur compounds, and greenhouse gases, were generated during the chemical scrubbing and biotrickling processes.

Keywords: Biotreatment; Food waste; Health risk; Odor; Secondary pollution

O-B-3 - Evaluation of An Anaerobic Digestion/Pyrolysis Co-processing System for Sustainable Food Waste Valorization

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Abstract: The study assessed the economic and environmental feasibility of segregating food waste (FW) into liquid (slurry) and solid fractions with inert impurities, and

processing each fraction using anaerobic digestion (AD) and pyrolysis (ADCo-Py), respectively. Biomethane potential tests showed higher methane production from FW slurry (572.88 mL/gVSfs) compared to the whole fraction FW (294.37 mL/gVSfs). Pyrolyzing the solid FW fraction reduced nitrogen compounds in bio-oil by 62% compared to the whole FW fraction, promising a low-nitrogen biodiesel product. While all systems required external energy, AD integrated with incineration (ADCo-INC) required the least. Techno-economic analysis favored ADCo-Py, with a net present value (NPV) of $15 million and internal rate of return (IRR) of 34%, surpassing even ADCo INC. Life cycle analysis (LCA) for environmental impact Indicated that both ADCo-Py and ADCo-INC were feasible in mitigating global warming potential (GWP) than stand-alone AD or pyrolysis. Pretreatments had the most significant influence on GWP, ecotoxicity potential (ETP), and acidification potential (AP). ADCo-Py was the most advantageous among all systems due to higher product yield, making it a more sustainable waste-reducing option in the circular economy. These findings highlight the possibility of replacing the matriculas FW source separation at the consumer side by ADCo-Py system at the end treatment side for better energy and economic achievements in sustainable waste management.

Keywords: Anaerobic digestion; Pyrolysis; Food waste contaminants; Bioenergy; Resource recovery; Circular economy

O-B-4 - Integrated Biogas Upgrading and Fertilizer Production Using Electrochemical pH Swing Technology

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Abstract: Bioenergy with carbon capture and utilization (BECCU) is an emerging strategy that integrates low-carbon energy production with negative carbon emission technologies. Biogas, a gaseous-phase biomass resource, typically consists of methane (CH_4), carbon dioxide (CO_2), and trace impurities. While its high methane content contributes to a strong heating value, the presence of CO_2 and other impurities

significantly reduces the specific heating capacity. This study develops a biogas upgrading system based on an electrochemical pH swing device, incorporating CO_2 capture and utilization technologies, and evaluates its operational performance. The pH swing mechanism generates a strongly alkaline solution, which enhances CO_2 solubility and facilitates its conversion into value-added resources such as fertilizer production, thereby improving biomass productivity and contributing to circular agriculture. In this study, the electrochemical pH-swing device is operated under continuous conditions, and the effect of key operational parameters including applied cell voltage, optimal operation time, and gas-to-liquid ratio is systematically investigated. Experimental results confirm that the proposed electrochemical system efficiently transforms CO_2 into an aqueous bicarbonate solution. The electrochemical process can be sustained within an operating range of 1–3 V per cell, with higher voltage enabling higher gas-to-liquid ratios; however, excessive gas holdup must be carefully avoided. By coupling CO_2 removal with downstream biological utilization, the process offers a closed-loop strategy for renewable energy generation and carbon valorization. These findings highlight a practical pathway toward BECCU, supporting the broader goals of circular bioeconomy development.

Keywords: Biogas upgrading; BECCU; Electrochemical separation; Sustainable agriculture

O-B-5 - Growing Duckweed in Swine Wastewater and Its Conversion to Biofuel

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Abstract: *Spirodela polyrrhiza*, a fast-growing duckweed with high starch and low lignin content, shows promise as a feedstock for bioenergy. Abscisic acid (ABA) is a biological hormone that controls plant growth and stress response. The effects of different ABA concentrations on duckweed biomass growth, carbon dioxide fixation, formation of photosynthetic pigments (Chlorophyll a, Chlorophyll b, and carotenoids), the activities of soluble starch synthase and starch branching enzyme, and the starch content of biomass were investigated. The results showed that the highest starch content in duckweed (21.8% dry weight) was achieved in 1.0×10^{-2} mg/L ABA medium, 70.3% higher than that of the control medium without ABA. The highest adenosine diphosphate (ADP)-glucose pyrophosphorylase activity was observed in the 1.0×10^{-2} mg/L ABA medium, which was caused by the up-regulation expression of ADP-glucose pyrophosphorylase 2. Further investigations on cell ultra-structures and stomatal property of the duckweed indicated that ABA increased the number and size of starch granules and stomatal size in duckweed cells. These enhancements lead to a greatly improved energy flow in the aquatic plant from photosynthesis to carbon storage, making duckweed a potential renewable bioenergy crop. After enzymatic hydrolysis and yeast fermentation, 94.7% of

the theoretical starch conversion was achieved.

Keywords: Abscisic acid; Bioethanol; Enzyme; *Spirodela polyrrhiza*; Starch; Swine wastewater

O-B-6 - Effects of Fluctuations in Hydrogen Partial Pressure on In-situ Biomethanation

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Abstract: In-situ biomethanation enhances methane concentration by converting biogas CO_2 through its reaction with hydrogen. Previous studies have investigated hydrogen supply under mesophilic conditions using sludge with an organic loading rate (OLR) of approximately 1 g VS/L/d. This study aimed to elucidate the effect of hydrogen partial pressure under conditions where OLR was increased to 2 g VS/L/d. Laboratory-scale batch experiments were conducted using dog food as the organic substrate. The effects of three hydrogen supply ratios (H_2/CO_2 = 1.3, 4.0, 6.7) and three different K_La values (approximately 4, 8, 12 h^{-1}) on pH and organic acid accumulation characteristics were evaluated. When the hydrogen supply speed was increased (initially 4 L/L/d), the pH decreased to 6.6, and organic acid accumulation was observed. Although previous studies have reported an elevation in pH, a sharp decline in hydrogen partial pressure tended to reduce the pH. A sudden reduction in hydrogen partial pressure from 0.93 to 0 atm was found to impact acidogens, causing a decrease in pH. Furthermore, the increased hydrogen supply speed led to formate accumulation, indicating a greater contribution from the Wood-Ljungdahl pathway. These results reveal new operational parameters relevant for system control.

Keywords: Biological hydrogen methanation; In-situ biomethanation; Power-to-methane; Organic acid accumulation; pH

O-B-7 - Performance of Proton-coupled Electron Transfer Using Neutral Red Reversible Redox-active Material for Electrochemical Biogas Upgrading

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Abstract: Biogas produced via anaerobic digestion represents a renewable and environmentally beneficial energy source, yet it typically contains ~40% CO_2, limiting its direct use as fuel and necessitating effective upgrading techniques to increase its methane purity. Addressing this critical hurdle, this study proposes an innovative electrochemical biogas upgrading method utilizing proton-coupled electron transfer (PCET) with neutral red (NR) as a reversible redox-active mediator. A three-compartment electrochemical cell employing the NR/NRH_2 redox cycle was developed to achieve significant pH swings, facilitating efficient CO_2 absorption and release without external reagents or thermal energy. Batch tests of PCET using NR at a constant current density of 8 mA/cm² demonstrated rapid pH transitions, achieving a pH above 12 in the base chamber and below 5 in the acid chamber within 15 minutes. The stable voltage profile (~3.45 V) confirmed robust and sustainable electrochemical performance. The NR-based PCET system also exhibited high redox reversibility and stability under operational conditions. The developed PCET system effectively captures and converts CO_2 into bicarbonate solution product, presenting a promising energy-efficient approach compatible with existing biogas infrastructure. This technology offers a sustainable pathway for CO_2 removal and utilization, significantly enhancing biogas quality for broader applications and scalable integration into biogas facilities.

Keywords: Anaerobic digestion; Biogas upgrading; CO_2 capture; Electrochemical separation; Neutral red

O-B-8 - Enhancing Sewage Sludge Anaerobic Digestion via Hydrogen and CO_2 Co-feeding: A Mesophilic and Thermophilic Comparison

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Abstract: Anaerobic digestion (AD) is a promising technology for renewable energy recovery from organic waste, with hydrogen addition emerging as an effective strategy to enhance methane production. This study compares mesophilic (35 °C) and thermophilic (55 °C) semi-continuous AD systems under controlled hydrogen loadings ranging up to 2.15 NL-H_2 L^{-1} d^{-1}. Exogenous CO_2 was later supplemented at levels lower, comparable, and higher than CO_2 produced from substrate sludge (0.05, 0.15, and 0.30 NL-CO_2 L^{-1} d^{-1}, respectively). Methane yield, pH, volatile fatty acids (VFAs), and microbial dynamics

were monitored to assess system performance. Under long-term hydrogen supply of 0.55 NL-H_2 L^{-1} d^{-1}, thermophilic digestion achieved stable biogas yield of 0.62 NL g-VS added^{-1}, approximately 5% higher than the mesophilic counterpart. However, thermophilic system exhibited elevated pH (8.1 ± 0.1) and VFAs accumulation (0.01–2.08 g L^{-1} total VFAs), suggesting increased vulnerability to inhibition. Mesophilic system maintained more favorable operating conditions, with pH of 7.9 ± 0.2 and lower VFAs concentrations (< 0.40 g L^{-1}). At highest CO_2 loadings, both systems showed over 30% increases in daily methane production relative to baseline, suggesting added CO_2 was effectively converted. Post-operation methanogenic batch tests revealed suppressed acetoclastic activity in thermophilic inoculum, whereas mesophilic inoculum retained methanogenic activity. These findings highlight the potential of hydrogen-assisted AD for carbon-neutral biogas production.

Keywords: Biogas upgrading; Hydrogenotrophic methanogenesis; Microbial resilience; Process inhibition; Sludge treatment

O-B-9 - Enhancing High-solid Anaerobic Digestion with In-situ Nanobubble Generation via Biogas Recirculation

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Abstract: Anaerobic digestion (AD) is a mature technology for converting organic waste into bioenergy and reducing greenhouse gas emissions. However, high-solid AD systems often face challenges such as extended lag phases, low methane content, and reduced biogas yield. Introducing an appropriate amount of nanobubbles (NBs) into such systems can promote hydrolysis, enhance microbial activity, and thereby improve methane production. In this study, an in-situ nanobubble generator was first integrated into a high-solid AD system with liquid and biogas recirculation. The frequency of biogas recirculation was adjusted to regulate the generation of NBs. Results demonstrated that NBs generation significantly enhanced methane production by 148%–208% compared to the control with the common airstone for biogas recirculation. Interestingly, the free ammonia nitrogen was notably reduced at all conditions of NBs generation, which may contribute to the largely enhanced methane production. The highest methane production was achieved at lower recirculation frequency (1-h on/5-h off), reaching 218.34 mL/g VS. Excessive NBs generation may lead to the transient formation of reactive oxygen species (ROS), which could disrupt microbial metabolisms and negatively affect the system.

Keywords: Biogas recirculation; High-solid anaerobic digestion; Ammonia inhibition; Nanobubble technology

O-B-10 - Basic Research on Hydrogen Generation Using Cow Dung and Livestock Waste

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Abstract: Hydrogen does not emit CO_2 when burned, so it is attracting attention as the next generation of clean energy. However, A system for providing a stable supply of hydrogen with low production costs has not yet been fully established. Hydrogen production from organic waste has been attracting attention, but the issue with hydrogen production from organic waste is instability, and there is a need to develop a hydrogen fermentation culture system with high hydrogen production capacity and sustainability. Therefore, this study aimed to develop a hydrogen fermentation system that utilizes cow dung and waste milk, which is a livestock waste, and conducted basic research on hydrogen production from these materials. 10 mL of waste milk was added to 10 mL of cow dung slurry to prepare a culture solution, and hydrogen fermentation was carried out (culture temperature 75 °C, culture period 7 days). The waste milk was placed in a water bath at 80 ℃ for 30 minutes to decompose the antibiotics before use in the experiment. Hydrogen was measured using a portable measuring device that uses catalytic combustion. As a result, hydrogen production was confirmed, suggesting the possibility of hydrogen production from cow dung and waste milk.

Keywords: Cow dung; Waste milk; Livestock waste; Hydrogen; Hydrogen fermentation

O-B-11 - Comparative Evaluation of Hydrothermal Carbonization and Pyrolysis of Cinnamon Leaf Biomass for Solid Fuel Production

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Abstract: Cinnamon leaf (CL), an abundant and underutilized agricultural residue in Sri Lanka, possesses significant potential for biofuel production. This study investigates the fuel properties of hydrochars derived from CL via hydrothermal carbonization (HTC) at

three temperatures (190, 220, 260 °C) and two residence times (30 and 60 min), and compares them with raw CL and its biochar (CLBC) from pyrolysis. Results find a decreasing trend in hydrochar yield with increasing temperature. However, carbon content increased while H/C and O/C ratios decreased, indicating enhanced aromaticity and carbonization. The hydrochar produced at 260 °C for 60 min exhibited the highest higher heating value (HHV) of 27.35 MJ/kg, while the hydrochar at 190 °C for 60 min showed the most efficient energy recovery of 74.6%. Additionally, thermogravimetric analysis revealed the improved stability of hydrochars. Although CLBC displayed favourable atomic ratios, its high ash content degrades its fuel quality. Thus, HTC, rather than the common pyrolysis, is more effective for enhancing fuel properties and energy densification of cinnamon leaf. HTC of CL offers a sustainable and energy-efficient pathway for crop residue management, producing high-quality solid biofuels that can address the looming energy crisis through sustainable and green energy solutions.

Keywords: Biochar; Biofuels; Cinnamon leaf; Fuel property; Hydrothermal carbonization

O-B-12 - Direct Utilization of Ammonia-containing Liquid Digestate Enhances Lettuce Quality and Nutrient Uptake in pH-controlled Hydroponic Systems

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Abstract: Liquid digestate (LD) derived from anaerobic digestion (AD) of organic waste represents a promising sustainable nutrient source for hydroponic cultivation. However, the elevated ammonia nitrogen concentrations inherent in LD may exhibit significant phytotoxicity toward cultivated plants. In this study, the efficacy of strategic pH regulation on direct LD utilization in hydroponic lettuce production was systematically evaluated through six distinct treatments: LD-based nutrient solutions with or without pH control using NaOH; LD-based nutrient solution with pH control using self-buffering ability of LD; ammonium-based Hoagland's solutions with or without pH control; nitrate-based Hoagland's solution as control. Following 32 days of hydroponic cultivation, pH-controlled system with LD application achieved lettuce fresh weights statistically equivalent to the control (1.6-fold higher than the ammonium-based Hoagland's solution without pH control), with concurrent enhancement of bioactive compound contents, including chlorophylls, phenolics, amino acids, and soluble proteins. Microbial community analyses further revealed that pH regulation promoted beneficial rhizosphere and liquid-phase microbial assemblages, potentially facilitating enhanced nutrient uptake efficiency. Therefore, pH regulation emerges as an optimal approach for direct utilization of LD in hydroponic systems, enabling effective valorization of organic waste while

maintaining superior crop quality and yield performance for sustainable food production.

Keywords: Liquid digestate; Hydroponic; pH control; Nitrogen use efficiency; Microbial community

O-B-13 - Enhanced Biogas Production and Microbial Metabolic Pathways of Electro-anaerobic Digestion under Different Applied Voltages

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Abstract: Energy transition is essential for achieving net-zero carbon emissions by 2050. Bioenergy contributes around 10% to greenhouse gas reductions, ranking fourth among key technologies. Anaerobic digestion (AD), converting organic matter to methane through hydrolysis, acidogenesis, acetogenesis, and methanogenesis, faces challenges like slow hydrolysis, VFA accumulation, and microbial sensitivity. Electro-assisted anaerobic digestion (EAD) addresses these issues by applying external voltage to promote direct interspecies electron transfer (DIET), enhancing methane production efficiency. Yet, microbial metabolic specialization involving key genes (e.g., *mcrA, pilA, omcS*) remains inadequately understood. This study evaluates EAD at various voltages (0–0.9 V) using simulated food waste in 1-L reactors, comparing methane yield, COD dynamics, conductivity, and cyclic voltammetry. Microbial communities were characterized by 16S rRNA sequencing and metagenomics. Kinetic models and life cycle assessment (LCA) were employed to quantify system efficiency and environmental impacts. Preliminary results indicated optimal methane production at 0.6 V, outperforming higher voltages (1.2 V and 1.8 V), suggesting inhibition of methanogens at elevated potentials. Current fluctuations observed at 1.2 V deduce correlations with extracellular electron transfer (EET) genes. This study clarifies voltage-mediated microbial behaviours, metabolic pathways, and EET gene expression, contributing toward an optimized EAD kinetic model with improved methane production and sustainability.

Keywords: DIET, Direct interspecies electron transfer; EAD, Electro-assisted anaerobic digestion; EET, Extracellular electron transfer; metagenomics

Theme III: Biomass Reclamation and Utilization

O-C-1 - Sustainable Antioxidant Platform Based on FeCu–lychee Wood Derived Carbon Dot Functionalized Biochar from Agricultural Waste

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Abstract: Sustainable antioxidant materials are essential for combating oxidative stress in biomedical, environmental, and food systems. This necessity drives the development of innovative materials that integrate high efficiency, recyclability, and environmentally friendly sources. In this study, we report a biochar-based antioxidant platform synthesized from agricultural waste (rice husk), functionalized with carbon nanodots (CDs) derived from lychee wood, and bimetallic iron–copper (FeCu) nanoparticles, forming a FeCu-CD@Biochar composite. The material was structurally characterized using FT-IR, XRD, TEM, and contact angle analysis. Boehm titration confirmed the increased density of oxygen-containing functional groups following CD modification. Antioxidant capacity was evaluated via $ABTS^{\bullet+}$ radical scavenging, with FeCu–CD@Biochar showing significantly higher removal efficiency than unmodified biochar and CDs alone. The enhanced performance is attributed to the synergistic effects of electron-donating groups from CDs and redox cycling of FeCu nanoparticles. Notably, under visible light irradiation, the scavenging rate increased to approximately 1.87-fold that of the dark condition, indicating a photocatalytic mechanism involving photogenerated electron-hole pairs facilitating radical neutralization. The composite's magnetic properties also enable efficient recovery and reuse. This work presents a green, recyclable, and light activated antioxidant system derived entirely from agricultural byproducts, with promising potential for antioxidant applications.

Keywords: Sustainable antioxidant materials; Lychee wood; Carbon nanodots; Bimetallic iron–copper nanoparticles; Photocatalytic radical scavenging

O-C-2 - Valorizing Spent Coffee Residue as Carbon-based Catalysts for Low Carbon Urea Electrosynthesis from Nitrate and Bicarbonate

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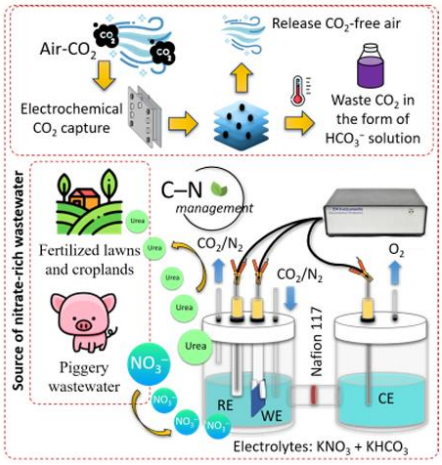
Abstract: Escalating fertilizer demand and nitrate-rich effluents make sustainable urea synthesis urgent. Conventional Haber–Bosch/urea plants are energy- and carbon-intensive, while most electrochemical C−N coupling studies still rely on high-purity CO_2. We propose a circular route that couples wastewater nitrate reduction with bicarbonate, representative of CO_2 captured electrochemically, as the carbon source. Spent coffee residue is upcycled to a conductive biochar (SCB) supporting $CuWO_4$ on a carbon-paste electrode ($CuWO_4$/SCB/CPE). This presentation will detail catalyst preparation and physicochemical characterization, electrolyte optimization, and rigorous urea quantification with appropriate blanks and isotopic controls to avoid analytical artifacts. Density functional theory (DFT) will probe the adsorption and coupling of *CO/*NH_x intermediates, guiding composition and potential windows. A cradle-to-gate life-cycle assessment (LCA) and techno-economic analysis (TEA) benchmark the pathway against conventional urea production and alternative electrosynthetic routes. By valorizing two waste streams, nitrate and captured bicarbonate, on a low-cost, biomass-derived carbon, this work targets urea formation at reduced cell voltages while suppressing competing reactions. We will share first performance figures, mechanistic insights, and sustainability hotspots, outlining design rules for scaling waste-to-urea electrosynthesis.



Keywords: Bicarbonate; Circular economy; Electrosynthesis; Nitrate; Spent coffee biochar; Urea

O-C-4 - Mitigating PAH Formation and Enhancing Oxidative Degradation Using Pineapple Leaf Biochar in Sludge Treatment

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Abstract: This study investigates the preparation, characterization, and environmental application of pineapple leaf biochar (PLBC) for degrading phthalates in waste activated sludge (WAS). Initially, the formation of polycyclic aromatic hydrocarbons (PAHs) during pyrolysis was analyzed, revealing that PAH yields peaked at 300 °C under CO_2 and were minimized at 700 °C under N_2. The introduction of heteroatom dopants (N, B, O, P, NB, NS) effectively suppressed PAH formation by up to 96%, showcasing the ability to mitigate toxic byproducts through pyrolysis atmosphere and dopant optimization. Comprehensive characterization of PLBC, including surface functional groups, zeta potential, particle size, and elemental composition, demonstrated that higher pyrolysis temperatures enhance aromaticity and carbon content while diminishing oxygen functionality.

In oxidative degradation experiments, PLBC combined with urea hydrogen peroxide (UHP) proved effective in degrading phthalates in WAS. Key factors, such as UHP concentration and pyrolysis conditions, significantly influenced degradation efficiency. Notably, PLBC prepared at 900 °C under N_2 exhibited superior removal performance, attributed to its elevated carbon content and enhanced catalytic activity. These findings underscore PLBC's dual potential for reducing toxic byproducts during synthesis and advancing pollutant treatment processes through optimized oxidation strategies.

Keywords: Polycyclic aromatic hydrocarbons; Phthalates; Pineapple leaf biochar; Heteroatom doping; Oxidative degradation reactions

O-C-5 - Cultivation of Protein-rich Microalgae Using Swine Wastewater in Pilot-scale Study and Development of Microalgae-based Animal Feed

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Abstract: Microalgae are regarded as a promising alternative protein source due to their rapid growth rate, lack of arable land requirements, and diverse applications for producing valuable biomass. Utilizing wastewater as the cultivation broth can further reduce production costs. In this study, a pilot system comprising two reactors-anaerobic fermentation and microalgae cultivation-was designed for on-site operation using swine wastewater as the broth and Chlorella as the microalgae species. During semi-continuous operation, the anaerobic reactor generated volatile fatty acids reaching 2676.7 mg COD/L, predominantly acetic acid, which was readily consumed in the subsequent microalgae cultivation reactor. The system achieved high removal efficiencies for SCOD (81.9%), TP (91.2%), TN (62.8%), and NH_4^+-N (64.4%) from the swine wastewater. The mechanisms underlying nutrient removal (primarily nitrogen and phosphorus) and shifts

in the microbial community were investigated. The protein content in the harvested microalgae biomass reached 52.4%. When substituting 20% of the soybean content in conventional feed formulations with the harvest microalgae, the resulting microalgae-composite animal feed demonstrated compliance with all parameters specified in the National Feed Hygiene Standards. Overall, these findings not only provide a scientific foundation for incorporating microalgae into animal feed but also offer novel perspectives for developing innovative and sustainable feed resources.

