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BOOK OF ABSTRACTS

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SNOB AND SMART NATURE-BASED SOLUTIONS IN WATER SECTOR: A NEW CATALOGUE FOR SUPPORTING DECISION MAKING FOR SUSTAINABLE WATER MANAGEMENT

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Nature-based Solutions (NbS) have gained worldwide momentum in the past few years particularly within the European Union, which strongly advocates their implementation for a variety of purposes. In urban areas, NbS are particularly valued as key strategies for climate change adaptation. Greening urban spaces - whether by planting trees or incorporating vegetation on the ground, rooftops, or walls - not only mitigates the effects of heatwaves by lowering city temperatures but also supports urban biodiversity, manages stormwater, purifies polluted water and air, enhances city aesthetics, and creates spaces that foster community interaction and social well-being. However, plant growth is contingent upon adequate water supply, especially when intended to cool a city. The cooling effect of plants is primarily driven by evapotranspiration, a process in which water from plant leaves transitions from liquid to gas, absorbing heat from the surrounding environment.

The URWAN project's NbS catalogue recognises that the link between NbS and water cannot be overlooked when designing NbS and emphasises these interdependencies. It considers the ecosystem services that nature-based solutions can provide while highlighting the potential water requirements of the different solutions. To address this, the catalogue divided twenty NbS into two categories: nine NBS are classified as Water "snob" NbS, which do not account for their water requirements and depend on conventional potable water sources from public networks, like green façade vertical garden, and artificial pond/wetland. Other 11 are classified as Water "smart" NbS, which are designed to utilise alternative water sources beyond potable supplies. Some water-smart NbS even serve dual purposes, they can purify alternative water sources, such as wastewater, and are devised to treat volumes significantly exceeding their own needs. The treated water could be collected into a storage tank and can be used for non-potable purposes, for example water recycling green façades are green walls that reproduce constructed wetland processes to treat and reuse greywater. This system consists of trenches planted with appropriate plants that grow vertically to cover the surface of the wall, the treated water could be collect and reuse for filling toilet cisterns, or to irrigate *water-snob* NbS transforming them into sustainable *smart* solutions.

The catalogue is designed as a user-friendly tool for final users to easily understand the currently available nature-based solutions, snob and smart. Each solution is described by a non-technical description outlining the main features of the solution and a graphical scheme illustrating how it works and icons underlining the multi-benefits provided for people and the environment. Other information included for each solution is the scale of application and the cost of investment and maintenance. By providing an overview of the costs, benefits, and trade-offs of different nature-based solutions, the URWAN project's NbS catalogue aims supporting public authorities and stakeholders in making conscious and informed decisions.

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BIO of Presenter:

Anacleto Rizzo is partner of IRIDRA Srl since 2018. He M.Sc. in Civil Engineering, PhD in Engineering for Natural and Built Environment in 2013. He has 10 years of experience in sustainable water management, wetland treatment, green-blue infrastructure, and nature-based solutions.

A COMPREHENSIVE TIMELINE FOR AERATED AND NONAERATED MESOCOSM ESTABLISHMENT WITH MULTIPLE SPECIES OF MACROPHYTES CONSIDERED

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Research into mechanisms underlying fundamental processes in treatment wetlands often requires lab scale experiments before investment into pilot scale projects can be approached. Often, the lab scale approach is to utilize treatment wetland mesocosms which allow for greater control of variables, replication, and are significantly cheaper compared to pilot scale treatment wetlands. One of the major limitations of mesocosm scale experiments is the time required after a mesocosm is first constructed before it is considered established and representative. This establishment time is generally termed the "start-up" period. Generally, 100 days has been considered adequate for most purposes for the start-up period, however, this choice is usually informed by limited data in the literature surrounding the start-up process. There have been limited attempts thus far to actively refine the currently held 100-day standard and it has been based on only a few studies that consider a small fraction of the different design choices that may influence what is considered as "established" for treatment wetland mesocosms. Similarly, the parameters that the start-up period has been based on in these studies is usually limited to microbial measurements or water treatment parameters, with no attempts thus far to link the water chemistry processes during start up to the microbial measurements of major interest. This project's goal was to provide greater insight into the start-up process in treatment wetland mesocosms with different design aspects including aeration status and the plant species present, while also refining the current start up timeline to include a broader characterization suite. The unpublished data from four previous experimental regimes that used the same mesocosm construction, bed media, simulated wastewater, and location were used for the characterization of the start-up process. Each previous experimental regime included a set of replicated aerated and nonaerated mesocosms, only differing in the plants that were present and the length of time the start-up period was tracked. The characterization suite used in each of the four experimental regimes was based on water chemistry, hydrology, and microbial activity, function, and structure which were compared through correlation analysis, ANOVAs, Tukey-HSDs, and principal component analyses, to determine the start-up relationships between mesocosm design parameters and the characterization suite. A refined start-up timeline is currently being produced to include each parameter that was tracked for each mesocosm design. Thus far, analysis of water chemistry parameters including, dissolved oxygen, pH, ORP, temperature, conductivity, and ammonium concentration have been compared for relations between parameters and the design parameters during start up. The analysis showed that aeration and plant species act independently and as covariables in influencing water chemistry parameters during start up. There was a clear stratification for most parameter values between the aerated and nonaerated mesocosms in each experiment group, such as the pH or ORP, while certain parameters like the conductivity were more significantly influenced by the plant species that were present. These results will be coupled to the remaining parameters to provide the comprehensive timeline of establishing treatment wetland mesocosms with differing designs.

BIO of Presenter:
Isaac is a PhD candidate at the Royal Military College of Canada in the Environmental Sciences Group. Isaac's work focuses on treatment wetland mesocosms which he uses to study PFAS, mesocosm establishment, biofilm structure and composition, and aeration dynamics.

NATURE-BASED SOLUTIONS FOR LAKE RESTORATION: FROM INNOVATION TO MAINSTREAM

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Lakes across Europe are increasingly affected by multiple pressures, including eutrophication, invasive species, land-use changes, and the intensifying impacts of climate change. These stressors contribute to the degradation of water quality, the decline of biodiversity, and the disruption of ecosystem services essential to both communities and local economies.
Conventional restoration approaches, often based on intensive engineering or chemical treatments, can be effective in the short term but frequently fall short in promoting long-term ecological resilience.
Nature-Based Solutions (NbS) have emerged as promising alternatives. These approaches leverage natural processes to rehabilitate ecosystems while providing multiple co-benefits such as carbon sequestration, flood regulation, and improved recreational and cultural value.
A structured literature review was conducted as part of the FutureLakes project to identify and evaluate NbS available and applied to lake restoration. Data from discovered peer-reviewed literature were extracted on intervention typology, design characteristics, implementation context, and policy alignment with frameworks such as the EU Biodiversity Strategy, Water Framework Directive, European Green Deal, and Bioeconomy Strategy. The review also includes information on costs, governance, and operational performance, forming the basis for a broader analysis of Nature-Based Solutions in practice. Building on these insights, this contribution presents a synthesis of reported NbS case studies, ranging from well-established practices, such as vegetated buffer strips to intercept agricultural runoff and constructed wetlands for nutrient removal, and biomanipulation for healthy functioning of lake foodwebs to more experimental approaches like shoreline rewilding, in-lake floating wetlands and habitat restructuring through macrophyte re-establishment.
Key lessons include the importance of integrating NbS into catchment-wide management plans, the value of co-design with stakeholders to strengthen institutional credibility and community engagement, and the need for robust monitoring systems to evaluate performance over time.
These insights highlight the potential of NbS to support adaptive and resilient freshwater systems while reinforcing the need for a paradigm shift in restoration practice that incorporates ecological complexity, promotes multifunctionality, and integrates restoration within broader social and policy frameworks. Future priorities include the upscaling of effective interventions, alignment with EU restoration targets, and the systematic assessment of long-term performance and governance models.

Acknowledgment: This work was supported by the FutureLakes project, funded under the European Union's Horizon Europe research and innovation programme, Mission Ocean, Seas and Waters (Grant Agreement No. 101156425).

BIO of Presenter:
Chiara Sarti holds an MSc in Environmental Chemistry and a PhD in Chemical Sciences obtained at the University of Florence, in collaboration with IRIDRA and Cranfield University. Her research focuses on nature-based solutions for water protection, with particular attention to emerging contaminants.

CONSTRUCTED WETLANDS AND CLIMATE ADAPTATION: CASE STUDY: THE NETHERLANDS

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Constructed wetlands are one type of Sustainable Urban Drainage System (SUDS) that have been used for decades in The Netherlands. They provide stormwater conveyance and improve stormwater quality. European regulations for water quality dictate lower concentrations for an array of pollutants. In addition, higher storage capacities are needed with higher intensity of rainfall. Both these instances require a better understanding of the characteristics of influent and the storage capacity of Dutch constructed wetlands. This paper presents an overview of 137 different constructed wetlands from the Netherlands that have been implemented in the last 25 years. Their locations and storage volume is reviewed to estimate their contribution to climate adaptation compared to other systems in The Netherlands.

Background: A national overview of sustainable urban drainage systems (SuDS) or nature-based solutions (NBS) on private and public ground in a city or on national level is often not available. Often several types of NBS are implemented and for maintaining the long-term efficiency of these NBS several methods are required. Insights of water storage volumes indicate that most NBS are implemented on street or house level without knowledge of their contribution (amount and volume) to the total climate adaptation ambition or demand of a city or a country.

Methodology: To answer the research question 'what is the quantitative contribution of wetlands', a large dataset of sustainable urban drainage systems (SuDS) or nature-based solutions (NBS) is required. The open-source citizen science platform ClimateScan, mapped over 20.000 projects related to climate adaptation around the globe in 10 years, with an average of more than 3000 registered users uploading. Basic insights of constructed wetlands are provided that contain information on the category and location and additional info (if available: photos, videos, research papers and data).

Calculation water storage volume distribution of NBS: To determine the dimensions of wetlands and other green infrastructure there are 2 types of input from ClimateScan: The surface (length and width) is determined from polygon of ClimateScan projects. Large surfaces of >10.000m2 (unlikely in urban dense area) are checked or removed. If no polygon is available (a point) the average is taken of all points in that category. Constructed wetlands allow 0.3-0.5 m water depth as storage but this will not be available at all times so calculations are made with 20 cm of water storage. The amount of storage volume of 5 types of climate adaptation measures in the Netherlands can be found in the table below. Constructed wetlands are 15% of that total storage volume.

Measure	**Number**	**Storage depth [m]**	**Storage volume [m³]**
Bioswales & Raingardens	3072	0,3	731978
Green Roof	725	0,1	58922
Permeable Pavement	814	0,3	103969
Retention Pond	409	0,2	376047
Constructed wetland	**137**	**0,2**	**202460**
Watersquare	31	0,5	18786
Storage volume [m³]	**5.188**		**1.492.162**

Results: First calculations show that over 25.000.000 m³ of storage volume was created in the last 20 years in the Netherlands for climate adaptation. Constructed wetlands are an important part of this. Over 137 locations are identified and over 10 are monitored (monitoring locations and results can be assessed by pressing the medaille in left top corner). The results show that some regions have more wetland urban storage than others, both in quantity and volume. For example: the capital city Amsterdam has over 37 parks and in almost half of them constructed wetlands are implemented for water storage and treatment of pollutants. Because of the open-source character of the method ClimateScan.org, it's easy to engage partners to upload constructed wetland and other climate adaptation measures and contribute to the knowledge of wetlands in the world, instead of in The Netherlands only.

BIO of Presenter:

dr.ir. Floris Boogaard has over 25 years experience in climate adaptation and optimising the efficiency of urban Nature Based Solutions. Floris founded ClimateScan.org and international ClimateCafes, as well as being the research coordinator at Building Fieldlab in Groningen, testing climate adaptation innovations to mitigate floods, drought and heat stress.

RESULTS OF A CERTIFICATION PROCESS OF AN AERATED TREATMENT WETLAND AIR:PHYT

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Evaluation of pollutant removal in a small-scale constructed wetland with forced bed aeration was carried out over a monitored period of nearly one year (from spring 2024 to 2025). The system was sampled weekly using 24-hour composite samples at both inlet and outlet. The measurements were carried out by the Testing Laboratory of Water Management Installations of the T. G. Masaryk Water Research Institute in Prague, following the EN 12566-3+A2 standard as part of the system's certification process. The tested system was dimensioned for 3 population equivalents (PE) with a surface area of 0.5 m^2/PE. Parameters measured included pH, total suspended solids (NL 105), chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonium nitrogen (N-NH4), total nitrogen (TN), and total phosphorus (TP).

The results demonstrate consistently high removal efficiencies for organic pollutants and suspended solids. COD removal reached 96.5% (avg. inflow 391 mg/l, outflow 21 mg/l; median inflow 391 mg/l, outflow 20 mg/l), BOD 98.9% (avg. inflow 210 mg/l, outflow 2.5 mg/l; median inflow 210 mg/l, outflow 2.2 mg/l), and suspended solids 99.1%. Ammonium nitrogen was also effectively removed with an average efficiency of 96.4% (avg. inflow 34.4 mg/l, outflow 1.4 mg/l; median inflow 34.8 mg/l, outflow 1.3 mg/l).

In contrast, nutrient removal showed greater variability. Total nitrogen was removed with a moderate efficiency of 52.9%, and total phosphorus with an average efficiency of only 40.2%, ranging from -0.5% to 82.6%. These fluctuations indicate unstable phosphorus dynamics, possibly influenced by inflow variability or internal cycling.

While the system performed very well in terms of organic matter and ammonium removal, further optimization is needed to improve nutrient removal. Modifications to enhance phosphorus and nitrogen capture are currently being developed.
These findings support the continued use and refinement of aerated wetlands as compact, efficient systems for decentralized wastewater treatment in a broad range of applications.

BIO of Presenter:
Vít Rous is a landscape water engineer at Grania, specializing in the integration of decentralized water systems and green infrastructure in urban and rural environments.

IMPLEMENTING NATURE-BASED SOLUTIONS FOR THE RESTORATION OF EUROPEAN NATURAL LAKES: INSIGHTS FROM PROCLEANLAKES THREE DEMONSTRATION SITES

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Abstract

European Natural Lakes (ENL) are critical ecosystems that support biodiversity, deliver essential ecosystem services, and contribute to cultural identity and community well-being. However, they are increasingly threatened by nutrient pollution, habitat degradation, invasive species, and climate change. Addressing these complex pressures calls for integrated and adaptive strategies rooted in nature-based approaches.The EU-funded Horizon Europe project **ProCleanLakes** aims to develop a science-based Action Plan and Guidelines for the long-term restoration and protection of ENL ecosystems. At the core of the project is the implementation of site-specific, integrative Nature-based Solutions (NbS) tailored to the ecological and socio-economic context of each lake. The project brings together scientists, practitioners, decision-makers, and citizens to co-create effective and transferable solutions.

NbS will be tested at three **demonstration sites**:

- Trichonis Lake (Greece), where eutrophication from agricultural runoff and urban wastewater is addressed through the restoration of riparian buffer zones and re-establishment of native aquatic vegetation.
- Brates Lake (Romania), where renaturalisation of agricultural water channels, managed wetland creation and shoreline renaturalization will be applied to tackle nutrient rich effluents and high sediment load.
- Langvatnet Lake (Norway), where heavy metal contamination (mostly copper) from effluents from abandoned mining sites will be mitigated through bioremediation techniques and subsurface constructed wetlands.

These interventions are supported by digital tools for ecosystem monitoring, restoration tracking, and knowledge transfer. Three additional **monitoring sites** will provide comparative insights into long-term performance and scalability. ProCleanLakes also promotes circular economy based business models and active public engagement. A key feature of the project is its adaptive, learning-by-doing approach — integrating feedback from citizens and stakeholders to inform the development of the ENL Action Plan and improve both ecological outcomes and social acceptance.

Acknowledgment
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BIO of Presenter:
Dr. Eriona Canga is an environmental scientist at *alchemia-nova research & innovation* in Vienna, Austria. With a Ph.D. from Aarhus University (2014), her 14 years of expertise includes wastewater treatment, constructed wetlands, and other nature-based solutions. Her professional work addresses sustainable water management, circular cities, and resource recovery.

FROM DISCHARGE TO RECHARGE: INNOVATIVE WETLAND DESIGN IN EDGEWATER, FLORIDA

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The City of Edgewater, Florida, USA is in the design phase of an infiltration wetland system to manage wastewater effluent that is presently discharged into the nutrient-sensitive Indian River Lagoon. This initiative is driven by new state regulations that prohibit the discharge of treated municipal wastewater into surface waters, as well as by funding from the State of Florida aimed at reducing nutrient pollution in the lagoon. The Indian River Lagoon, a 250-kilometer-long estuary located between east Florida's barrier islands and mainland, is recognized as one of the most biodiverse estuaries in North America. Protecting this ecologically vital system has become a priority, prompting innovative approaches, like infiltration wetlands, to enhance water quality and support sustainable water management.

Infiltration wetlands have emerged as a preferred strategy for managing municipal wastewater effluent in Florida, USA, due to their effectiveness in protecting water quality and supporting long-term groundwater recharge. Traditionally, these systems were designed similarly to free water surface wetlands, incorporating inlet and outlet deep zones—and sometimes intermediate ones—to promote plug-flow hydraulics across the treatment marsh. This configuration performs well under steady flow conditions, optimizing surface treatment. However, during periods of low flow—often caused by limited water availability and competing demands for reclaimed water—sheet flow may not occur, leading to marsh erosion, channelization, reduced treatment performance, and plant stress.

To address these challenges, a novel design approach was developed for infiltration wetlands facing extreme flow variability. This new configuration centers the inflow within each cell in a deep zone that intersects the groundwater table. The cell bottoms are gently sloped, allowing water to accumulate and expand outward from the center as levels rise, and recede inward during dry periods—mimicking natural depressional wetlands. Vegetation is arranged in concentric planting zones: deep-zone species (e.g., *Schoenoplectus californicus*) at the center, emergent marsh species (e.g., *Pontederia cordata*) in the mid-zone, and transitional species (e.g., *Canna flaccida*) near the berm. While this design departs from traditional surface hydraulics, performance data show that water quality improvements are primarily driven by subsurface biological processes during infiltration, not surface flow.

This presentation highlights the first implementation of this design in Edgewater, Florida, where reclaimed water is unavailable for 4–6 months annually due to high irrigation demand during dry seasons. In contrast, wet seasons bring flows ranging from 5,000 to 13,000 m^3/day due to reduced irrigation and increased inflow/infiltration within the wastewater collection system. The system's design is based on detailed water balance modeling and dynamic infiltration analysis to define hydropatterns for each planting zone. This ensures the wetland can accommodate seasonal variability while sustaining healthy vegetation and maintaining high treatment performance.

This innovative design not only addresses the operational challenges of variable flow conditions but also sets a precedent for sustainable wastewater management in nutrient-sensitive regions. By aligning ecological function with regulatory compliance, this project demonstrates how infiltration wetlands can serve as a resilient, nature-based solution for protecting Florida's water resources and restoring the health of critical ecosystems like the Indian River Lagoon.

BIO of Presenter:
Rafael is Jacobs' Global Practice Leader for Natural Treatment Systems with over 20 years of experience in treatment wetland design. He has led large-scale, innovative, and award-winning wetland projects that advance sustainable wastewater management, enhance water quality, and transform infrastructure into ecological assets.

THE DESIGN OF HYDROLOGICAL PROCESSES SIGNIFICANTLY INFLUENCES 6PPD-QUINONE REMOVAL EFFICIENCY IN BIORETENTION CELLS

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6PPD-Quinone (6PPD-Q), the ozonation product of tire antioxidant 6PPD, poses severe ecological risks with a LC_{50} of 95 ng/L for Coho Salmon. Its pervasive detection in urban stormwater drives urgent demand for Nature-based solution controls. We systematically evaluated eight bioretention cell designs with different hydrologic processes to address two critical gaps: configuration-dependent removal efficiency and transformation pathways. The key results of the study show that:

(1) Retention layer design elevates 6PPD-Quinone migration risk

The 100 mm retention layer configuration demonstrated 35.8%-49.5% 6PPD-Q removal efficiency, indicating increased migration risk compared to bioretention cells without retention layers.

(2) Increased substrate layer height mitigates retention layer-induced 6PPD-Quinon migration risk

When the media layer height was elevated from 400 mm to 550 mm, the 6PPD-Q removal efficiency in bioretention cells with retention layers improved to 64.6%-72.3%.

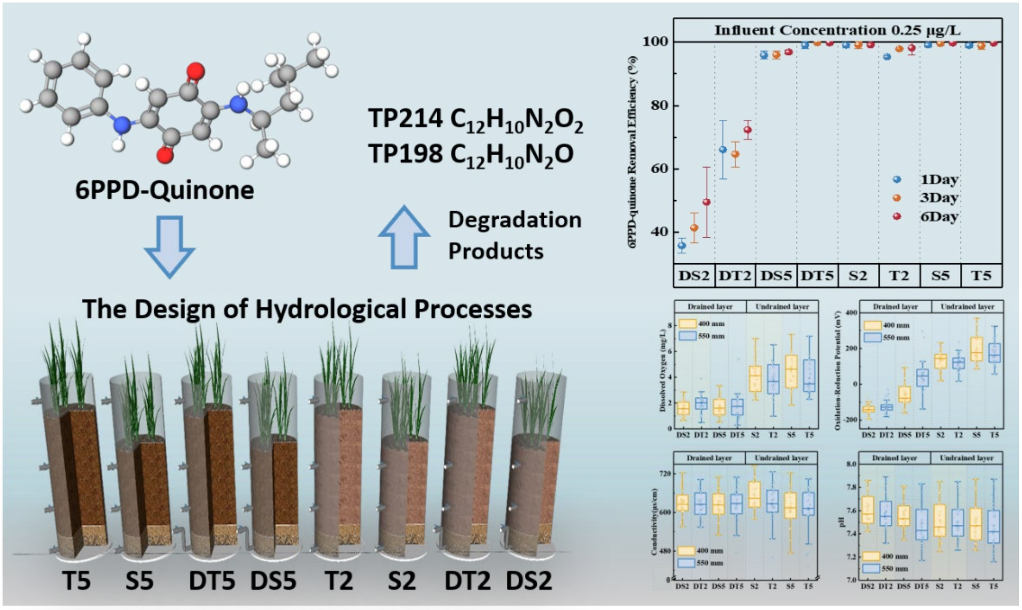
(3) Surface-layer removal of 6PPD-Quinone in bioretention systems

Stratified sampling of effluent from all bioretention cells revealed that 40.0%-89.8% of 6PDD-Q was removed within the 0-100 mm surface media layer. Notably, effluent 6PPD-Quinone concentrations increased after passing through retention layers.

(4) Partial degradation of 6PPD-Quinone in bioretention cells

UPLC-Q-TOF analysis identified degradation products of 6PPD-Q in bioretention substrate, including compounds with molecular formulas $C_{12}H_{10}N_2O_2$ and $C_{12}H_{10}N_2O$.

Keywords: 6PPD-Quinone, Bioretention Cells, hydrologic process



BIO of Presenter:

Shuangqi Wu is a second-year Ph.D. candidate at the College of Environmental Science and Engineering, Tongji University. His research focuses on nature-based solutions for urban sustainability and the behavior of priority and emerging pollutants in wetland ecosystems.

OPTIMIZING AERATED CONSTRUCTED WETLAND DESIGNS THROUGH TANK-IN-SERIES MESOCOSM STUDIES

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Abstract
Constructed Wetlands (CW) are a well-known green technology with multiple benefits in terms of pollutant removal efficiency, cost-efficiency and environmental performance. One of the main limitations of CW is the higher area demand, which limits the application range to areas with adequate land, e.g., small and medium settlements. Although various modifications have been tested to optimize the design in terms of both pollutant removal and reducing area demands, artificial aeration appears to provide the best efficiency in terms of reduced area requirements. Artificial wetlands have been used for many years, but there is still room for further improvements in energy consumption and design configuration.
This project studies three artificial wetland designs following the tank-in-series approach, i.e., pilot CW units consist of tanks connected in series treating both raw and primary wastewater. More specifically:

- **unit PA4**: 4 IBC tanks (1 m^3 each) connected in series, filled with medium gravel (8-20mm) and cobbles, and having a total depth of 90 cm. Water level is set at 80 cm depth. All tanks are equipped with individual aeration equipment. The third tank also contains a layer of biochar. Primary effluent is applied at the top of the first two tanks. The hydraulic load is 0.24 m/d for a daily inflow that varied between 600-1000 L/day. Planted with a mix of *Phragmites australis* and *Arundo donax*.
- **unit PA3**: 3 IBC tanks (1 m^3 each) connected in series, filled with medium gravel (8-20mm) and cobbles, and having a total depth of 90 cm. Water level is set at 80 cm depth. All tanks are equipped with individual aeration equipment. The water flow follows a meandric path, i.e., the first and second tanks are connected at the bottom, and the second and third tank are connected at the top. The second tank contains a layer of biochar. Primary effluent is applied at the top of the first tank. The hydraulic load is 0.19 m/d for an inflow around 600 L/day. Planted with a mix of *Phragmites australis* and *Arundo donax*.
- **unit RPLA**: 1 IBC tank (1 m^3 each), filled with recycled HDPE, biochar and LECA, with a total depth of 80 cm. Water level is set at 70 cm depth. The tank is equipped with aeration equipment. Raw wastewater after screening is applied at the top of the tank (LECA layer). The applied hydraulic load is 0.19 m/d for an inflow around 200 L/day. Planted with a mix of *Phragmites australis* and *Arundo donax*.

Regular samplings and analyses in the influent and effluents of the units take place for the determination of a series of physicochemical parameters and micropollutants. This work will present the overall results of the mesocosms after the first operational year.

Acknowledgements
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BIO of Presenter:
Dr. Stefanakis is Assistant Professor at the School of Chemical and Environmental Engineering, Technical University of Crete in Greece. He is the Co-Chair of the Specialist Group on Wetland Systems and Water Pollution Control of the International Water Association, as well as elected President of the International Ecological Engineering Society. He is an active professional Engineer and Researcher with more than 15 years of experience in the design, operation and implementation of NBS and constructed wetlands projects internationally.

STORMWATER TREATMENT: COMPACT CSO-CW – A SOLUTION FOR URBAN AREAS?

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Introduction

Constructed wetlands for combined sewer overflows (CSO-CWs) are nature-based solutions and an effective method to mitigate emissions from otherwise untreated stormwater (Rizzo et al., 2020). The core of their functionality is the filter substrate, which plays a crucial role in adsorbing and retaining nutrients, oxygen-depleting substances, particulate contaminants, heavy metals, pathogens, and micropollutants. The most significant operating factor influencing treatment performance in CSO-CWs is the area-related flow rate, which ranges from 0.01–0.05 L/(s*m²), for standard dimensioning, depending on the treatment objectives. CSO-CWs are characterized by high treatment performance coupled with low maintenance costs; however, their surface area, due to the area-related flow rate required, is a major design obstacle. Approximately 1 % of the connected impervious area should be allocated as a filter surface to ensure optimal treatment efficiency (Grotehusmann et al., 2015). In urban areas, there is often insufficient space available for large-scale CSO-CW installations. Therefore, the StopUP research project aims to develop a more compact variant: the compact CSO-CW.

Methods

Reducing the CSO-CW's surface area is only possible by increasing the area-related flow rate if the same CSO discharge should be treated. However, increasing the flow rate reduces the residence time within the filter substrate, leading to a lower treatment performance. To address this challenge, two adjustments were implemented: 1) exploring filter substrates with different properties than sand for CSO treatment, and 2) enhancing treatment performance by adding biodegradable flocculation agents (bFAs) to the CSO-CW inflow, thereby promoting agglomeration of particulate contaminants.

To identify suitable bFAs for the use in CSO-CWs, a preliminary screening of 16 bFAs was conducted with a Jar-Tester. Lab-scale column tests using six different filter substrates without bFA dosing were conducted to pre-select suitable filter substrates for semi-technical pilot tests. To compensate for the reduced treatment performance due to the increased flow rate, further experiments were conducted using four semi-technical-scale CSO-CWs with bFA dosing.