Keywords: Feed development; Microalgae cultivation; Pilot-scale operation; Protein accumulation; Swine wastewater

O-C-6 - Phages-bacteria Interactions Underlying the Dynamics of Polyhydroxyalkanoates-producing Mixed Microbial Cultures via Metaomics Study

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Abstract: Currently, the production of polyhydroxyalkanoates (PHAs) by mixed microbial cultures (MMCs) using complex waste biomass can recycle biomass and reduce plastic pollution. The process includes: 1) producing short-chain carboxylic acids (SCCAs) that serve as substrates of PHAs production by anaerobic fermentation; 2) enriching microbial communities with PHAs-synthesizing capacity from activated sludge; 3) the maximum PHAs accumulation of enriched MMCs using SCCAs. Of these, the second step is the most important in the process.

However, the dynamics of the structure of polyhydroxyalkanoates-producing mixed microbial cultures (PHA-MMCs) during enrichment and maintenance is an unsolved problem. The effect of phages has been proposed as a cause of dynamic changes in community structure, but evidence is lacking.

To address this question, five PHA-MMCs were enriched, and biological samples were sampled temporally to study the interactions between phage and bacterial members by combining metagenomics and metatranscriptomics.

A total of 963 metagenome-assemble genomes (MAGs) and 4294 phage operational taxonomic units (pOTUs) were assembled from bulk metagenomic data. The dynamic changes in the structure of phage and bacterial communities were remarkably consistent. Structural equation modeling analysis showed that phages could infect and lyse dominant species to vacate ecological niches for other species, resulting in a community succession state in which dominant species alternated. Seven key auxiliary metabolic genes (AMGs), *phaC*, *fadJ*, *acs*, *ackA*, *phbB*, *acdAB*, and *fadD*, potentially contributing to the PHA synthesis were identified from phage sequences. Importantly, these AMGs were

transcribed, indicating that they were in an active expression state.

The meta-analysis provides the first catalog of phages in PHA-MMCs and the AMGs they carry, as well as how they affect the dynamic changes of bacterial communities. This study provides a reference for subsequent studies on understanding and regulating the microbial community structure of open microbial systems.

Keywords: Auxiliary metabolic genes; Mixed microbial cultures; Phages-host dynamics; Polyhydroxyalkanoates

O-C-7 - Thermophilic Aerobic Digestion of Wastewater Sludge for Producing Class A Biosolids and Effects of Digestion on Sludge Dewaterability

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Abstract: Wastewater treatment facilities produce large amounts of residual solids as sludge. The management and handling of wastewater sludge is a costly task that involve in sludge stabilization (e.g. digestion), dewatering, and final disposal. Thermophilic digestion, as a recognized cost-effective and environmentally sustainable process, treats sludge at high temperatures (50-70 ℃) for producing Class A biosolids that are essentially pathogen free. By USEPA 40 CFR Part 503 regulation, Class A biosolids can be beneficially used as fertilizer for unrestricted land application. Full-scale experience from thermophilic digestion facilities in North America revealed that thermophilically digested sludge consumed higher amounts of conditioning polymers required for dewatering than conventionally (mesophilically) digested biosolids, which resulted in increased cost for sludge handling. This presentation is to discuss (1) thermophilic aerobic sludge digestion process and its full-scale engineering applications; (2) Class A biosolids and its land application for resource recovery; (3) findings from a research that investigated how the major operational parameters of and the role of biopolymers (extracellular proteins) from thermophilic aerobic digestion affected the dewatering properties of the digested sludge. Learnings from this presentation can benefit researchers and engineering practitioners to develop cost-effective wastewater sludge handling and treatment solution.

Keywords: Dewaterability; Thermophilic aerobic digestion; Wastewater sludge

O-C-8 - Nutrients Recovery and Functional Biomaterials Production by Hydrothermal Treatment of Algal-bacterial Granular Sludge

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Abstract: Generation of wastewater by year 2050 is expected to be increased due to the consumption pattern variation of humans as well as the progress of hygienical behavior of them. Recent studies are therefore focusing on sustainable technology for treating the increasing wastewater such as algal-bacterial granular sludge (ABGS) system instead of conventional activated sludge process which has several drawbacks complying to the present world context. However, management of the main byproduct from the ABGS system, i.e., sludge, has not been considered up to now. This study for the first time aims to investigate nutrient recovery from ABGS using hydrothermal treatment (HTC). HTC as a promising thermochemical technique to treat wet biomass at relatively low operating conditions can produce valuable biomaterials from wet waste. In this study more than 75% liquid could be recovered after HTC of ABGS at 120–280 ℃ for 30 or 60 min, to which the primary nutrients of N, P and K were transferred from solid phase. Moreover, the highest germination index of 142% was obtained in the germination test on Komatsuna seeds with the HT liquor produced from HTC at 180℃ for 60 min after being diluted to 1:500 ($180H_L60$ (1:500)), indicating its phytotoxic free property. Besides 100% germination, $180H_L60$ (1:500) achieved the maximum average root length (15.44 mm), demonstrating its potential for being applied as a liquid fertilizer compared to a commercially available bio humic liquid. The current results highlight the promising applications of ABGS in agroindustry in the near future.

Keywords: Algal-bacterial granular sludge; Bio liquid fertilizer; Hydrothermal treatment; Nutrient Recovery; Sustainability; Wastewater treatment

O-C-9 - NH_4^+ Adsorption Capacity of Biochars Derived from Coffee Husk and Sugarcane Bagasse in Water Treatment

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Abstract: This study is to investigate the ammonium adsorption capacity of biochars produced from biomass residues in Vietnam, i.e. sugarcane bagasse biochar and coffee husks biochar, in water treatment. Biochars were produced under limited oxygen conditions at temperature of 450 °C. The adsorption capacity was evaluated from two aspects, contact time and initial ammonium concentration. For contact time, the biochars were exposed to a solution containing 10 mg NH_4^+/L for a varying time duration; as for initial ammonium concentration, the biochars were tested in NH_4^+ solution at different ammonium concentrations, ranging from 0 to 30 mg NH_4^+/L. The equilibrium adsorption data were processed and analyzed by using Langmuir and Freundlich adsorption isotherm

models. Results showed that the two biochars are alkaline, with relatively high carbon content (40.91% in sugarcane bagasse biochar and 53.01% in coffee husk biochar). The sugarcane bagasse biochar exhibited a significantly higher NH_4^+ adsorption capacity (8.55 mg-N/g) compared to coffee husk biochar (1.18 mg-N/g). In addition, the experimental adsorption data of sugarcane bagasse biochar (R^2 = 0.96~0.99) can better fit Langmuir and Freundlich models than those of coffee husk biochar (R^2 = 0.82~0.83). These findings suggest that sugarcane bagasse biochar is a promising and low-cost material for ammonium removal in water treatment applications.

Key words: Adsorption; ammonium; Coffee husk biochar; Equilibrium adsorption; Sugarcane bagasse biochar

O-C-10 - Valorization of Liquid Digestate-derived Humic Substances as Microalgal Biostimulants: Insights into Dose-response and Structure–response Relationships

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Abstract: Microalgae-based bioprocesses offer a sustainable strategy for valorizing liquid digestate (LD), the nutrient-rich aqueous fraction produced during anaerobic digestion. Rich in humic substances (HS) such as humic acid (HA) and fulvic acid (FA), LD shows potential as a source of natural biostimulants for microalgae cultivation. In this study, HA and FA were extracted from LD and characterized by FTIR, GC-MS, and 3D-EEM spectroscopy. Scenedesmus sp. was exposed to graded concentrations of each HS, and physiological responses were assessed. Results showed that lower concentrations of HA (≤ 50 mg C/L) and FA (≤ 20 mg C/L) slightly promoted biomass growth, while higher concentrations significantly inhibited growth and induced oxidative stress in microalgae. 3D-EEM results suggest limited degradation of HA and partial utilization of FA. Correlation analysis between microalgal responses and fluorescence-region change revealed structure–response relationships, linking specific DOM features to physiological outcomes. These findings provide insights into the dual effects of LD-derived HS and support their concentration optimization in microalgae-based wastewater valorization systems.

Keywords: Microalgae cultivation; Liquid digestate; Biostimulant; Humic substances

O-C-11 - Integrated Co-hydrothermal Carbonization of Microalgae and Microplastics

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Abstract: The extensive occurrence of microplastics in wastewater streams poses significant environmental challenges but simultaneously offers potential for resource recovery due to their substantial calorific content. Conversely, microalgae provide notable environmental advantages but typically exhibit lower energy densities. This research investigates the co-hydrothermal carbonization (co-HTC) process combining microalgae with polyethylene microplastics as an eco-friendly approach to generate high-quality solid biofuels. A central composite design (CCD) was utilized to determine optimal operating parameters, specifically targeting reaction temperature (180-240 °C), residence time (20-60 min), and microplastic concentration (10-40 wt%). Optimal scenarios identified for yield maximization (180 °C, 20 min, 40 wt%) and energy enhancement (230 °C, 60 min, 40 wt%) resulted in hydrochar yields reaching 64.60 wt% and high heating values (HHVs) up to 41.67 $MJ \cdot kg^{-1}$, respectively. Characterization of optimized hydrochars indicated significantly decreased O/C ratios, enhanced thermal stability, and improved combustion characteristics. Further analysis through FTIR and XPS techniques confirmed substantial deoxygenation and the development of carbon-rich surfaces. Ultimately, this research presents a comprehensive approach for managing plastic waste and enhancing microalgae utilization, aligning closely with circular bioeconomy principles.

Keywords: Co-hydrothermal carbonization; Hydrochar; Microalgae; Microplastic; Thermochemical

Theme IV: Biosystems and Bioassays

O-D-1 - Regulating the Carbon-to-Nitrogen Ratio for Enhanced Reconstruction Efficiency in *Litopenaeus vannamei* Aquaculture Systems

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Abstract: Intensive shrimp farming faces challenges of water quality deterioration and excessive chemical usage. This study utilized glucose supplementation to regulate carbon-to-nitrogen ratios (C/N): C/N = 5 (control), 10, 15, and 20, comprehensively evaluating impacts on water quality, shrimp growth performance, and product quality. Results revealed that C/N = 20 significantly improved the aquatic environment, achieving reductions of 57.43% in nitrite-N (NO_2^--N), 59.86% in nitrate-N (NO_3^--N), 67.79% in total nitrogen (TN), 67.02% in total phosphorus (TP), and 98.37% in ammonia-N (NH_4^+-N). The C/N = 15 group demonstrated optimal growth performance, with body length, body weight, and specific growth rate (SGR) increasing by 15.91%, 31.89%, and 33.21% respectively versus controls, while simultaneously enhancing muscle nutritional composition, amino acid profile, and textural properties. Organic carbon amendment promoted heterotrophic microbial dominance, forming bioflocs that improved feed utilization efficiency. By integrating microbial ecological regulation with nutritional management, this study establishes a scientifically validated, eco-friendly aquaculture strategy that reduces dependence on chemical interventions, offering dual theoretical and practical significance for sustainable industry development.

Keywords: Carbon-nitrogen ratio regulation; *Litopenaeus vannamei*; Water quality control; Quality characteristics; Environmental quality control

O-D-2 - Ultrasensitive Detection of Antibiotic Resistance Genes Using Core-shell Au@Ag-Au SERS Nanotag-based Lateral Flow Assay

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Abstract: Antibiotic-resistance genes (ARGs) released by intensive livestock farming threaten ecosystems and public health. Here we present a surface-enhanced Raman scattering (SERS) lateral-flow assay that enables rapid, ultrasensitive detection of the representative ARG sul1. Core-shell Au@Ag-Au SERS nanotags embedded with 4mercaptobenzonitrile (4-MBN) were synthesized after systematic reporter screening; 4MBN furnishes a strong signal in the Raman-silent region, avoiding matrix interference. By tuning the concentration of the gold growth solution, shell thickness was optimized

and the highest Raman intensity achieved, supporting sub-nanomolar sensitivity. The test strip comprises a nitrocellulose membrane with immobilized DNA capture probes on the test (T) line and 4-MBN-encoded nanotag-detection probes on the conjugate pad. When the target sequence is present, a sandwich hybridization complex forms on the T line; the accumulated nanotags are then read by a portable Raman spectrometer. The assay detects sul1 spiked into agricultural wastewater within 15 min and quantifies it over a concentration gradient, underlining its suitability for field deployment. Beyond high sensitivity, the strip's ease of use and handheld instrumentation promise routine on-site surveillance of ARGs contaminations. The modular probe design can be readily adapted to additional ARG targets (e.g. tetA, blaTEM), further extending the assay's environmental surveillance capacity.

Keywords: Au@Ag-Au nanotags; Antibiotic resistance genes; Lateral flow assay; Surface-enhanced Raman Scattering (SERS); Ultrasensitive detection

Theme V: Microalgal-bacterial Consortium and Its Advancements

O-E-1 - Algal-bacterial Granule System Achieves Negative Non-CO_2 Greenhouse Gas Emissions by Off-gas Circulation

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Abstract: Biological non-CO_2 greenhouse gas (N_2O and CH_4) emissions are challenging the development of low-carbon wastewater treatment. Algal-bacterial granule technology has been regarded as a low-carbon technology due to its granule structure and coexisting microalgae. However, its potential in carbon emission mitigation remains to be explored. This study constructed a gas recirculation sequencing batch reactor with algal-bacterial granules, in which N_2O, CH_4 and CO_2 can be enclosed for biological removal. Results indicated that N_2O emission factors were approximately 0.45 ± 0.18% (kg N_2O-N/kg NH_4^+-N removed) before two stages, uncorrected with microalgae growth. It was lower than 1.4 ± 0.7% in the control biosystem without gas circulation. This mitigation was attributed to the heterotrophic denitrification process, in which the generated N_2O can be efficiently converted to N_2 due to the prolonged contact time between bacteria and N_2O by gas circulation. The system showed a very low CH_4 emission but great potential in CO_2 fixation. It was estimated that N_2O and CH_4 emissions can be offset by photosynthetically fixed CO_2 when Chlorophyl-a achieved 5.8 mg/g-VSS in the gas recirculation system. This study provides an efficient and feasible carbon emission reduction strategy for achieving 'dual carbon' goals in the wastewater treatment industry.

Keywords: Algal-bacterial granules; Carbon fixation; Greenhouse gas emissions; Microalgal assimilation; Granular stability

O-E-2 - Microalgae-driven Optimization of Algal-bacterial Granular Sludge for Saline Aquaculture Wastewater Remediation

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Abstract: Algal-bacterial granular sludge (ABGS) holds great promise for the treatment of saline aquaculture wastewater, enabling simultaneous pollutant removal and biomass resource recovery. However, its long start-up period and variable stability under high salinity conditions currently limit its large-scale application. In this study, we systematically evaluated the effects of four microalgae species (*Chlorella* sp., *Dunaliella salina*, *Tetraselmis* sp., and *Spirulina platensis*) on ABGS formation and nutrient removal performance. Notably, the reactor (R2) with *Dunaliella salina* addition exhibited the shortest formation time, while the reactor (R4) with *Chlorella* sp. achieved optimal pollutant removal through enhanced algal-bacterial synergy and granule stratification. Species selection directly modulated the composition of extracellular polymeric substances (EPS), with R4 displaying the highest protein/polysaccharide ratio (1.35) and β-sheet dominance (69.96%), correlating with robust granular integrity. Three-dimensional excitation-emission matrix fluorescence regional integration (3D-EEM/FRI) analysis confirmed that microalgae-driven shifts in aromatic protein components were critical for stability. Furthermore, species inoculation reshaped the prokaryotic-eukaryotic consortia, with R4 and R2 fostering salt-tolerant taxa and synergistic algae-bacteria partnerships. These findings provide the first evidence of microalgae-bacterial interactions and adaptation from an ecological perspective, which accelerates ABGS maturation, enhances structural stability, and improves treatment efficiency in saline environments.

Keywords: Algal-bacterial consortia; Biogranulation; Mariculture wastewater; Microbial dynamics; Nutrient removal

O-E-3 - Impact of Morphological Variations and Microbial Growth Imbalance on Algal-bacterial Aerobic Granular Sludge: Performance and Mechanisms

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Abstract: Algal-bacterial aerobic granular sludge (AGS) has emerged as a promising solution for sustainable wastewater treatment. Granular morphologies in algal-bacterial AGS, including radial, wrapped, and spotty patterns, form under specific granulation stages or environmental conditions. However, the underlying mechanisms and functional roles of these morphologies remain insufficiently characterized. This study systematically compares the structural and functional characteristics of algal-bacterial AGS with different morphologies, highlighting their effects on nutrient distribution, microbial metabolism, community structure, settleability, and stability. Morphological variations are hypothesized to result from steep substrate gradients, stress-induced excessive production of extracellular polymeric substances (EPS), as well as localized metabolic activity or resource imbalances. Furthermore, the roles of microbial interactions, particularly the imbalance between microalgae and bacteria, and their influence on mass transfer, treatment performance, and pollutant tolerance were explored. By revealing the mechanisms driving morphological differentiation and its functional implications, this study aims to identify targeted regulation strategies for enhancing treatment efficiency. More in-depth work is required to provide theoretical support for the scalable and long-term implementation of algal-bacterial AGS systems in next-generation sustainable wastewater treatment plants.

Keywords: Algal-bacterial aerobic granular sludge; Granular morphology; Microalgal bacterial symbiosis; Morphological differentiation; Sustainable wastewater treatment

Theme VI: Greenhouse gases emission/mitigation and carbon/nitrogen neutrality

O-F-1 - Carbon Emissions Calculation and Driving Factors Analysis of Sewer Systems in China

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Abstract: Sewer systems, as an invisible source of greenhouse gas (GHG) emissions within sewage systems, have a significant impact on climate change that cannot be ignored. In this study, we utilized the mass balance method to calculate and compare the GHG emissions and composition of sewer systems in 31 provincial-level administrative regions in China, and analyzed their spatial clustering patterns. Additionally, we identified the primary factors driving GHG emissions from sewer systems. The results show that in the year of 2022, China's sewer GHG emissions amounted to 12.80 Mt CO_2-eq, accounting for approximately 20% of the emissions from wastewater treatment industry. Among these emission components, uncollected wastewater accounted for 2.54% ~ 85.86%, pollutant attenuation within the pipeline accounted for 11.86% ~ 59.61%, and electricity accounted for 2.39% ~ 41.13%. The CH_4 emissions accounted for 56.58% ~ 78.57%. The carbon emission intensity ranged from 0.10 to 0.48 kg CO_2-eq/m^3. Additionally, among GHG emissions from pollutant attenuation within the pipeline, gravity pipeline accounted for up to 24.0%. Spatial clustering analysis indicates that carbon emission intensity forms a 'high-high' cluster in the southwestern region of China. Correlation analysis and principal component analysis results show that carbon emissions from sewer systems are influenced by the coupled effects of 'economic-social-natural' factors, with economic and social factors having a greater impact than natural factors. This highlights the importance of water conservation, rational network layout, and improving pollutant collection rates. This study provides data support and policy references for the low-carbon sustainable transformation of urban water systems.

Keywords: Sewer systems; Greenhouse gas emissions; 'Economic-social-natural' coupling; Driving factors; Sustainability

O-F-2 - Quantifying Urban Food Nitrogen Flows in Tokyo: Urban Nitrogen Management Insights

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Abstract: The global food system accounts for approximately one-third of the total environmental footprint. Urbanization concentrates population growth and intensive consumption in cities, making cities both key drivers and primary sources of the nitrogen

(N) footprint. Tokyo, with low food self-sufficiency, distinct diets, and extensive food waste treatment, serves as a representative case for urban food N flow analysis.

However, most studies on urban food N dynamics focused on developing countries or specific products, such as seafood. Analyses focused on the entire food system in highly urbanized areas of developed countries remain limited.

This study examined Tokyo's 23 wards in 2019, using a mass balance approach to establish an urban food N flow framework. We quantified N inputs (producer side), consumption (consumer side), and outputs (treatment side), and developed an urban food N flow diagram. Additionally, we calculated N footprints from treatment processes to assess environmental impacts.

In 2019, Tokyo's food system received about 158,553 tons of N, with 68,378 tons N consumed. Significant amounts of reactive N (Nr) were released during incineration and wastewater treatment, quantified as the N footprint to assess the environmental impacts. This study identified the key pathways and characteristics of urban food N flows of Tokyo and provides insights for decision-making on urban N management.

Keywords: Food system; Nitrogen flow; Nitrogen footprint; Tokyo; Urban

O-F-3 - Biochar Preparation and Carbon Sequestration and Emission Reduction Technologies in Paddy Fields

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Abstract: Carbon removal technologies, including chemical methods and biological carbon sequestration, are essential for achieving global carbon neutrality. Biological carbon sequestration technologies have drawn considerable attention due to their ecological benefits and cost-effectiveness. Biochar has demonstrated substantial potential in soil carbon sequestration and greenhouse gas mitigation, yet systematic assessments of its production and application are still limited. This study systematically optimized biochar production technologies and evaluated their effectiveness in rice paddy systems. Major achievements include: (1) Developing and optimizing biochar production processes and equipment, identifying an optimal pyrolysis temperature of 500℃ for rice straw, achieving a biochar carbon content of 53%, and enhancing biochar adsorption capacity through Fe_3O_4 magnetization, increasing specific surface area by 310.6% and pore volume by 512.5%; (2) Laboratory and field experiments revealed that applying biochar produced at 500 ℃ significantly reduced methane (CH_4) and nitrous oxide (N_2O) emissions by up to 91.77% and 38.21%, respectively, and increased rice yield by 28%; (3) Lifecycle assessment (LCA) of practical applications indicated that transportation contributed most (92%) of carbon emissions, recommending extending application intervals for mutual economic benefit between farmers and producers. These findings

provide essential theoretical and technical support for biochar's large-scale agricultural application.

Keywords: Biochar; Paddy field carbon sequestration and emission reduction; Carbon peaking and carbon neutrality

O-F-4 - Assessing the Impact of Spent Coffee Grounds Compost on Reducing Greenhouse Gas Emissions and Improving Soil Carbon in Short-cycle Crop Production

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Abstract: This study assessed the impact of spent coffee grounds (SCG) compost on greenhouse gas (GHG) emissions, soil carbon dynamics, and yield in short-cycle amaranth production. Experimental treatments contrasted soils with a prolonged history of SCG compost application against untreated soils, with or without the incorporation of fresh SCG compost. The findings indicated that the integration of prolonged SCG treatment and fresh compost almost quadrupled amaranth yield in comparison to untreated soil. During the 28-day growth phase, total GHG emissions declined from 1.8 to 1.6 t CO_2-eq ha^{-1}, with SCG-amended plots demonstrating a 52% drop in emission intensity. Decreases in N_2O emissions and enhanced nitrogen utilization efficiency correlated with alterations in microbial communities favoring nitrifying and denitrifying taxa. The use of compost improved soil chemical characteristics, such as elevated total carbon and nitrogen levels, higher pH buffering capacity, and decreased electrical conductivity. The data demonstrate that SCG compost serves as an efficacious soil amendment for reconciling agricultural productivity with environmental sustainability, in accordance with the tenets of circular agriculture.

Keywords: Short-term leafy vegetable; Spent coffee grounds (SCG); Greenhouse gas (GHG); Carbon storage; Global warming potential (GWP)

O-F-5 - Organic Carbon-equivalent Inputs in Paddies: Impacts on GHG Reduction, Rice Quality, and Soil Health

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Abstract: Achieving carbon neutrality in rice cultivation requires optimizing organic amendments to simultaneously enhance productivity, soil health, and reduce greenhouse gas (GHG) emissions. While straw, biochar, and manure effects have been studied individually, their comparative efficacy remains unclear due to variable experimental conditions. Here, rice straw, fermented pig manure, and biochar were respectively amended at a dose of 1,200 kg C ha^{-1} in a paddy field. We monitored GHG fluxes, assessed soil physicochemical properties and microbial diversity, calculated a comprehensive soil health index (SHI), and measured rice agronomic traits. Biochar application significantly reduced cumulative CH_4 emissions and N_2O emissions, lowering the global warming potential (GWP) by 29.9% compared to control. Conversely, manure increased CH_4 emissions by 53.9% and GWP by 41.0%. Straw showed no net GWP change. Biochar induced the greatest SHI improvement (+ 10.14 units) by enhancing soil organic carbon, dissolved organic carbon, and nutrients. Manure significantly boosted rice yield (155.7%), while biochar and straw showed limited yield effects but improved key agronomic traits. In general, biochar application, despite limited short-term yield gains at this rate, offers the most favorable trade-off by significantly mitigating GHG emissions and enhancing soil health, positioning it as a strategic solution for sustainable rice cultivation toward carbon neutrality.

Keywords: Carbon neutrality; Organic amendments; Rice plant; Soil health

Theme VII Sustainable Management and Analysis

O-G-1 - Research Framework for Low-carbon Urban Development: A Case Study of Shanghai, China

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Abstract: CO_2 emissions from energy consumption, especially in cities, are significant contributors to the global greenhouse effect. Cities are playing an increasingly important role in mitigating climate change. This study explores the pathways for reducing CO_2 in cities by establishing a systematic CO_2 emission research framework, which is applied to Shanghai as the research area. The framework (1) decomposes CO_2 emission factors using

the Logarithmic Mean Divisia Index (LMDI), (2) analyses the decoupling state using the Tapio decoupling (TD) model, (3) evaluates decoupling efforts for driving factors, and (4) predicts future CO_2 emissions through Low the Emissions Analysis Platform (LEAP) model. The decomposition results showed that economic was the primary driver of CO_2 emissions in Shanghai. Energy intensity was the primary factor for reducing CO_2 emissions. Moreover, the decoupling state of Shanghai gradually improved, which promoted the decoupling of the industrial sector, but suppressed the decoupling of the trade sector. The energy intensity played an important role in decoupling in Shanghai. Scenario simulations showed that strict and diversified policy implementation can effectively reduce CO_2 emissions. Finally, policy recommendations were proposed based on the results. This study provides a reference for the development of low-carbon cities.

Keywords: CO_2 emissions; Decomposition; Decoupling; Scenario analysis; Shanghai

O-G-2 - Comparative Life Cycle Assessment of Conventional, Environmentally Friendly, and Organic Rice Production Systems

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Abstract: As consumer awareness of the environmental impacts of agricultural products increases, Indonesian farmers are increasingly adopting organic rice production systems, despite the lower yields compared to conventional rice. This study aimed to compare the environmental impacts of conventional, environmentally friendly, and organic rice production systems using Life Cycle Assessment (LCA). The system boundary extends from the cradle to the farm gate, and the functional unit is 1 kg of harvested rice grain. The assessment considered eighteen impact categories. Results showed that conventional rice production systems had the highest environmental impact in ten categories compared to environmentally friendly and organic systems. Meanwhile, environmentally friendly systems had the highest impact in eight other categories: climate change, human toxicity (non-carcinogenic), land use, material resources (metals/minerals), ozone depletion, particulate matter formation, and photochemical oxidant formation (human health and terrestrial ecosystems). The climate change impact indicated that environmentally friendly systems had the greatest impact due to the use of urea fertilizer, irrigation, and liquid organic fertilizer, which were not used optimally. Environmental impacts are expected to decrease as agriculture fully transitions to organic systems using optimization methods. Overall, organic rice production systems are the most effective method for reducing environmental impact and promoting sustainable agriculture.

Keywords: Environmental impacts; Life cycle assessment; Organic rice production

O-G-3 - Next-generation Pig Husbandry: Environmental Impact Reduction via Feed Improvement and Biogas Valorization

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Abstract: Pig husbandry contributes significantly to environmental pollution, impacting air and water quality and spreading pathogens, to name a few. In 2021, it was identified to be the second largest source of greenhouse gas (GHG) emissions in meat production sectors. To address these impacts, this study introduces a novel pig husbandry system that incorporates improved feed composition, dry anaerobic digestion (dry AD), and biogas valorization. Using life cycle assessment (LCA), the system's environmental impacts were analyzed across several categories, including climate change, acidification, eutrophication, and biological toxicity. Key improvements include replacing soybean in pig feed with fish-based alternatives, using dry AD to convert waste into biogas and digestate (a crop fertilizer), and converting biogas into high-value chemicals. These changes show a notable reduction in environmental burdens when compared to conventional pig husbandry. The study further explores different biotic and abiotic pathways for producing chemicals from biogas, all of which act as carbon sinks, helping to capture carbon that would otherwise be released into the atmosphere. By promoting waste recycling and resource recovery, this next-generation system serves as an example of circular bioeconomy, demonstrating the potential to significantly lower environmental impacts while maintaining productivity and advancing sustainable agricultural practices.

Keywords: Biogas valorization; Dry anaerobic digestion; Environmental impact; Feed improvement; Life cycle assessment; Pig husbandry

O-G-4 - Powering Sustainability with Biofertilizer: 3E Life Cycle Assessment in Acidic Rice Systems

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Abstract: Acidic soils reduce nutrient availability, leading to poor soil fertility and low rice productivity. In Malaysia, Ground Magnesium Limestone (GML) is commonly used to reduce the acidity and improve the yields. However, the yield remains insufficient to meet growing demands. In this study, biofertilizer was produced from palm oil mill waste, including palm oil mill effluent (POME) and empty fruit bunches (EFB), through bio-composting. These biomass residues are usually disposed of through land application, which triggers environmental and economic concerns. Redirecting it into biofertilizer production offers a sustainable alternative. This study evaluates the synergic integration of GML and biofertilizer using Life Cycle Assessment (LCA) framework, focusing on 3E (Energy, Environmental, Economic). Primary data obtained from the Integrated Agricultural Development Area (IADA) Seberang Perak, Malaysia, for the 2023/2024 season. Results showed the integration of GML and biofertilizer increased rice yield by 40%, while reducing environmental impacts by 25–28%. Economically, although biofertilizer adds cost, the benefit-cost ratio improved to 1.12, indicating yield gains outweigh the cost input. These findings highlighted that biofertilizer can serve as a sustainable input for rice production on acidic soils, offering significant benefits on energy efficiency, environmental mitigation, and economic return. This study supports comprehensive evaluation for sustainable rice farming under challenging soil conditions.

Keywords: Biofertilizer; Acidic soil; Life cycle assessment

O-G-5 - Combined Exposure to Polyethylene Microplastics and Elevated Seawater Temperature Induces Oxidative Imbalance and Histopathological Damage in Coral *Briareum Violacea*

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Abstract: Microplastic pollution and elevated seawater temperatures are known to negatively affect coral health. However, their combined impacts on coral physiological responses have yet to be fully elucidated. This study investigates the combined effects of polyethylene microplastics (PE-MPs) and elevated seawater temperatures (30 °C and 32 °C, with 26 °C as the control) on oxidative responses in the coral *Briareum violacea*. Coral polyp length and adaptability were monitored daily, while zooxanthellae density, oxidative biomarkers including the activities of superoxide dismutase (SOD), catalase

(CAT), glutathione peroxidase (GPx), and glutathione S-transferase (GST), as well as glutathione (GSH) and malondialdehyde (MDA) levels, and histopathology were assessed at weeks 4 and 8. The results indicated that combined exposure to PE-MPs with seawater temperatures (30 °C and 32 °C) significantly impaired coral adaptability and increased zooxanthellae loss. This was associated with elevated lipid peroxidation MDA levels, dysregulation of antioxidant enzymes (including increased SOD and GST activities and GSH content, an initial rise followed by a decline in CAT activity, and a decrease in GPx activity), and severe tissue damage, including mesenteric atrophy and vacuolation. These findings suggest that the combined exposure of PE-MPs and elevated seawater temperature exerts synergistically detrimental effects on coral physiological health and oxidative homeostasis.

Keywords: Coral; Histopathology; Oxidative stress; Polyethylene microplastics; Thermal stress

O-G-6 - Tissue-specific Distribution of Rare Earth Elements in Rays Collected from Southwestern Taiwan

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Abstract: Cartilaginous fishes are mostly apex predators in marine food webs and are distinguished by their unique cartilaginous skeletons. This study investigated the distribution of rare earth elements (REEs) in 57 rays collected from the southwestern coast of Taiwan in September 2024, a region adjacent to major industrial zones. REEs are increasingly recognized as emerging pollutants, primarily released through mining, smelting, processing, and industrial wastewater. They can disperse in air, soil, and water, subsequently bioaccumulating through the food chain and posing potential ecological and human health risks. Muscle tissues of the rays were analyzed for 15 REEs. Samples were digested using a hotplate method and quantified via inductively coupled plasma mass spectrometry (ICP-MS). Scandium (Sc) was the most abundant element, with an average concentration of 4.76 ± 8.70 μg/kg dw. Three individuals exhibited exceptionally highest Sc levels: *N. orientalis* and *N. varidens* with concentrations of 45 and 24.73 μg/kg dw, respectively. This study provides baseline data on REE accumulation in marine apex

predators from Taiwan's southwestern waters and highlights the potential ecological implications of REE contamination in industrialized coastal regions.

Keywords: La; SDG17

O-G-7 - Life Cycle Sustainability Assessment of Seaweed-based Chemical Production: Indonesia Case Study

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Abstract: This study focuses on the sustainability aspect of seaweed-based chemical production in Indonesia, especially sodium alginate and fucoidan. These chemicals can be extracted from Indonesian brown seaweed. During their production systems, the three pillars of sustainability (environmental, economic, and social) were assessed by using life cycle assessment (LCA) methodology. The process-based LCA, life cycle costing (LCC), and social LCA were used in this study, respectively. The Ecoinvent and PSILCA databases were used to calculate process-based LCA and Social LCA in OpenLCA software, respectively. Findings reveal that optimizing processing techniques and integrating circular economy principles can reduce chemical stream into environment. Thus, their sustainability index will increase. This Indonesian case study and practices can be a good recommendation to ensure long-term sustainability in Indonesia's seaweed industry.

Keywords: Life cycle assessment; Life cycle costing; Social life cycle assessment; Sustainability

O-G-9 - Sustainable Supply Chain Seaweed Production Based on Life Cycle Assessment Perspective: South Sulawesi Case Study

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Abstract: Seaweed production has increased significantly over the years globally. Indonesia as the third seaweed provider worldwide, has been practicing the whole supply chain of seaweed, starting from the production, processing, distribution, and eventually sale to the consumers. Despite its health benefits and nutritional richness, sustainability

of its supply chain through life cycle thinking is enhanced by adopting some measures from minimizing processing waste, optimizing energy use, and repurposing byproducts. This will ensure the long-term viability of the supply chain with minimum environmental impact. This research highlights the practical situation lays in South Sulawesi, Indonesia, where production of seaweed is massive and remain as the major seaweed hub in the island. Annual seaweed harvests reach approximately 1500 kg, raising local challenges such as production efficiency and other technical and social issues. This paper calculated the supply chain-based life cycle assessment based on this functional unit.

Keywords: Life cycle assessment; Seaweed production; South Sulawesi; Sustainability; Supply chain

Theme VIII Other Systems or Conversions Relating to Sustainability

O-H-1 - PIV-based Investigation of Oil Droplet Distribution and Critical Separation Size in a Grease Trap

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Abstract: A grease trap is a simple pretreatment device used to separate oil and water by gravity, but its installation is not required in many regions and countries. Understanding its operation principles and separation efficiency is crucial for promoting its broader adoption. This study investigates the oil droplet motion and separation performance of a grease trap using Particle Image Velocimetry (PIV) and computer vision-based image analysis. A highly transparent glass grease trap (L850 × W500 × H500 mm) was fabricated for experimental analysis under three flow rates: 7.5 L/min, 10.0 L/min, and 15.0 L/min, with 100 mL of oil (oleic acid) introduced in each trial. A high-speed camera (100 to 300 FPS) was used to track the movement of oil droplet, and then OpenCV2 based image processing was applied to quantify the oil droplets' size, distribution, and quantity at a given time. Their rising velocity followed Stokes' Law, and the grease trap effectively separated droplets larger than 0.96 mm. The results show that the separation efficiency is approximately 97.8% for oil droplet diameters > 0.99 mm. These findings provide critical insight for optimizing grease trap design and enhancing oil-water treatment efficiency.

Keywords: Grease trap; Particle image velocimetry; Oil droplets; Oil-water separation; OpenCV

O-H-2 - Removal of Perfluorooctanoic Acid Using Biopolymer Functionalized Graphene Oxide Nanocomposite

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Abstract: Perfluorooctanoic acid (PFOA) is a recalcitrant emerging organic contaminant from the per- and polyfluoroalkyl substances (PFAS) family that poses serious environmental challenges. Its widespread occurrence and significant bioaccumulation have sparked growing global concern, underscoring the urgent need for effective removal strategies. Among existing treatment methods, adsorption has shown considerable effectiveness in removing PFOA, and there is a continued need to develop more efficient adsorbents for this purpose. In this context, this study prepared ultrasonic-assisted chitosan-functionalized graphene oxide (GO-CS) nanocomposite and used for PFOA removal. In batch experiments, the GO-CS nanocomposite achieved highest PFOA removal of ~95% under favorable conditions (adsorbent dose: 240 mg/L, pH: 4, and time: 120 min). Non-linear regression analysis revealed that adsorption process followed pseudo-second-order kinetics and was best represented by the Langmuir isotherm model, with a Q_{max} of ~607 mg/g. The thermodynamic analysis revealed that the adsorption of PFOA onto GO-CS was spontaneous and exothermic in nature. Spectroscopic and zeta potential analyses confirmed that electrostatic interaction and hydrogen bonding are the primary mechanisms facilitating PFOA adsorption. Overall, this study provides valuable insights into the adsorption behavior of PFOA and highlights the substantial potential of chitosan-functionalized graphene oxide nanocomposite as highly efficient adsorbent for PFOA removal.

Keywords: Adsorption; Chitosan; Graphene oxide; Nanocomposite; PFOA

O-H-3 - Application of GOx-Based Enzymatic Bioleaching for Co and Ni Recovery from Spent Lithium-ion Batteries

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Abstract: Global transition toward electrification and digitalization is accelerating lithium-ion battery (LIB) usage across industries. This widespread adoption is leading to

a rapid increase in spent LIBs, which, while presenting environmental concerns, also offer a substantial secondary source of critical metals such as Li, Co, Ni, and Mn. Efficient recovery can reduce import dependence and support domestic supply chains. This study presents a simple, efficient, and environmentally benign enzymatic bioleaching method to recover Co and Ni from spent LIB cathode materials. In this regard, the influences of various process parameters, such as GO_x content (100−1000 U/L), pulp density (1−10 g/L), Fe^{2+} concentration (1−27 mM), and mixing speed (150−450 rpm), on metal bioleaching from the black powder of size fraction < 75 μm were studied at a constant temperature of 35 ºC, pH 3.5 and D-glucose content of 20 mM. The results showed that the optimal condition for leaching of Co and Ni occurred at GO_x content of 500 U/L, Fe^{2+} concentration of 27 mM, pulp density of 2 g/L, and mixing speed of ~300 rpm. Under these optimal conditions, maximum metal extraction efficiencies of more than 95% of Co, and Ni were leached from the homogenized LIBs particles were attained in 120 h. Oxidation of metals present in the spent LIB powder by Fe^{3+} ions generated from enzyme catalyzed oxidation of Fe^{2+} ions contributed to the efficient and faster metal extraction during the enzymatic bioleaching process. Furthermore, the analysis of cathode black powder before and after bioleaching, using XRD, FE-SEM, and FTIR techniques, revealed significant alterations in the phase, structure, and micro-morphology of the particles, affirming enzymatic bioleaching as an effective method for recovering metals from spent LIBs. The enzymatic bioleaching process, followed by downstream methods such as solvent extraction, electro-winning, and chemical precipitation to selectively recover metals from leached liquor, can be regarded as an integrated beneficiation technique for metal recovery from spent LIBs.

Keywords: Bioleaching; Critical metals; Circular economy; Glucose oxidase; Li-ion batteries; Resource recovery

O-H-4 - Synergistic Confinement and Polar Recognition in a Methyl-engineered Ultramicroporous MOF for boosted Xe/Kr separation

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Abstract: The separation of xenon (Xe) and krypton (Kr), critical for nuclear reprocessing and industrial gas purification, with significant implications for resource efficiency and environmental sustainability. Here, we present Zn-DMTDC-BPY, a methyl functionalized ultramicroporous metal-organic framework (MOF) with one-dimensional channels featuring alternating narrow apertures (3.9 Å) and enlarged cavities (8.4 Å), designed to synergistically exploit size sieving and polarity-driven Xe recognition. The methyl functionalized framework exhibits exceptional stability, retaining crystallinity and porosity after prolonged exposure to water and acidic/basic environments. DFT

calculations reveal that the confined pore geometry preferentially restricts Xe diffusion, while methyl functional groups enhance Xe affinity through dipole interactions. This dual mechanism endows Zn-DMTDC-BPY with a mixed-gas Xe/Kr selectivity of 6.24 and a moderate Xe adsorption capacity (2.27 mmol g^{-1}), outperforming many ultramicroporous MOFs. Dynamic breakthrough experiments further validate its separation efficacy and recyclability. By integrating confinement engineering with chemical recognition, our work establishes ligand methylation as a critical tool for separating molecules with subtle differences, advancing MOF design toward practical gas separation technologies.

Keywords: Ultramicroporous MOF; Xe/Kr separation; Methyl functionalization; Adsorption; DFT calculations

O-H-5 - Green Design for Low-carbon Ethylene Production via Electrochemical Carbon Dioxide Reduction

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Abstract: This study proposes a green design strategy for the electrochemical reduction of carbon dioxide to ethylene (C_2H_4) aimed at achieving low carbon emissions. The developed system utilizes a carefully designed electrochemical cell based on sustainable materials and optimized components for enhanced environmental performance. A copper cathode integrated with carbon paper, replacing conventional copper/PTFE materials, and an anode employing nickel foam instead of iridium oxide on titanium sheets significantly reduces the overall carbon footprint of the ethylene production process. Life cycle assessment (LCA) conducted using the ReCiPe midpoint methodology highlights a substantial reduction in greenhouse gas emissions, from an original 32.2 kg CO_2eq to 1.2 kg CO_2eq per kg of C_2H_4 produced, demonstrating superior environmental benefits compared to conventional electrolysis technologies. The innovative material substitutions and optimized cell design presented here significantly contribute toward achieving sustainable chemical manufacturing, providing a viable solution aligned with the principles of a circular carbon economy and green chemistry.

Keywords: Circular economy; Electrochemical carbon dioxide reduction; Green design; Low carbon production; Life cycle assessment; Sustainable ethylene production

O-H-6 - Polystyrene Nanoplastics Exposure Induces Oxidative Stress on Lung Cancer Cells

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Abstracts: Plastic pollution constitutes a significant environmental issue, as plastics continuously degrade into microplastics and nanoplastics. Microplastics are widely documented in the global atmosphere, with polystyrene (PS) particles identified as a major contributor to atmospheric microplastic pollution. Nanoplastics (NPs) represent emerging pollutants with uncertain toxicity levels, frequently utilized in manufacturing and personal care products. Nanoparticles are readily inhaled by individuals, subsequently migrating to the bronchi and depositing in the alveoli, which can contribute to numerous respiratory diseases. This study aims to evaluate the capacity of PS-NPs to induce oxidative stress in the human lung adenocarcinoma A549 cell line. We assessed the impact of PS-NPs at different concentrations on A549 cells after 12, 24, and 48 h using the MTT assay. We then analyzed several oxidative stress biomarkers, including levels of reactive oxygen species (ROS), mitochondrial membrane potential (MMP), and malondialdehyde (MDA), as well as the activities of superoxide dismutase (SOD) and glutathione S-transferase (GST) enzymes. The findings indicated that PS-NPs reduced the viability of A549 cells and induced oxidative stress, as evidenced by elevated levels of ROS and MDA, increased activities of SOD and GST, and a reduction in MMP levels. Briefly, PS-NPs inhalation may influence human respiratory health.

Keywords: Lung cancer cells; Oxidative stress; Olastic pollution; Oolystyrene-nanoplastics

O-H-7 - The Characteristics and Evaluation of Factors Influencing the Change of Dissolved Organic Carbon in Arctic Rivers

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Abstract: The Arctic region is one of the most sensitive regions to global climate change, and the permafrost, as an important component of the Arctic ecosystem, plays a role in the carbon cycle and maintaining ecological stability. Riverine organic carbon (ROC), linking land and ocean, serves as a key indicator for the Arctic carbon budget. Permafrost thaw impacts ROC transport through direct carbon release and indirect effects like altered hydrology and vegetation, introducing uncertainty. This study used a permafrost table temperature model and the Stefan equation to analyze Arctic basins. Spatiotemporal patterns were extracted using Empirical Orthogonal Function (EOF) analysis, while riverine dissolved organic carbon (DOC) and particulate organic carbon (POC) fluxes were estimated via the LOADEST model. The results indicate that:

(1) Permafrost degradation was evidenced by rising permafrost table temperatures (0.23– 0.42 °C/decade) and increased active layer thickness (1.18–4.16 cm/decade), with ALT exhibiting a decreasing south-north gradient jointly influenced by topography, latitude, and climate; (2) Riverine organic carbon export showed an average DOC flux of 18.46 Tg/yr (Lena River-dominated at 37%) and POC flux of 2.81 Tg/yr (Mackenzie River-dominated at 25%), both peaking in summer (DOC:9–70%; POC: 54–76% of annual export).

Keywords: Arctic region; Dissolved organic carbon; Spatiotemporal response mechanisms

O-H-8 - Analyzing the Effect of Oxygen-rich Torrefaction on Hydrogen Peroxide-pretreated Bamboo Using Analysis of Variance

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Abstract: This research delves into how the combination of hydrogen peroxide (H_2O_2) pretreatment and oxygen-rich torrefaction impacts the physicochemical features and environmental sustainability of biochar derived from bamboo. Moving away from traditional torrefaction carried out under inert conditions, this method utilizes controlled oxidative environments to enhance the efficiency of thermal conversion. The investigation systematically optimized three significant factors torrefaction temperature, oxygen levels, and H_2O_2 concentration using the Taguchi design coupled with artificial neural network (ANN) modeling, aiming to identify parameter settings that produce superior biochar quality. Among sixteen experimental scenarios, the condition involving

torrefaction at 260 °C with 30% oxygen and 17.5% H_2O_2 (Run 16) generated biochar exhibiting elevated calorific value, improved porosity, and enhanced thermal resilience. The biochar's characteristics were thoroughly evaluated through thermogravimetric analysis (TGA), Brunauer Emmett Teller (BET) surface area measurement, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). Findings indicated that the presence of oxygen and H_2O_2 accelerated devolatilization processes and induced structural modifications, ultimately boosting the energy density and adsorption capabilities of the produced biochar. Moreover, a life cycle assessment (LCA) performed under the optimal conditions reinforced the potential of this approach in achieving climate-positive energy solutions.