Results

Chitosan-based bFAs achieved the best turbidity reductions of up to 80 % in water similar to CSO discharges. In the lab-scale column tests, it was found that the investigated filter substrates – without bFAs dosing – had lower treatment performance for most parameters at the doubled flow rate (0.01 L/(s*m²)) compared to conventional CSO-CW set-up. However, the typical CSO-CW system at a doubled flow rate showed only a maximum of 10 % reduction in treatment performance compared to the conventional flow rate for the examined parameters (COD, NH_4-N, TSS).

At the time the abstract was written (04/2025), results from the semi-technical CSO-CWs with bFAs dosing were unavailable. However, by the conference, these tests will be completed and analyzed, allowing the presentation to include findings on the optimal dosage of bFAs for CSO spills, laboratory column tests, and semi-technical-scale CSO-CW experiments without and with bFAs dosing.

References

Grotehusmann et al. (2015) Retention Soil Filters - Handbook for Planning, Building and Construction. MKULNV (Eds.) (in German)
Rizzo et al. (2020) *Science of the Total Environment* 727, 138618

BIO of Presenter:
She studied environmental engineering at RWTH Aachen University. Since 04/2023, she has been working as research assistant at the Institute of Environmental Engineering (ISA) at RWTH Aachen University, where she also serves as deputy head of the laboratory. Previous studies: Re-Carbonation of CSO-CW in Germany, behavior of microplastics, toxicological and ecotoxicological effects of fragrances in the aquatic environment.

PERFORMANCE OF A NITRIFYING CONSTRUCTED WETLAND UNDER HIGH AMMONIUM LOADING FROM URINE-DERIVED EFFLUENTS

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BIO of Presenter: PhD candidate in Environmental Technologies, has been working with decentralized and household sanitation as well as nature-based solutions since 2018 in riverside communities of the Pantanal, Brazil. Chemical engineer, currently an exchange researcher at RPTU, Germany, with a focus on resource-oriented sanitation.

Note: Oral presentation

High-nitrogen effluents, particularly from urine-based nutrient recovery systems, can represent a challenge for decentralized treatment. In Rhineland-Palatinate, Germany, a vertical-flow constructed wetland (unplanted)—referred to from here on as high nitrogen (N) load CW—was designed to treat the supernatant generated after struvite precipitation from stored urine. The high N load CW receives supernatant with up to 5420 mg/L TN, of which 4800 mg/L are NH_4-N. Although the specialized CW was designed for 16 users, the system has experienced seasonal peaks of up to 80–100 users over the past four years. After six years of operation, irreversible clogging led to filter media replacement, prompting this study to evaluate the new media and identify clogging causes.

The high N load CW comprises a 4 m^2 vertical flow filter bed receiving intermittent inflows of urine supernatant following struvite (MAP) precipitation events. Each feeding event introduces 140 L of effluent, resulting in a mean hydraulic loading rate of around 4.4 L/(m^2·day). Initially filled with zeolite-rich lava sand (0–4 mm, BET 81.9 m^2/g), the filter became clogged in Mai2024 and was replaced with a lava sand of lower BET (39.1 m^2/g). Performance was monitored over an 8-month period (July 2024–January 2025), with 13 influent/effluent sample pairs analyzed for NH_4-N, NO_2-N, NO_3-N, COD, TN, TP, pH, conductivity and turbidity. Soil and mineral analyses, including BET, d10, permeability (Kfa), and chemical composition, were performed to investigate clogging causes and media transformation.

The high N load CW removed NH_4-N on average with 83.5% efficiency (influent 2.9–4.8 g/L to effluent 0.28–1.4 g/L), with significant nitrification (NO_3-N >1400 mg/L), although nitrite (NO_2-N) accumulation reached up to 410 mg/L at times. COD removal ranged from 36–83%; TN was reduced by approx. 38%. Turbidity declined on average from 409 NTU to 13.2 NTU at the outlet. Investigation of the former clogged system was linked to salt precipitation, accumulation of fine particles (d_{10} as low as 0.008 mm), and permeability loss (Kfa dropped to 6.7×10^{-7} m/s). The new filter, despite operational stability in ammonium removal after a two-month start-up, exhibits sub-optimal granulometry (d_{10} = 0.016 mm) and a calculated Kfa of 2.6×10^{-6} m/s, alongside lower BET and CEC values (15.3 $cmol^+$/kg), indicating reduced adsorption capacity and suggesting ongoing clogging risks. Encouragingly, low NH_4-N effluent concentrations persisted through winter, indicating robust microbial adaptation.

The high N load CW effectively reduces ammonium and organic load from urine-derived effluents, demonstrating the potential of such systems. However, filter media characteristics and operational history critically affect long-term performance and resilience. Clogging in the original media was primarily attributed to mineral buildup and the ingress of fine particles, severely altering the filter's granulometry and hydraulic function. While the replacement media is functional, operational strategies are crucial for ensuring its long-term durability and preventing premature failure, such as enhanced upstream struvite separation, refined intermittent feeding strategies, and potential vegetation integration. This study provides key insights into design and operational considerations for developing sustainable, nature-based N treatment solutions for challenging decentralized wastewater streams in variable contexts.

THE EFFECT OF RECONSTRUCTION OF PEATLAND FOREST DRAINAGE DITCHES AND THE ASSESSMENT OF FRESHWATER PROTECTION MEASURES

Jürgen Sarjas [1], Margit Kõiv-Vainik[1], Kadir Yildiz[1], Isaac Okiti[1], Ilona Tamm[1], Mihkel Pindus[1], and Kuno Kasak[1]*

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Abstract

Draining peatlands is a common practice in forestry to allocate new land for growing trees. The lowered water table facilitates accelerated tree growth but exposes the nutrient-rich peat soil to oxygen, triggering peat mineralization and decomposition. This leads to an increase in CO_2 emissions and the leaching of nutrients, organic matter, and solids from the soil. While the accelerated tree growth may partially offset CO_2 emissions, the drainage ditches are possible hotspots for greenhouse gas (GHG) emissions, especially when the ditches are left unmanaged.

This study monitors water quantity and quality, and GHG emissions in ditches of four sub-catchments of a 507.6 ha peatland forest drainage system in western Estonia, before, during, and after extensive reconstruction works. To mitigate the negative impacts of these works, ecological water protection measures - sedimentation ponds (SP) and hybrid systems (HS) combining sedimentation ponds with treatment wetlands - are used. From July 2022, once per month, water temperature, dissolved oxygen content, electrical conductivity, pH, redox potential, and turbidity have been measured onsite from the ditches, two SB-s, and two HS-s. From grab samples total nitrogen (TN), nitrite-nitrogen, nitrate-nitrogen, total phosphorus (TP), phosphate-phosphorus, total suspended solids (TSS), total organic carbon (TOC), total inorganic carbon, dissolved organic carbon, ammonium, sulfate, total iron, magnesium, calcium, and chlorides are analyzed in the laboratory. Flow rates monitored from the outflows of mitigation measures with V-weirs combined with automated water level loggers are the basis for the estimation of potential sediment and nutrient loads. From April 2023, monthly CO_2 and CH_4 fluxes have been measured during the vegetation period on four 0.6 km sections of ditches entering mitigation measures with a floating chamber and portable LI-7810 trace gas analyzer. In addition, an extensive random mapping of GHG emissions from the ditches of the whole drainage system was conducted before and will be repeated after the reconstruction works.

The median concentration (range presented in parenthesis) of TN 3.15 (0.78-15.0), TP was 0.027 (0.012-0.281), TSS 8.0 (2.0-200), and TOC 54.0 (28-81) mg L^{-1} are indicating that the studied ditches are a source of diffused water pollution, foremost for phosphorus.

The median CH_4 and CO_2 flux emissions from unmanaged ditches entering mitigation measures were 0.30 (0.01-85.28) mg CH_4-C m^{-2} h^{-1} and 30.66 (0.39-645) mg CO_2-C m^{-2} h^{-1}, respectively. The first mapping (n=63) resulted in median CH_4 and CO_2 emissions of 0.67 (0.06-69.40) mg CH_4-C m^{-2} h^{-1} and 32.02 (0.39-276.98) mg CO_2-C m^{-2} h^{-1}. GHG emissions from unmanaged ditches show high seasonal variability, high emissions in summer, and relatively low mean emissions during autumn and spring.

This study gives unique information about the water quantity and quality, and GHG emissions in peatland forest drainage ditches. Based on this, we can evaluate the impact of reconstruction works (scheduled for summer 2025) on peatland forest ditches and the performance of mitigation measures.

BIO of Presenter:

I am an environmental technology PhD candidate at the University of Tartu, Estonia. My main field of study is the mitigation of diffuse pollution originating from agriculture and forestry. I focus mainly on the use and the enhancement of treatment wetlands as a freshwater protection measure.

LANDFILL LEACHATE TREATMENT USING VERTICAL WALL SYSTEMS, VERTECO®

Eriona Canga [1], Ece Kendir Cakmak[2], Heinz Gattringer[1], Tiziana Centofanti[3], Zeynep Cetecioglu[2], Clara Conte[4], Erell Nunes[5].*

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Abstract

Landfill leachate, characterized by high concentrations of organic matter, ammoniacal nitrogen, heavy metals, and other contaminants, posed significant environmental challenges (Mojiri et al., 2020; Xiang et al., 2025) and Nature-based Solutions (NbS) offer eco-friendly and cost-effective solutions for its treatment. This study aimed to investigate the application of NbS for landfill leachate treatment through an innovative but existing vertECO® green wall system (alchemia-nova). The study encompassed two experimental phases: a small-scale mini green wall system and a full-scale vertECO® prototype. In the first phase, three mini vertECO® systems were constructed, incorporating two vegetated setups with halophyte and hyperaccumulator plants, and one unvegetated control. The substrate used in these systems consisted of a mixture of gravel, zeolite, biochar, and lightweight expanded clay aggregate. Under impounded conditions, the unvegetated system achieved superior heavy metal retention through adsorption, while vegetated systems faced challenges related to extreme heat and salinity, which impacted plant survival. In the second phase, the full-scale vertECO® prototype, composed of vertical subsurface flow beds with aerated and anoxic zones, demonstrated substantial pollutant reductions, including chemical oxygen demand (COD), ammonium (NH_4), and metals and metalloids (As, Pb, B, Cr, Fe, Ni). However, operational challenges, such as system clogging and uneven flow distribution, underscored the need for further optimization. The experiments demonstrated that the vertECO® system has significant potential as a sustainable solution for landfill leachate treatment. Its scalability to a pilot-level trial (TRL 5) appeared promising, provided operational challenges are addressed. To enhance system performance and reliability, future efforts should prioritize optimizing substrate and plant configurations, selecting resilient plant species, mitigating extreme environmental impacts, and conducting long-term pilot-scale trials under diverse conditions. Furthermore, exploring the economic feasibility of integrating phytomining into landfill leachate management for extraction of valuable materials from vertECO® plants could enhance the sustainability and circularity of this innovative approach.

References

Mojiri, A., Zhou, J. L., Ratnaweera, H., et al. (2020). Treatment of landfill leachate with different techniques: an overview. Journal of Water Reuse and Desalination.

Xiang, R., Wei, W., Mei, T., et al. (2025). A Review on Landfill Leachate Treatment Technologies: Comparative Analysis of Methods and Process Innovation. Applied Sciences.

Acknowledgment

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BIO of Presenter:

Dr. Eriona Canga is an environmental scientist at alchemia-nova research and innovation in Vienna. With a Ph.D. from Aarhus University (2014), her expertise includes wastewater treatment, constructed wetlands, and nature-based solutions. She focuses on sustainable water management, circular cities, and resource recovery.

EMERGING CONTAMINANTS IN SLUDGE TREATMENT REED BEDS: DEGRADATION, PERSISTANCY OR ACCUMULATION?

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Sludge treatment reed beds (STRBs) offer a sustainable and low-energy solution for dewatering and stabilizing sewage sludge. While widely recognized for their robustness in sludge mineralization, the fate of micropollutants in these systems—and the implications for the final biosolid product—remains poorly understood. This study investigated the behavior of 49 organic micropollutants (pharmaceuticals and pesticides) over the course of one year in pilot-scale STRBs operated under three different aeration regimes, aiming to determine whether enhanced aeration improves micropollutant removal.

Figure 1: the studied STRBs systems

From the full compound set, 25 micropollutants consistently detected at least ten times above their limit of detection were selected for in-depth analysis. Most showed signs of degradation across all aeration types, suggesting that aeration intensity may play a smaller role than expected and that other environmental factors likely drive micropollutant breakdown. This observation was confirmed through a statistical linear mixed model, which included variables such as compound type (pharmaceutical or pesticide), compound group (chemical class), and aeration type—all of which showed no significant effect on degradation. Notably, several compounds, such as benzalkonium chlorides (BACs), carbamazepine, and propranolol, persisted or accumulated in the system, raising potential environmental concerns.

Given the absence of current legislation on micropollutant occurrence in biosolids, a risk assessment was performed using available ecotoxicological data to estimate potential risks. Results indicated that while most compounds posed low ecological risk (RQ < 1), a few—namely trimethoprim (RQ = 8.25) and azithromycin (RQ up to 4.50)—showed high toxicity potential to soil microbial communities.
These findings highlight both the potential and limitations of STRBs for micropollutant removal. While they represent a sustainable tool for sludge management, the persistence of certain compounds calls for further evaluation. Understanding degradation pathways and ecological risks is essential to support safe biosolid reuse. To the best of the author's knowledge, this is the first study of its kind to evaluate STRB effectiveness in reducing micropollutant loads and to assess ecological risks within a circular economy framework.

BIO of Presenter:
Alba Martinez I Quer is a postdoctoral researcher at the Department of Environmental Science, Aarhus University. She researches within the intersection of environmental chemistry and microbiology in constructed wetlands using analytical chemistry and molecular microbiology to understand biodegradation pathways and actors.

MODEL-BASED ANALYSIS OF A FREE WATER SURFACE CONSTRUCTED WETLAND TREATING EUTROPHIED RIVER WATER

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Abstract

This research is conducted within the Aquatuur project, which aims to enhance freshwater availability by improving the quality of various water streams, thereby supporting a more sustainable water supply. One of the project's case studies concerns the Ringbeek creek (Oostkamp, Belgium). Nitrogen and phosphorus levels in that creek often exceed the EU environmental standards, especially after long periods of drought followed by intense rainfall. The high nutrient levels in this area mainly emerge from agricultural run-off, and ill-functioning on-site treatment systems for households not connected to the sewer network. To tackle this, a 3200 m² free water surface constructed wetland is being implemented. The wetland itself will not suffice for the complete treatment of the Ringbeek, but is intended for peak-shaving: only during events when the concentrations exceed the EU standards, water will be sent to the wetland for treatment.

A derivative of the SURFWET model (Aragones et al., 2020) was applied in R to analyze wetland performance. Following a five-year steady-state baseline simulation, parameter tuning was performed using inflow water characteristics of 32.3 mg/L COD, 13.5 mg/L TN, and 2.5 mg/L TP at a flow rate of 800 m³/day. Three operational scenarios were evaluated: (1) continuous feeding, (2) intermittent feeding, and (3) variable flow rates. Key initial findings include:

- Simulated nitrogen removal reached 191 g N/m²·yr, significantly exceeding the 93 g N/m²·yr median reported for freshwater treatment wetlands (Land et al., 2016). Denitrification accounted for 97% of nitrate removal, while plant uptake only contributed 3%.
- Inorganic phosphorus removal was primarily driven by microbial assimilation (85%), followed by plant uptake (15%). However, simulated inorganic phosphorus removal was occasionally slightly negative which possibly originates from a structural model limitation: the lack of precipitation and sorption processes
- Lowering the flow rate to 400 m³/day improved removal efficiencies across most parameters, except for organic nitrogen, which decreased by 52%.

Aragones, D. G., Sanchez-Ramos, D., & Calvo, G. F. (2020). SURFWET: A biokinetic model for surface flow constructed wetlands. Science of the Total Environment, 723, 137650.
Land, M., Granéli, W., Grimvall, A., Hoffmann, C. C., Mitsch, W. J., Tonderski, K. S., & Verhoeven, J. T. (2016). How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review. Environmental Evidence, 5, 1-26.

Acknowledgements

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BIO of Presenter:

After obtaining a master's degree from Ghent University in Bioscience Engineering: Environmental Technology, Lukas Willems worked for over a year at a start-up company in electrochemical water treatment. Subsequently, he started a PhD position at Ghent University, where he is researching nature-based solutions for surface water treatment.

15 YEARS EXPERIENCE OF AERATED TREATMENT WETLANDS PERFORMANCE IN THE UK WITH A FOCUS ON CSO AND STORMWATER TREATMENT APPLICATIONS

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Abstract

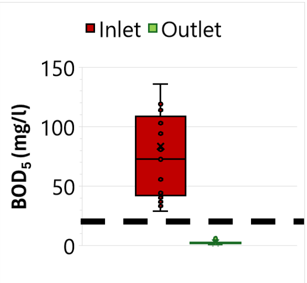
Aerated wetlands with Forced Bed Aeration (FBA™) were first introduced into the UK wastewater treatment industry in 2008. The introduction has been hugely successful with over 200 full-scale systems now in operation, ranging from small systems treating wastewater generated by a few people to large systems over 2.0ha in size. This success is largely due to their high performance, optimized footprints and design flexibility allowing implementation across a wide range of applications, including secondary and tertiary sewage treatment, food and beverage industries, industrial process waters, as well as stormwater and CSO treatment.

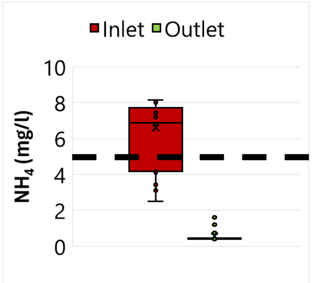
In this study we will analyze water quality data generated through routine maintenance of these systems to demonstrate the performance of different aerated wetland configurations and applications. The study will focus on typical UK approaches for CSO and stormwater treatment with case studies and commissioning performance data for a new 1,750m^2 SVF aerated wetland installed in Lancashire, UK.

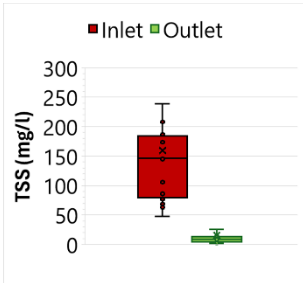
After installation, event duration monitoring demonstrated load reductions of 81%, 79% and 60% for BOD_5, NH_4 and TSS respectively whilst 95th%ile final effluent concentrations of 4.1mg/l, 0.94mg/l and 29mg/l have been recorded helping the receiving water achieve a good ecological status.

Spill event load removal (spot samples through event duration)

Event No.	N	Rain	Spill	Spill Vol	BOD_5 Load in	BOD_5 Load Out	BOD_5 Load removed		NH_4 Load in	NH_4 Load Out	NH_4 Load removed		TSS Load in	TSS Load Out	TSS Load removed	
		mm	hrs	m³	kg/d	kg/d	kg/d	%	kg/d	kg/d	kg/d	%	kg/d	kg/d	kg/d	%
1	24	31.46	45.00	5,115	148	40.57	107	72.55	12.74	10.15	2.59	20.30	905	104	802	88.53
2	19	1.68	4.00	230	18.56	7.62	10.94	58.93	1.71	0.09	1.61	94.50	33.36	7.86	25.50	76.45
3	22	12.85	20.00	414	42.62	0.86	41.75	97.97	3.32	0.01	3.31	99.84	86.06	24.87	61.19	71.10
4	7	5.13	3.00	146	17.32	0.84	16.48	95.13	0.60	0.002	0.60	99.62	34.79	33.31	1.48	4.24
Cumulative totals treated And removed loads				**5,905**	**226**	**50**	**176**	**81.15**	**18.36**	**10.25**	**8.11**	**78.56**	**1060**	**170**	**890**	**60.08**







BIO of Presenter:

Andy is an Environmental Scientist specializing in the treatment of wastewater using constructed wetland technologies and representing ARM Group Ltd in consultancy design and R&D activities since 2016. Andy promotes sustainable water treatment through professional networks including the UK Constructed Wetland Association (CWA) and Global Wetland Technology Group (GWT).

NEXT-GENERATION VERTICAL FLOW CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT AND SLUDGE MANAGEMENT IN SMALL POPULATIONS

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BACKGROUND

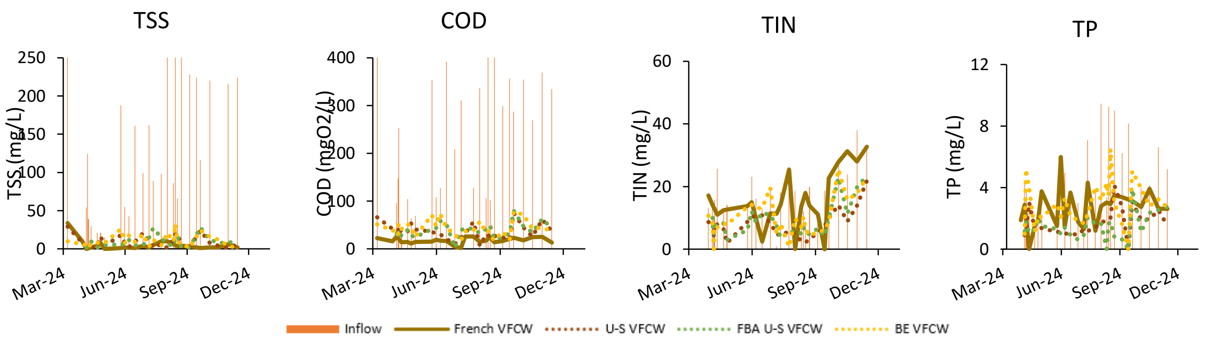
Managing wastewater in small populations (<2000 PE) is challenging due to the inadequacy of centralized treatment facilities, leading to growing interest in more decentralized, on-site solutions. Nature-based solutions (NbS), like Vertical Flow Constructed Wetlands (VFCWs), are deemed as promising alternatives. However, these technologies require an extensive space (>2.0 m^2/PE) and cannot perform denitrification. Recent innovations aim to enhance VFCWs efficiency. The present study compares the performance of traditional French VFCW and three novel designs for municipal wastewater treatment and sludge management of small populations.

MATERIALS AND METHODS

French and novel VFCWs designs, consisting of a) unsaturated-saturated, b) forced bed aeration unsaturated-saturated, and c) bioelectroconductive forced bed aeration unsaturated-saturated, were operated using raw municipal wastewater as inflow feed. Hydraulic loading rate was set at 0,3 $m^3/m^2/d$ for all pilots. Parameters set for biweekly monitoring included frequent contaminants in wastewater like total suspended solids (TSS), chemical oxygen demand (COD), total inorganic nitrogen (TIN) and total phosphorous (TP).

RESULTS AND DISCUSSION

Results for TSS, COD, TIN, and TP concentration in the influent and effluent of French and novel pilots are shown below. All configurations presented below permissible values for COD and TSS in their effluents. Changes in TIN effluent concentration was observed in French pilots, likely related to a lack of denitrification anoxic processes. On the contrary, novel pilot configurations showed a constant TIN concentration in the effluent. Further testing of the VFCW pilots is needed to provide conclusive remarks.



BIO of Presenter:

Enrique Romero-Frasca works as a Researcher at FCC Aqualia Department of Innovation and Technology. He holds a Ph.D. in Environmental Engineering and has 5+ years of experience working with microalgae-based treatment technologies. Enrique currently manages H2020 NICE project in Aqualia to promote NbS in the Spanish water utility sector.

REFLECTIONS ON A DECADE OF IN-STREAM TREATMENT WETLAND RESEARCH TO REDUCE AGRICULTURAL DIFFUSE POLLUTION: SUCCESSES, CHALLENGES, AND LESSONS LEARNED

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Free surface water treatment wetlands are effective measures for reducing agricultural diffuse pollution. Depending on catchment size, hydrology, and nutrient loading, these systems are designed either as in-stream or off-stream wetlands. In off-stream wetlands, only a portion of ditch water is diverted into the treatment area, while in-stream wetlands receive the full flow, making them more vulnerable to sudden flood events. This increases design challenges, as undersized systems may fail to treat water efficiently. Due to their more complex hydrological dynamics, in-stream wetlands are less commonly constructed and studied than their off-stream counterparts. Here, we present a decade-long dataset from the Vända in-stream treatment wetland system, located in southern Estonia, established to mitigate agricultural diffuse pollution. The system comprises two sequential free-water surface wetlands, both densely vegetated with emergent macrophytes such as *Phragmites australis* and *Typha latifolia*. Over the years, we have extensively investigated the Vända system's performance, examining water treatment efficiency, greenhouse gas emissions, biodiversity, vegetation development, and more recently, the reuse potential of nutrient-rich sediments. The wetland exhibited strong seasonal and interannual variability in both water treatment efficiency and greenhouse gas emissions. As vegetation matured, nutrient removal efficiency improved substantially and remained high even after 10 years of operation. Peak retention rates reached up to 11.3 kg/ha/d for total nitrogen, 0.64 kg/ha/d for total phosphorus, and 17.05 kg/ha/d for total organic carbon. However, long-term biogeochemical monitoring also revealed increasing methane emissions, particularly during low-flow, warm-season periods that promote reducing conditions. Nitrous oxide emissions were closely linked to water level fluctuations, highlighting trade-offs between pollutant removal and climate mitigation. Greenhouse gas hotspot and hot moment analyses revealed spatial heterogeneity in methane and nitrous oxide fluxes, indicating that targeted interventions, such as improved flow control, periodic sediment removal, and vegetation harvesting can help mitigate emissions without compromising treatment performance. Beyond water quality enhancement, the wetlands also supported amphibian colonization by offering suitable breeding habitats, unlike nearby sedimentation or farm ponds. This work demonstrates that while in-stream wetlands face challenges due to variable flow and nutrient inputs, they provide valuable ecosystem services. Optimizing their long-term performance requires adaptive management, regular maintenance, and integrated planning to balance water quality goals, biodiversity conservation, and climate mitigation

BIO of Presenter:
Kuno Kasak is a professor in environmental technology at the University of Tartu. His main research interest is related to wetland biogeochemical studies involving their water treatment efficiency, greenhouse gas emissions and biodiversity.

WETLANDS FOR DROUGHT RESILIENCE: DEMONSTRATING COST-EFFECTIVE NATURE-BASED SOLUTIONS ACROSS EUROPE

NBS4Drought Consortium (presenter: Shubiao Wu, Coordinator) [1*]
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As droughts intensify across Europe due to climate change, wetlands are increasingly recognized as critical infrastructures for climate adaptation. The NBS4Drought project addresses this challenge by designing, implementing, and evaluating wetland-based Nature-Based Solutions (NBS) that enhance drought resilience through improved water retention, water quality, ecosystem function, and community engagement.

Spanning seven demonstration sites across Europe—including urban parks, peri-urban treatment systems, rewetting of organic soils, and riparian restorations—the project tests diverse wetland typologies under real-world drought conditions. These interventions are co-designed with local stakeholders and evaluated using an interdisciplinary framework that captures both ecological and socio-economic dimensions. Each site is assessed through detailed hydrological and water quality monitoring, including analysis of nutrients, emerging contaminants, and microplastics. Greenhouse gas fluxes and biodiversity indicators are tracked to evaluate broader ecosystem function, while carbon sequestration potential is measured through soil and biomass sampling. Life cycle assessment and socio-economic evaluation further provide insight into the overall environmental footprint and cost-effectiveness of each intervention. Public perception and community engagement are continuously assessed through citizen science initiatives and real-time digital surveys.

A key innovation of the project lies in its use of a neurosymbolic AI-driven expert system and a Decision Support System (DSS), which integrate data from ongoing monitoring, stakeholder input, and past case studies to provide tailored, transparent recommendations for site-specific NBS design and replication. This technological backbone enables users—from municipalities to practitioners—to make informed decisions grounded in scientific evidence and practical experience.