Keywords: Biochar; H_2O_2 pretreatment; Life cycle assessment; Oxygen-rich; Taguchi method; Torrefaction

O-H-9 - A Chemical-biological Process Based on H_2O_2/O_3 Lysis and Cryptic Growth for In-situ Reduction of Waste Activated Sludge

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Abstract: In addressing the expensive transportation and disposal cost of the waste activated sludge (WAS), an in-situ sludge reduction strategy was developed in this study based on H_2O_2/O_3 lysis and cryptic growth process. The critical roles of sludge solubilization and biodegradability of sludge lysate were analyzed comprehensively. Under a dosage of 0.36 g O_3/g mixed liquor volatile suspended solids (MLVSS), the H_2O_2 addition (H_2O_2/O_3 molar ratio was 0.25) achieved a significant improvement of sludge cell lysis performance in terms of MLVSS reduction ratio (35.2% vs. 26.3%). Compared with O_3 alone, the sludge lysate treated by H_2O_2/O_3 exhibited a higher biodegradability, as the value of BOD_5/COD increased from 0.72 to 0.79, accompanied with the mean specific rate at 6.71 and 7.42 h^{-1}, respectively. Reintroduction of H_2O_2/O_3-treated sludge to the mainstream biological process facilitated further hydrolysis of oxidized sludge fragments, achieving an overall sludge reduction ratio of 29.1% without affecting effluent quality adversely. Pilot-scale experiment at 2.4 m^3/d treatment capacity also demonstrated a similar sludge reduction performance of 28.1% in term of MLVSS. Economic analysis revealed that the net benefit of in-situ sludge reduction reached to 132/t dry sludge (DS), highlighting the significant potential of the combined H_2O_2/O_3 method for effective sludge reduction.

Keywords: Cryptic growth; Economic benefit; H_2O_2/O_3 lysis; Pilot experiment; Sludge reduction

O-H-10 - Sustainable Recovery of Spent Lithium-ion Batteries (LIBs) Using Hydrogen Evolution Reaction Catalysts and Metal Recovery

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Abstract: With the rapid growth of electric vehicles (EVs) and portable electronics, lithium-ion battery (LIB) consumption has surged, leading to an increase in spent LIBs (sLIBs). These are rich in valuable metals and toxic chemicals that, without proper recycling, can significantly harm the environment. However, current recycling methods, such as pyrometallurgy and hydrometallurgy, while mature, are energy-intensive, polluting, or complex. As the world moves toward net-zero emissions, the demand for sustainable and economically beneficial recycling approaches becomes increasingly critical. This study presents an innovative strategy combining material upcycling and electrocatalysis. Spent $LiFePO_4$ (LFP) cathode materials are processed into black powder and coated onto nickel foam (NF) for use in hydrogen evolution reactions (HER). Using fluorine-rich Nafion as a functional binder and acetylene black (AB) for conductivity enhancement, the optimized M12 N-AB (0.3)/NF electrode achieved a low overpotential (205.3 mV at the current density of 10 mA cm^{-2}) and a Tafel slope of 102 mV dec^{-1}-outperforming many waste-derived catalysts. Characterization via SEM, XRD, XPS, and TGA/DTG confirmed structural stability and the critical role of Nafion in surface chemistry and charge transport. EIS analysis revealed synergistic ion-electron transport as a key factor in catalytic efficiency. The electrode also maintained stable performance after 96 hours, demonstrating excellent durability. This work presents a scalable route for transforming battery waste into efficient HER catalysts, highlighting the potential of sustainable, fluorine-based binder engineering in hydrogen production and circular economy applications.

Keywords: Green hydrogen; Renewable energy; Spent lithium-ion batteries; Sustainability

O-H-11 - A Novel Dual-ligand Zn(II) MOF with Bidirectional Channels Exhibiting Enhanced CO_2 Adsorption

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Abstract: A novel dual-ligand zinc(II) metal-organic framework (MOF), formulated as Zn(tdc)(3-mtz) (where H_2tdc = 2,5-thiophenedicarboxylic acid and 3-mtz = 3-methyl1,2,4-triazole), was successfully synthesized. The compound was prepared via a solvothermal self-assembly reaction utilizing $Zn(NO_3)_2$, H_2tdc, and 3-mtz as starting materials. Single-crystal X-ray diffraction analysis revealed that the crystal structure crystallizes in the orthorhombic space group Pnma. The framework features small channels (12.8 × 1.0 Å²) running along the *a*-axis and larger channels (5.7 × 10.8 Å²) along the *c*-axis, resulting in a calculated porosity of 41.3%. Gas adsorption studies demonstrated that the desolvated sample possesses a high adsorption capacity for carbon dioxide (CO_2).

Keywords: Dual-ligand MOF; Bidirectional channels; CO_2 adsorption

O-H-12 - Overcoming Data Scarcity: KM-Bagging for Accurate Coagulant Dosage Prediction

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Abstract: Accurate coagulant dosage prediction is critical for ensuring the safety and cost-effectiveness of drinking water treatment, yet it is often hindered by the limited availability data from drinking water treatment plants. In this study, we propose a KM-Bagging framework that integrates K-Means clustering with Bagging ensemble learning. Based on the characteristics of raw water turbidity and temperature, water quality is categorized into three clusters (low-turbidity/low-temperature, high-turbidity/high-temperature, and transitional) using the elbow rule. The training and validation sets were split using stratified sampling at a ratio of 8:2. To evaluate the prediction performance of the model, it was compared with seven learning algorithms, including SVR, RF, and XGBoost. The results showed that KM-Bagging achieves a coefficient of determination (R^2) of 0.81 and a mean absolute percentage error (MAPE) of 4.23% on the full dataset (n = 1095), outperforming individual models. When data are halved, the model maintained strong generalization (R^2 = 0.64, MAPE = 5.73%). Compared to random partitioning, water quality-based clustering increases test R^2 by 5% and reduces MAPE by 3%, mitigating both overfitting and underfitting. This framework offers a robust and practical solution for developing reliable predictive models in process-control

environments with limited data, which contributes to more intelligent and efficient water resource management.

Keywords: Coagulant dosage prediction; Drinking water treatment plants; KM-Bagging framework; Machine learning; Small sample generalization

Poster Presentation

Theme I: Biological waste/wastewater treatment

P-A-1 - Effect of pH on the Performance of a Simultaneous Methanogenesis-Feammox-denitrification System Treating Aquaculture Wastewater

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Abstract: The effects of different pH levels (5, 6, 7 and 8) on organic matter degradation, nitrogen removal, and methane production in the simultaneous methanogenesis Feammox-denitrification (SMFD) system were systematically evaluated. Regarding organic matter removal, the SMFD system demonstrated a strong pH adaptability, achieving efficient organic matter degradation efficiencies across the pH range of 5 to 8. Additionally, under near-neutral pH conditions (6 to 8), both the Feammox and methanogenesis processes functioned well. The optimal pH for Feammox was found to be 7, while that for methanogenesis was 8. Metagenomic analysis revealed that the Feammox process in the SMFD system was predominantly carried out by iron-reducing bacteria, specifically *Clostridium* and *Ignavibacterium*, which exhibited enhanced activity in near-neutral pH environments. The transformation of $NH4^+$-N in the SMFD system was primarily driven by the Feammox process, with genes such as *mtrABC*, *fccAB*, and *ppcAD* associated with Fe(III) reduction showing relatively higher expression levels in samples cultivated at pH 6–7. Overall, the SMFD system can achieve effective removal of organic matter and ammonia nitrogen at the near neutral pH range of 6-8, offering a cost-effective, environmentally friendly, and highly efficient strategy for treating fish sludge.

Keywords: Methane production; Nitrogen removal; Organic matter removal; Metagenomic analysis; Wastewater treatment

P-A-2 - Preparation of Gel Granular Sludge and Its Application in Marine Aquaculture Wastewater Treatment

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Abstract: In this study, gel granular sludge was prepared by embedding activated sludge

(AS) into the natural organic polymers. 1% sodium alginate and 2% chitosan were used as the embedding medium, and 2% $CaCl_2$ was used as cross-linking agent to prepare the gel granules. Sequencing batch reactors (SBRs) were used to assess the performance of gel granular sludge in treating marine aquaculture wastewater, with AS serving as the control group. The organic matter removal performance, nutrient removal efficiency, sludge sedimentation performance, particle structure, biomass concentration, and microbial community structure were regularly monitored in both reactors. The study focused on evaluating the startup time, nutrient removal efficiency, and long-term operational stability of the gel granular sludge system compared to conventional granular sludge. The results of this study will provide a scientific basis for the efficient operation of biological treatment of marine aquaculture wastewater.

Keywords: Embedding immobilization; Gel granular sludge; Marine aquaculture wastewater; Nutrient removal

P-A-3 - Impact of Fe(III)/N Ratio on Organic Matter and Nitrogen Removal in Integrated Anaerobic Systems Treating Aquaculture Wastewater

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Abstract: Iron (Fe) oxides not only contribute to the organic carbon (C) biogeochemical cycling through dissimilatory iron reduction (DIR) process, but also participate in complex nitrogen (N) cycling, via processes like Feammox and nitrate-dependent ferrous oxidation (NDFO). In the present study, integrated Feammox-NDFO/heterotrophic denitrification systems with different iron amounts were constructed, to investigate the effects of different Fe/N ratios (Fe/N = 1, 3, 6, 8, COD/N = 10) on the removal performance of organic C and N. The results indicated that the COD removal efficiency at Fe/N = 1 was 50%-125% higher than at other ratios. Meanwhile, the system also achieved the highest ammonium conversion efficiency via Feammox at this condition, followed by Fe/N of 3. Low Fe/N ratios (1-3) channeled 70%-90% of ammonium to nitrate, whereas high Fe/N ratios (6-8) shifted the dominant Feammox product to nitrite (~52%), which was subsequently removed through NDFO and/or heterotrophic denitrification. Furthermore, *Ignavibacterium*, *Geobacter*, and *Longilinea* were identified as potential functional bacteria for Feammox, while *Comamonas* and *Pseudomonas* were for NDFO, and *Thauera* and *Alicycliphilus* were for heterotrophic denitrifiers. Our findings will contribute to a deeper understanding of Fe-N coupling systems.

Keywords: Feammox; NDFO; Fe/N ratio; Nitrite accumulation; Microbial community

P-A-4 - Seasonal Dynamics of Microcystin Degrading Bacteria and Degradation Ability in Natural Lake

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Abstract: Many studies have indicated that biodegradation primarily accounts for the reduction of microcystin (MC) levels in freshwater ecosystems. However, there is limited understanding of the seasonal change of MC-degrading bacteria and their biodegradation activities in natural environments due to a scarcity of field research. This study aims to investigate how the abundance of MC-degrading bacteria and their degradation activities fluctuate with the seasons in a eutrophic lake. Water samples from Lake Miyuki, where severe cyanobacterial blooms occur annually, were collected monthly from April to October. After filtering to remove cyanobacterial cells, biodegradation tests were performed using bacterial cells obtained from the lake water. In an early June 4th test, the MC concentration decreased to approximately 40% of the initial level within four days. Conversely, a test conducted in late June 18th showed that MC concentration became undetectable after just two days. Additionally, qPCR was performed to measure the copy number of MC-degrading bacteria, revealing a trend of increasing bacterial abundance as MC concentrations declined. More repeatable tests were confirmed to confirm the above findings.

Keywords: Biodegradation; Cyanobacterial bloom; Microcystin; *MlrA* gene; qPCR; Seasonal change

P-A-5 - Exploring Sulfur Uptake by Cyanobacteria under Varying Nutrient Conditions in Sulfur-containing Wastewater

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Abstract: Sulfur-containing wastewater typically contains a mix of reduced (e.g., hydrogen sulfide, sulfite) and oxidized (e.g., sulfate, thiosulfate) sulfur compounds, which

contribute to odor pollution, reduce dissolved oxygen levels, and disrupt microbial activity. Traditional physicochemical desulfurization methods are effective but require large amounts of chemicals and energy, conflicting with carbon reduction goals. As photosynthetic organisms, cyanobacteria can use light and CO_2 for autotrophic growth while assimilating sulfur into their biomass, offering a low-carbon and biomass-utilizing alternative for sulfur removal.

This study focuses on screening efficient desulfurizing cyanobacterial strains and identifying optimal cultivation conditions. We evaluated the desulfurization capabilities of three strains—*Oscillatoria limnetica*, *Synechocystis alina*, and *Nostoc* sp.—under varying carbon, nitrogen, and phosphorus levels, as well as under autotrophic, heterotrophic, and mixotrophic conditions. Key algal parameters (biomass, chlorophyll, protein, carbohydrates) and water quality indicators (pH, carbon, nitrogen, phosphorus, sulfur) were monitored to assess both algal responses and sulfur removal efficiency. Based on these data and intracellular component analysis, we identified preliminary optimal conditions for removing different sulfur species. The results offer valuable operational guidance for integrating phototrophic desulfurization into wastewater treatment and support the potential for sulfur recovery through cyanobacterial biomass.

Keywords: Cyanobacteria; Sulfur uptake; Wastewater treatment

P-A-6 - Microbial Colonization and Succession on Polylactic Acid Microplastics (PLA MPs) in Mangrove Forests - the Role of Environmental Conditions and Plastic Properties

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Abstract: The concerns about possible risks of biodegradable plastics have increased in recent years. In this study, two types of biodegradable polylactic acid (PLA) MPs, 604 (low molecular weight) and 801 (high molecular weight), were incubated in-situ in mangrove ecosystems, across four different environmental matrix - mangrove sediment, mangrove water, mangrove air and beach air for 90 days. The fluorescence staining combined with scanning electron microscopy (SEM) results revealed that microbial colonization (both algae and bacteria) tended to be in the areas of depressions and cavities on MPs, which presumably showed signs of microbial degradation on the surface of the plastics. Over the 90-day period, microbial colonization and succession on the plastics was significantly influenced by both environmental conditions and the properties of the MPs. Microbial colonization on plastic samples in mangrove sediment progressed more rapidly than that in mangrove water. Correspondingly, microbial communities on plastics

in sediment showed high similarity to those in the surrounding environment, whereas the opposite was observed in water. Environmental disturbances and nutrient availability in different matrices also led to distinct microbial succession pathways for the two types of MPs. In sediment, which provided the most stable and nutrient-rich environment, divergent succession patterns were observed between 604 and 801 PLA MPs. Conversely, in flowing water and air, where environmental pressures were higher, convergent succession patterns were found. It is worth noting that the relatively stable environmental conditions and limited nutrient sources in mangrove air resulted in the highest enrichment of potential PLA-degrading microorganisms on both types of PLA MPs. Our findings highlighted the critical role of environmental conditions and MP properties in shaping microbial colonization and succession on PLA MPs. These results provided valuable scientific insights into the environmental degradation processes and long-term ecological risks of biodegradable plastics in mangrove coastal ecosystems.

Keywords: Polylactic acid; Microplastics; Microbial colonization; Microbial succession; Mangrove ecosystems

P-A-7 - Optimizing Vanadium(V) Removal in Groundwater with Machine Learning Predictions

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Abstract: Vanadium(V) contamination in groundwater is a severe problem. Wheat straw was employed as the main packing material, supplemented by ceramsite and medical stone as auxiliary fillers in both segmented and mixed packing reactors. The reactor with segmented packing (97.8%) demonstrated markedly superior performance in vanadium(V) removal efficiency compared to the mixed packing reactor (76.3%). Genomic analysis of microbial communities revealed that microbes in the segmented packing reactor were more efficient in utilizing Fe, Mo and DOM, thus promoting the biological Vanadium(V) reduction. Moreover, Vanadium(V) stimulation led to the secretion of EPS, playing a significant role in enhancing Vanadium(V) removal. The machine learning (gradient boosting tree model) for high-precision prediction of Vanadium(V) concentrations, achieving prediction accuracies around 98% for segmented packing and 99% for mixed packing reactors. The application of machine learning models demonstrates the effectiveness of data-driven approaches in predicting reactor performance, providing a paradigm reference for future machine learning applications. Additionally, this study offers new perspectives for the real-time optimization and control

of bioreactors.

Keywords: Vanadium(V); Wheat straw; Packing method; EPS; Machine learning

P-A-8 - Potentials of Electrochemical-sulfate Reducing Bacteria (SRB) Hybrid Systems for Heavy Metals Removal from Wastewater

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Abstract: Heavy metals in wastewater present long-term risks due to their persistence and toxicity, which are also challenging the sustainable management of wastewater treatment plants. To cope with this problem, Sulfate Reducing Bacteria (SRB) have been investigated for biologically driven metal removal via sulfide precipitation. However, its practical application remains a challenge owing to such issues including microbial instability and carbon source dependency. Electrochemical technologies have been increasingly integrated with SRB-based biological treatment systems to address these limitations. By providing controlled electron flow, stabilizing redox environment, and promoting biofilm formation, they can enhance SRB activity under various conditions. This review summarizes the recent advancements on electrochemical-SRB hybrid systems like microbial fuel cells (MFCs) and microbial electrolysis cells (MECs) for the remediation of heavy metals such as copper, chromium, and antimony. Literature review shows these integrated systems can achieve improved removal efficiency and resource recovery benefits. By aligning microbial capabilities with electrochemical control, such platforms can offer promising solutions for heavy metal-containing wastewater treatment.

Keywords: Electrochemical technology; Heavy metals; Sulfate-reducing bacteria

P-A-9 - Antibiotic Characterization in Livestock and Aquaculture Wastewater via Excitation-emission Matrix Fluorescence Spectroscopy: Current Challenges and Future Perspectives

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Abstract: Antibiotic residues in livestock and aquaculture wastewater induce environmental persistence and antibiotic resistance generation, disrupting aquatic ecosystems and increasing human health risks through food chain contamination. Rapid

characterization of antibiotics is essential for timely risk assessment and implementing effective pollution control measures to mitigate these threats. Excitation-emission matrix (EEM) fluorescence spectroscopy, distinguished by capturing unique spectral fingerprints and rapid characterization of antibiotics in complex matrices, supporting environmental pollution monitoring. We systematically reviewed the literature published over the past decade on the application of EEM fluorescence spectroscopy in antibiotic characterization, EEM fluorescence spectroscopy combined with parallel factor analysis is the most predominant used method for characterizing antibiotics. This study critically analyzed the difficulties and challenges of applying EEM fluorescence spectroscopy to the characterization of antibiotics in livestock and aquaculture wastewater. Different from general antibiotic-containing wastewater, livestock and aquaculture wastewater exhibit greater matrix complexity due to higher organic matters and unique interferents, which amplify fluorescence quenching and spectral overlap challenges. Finally, future perspectives were provided to promote the practical application of this technology for antibiotic characterization in livestock and aquaculture wastewater.

Keywords: Antibiotics; Aquaculture wastewater; Livestock wastewater; Excitation emission matrix fluorescence spectroscopy

P-A-10 - Functions of Complex Carbon Sources in Granular Sludge Formation: Granule Development, EPS Excretion and Microbial Community: A Mini Review

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Abstract: Granular sludge systems have emerged as an attractive alternative for modern wastewater treatment as they offer excellent settleability, superior nutrient removal and reduced carbon footprint. However, a significant knowledge gap exists between laboratory studies primarily utilizing simple carbon sources, and real-world applications with diverse and complex carbon compounds. These complex sources profoundly impact granular sludge performance, yet their specific roles in granulation are not often clarified. This review offers an insight on the current understanding of their impact on granulation, specifically detailing their impacts on granule formation and morphology, extracellular polymeric substances excretion, and microbial community dynamics. Analysis of existing literature reveals that complex carbon sources influence granule development speed and morphology, and in some cases granule structure stability. The review also highlights while complex carbon sources can impede biodegradability and challenge nutrient removal efficiency, they often foster a more robust microbial community. Finally, the critical discrepancies between laboratory-scale findings and real-world applications are discussed, outlining future research directions. This review underscores that a deeper

understanding of the impact of complex carbon sources is crucial to unlock the full potential of granular sludge systems in diverse wastewater scenarios.

Keywords: Complex carbon source; Extracellular polymeric substances; Microbial community; Sludge granulation; Wastewater treatment

P-A-11 - Shifting Nitrogen Pathways toward Nitrogen Assimilation with Enhanced Protein Production in Activated Sludge via Nitrification Suppression

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Abstract: Nitrification/denitrification in conventional activated sludge systems often causes permanent nitrogen loss. This study explores whether inhibition of autotrophic nitrification via allylthiourea can shift nitrogen loss towards microbial assimilation with enhanced protein accumulation in sludge biomass. Two sequencing batch reactors were operated: control group (R_C) and test group with allylthiourea addition (R_T). In R_T the NH_4^+-N removal declined from 97-99% (R_C) to 45-55%, indicating its effective nitrification inhibition with less nitrogen removal. Some slight decrease in total organic carbon removal was also detected in R_T (75-85%) when compared to R_C (~ 95%). On day 20, R_T biomass contained about 22% higher contents of total nitrogen (TN, 91.41 mg/g-VSS) and proteins (92.04 mg/g-VSS) than R_C biomass (74.67 mg/g-VSS of TN and 75.73 mg/g-VSS of proteins). These observations show that nitrification inhibition can shift nitrogen metabolism toward assimilation, promoting nitrogen reservation and protein-rich biomass production. Although TN removal declined, this strategy offers a viable alternative for resource recovery, particularly from low C/N wastewater where carbon limitation may hinder denitrification but not assimilation. Results from this study suggest that when redirecting nitrogen from loss to valorization, the wastewater facilities can be transited to bio-circular economy and resource-oriented systems.

Keywords: Activated sludge; Allylthiourea; Nitrification inhibition; Nitrogen assimilation; Resource recovery

P-A-12 - Beyond Filter Cake Filtration: New Insights into Secondary Dewatering of Drinking Water Centrifuge Sludge Through Cell Lysis and Release of Bound Water

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Abstract: Effective chemical conditioning techniques are critical for enhancing centrifugal sludge dewatering in water supply plants. This study investigated conditioning methods for drinking water sludge, focusing on flocculation treatment and salt addition. While common flocculants showed no significant dewatering improvement, NaCl demonstrated particularly effective dewatering performance, exhibiting excellent applicability. At the optimal dosage (40%/TS), the sludge moisture content (Mc) decreased from 56.08% to 48.12%, with minimal residual sludge adhering to the filter cloth. This NaCl conditioning technique significantly outperformed conventional coagulants/flocculants in dewatering efficiency. It facilitates bound water release without relying on filter cake pore structure optimization. Furthermore, NaCl dosage induces protein precipitation from the liquid phase and disrupts the hydrophilic structure of proteins, thereby enhancing dewatering performance.

Keywords: Cell lysis; Drinking water sludge; Filter cake structure; Secondary dewatering

P-A-13 - Synthesis and Characterization of High-porosity Polyurethane Foam for Immobilization of Nitrifying Bacteria in Wastewater Treatment

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Abstract: This study addresses the critical need for reproducible, high-performance microbial carriers for efficient wastewater treatment by synthesizing polyurethane (PU) foam carriers with enhanced porosity, structural stability, and biocompatibility. The PU foam is synthesized by one-shot synthesis method using toluene diisocyanate (80% 2,4-TDI + 20% 2,6-TDI)/methylene diphenyl diisocyanate (MDI) and polypropylene glycol (PPG)/polyethylene glycol (PEG). Water is used as a blowing agent to generate CO_2, and incorporated 1, 1, 1-Tris (hydroxymethyl) propane (TMP) to improve crosslink density and hydrolytic resistance. Catalysts N, N-Dimethylcyclohexylamine (DMCHA) and dibutyltin dilaurate (DBTDL) are tailored to optimize foaming and polymerization kinetics, while polyoxyethylene polyoxypropylene glycol surfactant is used for regulating pore formation. Soluble porogens (sucrose and urea) are also embedded during synthesis,

followed by ultrasonication, washing, drying, and sterilization to produce open-cell foams with high interconnectivity. The synthesized PU foam is characterized by μ-CT, SEM, and compression testing to assess porosity (> 85%), pore size distribution (100–350 μm), and mechanical/water stability. Microbial immobilization efficacy is evaluated by quantifying cell loading (> 10^8 CFU/g) and nitrification activity in simulated wastewater. This PU foam is expected to outperform standard carriers by delivering superior microbial retention and stability. Overall, this research controlled fabrication and characterization protocol, offering reproducible data and a scalable foundation for advanced bioreactor and wastewater treatment applications.

Keywords: Microbial immobilization; Nitrifying bacteria; Polyurethane foam; Porosity; Structural stability; Wastewater treatment

P-A-14 - Microbial Immobilization on PVA/LDH Composites for Enhanced Nitrogen Removal from Aquaculture Wastewater

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Abstract: Ammonia nitrogen (NH_4^+-N or NH_3-N) and nitrite nitrogen (NO_2^--N) are highly toxic to aquatic organisms in aquaculture. Microbial immobilization technology has emerged as a promising method to address this challenge. In a previous study, the poly (vinyl formal) (PVF) foam was synthesized by the acetalization of poly (vinyl alcohol) (PVA) and paraformaldehyde to serve as a microbial carrier. To further enhance mechanical strength, porosity, hydrophilicity, and pH buffering capacity, novel poly (vinyl alcohol)/layered double hydroxide (PVA/LDH) carriers were fabricated via an in-situ hydrothermal method. The structural and physicochemical properties of the carriers were characterized by SEM, FT-IR, BET, TG-DTA, swelling degree, and mechanical stability analyses. In 40-day long-term experiments, the PVA/LDH biocarriers demonstrated excellent nitrogen removal performance under low NH_4^+-N levels at a 20% packing ratio. Effluent NH_4^+-N and NO_2^--N concentrations remained below 0.5 mg/L, and ammonia removal efficiency exceeded 95% with a biomass density of 0.0569 g VSS·g^{-1} carrier. The system pH was consistently maintained between 7.0 and 8.4 throughout the operation. The results indicated that the PVA/LDH carriers support microbial growth and ensure operational stability. This research is expected to contribute to the realization of a more environmentally friendly, cost-effective, and efficient closed-loop water system for high-density land-based aquaculture.

Keywords: Ammonia nitrogen; Nitrite nitrogen; Nitrifying bacteria; Microbial

immobilization; Poly (vinyl formal); Poly (vinyl alcohol)/layered double hydroxide

P-A-15 - Structural Extracellular Polymer-sodium Alginate Immobilized Aerobic Denitrifying Bacteria for the Treatment of Nitrogen-containing Wastewater

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Abstract: The immobilization technology of aerobic denitrifying bacteria (ADB) enables efficient treatment of nitrogen-containing wastewater. This study utilized structural extracellular polymeric substances(sEPS) and sodium alginate (SA) to embed aerobic denitrifying bacteria for treating nitrate wastewater. The results showed that the optimal conditions for immobilizing aerobic denitrifying bacteria were 2% SA, 3% calcium chloride, 2 g/L sEPS, and a cross-linking time of 12 h. sEPS could reduce the swelling rate of gel granules and improve their mechanical strength and mass transfer performance. A 28-day continuous operation experiment indicated that the sEPS/SA-ADB granules maintained a NO_3^--N removal efficiency of 94.8%-99.5%, COD removal efficiency stable at 71.8%-77.2%, and effluent NH_4^+-N and NO_2^--N concentrations stabilized at 0.31–0.43 mg/L and 0.18–0.29 mg/L, respectively. The swelling rate of the sEPS/SA ADB granules remained at 40.3%–48.3%. Although the compressive strength of the sEPS/SA-ADB granules decreased from 0.72 MPa to 0.02 MPa after 28 days of continuous operation, the granules did not completely disintegrate, demonstrating that the sEPS/SA-ADB granules exhibited good reusability. This study provides technical support for the application of aerobic denitrifying bacteria technology in treating nitrogen-containing wastewater.

Keywords: Aerobic denitrifying bacteria; Denitrification; sEPS; Sodium alginate

P-A-16 - Recirculating Aquaculture Systems with Efficient Aquaculture Wastewater Treatments under Low Ammonia Loading: A Case Study on *Litopenaeus vannamei* Farming

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Abstract: Ammonia nitrogen and nitrite nitrogen in aquaculture wastewater pose a severe threat to animal health in recirculating aquaculture systems, emphasizing the urgent need for effective wastewater treatment technologies especially under low ammonia loading. In this study, three bio-carrier materials—hydrophilic carrier, hydrophobic carrier, and household sponge—were evaluated in simulated wastewater with an initial ammonia nitrogen concentration of 8.5–12 mg/L, followed by continuous aeration for 6 hours. The hydrophobic bio-carrier achieved the highest ammonium removal efficiency (72.7%), outperforming the household sponge (62.5%) and the hydrophilic material (35.3%). Subsequently, the hydrophobic carrier was applied in the recirculating aquaculture system for *Litopenaeus vannamei* farming at 20 kg/m³. Throughout the two-year cultivation period, ammonia nitrogen kept at 0 mg/L, and nitrite nitrogen kept below 0.5 mg/L. These results demonstrate that the selected hydrophobic bio-carrier effectively maintains water quality under low ammonia loading, providing a reliable and scalable aquaculture wastewater treatment solution for sustainable aquaculture.

Keywords: Aquaculture wastewater treatment; Bio-carrier; Recirculating aquaculture
Theme II: Bioenergy and Resource Recoveryng

P-B-1 - Selective Enhancement of Methane Production and Phosphorus Recovery by Mg-Fe Layered Double Hydroxides in Anaerobic Digestion of Food Waste

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Abstract: Anaerobic digestion (AD) is a promising technology for bioenergy recovery from organic waste. However, AD processes operated under high organic loading rates (OLRs) are often hindered by rapid acid accumulation, pH decline, and reduced biogas yields, thereby necessitating strategies to improve process stability and energy conversion efficiency. This study investigates the effects of Mg-Fe layered double hydroxides (LDHs) addition on the performance of food waste digestion under three substrate-to-inoculum (S/I) ratios (2/1, 1/1, and 1/2). The results demonstrate that Mg-Fe LDHs effectively mitigates acidification and significantly enhances both methane yield and methane content, particularly under high S/I condition. Concurrently, LDHs addition was found to reduce phosphorus concentrations in the digester, suggesting potential benefits for

downstream nutrient management. The underlying mechanisms of these effects are currently under further investigation. Overall, this study provides novel insights into the application of Mg-Fe LDHs as multifunctional additives in AD systems, contributing to improved biogas production and resource recovery from food waste, with implications for advancing sustainable waste-to-energy technologies.

Keywords: Anaerobic digestion; Methane content; Layered double hydroxides; Phosphorus recovery

P-B-2 - Fertilizer Potential of Solid Digestate from a High-solid Anaerobic Digestion System with Liquid and Biogas Recirculation

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Abstract: Solid digestate generated after anaerobic digestion (AD) could be a promising fertilizer, while the fertilizer value varied according to the substrates and operation conditions. This study evaluated the fertilizer potential of the solid digestate from an innovative high-solid AD system with biogas-liquid recirculation for treating chicken manure and rice husks. The following 6 groups were designed and tested in a field experiment cultivating Chinese cabbage, including a control with no fertilizer application (T1), chicken manure compost (T2) applied at a dosage of 15 g-N/m^2 (recommended application amount), digestate applied at dosages of 15 (T3), 30 (T4) and 45 (T5) g-N/m^2, and digestate applied at dosage of 15 g-N/m^2 supplying with phosphorus and potassium (T6) equivalent to the amount in T2. Results showed that the digestate exhibited similar fertilizer effect to the compost, achieving comparable plant yield (61.7 (T3) versus 63.2 (T2) g/plant) and slightly higher nitrogen use efficiency (NUE) of 46.3%. The increase in digestate dosages increased plant yield up to 85.6 g/plant; however, the NUE was significantly lowered to around 22.3-27.4%. Supplying phosphorus and potassium in digestate application (T6) further increase the plant yield to 72.02 g/plant, suggesting the outstanding fertilizer potential of digestate when balanced nutrients was supplied

Keywords: Anaerobic digestate; Fertilization; Nutrient use efficiency

P-B-3 - An Integrated System of Anaerobic Digestion and Recirculating Aquaculture for Sustainable Shrimp Farming

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Abstract: A novel 3-cubic meter fermentation device employing high-solid anaerobic digestion has been developed for the purpose of treating livestock and agricultural waste. Through effective liquid and gas circulation, high-efficiency anaerobic digestion was achieved at a total solid (TS) content exceeding 22% and methane (CH_4) content reached to 70%. Recirculating aquaculture for White-leg shrimp offers the advantages of a short growth cycle and significant water resource savings. However, the growth of shrimp requires a water temperature of 25 °C or higher, posing a challenge for maintaining this temperature during winter cultivation. This study resolves this issue by combusting the biogas produced from the 3-cubic-meter fermentation device to generate hot water. The hot water is then circulated to heat the aquaculture tank, thereby maintaining the required water temperature. For winter operation, an energy balance calculation is required to determine the necessary amount of cattle manure and rice husk that should be processed in the 3-cubic-meter fermentation device to produce enough biogas for maintaining the water temperature in recirculating aquaculture.

Keywords: Dry anaerobic digestion; Recirculating aquaculture system; Waste-to-energy; Sustainable aquaculture

P-B-4 - Effects of Liquid Digestate from Different Types of Food Waste as Fertilizer on the Growth of Hydroponic Lettuce

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Abstract: Liquid digestate (LD), produced through the anaerobic digestion (AD) of food waste, represents a promising organic nutrient source for hydroponic cultivation. This study compared the methane production potential and fertilization characteristics of LDs derived from four single-category food wastes: rice, vegetables, meat, and soybean dregs. AD experiment was carried out under mesophilic conditions (35 ± 1 °C) for 45 days. Among the tested substrates, meat-derived LD exhibited the highest methane yield (1223.32 ± 372.55 mL/g VS added), followed by soybean dregs (1106.26 ± 81.42 mL/g VS added), vegetables (990.37 ± 84.66 mL/g VS added), and rice (741.87 ± 531.96 mL/g

VS added). Regarding fertilization properties, meat-derived LD showed the highest total nitrogen content (2008.98 ± 0.03 mg/L), while rice-derived LD contained the highest level of indole-3-acetic acid (IAA) (307.85 ± 0.03 mg/L). Seed germination assays revealed that the germination index (GI) values for both the soybean dreg-derived and vegetable-derived LD groups exceeded 200%. Following a 34-day hydroponic cultivation, lettuce grown with rice-derived LD achieved the highest shoot biomass (45.57g), suggesting superior growth-promoting potential. The distinct bioactivity observed among different LD types may be associated with phytohormonal content or other compositional parameters. Further correlation analysis between fresh weight and IAA, as well as other physicochemical traits, is recommended to identify key factors driving plant performance and inform effective LD reuse strategies in circular agriculture.

Keywords: Anaerobic digestion; Food waste; Liquid digestate; Organic fertilizer; Hydroponics

P-B-5 - Permeability Test in Dry Methane Fermentation

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Abstract: Dry methane fermentation allows raw materials to be stacked to a certain height within the fermentation tank because they are solid and self-supporting. This increases the processing capacity per unit area, offering advantages such as space savings and smaller facilities. However, as the height of the raw material increases, permeability decreases, and insufficient liquid circulation may reduce the efficiency of methane fermentation. This experiment aims to determine the amount of liquid reduction, the required additional water for improving liquid circulation and fermentation efficiency, and the optimal circulation frequency after the raw materials (cow manure and pruned branches) become saturated. Saturation is achieved by adding a pre-calculated amount of water at the initial input stage and then circulating the liquid.

Keywords: Dry methane fermentation, Permeability, Cow manure, Pruned branches

P-B-6 - Controlling Factors on the Co-recovery of Structural Extracellular Polymeric Substances and Volatile Fatty Acids from Anaerobic Fermentation of Food Waste

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Abstract: Approximately one-third of global food is ultimately wasted as food waste, which are rich in recoverable nutrients. In our previous study, we successfully achieved the simultaneous recovery of two high-value products—structural extracellular polymeric substances (SEPS) and volatile fatty acids (VFAs)—from the anaerobic fermentation of food waste, with optimal yield and quality obtained under a substrate-to-inoculum ratio (S/I) of 1. Beyond the S/I ratio, environmental parameters such as temperature, pH, and substrate composition were also found to significantly influence the yield and characteristics of both SEPS and VFAs. In this study, the effects of these key external parameters on the co-recovery efficiency and quality of SEPS and VFAs were systematically investigated. The findings provide important references to precisely regulate product yield and properties, thereby enhancing the economic value while minimizing environmental impact, contributing to the advancement of circular economy and carbon neutrality goals.

Keywords: Food waste; Anaerobic fermentation; Structural extracellular polymeric substances; Volatile fatty acids; Resource recovery

P-B-7 - Enhanced Biogas Production from High-solid Anaerobic Digestion of Rice Husk by Adding Air Nanobubble Water

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Abstract: High-solid anaerobic digestion (HSAD) is a promising approach for renewable

energy recovery from rice husk, one of the most abundant agricultural wastes. However, the process is often hindered by the high lignin content and compact structure of rice husks and the high carbon-to-nitrogen ratio, leading to poor hydrolysis efficiency, volatile fatty acids (VFAs) accumulation, and reduced methane yield. In this study, air nanobubble water (air-NBW) was introduced into the HSAD system at TS levels of 10%, 15%, and 20% to enhance biodegradation performance of rice husks. Compared with the control adding deionized water, air-NBW significantly improved cumulative methane production by 8.1%–19.2% and enhanced volatile solids (VS) degradation. VFAs accumulated rapidly in the early stage while declining faster in all NBW groups, suggesting improved acidogenesis and methanogenesis. The improvement on protein degradation was most pronounced at TS of 20%, while for carbohydrate degradation, the improvement was the highest at TS of 10%.

These results indicate that air-NBW can promote substrate solubilization, accelerate hydrolysis, and improve methane production in HSAD of rice husks, highlighting the potential application of nanobubble technology in HSAD of lignocellulosic biomass for green bioenergy conversion.

Keywords: Dry anaerobic digestion; Rice husk; Nanobubble water; High organic loading

P-B-8 - Integrating Heterotrophic Nitrification and Algal Assimilation in A High-solid Anaerobic Digestion System with Liquid Recirculation for Methane Enhancement and Nitrogen Recovery

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Abstract: Liquid recirculation in high-solid anaerobic digestion (HSAD) systems can overcome low methane production caused by poor mass transfer. However, the recirculated liquid digestate often contains high concentrations of ammonia nitrogen (AN), and high free ammonia (FA) content could significantly inhibit methanogenesis. Previous studies mainly focused on pH regulation to reduce FA toxicity. However, AN can still accumulate continuously, reaching up to 8,000 mg/L when livestock manure is used as the substrate. Under such conditions, controlling pH alone becomes increasingly difficult and costly. Conventional treatment methods for ammonia-rich digestate after anaerobic digestion are often inefficient, expensive, and unable to recover nitrogen resources. This study proposes an innovative liquid-circulating HSAD system coupled with efficient heterotrophic ammonia oxidation and algal nitrogen assimilation. The aim is to simultaneously relieve ammonia inhibition, enhance methane production, and convert nitrogen into algal biomass. At present, the heterotrophic ammonia oxidation unit

using rice husk bio-carriers has achieved an ammonia removal rate of 200 g N/m³·d and a nitrification rate of 160 g N/m³·d under C/N = 1:1 and aeration rate of 1.0 L/min. The integration with the upstream HSAD and downstream algal assimilation modules is in progress, aiming to build a complete pathway for nitrogen recovery and resource utilization.

Keywords: Algal nitrogen assimilation; High-solid anaerobic digestion; Heterotrophic nitrification; Nitrogen recovery

P-B-9 - Effect of Applied Voltage Level and Timing on Methane Production in a Microbial Electrolysis Cell-Assisted Anaerobic Digestion System Treating Pig Manure

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Abstract: The global energy crisis and growing environmental concerns have increased the demand for renewable energy alternatives. Anaerobic digestion (AD) of pig manure offers a sustainable solution for waste management and bioenergy recovery, yet often suffers from low methane yields and process inefficiencies. Integrating microbial electrolysis cells (MECs) into AD has emerged as a promising strategy to improve methane production by enhancing microbial activity and facilitating direct interspecies electron transfer. Notably, MEC-AD systems can achieve high energy recovery with minimal external voltage input, offering an energy-efficient alternative for waste-to-energy conversion. Interestingly, applying voltage from the first day of AD may disrupt hydrolysis due to electron competition between electrodes and fermentative microbes, ultimately impairing overall digestion performance. When the voltage was applied after day 6, allowing hydrolysis to proceed more effectively, approximately 10% higher methane yield was achieved. These findings highlight the importance of both voltage level and application timing in optimizing MEC-AD systems for enhanced bioenergy production from pig manure.

Keywords: Anaerobic digestion (AD); Applied voltage timing; Microbial electrolysis cell (MEC)

P-B-10 - Coupled Fouling Dynamics of Particulates and Dissolved Organic Matter in Digestate Treatment: Insights from Real-time Optical Coherence Tomography

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Abstract: Membrane fouling continues to challenge the sustainable treatment of high-strength food-waste digestate in membrane bioreactors (MBRs). Here, we systematically quantify the impact of graded particle removal—via centrifugation at 4 000, 7 000, and 10 000 rpm—on fouling dynamics. Real-time optical coherence tomography (OCT) coupled with flux monitoring, SEM-EDS, FTIR, and Raman spectroscopy was employed to visualise and characterise fouling development in situ. Increasing centrifugation speed slowed the initial flux decline but promoted denser, more irreversible fouling layers. At 10000 rpm, protein and polysaccharide concentrations in the supernatant fell by 22 %, yet Raman spectra revealed ~200 % stronger disulfide-bond signals and an ~81 % rise in C–O–C linkages, evidencing intensified molecular cross-linking by low-molecular-weight dissolved organic matter. OCT confirmed a transition from reversible surface deposition to pore-blocking internal fouling as particulate content diminished. These results indicate that overly aggressive pretreatment can aggravate internal fouling, counteracting its intended benefit. An optimised, moderate particle-removal strategy—guided by in-line OCT—is therefore vital for resource-efficient MBR operation and aligns with the bioprocess-sustainability goals of ICBS 2025.

Keywords: Digestate pretreatment; Dissolved organic matter (DOM); Membrane fouling; Optical coherence tomography (OCT); Particle; Sustainability

P-B-11 - The study on the Mechanisms Underlying the Enhancement of Anaerobic Digestion of High-lipid Substrates through the Regulation of Unsaturated Fatty Acid Degradation via ECI Enzymes

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Abstract: In anaerobic digestion systems, lipids exhibit a higher biogas potential, particularly due to the role of unsaturated fatty acids in the β-oxidation process, where the degradation of double bonds has been identified as a key rate-limiting step compared to saturated fatty acids. To address this challenge and enhance methane production efficiency, the addition of ECI enzymes effectively regulates the entire anaerobic digestion process. The incorporation of ECI enzymes significantly increases methane yield. Furthermore, the enzyme addition promotes the abundance of certain

bacteria and archaea. This study provides scientific evidence to elucidate the potential mechanisms of enzyme biostimulation.

Keywords: Anaerobic digestion; Unsaturated fatty acid; ECI enzyme; β-oxidation

Theme III: Biomass Reclamation and Utilization

P-C-1 - Modified Biochar Mitigates Nitrogen Loss in Distilled Grain Waste Composting by Modulating Microbial Community Assembly and Function

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Abstract: Pristine biochar (DB)-assisted composting can enhance product maturity and mitigate nitrogen loss, but its efficacy varies and is limited by feedstock variability and preparation conditions, highlighting the need for surface modifications to optimize performance. This study systematically investigated the effects of DB and KOH-modified biochar (DBK) on compost maturity, nitrogen loss, and the related microbial mechanisms during the composting of distilled grain waste, using a group without biochar addition (D) as the control. Results indicated that DBK exhibited a specific surface area of 644.33 m^2/g and was rich in pore structures and functional groups. DBK significantly promoted compost maturity, with the seed germination index (GI) reaching 70% by 23 d and biological nitrification occurring earlier (16 d). Additionally, compared to D and DB, DBK reduced nitrogen loss by 34.13% and 10.47%, respectively. DBK accelerates critical nitrogen transformation processes by increasing the abundance of nitrogen-fixing bacteria and associated functional genes. Neutral community modeling and symbiotic networks indicated higher microbial community complexity and stochasticity, thereby promoting functional redundancy and improving nitrogen retention. Furthermore, *Actinomadura* and *Chryseolinea* were identified as key microbial drivers of nitrogen transformation, with their *nxrABC* and hao genes playing crucial roles in establishing efficient 'microbe-gene' synergistic mechanisms. Finally, economic analysis indicated that DBK generated a net profit of up to 63.63 RMB/t. These findings provide a theoretical basis for using modified biochar to promote maturity and control nitrogen loss during composting.

Keywords: Composting; KOH-modified biochar; Maturity; Nitrogen loss; Net profit

P-C-2 - Utilization of Concrete Wash Water (CWW) for Enhanced Microalgae Cultivation

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Abstract: Concrete wash water (CWW), a highly alkaline byproduct from concrete plants containing abundant sulfate (SO_4^{2-}) and calcium (Ca^{2+}), is typically difficult and costly to treat. In this study, a specific microalga, *Scenedesmus* sp., was identified that not only tolerates the harsh conditions of CWW but also utilizes its high S and Ca contents to promote growth. The supplementation of different nitrogen forms, including ammonium (NH_4^+) and nitrate (NO_3^-), on algal growth in CWW was investigated. Results showed that nitrate-supplemented CWW significantly enhanced algal biomass, reaching 1.28 g/L, 32% higher than the control without CWW addition. Both NH_4^+ and NO_3^- removal exceeded 85%, indicating active nitrogen uptake. Biochemical analysis further revealed higher accumulation of chlorophyll-*a* (105.9 mg/g) and carbohydrate (127.1 mg/g), indicating robust metabolic activity in the presence of CWW. These findings demonstrate the potential of converting CWW from a problematic waste into a growth-promoting medium for microalgae, providing a sustainable approach for nutrient recovery, wastewater treatment, and biomass production.

Keywords: Concrete wash water; Microalgae; Sulfate

P-C-3 - Regulatory Mechanism of Haa1p and Hap4p in *Saccharomyces cerevisiae* to Mixed Acetic Acid and Formic Acid When Fermenting Mixed Glucose and Xylose

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Abstract: Acetic and formic acid are two common inhibitors that coexist with glucose and xylose in lignocellulosic hydrolysates, which impair the fermentation performance of

Saccharomyces cerevisiae. Enhancing yeast tolerance to these inhibitors is crucial for efficient industrial bioethanol production. Previous transcriptomic studies have indicated the involvement of the transcription factors Haa1p and Hap4p in the cellular response to mixed acetic and formic acid stress. This study aimed to further elucidate their regulatory roles in conferring tolerance to this combined stress condition. Comparative transcriptomic analysis was conducted using the engineered strains s6H3 (*HAA1*-overexpressing) and s6P5 (*HAP4*-overexpressing), in comparison with the original strain s6.