The project is led by a strong consortium of 24 partners from 10 countries, uniting universities, research institutes, SMEs, public authorities, NGOs, and international organizations. This transdisciplinary structure ensures that ecological design is matched with governance insight, financial viability, and long-term social acceptance. By combining scientific innovation with participatory design and robust evaluation, NBS4Drought delivers actionable pathways for mainstreaming wetlands as multifunctional solutions to drought across Europe. This presentation will highlight early outcomes from the showcases and explore how data-driven, stakeholder-led wetland interventions can contribute to a more resilient and sustainable water future.

BIO of Presenter:
Dr. Shubiao Wu is an Associate Professor at Aarhus University's Department of Agroecology, specializing in wetland biogeochemistry and nature-based solutions for environmental challenges. His research focuses on nutrient and carbon cycling in wetlands, exploring new pathways of greenhouse gas emissions and mitigation strategies. Dr. Wu has coordinated several international projects, including Horizon Europe initiatives, exemplifying his commitment to advancing wetlands research through interdisciplinary cooperation and strategic international partnerships !

NOVEL RECYCLING MATERIALS FROM PAPER ASH AND CONSTRUCTION WASTE FOR FURTHER PHOSPHORUS REMOVAL IN POLISHING VERTICAL FLOW CONSTRUCTED WETLANDS AT HIGH HYDRAULIC LOADING RATES

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Even though wastewater treatment plants (WWTP) already eliminate large amounts of phosphorus (P), there are some water bodies that still need further protection. Constructed wetlands (CW) as a nature-based solution can be equipped with special materials for advanced phosphorus removal from secondary effluent. In order to conserve resources, alternative ways should be found to generate safe filter materials for this purpose, which are also available worldwide in similar quality. In this project, a novel porous material produced in a hydrothermal process from masonry rubble and paper ash (HTG - hydrothermal granulates) is compared to crushed concrete sand (CCS). Because of their high alkalinity, both materials need to be mixed with a basic material. In Germany, there has been very good experience with lava sand for CW, but lava sand resources are also limited and not available everywhere. Therefore, in this work besides lava sand, also quartz sand was compared as a basic material. This work investigates whether the material mixtures can be used to achieve very low phosphate concentrations. Also, it is explored, if the choice of the basic material has an effect on the performance, and whether the feed rate can be increased to build smaller filters without significantly affecting the purification objective.

In the experimental set-up, four half-technical vertical flow CW columns with a diameter of 29 cm and a filter layer height of 60 cm were operated in an indoor facility. Column 1 contained 80 wt% lava sand (0.3–2 mm) and 20 wt% HTG (0.5–2 mm), while column 2 was filled with 80 wt% quartz sand (0.2–2 mm) and 20 wt% HTG (0.5–2 mm). Column 3 combined 80 wt% lava sand (0.3–2 mm) with 20 wt% CCS (0.5–2 mm), and column 4 used 80 wt% quartz sand (0.3–2 mm) and 20 wt% CCS. To include the complex water matrix, the effluent of a local WWTP was used as an inflow to the columns. The column influent was augmented with phosphate to achieve a concentration of 1.5 mg/L PO_4-P, thus establishing a more realistic use case and enabling the facilitation of elimination analytics. From day 1 to day 43, the system was fed with 300 L/m²/d with four flush feed intervals. The hydraulic loading rate (HLR) was raised to 600 L/m²/d and eight flushes per day from day 44 on.

After a short start-up period, the effluent values of all columns fell below 0.06 mg/L PO_4-P and elimination rates exceeded 95 %. The pH values of the column effluents were 9.4, 10.2, 10.8 and 11.6 for column 1, 2, 3, and 4 respectively, and would therefore be too high to discharge directly into a sensitive water body. The HTG shows lower pH values than the CCS, while also the lavasand balances the pH. In pretests with small laboratory colums (diameter 5.4 cm, filter height 45 cm), the pH was about one pH step lower, probably due to less contact time and less dissolution of OH^- ions, emphasizing the importance of filter height and contact time.

From day 44 to day 73, HLR was increased to 600 L/m²/d with eight flush feed intervals per day. Concentrations of PO_4-P increased until day 73, at which point they reached 0.30, 0.16, 0.17 and 0.51 mg/L, for column 1, 2, 3, and 4 respectively, although the phosphate loading capacity of HTG and CCS should not have been exhausted. On day 73, the pH had dropped to 9.2, 9.4, 9.7 and 9.7 in the four columns, indicating that the leaching effect may be coming to an end or that the high HLR is reducing the dissolution effect. The next step will be to reduce the HLR back to 300 L/m²/d, to see if the effluent concentrations and pH of the columns return to previous levels.

Oral presentation preferred.

BIO of Presenter:

Verena Hilgenfeldt is a research associate at the department "Resource-Efficient Wastewater Technology" at RPTU University of Kaiserslautern-Landau since 2020. She holds degrees in Chemical Engineering and Water Science and Engineering from Karlsruhe Institute of Technology. Her research focuses on integrating innovative solutions into existing infrastructure and sustainable water management.

PREDICTION OF THE REMOVAL EFFICIENCY OF EMERGING ORGANIC CONTAMINANTS BASED ON THE REMOVAL EFFICIENCY OF CONVENTIONAL WATER QUALITY PARAMETERS IN CONSTRUCTED WETLANDS

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Abstract

This study investigates the prediction of the removal efficiency of pharmaceuticals (PhCs), personal care products (PCPs) and steroidal hormones (SHs) based on the removal efficiency of conventional water quality parameters (CWQPs) including total suspended solids (TSS), chemical oxygen demand (COD), ammonium-nitrogen NH4N) and total phosphorus (TP) in horizontal subsurface flow constructed wetlands (HFCWs). Previous research demonstrated a correlation between CWQPs and emerging organic contaminants (EOCs) removal in CWs, notably between NH4N and TSS with biodegradable EOCs and those removed by sorption processes, respectively; however, the lack of predictive modelling underscores the need for comprehensive statistical analysis to improve process understanding and EOCs management in CWs. Therefore, predictive models are formed based on statistical analysis underpinned by principal component, correlation and multiple linear regression analyses of a global data set compiled from peer-reviewed publications. In the calibration process, various combinations of dependent variables were used to formulate multiple linear regression equations. For example, removal efficiency was estimated using TSS and COD in one model. Then, other variables (e.g. NH4N and TP) were added into the model. The resulting regressions models were validated on an independent data (test set). The selection of acceptable/best performing models was based on root mean square error (RMSE) (< 25%), relative root mean squared error (RRMSE) (< 0.3), Theil's inequality coefficient (U) (< 0.3) and the number of predictants in the equation (the lower the better). The results indicate that the CWQPs are good predictors of the removal efficiency of the examined EOCs. COD and NH4N are the most significant predicators followed by TSS and TP.

The best predictive model for PhCs was composed of COD and NH4N (RMSE: training set: 16%; test set: 18%; RRMSE: training set: 0.25; test set: 0.27; U: training set: 0.25; test set: 0.26). Similarly, a combination of COD and NH4N formed a credible model for predicting the removal efficiency of SHs (RMSE: training set: 11%; test set: 9.0%; RRMSE: training set: 0.17; test set: 0.18; U: training set: 0.17; test set: 0.18). In the case of PCPs, the best performing model was composed of TSS, COD and NH4N (RMSE: training set: 2.0%; test set: 13%; RRMSE: training set: 0.03; test set: 0.20; U: training set: 0.03; test set: 0.20). Similarly, generic models by combining data of PhCs and PCPs, PhCs and SHs, PCPs and SHs, and PhCs, PCPs and SHs showed acceptable performance. The best performing combined model for the prediction of PhCs, PCPs and SHs was based on COD and NH4N (RMSE: training set: 14%; test set: 15%; RRMSE: training set: 0.23; test set: 0.23; U: training set: 0.22; test set: 0.22). Additionally, a novel decision support tool, named REOCW-CWQP, was developed to readily estimate the removal efficiency of EOCs based on the removal efficiency of CWQPs, and facilitate the decision-making process. The information obtained by using these models may guide researchers, practitioners, policy makers and citizens in enhancing knowledge and understanding on removal processes of EOCs and for the design of HFCWs in the field conditions suitable for the removal of both CWQPs and EOCs.

BIO of Presenter:
Dr. Huma Ilyas is a postdoctoral assistant at LIWET – Laboratory of Industrial Water and Ecotechnology, Department of Green Chemistry and Technology, Ghent University Campus Kortrijk, Belgium. Her research focus is to develop novel models of constructed wetlands for simulation of emerging organic contaminants using process-based and data driven modelling approaches.

QUANTIFYING TREATMENT SYSTEM RESILIENCE TO SHOCK LOADINGS IN PARTIALLY SATURATED VERTICAL FLOW CONSTRUCTED WETLANDS

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Abstract (Proposed Oral Presentation for WETPOL 2025)

Partially Saturated Vertical Flow (PSVF) constructed wetlands are a novel adaptation of traditional vertical flow (VF) systems, designed to enhance nitrogen removal without increasing physical footprint or energy inputs. They consist of single-stage filters (~900 mm deep) operated continuously with only brief resting intervals between influent loadings. A key differentiation in our PSVF wetlands is the inclusion of a saturated bottom layer containing pine woodchips, which acts as a solid carbon source to promote denitrification. Coarse media such as gravel and zeolite are used to reduce clogging risk, distinguishing these systems from sand-based VF wetlands.

Baseline performance of PSVF wetlands has been previously published (Singh et al., 2024) and presented at ICWS 2024 in Martinique, where the presentation was well received. For WETPOL 2025, we propose an oral presentation that builds on this earlier work by evaluating the resilience of PSVF wetlands under real-world disturbance scenarios. Specifically, we aim to quantify system performance before, during and after:

1. Shock hydraulic loading (5 × normal hydraulic loading rate for 5 days)
2. Low usage or dormancy (no influent for up to 4 weeks)
3. Operational failures (e.g., pump or power failures while wastewater continues to flow in)

Each disturbance event will be preceded by baseline monitoring, with continued sampling throughout the disturbance and recovery phases. This work will contribute valuable insights into the operational robustness of PSVF wetlands under non-ideal conditions, informing both future design refinements and operational management strategies for decentralised wastewater treatment.

<u>BIO of Presenter</u>:

Sukhjit Pal Singh has been a process engineer for eight years. He has a passion to do better for the environment through his work in water and wastewater projects. He is currently working towards a PhD in environmental engineering focusing on developing robust partially saturated vertical flow wetland treatments for domestic wastewater.

<u>References:</u>

Singh, S. P., Tanner, C. C., Sukias, J. P. S., Lay, M. C., & Glasgow, G. D. E. (2024). Multilayer partially saturated vertical flow wetlands for advanced small community wastewater treatment. *Ecological Engineering*, *209*(107390), 107390.

REMOVAL OF NITROGEN COMPOUNDS AND GREENHOUSE GASES MITIGATION IN REAL-SCALE MICROBIAL ELECTROCHEMICAL-BASED TREATMENT WETLANDS (METLAND)

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Given the different microbial and biogeochemical processes involved in the removal of pollutants, treatment wetlands (TWs) have the potential of being a source of Green House Gases (GHGs), particularly when operating under anaerobic conditions typical of saturated systems. TWs seem to have less environmental impact, in terms of resource consumption and GHG emissions, compared to conventional wastewater treatment. Although TWs have a larger environmental footprint than conventional treatment systems in terms of land use, and their GHGs output remain significant due to the high global warming potential of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Yin et al., 2023). These emissions are strongly influenced by the system's design and operational conditions. Some of the latest improvements of TW technology includes their combination with Microbial Electrochemical Technologies (METs) based on the metabolism of Electroactive Bacteria (EAB). These bacteria can transfer electrons to electro-conductive materials, that act as unlimited electron acceptors.

The integration of METs into TW has led to the development of METland technology, which shows potential sustainable and efficient wastewater treatment (Peñacoba-Antona et al., 2021; Ramírez-Vargas et al., 2018). This potential is attributed to the use of electroconductive carbon-based materials that stimulate EAB activity and promote efficient extracellular electron transfer (Prado De Nicolás et al., 2022). This capacity can maximize substrate consumption, limiting electrons availability for methane generation and biomass build-up. However, several processes in METland systems, such as the improvement of nitrogen removal and their environmental GHGs emissions, are still under study to improve their performance and design. Therefore, the objective of this study was to assess nitrogen removal (total nitrogen, NH_4^+ N, and NO_3^--N) and greenhouse gas emissions (CH_4, CO_2, and N_2O) from real-scale METland system. The system, constructed in 2018 from over 200 population equivalents (PE), consist of two electroconductive beds each (40 m^2 each) operating year-round under identical loading but with different saturation conditions. The study demonstrated that real-scale METland systems consistently achieved removal efficiencies exceeding 90% for BOD_5 and COD, over 50% for NH_4^+-N, and up to 90% for NO_3^--N. Regarding GHG emissions, CH_4 fluxes ranged from 0.48 to 17.6 mg m^{-2} ha^{-1} during the summer–autumn period, and from 14.4 to 23.3 mg m^{-2} ha^{-1} in the winter–spring season. These findings underscore the potential of METlands as robust, low-carbon, decentralized wastewater treatment solutions, capable of delivering high levels of organic matter removal, nitrogen reduction and substantial mitigation of GHG emissions.

References

Peñacoba-Antona, L., Senán-Salinas, J., Aguirre-Sierra, A., Letón, P., Salas, J.J., García-Calvo, E., Esteve-Núñez, A., 2021. Assessing METland® Design and Performance Through LCA: Techno-Environmental Study With Multifunctional Unit Perspective. Front. Microbiol. 12, 652173. https://doi.org/10.3389/fmicb.2021.652173

Prado De Nicolás, A., Berenguer, R., Esteve-Núñez, A., 2022. Evaluating bioelectrochemically-assisted constructed wetland (METland®) for treating wastewater: Analysis of materials, performance and electroactive communities. Chem. Eng. J. 440, 135748. https://doi.org/10.1016/j.cej.2022.135748

Ramírez-Vargas, C.A., Prado, A., Arias, C.A., Carvalho, P.N., Esteve-Núñez, A., Brix, H., 2018. Microbial Electrochemical Technologies for Wastewater Treatment: Principles and Evolution from Microbial Fuel Cells to Bioelectrochemical-Based Constructed Wetlands. Water 10, 1128. https://doi.org/10.3390/w10091128

Yin, Xiaoxue, Jiang, C., Xu, S., Yu, X., Yin, Xiaolin, Wang, J., Maihaiti, M., Wang, C., Zheng, X., Zhuang, X., 2023. Greenhouse Gases Emissions of Constructed Wetlands: Mechanisms and Affecting Factors. Water 15, 2871. https://doi.org/10.3390/w15162871

BIO of Presenter:
I am an Industrial Ph.D. candidate funded by the Government of Madrid's fellowship program, affiliated with Universidad de Alcalá and METfilter S.L. My research focuses on optimizing bioelectrochemical wetlands (METland) for sustainable wastewater treatment and exploring their potential reuse in agriculture.

DEVELOPMENT OF A SUROGATE MODEL TO IMPOOVE THE DESING OF VF WETLANDS

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The presented study aimed to achieve two objectives: (1) to assess the impact of key design and operational parameters of VF wetlands on the removal of COD and NH_4-N from domestic wastewater; and (2) to develop a predictive model to aid in the design of VF wetlands. The parameters considered were substrate depth, openings per m2, organic loading rate, grain size, and loading interval, under various water temperatures (5 to 20°C). To generate effluent concentrations for all scenarios, we used the HYDRUS Wetland Module CWM2D. For VF wetlands, the model has been calibrated in previous studies for different substrate grain size distribution and for both water flow and pollutant transport and degradation. In total 1224 numerical experiments were carried out using the parameters shown in Figure 1. The results provide insights in of the importance of design parameters. For instance, the temperature and the openings per m² as well as the grain size influence the treatment performance.

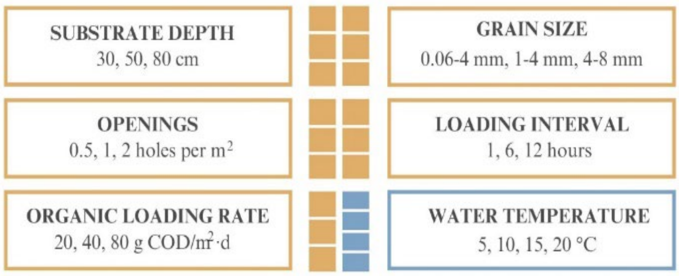

Figure 1: Parameters for the numerical experiments

The results of the models are further used to train and validate different machine learning algorithms using linear, polynomial, and symbolic regression, XGBoost, and support vector regression. We discussed the results comparing the performance of the regression models, i.e. how well they fit the results of the numerical experiments, versus their complexity, i.e. is the model a second-degree polynomial or a complex combination of hundreds of weighted trees. Model complexity can be seen as the opposite to interoperability which is a desired feature for a design model. For instance, despite the tree-based algorithm XGBoost achieve the best performance, its lack of interpretability will make it a less desirable model for design than a polynomial regression. Symbolic regression proved to be a promising approach as it enables to search relationship beyond polynomial models however it presents a large computational cost and some expertise to select the best model. To test the surrogate models on real data a database from literature of VF wetlands is compiled. The testing is ongoing and will be presented.

BIO of Presenter:
Dr. Bernhard Pucher holds a tenure track position in water supply at BOKU University. His field of research includes the investigation of nature-based solutions for water pollution control and urban water management including water reuse. Another research focus is modeling water flow and solute transport in porous media.

OPTIMIZING CONSTRUCTED WETLANDS FOR NUTRIENT REMOVAL FROM SECONDARY EFFLUENT

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Artificial eutrophication, triggered by phosphorus (P) and nitrogen (N), remains a major environmental issue. This process leads to consequences in aquatic ecosystems, such as loss of biodiversity, reduced dissolved oxygen levels, cyanobacteria blooms, and decreased in water quality. Tertiary treatment of domestic sewage using technologies that reduce energy consumption and costs becomes essential for aquatic ecosystems. Constructed wetlands (CWs) are efficient, low-cost and sustainable systems. They simulate natural wetlands by using macrophytes, natural materials, and microbial communities in the system, to reduce pollutants such as nutrients. While the main focus of CW is the treatment of raw or primary effluents, there is an increasing interest for this technology as polishing systems targeting nutrients. This study aims to evaluate the efficiency of various subsurface CWs in the removal of nutrients from treated municipal wastewater comparing the vertical and horizontal subsurface flow.

About 6 pilot scale CWs units are installed at the Wastewater Treatment Plant (WWTP) of Chania in Crete, Greece; 3 with vertical (VF) and 3 with horizontal subsurface flow (HF). The HFCW units H1 (planted) and H2 (unplanted) as well as the VFCW units V1 (planted) and V2 (unplanted) contain gravel, zeolite, and water treatment alum-sludge as substrate. The planted HFCW unit H3 and the VFCW unit V3 contain alum-sludge biochar as an additional substrate. The substrate height in the HFCW units is 35 cm and in the VFCW 70 cm. Four plants of *Typha latifolia* and one of *Phragmites australis* were placed in the HFCWs and three plants of *T. latifolia* and one of *P. australis* in the VFCW. All units have a passive aeration system through perforated polyvinyl chloride pipes.

The CWs acclimatization started in December 2024. The units were fed three times daily with treated wastewater from the WWTP. The HFCW units are fed with 36.8 L/day and the VFCW with 38.8 L/day. The hydraulic loading rate in the HFCW and VFCW units is 0.096 L/day and 0.197 L/day, respectively. After one month of acclimatization, regular samples collection takes place from all units' effluents as well as the influent treated effluent. Samples are analyzed immediately at the Laboratory of Environmental Engineering and Management to determine pH, electrical conductivity, total suspended solids (TSS), dissolved organic carbon, total nitrogen (TN), ammonium nitrogen (NH_4-N), nitrate (NO_3^-), total phosphorus (TP) and phosphate (PO_4^{3-}).

In the first 4 months of operation, the planted units achieved average removal of TN ranged from 68 to 84%, of NH_4-N from 82 to 87%, and of TP and PO_4^{3-} from 84 to 87%, respectively. This study will show the overall results over an extended operational period under varying loading rates.

<u>BIO of Presenter</u>:

Marcio Yukihiro Kohatsu is a third-year PhD candidate in the Postgraduate Program in Hydraulic and Sanitation Engineering at the São Carlos School of Engineering, São Paulo University, Brazil. As part of his PhD, he is undertaking a one-year research project at the Technical University of Crete in Greece, focusing on constructed wetlands for tertiary treatment of domestic wastewater.

INFLUENCE OF EXTERNAL RESISTANCE ON MICROBIAL VARIETY OF ELECTROCHEMICALLY ASSISTED CONSTRUCTED WETLANDS

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Constructed wetlands are influenced by several factors including microbial diversity, which is a key component in the removal of various pollutants. The implementation of an electrochemical cell in a wetland could alter the bioelectrochemical conditions of its internal environment, which could influence the microbial diversity present. The objective of this work was to test a set of six electrochemically assisted constructed wetlands (EACW) under different external resistance values to evaluate the influence of resistance on wetland dynamics. With this aim, six laboratory-scale upflow EACWs were installed (5 L), each connected to different value of external resistance (0.1, 1, 5, 10, 20 kΩ and open circuit). The plant species *Phragmites australis* and synthetic wastewater were employed by coupling the components of a microbial fuel cell (carbon felt as electrodes, stainless steel plate as current collector, synthetic non-woven fabric as separator). Voltage, power and current density were recorded for 203 days. Analysis for chemical oxygen demand, NO_3^-, NO_2^-, NH_4^+, SO_4^{2-}, and microbiological tests were carried out in order to evaluate the influence of electrical resistance on the system, and on the electrical performance. Based on the results it was demonstrated that different values of external resistance significantly affect power and current density, organic matter, nitrogen and sulfur species (NO_3^-, NO_2^-, SO_4^{2-}). There was a nitrogen removal of 80 % for nitrates and 41 % for ammonium nitrogen in EACWs, this could be attributed to the nitrification and denitrification processes. The maximum power density (49.8 mW/m^2) was obtained in the EACW with an external resistance of 0.1 kΩ, nevertheless, the system with the highest growth of Geobacter (electrogenic bacteria) was the EACW connected to a 10 kΩ resistance, which presented similar results in power production. According to the metabarcoding analysis performed, it was determined that the microbial communities were influenced by the value of the external resistance, it was observed that the reactor connected to the 10 kΩ resistance presented the highest relative abundance of electrogenic microorganisms, but this system contained the highest relative abundance of microorganisms competing for electron donors as methanogenics. Finally, the presence of methanogenic and other species could help establish a better understanding of the processes in these systems and could lead to modifying their configuration to obtain higher pollutants removal.

<u>BIO of Presenter</u>:

Research in water purification and constructed wetlands for water treatment and power generation by means of bioelectrochemical systems. Publication of scientific articles, book chapters and scientific dissemination. Thesis director. Participation in national and international scientific events, coordinator of the Latin-American ISMET webinars. Director of two water purification plants at UNAM, proposing projects about rainwater harvesting.

HOW SMALL IS BIG ENOUGH? BIG DATA-DRIVEN MACHINE LEARNING PREDICTIONS FOR TREATMENT WETLAND PERFORMANCES

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Nature-based solutions (NbS) employ natural processes to address environmental challenges and are increasingly valued for their sustainability and ecological benefits. However, their implementation also presents practical and analytical challenges. Machine learning (ML), a form of artificial intelligence (AI), is widely used in environmental research to support data prediction and analysis. A key challenge in achieving accurate ML predictions is the requirement for large datasets. This study aims to quantitatively examine the challenges of applying NbS for wastewater treatment and assess the feasibility of ML tools in supporting related data analysis.

Supervised ML models assessed in this study include neural networks (NN), gradient boosting, support vector machines (SVM), linear regression (LR), and tree-based models. NN models were applied in 11 studies to predict treatment performances of chemical micropollutants, organics, nutrients, and greenhouse gases emissions in TWs. Gradient boosting methods were used in 2 studies to predict GHG emissions, while 8 studies applied SVM for predicting hydraulic performance, water quality indices, and the removal or concentration of organics and nutrients. Tree-based models were also used in 8 studies to estimate TW performance and removal of pollutants. Regression models were applied in 8 studies for estimating pollutant removals, as well as for designing filter media in TWs.

The R^2 metric offers clearer and more interpretable insights compared to error-based metrics such as MSE, RMSE, and MAE, and is recommended as a standard for evaluating regression model performance. Most datasets used in TW-related studies comprised fewer than 1,000 data points, and results showed inconsistent relationships between dataset size and model performance (particularly R^2). Some studies with small datasets achieved high R^2 values, whereas others with larger datasets performed poorly contradicting the common assumption that model accuracy improves with increasing dataset size. However, normalised error metrics such as NRMSE, NMAE, and NMSE generally decreased with larger datasets, indicating improved accuracy and partially supporting the hypothesis.

The performance of ML models in TW applications is strongly influenced by both the size and quality of the datasets used. Small or inconsistent datasets limit reliability, highlighting the need for larger, high-quality datasets to accurately model complex biological processes. A key limitation of this study is that most existing studies employed datasets that were too small to robustly validate ML performance. The demonstrated success of ML in other fields using datasets exceeding 500,000 records suggests significant potential for advancing TW modelling if similar data volumes can be achieved. In addition to dataset size, data quality must be considered. Standardising TW monitoring methods would support the generation of high-quality data and enhance the effectiveness of ML approaches.

BIO of Presenter:
Dr Tao Lyu is a Senior Lecturer in Green Technologies and the Environmental Engineering MSc course director at Cranfield University. He received his PhD from Aarhus University in 2016, and his research focuses on the innovation and implementation of treatment wetlands for micropollutants removal.

KEY CLOGGING FACTORS IN CONSTRUCTED WETLANDS AND THEIR FORMATION MECHANISMS

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Half of constructed wetlands (CWs) will become clogged within 5 to 10 years, resulting in hydraulic failure, reduced treatment performance and a much shorter service life[1,2]. Vymazal et al.[3] concluded that with proper design, CWs can be operated for more than 20 years with stable treatment efficiency.

In this study, we first designed five types of horizontal CW devices (Fig. 1a): rectangular, trapezoidal, inverted trapezoidal, central radial flow and peripheral radial flow. Using the dye tracer method combined with image processing, the inverted trapezoidal device showed the best hydraulic performance. Secondly, we designed four vertical CW devices (Fig. 1b): rectangular, triangular, cylindrical and inclined cylindrical, and no significant difference in permeability coefficient (Ks) was observed. Thirdly, based on the previous results, mesocosm experiment was designed (Fig. 1c) with the addition of a kidney-shaped CW with multi-stage folding baffles. The results of the study showed that (1) the infiltration performance is optimal for the trapezoidal and lowest for the rectangular type; (2) the peripheral radial flow and kidney-shaped type have the highest pollutant removal capacity and treatment capacity for COD, TN, TP and TSS.

In order to study the bioclogging components and their formation mechanisms in detail, we studied a 5-year and a 12-year CW (Fig. 1d). We investigated the degree of clogging using a self-improved falling head test method, the composition of polysaccharides, proteins, DNA and humic acids in EPS, the microbial diversity and its metabolites, by spatio-temporal sampling, which will be developed in detail in the presentation.

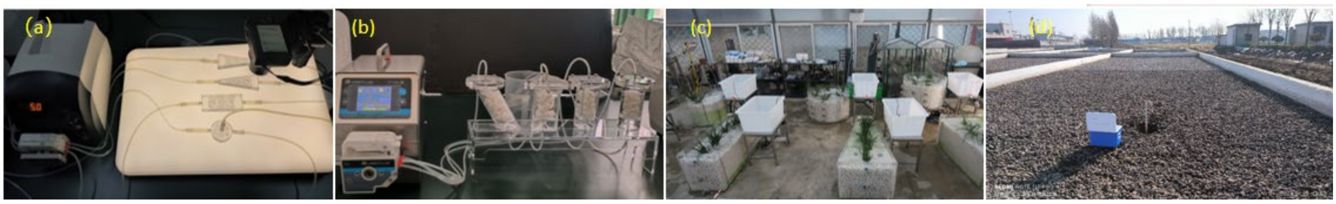

Fig. 1 (a)Microcosm: in-house horizontal constructed wetlands; (b)Microcosm: in-house vertical constructed wetlands; (c)Mesocosm experiment: in-house constructed wetlands; (d)Field experiment: in a five-year-old constructed wetland.