Both *HAA1* and *HAP4* overexpression improved fermentation performance, both in the presence and absence of inhibitors. *HAA1* overexpression led to a greater number of differentially expressed genes (DEGs) under mixed acid stress compared to non-inhibitory conditions. Genes involved in glycolysis, the pentose phosphate pathway (PPP), necroptosis, and ribosome biogenesis were significantly downregulated, whereas those associated with the glyoxylate cycle, nucleotide metabolism, and RNA polymerase activity were significantly upregulated. In contrast, *HAP4* overexpression resulted in fewer DEGs under acid stress conditions, which may be attributed to the intrinsic induction of *HAP4* in the original strain s6 under acid exposure. Under these conditions, genes related to metabolic regulation, RNA processing, and transcription were significantly downregulated, while those involved in transport, ribosome biogenesis, genome stability, and sporulation were significantly upregulated. Collectively, both Haa1p and Hap4p appear to regulate other transcription factors, thereby indirectly influencing global gene expression in response to mixed acetic and formic acid stress.

This study provides the experimental evidence for the protective role of Haa1p and Hap4p under combined acetic and formic acid stress. Regulatory mechanisms underlying the responses of Haa1p and Hap4p to combined acid stress were identified, expanding current understanding of yeast stress adaptation.

Keywords: *Saccharomyces cerevisiae*, *HAA1*, *HAP4*, Transcriptome, Weak acids tolerance, Xylose fermentation

P-C-4 - Use of Waste Algal–bacterial Granular Sludge as Potential Soil Amendments

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Abstract: Increasing attention has been paid to algal-bacterial granular sludge (ABGS) system nowadays due to its high efficiency for nutrients removal, resource recovery, carbon sequestration, and possible circular economy creation in wastewater industry. This study attempted to evaluate the nutrient-rich waste ABGS as a soil amendment in pot experiments. The waste ABGS was added to the pot soil at the following granular biomass

to soil mass ratios of 0.5%, 1%, and 2% (dw/dw), respectively in compare to soil only (the control), and Komatsuna (*Brassica rapa var. perviridis*) were planted in the pots for 45 days. The variation of soil fertility, reflected by available phosphorus, total nitrogen, exchangeable K, Ca, Mg, etc., were monitored to demonstrate the impact of waste ABGS on soil properties. Plant yield and quality (e.g., soluble protein, vitamin C) were determined to characterize the promotion effect of waste ABGS; in addition, the contents of heavy metals were also quantified in the plants to further assess food safety. Results from this study can provide new insights into the reclamation of waste ABGS as potential soil amendments, which can also offer technical support for its future engineering applications.

Keywords: Algal-bacterial aerobic granular sludge; Komatsuna; Pot experiment; Soil fertility

P-C-5 – Biostimulating Effect of Dissolved Organic Matter (DOM) in Anaerobic Digestate on Hydroponic Cultivation

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Abstract: The digestate after anaerobic digestion (AD) treatment of organic waste shows high fertilizer value and the dissolved organic matters (DOM) in the digestate might play important role since it was reported to contain possible plant hormones. However, its effect on plant growth has not been systematically studied and the effective components in the DOM have not been identified, hindering the optimization of AD process for functional fertilizer production. In this study, the different fractions of DOM are extracted from anaerobic digestate. The effect of extracted DOM on plant growth is confirmed through seed germination test and hydroponic cultivation experiment. The possible active components are identified by GC-MS and LC-MS determination and correlation analysis. This study is also expected to establish standard extraction and characterization techniques for DOM and to confirm the optimal application strategy of DOM in hydroponics, aiming to provide references for potential application.

Keywords: Anaerobic digestate; Dissolved organic matter; Hydroponic; Biostimulants

P-C-6 - Fermenting Fruit Peel Waste Substrates with *Bacillus subtilis* for Growth Performance of Black Soldier Fly Larvae, *Hermetia illucens* (LINNAEUS) in CEBU City

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Abstract: Black Soldier Fly Larvae (BSFL) are globally recognized for their remarkable ability to convert organic waste into high-value protein, making them vital to sustainable waste management and animal feed production. This study investigates the growth performance of Black Soldier Fly Larvae (BSFL) using fermented fruit wastes—specifically banana and mango peels—as alternative feed substrates. Substrates were fermented using Bacillus subtilis (ATCC 6051) to improve their nutritional quality and suitability for BSFL rearing. Five feeding treatments were evaluated: commercial feed (CF), fermented banana peel (BP), fermented mango peel (MP), mixed fermented peel (MFP), and unfermented peel (UP). Key performance indicators included feed consumption, final larval weight, biomass gained, feed conversion rate, mortality rate, and daily growth rate. Among the experimental groups, BP and MFP demonstrated markedly better growth performance compared to the unfermented treatment, with BP achieving a biomass gain of 3.89 ± 0.37 g and a growth rate of 0.32 ± 0.03 g/day. In contrast, UP exhibited the poorest performance with a growth rate of 0.20 ± 0.05 g/day and the highest mortality rate (4.33%). While CF yielded the highest overall outcomes—such as a final larval weight of 0.21 ± 0.01 g, a conversion rate of 0.08 ± 0.01%, and a growth rate of 0.41 ± 0.01 g/day—fermented substrates still outperformed unfermented ones significantly. These findings support the concept that fermentation significantly enhances substrate quality, positioning fermented fruit peels as promising low-cost, sustainable alternatives to conventional larval feeds for BSFL-based waste bioconversion systems.

Keywords: Bacillus subtilis; Bioconversion; Black soldier fly; Lignocellulosic waste; Solid-state fermentation

P-C-7 - Ultrasound Assisted Freezing Pretreatment and Isomalto-oligosaccharides for Enhancing Maceration Efficiency, Quality, and Volatile Metabolites of Japanese Apricot Syrup

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Abstract: It is essential to investigate the optimal maceration process to enhance the sensory appeal and health benefits of Japanese apricot syrup. This study aims to improve efficiency and quality of macerating Japanese apricot syrup using Isomalto-

oligosaccharides (IMO) and ultrasound-assisted freezing pretreatment. The effects were compared to that treated by white granulated sugar and/or at room temperature. The ultrasound-assisted aging treatments were conducted at 200 W, 400 W, and 500 W. UPLC and HS-SPME-GC-MS were employed to assess the effects of these treatments on nutrient extraction, antioxidant capacity, and aroma profiles. The results showed that 400W-IMO-Freezing pretreatment-7 days was the optimal method for macerating syrup. This approach improved apricot syrup with efficiency yield, an appealing color, a balanced taste, smooth texture, stable antioxidant activity, and an enriched profile of pleasant volatile compounds. Butyrolactone emerged as a characteristic volatile metabolite. Additionally, nitrite content was significantly reduced. This study provides an innovative and optimized method for producing Japanese apricot syrup, enhancing its sensory quality and health-promoting properties.

Keywords: Freezing pretreatment; Isomalto-oligosaccharides; Japanese apricot syrup; Nutrition; Ultrasound; Volatile metabolites.

Theme IV: Biosystems and Bioassay

P-D-1 - Effects and Solutions of Carbon Dioxide on Fish in Recirculating Aquaculture Systems

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Abstract: In recirculating aquaculture systems (RAS), the rise in aquaculture production has drawn increasing attention to the effects of carbon dioxide (CO_2) on fish health and water quality. However, the behavior and control of CO_2 within RAS lack systematic understanding, and current removal methods remain insufficient. This review summarizes recent developments and innovative strategies based on domestic and international literature. It highlights the importance of identifying CO_2 sources and establishing balance systems, and explores the interactions between CO_2, alkalinity, pH, and partial pressure, emphasizing the need for further investigation into the combined effects of these factors over diurnal cycles. Additionally, CO_2-induced issues such as hypercapnia and nephrocalcinosis are reviewed, along with mitigation strategies including physical stripping, chemical treatment, and biological fixation to reduce CO_2 stress on aquatic animals. Long-term exposure effects on fish growth and welfare are also underscored as a priority for future research. Practical approaches such as improving aeration efficiency, applying chemical reagents, and screening effective microbial agents are discussed. The design of advanced reactors is recommended to enhance CO_2 fixation. This study

provides theoretical insights and technical references to guide CO_2 regulation in RAS and promote sustainable, health-oriented aquaculture development.

Keywords: Carbon dioxide; Fish health; Recirculating aquaculture; Regulation strategies; Water quality

P-D-2 - Effect of Dissolved Inorganic Carbon on Hydroponic Lettuce Growth

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Abstract: Hydroponic systems provide a promising solution by offering higher yields with reduced land requirements. CO_2 plays a vital role in photosynthesis; However, the effect of rhizosphere-supplied inorganic carbon on plant growth in hydroponic systems remains unclear. In this study, the effects of dissolved inorganic carbon (DIC) on hydroponic lettuce growth were investigated at six different concentrations (L1: 0 mM (control), L2: 0.2 mM, L3: 0.4 mM, L4: 0.8 mM, L5: 1.6 mM, L6: 3.2 mM). During 26-day hydroponic cultivation, water quality parameters were monitored, and the bioactive compounds and elemental contents in the lettuce at harvest were determined. Results showed that DIC at lower than 1.6 mM promoted lettuce growth, while high DIC (3.2 mM) significantly inhibited biomass accumulation. Moderate DIC (0.2 mM–1.6 mM) promoted NO_3^- absorption and enhanced nitrogen utilization. Optimal DIC (0.4 mM–1.6 mM) enhanced chlorophyll-*a*, carotenoids, and soluble sugar contents in lettuce, while higher DIC inhibited pigment and sugar synthesis. Total phenolics in lettuce decreased with rising DIC, reflecting a growth-defense trade-off. The findings indicate that optimal DIC supply in the rhizosphere enhances plant growth in hydroponics, while excessive DIC could cause physiological stress, reduce oxygen availability, and inhibit nutrient transformation, leading to nutrient imbalances and growth inhibition.

Keywords: Hydroponic system; Inorganic carbon; Lettuce growth; Bioactive compounds

P-D-3 - Comparison of the Environmental Impact of Hydroponic Cultivation and Conventional Cultivation of Soybeans

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Abstract: Soybeans are rich in plant protein and demand for them is expanding

worldwide, but climate change make it difficult to produce them stably in open fields in recent year. A plant factory is a cultivation facility where the environment can be completely controlled, and soybeans can be grown there year-round, regardless of the climate. However, there have been no studies that have examined the sustainability of soybean cultivation in plant factories. Therefore, the aim of this study was to compare the environmental impacts of soybean cultivation in a plant factory and in the open field.

We cultivated soybeans in a hydroponic culture in our own plant factory (Fig. 1) and evaluated the environmental impacts using data such as measured yields and fertilizer use. In this study, LCA was conducted using the LIME2 characterization method and by means of the Simapro v 6.0 software. The functional unit used in this analysis was 1 kg soybeans. The evaluation was mainly conducted from the perspectives of climate change, ecotoxicity, and land occupation.

The LIME2 assessment showed that the climate change potential of plant factory cultivation was greater than that of open-field cultivation, while the biological toxicity potential and eutrophication potential were smaller in plant factory cultivation (Fig.2). For reduction of the environmental impact of soybean cultivation in plant factories, it is possible to develop varieties that can maintain yield even with low light intensity to reduce the power consumption of light sources, and use compost components derived from livestock manure as fertilizer for hydroponic cultivation.

Fig. 1 Soybean hydroponic cultivation

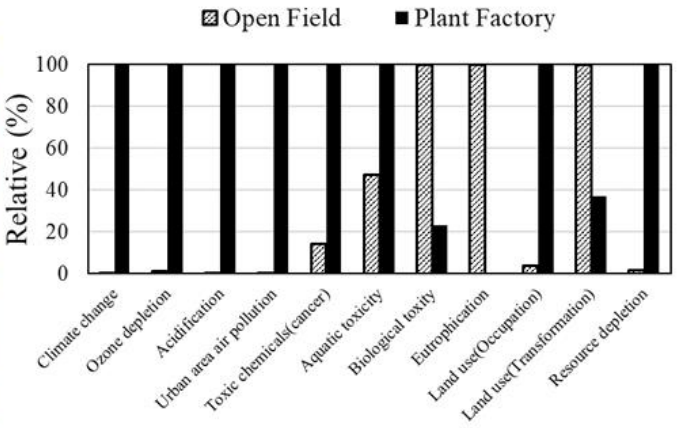

Fig. 2 Comparison of environmental impact

Keywords: Hydroponics; Soybeans; Plant factory

P-D-4 - Evaluation of The Growth Performance and 16s Metabarcoding Analysis of The Cecal Gut Bacteria in Broiler Chickens Under A *Bacillus Subtilis* (Atcc 6051)-Fermented *Halymenia Durvillei* Bory De Saint Vincent (Rhodophyta) Supplemented Feeds Diet

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Abstract: The gut microbiome plays a critical role in the chickens' health. This study explores the effects of the supplementation of 1% *Halymenia durvillei* that was fermented with *Bacillus subtilis* 6051 (FHD) and supplemented in the commercial feeds diet in broilers. Cecal-tissue samples from 35-day old broilers were screened for their bacterial microbiome. Body weight (BW) and Feed Conversion Ratio (FCR) did not show any statistically significant changes across the growth phases ($p > 0.05$). Body weight gain (BWG) showed statistically significant difference at the last feeding phase in the broilers fed with FHD compared to the broilers without FHD ($p < 0.01$). The SP group also had a lower average daily feed intake (ADFI) compared to the RC group. Although, no significant differences in FCR and BWG were noted between the two groups, suggesting a certain degree of increased feed efficiency on the supplemented group. No changes in α-diversity ($p > 0.05$), β-diversity (Bray-Curtis; $p < 0.09$) and relative abundance indices were noted. However, notable shifts in certain taxa were observed between the two groups. These findings suggest FHD supplementation does not disrupt bacterial diversity but may beneficially modulate the gut microbiota groups that are more adept in enhancing nutrient digestion and uptake.

Keywords: Broiler; Cecum; Gut microbiota; Metagenomics

Theme V: Microalgal-bacterial Consortium and Its Advancements

P-E-1 - Nitrogen Metabolism May Control Phosphorus Fate and Recovery in Algal-bacterial Granular Sludge-based Wastewater Treatment System

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Abstract: This study investigated the influences of different nitrogen transformation pathways in algal-bacterial granular sludge (ABGS)-based wastewater treatment system on phosphorus removal mechanisms and recovery potential. Through altering influent nitrogen sources and gradual acclimation, the ABGS system initially dominated by nitrification (NI) was converted into denitrification (DN)-dominated and organic nitrogen hydrolysis (ON)-dominated systems in 36 and 76 days, respectively. Phosphorus removal in the NI system followed a typical enhanced biological phosphorus removal (EBPR) process, while heterotrophic assimilation mainly occurred in the ON system. In contrast, phosphorus removal in the DN system relied heavily on biologically induced chemical precipitation, with phosphorus predominantly stored as apatite phosphorus (31.68 mg P/g-SS) rather than poly-P. These shifts in metabolic pathways led to distinct changes in

sludge morphology and microbial communities. *Dechloromonas* sp. (11.64%) dominated the ON system, while the DN system had higher phototroph abundance with increased pH and accelerated hydroxyapatite (HAP, $Ca_5(PO_4)_3OH$) formation. Results from this study show that the ON system can suppress phosphorus accumulating organisms (PAOs) activity, while the DN-dominated ABGS possesses greater potential for phosphorus recovery.

Keywords: Algal-bacterial aerobic granular sludge; Denitrification; Hydroxyapatite; Organic nitrogen hydrolysis; Phosphorus recovery

P-E-2 - Preliminary Examination of Resilience and Resource Recovery of Algal-bacterial Granular Sludge from Extreme Acidic and Alkaline Wastewaters

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Abstract: Algal-bacterial granular sludge (ABGS) has demonstrated considerable potential for nutrient removal and alginate-like exopolysaccharide (ALE) recovery from wastewater. However, the complex nature of real wastewater may occasionally result in extreme pH conditions, under which the resilience and resource recovery capacity of ABGS requires clarification. In this study, ABGS samples were subjected to simulated extreme acidic (pH 3) and alkaline (pH 12) wastewater for varying durations, followed by recovery under a typical operational pH 8. Nutrient removal, microbial activity, and resource recovery were assessed. Pronounced surface cracking and elemental loss (P, K, Ca) were detected under acidic conditions, while structural integrity was maintained under pH 12. Functional bacteria remained active at pH 12, with system performance partially recovered after three recovery cycles. Notably, the relative abundance of Firmicutes increased to 21.2%, contributing to enhanced granule stability. ALE production peaked at 200 mg/g-VSS under pH 3 and remained above 160 mg/g-VSS upon repeated exposure, which gradually decreased from 96 to 70 mg/g-VSS at pH 12. Results show that although pollutant removal was impaired under extreme acidic conditions, valuable compounds like ALE recovery was promoted. Wastewater pH management coupling resource recovery strategies may improve the robustness and resource recovery of algal-bacterial AGS systems.

Keywords: Algal-bacterial granular sludge; Alginate-like exopolysaccharide; Extreme pH; Granule functionality; Microbial community; Nutrient removal

P-E-3 - Distinct Phosphorus Speciation and Distribution in Algal-bacterial Aerobic Granular Sludge-based Wastewater Treatment Systems Under Different Nitrogen Conversion Pathways

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Abstract: This study systematically investigated the nitrogen and phosphorus removal performance, as well as the phosphorus speciation and distribution, in algal-bacterial granular sludge (ABGS) systems dominated by organic nitrogen hydrolysis (ON), nitrification (NI), and denitrification (DN) pathways. In the ON and NI systems, 44% and 66% of total phosphorus were stored within extracellular polymeric substances (EPS), respectively, while 95% of phosphorus was retained as the residual fraction in the DN system. The DN biomass exhibited a mineralized core primarily composed of hydroxyapatite (HAP, $Ca_5(PO_4)_3OH$). In the NI biomass, orthophosphate and polyphosphate were the predominant inorganic phosphorus (IP) forms, whereas pyrophosphate was more abundant in the ON system. Autotrophic nitrification, rather than heterotrophic nitrification, was the primary nitrogen transformation pathway in the NI system, with a specific autotrophic nitrification rate of 1.22 mg N/g-VSS·h. Interestingly, the DN system demonstrated the highest aerobic (11.80 mg N/g-VSS·h) and anaerobic (11.30 mg N/g-VSS·h) denitrification activities. However, the highest aerobic biological phosphorus removal rate (2.00 mg P/g-VSS·h) was detected in the NI system, indicating the giant difference of distinct phosphorus removal mechanisms. Results from this study provide new insights into the interrelationship between nitrogen and phosphorus removal processes in ABGS-based wastewater treatment systems.

Keywords: Algal-bacterial aerobic granular sludge; Autotrophic nitrification; Orthophosphate; Phosphorus species

P-E-4 - Shrimp Aquaculture Wastewater Treatment in a Continuous-flow Algal-bacterial Granular Sludge Bioreactor: Effects of Light and Stocking Density on Performance and Resource Recovery

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Abstract: Recirculating aquaculture system (RAS) is a promising solution for aquaculture industry by recycling 90-99% of aquaculture wastewater, thereby minimizing freshwater use and pollutants discharge. However, the widespread application of RAS remains limited due to the shortcomings of conventional biofilters applied, including low nutrient removal, high aeration energy demand and low/no high-value resource recovery. In this study, a continuous-flow recirculating system coupling algal-bacterial granular sludge (ABGS) was applied to treat wastewater from *Neocaridina denticulata* culture at two different stocking densities (0.15 and 0.45 kg/m^3). During the 28 days' operation, the continuous-flow ABGS exhibited good nutrient removal performance at both stocking densities, maintaining NH_4^+-N < 0.9 mg/L and NO_2^--N < 0.1 mg/L, which are considered non-toxic to shrimp. As for the effect of illumination on the system performance, two light intensities (4,000 and 12,000 lux) were examined under each stocking density. A high light intensity (12,000 lux) was found to induce more secretion of extracellular polymeric substances, about 352 mg/g of volatile suspended solids on day 28 at stocking intensity of 0.45 kg/m^3, suggesting its high-value product recovery potential. This study offers a sustainable and low-carbon alternative for aquaculture industry, contributing to both environmental protection and circular bioeconomy.

Keywords: Algal-bacterial granular sludge; Aquaculture wastewater; Continuous-flow reactor; High-value product; Recirculating aquaculture system

P-E-5 - Phosphorus Accumulation Performance and Recoverability of Algal-bacterial Granular Sludge under Low Light Conditions

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Abstract: As a novel and promising bio-granule technology, algal-bacterial granular sludge (ABGS) enables energy savings during wastewater treatment and is capable of effective phosphorus recovery. Light condition plays a key role in ABGS formation, properties, nutrient removal efficiency, and microbial community. However, insufficient light illumination such as cloudy or rainy weather, as well as in underground treatment facilities under power-off conditions, pose significant challenges to its practical application. To address this challenge, in this study a 14-day low light illumination was applied to an ABGS system, followed by 30-day recovery tests. The recovery tests included four scenarios: Scenario 1 (control, natural sunlight), Scenario 2 (increasing light intensity), Scenario 3 (extending light duration), and Scenario 4 (increasing aeration intensity). During the low light illumination period, the system phosphorus removal

efficiency declined from 89% to 33%, and the phosphorus content in sludge decreased from 36.8 to 28.2 mg-P/g of suspended solids (SS). In the recovery tests, Scenario 2 demonstrated the best recovery performance, with chlorophyll content increased from 2.72 to 6.33 mg/g of volatile suspended solids (VSS), and total nitrogen and phosphorus removal improved from 57.1% to 98.5% and from 49.8% to 81.1%, respectively. Scenario 3 also facilitated the system recovery. These findings suggest that prolonged low light conditions may impair AGS system performance, while some strategies such as increasing light intensity and duration can be applied to better and recover the ABGS system performance.

Keywords: Algal-bacterial granular sludge; Low light stress; Nutrients removal; Phosphorus accumulation; System recovery

P-E-6 - Enhanced Phosphorus Removal by Algal-bacterial Granular Sludge System Coupling pH Control with Acetic Acid: Closed-loop Resource Management in Recirculating Aquaculture System

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Abstract: Integrating algal-bacterial granular sludge (ABGS) into recirculating aquaculture system (RAS) shows great potential to reduce energy consumption and carbon footprint, maintain water quality, and facilitate resource recovery. However, algal photosynthesis inevitably elevates the system pH, which may destabilize water quality and suppress biological phosphorus (P) removal in the context of RAS due to its low water exchange. In this study, acetic acid (HAc) and sodium acetate (NaAc) were used to adjust the system pH with their system performance, especially P removal, being compared. Results show that use of HAc can effectively maintain the system pH below 8.2 over 15 days' continuous operation, and the HAc-ABGS system achieved P removal of 57%; while under the same operation conditions, almost no P removal was detected in the NaAc-ABGS. However, both systems demonstrated stable total nitrogen removal (> 93%), with NH_4^+-N and NO_2^--N undetectable, and NO_3^--N < 5 mg/L in the system during 15 days' operation. Further mechanisms analysis suggested that polyphosphate-accumulating organism (PAO)- driven P uptake rather than Ca-P precipitation dominated the HAc-ABGS system. As such, this study proposed a sustainable RAS system by coupling acidogenic fermentation (to provide HAc source) of waste ABGS and fish sludge with the HAc-ABGS system to guarantee water quality and resource recovery in the closed-loop RAS.