References:

[1]Cooper D, Griffin P, Cooper PF. Factors affecting the longevity of sub-surface horizontal flow systems operating as tertiary treatment for sewage effluent. In: Vymazal J, Wastewater treatment, plant dynamics and management in constructed and natural wetlands. Backhuys Publishers, Leiden, The Netherlands, 2008: 191-198.

[2] Dotro G, Chazarenc F. Solids accumulation and clogging. Sustainable Sanitation Practice Journal, 2014, 18: 8-14.

[3] Vymazal J. Is removal of organics and suspended solids in horizontal sub-surface flow constructed wetlands sustainable for twenty and more years?. Chemical Engineering Journal, 2019, 378: 122117.

BIO of Presenter:
Dr. Jing Zhang received her PhD from the Université Paris-Saclay in 2020 and is an Associate Professor at CRAES. She has published more than twenty high-level scientific papers. She has focused on the field of solutions for sustainable operation of constructed wetlands, microbes and their functions in constructed wetlands.

MICROBIAL COMMUNITY IN MICROBIAL ELECTROCHEMICAL TECHNOLOGY CONSTRUCTED WETLANDS AND THE INFLUENCE OF CARRIER MATERIAL

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Microbial electrochemical-based constructed wetlands (CW) are engineered systems (referred to as METlands®) that use microbial fuel cell (MFC) principles, aiming at improving treatment efficiency. In METlands, electroconductive materials are used as wetland media instead of, e.g., gravel. The media acts as the connection between anoxic zones (anode, lower oxidation-reduction potential (ORP)) and oxic zones (cathode, higher ORP). By using electroconductive media, the CW becomes a short-circuited (no resistors between electrodes) MFC. Published reports advocate that these systems can enhance organic biodegradation rates and reduce clogging issues of conventional CW. However, despite studies so far reporting that METlands have the potential to outperform conventional CW, further research is still needed for the development of technology.

This study focuses on the characterization of electroconductive (EC) materials and associated microbial processes in METland® systems designed for wastewater treatment. Triplicate vertical up-flow columns (diameter: 10 cm; height: 60 cm) were used to test three types of EC biochar (olive pit, wood chip, and wood pellet), coke, and gravel (as a reference medium). All systems were fed with primary-treated municipal wastewater (~0.75 L/day). Material characterization was performed using scanning electron microscopy (SEM), X-ray diffraction (XRD), and cell voltammetry to evaluate surface morphology, crystallographic structure, and electrochemical behavior. Microbial community analysis in the developed biofilms was conducted via DNA isolation, 16S rRNA gene amplicon sequencing, and metagenomic analysis. To assess spatial organization and metabolic activity within biofilms, fluorescence in situ hybridization with bioorthogonal non-canonical amino acid tagging (FISH-BONCAT) was applied. Additionally, DNA extractions and sequencing combined with fluorescence-activated cell sorting (FACS) was used to target active microbial populations, distinguishing them from inactive or dead cells often captured in bulk DNA extractions.

The results showed that EC materials (biochar and coke) had greater removal of organics and nutrients compared to gravel. E.g., biochar columns achieved the highest COD removals (81-83%), followed by coke (79.6%) and gravel (69.7%). The overall relative abundance of EAB bacteria remained low across all biofilm samples (all columns at different depths), but it was the most abundant in samples extracted from the best-performing biochar materials (i.e., the woodchip-based biochar). The presentation will include results from full-sample DNA extractions (dead and alive cells), providing insights into the total microbial community present in the biofilms. Comparative scanning electron microscopy (SEM) analyses of clean and used materials will be shown to illustrate biofilm development. Additionally, material characterization data from the pilot system, including X-ray photoelectron spectroscopy (XPS), comparing used and clean materials, will be presented. Further microbial analysis is currently underway using FACS and FISH-BONCAT to investigate the spatial distribution and metabolic activity of biofilm-associated bacteria.

BIO of Presenter:
Laura Tarvainen is a Ph.D. student at the University of Oulu in the Water Energy and Environmental Engineering unit. Started in the year 2023 and is working with nature-based solutions in wastewater treatment.

PHOSPHORUS ADSORPTION MODELLING IN A TIDAL-FLOW TREATMENT WETLAND

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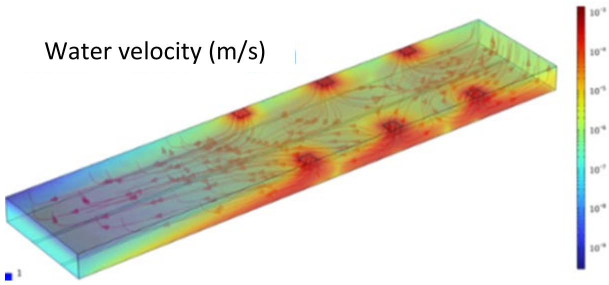
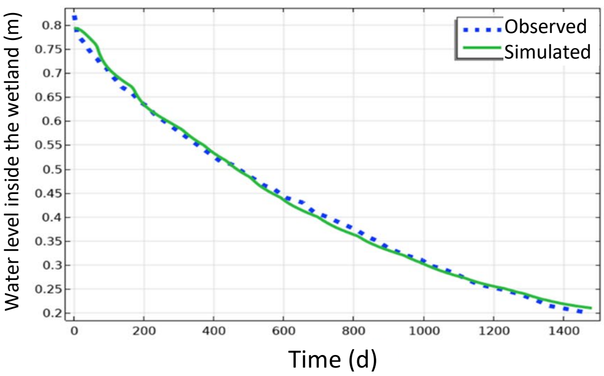
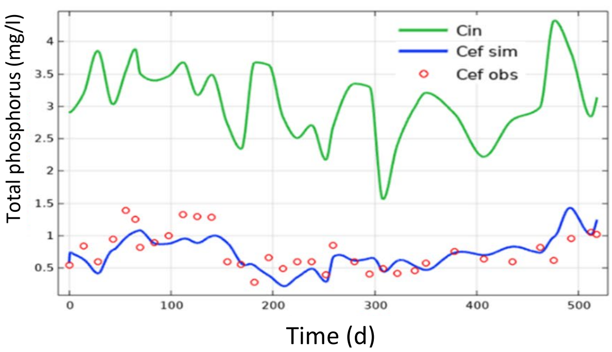
Phosphorus removal by plants in treatment wetlands (TW) is not always sufficient when the treated wastewater is discharged to eutrophication-sensitive water bodies. This process can be enhanced by dosing natural or chemical coagulants or using adsorbent materials as filtering media. Drinking water treatment sludge (DWTS) has been demonstrated to have a high phosphorus sorption capacity.
Thanks to LIFE Renaturwat project, a tidal-flow TW was constructed in Los Monasterios wastewater treatment plant (WWTP). This wetland has a surface area of 60 m^2 and a total depth of 1.20 m, with a layer of 0.8 m filled with DWTS. Several field and laboratory determinations were performed to obtain the hydraulic and quality models: water volume treated, phosphorus removal, fill and drain velocities by measuring the water level inside the TW, real and bulk density, porosity, saturated hydraulic conductivity, and the water retention curve to obtain the Van Genutchen parameters.
The phosphorus adsorption model was coupled to a 3D computacional fluid dymanics (CFD) model, using COMSOL Multiphysics. The hydrodynamic model was based in the Richards' equation, which gives water velocity and pressure in a non-saturated porous media, together with Van Genutchen water retention model. For phosphorus modelling, non-equilibrium kinetics was introduced in the module for the transport of diluted species in unsaturated porous media.
The results obtained indicate a good fitting of the model for both the hydrodynamic behavior and the phosphorus removal. Once calibrated the model can be used to simulate scenarios of different operation conditions, lifespan estimation, identify dead zones or design new TWs. These will be presented in the conference.







Acknowledgements: LIFE Renaturwat (LIFE19/ENV/ES) received funding from the LIFE Program of European Union.

BIO of Presenter:
Carmen Hernández-Crespo is researcher and professor in Polytechnic University of Valencia. Her research areas are focused on TWs for a variety of applications, Sustainable Urban Drainage Systems for stormwater management and biodiversity improvement, with emphasis in microplastics retention, and mathematical modelling.

MICROPLASTIC INTERFERENCE IN FUNCTIONS OF CONSTRUCTED WETLANDS

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Microplastics as an emerging pollutant have attracted greater scientific attention in recent decade. The size of these plastic particles are less than 5 mm. MPs could be produced for a purpose as personal care products or generated through wear and tear of large plastic particles. Wastewater is an important medium which carries microplastics up to the treatment systems. Constructed wetlands (CWs) have been used to treat tertiary wastewaters. CWs is a low-cost, low maintenance, and easy in operation wastewater treatment technology. CW utilises the microbial metabolism as its moving force during wastewater treatment. Presence of inert plastic particles in wastewater could interfere with microbial metabolism of CWs leading to impaired treatment efficiency. Microplastics may intercept in CWs due to its large substrate matrix profile. These microplastics may interact through its surface property and could support distinct microbial community composition and differed biological interaction. The effect of MPs on physicochemical properties, biofilm development, microbial diversity, and treatment performance of CWs is still unclear. It needs extensive research to establish the impact of MPs in CW systems. In this study we have assessed the MPs impact on nitrogen transformation, organics degradation, and other pollutant removal efficiency. Some work in the same line have been done to establish the effect of MPs presence in wastewater in CWs. In our study, we have fabricated three vertical flow lab-scale constructed wetland reactors using different substrate matrix. Garden gravel as control, graphite granules, and biochar (*Canna indica*) was used as substrate material. Synthetic wastewater was fed in all three reactors and operated in vertical flow direction (VFCW). Synthetic wastewater used in the study was adopted and modified from. Polyethylene terephthalate (PET) and high-density polyethylene (HDPE) microplastics were used in second phase of two-phase study. In our experiment soft drink bottles and their caps were used to produce 300-600 µm MPs fragments. These VFCW set-ups were incubated for 45 days and then chemical oxygen demand (COD), NH_4^+, NO_2^-, NO_3^-, PO_4^{3-} and SO_4^{2-}, volatile suspended solids (VSS) were analyzed of both phases. MPs have interfered with operating condition parameters like dissolved oxygen, oxidation-reduction potential. MPs have enhanced the COD removal. Whereas NH_4^+ and SO_4^{2-} removal was reduced in all the CW systems. MPs could interfere with ammonium oxidizing bacteria which decreases the ammonium oxidation. All three systems have shown the same pattern of decrease in ammonium removal. In contrast, no significant difference was visualized in NO_3^- removal. Detailed experiment is required to assess the effects of MPs size, functional groups, origin, distribution, physico-chemical interference, and long-term impact in CW systems.

BIO of Presenter:
Saurabh Dwivedi is a Ph. D. scholar at AcSIR and CSIR-Institute of Minerals and Materials Technology, India, and he is working on microplastics and other emerging pollutants of wastewater. He is in last stage of his Ph.D. and looking for a postdoctoral position.

INTENSIFIED MULTI-STAGE CONSTRUCTED WETLAND TO VALORISE ANAEROBIC DIGESTATE CENTRATE IN ANOXIC BIOGAS DESULPHURISATION

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Constructed Wetlands (CWs) represent an efficient eco-technological conglomerate interweaving water security, energy possibility and environmental protection. These natural treatment systems are a sustainable and viable option for the treatment of domestic and urban wastewater. However, further research on their application to more complex wastewater, such as anaerobic digestate centrate, is required to expand their application niche.

Herein, two independents multi-stage CWs, one filled with sand and gravel (as a blank) and other filled mainly with drinking water treatment sludge (DWTS) has been investigated to achieve simultaneous removal of ammonium (NH_4^+) and phosphorous (P) from centrate, to provide an alternative nitrified stream to be used as electron and nutrient source during anoxic biogas biodesulphurisation. Both systems were identical in terms of configuration and operation. Each one was composed by 3 stages connected in series. The first one consisted in three parallel "Tidal Flow" CWs operating alternatively. The second stage was composed of two Vertical Flow CWs operating in parallel and their effluents were mixed and discharged by gravity into the third stage, which was composed of a Horizontal Subsurface CW. Different operational strategies, number of cycles per day and contact time (Tc) were tested during 16 months.

DWTS system showed a higher NH_4^+ removal capacity during the whole monitoring period. Average NH_4^+-N concentrations were reduced through this system from 453 to 21 mgN/L, 504 to 58 mgN/L and 438 to 68 mgN/L, operating under 2, 4 and 6 cycles/day and with a Tc of 30 min. The effluent obtained showed average NO_3^--N concentrations of 412, 455 and 255 mgN/L. The results show that the nitrification process occurred at high rates in the DWTS system, obtaining an ideal nitrified stream to be valorised in anoxic biogas biodesulphurisation. This high nitrification yield, compared with those achieved in the gravel system (29-53% NH_4^+ removal efficiencies), could be associated with a high adsorption capacity of the substrate during the flooded period, and higher levels of microbial diversity of N-cycle-associated microorganisms. In fact, Ammonia oxidising archaea (AOA) had a significantly greater development in the DWTS units, being almost negligible in gravel units. Regarding P removal, the DWTS system reached significantly higher removal efficiencies (96-99%) than the gravel system (26-46%), obtaining an average total P concentration of 0.5 mg/L at the outlet stream. P removal was stable regardless of the operational conditions applied.

In view of results, the intensified Multi-stage CW filled with DWTS has shown to be feasible treating centrate. The DWTS system has shown both nitrification capacity and phosphorus removal efficiencies higher than those reached using a conventional substrate. Furthermore, the nitrates production achieved demonstrates that the innovative multi-stage CW developed is an efficient and low-cost technology which can be used to supply a nitrified stream for the anoxic biogas biodesulphurisation process, making it more sustainable.

BIO of Presenter:
Núria Oliver is a senior researcher with a PhD based on the use of CWs for restoring ecosystems and currently responsible for the research line focused on the use of CWs for wastewaters valorisation in Global Omnium company.

FROM DOSE VOLUME TO WETLAND PERFORMANCE: LEVERAGING MEDIA RETENTION FOR PREDICTIVE DESIGN

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Non-saturated vertical flow treatment wetlands (VFTWs) present unique design challenges due to the difficulty of determining hydraulic residence time under unsaturated, pulse-loaded flow conditions. These systems receive discrete doses at intervals ranging from minutes to hours. Each dosing event triggers a hydrologic cycle where water infiltrates the medium, briefly saturates pore spaces, and drains, causing fluctuations in the water volume retained within the bed. This variability, combined with rapid drainage, limits the applicability of designing from a kinetic perspective with design instead relying on rule-of-thumb criteria like HLR, and mass loading restrictions. This research aims to build on current design practices by relating media gradation to water retention in the wetland between doses.

Retention volume (RV), defined as the volume of water retained in the medium after gravitational drainage reflects the portion of each applied dose that remains in contact with the medium and available for treatment. Dose volume (DV) is the volume of water delivered per dosing event. The ratio of DV to RV, expressed as the dose volume fraction (Ψ = DV/RV), provides a practical, volume-based parameter that captures the extent of dose retention and enables improved prediction and optimization of VFTW performance across media types and dosing strategies.

Using the conversion of ammonium (NH_4-N) to nitrate (NO_3-N) as a proxy for nitrification, this study introduces the use of the dose volume fraction (Ψ = DV/RV) as a unifying parameter to assess the combined influence of HLR, DV, and S_r on NH_4-N removal efficiency in VFTWs. Experiments were conducted in unplanted mesocosms housed in a temperature-controlled greenhouse (24 °C), using two distinct media sizes with different S_r values: sand (d_{50} = 0.4 mm, S_r = 0.19) and gravel (d_{50} = 5 mm, S_r = 0.09). Two DV values and four HLRs were applied across both media using a synthetic wastewater containing 120 ± 1 mg L^{-1} NH_4-N (from NH_4Cl), and micronutrients, but no organic carbon source. Across all conditions, sand consistently produced more NO_3-N than gravel. In both media, nitrification efficiency improved with lower HLRs and, at a given HLR, with smaller DVs. Notably, the use of Ψ reduced the confounding effects of media size, DV, and HLR. When Ψ was held constant (Ψ = 0.17), sand and gravel produced nearly identical NO_3-N concentrations, even though the sand received double the HLR, demonstrating that Ψ can normalize NH_4-N removal efficiency across media types. Similarly, for any given HLR, decreasing Ψ led to increased NO_3-N production regardless of medium type, indicating that Ψ can be used to optimize DV for a fixed HLR. This parameter shows promise as a scalable design tool for broader applications in porous media-based treatment systems.

BIO of Presenter:
Otto Stein, Distinguished Professor Emeritus at Montana State University, led an interdisciplinary team focused on using constructed wetlands for water quality amelioration. He is a co-author of the textbook “Treatment Wetlands” and over 90 other publications on treatment wetlands.

Keywords: Vertical Flow treatment wetland design, nitrification, operational parameters

APPLICATION OF FLOATING WETLANDS FOR LANDFILL LEACHATE TREATMENT

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Introduction

Floating Treatment Wetlands (FTWs) represent a promising nature-based solution (NBS) for improving the quality of landfill leachate. Within the LIFE Green Adapt project, the Xiloga landfill leachate ponds were an opportunity to test »open water surface treatment lagoons with floating treatment islands/wetland«. The primary objective was to validate the potential of FTWs and assess their effectiveness in treating heavily polluted leachate characterized by high concentrations of ammonium, organic matter, and elevated pH values. The treatment of leachate is designed as a two-stage process (see Figure 1), consisting of a FTW followed by an innovative combination of Aerated Vertical flow TW with geopolymers (GPs-ATW) and by Electroactive Based Treatment Wetland (EAB-TW).

Materials and methods

Floating treatment wetland (FTW) consists of a buoyant structure in which macrophytes are planted. The floating wetlands at Xiloga are assembled from waste materials that were obtained from the landfill itself. At least three species of plants that can withstand harsh conditions were identified.

Figure 1: Treatment process flow diagram

Major challenges were to find plants that could withstand difficult conditions (currently, min. three (3) plant species could withstand harsh conditions. The existing ponds provided good conditions for efficiency: their volume enables dilution of inflow, and prolongs retention times and space for sedimentation.

Results and discussion

Table 1: Summarized analytical results of the FTW

	Inlet	Outlet
COD (mg/L)	1062 ± 469	343 ± 131
NH_4^+ (mg/L)	1915 ± 1184	401 ± 369
PO_4^{3-} (mg/L)	20 ± 22	10 ± 10

The treatment efficiency results, presented in Table 1, indicate that the FTW system removes 74 ± 9 % of COD, 78 ± 13% of NH_4, and 39 ± 38 of PO_4^{3-}. These results are very promising.

Conclusions

- Considering the simplicity of treatment solution efficiency for all parameters is considered very satisfying.
- FTWs have shown a consistent and robust main treatment to remove the major contaminant load of the highly polluted leachate wastewater.
- This is very encouraging, calling for broader use of this technology.

BIO of Presenter
Urša Brodnik, Engineer with 12+ years' experience in environmental fields, is working at LIMNOS as a Head of an engineering department. She is specialized in designing, developing, and implementing different nature-based solutions, such as various types of treatment wetlands. In recent years she gained experience in ecosystem ecology related to water resource protection solutions.

METAKAOLIN AS AN ADSORPTION MATERIAL FOR THE LEACHATE TREATMENT OF AN INDUSTRIAL LANDFILL

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Introduction

Europe has more than 500,000 landfills, some of which are uncontrolled and lack proper design, requiring over 140 years to stabilize. Nature-based solutions (NBS) have emerged as cost-effective technologies to reduce pollution from these infrastructures. The LIFE GreenAdapt project aims to provide solutions to reduce and treat polluted wastewater from landfills. Biotechnosoils, a mix of organic and inorganic materials with grass, are proposed to waterproof the surface and minimize wastewater percolation. A two-stage NBS scheme was developed to treat contaminated water (see Figure 1). The first stage uses a floating treatment wetland (FTW), and the second stage assesses a *GeoPolymer Aerated Wetland* (GP-ATW). This communication focuses on assessing the GP-ATW within the FTW + GP-ATW system.

Materials and methods

The prototype stage consisted of a two-steps treatment in which first a floating treatment wetland (FTW), has been installed for treating the overall flow of leachate from the landfill. Coupled-in-series to this FTW a GP-ATW was installed as a polishing step of the incoming still polluted water coming from the FTW.

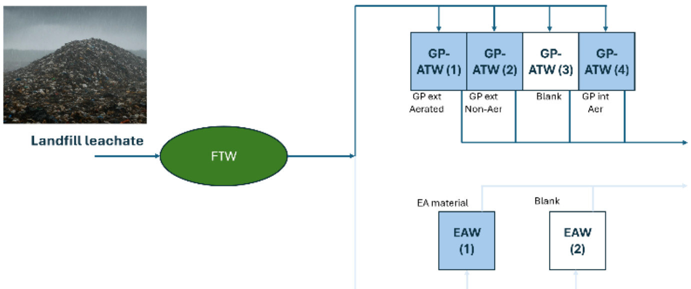

Figure 1. Flowchart of the FTW + GP-ATW prototype installed in a real landfill.

The geopolymer was filled with a novel material, metakaolin derived from kaolin through a new chemical process developed within the project. The prototype configuration was designed to evaluate the necessity of aeration and the impact of the metakaolin's location (inside or outside the system). These approaches were compared to a blank control without metakaolin. Notably, the GP-ATW will be studied under three different configurations: aerated, non-aerated, and a blank.

Results and discussion

Table 1. Summarized analytical results of the combined FTW + GP-ATW

	Inlet	Outlet (FTW + GP ATW)
COD (mg/L)	1457 ± 766	126 ± 91
TN (mg/L)	1713 ± 904	93 ± 36
TP (mg/L)	27 ± 25	4 ± 3

The combined FTW + GP-ATW system achieved a high COD removal rate, averaging 88 ± 10%. Nutrient removal was also significant, with average removal rates of 94 ± 5% for total nitrogen (TN) and 79 ± 18% for total phosphorus (TP), attributed to the synergistic effect of physical and biochemical mechanisms. These results, along with those in Table 1, demonstrate the strong viability and robustness of the proposed technology for treating highly polluted wastewater.

Conclusions

- The combined FTW + GP-ATW system has proven to be a feasible technology for treating highly polluted leachate wastewater.
- No material exhaustion was observed during the 500-day operational period for any of the tracked pollutants.
- The innovative metakaolin exhibited remarkable performance in pollutant removal efficiency and adsorption capacity.

BIO of the Presenter.

Álvaro Silva Teira, Chemical Engineer with a PhD in Environmental Engineering and 15+ years' experience in environmental fields, is working at AIMEN's Senior Researcher in projects as LIFE GreenAdapt (ending 2025). He also holds an Executive MBA and MIT Sustainability Program qualification.

QUANTIFYING INFILTRATION AND RAINFALL ACTIVATION THRESHOLDS IN A BIORETENTION SYSTEM USING SOIL MOISTURE DATA

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In recent years, a growing demand for implementing Nature-based Solutions for stormwater management has been made by urban planners, driven primarily by the increased frequency of pluvial flooding linked to climate change. Sustainable Drainage Systems (SuDS) offer an effective solution to decrease the load on existing sewer systems by favouring on-site stormwater infiltration. The control of the runoff water quantity is one of the main categories of benefits that can be achieved by SuDS according to guidelines and manuals.

This study focuses on a parking lot in Solaro (Milan) where stormwater is directed either into a conventional drainage system or into a bioretention system. Both systems are connected to infiltration shafts, which include overflow mechanisms linked to the existing sewer network. Within the bioretention area, six soil moisture sensors were installed at various depths (from 5 cm down to 55 cm, at 10 cm intervals) and the readings were logged at 10-minute intervals for at least 2 years. Additionally, precipitation data were provided by rain gauges installed near the site. The goal of the study is to correlate the soil moisture data from the bioretention system with rainfall events, to identify the precipitation thresholds that activate the SuDS system and to quantify the volume of water infiltrated through the bioretention cells and the infiltration shafts.

The results show a consistent response of the soil moisture sensors to rainfall events. Almost every rainfall event caused an increase in soil moisture at multiple depths. The high sampling frequency enabled the observation of a top-down infiltration pattern for low to moderate rainfall events (30 mm/d), while during more intense events (200 mm/d), moisture increased from the bottom upwards, suggesting that the shafts infiltration capacity was exceeded by the volume of incoming water. Moreover, a relationship between daily rainfall intensity and soil moisture levels was identified, allowing the determination of activation thresholds and estimation of infiltrated water volumes. By comparing the sensors placed at 5 cm and 55 cm depths, a 10% increase was observed in soil moisture by rainfall with an intensity of 10 mm/d at 5 cm, whereas an intensity of 40 mm/d is required at 55 cm. Thus, the installed sensors could be considered as an appropriate monitoring solutions for assessing the functionality of a bioretention area inside a complex drainage system.

The final objective will focus on assessing the feasibility of using soil moisture sensors within SuDS as low-cost tools for integrated water management services. This would facilitate both the evaluation of system performance, quantifying the stormwater volumes infiltrated and so diverted from the sewer network, and the operation and maintenance, permitting to set alert for controlling SuDS functioning and eventually emergency irrigation during drought periods.

Acknowledgement

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BIO of Presenter:

Fabio Masi is R&D Manager and Technical Director of IRIDRA Srl, since 1998 and Vice-President of Global Wetland Technology since 2012. He is PhD in Environmental Sciences and MSc in Environmental Chemistry (1991). He has more than 30 years of experience in sustainable water management and nature-based solutions for wastewater treatment.

DEEP DNA SEQUENCING OF BIOFILMS IN A COLD-CLIMATE TREATMENT WETLAND: INSIGHTS OF SEASONAL OPERATION ON NITROGEN TRANSFORMATIONS

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Treatment wetlands (TW) use microbial processes to remove contaminants from various wastewaters; however, changes in temperature are thought to significantly impact community structures and capabilities. This study investigates microbial community dynamics and nitrogen pathways using shotgun, next generation metagenomic sequencing (NGS) in a two-stage, vertical-flow pilot TW treating ski resort wastewater. The first stage of the TW is partially saturated to provide conditions favorable to denitrification and the unsaturated second stage demonstrates efficient total ammonium conversion to nitrate. A recycle stream returns the generated nitrate to the first, denitrifying stage where it is removed alongside organic carbon. The TW treats kitchen and lavatory wastewater from lodges during the ski season, mid-December to mid-April, and recirculates stream water the remainder of the year to maintain plant health. The TW is planted with native *Carex utriculata* (sedge) and *Schoenoplectus acutus* (bulrush) species.

In 2022, biofilm sampling devices were installed in both stages of the TW, consisting of steel mesh tubes (with PVC endcaps?) filled with media taken directly from the TW to allow for biofilm attachment and growth. The tubes were either buried in the shallow media of the TW stages (15 cm depth) or placed into vertical PVC tubes installed in the first stage for sampling the deep, saturated zone (60 cm). Samplers were collected at two intervals, in March during the operating season of the TW and in September after five months without wastewater input. The biofilms on the media within the samplers was subject to DNA extraction and shotgun, metagenomic NGS (1.2 gb per sample).

Despite low winter water temperatures of 2-5 °C, nitrification and denitrification pathways were identified in the aerobic and anoxic stages, respectively. Minimal changes in α-diversity of biofilms at each sampling location were observed from the operational season to the system's annual 8-month rest period. Results of PCoA and β-diversity analysis indicate that assumed redox conditions associated with sampling location play a significant role in community differences, but communities are relatively consistent between operational and rest seasons. The analysis of gene abundances with stage and sampling month indicates minimal changes in nitrogen metabolic capabilities and apparent dominant metabolic pathways between operating and non-operating seasons. Additionally, this study identifies plant-associated microbial genera across both sampling times which points to the potentially important role that plants may play in stabilizing the development and long-term persistence of biofilms in TW. The study is the first to discern community dynamics and functional potential of a cold-climate, field-scale TW using metagenomic NGS.