Keywords: Algal-bacterial aerobic granular sludge; Phosphorus removal; Recirculating

aquaculture system; Resource management

P-E-7 - Nitrogen Assimilation May Facilitate Enhanced Nitrogen Removal and Reservation in Algal-bacterial Granular Sludge

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Abstract: Algal-bacterial granular sludge (ABGS), rather than bacterial aerobic granular sludge (BAGS), possesses potential for sustainable nitrogen management. Still, its nitrogen removal mechanisms and advantages over BAGS remain unclear. In this study, two 16-L sequencing batch reactors containing BAGS and ABGS respectively were operated in parallel to treat synthetic domestic wastewater. Both systems achieved efficient ammonia removal (> 95%) but differed in nitrogen removal pathways. BAGS relied almost entirely on nitrification/denitrification, while ABGS exhibited a notable contribution by ammonia assimilation. Despite similar microbial communities, cyanobacteria accounted for 7.22% in ABGS while only 0.14% in BAGS, suggesting a photoautotrophic role in nitrogen reservation. When allylthiourea was introduced to inhibit their nitrification process, BAGS declined to only 1.55% of its original NH_4^+-N removal capacity, whereas ABGS maintained 32.57% highlighting its assimilation potential. Their specific ammonia removal rates, averagely 1.21 mg-N/g-VS·h (BAGS) and 1.41 mg-N/g-VS·h (ABGS) under normal operation, were 0.07 and 2.15 mg-N/gVS·h respectively with allylthiourea addition. Their specific nitrate removal rates were detected as 5.62 mg-N/g-VS·h (BAGS) and 4.26 mg-N/g-VS·h (ABGS), consistent with microbial community structure. These findings suggest that ABGS can integrate nitrification/denitrification with assimilative nitrogen reservation, offering a synergistic strategy for nitrogen removal and bionitrogen recovery from low-strength wastewater.

Keywords: Algal-bacterial granular sludge; Bacterial aerobic granular sludge; Biomass retention; Low-strength wastewater; Nitrogen assimilation

P-E-8 - Preliminary Analysis of Nutrients Reclamation from Waste Algal-bacterial Granule Sludge for Komatsuna Farming

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Abstract: This study aims to investigate the nutrients recovery potential of waste algal-bacterial granular sludge (ABGS) through komatsuna (*Brassica rapa var. perviridis*) farming. A two-layer reclamation and farming system is adopted and established in this study: the upper layer is the reclamation zone filled with nutrient-free soil, while the lower layer serves as a water reservoir containing ABGS. ABGS equivalent to 2% of the soil dry weight was added for nutrients supply via their release into water phase for irrigation. This test was divided into four groups: (1) Blank control group (no fertilizer introduction), (2) Positive control (with commercial fertilizer), (3) Intact ABGS as nutrients supplier, and (4) Crushed ABGS as nutrients supplier. The variations of water quality parameters including PO_4^{3-}, NO_3^-, NO_2^-, etc. were monitored to record the changes in water quality along with the test. Soil fertility, especially Olsen-P and total nitrogen, was analyzed to reflect nutrient recycling efficiency of the waste ABGS. The growth and plant quality of *Brassica rapa var. perviridis* were recorded for 45 days to examine the feasibility and plant safety. Results from this study can offer valuable insights into the reclamation valuation of waste ABGS and provide scientific guidance for its future application in the real world.

Keywords: Algal-bacterial granular sludge; Komatsuna farming; Nutrients release; Reclamation valuation; Soil fertility

P-E-9 - Algal and Bacterial Extracellular Polymeric Substances (EPS): Similarities, Differences, and Synergistic Prospects for Environmental Remediation – A Review

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Abstract: Extracellular polymeric substances (EPS), secreted by both algae and bacteria, are complex biopolymers that play essential roles in microbial survival, community structuring, and pollutant mitigation. This review systematically compares the composition, biosynthetic mechanisms, and functional properties of algal and bacterial EPS, highlighting their unified ecological niches and specific strengths. Algal EPS, typically rich in high-molecular-weight polysaccharides with abundant functional groups, demonstrate strong adsorption capacity for heavy metals and support the formation of porous, photosynthetically active biofilms. In contrast, bacterial EPS exhibit high structural stability, biofilm cohesion, and resistance to environmental stress, contributing significantly to flocculation and organic pollutant degradation. The co-culture of algae

and bacteria enables EPS-mediated synergistic mechanisms—such as enhanced biofilm construction, auto-flocculation, and multi-pollutant removal—that are promising for advanced wastewater treatment and soil remediation. However, challenges remain, including EPS source differentiation, structure-function elucidation, and system stability under high pollutant loads. This review aims to systematically compare the compositional and functional differences of algal and bacterial EPS, evaluate their synergistic mechanisms in environmental remediation—including wastewater treatment, heavy metal removal, and soil remediation. It also explores future directions based on multi-omics integration and EPS-mediated bioreactor systems.

Keywords: Algae; Bacteria; Environmental remediation; Extracellular polymeric substances; Synergistic effect

P-E-10 - Evaluation and Comparison of Shrimp Farming Wastewater Treatment Using Bacterial and Algal-bacterial Granular Sludges in the Context of Vietnam

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Abstract: Shrimp farming is a key aquaculture sector in Vietnam, contributing over $ 4 billion annually, which was 1.3 million tons in 2024. At the same time this industry generates large volumes of wastewater rich in organic matter and nitrogen compounds, which can harm aquatic ecosystems if improperly treated. Effective wastewater treatment is therefore essential for its sustainable development. This study evaluated and compared the bacterial aerobic granular sludge (BAGS) and algal-bacterial granular sludge (ABGS) in treating wastewater from shrimp farming in the context of Vietnam. Both types of granules consistently achieved > 90% of nitrite (NO_2^-), phosphate (PO_4^{3-}), and ammonium (NH_4^+). In the ABGS biomass, a slightly higher total nitrogen (TN) content (204.62 mg/g-VSS) was detected, likely attributed to nitrogen absorption by microalgae. Notably, the VSS/SS ratio decreased significantly after transferring to shrimp wastewater treatment, reaching 73% and 76% in the ABGS and BAGS systems, respectively. In addition, an approximately 6% higher average extracellular polymeric substances (EPS) content was detected in ABGS biomass (145.50 mg/g-VSS) than in BAGS biomass, suggesting the superior structural stability of ABGS. These findings can offer valuable insights into the practical implementation of ABGS technology for sustainable aquaculture wastewater management in Vietnam.

Keywords: Algal-bacterial aerobic granular sludge; Bacterial aerobic granular sludge; Shrimp farming wastewater Treatment

P-E-11 - Self-sufficiency of Carbon Source in Bacterial and Algal-bacterial Granular Sludge-based Wastewater Treatment Systems Coupling with Anaerobic Fermentation of Waste Granular Sludge

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Abstract: The dual challenges of carbon source shortage and excess waste activated sludge generation hinder the sustainable operation of wastewater treatment plants (WWTPs). This study evaluated the feasibility of volatile fatty acids (VFAs) production from anaerobic fermentation of bacterial aerobic granular sludge (BAGS) and algal-bacterial granular sludge (ABGS), aiming to achieve both sludge reduction and carbon source recovery. After seven days of fermentation, ABGS yielded VFAs with 3497.32 ± 68.39 mg-chemical oxygen demand (COD)/L, significantly higher than that from BAGS (2909.77 ± 57.14 mg-COD/L), contributing to sludge mass reduction of 29.42% and 28.10%, respectively. The produced VFAs were dominated by acetic acids (HAc) and propionic acids (HPr), occupying 70% of total VFAs. Then both fermentation liquids were used as carbon sources in enhanced biological P removal (EBPR) batch tests, a higher P release (20 mg/L) and nearly complete P removal (P < 0.01 mg/L) were detected in addition to effective ammonia oxidation. In the two granular sludge systems, besides a high carbon self-sufficiency of 59%, a considerable cost saving due to much less external carbon demand demonstrates strong potential for reducing chemical inputs in EBPR processes. This study provides an integrated solution for sludge minimization, nutrient recovery, and internal carbon recycling, thereby advancing the development of resource- and energy-efficient WWTPs.

Keywords: Algal bacterial granular sludge; Anaerobic fermentation; Carbon source; Enhanced biological phosphorus removal; Volatile fatty acids

P-E-12 - A Mini Review on Algal-bacterial Aerobic Granular Sludge for Emerging Pollutants Removal

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Abstract: The presence of emerging pollutants in wastewater poses a long-lasting threat to human health and the environment. This review focuses on the efficacy and underlying principles of algal-bacterial granular sludge (ABGS) in eliminating the emerging pollutants in comparison to conventional activated sludge (CAS) and bacterial aerobic granular sludge (BAGS). Seen from the literature review, compared to CAS and BAGS, ABGS emerges as a more potent process in antibiotics removal, moreover exhibits an excellent performance on preventing the proliferation of antibiotic resistance genes. The exceptional adsorption capability and settleability of ABGS underscore its proficiency in eliminating microplastics. Considering some microalgae's documented success in degrading endocrine disrupting compounds, the potential of ABGS in this regard is worthy of being further explored. However, CAS, BAGS and ABGS exhibit limited efficacy in the degradation of polychlorinated organic pollutants. This review provides in-depth insights into the implementation and optimization of BAGS/ABGS process for emerging pollutants removal in sustainable wastewater industry.

Keywords: Algal-bacterial granular sludge; Emerging pollutants; Wastewater treatment

P-E-13 - Tidal Fluctuation of Dissolved Oxygen in Algal–bacterial Granular Sludge: Visualizing O_2 Penetration and Distribution under Different Oxygenation Strategies

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Abstract: One of the key advantages for algal-bacterial granular sludge (ABGS) in wastewater treatment lies in the photosynthetic oxygen produced by microalgae and then utilized by bacteria for organics degradation and nutrient removal, thereby reducing energy consumption associated with mechanical aeration. Although both mechanical aeration and illumination operations are commonly applied to enhance oxygen availability in ABGS systems, the spatial and temporal characteristics distinguishing

mechanical from photosynthetic oxygenation remain poorly understood. This study presents cross-sectional dissolved oxygen (DO) profiles within ABGS under varying light and mechanical aeration conditions, revealing a stratified internal DO profile and dynamic distribution. Results showed that oxygen from artificial aeration was insufficient at a certain depth (~ 0.8 mm) within the granules to elevate the internal DO levels. In contrast, photosynthetically produced oxygen readily penetrated the granules and rapidly increased the local DO concentration to over 4 mg/L within 30 min. Based on these observations, a 'tidal phenomenon' was proposed to describe the dynamic DO fluctuations within granules, driven by the interplay between photosynthetic oxygen production, mechanical aeration, microbial consumption, and diffusion processes. These findings can help elucidate the distinct roles of light illumination and mechanical aeration in shaping internal DO gradients and offer theoretical guidance for designing energy-efficient and light-driven ABGS systems.

Keywords: Algal-bacterial granular sludge; Dissolved oxygen; Light illumination; Artificial aeration

Theme VI: Greenhouse gases emission/mitigation and carbon/nitrogen neutrality

P-F-1 - Functionalized Carbon Nanotubes Catalysts Achieve Efficient CO_2 Conversion

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Abstract: With the increasingly severe global climate change issue, the efficient conversion of CO_2 has become a key topic of widespread concern. Carbon nanotubes possess unique nanoscale structures and excellent physical and chemical properties, and are widely used in electronic devices, composite materials, energy storage, and catalysis, among other fields. By functionalizing carbon nanotubes and introducing specific active sites and functional groups on their surfaces, the catalyst's ability to reduce CO_2 was significantly enhanced. The microstructure and surface chemical properties of functionalized carbon nanotubes were deeply studied by using advanced characterization techniques. The results show that the functionalized carbon nanotube catalyst achieves a high CO_2 conversion rate and product selectivity under mild reaction conditions, and its catalytic activity and stability are superior to those of traditional catalysts. Further

mechanism studies have revealed the interaction mechanism between the surface active sites of functionalized carbon nanotubes and CO_2 molecules, providing a theoretical basis for the design and optimization of catalysts. This research offers a new strategy and approach for achieving efficient conversion of CO_2, which is expected to play a significant role in areas such as mitigating the greenhouse effect and developing renewable energy.

Keywords: Carbon nanotubes; Carbon dioxide reduction reaction; Catalysts

P-F-2 - Comprehensive Evaluation of GHG Impacts and Eco-environmental Benefits of Rice Straw Dry Anaerobic Fermentation in Yangtze River Delta Paddy Fields

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Abstract: The resource utilization of rice straw via off-field dry anaerobic digestion was evaluated to assess greenhouse gas (GHG) emissions and eco-environmental benefits. Field plots were monitored across the rice season CH_4 and N_2O fluxes were continuously measured using a high-frequency online monitoring system. A life cycle assessment covered straw collection, pretreatment, dry anaerobic digestion, combined heat and power (CHP), and digestate composting. Results indicated that CH_4 emissions peaked under full straw incorporation (120.01 kg CH_4 ha^{-1} yr^{-1}) and were much lower with digestate application (50.60 kg CH_4 ha^{-1} yr^{-1}); over 99% of CH_4 was emitted during the rice-growing season. N_2O emissions were highest with chemical fertilizer only (5.36 kg N_2O ha^{-1} yr^{-1}) and lowest with digestate (1.30 kg N_2O ha^{-1} yr^{-1}), concentrated during mid-season drainage and post-harvest drying. LCA showed that dry anaerobic digestion outperformed full straw incorporation per ton of straw in climate change (-143.05 kg CO_2-eq) and resource use (-2867 MJ primary energy). Substituting biogas for fossil energy and digestate for chemical fertilizers offset about 80–90% of impacts from CHP and composting. Overall, off-field dry anaerobic digestion of rice straw substantially reduces GHG emissions and delivers superior eco-environmental benefits, supporting agricultural carbon neutrality and sustainable development in the Yangtze River Delta.

Keywords: Rice straw; Dry anaerobic digestion; Greenhouse gas (GHG) emissions; Life cycle assessment (LCA); Eco-environmental benefits

P-F-3 - The Carbon and Nitrogen Footprint in Application of Algal-bacterial Granular Sludge Technology to Municipal Wastewater Treatment

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Abstract: Algal-bacterial granular sludge (ABGS) offers multifaceted benefits for wastewater treatment. Its rapid settleability reduces chemical dosing, while its photosynthetic capability eliminates mechanical aeration, significantly reducing energy consumption while enhancing resource recovery. Despite its remarkable advantages, ABGS has yet to be implemented at full scale for municipal wastewater treatment.

To encourage the adoption of ABGS as a promising alternative for municipal wastewater treatment, this study quantitatively reveals its carbon and nitrogen footprint and provides a robust data foundation. The Kasumigaura Purification Center, a wastewater treatment plant that plays a primary role in maintaining the water quality of Lake Kasumigaura by treating nearly 80% of municipal wastewater from its surrounding catchment area, was selected as the case study. Two candidate systems, i.e., bacterial aerobic granular sludge (BAGS) in continuous flow reactors (CFRs) and ABGS, were compared against the existing and widely applied conventional activated sludge (CAS) systems. Life-cycle assessment (LCA) was applied to focus on carbon and nitrogen footprints and quantify the resulting changes in these footprints by analyzing reductions in key inputs, such as electricity and chemicals. This evidence can serve as a proposal, demonstrating that this technology is a compelling option for realizing Japan's transition to a low-carbon society.

Keywords: Bacterial aerobic granular sludge; Algal-bacterial granular sludge; Carbon footprint; Life-cycle assessment; Wastewater treatment

P-F-4 - How Can ASEAN Countries Move to Low-carbon Development Pathways

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Abstract: Due to rapid economic and energy growth, ASEAN faces rising CO_2 emissions that may hinder its climate goals. This study analyses emission drivers, decoupling status and future trends, aiming to provide a basis for ASEAN's emission reduction policies and low-carbon transformation. We apply the LMDI model to decompose emission factors, use the Tapio model to assess decoupling between emissions and growth, and adopt an extended STIRPAT model to project CO_2 emissions under four scenarios (2023–2050).

Results show that population and economic growth are the main drivers, while improved energy intensity supports reductions. Singapore shows the strongest decoupling (index = 0.05). Under the ultra-low-carbon scenario (S4), ASEAN's 2025 emissions are projected to be 427.26 million tons lower than in the baseline (S1). Countries like Singapore and Vietnam are expected to peak or stabilize emissions. Findings highlight the critical role of renewable energy in deep decarbonization.

Keywords: ASEAN; CO_2 emissions; Decoupling; Decomposition; STIRPAT

P-F-5 - High Light Intensity and Transmittance Enhances C_4 and CAM Pathways for CO_2 Concentrating in Attached *Chlorella*: Proteomic Insights into Regulatory Mechanisms

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Abstract: Light serves as the main energy source for photosynthesis, microalgae growth may be limited by excessive light in the attached upper layer (photoinhibition) or insufficient light in the bottom layer (photo limitation). Determining the optimal light intensity range is crucial for the attached CO_2 absorption-microalgae conversion (CAMC) system, so this study set 90, 120, 150, 180 μmol m^{-2} s^{-1} and incremental light strategy (ILS). The light intensity of the ILS group increased with the thickness of the attached microalgae biofilm and the biomass density reached 14.6 g m^{-2}. Surprisingly, under fixed high light intensity of 180 μmol m^{-2} s^{-1} biomass density was only slightly lower than in the ILS group, even with the highest specific growth rate. In comparison, microalgae biofilm with high transmittance and low water content under high light intensity, which further regulated the adaptive CO_2 concentrating mechanism (CCM) of attached cultivation. Proteomics revealed up-regulation of C_4 and CAM (effective CCM for adaptation to high light and drought) pathway-related protein expressions, leading to efficient carbon fixation and bioconversion. The result provides valuable insights into optimizing light intensity and CO_2 concentrating mechanism for enhancing microalgae-based carbon fixation systems, offering potential applications in sustainable bioenergy production and carbon capture.

Keywords: Attached cultivation; Carbon capture; CO_2 concentrating mechanism; Light intensity; Proteomics

P-F-6 - Research on the Impact of Industrial Digitalization on Emission Reduction in Guangdong Province from a Sectoral Perspective

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Abstract: As global pressure to reduce carbon emissions intensifies, China is deploying digital technologies to foster sustainable industrial growth by enhancing efficiency and managing emissions. This study segments the industrial sector into 17 subsectors and analyzes 2012 and 2017 input-output data. By integrating dynamic input-output modeling with structural decomposition analysis (SDA), we quantify the subsector-specific impacts of digital transformation on carbon emissions. The findings offer a detailed assessment of how digital adoption has reshaped emission trajectories across industries, providing actionable insights for policymakers to tailor targeted decarbonization strategies.

Keywords: Digitalization; Carbon emissions; Downscale structural decomposition analysis; Environmentally-extended input-output model; Industry sectors

P-F-7 - Role of Extracellular Polymeric Substances in Enhancing High Bicarbonate Tolerance in CO_2 Absorption-microalgae Conversion System via Attached Cultivation: A Metabolomic Perspective

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Abstract: CO_2 absorption-microalgae conversion (CAMC) system has long been limited by the low efficiency of bicarbonate conversion, and microalgae cells in traditional suspension cultivation have poor tolerance to bicarbonate concentration. This study compared the effects of different bicarbonate concentration gradients on the attached CAMC system, with the optimal bicarbonate concentration (10 mM) for suspension cultivation as a control. The results suggested that 20 mM bicarbonate concentration was the optimal concentration for CAMC system under attached cultivation, and the biomass density was as high as 12.4 g m^{-2}, which was significantly increased by 69.9% compared with the control. Notably, the secretion of extracellular polymeric substances (EPS) plays

a crucial role in this process by buffering and adsorbing nutrients, thereby enhancing the adaptability of attached microalgae. At the microscopic level, attached cultivation tends to secrete more EPS, which has a buffering effect against high bicarbonate stress to protect cells from stressful environments. This buffering effect is crucial for maintaining the stability of the microalgae growth environment in CAMC system. Metabolomics revealed significant changes in intracellular metabolic flux and substance composition. The Calvin cycle and TCA cycle were up-regulated, inducing more carbon flux into the central carbon metabolism required for the growth of *Chlorella.*

Keywords: Attached cultivation; Bicarbonate; Carbon fixation; Extracellular polymeric substances; Metabolomic

P-F-8 - Optimizing Light Intensity Strategies in CO_2 Absorption-microalgae Conversion System: Towards Efficient Carbon Utilization and Sustainable Protein Biorefining

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Abstract: Different step-wise light intensity strategies were developed to enhance CO_2 absorption-microalgae conversion (CAMC) system for efficient carbon fixation and carbon conversion. For constant light intensity, Chlorella L166 had the maximum biomass and carbon fixation capacity at 8000 Lux. Based on this, the lighting conditions were flexibly adjusted in the early and late stages of cultivation, and step-wise light intensity Strategy I~IV were designed. Among them, Strategy IV significantly increased the biomass to 1.1 g/L and the carbon fixation capacity to 234.2 mg/L/d. The chlorophyll and carotenoid yields increased by 16.1% and 8.3% compared with 8000 Lux, reaching 21.0 mg/L and 9.2 mg/L respectively. More efficient photosynthesis promotes the bioconversion of HCO_3^- into high value-added products, especially carbon flow tends to synthesize proteins. Moreover, Strategy IV reduced light energy consumption by 18.8% without compromising productivity. This study demonstrated light strategy effectively enhanced carbon utilization, enabling cost-effective conversion in algae-based biorefineries.

Keywords: Carbon utilization; Carbon conversion; *Chlorella*; Light; Photosynthesis

P-F-9 - Transcriptomics Reveals Enhanced Carbon Fixation Mechanism in CO_2 Absorption-microalgae Conversion System under Batch Feeding Mode

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Abstract: This study optimized the feeding mode of the ArgK-rich solution to further enhance the performance of CO_2 absorption-microalgae conversion (CAMC) system. Among the different batch feeding modes, Mode 1-2 with a small amount in the adaptation period, a large amount in the growth period, and a small amount in the stable period performed best. Compared to direct addition, biomass concentration, HCO_3^- utilization efficiency and carbon fixation increased by 9.8%, 30.6% and 12.0% respectively. Meanwhile, the yields of chlorophyll, carotenoids and carbohydrates increased by 27.5%, 10.1% and 31.3%, respectively. In addition, transcriptomic analysis was employed to elucidate the mechanisms underlying the enhanced growth and metabolism of microalgae. The results indicated that batch feeding up-regulated gene expression in pathways related to ribosome, carbohydrate synthesis, TCA cycle and photosynthesis, thereby promoting more energy flow toward the accumulation of carbon fixation, carbohydrates and proteins.

Keywords: CAMC system; Carbon fixation; Feeding mode; Photosynthesis; Transcriptomic

Theme VII: Sustainable Management and Analysis

P-G-1 - Digital Development of China's Ecological Environment Is Needed under the Coordinated Landscape

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Abstract: The development of China's ecological environment in the pattern of geographical latitudinal change requires the sharing and cooperation of ecological achievements under the landscape of coordination in order to weaken the imbalance of the cross-regional ecological level and the lag in ecological construction. Under the "dual

carbon" strategy, new engine power should be injected into China's ecological environment, serving as a catalyst for sustainable development. Applying the digital support system to empower ecological sustainability, a new bottom-up eco-development mechanism integrating digital information, digital management, digital decision-making, and digital services can be created to realize smart ecology. Digital empowerment of ecology will further expand the ecological value increment of ecologically fragile areas and map the development of beautiful China.

Keywords: Ecological environment; Coordination; Digital development; Sustainable empowerment

P-G-2 - Large-scale Sustainable Utilization of Bauxite Slag (Red Mud): Properties, Hazards and Recycling Perspectives

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Abstract: Red mud (RM) is a bulk solid by-product generated by the alumina industry. The high pH and heavy metal content pose significant environmental challenges for the management and disposal of RM. This review emphasizes the potential of RM as a source of valuable raw materials. The composition, properties, environmental hazards and current status of the comprehensive utilization of RM are discussed. A systematic classification and statistical analysis of RM-related publications from 2010 to 2025 was conducted using literature databases. The results indicate that current research on the comprehensive utilization of RM primarily focuses on four areas: metallurgy (metal recovery), construction (e.g., ceramics, bricks, and geopolymers), environmental remediation (e.g., pollutant removal, carbon-containing air pollution removal), and soil restoration. Within these fields, the fundamental principles, research progress, and potential for industrial application are examined, while the advantages and disadvantages of each method are evaluated from both economic and environmental perspectives. Furthermore, we address health and safety considerations, life cycle assessment (LCA), and a comprehensive evaluation of RM applications to assess their feasibility and sustainability. This review uniquely integrates the comprehensive recycling of RM with sustainable economic strategies, presenting a holistic framework for the effective utilization of RM within a circular economy.

Keywords: Red mud; Alumina refinery waste; Valorization; Circular economy; Sustainability

P-G-3 - The Influence of Human Activities on Water Quality Changes in the Taihu Basin: A Study on Management Strategy Optimization

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Abstract: Taihu Lake, located in the Yangtze River Delta, is one of China's most important freshwater lakes. In recent decades, rapid urban development and intensive human activities have caused serious water pollution. Eutrophication, algal blooms, and ecosystem degradation remain widespread, even after years of local control efforts. Agricultural runoff and domestic wastewater are still major sources of pollution, and their impact is not fully understood. This study focuses on how human activities influence the water environment in the Taihu Basin. It aims to identify key pollutant sources, reveal their spatial distribution, and assess related ecological risks. The study also examines current policy gaps and explores more effective management strategies. The research uses data from the past ten years, including environmental reports and policy documents. GIS tools are applied to map pollutant discharge and show spatial patterns. SPSS is used to analyze the relationship between pollution levels and human activity intensity. By linking human activities with water quality changes, this study provides practical suggestions for emission control and ecological restoration. The findings are expected to support sustainable water governance and improve long-term water quality in the Taihu region.

Keywords: GIS; Human activities; Taihu basin; Water quality

P-G-4 - Coastal Saltmarsh Sustainability Governance: Multilevel Social Ecological Networks for Conservation-development Tradeoffs

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Abstract: Sustainable management of ecological connectivity across large-scale regions is frequently hindered by misalignment between ecological systems and administrative boundaries. Collaboration among management organizations in different areas can help overcome this problem. However, few studies have analyzed how collaboration levels vary along connectivity gradients. We developed a multilevel social-ecological network analysis (SENA) approach to analyze collaboration patterns across local, subregional, and regional government agencies working in genetically connected coastal areas of China's Yellow River Delta. This framework enabled analysis of social-ecological alignment in both conservation and development networks. Results showed areas with the potential to realize social-ecological alignment, where collaborative networks were measured by social network density on each ecological edge. Results reveal that development networks exhibit greater potential than conservation networks at most levels to overcome misalignment in the social-ecological system, also known as scale mismatch. Empirical evidence linked enhanced communication within development networks to improved ecological conditions. The multilevel SENA advanced in this paper provides a replicable framework for improving sustainable resource governance in connected landscapes. It equips decision-makers with a diagnostic tool to identify governance gaps, optimize collaborative structures, and align management interventions with ecological connectivity needs, ultimately enhancing long-term ecosystem resilience.

Keywords: Coastal saltmarsh; Landscape connectivity; Scale mismatch; Social ecological network; Sustainable management

Theme VIII: Biogeochemistry and flocculation in water

P-H-1 - Coagulant Selection and Multimodal Process Design for High Turbidity Raw Water Treatment: A Multi-scale Experimental Study

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Abstract: This study conducts systematic research on high turbidity raw water treatment in the Southwest of China. The raw water from the lake exhibits wide turbidity variations with high suspended solids content (154-11,000 mg/L, can be higher than 37,500 mg/L) during flood seasons, severely impacting normal plant operations. Comprehensive analytical methods including physicochemical analysis, X-ray diffraction (XRD), and thermogravimetric-differential scanning calorimetry (TG-DSC) were employed to

characterize raw water properties. Laboratory-scale, pilot-scale, and field trials optimized flocculation-sedimentation parameters. Various coagulants including polyaluminum chloride (PAC), $FeCl_3$, and polyacrylamide (PAM) were screened for optimal dosages and process conditions. Results demonstrated that regional high turbidity raw water exhibits distinct particle characteristics, with PAC showing superior performance over PAM in pre-sedimentation. A comprehensive coagulant dosing reference table was established for different turbidity conditions. Key process parameters including pre-sedimentation surface loading and lamella settler upflow velocity were determined through pilot studies. In addition, we have developed a multimodal intelligent dosing system integrating high resolution camera visual modality capturing water color, transparency, and particle distribution, combined with real-time sensor monitoring of turbidity, pH, and electrical conductivity. Image processing techniques were used to extract turbidity features and particle size information to optimize coagulation process. This research provides scientific foundation for high turbidity water treatment design and intelligent dosing system.

Keywords: High turbidity raw water; Flocculation; Multimodal system; Intelligent dosing; Water treatment

P-H-2 - Effect of Turbulent Flow on the Aggregation Kinetics of Polystyrene Colloidal Particles

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Abstract: Colloidal aggregation is essential in water treatment systems, where turbulence enhances particle collisions. However, the influence of different mixing methods and the validity of classical models under practical conditions remain unclear. This study examines how different factors affect the aggregation of polystyrene latex (PSL) particles, serving as model microplastics, under different mixing conditions. In this study, PSL particles of 1.2 μm and 2.0 μm in diameter were suspended in KCl solutions with pH adjusted to 4.0. Aggregation was monitored by measuring the absorbance of suspension using a UV spectrophotometer to examine effects of particle size, mixing types, shear rate, and ionic strength. The results revealed that aggregation was affected by particle size, mixing types, speed, and ionic strength. The aggregation rates increased with KCl concentration and were higher under turbulent mixing, particularly for larger particles. End-over-end rotation produced faster aggregation than orbital shaking. Observed rates were lower than theoretical predictions based on the Saffman&Turner, highlighting the

need to adjust assumptions on collision efficiency under practical conditions. By systematically comparing mixing types, this study reveals that aggregation depends on local shear characteristics rather than mixing speed alone, challenging classical assumptions of isotropic turbulence and constant collision efficiency in colloidal aggregation modeling.

Keywords: Aggregation; Colloid; Electrolyte; Mixing; Particle size; Turbulence

P-H-3 - Research on Enhanced Sludge Dewatering by Electrolysis Coupled with Peracetic Acid in a Pyrite-based Three-dimensional Electrode System

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Abstract: With the rapid development of wastewater treatment, the output of waste activated sludge (WAS) has increased significantly. Traditional dewatering processes are difficult to achieve efficient dewatering performance, which seriously restricts the efficient and harmless disposal of sludge. To address these limitations, this study proposes a new sludge dewatering approach by coupling a three-dimensional pyrite-based electrode system with a peracetic acid (PAA) advanced oxidation process, which demonstrates remarkable enhancement in dewatering performance. This process ingeniously reduces costs and enhances dewatering efficiency through three steps: oxidation, flocculation, and recycling. In this study, the optimal process conditions were determined as 40 V voltage, 60 mg/g Total solids (TS) PAA dosage, 100 mg/g TS pyrite dosage, and an electrolysis time of 20 min. These conditions significantly reduced sludge water content and capillary suction time. Quenching experiments show that organic free radicals and hydroxyl radicals are the main active species, which cause the rupture of sludge flocs and the transformation of intracellular bound water into free water, thereby improving the efficiency of sludge dewatering. The three-dimensional electrode system reduced the voltage conditions and enhanced the activation efficiency of PAA. After five cycles of reuse and regeneration, pyrite still demonstrated a relatively good activation efficiency.

Keywords: Advanced oxidation process; Peracetic acid; Pyrite; Sludge dewatering; Three-dimensional electrode

P-H-4 - Microbial Response to Different Types of Shear Force in Granulation of Flocculent Activated Sludge

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Abstract: The existing wastewater treatment systems using activated sludge are not considered sustainable due to their high energy consumption by mechanical aeration and a huge amount of excess sludge production. Since the first report on aerobic granular sludge (AGS) from a laboratory-scale sequencing batch reactor in Japan in the mid-1990s, AGS can be relatively easy to obtain, which has demonstrated excellent removal efficiencies of organic matter, nitrogen, and phosphorus. In addition, its excellent sludge settleability allows the system operation at higher suspended solids concentration and shorter hydraulic retention time. Up to now, however, there is no standard method established to form stable granules from flocculent activated sludge, limiting its practical application in wastewater treatment facilities. As is known, granulation of flocculent activated sludge can be achieved by (1) high hydrodynamic shear force, (2) repeated feast and famine conditions, and (3) washout of non-granulated biomass. Still, little information is available on the relationship between microbial response and shear force. In this study, to examine the effect of flow patterns on granulation, granulation progress was considered by changing aeration intensity and aeration time. The changes after the initial AGS formation, which is mainly related to hydraulic shear forces, were expected to be significant.

Keywords: Aerobic granular sludge; Aeration time; Aeration intensity; Flocculent activated sludge; Granulation process; Hydraulic Shear force

P-H-5 - Unlocking Centrifugal Sludge Secondary Dewatering via Organic Polymer Flocculants: Macropores Expansion and Drainage Networks

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Abstract： Compared with the residual sludge, the centrifugal residual sludge (CRS) has more complex characteristics. Therefore, an efficient and versatile treatment process is essential for enhanced dewatering performance. This study analyzed the applicability of typical inorganic/organic conditioning agents and explored critical factors and mechanisms enabling secondary dewatering. Results showed that only the polydimethylidene dicyclohexyl ammonium chloride (PDMD) could reduce the sludge water content from 77.89% to 70.82%, while the sludge leakage quality decreased by 66.29% and the filter cloth residual quality decreased by 93%. Furthermore, we systematically investigated the dewatering mechanism through comprehensive analyses of water migration, solid-liquid interface affinity, rheological properties, and filter cake microstructure. The results revealed strong negative correlations between moisture content and key filter cake parameters: pore number (Rp = -0.99, $p < 0.01$), porosity (Rp = -0.98, $p < 0.05$), and throat number (Rp = -0.99, $p < 0.05$). These findings demonstrate that PDMD conditioning enhances dewatering by creating an interconnected macroporous structure that facilitates efficient water removal during filtration. In addition, the calorific value and economic cost of CRS were evaluated, providing a theoretical basis for its engineering applicability and offering a new perspective for the treatment and disposal of CRS.

Keywords: Centrifugal residual sludge; Engineering applicability; Networks structure; Polymeric flocculants; Secondary dewatering

P-H-6 - Flocculation of Anaerobic Digestate for Enhanced Microalgae Cultivation and Nutrient Recovery

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Abstract: Anaerobic digestion is an effective biological process for converting organic waste into biogas, with liquid digestate (LD) generated as a by-product. Due to its high concentrations of nitrogen and phosphorus, LD need to be treated before discharging into the environment which increase the overall operation cost of biogas plant. Microalgae cultivation presents a promising strategy for nutrient recovery and biomass production. However, the high colority of LD limits light penetration, thereby restricting algal growth. In this study, three different types of flocculants were employed for the pretreatment of LD to reduce its colority, including ferric chloride ($FeCl_3$), polyferric sulfate (PFS), and chitosan. Results showed that $FeCl_3$ (1.5 g/L), chitosan (0.1 g/L), and PFS (2.5 g/L) achieved efficient colority removal by 85%, 61%, and 74%, respectively, while the

phosphorus can be retained in the liquid when using chitosan. Due to the effective colority removal and the simultaneous retention of substantial nutrients, the pretreated LD exhibits great potential for microalgae cultivation.

Keywords: Anaerobic digestate; Chrominance; Flocculation; Microalgae cultivation

P-H-7 - Lignin-based Barrier Breaking Caused Supernatant Deterioration: A Molecular-level Characterization of DOM for Exploration of Sludge-flocculant Interfacial Processes

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Abstract: Despite the widespread use of flocculation during dredged sludge dewatering, interfacial interactions between flocculants and sludge remain poorly understood. Clarifying the roles of flocculants in sludge destabilization and aggregation is crucial for technology advancement. This study investigated these interactions by analyzing molecular transformations of dissolved organic matter (DOM) in supernatant using Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). Van Krevelen diagrams revealed that increasing flocculant charge density (from 30% to 70%) removed allochthonous lignin (25.65% to 9.94%) but dramatically released autochthonous lignin (13.89% to 29.74%), causing significant supernatant deterioration. Unsaturation and oxidation degree analyses indicated preferential reaction of carboxyl-rich compounds with high-charge-density polymers. Two-dimensional Fourier transform infrared correlation spectroscopy (2D-FTIR-COS) further confirmed the reaction sequences of functional groups in sludge particulates. A hierarchical layer structure was proposed to illustrate DOM component distribution, and a lignin-based barrier breaking mechanism was used to explain dewatering efficiency differences and supernatant deterioration variations across polymer charge densities. This work provides novel insights for elucidating sludge-flocculant interfacial processes and advancing efficient, eco-friendly dewatering technologies.

Keywords: Cationic polyacrylamide; Dissolved organic matter; Dredged sludge; FT-ICR MS; Interfacial processes

Theme IX: Other Systems or Conversions Relating to Sustainability

P-I-1 - High-Efficiency Extraction of Al and SiO_2 from High-alumina Coal Fly Ash via Na_2CO_3 Roasting Activation and HCl Leaching

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Abstract: This study used high-alumina CFA as raw material and activates it by adding Na_2CO_3 and calcining at high temperatures to produce nepheline. The effects of feed ratio and temperature on calcination products were investigated. HCl leaching is used to extract Al from the clinker and recover SiO_2. The effects of acid concentration, solid–liquid ratio, reaction temperature, and reaction time on the leaching efficiency of Al were investigated. The response surface method was used to study the interaction between influencing factors, and optimization achieved a maximum leaching rate of 96%. The SiO_2 residue was further evaluated against industrial standards to assess its suitability for secondary applications. By integrating the recovery of Al_2O_3 and SiO_2, this work aims to establish a comprehensive resource utilization strategy, thereby maximizing the economic and environmental benefits of CFA valorization.

Keywords: High-alumina CFA; Nepheline; HCl leaching; SiO_2 powder

P-I-2 - Protective Effects of *Sargassum Crassifolium* Extract Against Oxidative Stress Induced by Co-exposure to Polystyrene Nanoplastics and Cadmium in Clone 9 Cells

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Abstract: Combined exposure to nanoplastics and heavy metals is known to induce oxidative stress, a significant threat to organismal health. *Sargassum*, a brown alga, is rich in natural antioxidant compounds; however, its potential role in mitigating pollutant-

induced oxidative stress remains to be further evaluated. This study evaluated the effects of *Sargassum crassifolium* extract (SCE) at 10, 100, and 250 μg/mL for regulating the oxidative stress induced by polystyrene nanoplastics (PS-NPs) combined with cadmium (Cd) in Clone 9 cells. After 48 hr of treatment, cell viability, mitochondrial membrane potential (MMP), oxidative parameters (including reactive oxygen species (ROS) and malondialdehyde (MDA) level), and antioxidant parameters (including superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx), and heme oxygenase-1 (HO-1)) were analyzed. The results showed that 100 and 250 μg/mL of SCE significantly increased cell viability and reduced ROS levels compared to PS-NPs combined with Cd alone. Furthermore, different concentrations of SCE significantly improved MMP levels, increased antioxidant activities (SOD, CAT, and GPx), upregulated the expression of antioxidant-related genes (SOD, CAT, GPx, and HO-1), and decreased MDA levels. These findings demonstrate that SCE enhances antioxidant defenses to mitigate oxidative damage induced by simultaneous exposure to nanoplastics and heavy metals.

Keywords: Antioxidant; Cadmium; Clone 9 cells; Polystyrene nanoplastics; *Sargassum crassifolium* extract

P-I-3 - Efficient Adsorption Removal of Phosphate from Aquaculture Effluent by Waste Eggshell-modified Peanut Shell Biochar Microspheres Adsorbent Materials

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Abstract: Phosphorus pollution is a key driver of aquatic eutrophication, while China's substantial waste biomass production demands sustainable solutions. This study developed recyclable biochar microspheres (E-P) from abundant waste resources (peanut shells and eggshells) through sodium alginate cross-linking for efficient phosphate removal. The E-P beads exhibited excellent adsorption performance across a wide pH range (3-12) with notable selectivity. Optimal conditions (1:1 mass ratio, 775 °C pyrolysis) yielded a maximum phosphate adsorption capacity of 82.6 mg/g. Characterization revealed the removal mechanism involved both apatite ($Ca_5(PO_4)_3(OH)$) formation and generation of calcium-phosphorus intermediates. The adsorption process followed pseudo-second-order kinetics and was best described by the Langmuir isotherm model. When applied to real aquaculture effluent, the E-P beads achieved remarkable 90.5-95.9% total phosphorus removal. This work presents a dual-benefit strategy that simultaneously addresses waste biomass utilization and phosphorus pollution control, offering significant potential for sustainable water treatment applications.

Keywords: Phosphorus removal by adsorption; Modified biochar microspheres; Peanut shell; Egg shell; Aquaculture effluent

P-I-4 - Sustainable Purification Strategies for Carbon Nanotubes: Tailoring Methods to SWCNT/MWCNT Structures and Impurities

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Abstract: Carbon nanotubes (CNTs), known for their exceptional properties, often contain synthesis-related impurities such as metal catalysts and amorphous carbon, which hinder their performance and environmental safety. Additionally, single-walled (SWCNTs) and multi-walled carbon nanotubes (MWCNTs) differ significantly in structural characteristics and impurity profiles, necessitating customized purification approaches. This study presents a sustainability-oriented classification strategy that matches CNT type and impurity nature to specific treatment methods. For SWCNTs, more moderate purification approaches are preferred to minimize structural disruption while effectively addressing residual impurities. In contrast, MWCNTs, due to their robust architecture, can tolerate relatively intensive treatment processes aimed at removing carbon-based and metallic contaminants. By optimizing purification efficiency while minimizing chemical waste and structural degradation, this approach aligns with sustainable management goals. The proposed framework enhances CNT performance in fields such as electronics, catalysis, and biomedicine, and promotes environmentally responsible nanomaterial processing.

Keywords: Carbon nanotubes; Sustainable purification; SWCNT; MWCNT; Metal catalyst removal; Environmental safety

P-I-5 - Gram-scale Ammonia Synthesis via Electrochemical Nitrate Reduction Using Enzyme-inspired Dual-atomic Cu Catalyst

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Abstract: The potential application prospects of green electricity-driven electrocatalytic nitrate reduction (NO_3RR) technology for the production of valuable ammonia have garnered widespread attention. However, designing electrocatalysts with remarkable activity and stability for the NO_3RR to realize gram-level ammonia production remains a significant hurdle in terms of practical application. In nature, the synergistic effect of the dual-site copper of nitrite reductase promotes the substrate adsorption and protonation, achieving efficient conversion of nitrite. Herein, enzyme-inspired Cu dual-atomic sites are constructed on polymeric carbon nitride (PCN-Cu-DAC). Systematic investigations indicate the dual-atomic Cu sites in the catalyst exhibit stronger proton transfer and synergistic nitrate adsorption interaction, thereby reducing the energy barrier for *NO protonation. Studies have shown that the PCN-Cu-DAC catalyst presents a remarkable ammonia (NH_3) yield (467 mg h^{-1} mg^{-1} cat. and 102 mg h^{-1} cm^{-2}) and achieves 11 g d^{-1} NH_3 yield at 6 A of current for 360 h. This work demonstrates the concept of mimicking natural nitrite reductase toward the continuous reduction of nitrate wastewater and promotes the production of NH_3.

Keywords: Ammonia synthesis; Dual active sites; Electrocatalysis; Enzyme-inspired; Polymeric carbon nitride

P-I-6 - CNTs with Encapsulated Co_3O_4 and MnO_2: Elucidating the Synergism of Nanoconfinement and Bimetallic Oxides in Activating Peroxymonosulfate for Water Decontamination

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Abstract: Developing high-efficiency catalysts for peroxymonosulfate activation toward organic water purification has drawn considerable attention, but continues to pose challenges. Herein, a novel carbon nanotubes (CNTs) nanoconfined materials were developed by encapsulating Co_3O_4 and MnO_2 nanoparticles in CNTs, which achieved significantly enhanced peroxymonosulfate activation efficiency for tetracycline (TC) elimination (93.0%), RhB (100%), ofloxacin (91.2%), ciprofloxacin (80.3%). Furthermore, the as- synthesized showed the superior capacity of resisting disturbance, reusability and stability. The density functional theory calculation (DFT) results unraveled that the uniformly distributed Bader charges of original CNTs were altered and electron delocalization occurring around the nano-confined Co_3O_4 and MnO_2 nanoparticles onto the interior of the CNTs, resulting in they were readily activated through transition and electron transfer. The mechanism study elucidated that non-free

radical pathway relayed on $^1O_2$ played a dominant role in TC elimination. Based on experimental, characterization and DFT result, the possible mechanism of enhanced peroxymonosulfate efficiency was presented. This study may provide may be instructive for highly efficient catalysts.

Keywords: Carbon nanotubes; Co-Mn bimetallic oxides nanoparticles; Degradation mechanism; Nano-confinement; Peroxymonosulfate

P-I-7 - Synthesis of COF-MOF Bilayer Membrane at Room Temperature for Efficient Recovery of Lithium Ions

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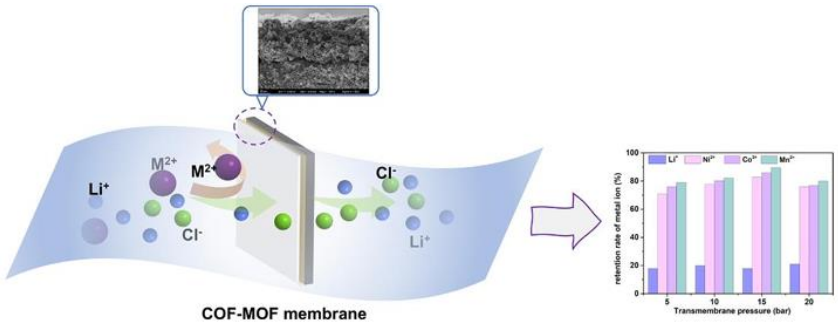
Abstract: With the booming development of the new energy industry, lithium-ion batteries, as a core component, have made their recycling and reuse of waste parts a crucial issue in environmental protection and sustainable development strategies. However, this field also faces many technical bottlenecks and challenges. In response, this paper innovatively proposes a composite double-layer COF-MOF membrane prepared by in-situ growth technology at room temperature. The membrane aims to efficiently separate various metal ions in lithium-containing wastewater through ultrafiltration. Under optimal transmembrane pressure (15 bar) and flow rate (0.8 L/m²/h) conditions, the COF-MOF membrane achieved an interception rate of 87% for Ni^{2+}, 88.7% for Co^{2+}, and as high as 90.4% for Mn^{2+}. On the other hand, the recovery of Li^+ was calculated using K_2CO_3 precipitation. Experimental results showed that when the reaction temperature was increased to 75 ◦C, the recovery rate of Li^+ reached a peak of 89.3%. This discovery not only provides a new idea for the recycling of lithium resources but also further verifies the broad application potential of COF-MOF membranes in the field of metal ion recovery.



Keywords: COF-MOF membrane; Li^+ recovery; Nanofiltration membrane; Synthetic at room temperature

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