BIO of Presenter:
Ellen Lauchnor is an associate professor of Environmental Engineering at Montana State University. She received her PhD from Oregon State University and is affiliated with the world-renowned Center for Biofilm Engineering at MSU. Her research interests include biofilm-driven processes in both bioremediation and nature-based wastewater treatment systems.

WETPOL 2025
GDAŃSK TECH, Gdansk, Poland

THE USE OF ELAN GIS-INTEGRATED TOOL FOR EXPLORING DECENTRALIZED WASTEWATER MANAGEMENT BY TREATMENT WETLANDS

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Urban water management encompasses intricate and interconnected processes, making it challenging to predict all the potential effects of employing different nature-based solutions and to determine their optimal dimensions and placements. Consequently, tools for integrated urban water management seem to be promising for assessing various scenarios and ultimately promoting the quicker adoption of nature-based solutions. In the past three years, we have been developing ELAN ("urban watEr pLanning scenArios for sustaiNable cities"), a Geographic Information System (GIS) based tool aimed at managing wastewater and storm water at the urban scale, incorporating wastewater treatment through treatment wetlands. The present iteration of ELAN features two components: the sewer module and the treatment wetland sizing module, which collectively offer a robust framework for enhancing wastewater management at the district scale using a multi-criteria strategy.
Utilizing the UFZ's *pysewer* code and publicly available data, the sewer module generates optimal networks for linking domestic wastewater sources to one or multiple treatment plants. The module for sizing treatment wetlands, also known as the process module, automatically constructs all feasible treatment trains by utilizing a predefined database of treatment processes. It then suggests an optimized sizing for those whose performance align with the user's specific context. This presentation will focus on the process module, detailing the methodology for generating, optimizing, and selecting treatment trains. Besides sizing optimization, the process module integrates a Multi-Criteria Decision Analysis (MCDA) approach to compare treatment trains that user can tune to weighting the relevant criteria. Indeed, at the process module level, MCDA incorporates technical, economic, and environmental elements to create a structured framework that helps in comparing alternatives by considering numerous relevant criteria for decision-making. Initially developed for the Caribbean setting as part of the CARIBSAN cooperation initiative, this methodology employs a Structured Decision-Making (SDM) approach, incorporating input from local stakeholders to establish essential criteria. The tool's modularity is further reinforced by its open-source design, enabling users to modify parameters and sizing equations according to their specific needs.
By integrating technical, economic, and environmental factors, ELAN offers a transparent, structured framework for comparing alternatives. The tool, currently being tested on real cases, allows users to explore a range of solutions tailored to their specific context, with all necessary criteria to make informed decisions.

BIO of Presenter:
Zoé Legeai is a junior research engineer at INRAE.

DEWATERING, TREATMENT AND FILTRATION OF STORMWATER AND SLUDGE IN A SLUDGE TREATMENT REEDBED SYSTEM

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Keywords :

Quality of feed sludge, sludge residue; area load; sludge residue height; loss on ignition; fat, organic matter, dewatering

Kallerup Sludge Treatment Reed Bed (STRB), located at 55.6634° N, 12.1972° E designed and operated by WSP Denmark, was established in 1996 for the purpose of dewatering and treating waste sludge from Kallerup WWTP and with a secondary function of storing and filtering excess wastewater from the WWTP during rain events. The STRB system, which was originally constructed with 8 basins, was established with a sludge treatment capacity of 240 tons DS yr $^{-1}$ and the capacity to store 6,000 m^3 of raw sewage water in 6 of the 8 basins in connection with rain events. In 2003/2004, the STRB system was enlarged with 2 more basins, which increased the total capacity to 300 tons DS yr $^{-1}$ corresponding to an average load of 25 tons DS per month and a maximum area-loading rate of 60 kg DS m^{-2} yr^{-1} based on daily sludge loads of 70 – 80 m^3 with a dry solid of 0.5 – 0.7 % dry solid. The additional basins provided an extra capacity of 2,000 m^3 more for storage and filtration of sewage water, resulting in total storage during storm events up to 8,000 m^3 in 8 of the 10 basins. In this full-scale study results and experience of stormwater treatment and sludge dewatering in the (STRB) during two operation periods (1996 – 2024) including emptying of the basins through approximately 30 years of operation are presented. Since 2009, the sludge production has stabilized to 160 – 200 tons DS yr^{-1}, which resulted in an area load of 24.7 – 40.9 kg DS m^{-2} yr^{-1}. Four-to-six-time yearly sewage water has been pumped from the stormwater basin to the STRB system, representing volumes in the order of magnitude that corresponds to 64 – 383 sewage water loads of 70 m^3. During the second operation period (2003 – 2024), approximately up to 1.70 m of sludge residue, equivalent to an accumulation rate of 0.06 – 0.10 m yr^{-1}, had accumulated in the basins. In this full-scale study, results and experience about sludge dewatering and stabilization of the sludge residue, mainly focused on sludge quality, dewatering in relation to the development of sludge quality and the effect of the growing heights of the sludge residues on the dewatering in the STRB systems, are presented. The maximum drainage rates during the operation period (2012 to 2016) for basin no. 10 have overall been very stable with maximum drainage rates of 0.018 – 0.024 l $sec^{-1}m^{-2}$ in the first of 7 to 9 batches (the quota). A significant decline in the maximum drainage rates has not been observed from the first to the last batch in the quota. The maximum runoff rates for the last batch in the quota have also been stable at a value around 0.011 – 0.024 l $sec^{-1}m^{-2}$. The stability of the sludge quality and the load strategy have contributed to maintaining drainage efficiency and the increasing sludge residue height seems to have no effect on sludge dewatering and drainage. From 2017 to 2024 The measuring of the sludge dewatering has shown that the maximum drainage rates have been lower than in previous years (before 2017) at 0.008 – 0.016 l $sec^{-1}m^{-2}$ in the first batch to 0.005 – 0.011 l $sec^{-1}m^{-2}$ in the last batch. It is obvious that higher concentrations of organic matter and/or fat result in a lower draining ability, lower dry solid % and more pronounced anaerobic conditions in the sludge residue. The development of the loss on ignition in the period from 2015 to 2024 significantly indicates an increase in organic matter. In the remaining basins' drainage rates in 2017 – 2024 are overall the same - between 0.005 – 0.008 l $sec^{-1}m^{-2}$ in the first batch to 0.005 – 0.004 l $sec^{-1}m^{-2}$ in the last batch.

BIO: **Steen Nielsen** is a senior manager with more than 37 years' experience with dimensioning and operation of Sludge Treatment Reed Bed System in relation to climate, sludge quality and with construction, rebuilding and operation of more than 70 full scale and test system. He has authored and coauthored more than 30 papers.

OPTIMIZATION OF ANODE POSITIONING IN CONSTRUCTED WETLANDS COUPLED WITH MICROBIAL FUEL CELLS BASED ON C/O MICROENVIRONMENT FOR SIMULTANEOUS REMOVAL OF DISINFECTION BY-PRODUCTS AND NITROGEN

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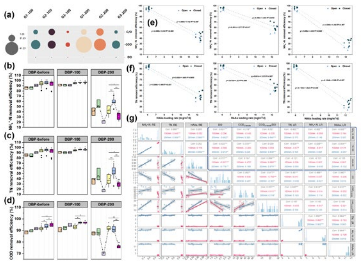
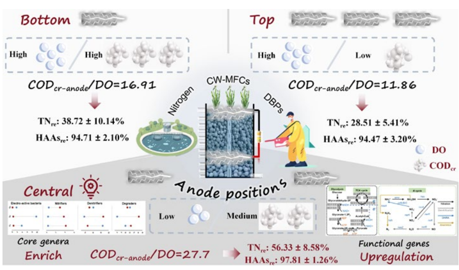
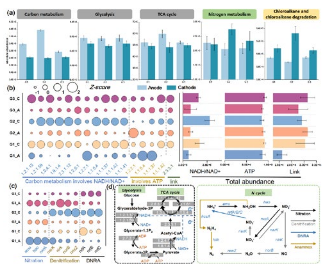
Abstract
Disinfection by-products (DBPs), including trihalomethanes (THMs) and haloacetic acids (HAAs), pose significant ecological and public health risks due to their carcinogenic and mutagenic properties. Constructed wetlands (CWs) have emerged as sustainable alternatives for DBP mitigation through synergistic plant-microbe interactions. However, their nitrogen-centric designs and susceptibility to DBP-induced microbial inhibition limit practical applications. The integration of microbial fuel cells (MFCs) into CWs (CW-MFCs) introduces electrochemical pathways to enhance pollutant removal efficiency. Electroactive biofilms on electrodes facilitate electron transfer for dehalogenation and nitrate reduction, while suppressing soluble microbial product (SMP) formation—a critical DBP precursor source. Despite these advantages, CW-MFC research remains focused on nitrogen and emerging contaminants, with limited exploration of DBP removal mechanisms. A key knowledge gap lies in optimizing anode positioning to balance redox gradients and carbon-oxygen microenvironments, which governs both dehalogenation and denitrification efficiencies. In this study, the potential of CW-MFCs for the synergistic removal of HAAs and nitrogen was comprehensively validated, highlighting the critical importance of anode positioning on the overall performance of CW-MFCs. A substantial nitrogen removal, HAAs degradation efficiencies, and bioelectricity generation were achieved due to the favorable carbon-oxygen environment predominant in the middle section of the CW-MFC (G2 group). This system facilitated the enrichment of functional microbial genera in a thermally favorable zone. Electroactive genera such as *Geobacter*, *Trichococcus*, and Ruminiclostridium were significantly enriched at the anode, which in turn markedly activated the autotrophic denitrifers (Paenibacillus), predominantly colonized the cathode (1.37%). Simultaneously, Geobacter (1.30%) and Trichococcus (3.36%) identified as HAA degraders were also significantly enriched at the cathode. Consequently, both the mutualistic resource-sharing effect among core genera and the high expression of relevant functional genes were observed in the electrode biofilm of G2. In conclusion, the strategic positioning of the anode within CW-MFCs can enhance the removal of nitrogen and DBPs while mitigating the formation of DBP precursors, thereby safeguarding aquatic ecosystems.







BIO of Presenter:
Jiawei Xie, a second-year Ph.D. candidate in Environmental Engineering at Tongji University, specializes in constructed wetland-bioelectrochemical coupled systems. A National Scholarship recipient and author of six first-authored SCI papers, he advances eco-technologies for wastewater treatment. Based in Shanghai, he explores cutting-edge low-carbon water remediation solutions.

PILOT CONSTRUCTED WETLAND DESIGNS FOR OLIVE MILL WASTEWATER TREATMENT

Panagiotis Regkouzas, Elissavet Koukouraki, Eirini Athanasiadou, Alexandros Stefanakis*
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The excessive production of olive oil in combination with the uncontrolled disposal of the by-product (olive mill waste) in the Mediterranean basin pose huge risks for the environment. Olive mill wastewater is rich in phenolic compounds and organics, thus, identifying and optimizing nature-based technologies is highly needed. Constructed wetlands (CW) are a green treatment technology where many processes take place that can provide efficient pollutants removal.

In this research project, six pilot-scale CWs are tested; four with horizontal flow (HF) and two with vertical flow (VF). The pilot unis are located at the open-air facilities at the Technical University of Crete and receive olive mill wastewater from a local mill located in Akrotiri, Chania in Greece. The pilot CWs use different substrate media such as: 'C' with zeolite & expanded clay aggregate (unplanted, HF), 'ZL' with zeolite & expanded clay aggregate (planted, HF), 'PB' with recycled HDPE & biochar (planted, HF), 'P' with recycled HDPE (planted, HF), 'L' with expanded clay aggregate (planted, VF), 'LPB' with expanded clay aggregate, recycled HDPE, biochar (planted, VF).

Sampling and analyses of the influent and CW effluents take place regularly for the determination of pH, electrical conductivity, BOD_5, COD, total phenols, TSS, color, TN, TP, NH_4-N, NO_3-N, PO_4-P. and pesticides. The pilot CW have been in operation under two different operation modes: with passive aeration (1st year) and with artificial aeration (2nd year). So far, there is a very high decrease in total phenols and organic matter especially in the two VFCW, exceeding 90%.

This work will demonstrate the overall efficiency of the tested pilot CW in treating this agro-industrial wastewater source.

Acknowledgments: This project is funded by the PRIMA-MED program, project "Reme-Diation: Resilient Mediterranean with a holistic approach to sustainable agriculture: Addressing challenges of water, soil, energy and biodiversity", contract No. 122N048.

BIO of Presenter:
Panagiotis Regkouzas is a post-doctoral researcher at the Technical University of Crete in the field of Environmental Engineering. His main research interests lie in the prism of circular economy and sustainability, emphasizing in solid waste and wastewater management technologies. He is an expert in biochar production and application in several fields. He is also studying the technology of Constructed Wetlands as Nature-Based Solutions for wastewater treatment.

EVALUATING THE ECOLOGICAL AND SOCIAL IMPACT OF URBAN RAIN GARDENS IN LUBLIN, POLAND

Barbara Sowińska-Świerkosz [1], Malwina Michalik-Śnieżek[2], Raimund Kemper [3], Hai-Ying Liu[4]*

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Rain gardens are nature-based solutions (NBS) designed to manage stormwater by collecting, absorbing, and infiltrating runoff from impervious surfaces. In Lublin, Poland, the city authorities are implementing such solutions as part of urban sustainability strategies. This study analyzed the ecological and social performance of four rain gardens located at John Paul II Park, Ochotnicza Street, Obrońców Pokoju Street and Peowiaków Center for Culture. The assessments carried out in 2024 and 2025, focusing on several indicators: stormwater retention, local temperature regulation, plant and pollinator biodiversity, pedestrian activity, public interest, and signs of vandalism. The results showed a generally positive ecological impact, including improved stormwater retention during heavy rainfall and temperature reduction of 0.4-2.2°C within a 5-meter radius, dependently on the season. Biodiversity also improved, with the highest Shannon diversity index recorded at 2.2. However, performance at one site was limited due to excessive shading of the vegetation. Social outcomes were more mixed. While some pedestrian activity and public interest were observed, challenges such as littering and limited community engagement were noted. The findings suggest that while the physical design and size of the gardens were generally adequate, greater attention to site selection, times and forms of stakeholder engagement (e.g., their role and involvement in decision-making and maintenance) and community integration is essential to maximize both ecological and social benefits of rain gardens in urban environments.

This research was funded by Biodiversa+, the European Biodiversity Partnership, in the context of the [NatureScape] project under the 2023-2024 BiodivNBS joint call. It was co-funded by the European Commission (GA No. 101052342) and the following funding organisations: [RCN - Research Council of Norway, Norway], [SNSF - Swiss National Science Foundation, Switzerland], [EPA - Environmental Protection Agency, Ireland], [NCN - Narodowe Centrum Nauki, Poland], [FCT - Fundação para a Ciência e a Tecnologia, I.P., Portugal], [LCS - Latvian Council of Science, Latvia], [MUR - Ministry of Universities and Research, Italy]

BIO of Presenter:

Barbara Sowińska-Świerkosz is associate professor at the University of Life Sciences in Lublin since 2019. Her research interest include: evaluation of NBS project, NBS impacts on landscape quality, co-design of NBS and application of Citizen Science in environmental research. She conducts research in international project teams and has written over 50 articles.

ATTENUATION OF DIFFUSE POLLUTION IN NATURE-BASED TREATMENT: MICROALGAL BIOCHAR AMPLIFIES HEAVY METAL UPTAKE AND STRESS TOLERANCE IN *CANNA INDICA*

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Ecological facilities, such as constructed wetlands, provide sustainable solutions for wastewater treatment. However, long-term operation risks secondary contamination because the substrates can accumulate contaminants like heavy metals (HMs). While wetland plants enable contaminant removal via phytoextraction and harvesting, but still face dual constraints: the limited efficiency of non-hyperaccumulators and poor scalability of phytoremediation strategies across diverse operational conditions. Therefore, developing cost-effective and easily implementable enhancement strategies is critical to optimize contaminant phytoextraction efficiency in wetland systems. In this study, a 12-week incubation experiment was conducted to explore the effect of the HMs' synergistic immobilization, dosage effect, and molecular mechanism of Microalgal biochar (MBC) in assisting wetland plant (*Canna indica*) in remediating Cuprum (Cu), zinc (Zn), and cadmium (Cd) contamination. The key results show that:

(1) MBC synergizes with *Canna,* reducing the risk of secondary release HMs:

- **Reduction of pollutant dispersion:** MBC-*Canna* significantly reduced the leaching of Cu, Zn, and Cd from the substrate into the overlying water column by 56.1, 58.5, and 83.3%, respectively.

(2) MBC promoted the enrichment and translocation of HMs in *Canna*:

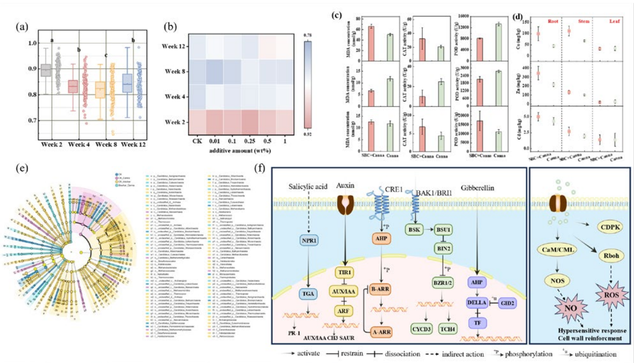
- **Improvement of plant physiological properties:** MBC increased *Canna* biomass and enhanced F_v/F_m under HMs-stress. Chlorophyll content rose from 0.78 to 2.56 mg/g at 0.01 - 0.5 wt% MBC.
- **Enhancement of plant enrichment and translocation capacity:** 0.5 wt% MBC increased Cu and Zn concentrations in *Canna* roots by 124% and 59%, and in stems by 65% and 16%, respectively.
- **Enhancement of plant resistance to oxidative stress:** 0.5 wt% MBC increased root catalase (CAT) and peroxidase (POD) activities by 56.8% and 52.7%, respectively.

(3) BC changed the expression of related genes in *Canna*:

- **Enhancement of HMs accumulation-related gene expression:** MBC enhanced the expression of over 2,000 functional genes (e.g. metal ion binding, oxidoreductase activity, etc.) in *Canna*.
- **Three key mechanisms of MBC enhance HMs uptake in *Canna*:** Enhances cell growth and preserves cellular structure, increases IAA levels, and regulates Ca^{2+} signaling pathways.

This study demonstrates that biochar-based substrate conditioners enhance HMs uptake and translocation efficiency in *Canna* by regulating HM-associated gene expression, providing a theoretical foundation for optimizing plant-substrate synergistic remediation technologies in constructed wetlands.

Key Words: Diffuse pollution mitigation, Heavy metal, Biochar, Wetland plant, Molecular mechanism



<u>BIO of Presenter</u>:

Weicong Wang, a 3rd-year Ph.D. candidate at Tongji University, mainly focuses on the attenuation of diffuse pollution, development of functional substrate, plant-substrate synergies, and phytoremediation of typical pollutants, and has published 16 SCI papers (7 papers as the first author) and 3 patents.

CONSTRUCTED WETLANDS FOR ENHANCED TREATMENT OF WASTEWATER TREATMENT PLANT EFFLUENT AND COMBINED SEWER OVERFLOW

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Municipal wastewater treatment plants (WWTP) and combined sewer overflow (CSO) discharge micropollutants into water bodies. Constructed wetlands are a simple and cost-effective way to treat wastewater. The utilization of constructed wetlands for micropollutant elimination from WWTP effluent is currently a subject of research with promising results and to date, constructed wetlands for this purpose have been implemented at least once on a large scale in Germany. The SpurO study (optimization of micropollutant removal from a receiving water perspective) is investigating a pilot plant consisting of four planted, vertical flow constructed wetlands filled with expanded clay (0 | 3 mm) and activated biochar (15%). The pilot plant is operated since June 2024 at a municipal WWTP in the southwest of Germany (56,000 p.e.). It is fed with effluent of the WWTP. It is noteworthy that one of the constructed wetlands has been in operation for several years, as part of the EU-Interreg CoMinGreat project. The objective of this study is to utilize constructed wetlands in an alternating manner to further treat effluent from a WWTP during dry weather and CSO during wet weather, when the stormwater retention basin exceeds its capacity and discharges, to increase water protection. In general, the aim is to show that this dual-purpose approach, utilizing constructed wetlands for combined WWTP effluent and CSO treatment, enhances water protection by ensuring continuous and efficient treatment under varying weather conditions.
From beginning of May until end of October 2025, one of the constructed wetlands will be operated not only with WWTP effluent but also with CSO discharge. Within the scope of the project, the hydraulic loading rate will be progressively increased, and a range of feed regimes will be investigated. The key point of this investigation lies in the duration of the feed and dry periods to reduce the space required. In addition, the maximum hydraulic loading rate for sufficient elimination of micropollutants is to be determined. Current studies from Luxembourg show that good micropollutant elimination can also be achieved with a feed rate of 100-200 $l/(m^2 \cdot d)$. At present, two of four wetlands at the pilot plant are fed with 313 $l/(m^2 \cdot d)$ and two with 438 $l/(m^2 \cdot d)$. Despite the significantly higher feed rate, all micropollutants of the European Wastewater Treatment Directive in annex 1, such as diclofenac, benzotriazole and so on are reduced by the constructed wetlands to below the limits of quantification (<0.05 µg/l). The reduction of micropollutants correlates with the reduction of the UV_{254} value. The UV_{254} can be used as an easy to measure proxy parameter. This correlation was originally established for GAC and ozone. The present results show that this correlation can also be applied to constructed wetlands. The results available to date indicate a significant potential for reducing emissions of standard wastewater parameters: The average total phosphorus concentration in the secondary clarifier effluent is 0.40 ± 0.23 mg/l TP (n = 20). This is reduced by the constructed wetlands to well below 0.05 mg/l TP. The Chemical Oxygen Demand (COD) is reduced from 19.0 ± 4.0 mg/l (n = 25) to 9.0 ± 2.0 mg/l (n = 23). Regarding the reduction of total nitrogen, a seasonal variation depending on plant growth and temperature can be observed, which is currently being investigated in more detail (Spring 2025).
In the oral contribution, the effluent quality of constructed wetlands will be presented, considering the removal of micropollutants as well as the influence on standard effluent parameters. Emphasis will be placed on the behaviour of micropollutant removal and synergy effects under alternating loading rates of WWTP effluent and CSO.

BIO of Presenter: **ORAL presentation preferred.**
Franziska Ehrhardt has been a PhD candidate at RPTU Kaiserslautern-Landau since October 2022. Previously she worked for two years in an engineering consultancy. Her current research focuses on constructed wetlands for targeted removal of organic micropollutants from WWTP effluent and CSO to enhance surface water quality.

MITIGATION OF TIRE-DERIVED MICROPOLLUTANTS AND METALS IN ROAD RUNOFF USING A RAINGARDEN

Elisabeth Rødland[1], Mari Gjeitnes[1], Anne-Luise Ribeiro[1], Ashenafi Gragne[1], Uta Brandt[1], Sondre Meland[1], Stina Karlstrøm[2], Pedro Carvalho[3], Vaidotas Kisielius[3]
[1]Norwegian Institute for Water Research, Oslo, Norway, [2]Oslo Municipality, Bymiljøetaten, [3]Department of Environmental Science, Aarhus University, Roskilde, Denmark
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Abstract
The negative impact from road pollution and especially tire wear particles (TWP) released into the environment has recently gained more attention, as new studies related to the chemical content, leaching capabilities of TWP and effects on organisms have been published. Much attention has also been directed towards establishing green, nature-based solutions in urban areas, including raingardens and bioretention cells. The aim of this study was to investigate the seasonal variation of pollutants in road runoff, including TWP, organic compounds, metals and water quality parameters, to assess the potential mitigation efficiency of a raingarden. Online sensors monitored the inlet and outlet of the raingarden continuously to supply data on water level, water temperature, turbidity and conductivity. Seven rainfall events were monitored: 2023: June (01), September (02, 03), November (05), 2024: May (06) and July (07). TWP was analysed PYR-GC/MS, organic compounds were analysed using HPLC-MS/MS and metals using ICP-MS. Levels of TWP varied between rainfalls but was on average higher in the inlet (2.57 ± 2.30 mg/L) compared to the outlet (0.488 ± 0.188 mg/L), resulting in 81% reduction. For the selected organic compounds (6PPD-Q, benzothiazole (BT), methylthiobenzothiazole (MTBT), hydroxybenzothiazole (OHBT), aminobenzothiazole (ABT) and mercaptobenzothiazole (MBT)) the levels also varied between the rainfall events, with the overall highest levels found in Rainfall 01. The highest level in the inlet was observed for BT (9.73 ± 6.76 µg/L), followed by OHBT (9.29 ± 7.72 µg/L), MTBT (1.23 ± 1.08 µg/L) and ABT (0.380 ± 0.247 µg/L) and 6PPD-Q (0.227 ± 0.160 µg/L). Comparing the inlet to the outlet values suggest an overall retention rate of 90% for MTBT, 81% for 6PPD-Q, 71% for OHBT, 68% for BT and 56% for ABT. For all rainfall events, the highest levels of metals were found for Na (77.8 mg/L), which is likely due to road salt (NaCl) coming into the raingarden during winter and being present in the raingarden over time. This is supported by high levels of Cl (94.2 mg/L) and the negative retention observed for both Cl (-248%) and Na (-215%), as well as high conductivity observed in the sensor data. Another interesting result is the negative retention of Zn (-245%), with more than three times as high levels of Zn observed in the outlet compared to the inlet. Zn is often used as an inorganic marker for TWP. However, the high levels of Zn observed in the outlet do not match the levels of TWP in the outlet, nor the levels of organic tire-related compounds. The relationship between the TWP, TSS and tire-related organic compounds were tested for linear correlation, in which high correlation ($R>0.8$) was found between 6PPD-Q and ABT (0.86), BT (0.94) and OHBT (0.86). No correlation was found between TWP or TSS and the tire-related compounds. Multivariate relationships were explored using PCA and RDA. The data presented are an important contribution to the scientific community, both for the presence of these compounds in road runoff and for the assessment of raingardens as nature-based solutions in urban areas.

BIO of Presenter:
Vaidotas Kisielius is a researcher specializing in environmental chemistry, with expertise in organic micropollutant monitoring and treatment technologies. His work focuses on advancing nature-based solutions and high-resolution analytical methods to improve urban water quality. He is currently based at Aarhus University.

IN SITU QUANTIFICATION OF AEROBIC PROCESSES IN SATURATED ZONES OF TREATMENT WETLANDS

F. Louage [1], S. W. H. Van Hulle[1], H. Peeters[2], F. Gritten[2], D. P. L. Rousseau[1]*
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Treatment wetlands (TWs) are engineered systems for wastewater treatment, where physical, chemical, and biological processes occur simultaneously. Quantifying these processes enables more targeted TW design based on specific wastewater characteristics.

The single well push-pull test (SWPPT) is a non-destructive in situ method suited for determining reaction rates under realistic conditions. A solution with known constituents is injected into the saturated zone and later extracted. Changes in solute concentrations, measured at different intervals, indicate whether consumption, production, or no reaction occurred. Reaction rate constants and stoichiometric ratios can then be derived from this change in solute concentrations. SWPPTs can be applied at different depths and locations in TWs, offering spatial resolution.

Multiple SWPPTs were performed on a compacted French-style TW in Dinant, Belgium, which receives raw municipal wastewater. The wastewater is batch fed on top of the TW. Next it infiltrates through an unsaturated gravel layer before entering a saturated zone below. The height of the saturated zone is set manually by controlling the drainage level.

Aerobic SWPPTs revealed that only depth—not horizontal position—influenced first-order rate constants (Figure 1). The oxygen-to-COD consumption ratio, governed by the heterotrophic yield coefficient (Y_H) averaged 0.58 ± 0.12 g COD g COD^{-1} across all tests, with no spatial variation (Figure 2).

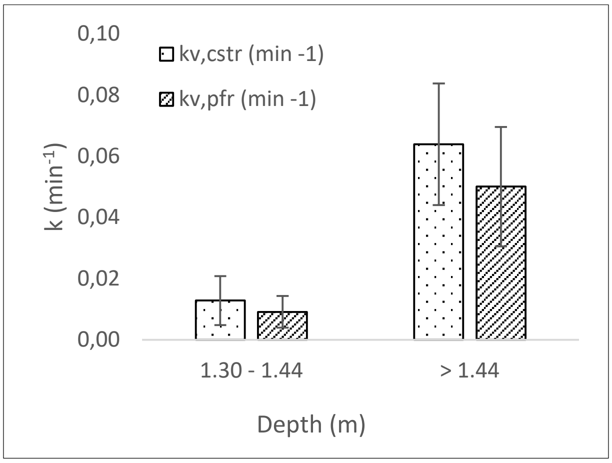

Figure 1: The volumetric first-order aerobic rate constants calculated considering the SWPPT as a well-mixed (CSTR) reactor and a plug-flow (PFR) reactor.

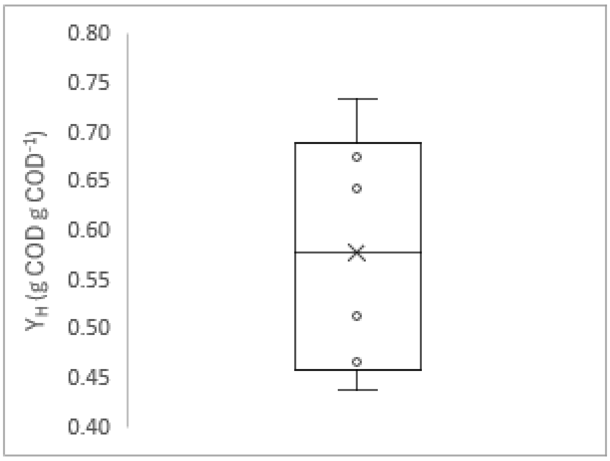

Figure 2: Box plot of the heterotrophic yield coefficient Y_H (g COD g COD^{-1})

BIO of Presenter:
Flor Louage is a PhD student and teaching assistant at Ghent University, Campus Kortrijk. He is involved in topics around nature based solutions for wastewater treatment. He did his master thesis in Ecuador on the treatment of shrimp pond effluent with local available macroalgae.

OPTIMIZATION OF A VERTICAL FLOW CONSTRUCTED WETLAND TREATING HIGH LOADS OF IMPORTED WASTEWATER: A CASE STUDY FROM WYŚMIERZYCE, POLAND

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In December 2024, a vertical flow constructed wetland (VFCW) system was commissioned in the town of Wyśmierzyce, Poland. Designed for a treatment capacity of 90 m^3/day, the system includes an Imhoff tank, a receiving station for imported wastewater, a mechanical screen, and two vertical flow filters. According to initial design parameters, up to 30% of the total wastewater was expected to originate from transported sources. In practice, however, this share has reached up to 60%, posing operational challenges due to the high variability and extreme pollutant loads of imported wastewater.

A five-month monitoring and optimization program was conducted to evaluate and enhance system performance under real-world conditions. Influent from septic tanks showed high pollutant concentrations, with average COD exceeding 3,500 mg/L, BOD_5 over 1,200 mg/L, and total suspended solids (TSS) above 1,700 mg/L. In comparison, domestic wastewater from the sewer system contained lower but still substantial loads (COD ~1,200 mg/L, BOD_5 ~420 mg/L, TSS ~310 mg/L). Despite these challenges, effluent concentrations consistently remained below legal thresholds (COD ~150 mg/L, BOD_5 ~40 mg/L, TSS ~50 mg/L).

To improve treatment efficiency and operational resilience, several optimization strategies were tested, including effluent recirculation (from both treatment stages), artificial aeration, and controlled mixing. Temperature-dependent performance variations were also documented, highlighting the importance of adaptive process control. The results demonstrate that with tailored management strategies, VFCWs can successfully handle atypically high loads from imported wastewater.

This presentation will share key operational insights and practical recommendations for the design, construction, and management of constructed wetlands treating variable influent sources. We believe this case study will be particularly valuable to practitioners facing similar challenges in decentralized wastewater treatment contexts.

Keywords: constructed wetlands, vertical flow, imported wastewater, decentralized treatment, process optimization, Poland

BIO of Presenter:

Łukasz Rodek is CEO of RDLS sp. z o.o. and a science manager at the University of Warsaw. RDLS designs and builds constructed wetlands in rural Poland and is the Polish partner of Global Wetland Technology. He focuses on practical applications of nature-based solutions for decentralized wastewater treatment.

EVALUATION OF POLLUTANT REMOVAL FROM ROAD RUNOFF USING FOUR DIFFERENT FILTER MEDIA

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Objectives

Stormwater runoff from roads frequently contains pollutants such as heavy metals, microplastics and organic compounds. This runoff is often drained into surface waters or decentralized infiltration systems, which raises environmental concerns. As part of the Horizon StopUP project, a case study is being evaluated in the city of Antwerp, Belgium, where runoff is treated through a sedimentation buffer and a filtration system, before being infiltrated into swales in a nearby park. The catchment covers an area of 4,5 hectares, with 75% impervious surface mainly being used as high-traffic roads (average daily traffic = 20.000 – 24.000 vehicles per day). This study aims to gain insights into runoff water quality within the catchment and to evaluate the removal capacity of different filtration systems for pollutants found in the catchment.

Materials and methods

To evaluate runoff quality, 12 grab samples were collected at the catchment drain and were analyzed in the lab. Additionally, the performance of four different filter media was evaluated using column tests. Four 7-liter columns were connected to an influent buffer, with pumps and flow meters installed to maintain a 1-hour retention time. Effluent from each column was collected in separate buffers. The columns were filled with four different filter media: sand, a 90/10 mixture of sand and activated carbon, a mineral-shell mixture (as used in the Urban Rainshell System, URS), and calcareous crushed stone (used as an infiltrating subfoundation for roads). Stormwater runoff from five rainfall events was collected onsite and filtered through each column in the lab. Influent and effluent samples were analyzed for 89 parameters, including TSS, COD, pH, chloride, nutrients, heavy metals and 50 PFAS compounds.

Results and conclusions

Elevated concentrations of total suspended solids (TSS, mean = 197 mg/L), chemical oxygen demand (COD, mean = 141 mg/L), total phosphorus (mean = 0,50 mg/L), copper (mean = 56,25 µg/L), lead (mean = 34,21 µg/L) and zinc (mean = 137,42 µg/L) were found in the influent samples. Sand filtration achieved average reductions in TSS (83%), COD (54%), total phosphorus (70%), lead (84%), and zinc (76%). However, copper removal was inconsistent, with effluent concentrations occasionally exceeding influent concentrations, likely due to remobilization of retained particles. The addition of activated carbon to the sand columns did not improve removal efficiencies and frequently led to higher effluent pollution concentrations. The mineral-shell mixture showed better performance, with average reductions in TSS (84%), COD (64%), total phosphorus (70%), lead (87%), and zinc (89%). The calcareous crushed stone performed the best overall, achieving reductions in TSS (90%), COD (68%), total phosphorus (73%), lead (88%), and zinc (92%).

The results of both the on-site monitoring campaign and the laboratory column tests confirm the necessity of treating stormwater runoff from high-traffic roads and show the potential of different filter media to tackle this challenge.

BIO of Presenter:
Neil Van den Broeck graduated from KU Leuven in 2020 with a degree in Environmental Engineering. At Aquafin, the wastewater utility of Flanders, Neil specializes in Sustainable Urban Drainage Systems (SUDS) for stormwater management.

BIOENERGY GENERATION AND REMOVAL OF SELECTED HEAVY METALS IN A FLOATING TREATMENT WETLAND SYSTEM LINKED WITH A MICROBIAL FUEL CELL

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Integrated systems of floating treatment wetlands (FTW) and microbial fuel cells (MFC) are a novel wastewater treatment approach (Colares et al., 2021).

As part of the 3M-WETCELL project, the effectiveness of nutrient purification (nitrogen, phosphorus, COD) and chosen heavy metals (Cu, Cd) in MFC and FTW-MFC systems planted with selected plant species - Phragmites australis (Pa) and Iris pseudacorus (Ip) was analyzed. The short-term (14-day) experiment utilized four medium-scale reactors (10 L): (1) FTW-MFC Pa, (2) FTW-MFC Ip, (3) FTW-MFC mix Pa+Ip, and (4) MFC. The reactors received synthetic wastewater with the following parameters: COD=350±7 mg/L, N_{total}=30±3 mg/L, P_{total}=10±1 mg/L, and chosen heavy metal dosages in pairs: Cu-Cd, Cd-Pb, and Pb-Cu. The initial heavy metal concentration was set at 5±0.3 mg/L. The 'batch' system was utilized to evaluate each configuration's purifying efficiency and bioenergy output.

In reactors fed with nutrients and Cu-Cd after 14 days, COD reduction was 62-68%, N_{total} 17-64%, and P_{total} up to 31% (FTW-MFC (3)); in MFC (4), no decrease in P_{total} was observed. Cadmium and copper were mostly deposited in roots, with removal efficiencies of (1) 46%, Cu 67%; (2) 40%, Cu 79%; and (3) 25%, Cu 69%. In the multi-species system, Cd removal was restricted. The maximum metal reduction was seen in MFC (4): Cd 90%, Cu 83%. Bioenergy generation was greatest in reactors (2) - 173.5 mV and (4) - 162.8 mV. The findings corroborate the efficacy of FTW-MFC and MFC in wastewater treatment and metal removal, showing a significant application potential.

References:

Colares, G.S., Dell'Osbel, N., Barbosa, C.V., Lutterbeck, C., Oliveira, G.A., Rodrigues, L.R., Bergmann, C.P., Rodriguez Lopez, D., Lawisch Rodriguez, A., Vymazal, J., Machado, E.L. (2021). Floating treatment wetlands integrated with microbial fuel cell for the treatment of urban wastewaters and bioenergy generation, Science of The Total Environment, Volume 766, 142474, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2020.142474.

Acknowledgements: The project „Integrated approach 3M (Macrophytes-Microbiome-Modelling) to elucidate mechanisms of bioenergy production and micropollutants transformation in Floating Treatment Wetlands combined with Microbial Fuel Cells" was funded by the National Science Centre in Poland within OPUS 22 [UMO-2021/43/8/NZ0/00787].

<u>BIO of Presenter</u>: Since 2016, Ph.D. Nicole Nawrot works as an assistant professor at Gdańsk University of Technology. In 2021, she finalized a Ph.D. in engineering and technological sciences. Her research interests include the presence of heavy metals in the environment, phytoremediation of contaminated sediments, soils, and wastewaters, nutrient cycling, and eutrophication prevention.

ENHANCING WASTEWATER TREATMENT AND ENERGY GENERATION THROUGH ELECTRODE-ASSISTED FLOATING TREATMENT WETLANDS

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Introduction
Floating Treatment Wetlands (FTWs) are a sub-type of Constructed Wetlands (CWs), not requiring substrates, but relying on buoyant rafts with plant roots extend in the water column. The effectiveness of wastewater treatment in FTWs is primarily driven by the bioactive surface area formed by plant roots, rhizomes, and biofilm, which facilitates key processes such as adsorption, nitrification, denitrification, and organic matter degradation (Colares et al., 2020). Microbial fuel cells (MFC) integrated with FTW represent a novel approach to wastewater treatment that simultaneously enables bioenergy generation. The oxidizing reactions occur on the anode, which works as an electron acceptor, while reduction processes take place on the cathode, which serves as an electron donor. This research investigated bioenergy production and COD, TN, and TP removal in mesoscale floating treatment wetlands integrated with electrodes (FTW-MFC) using *Phragmites australis* and *Iris pseudacorus*.

Materials and Methods
The experimental setup consisted of three reactors: FTW-MFC-PA (planted with *Phragmites australis*), FTW-MFC-IP (planted with *Iris pseudacorus*), and MFC (unplanted). All reactors, each with a volume of 0.15 m^3, were placed in a greenhouse. The experimental period lasted from August 8th to August 22nd, 2024, and followed a plant adaptation phase involving gradually increasing pollutant loads. Each of the three tanks was equipped with two graphite-based electrodes forming the MFC. The reactors were fed with synthetic wastewater and operated in batch mode with a duration of 14 days.

Results and discussion
The results indicate a clear advantage in pollutant removal efficiency for FTW-MFC reactors. In particular, for COD and TN, the removal efficiency exceeded 90% in the reactor planted with Phragmites (COD RE 94%, TN RE 95%). Effective treatment was also achieved with Iris, resulting in 89% COD removal and 71% TN removal. In terms of total phosphorus removal, the reactor without plants (MFC) performed better, achieving a TP removal efficiency of 69%, which was 33% higher than FTW-MFC-IP and 14% higher than FTW-MFC-PA. During the 14-day experiment, significant voltage generation was also recorded, with the highest value observed in the MFC reactor without plants, reaching 492.8 mV. The strongest correlation between temperature and voltage generation was also noted in this reactor, higher temperatures during the day corresponded with increased voltage, which may be linked to enhanced microbial activity at higher temperatures. On the other hand, the FTW-MFC reactors generated lower voltage, which may be related to internal resistance caused by the plants. The average voltages recorded were 126.4 mV for FTW-MFC-IP and 30.1 mV for FTW-MFC-PA. These results indicate more efficient wastewater treatment performance in the FTW-MFC integrated reactors, though some limitations in voltage generation were observed in such systems.

References:
Colares, G.S., Dell'Osbel, N., Wiesel, P.G., Oliveira, G.A., Lemos, P.H.Z., da Silva, F.P., Lutterbeck, C.A., Kist, L.T., Machado, ˆE.L., 2020. Floating treatment wetlands: a review and bibliometric analysis. Sci. Total Environ. 714, 136776 https://doi.org/10.1016/j.scitotenv.2020.136776.

BIO of Presenter:
Joanna Strycharz is a Ph.D. candidate at Gdańsk University of Technology, interested in nature-based solutions for wastewater treatment. Her research focuses on microbial fuel cells and plant-based systems for sustainable water management.

CONTAMINANT MIXTURE IMPACTS ON CONSTRUCTED TREATMENT WETLAND NITROGEN REMOVAL PROCESSES: A MESOCOSM STUDY

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Constructed treatment wetlands are used extensively across the world to mitigate surface runoff. While wetland treatment for nitrogen mitigation has been comprehensively reviewed, the implications of contaminants mixtures such as common-use pesticides, pharmaceuticals, and PFAS on nitrogen processes in treatment wetlands remain relatively unreviewed. Therefore, this study sought to determine the impact of contaminant mixtures often observed in regional rivers on nitrogen removal processes (e.g., microbial denitrification, plant uptake) in two constructed treatment wetland designs at a mesocosm scale. The contaminant mixtures were determined based on their occurrence and concentrations observed across regional surface waters in both urban (imidacloprid, caffeine, and PFOS) and rural (atrazine, glyphosate, and sulfate) environments that are used as drinking water sources. Two types of constructed treatment wetlands, floating treatment wetlands (FTWs) and free water surface wetlands (FWSs), along with planted and un-planted controls received batch applications to determine the impact of wetland design and contaminant mixtures on treatment removal potential using 24 mesocosms with replicates of three. Five experiments were conducted to determine if the addition of imidacloprid, caffeine, PFOS, atrazine, glyphosate, and sulfate impacted nitrate-N removal when present alone and as a mixture. This was followed by a ^{15}N tracer enrichment study to determine the specific nitrogen processes impacted by the contaminant mixtures in these wetlands. Contaminant mixtures were observed to inhibit nitrate-N removal from the water column compared to the presence of individual contaminants. However, 72–99 % of the nitrate-N was removed despite the wetland design or the presence of contaminant(s). The FWSs outperformed the FTWs earlier in the growing season (May–June) during cooler water temperatures, while the FTWs outperformed the FWSs once plants reached maturity and temperatures increased (July–September). Significant removal of contaminants were observed in both wetland designs with 28–89 %, 63–70 %, >90 %, and >92 % removal for PFOS, caffeine, glyphosate, and atrazine, respectively, while limited removal of sulfate was observed (≤57.9 %). Findings provide an improved understanding of the impacts different types of contaminants have on nitrogen removal processes within these systems. Further, observations provide guidance for constructed treatment wetland designs to be retrofitted specifically to treat and manage these contaminants while meeting nutrient removal goals.

Tiffany L. Messer, PhD:
Dr. Tiffany Messer is an associate professor and Gatton Foundation Endowed Chair at the University of Kentucky. Her work focuses on identifying, tracing, and treating nutrients and emerging contaminants using ecological engineering principals. She has been awarded over $23 million as PI or co-Pi and published over 44 peer-review publications.

REMOVAL OF PATHOGENIC INDICATORS IN AN AERATED HORIZONTAL FLOW TREATMENT WETLAND

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To face the challenges of climate change, many countries investigating reuse of treated wastewater. Nature-based solutions for wastewater treatment have shown a potential for contributing towards water reuse and circular water management. However, the capacity of treatment wetlands to remove the pathogenic indicators defined by reuse regulations remains an open question. The requirements for reuse of treated water in agriculture for the pathogens are set out in the regulation and must be as follows: lower than 10/100/1,000/10,000 CFU per 100mL respectively, for A/B/C/D classes, for *Escherichia coli*, total coliphages, *Clostridium perfringens* (or anaerobic sulfite-reducing bacteria spores). For the physico-chemical parameters must be lower than 5 NTU for turbidity and 10mg/L for TSS and $CBOD_5$.

Pathogen removal in passive horizontal flow treatment wetlands is limited (1 to 2 log per treatment stage for *Escherichia coli*). The addition of aeration has shown to improve *Escherichia coli* removal providing up to 4-log removal (Nivala et al., 2019). Despite being widely used as model, *E. coli* removal may not be representative of other groups of microorganisms such as viruses and protozoa.

A 20m² aerated horizontal flow treatment wetland fed with primary treated domestic wastewater was monitored over one year (from July 2024 August 2025, n = 36 samples). The performance of the system was assessed through the monitoring of conventional pollutants (COD, TSS, TOC, TN, NH_4-N, NO_3-N), physico-chemical parameters (DO, pH, ORP, Temperature) and pathogenic indicators (*Escherichia coli*, total coliforms, anaerobic sulfite-reducing bacteria spores, *Legionella pneumophila*, helminths, somatic coliphages).

Initial results showed 95% removal of COD, 42% removal of TN, and 99% removal of NH_4-N. Over the course of the study, the system showed geometric mean Log Removal Values (LRV) of *E. coli* (3.2 log), total coliforms (2.8 log) and anaerobic sulfite-reducing bacteria spores (1.8 log). The initial results show that elimination was not homogenous between different pathogens. The elimination of total coliforms and other bacteria was observed to be less than that of *E. coli*, suggesting that removal processes differ for these bacteria as well as for anaerobic sulfite-reducing bacteria spores. Over the course of this study, the treated effluent corresponded to class B in accordance with national French regulations on water reuse.

Further measurements involving other pathogens such as *Enterococcus faecalis* and *Legionella pneumophila* are in progress to investigate the potential of aerated treatment wetland technology to contribute to safe reuse of treated wastewater. Future research will focus on combining conventional colorimetric quantification monitoring methods with membrane filtration and molecular biology methods such as qPCR.

BIO of Presenter:

Diana Le Berre is a post-doctoral researcher at INRAE, research unit REVERSAAL. She has a PhD in molecular biology. Her current research focuses on wastewater treatment and how new methods in microbiology can help characterize microbial risks in treated wastewater.

HYDRUS 2D TO MODEL THE WASTEWATER FLOW AND POLLUTANTS REACTIVE TRANSPORT IN A FULL-SCALE HYBRID TREATMENT WETLAND IN SICILY

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Abstract

This study evaluates the treatment performance of a 11-year-old hybrid treatment wetland (TW) system treating effluents of the IKEA® store of Catania, southern Italy. The process-based model HYDRUS, with its Wetland Module, was used to simulate the water flow and the pollutants reactive transport within one horizontal and two vertical TW units. The biokinetic models CWM1 and the CW2D included in the Wetland module, were utilized to simulate TW units. This research aims to: (i) identify sensitive model parameters for guide data collection and prioritizes monitoring activities; (ii) provide a comprehensive understanding of hybrid-TW system processes by integrating both actual monitoring and predicted model data; (iii) evaluate the performance of each TW units. For the simulation study the Version 3 of the HYDRUS software is used. This software was designed for simulating water, heat and pollutants movement in one-, two- and three-dimensional variably saturated media. In the present study, to address the pollutant degradation, the biokinetic model CWM1 is chosen for the HF unit and the biokinetic model CW2D for the VF units. To calibrate and validate the transport model, tracer investigations and chemical wastewater tests were conducted.

Preliminary results have been obtained regarding HF unit for the period 2016-2022. These results show that the model is able to predict effluent concentrations also in case of high loads. In this case, TW's biological processes require more time to break down the increased organic load and reach a new stable outlet concentration. This emphasizes the need of considering peak load scenarios to correctly design and manage TWs. Despite the short observation period, the model effectively simulated the treatment unit's response to peak load events.

The results of the present work could confirm and strengthen previous findings, serving as a reference point for model validation through further simulations on the HF unit and the VF units as new observed data becomes available. The HYDRUS model can be a valid tool for a comprehensive understanding of the treatment performance of hybrid-TW systems subjected to highly variable loads in Mediterranean areas, once monitoring concentrations data are available at the inlet and at the outlet of each TW units.

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Acknowledgement

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DESIGNING GREEN WALLS FOR GREYWATER TREATMENT: CLIMATE INFLUENCE ON TREATMENT PERFORMANCE

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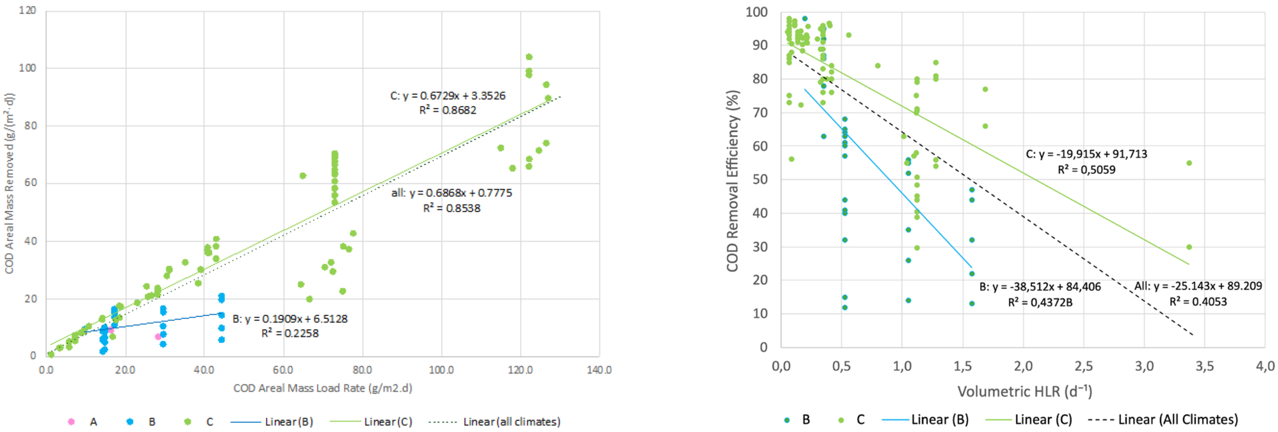
Green walls for greywater treatment have emerged as a solution to increase green spaces in densely urbanized areas while providing treated greywater for reuse. The present study conducted an extensive review of existing literature that addressed the treatment performance of green walls for greywater treatment, using a meta-analysis to identify key operational factors and treatment performance metrics. A total of 33 studies were identified and classified using the Köppen-Geiger climate classification, and analyzed the performance of COD, BOD, TOC, TSS, NH_4^+, TN, TP, and bacteriological parameters across different climate zones.

The performance indicators that more accurately predicted treatment performance were areal mass load and areal mass removal, especially for organic matter and nitrogen. Removal efficiency showed a high variability and more diffuse patterns, and as such should be addressed carefully given its relative nature. In general, Temperate climates showed better performance when compared to Arid climates. Regression equations based on mass loads were produced to assist in system design regarding organic matter, TSS, ammonia and total nitrogen. An example can be found for COD in Figure 1.



a) b)

Figure 1 – COD treatment performance for climate zones A (tropical savanna), B (Dry Arid) and C (Temperate): a) areal mass removed as a function of areal mass load; b) removal efficiency as a function of volumetric hydraulic loading rate.

Bacterial contamination parameters were only available for Temperate climate, where removals varied between 1 and 3 log for *E. coli*. As such, for specific reuse applications, the inclusion of a disinfection unit is advised to meet microbiological quality standards.

The findings also highlight the influence of filling media on treatment performance, such as coco coir mixtures, especially in Temperate areas.

Acknowledgments: The authors acknowledge the financial support of the Foundation for Science and Technology (FCT) through the project UIDB/04625/2025 of the research unit CERIS.

<u>BIO of Presenter</u>:
Ana Galvão is an Assistant Professor at Instituto Superior Técnico since 2003. Her research interests are focused on Nature-Based Solutions for water reuse and circularity, including constructed wetlands and green walls for greywater treatment

WATER PURIFICATION PERFORMANCE AND CARBON TRANSFORMATION MECHANISMS IN A LARGE RIVERINE CONSTRUCTED WETLAND

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Constructed wetlands serve as important ecosystems for water purification and carbon cycling. This study investigated a large riverine constructed wetland during its trial and stable operational stages, focusing on spatial–temporal water purification performance, sediment carbon burial, and the role of microbial communities in regulating carbon source/sink transitions.

The results showed clear spatial heterogeneity and a gradual improvement in water purification efficiency, particularly in COD and TN removal (increased from <25% to >40%). The pre-sedimentation ecological ponds (P) and subsurface flow wetlands (W) were the primary purification units, while posterior aquatic plant ponds (Z) exhibited mixed effects—reducing TP but sometimes increasing COD and NH_4^+-N concentrations. Throughout both stages, the wetland acted as a net carbon sink, with W units consistently sequestering the most carbon.

Sediment carbon burial varied by hydrological conditions and vegetation type. Resistance organic carbon (OC) was the dominant form, accounting for 74%–91% of total buried carbon, particularly in W units. Higher C/N ratios and water onion roots enhanced stable carbon deposition downstream. Carbon content in sediment was negatively correlated with overlying water COD, indicating a strong interaction between water quality and carbon storage potential.

Bacterial community succession reflected flow direction and operational maturity. Initially dominated by riverine species, the community evolved into a more stable, vegetation-linked microbiome. Plant-microbe symbiosis and elevated C/N ratios in W units supported the formation of stable carbon sinks. Functional predictions indicated that P, shore, and Z zones contributed more to methane oxidation and anaerobic fermentation, complementing the carbon sequestration processes of W units.

These findings emphasize the multifunctionality of constructed wetlands in nutrient removal and climate mitigation via carbon sequestration, providing insights into optimizing wetland design and management.

Keywords: Constructed Wetland, Water Purification, Carbon Sink, Carbon Source, Microbial Community

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Weidong Wang is a professor at the Research Center for Eco-Environmental Sciences of the Chinese Academy of Sciences, focused on the structure, function, and restoration of wetlands and land/inland water ecotones, as well as the ecological drinking water source protection.

FATE OF EMEGING BIOLOGICAL AND CHEMICAL MICROPOLLUTANTS IN SURFACE FLOW CONSTRUCTED WETLANDS

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Surface flow constructed wetlands, as a nature-based solutions (NbS), are designed and engineered to integrate seamlessly into ecosystems, leveraging naturally occurring microbial, plant, and soil processes to be able to purify contaminated water, air, and soil, particularly in reducing excess nutrients. In the changing world, the emergence of chemical and biological micropollutants (ECBMs), such as microplastics, pathogens, antimicrobial resistance genes, and per- and polyfluoroalkyl substances (PFAS) 'forever chemicals', presents unprecedented challenges. Unlike conventional pollutants like nutrients and organic matter, ECBMs are often recalcitrant, bioaccumulative, and toxic, posing significant ecological and health impacts even at trace concentrations. Microplastics have been found in human placentas, PFAS have polluted remote lakes, and antimicrobial resistance genes are increasingly reported in aquatic environments, driving the need for a One Health approach to manage these threats. While numerous studies have shown that NbS can effectively retain and mitigate some ECBMs, certain pollutants persist in NbS or transform into byproducts through biogeochemical processes, leading to long-term ecological risks and potential human health implications. Therefore, understanding the fate of ECBMs in NbS is critical to developing scalable, sustainable designs that ensure a better ecosystem.

This study investigated the removal and pathways of PFAS, microplastics, pathogens and antimicrobial resistance (AMR) in different applied surface flow constructed wetlands in the UK and Ireland. The systems demonstrated their capacities to safeguard natural water bodies by achieving discharge levels of the legacy PFOS (4–4.6 ng L^{-1}) and PFOA (1.79–3.27 ng L^{-1}) with removal efficiencies of 29%–38% and 15%–34%, respectively. The removal of pathogens and antimicrobial resistance (AMR) achieved up to 3 log removal against pathogens and AMR. More interestingly, the presence of microplastics demonstrated significant correlation with other ECBMs, indicating their 'carrier' function of other pollutants. Further research is necessary to address these complexities, but the findings are encouraging for the use of such constructed wetlands as scalable, eco-friendly solutions for mitigating ECBMs pollution and are instructive for optimising wetland design and operation to safeguard aquatic ecosystems.

BIO of Presenter:
Dr Tao Lyu is a Senior Lecturer in Green Technologies and the Environmental Engineering MSc course director at Cranfield University. He received his PhD from Aarhus University in 2016, and his research focuses on the innovation and implementation of treatment wetlands for micropollutants removal.

THE IMPACT OF MODIFIED BIOCHARS ON GREYWATER TREATMENT PROCESSES AND PLANT CONDITION IN GREEN WALL SYSTEMS

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Introduction
Green walls are effective, visually appealing systems for treating stormwater and greywater, primarily through substrate absorption and plant nutrient uptake. Various substrates have been used, but the effect of biochar addition remains largely unexplored. Biochar is gaining attention in wetland systems, making its application in green walls promising. This study assessed how biochar and modified biochar influence greywater treatment efficiency. It also examined their impact on plant health, appearance, and growth.
Methodology
Biochar produced from sunflower husks was added to the plant substrate containing sedge species, in comparison to pots without biochar. The setup consisted of three rows. The study focused on the efficiency of greywater treatment, along with an analysis of plant condition in relation to the substrate amendments. Biochar properties were also examined, including composition, SEM imaging, BET surface area analysis, and functional group identification using FTIR.
Results&Discusion
The results of the experiment showed that during the initial months, the treatment efficiency in columns with biochar was higher as showed in Figure 1. However, the results of plant analysis were similar for pots with and without biochar addition.

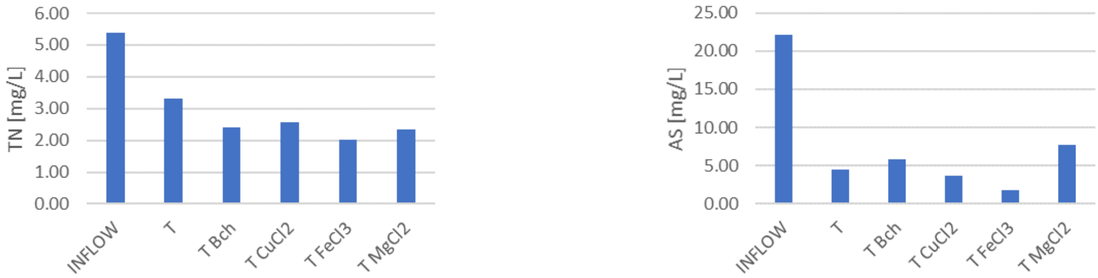

Figure 1 Results of anionic surfactant (AS) and total nitrogen (TN) removal in columns with the addition of various types of sunflower-derived biochar (Bch) modified with $CuCl_2$, $FeCl_3$, and $MgCl_2$, in comparison to the column without biochar (T) and the inflow concentration (INFLOW).

Conclusion
The wastewater treatment efficiency in green wall systems is high, applying not only to greywater but also to other types of wastewater, as confirmed in the literature. Particularly high treatment efficiency was achieved in pots with biochar modified with $FeCl_3$.

<u>BIO of Presenter</u>:
Karolina Matej-Łukowicz is an Assistant Professor at the Faculty of Civil and Environmental Engineering at Gdańsk University of Technology. Her research focuses on the phytoremediation process, with particular emphasis on its application in green wall systems. Since 2021, she has been investigating the influence of plant species, substrates, and green wall additives on the treatment efficiency of greywater.

ASSESSMENT OF CARBON AND NITROGEN ACCUMULATION AND RELEASE FROM THE ABOVEGROUND BIOMASS OF *MACROPHYTES* IN THE FREE-WATER SURFACE TREATMENT WETLAND IN ESTONIA

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Free-water surface treatment wetlands (FWS TWs) effectively reduce agricultural diffuse pollution. However, there is still a lack of information about the role of macrophytes in the uptake and release of C and N in FWS TWs. The amount of aboveground biomass and accumulated C and N removed by plant harvesting is unclear. When harvesting is not done, how quickly is this biomass decomposing, and are accumulated C and N released back to the water?

The main objectives of this study were to: a) determine the C and N uptake by macrophytes *Typha Latifolia* (broad-leaf cattail) and *Phragmites australis* (common reed) in FWS TW for agricultural diffuse pollution control in Estonia; b) determine the distribution and accumulation of C and N between the above- and belowground during winter harvesting; c) determine the decomposition rate of aboveground biomass that when not harvested ends up back in the wetland water and sediments.

Macrophytes were harvested during five winters (2018, 2019, 2021, 2022, and 2023) at 6 locations on the Vända TW (58.2826412, 26.722779). The aboveground biomass was harvested, and dry weight was measured from a 0.25 m^2 area per location. The roots and rhizomes were harvested and measured only in 2022 and 2023 using a 20 cm diameter metal pipe. From all samples, the C and N content were analyzed. To determine the decomposition rate of the aboveground biomass, the net sample bags (in 3 replicates), with leaves and stems, were inserted into water and sediment in 6 locations in the FWS TW for two years. The FWS TW results were compared with those of a eutrophic lake and a restored peatland. The changes in dry weight were measured from initial leaves and stems and from bags after 0.5, 1.0, 1.5, and 2.0 years. Changes in TC and TN content from the biomass were measured initially, after 0.5 and 2.0 years.

The winter harvesting of the aboveground biomass removed approximately 50% of plant biomass, and about 30% of N and P accumulated in the macrophytes, as most nutrients were already stored in the rhizomes by the end of the growing season. In the decomposition experiment, all leaves and stems showed a gradual decrease in biomass weight. The median remaining mass of cattail leaves and stems after 2 years in the water was 44% and 62%, respectively. In the TW sediment, the remaining mass was 52% of leaves and 63% of stems. The common reed leaves and stems decomposed more slowly than cattail in TW water and sediment (after 2 years in water, the leaves had 65% and in the sediment 78%; stems in water, 60%, and in the sediment, 75%). The C content in the remaining leaves and stems didn't change significantly compared to the initial contents. The N content of leaves and stems increased over time in water and sediment in all ecosystems. The changes of the C and N pools over time depended on the tissue type (leaves, stems). In cattail leaves, the remaining C% was smaller in TW water than in TW sediment after 6 months, but the differences disappeared after 2 years. Interestingly, the decomposition rate of leaves and stems of both species in TW during 2 years had in general much slower decomposition rate than in lake water (mass remaining of reed leaves 0% and stems 48%) and in restored peatland water (mass remaining of reed leaves 78% and stems 75%; cattail leaves 42% and stems 77%). These results help determine the optimal frequency of aboveground biomass harvesting, ensuring minimal release of N and C back to water during biomass decomposition.

BIO of presenter:
Margit Kõiv-Vainik is an Associate Professor in environmental technology at the University of Tartu. She conducts process-based research to enhance the efficiency of blue-green infrastructures in removing contaminants from urban stormwater, agricultural diffuse runoff, and wastewater from different sources.

EVALUATION OF THE FATE OF ORGANIC MICROPOLLUTANTS IN AN AERATED PILOT-SCALE TREATMENT WETLAND FOLLOWED BY TERTIARY ADSORBENT TREATMENT FOR COMBINED SEWER OVERFLOWS

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Context and objectives

Treatment wetlands (TWs) have demonstrated good efficiency in treating the major pollutants in combined sewer overflows (CSO), but their effectiveness remains limited for the dissolved fraction of micropollutants. One of the objectives of the NICE project was to evaluate the fate of organic micropollutants (mainly pharmaceutical) (i) in an aerated TW treating CSO, followed by (ii) two columns filled with specific adsorbent materials.

Methodology

The aerated TW was a pilot of 20 m^2 and 1.15 m in depth with 20 cm of gravel (2/4 mm) as an unsaturated filtration layer and a 95 cm-height bottom layer of coarse gravel (10/20 mm), permanently saturated. The pilot was fed with domestic wastewater mixed with stormwater (ratios ranging from 1:4 to 1:13 and highly diluted WW to reach typical concentrations of CSO) during more than a year. Samples were collected at the inlet and outlet of the pilot.

Both tertiary treatment columns had a diameter of 20 cm and contain 20 cm of specific adsorbent material such as, for the first column (C1): Rainclean® (commercial mixture including zeolite, iron hydroxide, coco fibers, activated carbon, lime, specifically developed for stormwater treatment) and for the second column (C2): biochar (Terra Fertilis®, produced from plant biomass). The columns were fed continuously at a rate of 0.32 m/h for 80 days after the pilot monitoring period and samples were collected at the inlet and outlet of the columns and at depths of 5 and 10 cm.

For both aerated TW and the columns, samples were analyzed for 63 organic micropollutants but not all could be detected or quantified in each sample.

Results

In general, the aerated TW showed positive removal efficiencies with considerable variability for both rubber products and pharmaceuticals. Compounds such as DEET, gabapentin and iomeprol, had moderate to low removal efficiencies for both filters, with median removal rates below 48%. Conversely, compounds such as carbamazepine had mostly negative removal efficiencies. The results showed moderate retention of micropollutants in the aerated CSO TW, with no considerable enhancement in removal due to aeration. The concentrations of organic micropollutants at the column inlet were lower than those measured at the pilot outlet. In general, biochar retained organic micropollutants better than Rainclean®. The highest retention efficiencies by the biochar were observed for benzotriazole (51%), amisulpride (49%), reaching concentrations below the limit of quantification, and 4-Methyl-1H-benzotriazole (69%). Irbesartan, which had mostly negative removal efficiencies in the aerated TW, showed retention of 12% and 17% after 20 cm of Rainclean® and biochar, respectively. Adding a treatment stage with an adsorbent material makes it possible to retain and/or complete the treatment of certain organic micropollutants contained in CSOs previously passed through an aerated TW. Given the range of micropollutants and their affinity for adsorption or not on different types of materials, it would be necessary to carry out lab tests (batch or dynamic) beforehand.

<u>BIO of Presenter</u>:

Ania Morvannou is a senior scientist at EcoBIRD who has been active in the field of treatment wetland modeling for the last 17 years. She owned a PhD degree from the UCL Louvain-la-Neuve, Belgium, and has previously been working at INRAE on several projects related to treatment wetlands.

THE EXPERIMENTAL GREEN WALL FACILITY. A LIVING FACADE FOR THIRSTY CITIES

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Water scarcity is an increasingly urgent challenge in urban environments, driving the need to implement sustainable water reuse strategies. Greywater represents 50% to 80% of total household wastewater (15–200 L/person/day), and contains fewer pollutants than blackwater, making it suitable for non-potable reuse. Green walls have emerged as compact, nature-based solutions for decentralized greywater treatment, aligning with urban sustainability goals by improving biodiversity, air quality, and resilience to water stress. They also offer co-benefits such as mitigating the urban heat island effect and increasing the green areas, which are scarce in many cities. Despite their potential, few real-scale studies report performance data, highlighting the need for more applied research into these systems.

Within this context, an ***Experimental Green Wall Facility*** has recently (February 2025) been constructed at the ICRA research center. The system, based on the "WetWall"[1], was designed to treat greywater (200 L/day) generated within the building, currently sourced from a kitchen sink and two washbasins on the upper floor, with gravity-fed flow to the treatment. The system consists of a pre-treatment stage (including a coarse filter and settler) followed by the green wall, installed on the facade of the building (Figure 1 left). The green wall is structured into three hierarchical levels: units, modules, and sectors. It comprises four independent sectors, each including a vertical module (five parallel units) and a horizontal module (three horizontal units) (Figure 1, right). This hybrid configuration enables both vertical and subsurface horizontal flows, promoting sequential aerobic and anaerobic conditions for enhanced treatment efficiency.
For this initial phase, which began in March 2025, a mixture of LECA and perlite (50-50%) are used as substrate in all sectors, while two types of plants are tested per sector: ornamentals (carex, ivy), aromatics (rosemary, lavender), edibles (lettuce, mint) and unplanted (control). The current target of the experiment is to evaluate the effluent quality for reuse and the plant health of the different sectors. The first results of the system's performance (hydraulics, contaminant removal, effluent quality, plant health and growth) are expected to be reported at the conference.

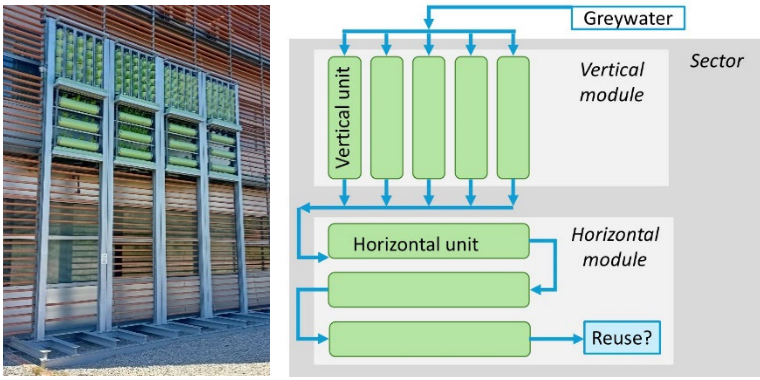

Figure 1. Picture of the greenwall (left) and scheme of the greywater flow through one sector (right).

[1] J.A. Castellar Da Cunha et al., 2018. https://doi.org/10.5004/dwt.2018.22143

<u>BIO of Presenter</u>: Esther Mendoza, postdoctoral researcher at ICRA, currently focuses her research on greenwalls for greywater treatment. With a PhD in Water Science and Technology and degrees in Environmental Sciences, she specializes in emerging contaminants' behavior and water reuse through membranes and nature-based solutions, combining advanced treatment technologies with sustainable environmental practices.

A PARADIGM SHIFT ON WILDFIRE: FROM PURE DISTURBANCE TO CATALYST FOR ORGANIC SOIL REWETTING

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Subtitle(s) if needed in Calibri 11pt bold

Organic soil rewetting is a key climate mitigation strategy, yet its implementation is often constrained by conflicts with agricultural land use. As wildfires increasingly affect drained organic soils, these fire-affected sites may become more socially acceptable for rewetting due to their diminished agricultural value. However, the post-rewetting greenhouse gas dynamics of such organic soils remain poorly understood. In this study, we simulated two levels of wildfire severity (5 and 10 minutes of surface burning) and assessed post-rewetting greenhouse gas responses over a three-month incubation. Results showed that compared to rewetting non-fire-affected soils, rewetting severely fire-affected soils can significantly reduce CH_4 emissions while maintaining CO_2 suppression, leading to a 60% reduction in total global warming potential. In contrast, rewetting slightly fire-affected soils increased both CH_4 and CO_2 emissions, ultimately leading to a 300% increase in total global warming potential. These contrasting results were associated with differing wildfire-induced changes in soil conditions (e.g., pH, electrical conductivity, and soil carbon stability) and microbial dynamics (e.g., methanogenic activity). Our findings suggest that severely fire-affected organic soils, which are often less suitable for agriculture, may offer both reduced land-use resistance and greater climate mitigation potential when rewetted.

<u>BIO of Presenter</u>:

Shihao Cui: PhD Fellow at Aarhus University, specializing in organic soil rewetting and greenhouse gas dynamics. He has published 3 first-author papers, including 2 in Nature Communications Earth & Environment and 1 in Environmental Science and Ecotechnology. He has also co-authored 2 papers in Environmental Science & Technology.

INTENSIFICATION STRATEGIES TO ENHANCE PERFORMANCE OF CONSTRUCTED WETLANDS FOR VALORISING ANAEROBIC DIGESTATE CENTRATE IN BIOGAS DESULPHURISATION

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Constructed wetlands (CWs) have emerged as a cost-effective and ecologically beneficial nature-based solution for wastewater treatment. Likewise, CWs offer a promising approach for treating complex wastewater streams such as anaerobic digestate centrate. However, to effectively manage this challenging effluent, further research is needed on intensification strategies to reduce the required land footprint to make them feasible and sustainable systems. Therefore, exploring intensification strategies is crucial to broader its applicability in treating such highly polluted streams.

Previous studies have investigated innovative multi-stage CWs using drinking water treatment sludge (DWTS) as a reactive substrate for valorising digestate centrate and its subsequent use as an electron acceptor stream in anoxic biogas biodesulphurisation, showing promising results. In these prior investigations, a reactive layer height of 0.30 m composed of a DWTS and sand mixture was employed.

Herein, this research explores lab-scale intensification strategies to reduce the footprint of these novel CWs. To this end, two 0.10 m diameter columns (A and B) were operated for 85 days treating digestate centrate, evaluating different reactive substrate mixtures and bed heights. In Column A, the increase in the percentage of DWTS material and the increase of the bed height of 0.80 m was studied. In Column B, the effect of doubling the bed height to a height of 1.60 m, while maintaining the relative filling percentage of the DWTS/sand mixture validated in previous studies, was investigated. The columns were operated in parallel under identical operational conditions for an experimental period of 85 days. In the start-up phase, which lasted 35 days, a system acclimatisation procedure was followed for the first 15 days. Columns were inoculated directly with activated sludge and enriched with secondary effluent from a Wastewater Treatment Plant (WWTP), and centrate feed concentration was progressively increased via dilutions until undiluted centrate was supplied. During 60 days, the columns were fed with centrate two cycles per day, with Hydraulic Loading Rates (HLRs) of 0.19 $m^3/m^2 \cdot day$ and 0.38 $m^3/m^2 \cdot day$ to Column A and Column B, respectively. At day 60, the feeding regime was changed to feed one cycle per day while maintaining the total daily HLR to assess the maximum treatment capacity per cycle.

A centrate stream with a mean NH_4^+-N concentration of 1185 ± 79 mgN/L was treated and average N concentrations (NO_2^--N + NO_3^--N) of 1089 ± 216 mgN/L and 1157 ± 203 mgN/L were obtained, reaching an average N production capacity of 238 ± 48 76 $gN/m^2 \cdot day$ and 434 ± 76 $gN/m^2 \cdot day$ in columns A and B respectively. Hence, in column B, a two-fold increase in N production capacity per square metre was successfully achieved without impairing the operation of the system. No significant differences were observed in the nitrification yields during 2-cycle or 1-cycle feeding operation, suggesting that the system has a potential higher treatment capacity. The high N concentrations obtained provide an ideal stream to be valorised in anoxic biogas biodesulphurisation. Results for column B are promising (2 m bed heights vs 0.5-1 m of heights conventionally used) to reduce significantly CW footprint. Hence, to validate these successful results and to test at a large scale, a pilot-scale intensified CW (1.5 m diameter, 3 m height) has been designed and built and is planned to be in operation in the next few months, so the preliminary results of this larger-scale system are expected in the coming months.

BIO of Presenter:
Rubén Hervás is a Chemical Engineer working in Wastewater Innovation Department of Global Omnium. He is currently pursuing his industrial PhD, investigating intensified constructed wetlands for the treatment of digestate centrate and their combination with biological technologies for biogas purification.

EXPERIMENTAL STUDY OF A PILOT GREEN WALL FOR GREYWATER TREATMENT IN TURIN (ITALY)

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In order to demonstrate the full-scale applicability of Nature-based Solutions for the management of greywater (GW; i.e., household wastewater excluding WC flushes), a pilot Green Wall was deployed at a cultural centre as part of the H2020 NICE project. Specifically, GW from office bathrooms is treated through vertical filtration across the Green Wall layers and subsequently reused for irrigation purposes within the cultural centre.

GW from bathroom sinks is stored in an underground degreaser to reduce the concentration of particulates and oils. GW is then pumped to the Green Wall, which has a vertical area of 6.5 m^2 (1.8 m width and 3.6 m height), with a designed treatment capacity of approximately 0.5 m^3/day. The structure consists of four modules, each containing three levels of eight pots, totalling 96 pots. Each pot is filled with 2.3 liters of filter media, i.e., a mixture of coconut fiber and lightweight expanded clay aggregate (LECA, 1–2 mm) (1:1), and sand (0.4–1 mm) (thin layer at the bottom). The system operates under an organic loading rate of 40 g COD/m^2/day and an oxygen removal rate of 15 g O_2/m^2/day, in line with the principles of vertical flow constructed wetlands operating under unsaturated conditions. GW is distributed across the upper portion of each module of the Green Wall using pressure-compensating valves. GW percolates vertically through the filter media of each pot, exits from the bottom, and flows sequentially through the following two levels of pots. A drainage channel at the base of each module collects the effluent, which is conveyed to a storage tank.
To assess water quality at both the inlet and outlet of the Green Wall, a monitoring plan has been implemented, measuring key physicochemical and microbiological parameters (e.g., turbidity, dissolved oxygen, electrical conductivity, temperature, BOD_5, COD, TSS, TP, TN, NH_4^+, NO_2^-, NO_3^-). This is complemented by a network of sensors monitoring hydro-climatic variables that influence the system's hydrological balance and are critical for plant growth. Two sensors—one installed on a bare wall and one on the Green Wall—measure air temperature, relative humidity, wet bulb temperature, and dew point temperature. Water level in the greywater storage tank is also monitored and temperature and volumetric water content are recorded in the media.

The results obtained from October 2024 to date indicate an initial stabilization phase in the Green Wall's performance. On one hand, the wall has begun to fulfil its pollutant filtering and removal functions, particularly with evidence of active nitrification. On the other hand, a temporary increase in TSS, COD, BOD_5, and total phosphorus has been observed in the effluent, attributable to the initial release of organic matter from the coconut fiber and very lightly polluted GW, since they originate only from washbasins. Further analyses are awaited at the end of the spring season, by which time the plants are expected to have fully developed their root systems and be operating at full physiological, ecological, and ecosystemic capacity. Ongoing analyses focus on hydro-climatic variables, particularly the temperature and humidity differences between the Green Wall and the bare wall. However, meaningful comparisons will only be possible once the vegetation reaches a mature stage of growth, at which point the evapotranspiration rate will become a decisive factor in temperature mitigation and air humidity regulation.

Fabiola Cannizzaro is a PhD candidate at Polytechnic of Turin, researching Nature Based Solutions. She is actually working on green walls and raingardens for water management and urban climate mitigation. Her work on Green Wall at Cecchi Point is developed within the NICE project.

FIRST STUDY ON EXPLORING SYNERGISTIC MECHANISMS OF GREENHOUSE GASES MITIGATION IN A PILOT SCALE WATERWORKS SLUDGE-BASED CONSTRUCTED WETLAND

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This study conducted a pilot-scale constructed wetlands (CW) investigation to demonstrate the promising potential of combining waterworks sludge (WS) with a novel pyrite-based lightweight substrate (PNLS) at a volumetric ratio of 2:1 to serve as a supplementary carbon source as substrates in CW systems. In addition to enhancing wastewater purification, such substrates can reduce greenhouse gas (GHG) emissions, simultaneously. The incorporation of the sulfur–iron (S-Fe) composite derived from pyrite significantly enhanced nutrient removal and effectively mitigated GHG emissions. The PNLS amendment notably improved nitrate removal, achieving optimal total nitrogen (TN) removal efficiency (75.9 ± 3.7%) through synergistic autotrophic denitrification and Feammox pathways. Concurrently, total phosphorus (TP) removal efficiency reached 94.3 ± 1.0%. Compared with the WS-only substrate system, the WS-PNLS configuration achieved the lowest integrated global warming potentials (GWP) at 27.33 mg/m^2/h CO2-eq., representing a 46.4% reduction in GHG emissions. Furthermore, the abundances of functional genes related to nitrification (AOA and AOB), denitrification (nirS, nirK, and nosZ), autotrophic denitrifiers, and methanotrophs were significantly enriched supporting a mixotrophic microbial environment conducive to GHG mitigation. Overall, this study proposed a novel substrate strategy for overcoming the limitations of low-carbon wastewater treatment in CWs while simultaneously achieving effective GHG emission reduction.

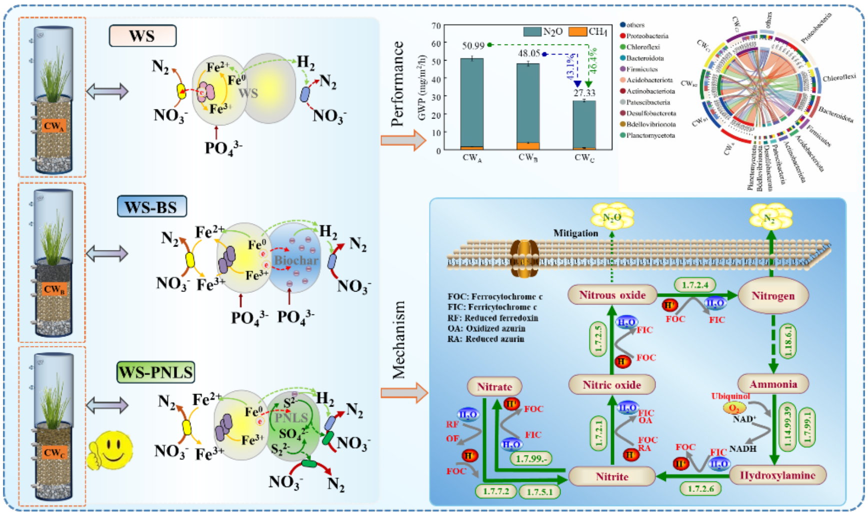

Fig. 1 Graphical abstract of three CWs for enhanced nitrogen removal and greenhouse gases mitigation

BIO of Presenter:
Yujie Yuan has been pursuing her doctoral studies since September 2020 in the research group of Professor Yaqian Zhao at the Department of Municipal and Environmental Engineering, Xi'an University of Technology, China. Her research primarily focuses on greenhouse gas emissions and wastewater treatment from constructed wetlands.

EVALUATION OF NATURE-BASED SOLUTIONS FOR THE REDUCTION OF ANTIBIOTICS FROM WASTEWATER BY CHEMICAL AND ECOTOXICOLOGICAL ANALYSES

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Conventional wastewater treatment technologies are not able to sufficiently remove pollutants such as antibiotics (AB) from wastewater, leading to environmental contamination and the spread of antimicrobial resistance. Nature-based solutions (NBS), such as treatment wetlands and salt marshes, offer great potential to address these issues. This study evaluated the performance of three different nature-based solutions (NBS) in Northeastern Spain—including horizontal flow and surface flow constructed wetlands (CWs) used as tertiary wastewater treatments, and a renaturalized wastewater effluent-dominated stream—and compared their effectiveness in antibiotic (AB) removal with that of a reference tertiary wastewater treatment system (coagulation, flocculation, UV radiation, and chlorination) and a non-renaturalized wastewater effluent-dominated stream. Concentrations of AB were determined by SPE-UPLC-HRMS, and the ecotoxicological assessment was achieved by combining extract-testing of wastewater using a chronic toxicity test with the microalgae *S. vacuolatus* and *in silico* modelling (Toxic Unit and "Iceberg modelling" approach).

Results show that the NBS systems significantly reduced the concentrations of AB, with certain AB such as clarythromycin and ofloxacin being more resistant to mitigation than others. Nevertheless, their performance consistently exceeded that of the reference strategies. Furthermore, the grouping of AB in mode-of-action groups (e.g. protein synthesis-, folate pathway- or DNA replication inhibitors) instead of chemical type groups (e.g. -mycins or -floxacins) reduced complexity in ecotoxicity mixture evaluation. It was also found that the combination of chemical analysis, toxicity testing of water extracts and *in-silico* evaluation of toxicity risks is an effective method for assessing the performance of NBS systems. Results may be used to manage NBS systems to further increase their AB attenuation capacity.

Overall, the study demonstrates that NBS systems can play an important role in reducing AB in wastewater. The combination of NBS systems with conventional wastewater treatment technologies and the application of ecotoxicity alone or in combination with *in-silico* methods for evaluating toxicity risks can lead to an effective solution for reducing pollutants in wastewater and help in improving environmental health.

BIO of Presenter:
Master and PhD in Biology, since 2000 work in different groundwater and surface water monitoring projects using a variant of organismic bioassays to assess toxicity and hazard reduction.

EFFECTS OF CONVENTIONAL SUBSTRATE AND IRRIGATION FREQUENCY ON THE PERFORMANCE OF GREEN WALLS FOR GREYWATER TREATMENT

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Water scarcity is currently a challenge for water management in many regions of the planet. Alternative water sources are currently seen as a positive contribution for this challenge, with treated wastewater being a potential one.

Within the multiple treatment alternatives for wastewater, the adaptation of green walls to treat greywater, i.e. from hand basins, washing machines, showers and baths has become an attractive alternative. This method allows for water recycling and treatment near the source, while taking up minimal space and offering the potential for urban greening. In this study, an adapted green wall for the treatment of a mix of real and synthetic greywater was analysed. The study compared the performance of two different filling media, namely a conventional gardening substrate and a mixture of perlite and coconut fibres in a 2:1 ratio. Two different irrigation regimes were also examined: one regime irrigated the green wall for three hours continuously each day, while the other regime involved irrigating for two hours three times a day.

The green wall has divided into 4 different groups, to allow for different combinations of filling media and irrigation frequency. Inflow and outflow greywater was analysed of each group for total suspended solids, volatile suspended solids, chemical oxygen demand, ammonium and nitrate. Additionally, in-situ measurements of specific parameters including pH, temperature, and dissolved oxygen were conducted. The removal efficiencies obtained in the green wall ranged from 79% to 82% for total suspended solids (TSS) with the conventional substrate, and from 91% to 94% with the coconut and perlite mixture. For chemical oxygen demand (COD), removal efficiencies varied between 30% and 42% with the conventional substrate, and between 68% and 73% with the coconut and perlite mixture. Additionally, all green wall configurations demonstrated high ammonium removal, achieving efficiencies between 96% and 97%. In contrast, nitrate removal was negative, with efficiencies ranging from -250% to -9%. The two different irrigation regimes did not significant influence water quality.

The results highlight the potential of green walls for greywater treatment, with emphasis on the use of coconut fibres and perlite as the filling media. This substrate demonstrated higher removal efficiencies for total suspended solids (TSS) and chemical oxygen demand (COD) compared to the conventional substrate. However, a more densely vegetated cover was obtained with conventional substrate.

Further studies are needed to better understand the system's capacity for removing pollutants and to optimize operational conditions for improved performance.

Acknowledgments: The authors acknowledge the financial support of the Foundation for Science and Technology (FCT) through the project UIDB/04625/2025 of the research unit CERIS.

BIO of Presenter:

Ana Galvão is an Assistant Professor at Instituto Superior Técnico since 2003. Her research interests are focused on Nature-Based Solutions for water reuse and circularity, including constructed wetlands and green walls for greywater treatment

EVALUATION OF LANDFILL LEACHATE PHYTOTOXICITY AND PFAAS UPTAKE BY EMERGENT MACROPHYTES

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Perfluoroalkylated acids (PFAAs) are ubiquitous xenobiotic substances characterized by high persistence, bioaccumulation potential and toxicity, which have attracted global attention due to their widespread presence in both water and biota. Since 2013, in a 150 km^2 catchment area in northeastern Italy (Veneto region), concerns have dramatically increased due to alarming PFAAs concentration in wastewaters as well as surface and groundwater; also leachates generated from landfills represent a significant source of PFAAs. Here, emergent aquatic macrophytes have been grown in mesocosms fed with different leachates generated in different landfills containing PFAAs, both perfluorocarboxylic acids (PFCAs) and perfluorosulfonic acids (PFSAs). The aim was to identify the most suitable plant species capable of withstanding high contaminant levels, removing the contaminants, and contributing to the sustainable management of landfill leachates. The study was conducted in an unheated greenhouse at Acque del Chiampo SpA wastewater treatment plant in Arzignano municipality, northeastern Italy. The experimental layout was a randomized block consisting of a total of 27 tanks (0.35 × 0.56 × 0.31 m), where 3 leachates and 3 vegetation species (*Carex elata* All. subsp. *elata*, *Typha latifolia* L. and *Phragmites australis* (Cav.) Trin. Ex Steud.) were tested for in a factorial combination with three replicates. Leachates (maximum total volume per tank = 50 L) contained high PFAAs concentrations (range of 5000-55000 ng/L), as well as characterized by high salinity (EC in the range 3600-21000 µS/cm) and ammonium concentrations in the range 100-1600 mg/L (NH_4^+). Each tank was filled with lightweight expanded clay aggregates to support vegetation growth. During the experiment, the influent was regularly sampled and analyzed, and vegetation was non-destructively monitored through high resolution hyperspectral spectroradiometer to determine plant physiological status. After the exposure period (March - November 2023), all plants were harvested, divided into aboveground and belowground tissues, washed, dried, homogenized and stored in polypropylene vials before chemical analyses. PFAAs concentration in leachates and in vegetal biomass was determined by liquid chromatography coupled to mass spectrometry (LC-MS/MS). The PFAAs uptake and translocation properties of the different vegetation species were also assessed according to different bioconcentration parameters. Results showed that plant growth was not affected by increasing PFAAs concentration, while the increased leachate salinity led to limited vegetation development, especially in *Carex elata*. It is noteworthy that all plant species demonstrated resilience, producing new tissues after the initial severe stress – also revealed by a change in spectral firms -without exhibiting complete senescence. The PFAAs concentration in roots increased with their increase in tested leachates and the mass removal efficiency increased with increasing bioavailable PFAAs concentration in tested solutions, confirming previous results (Pellizzaro et al., 2022; doi: 10.1016/j.jenvman.2022.114703). *Carex elata* exhibited the highest overall translocation of all PFAAs from roots to shoots, while *Typha latifolia* demonstrated the greatest accumulation efficiency for PFBS reaching concentrations of up to 44%, with the majority retained in the roots (up to 83%). This study demonstrated the ability of treating PFAAs contaminated landfill leachates by phytoremediation, showing that tested macrophytes can adapt to critical chemical conditions. Further investigation is required to assess constructed wetlands treatment performance on a larger scale and on other PFAAs-polluted matrices such as sludge.

BIO of Presenter: Alessandro Pellizzaro, biologist, PhD in Crop Science. He has been working in Acque del Chiampo laboratory since 2004. Acque del Chiampo SpA Società Benefit is the in-house manager of the integrated water cycle in the south-west area of the province of Vicenza, Veneto region, Italy.

OPTIMIZING SEWAGE SLUDGE DEWATERING IN SLUDGE TREATMENT WETLANDS UNDER THE MEDITERRANEAN CLIMATE

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Wastewater treatment processes produce a by-product material known as sewage sludge, characterized by the point it is produced as primary, biological or secondary sludge. The main aim in sewage sludge treatment is the increase of total solids (TS) content, the reduction in sludge volume and the decrease of the volatile solids (VS) to achieve sludge stabilization. Volume reduction, through dewatering and drying, is a key aspect to minimize handling, transportation and disposal costs. The majority of wastewater treatment plants (WWTPs) follow a linear sludge management model that is based on mechanical dewatering technologies (e.g., centrifugation, thickening), addition of chemicals (e.g. polyelectrolytes), daily transportation and the final sludge disposal to landfills as waste. Therefore, there is a need for a new circular model that will eliminate sludge view as a waste and will utilize this valuable by-product.

In this study, the green technology of Sludge Treatment Reed Beds (STRBs) of Sludge Treatment Wetlands is tested within an integrated sludge management approach towards reduced cost and environmental footprint and production of nutrient-rich biosolids. About 16 pilot STRBs are operating for 2 years at the WWTP of Chania in Crete, Greece. The pilot beds have different operation and construction parameters, such as planted/unplanted, presence of earthworms, different substrate media, different substrate thickness and different loading rates, aiming at identifying the most efficient and optimized design configuration. Most of the units are planted with a polyculture of local *Phragmites australis* and *Arundo donax* while the substrate consists of different layers of river gravel, sand and cobbles. The examined sludge loading rates (SLR) are 60 and 80 kg/TS/yr. Secondar sewage sludge comes from the WWTP of Chania, which treats wastewaters from 170,000 persons equivalent. This sludge is characterized by TS content of 1.4 (%) and VS content of 79.6 (% TS).

The results so far have been quite satisfactory, with the STRBs achieving a very high sludge volume reduction ranging from 91.6% to 97.5%. The SLR seems to slightly affect the sludge volume reduction, indicating that a higher SLR could be feasible. The presence of vegetation plays a key role in the effective dewatering process, while the presence of earthworms improves the overall performance. After the first harvesting event, *P. australis* became the dominant species, as *A. donax* could not survive and regenerate in most beds. TS content in the residual sludge reached up to 40% and 31% in SLR60 and SLR80, respectively, and by the end of the experiment it is expected to exceed 70%. The study will run for one more year. This work will present the overall results after the first two operational years.

Acknowledgment
This research project is entitled “Management and Valorization of Sewage Sludge in Circular Economy using Green technologies” and is funded by the Green Fund – Ministry of Environment and Energy of Greece.

BIO of Presenter:
Ioannis Asimakoulas is a PhD candidate in the School of Environmental Engineering at the Technical University of Crete, Greece. His research focuses on sustainable sewage sludge management through nature-based solutions (NBSs) such as constructed wetlands and composting.

OCCURRENCE OF SELECTED ORGANIC MICROPOLLUTANTS IN PILOT-SCALE REED BED SYSTEM TREATING BEACH WRACK

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The increasing accumulation of beach wrack (BW) on the Baltic coast poses both an environmental challenge and an opportunity for resource recovery. In this study, was evaluated the performance of experimental reed bed system (RBS) in treating BW by monitoring changes in basic parameters (dry matter, organic matter, total phosphorus and Kiejdahl's nitrogen) and the presence of organic micropollutants.

The pilot RBS is composed of eight parts (A–H), arranged within two intermediate bulk container, each measuring 1 x 1 x 1 meter. This setup was designed to assess the applicability of the technology for processing BW material.

Each part was subjected to a distinct pollutant input. The study involved not only pure macroalgal biomass, but also mixtures of BW with compost, distributed across various sections of the system to evaluate its treatment efficiency under differing substrate conditions.

Over the 2021 monitoring period, the systems exhibited variable average dry matter (27,1 – 58,5 %) and organic matter content (38,0- 55,2 % s.m). These differences highlight the influence of different substrate on decomposition dynamics and stabilization potential. The Kiejdahl's nitrogen range from 1, 61 % s.m. to 2,77 % s.m. and total phosphorus fluctuated in scope from 0,52 % s.m. to 22,67 % s.m depending on the quarter feeding configuration.

Targeted analyses were conducted for two classes of persistent organic pollutants (POPs): per- and polyfluoroalkyl substances (PFAS) and phthalic acid esters (PAEs).

While most PFAS concentrations remained below detection limits, sporadic detections (e.g., L-PFOS and PFBA) in some samples indicate the potential for occasional contamination from external sources or inherent presence in BW.

In contrast, phthalates were detected in measurable quantities, with dibutyl phthalate reaching concentrations exceeding 19000 μg/kg in part A and bis(2-ethylhexyl) phthalate showing elevated levels particularly in part C, F, and H.

These findings demonstrate the utility of reed based stabilization system in managing organic-rich coastal biomass, while also emphasizing the need to monitor potential micropollutant accumulation. The study provides new insights into the transformation and retention behavior of organic contaminants in nature-based treatment systems and supports the development of sustainable coastal biowaste management strategies.

BIO of Presenter:
Alicja Kupczyk is a doctoral student of environmental engineering, mining and energy at the Gdańsk University of Technology. The idea for a doctoral dissertation which is based on testing the possibility of using sewage sludge reed bed systems to processing sea organic waste, was inspired by participation in the "CONTRA" project.

BRIDGING CONSTRUCTED WETLAND AND ARTIFICIAL INTELLIGENCE IN WASTEWATER TREATMENT TO ACHIEVE INTELLIGENT ECOLOGY

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The 2024 Nobel Prize in Physics and Chemistry were both awarded to fields related to "AI (artificial intelligence) for Science". This groundbreaking achievement has undoubtedly injected powerful momentum into the development of this discipline. We are now witnessing an era of "AI for Science". Indeed, global environmental issues have become one of the most pressing challenges of our time. Problems such as climate change, biodiversity loss, and resource depletion demand innovative and sustainable solutions. AI is emerging as a promising tool, offering new opportunities for environmental protection. Constructed wetlands (CWs), as a nature-based environmental solution, have been increasingly applied across various ecological domains. The integration of AI has further expanded the potential of CWs. This review timely explores the application of different AI technologies in CWs and discusses algorithm selection for various challenges in CW management. Emerged AI applications in CWs include exploring greenhouse gas emissions, microbial community dynamics, emerging pollutant predictions, wetland system parameter optimisation, and wetland health assessment etc. to enhance the scientific understanding and sustainability of wetland management (Fig. 1). In addition, this review points out the opportunities, future prospects, and challenges of AI-driven CWs, providing valuable insights for further research and practical applications.

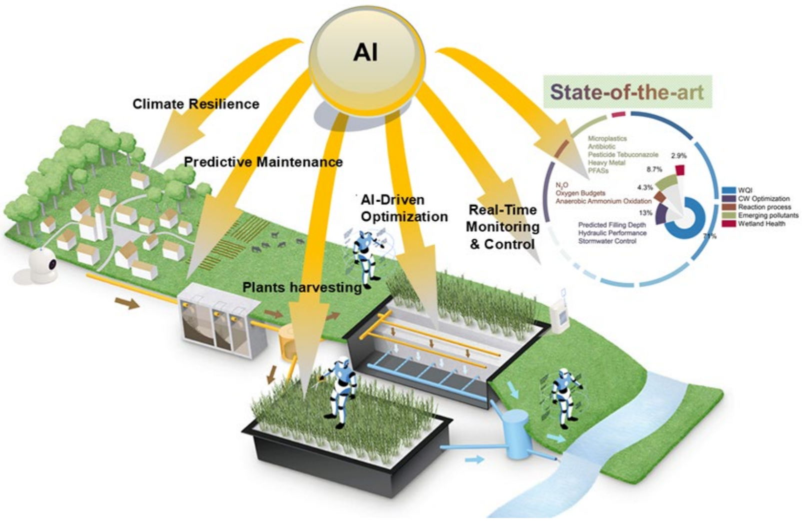

Fig. 1 Overview of the synergy between CW technology and AI in wastewater treatment

BIO of Presenter:
Yaqian Zhao is a Fellow member of IWA and Distinguished Professor in the Department of Municipal and Environmental Engineering, Xi'an University of Technology, China, since Jan. 2019 while he was an academic staff in University College Dublin, Ireland, from 2004 to 2018. He has published > 400 research papers and is a highly cited researcher (Elsevier).

TECHNICAL GUIDELINES FOR WATER QUALITY PURIFICATION OF CONSTRUCTED WETLANDS FOR PURIFYING LOW POLLUTION WATER AND ITS GUIDANCE FOR CHINA'S CONSTRUCTED WETLAND

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With the effective control of industrial wastewater and domestic sewage in waterbodies basins, effluent from WWTPs, agricultural runoff, polluted river water has become important reasons for the excessive water quality of water bodies. There is an urgent need to further remove pollutants.

The concept of "low-polluted water"(LPW) was initially introduced and applied in the context of pollution control for lakes such as Erhai and Fuxian in China. In 2011, key technologies research for treatment of LPW in Erhai and Taihu Lake were initiated. LPW refers to water in which the concentration values of major pollutants are worse than limits specified in Class V of the Environmental Quality Standards for Surface Water, but do not exceed limits stipulated in Grade Three standards of the GB 18918-2002. A large number of LPW quality purification constructed wetlands (CWs) have been built in China. CW project has played important role in improving water quality of Erhai, Dongting, Nansi, Taihu Lake, as well as Yangtze, Liaohe, Haihe River.

Cws are important technologies for purifying water quality, restoring aquatic ecology, increasing ecological space, and improving biodiversity. The effluent from cws can provide ecological base flow for water bodies, and provide recycled water for enterprises. It is of great significance to promote the recycling of regional recycled water and promote the construction of ecological civilization, enhance the economic value of cws, and facilitate the long-term operation of cws. On April 30, 2021, the Chinese Ministry of Ecology and Environment issued Technical Guidelines for Water Purification by Constructed Wetlands ([2021] No. 173) ("Guidelines"), which aimed to guide local governments in their work related to water purification of cws. Lu Shaoyong et al (2021) write a paper about Idea and system of the Guidelines.

One of the important reasons why existing cws have not been effectively utilized is that at least one of four stages of Design, Construction, Final Acceptance, Operation & Maintenance (DCFO) is unreasonable, as well as the problem of reconstruction and light management. Based on engineering practice and scientific research results, the "Guidelines" closely focus on the important factors that affect wetland water purification efficiency and long-term operation. For the first time, five districts based on the average temperature of the coldest month. The zoning design parameters were proposed, and the technical requirements for CFO were refined for the first time, providing a scientific approach for tailored cw water purification. In addition, it is proposed that the lifespan of cw project should not be less than 10 years. After the release of this "Guidelines", the research results have guided the feasibility study and design of LPW purification cw projects nationwide, as well as the technical review of more than 700 cw projects, involving an investment of over 50 billion yuan. In addition, the Technical Standard for cw in Shanxi, Shanghai, and Jiangsu Province have drawn on concept of LPT and DCFO content proposed in "Guidelines".

BIO of Presenter:
Lu Shaoyong, male, Hunan, China, Research Fellow and Doctoral Supervisor, graduated from Tsinghua University in December 2004 with a PhD degree. Working in China Academy of Environmental Sciences, engaged in lake ecological restoration and pollution prevention research and engineering for more than 20 years.

SUSTAINABLE ENHANCEMENT OF PALAFITTE HOUSING THROUGH INTEGRATED WATER MANAGEMENT IN BUENAVISTA, CIÉNAGA GRANDE DE SANTA MARTA, COLOMBIA.

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Context

The population of Buenavista is in the municipality of Sitio Nuevo, in the Department of Magdalena, in northern Colombia. This population is one of the three stilt communities settled within the estuary of the Ciénaga Grande de Santa Marta, the largest coastal lagoon in Colombia and one of the most productive ecosystems in the Colombian Caribbean. These communities build their homes as self-constructed stilt houses on wooden platforms, supported by wooden pilings, using materials native to the region. However, there are several challenges associated with this type of housing, as they suffer from critical overcrowding, lack access to potable water and basic sanitation services. This situation not only poses a risk of contaminating the estuary on which fishing, the community's main economic activity, depends—but, more importantly, it presents a serious threat to public health.

Methods

The "Tras la Perla Foundation", together with Corporación Andina de Fomento -CAF-, have implemented a pilot project for improving sanitation in the stilt community of Buenavista, with solutions for the use of rainwater and the collection, transport, treatment, and adequate final disposal of wastewater. The project consisted of four stages executed sequentially: i) baseline survey or sanitary census, ii) detailed design of improvement alternatives for 3 homes with individual wastewater treatment solution based on constructed wetlands, adapted to the conditions namely ground based, stilts based and a floating one iii) implementation of the three pilots, and iv) monitoring performance and the appropriation in the change of water management habits and its impact on the quality of life of the beneficiaries. Water quality is being analyzed monthly for organic matter parameters and nutrients, following standard methods. Being the solutions the first of its type in the world, and can serv as a model for the implementation in similar sites.

Results

In 2024, Buenavista recorded 1,250 mm of rainfall, with peaks in June (277 mm) and November (250 mm). This volume highlights strong potential for rainwater harvesting, capable of meeting most water needs for at least seven months of the year.

The average water consumption in the implemented households was 50 liters per person per day, primarily used for showering, laundry, and toilet flushing. Regarding water quality, rainwater showed a lower microbiological risk compared to surface water sources, highlighting its potential as a safer alternative supply.

Finally, the combined systems integrated a septic tank and wetland achieved removals greater than 80% for COD and 900% for TSS, with the septic system alone contributing less than 20%. These results highlight the critical role of constructed wetlands in enhancing pollutant removal beyond the capabilities of conventional septic systems operating under unconventional situations.

BIO of Presenter:

Carlos A. Arias, Civil Eng, MSc and PhD, senior Researcher art Aarhus University, with more than 30 years' experience in NbS, more than 130 Peer reviewed publications and coauthor of national guidelines.

MODELLING THE LONGEVITY OF A WOODCHIP BIOREACTOR OPERATING IN AN ARCTIC ENVIRONMENT USING HYDRUS-2D/CWM1

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Treatment of municipal wastewater in small-scale treatment systems, which are typical in remote Arctic regions, is challenging due to strong variation in wastewater yield from households and the harsh climatic conditions present. Denitrifying woodchip bioreactors are a passive treatment system which present a potential cost-efficient option for small-scale treatment facilities to remove nitrate-nitrogen (NO_3-N) when used in combination with other treatment units. The scientific community generally understands how denitrifying woodchip bioreactors operate but lacks a model which can simulate their performance and give a more detailed understanding of their operation, especially over longer periods of time.

In this study we modelled a woodchip bioreactor treating secondary effluent from a small-scale (300 PE) municipal wastewater treatment plant in Kallo (Kittilä) in Northern Finland. The bioreactor (Figure 1) contained birch woodchips (particle size 3cm x 1.4cm x 0.3cm) and was insulated with 12cm thick Finnfoam to allow year-round operation even in extremely low temperatures (-30°C). The bioreactor was approximately 4.3m x 1.6m x 0.31m and fitted with two material sampling points at approximately 1/3 and 2/3 of the way through the reactors lengthwise. The water level within the reactors was controlled via a v-notch weir which also served as the outflow sampling point and a flow measurement point. The hydraulic parameters of the model, which was constructed with HYDRUS-2D/CWM1, were calibrated using tracer test data collected from two different tracer tests conducted in August 2019 and September 2023 using a sodium chloride (NaCl) tracer. Influent and effluent NO_3 and chemical oxygen demand (COD) concentrations, along with other parameters, were taken periodically from July 2019 to October 2023 and were used to calibrate the release rate of carbon in the form of fermentable COD in the model.

Model scenarios of high and low flow and high and low NO_3-N concentrations were created based on flow data (collected via continuous monitoring) and NO_3-N concentration data which was collected throughout the study period.

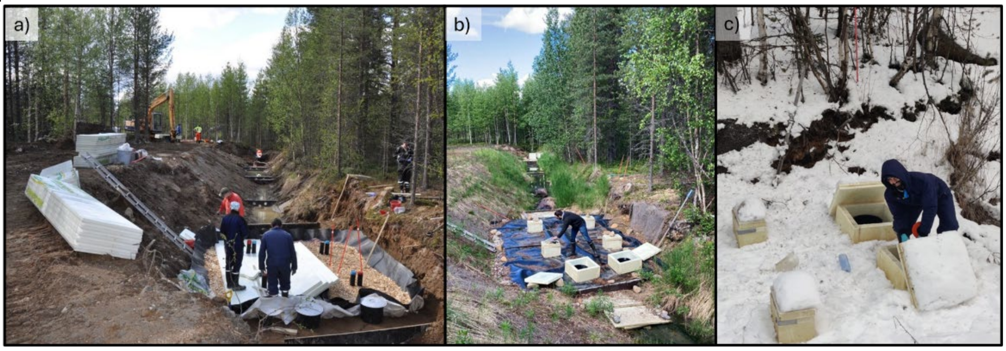

Figure 1. photo of construction of the bioreactor (a), monitoring of the bioreactor in summer conditions (b), and monitoring of the bioreactor in winter conditions (c).

<u>BIO of Presenter</u>:
I am in the fourth year of my PhD studies at the University of Oulu and have a background in Civil-Environmental engineering with experience in environmental monitoring and remediation. My research deals with the development of woodchip bioreactors for water treatment with a focus on nitrogen and micropollutant removal.

START-UP PHASE PERFORMANCE ASSESSMENT OF A PILOT-SCALE HYBRID SYSTEM FOR STORMWATER AND SNOW MELT TREATMENT

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Abstract
Urban growth has made stormwater and snowmelt management a critical challenge for urban planning. The increase in impervious surfaces raises flood risks and the transport of pollutants to water bodies. Stormwater contains various contaminants such as nutrients, heavy metals, pathogens, microplastics, and others, with concentrations varying based on urbanization, traffic, and land use. In cold climates, such as Nordic countries, this problem is especially complex since snowpacks can store pollutants that are released during melting season, posing significant risks to human health and the environment. Therefore, sustainable solutions are required to effectively manage stormwater and snowmelt waters.

This study evaluates the start-up phase performance of a pilot-scale hybrid system comprising settling tanks and woodchip bioreactors as a nature-based solution for treating stormwater and snowmelt in northern conditions. The system, built and commissioned in September of 2024 at Oritkari snow dump site in Oulu, Finland, alternately treats stormwater and melting water at a flow rate of 6 m^3/d. It includes two settling tanks -one conventional and one with lamellas (5 m length × 1.25 m width × 2.5 m depth)- operating in parallel, followed by two woodchip bioreactors (10 m × 1.25 m × 1.25 m) also operating in parallel, one of them filled with only woodchips (WBR) and the other with woodchips plus MgO-amended biochar (WBR+BC) placed at the end of the bioreactor, and intended to reduce phosphorus release commonly observed during the initial leaching phase of woodchips bioreactors.

Grab samples were collected from five points: system inflow, outflows of both settling tanks, and outflows of both bioreactors. Analyzed parameters included carbon (COD, TOC, DOC), nitrogen (TN, NH_4^+-N, NO_3^--N), phosphorus (TP, PO_4^{3-}-P), total suspended solids (TSS), and selected heavy metals.

Influent concentrations during the assessed period ranged from 420-520 µg/L (NH_4^+-N), 520-680 µg/L (NO_3^--N), 1,200-1,300 µg/L (TN), 180-240 µg/L (PO_4^{3-}-P), and 160-260 µg/L (TP), with TSS between 22-67 mg/L. Both bioreactors exhibited high removal efficiencies for NH_4^+-N (92-98%), NO_3^--N (99%), TN (69-72%), and TSS (72-92%). As anticipated, the WBR showed a significant phosphorus release during start-up, whereas the WBR+BC did not. Post start-up, phosphorus removal was higher in the WBR+BC (59% for PO_4^{3-}-P and 40% for TP) compared to the WBR (48% and 28%, respectively). Regarding heavy metals, removal efficiencies during the start-up phase exceeded 60% for Co, Cr, Cu, Ni, Pb, and U, and over 80% for Al, Fe, and V. No significant removal was observed for Cd, S, and Zn. After this phase, high removal efficiencies (>80%) were achieved for Al, Co, Cr, Cu, Fe, Pb, U, V, and Zn, with moderate removal (>50%) for Cd and Ni.

These preliminary findings demonstrate the potential of hybrid nature-based systems for cold-climate urban runoff treatment and highlight the importance of optimized configurations to address initial nutrient release.

BIO of Presenter:
Roger Laura Calle is a Civil Engineer with a MSc. in Hydraulic Engineering and Environment. Currently he is a 1st year Doctoral Researcher at the University of Oulu working with nature-based solutions for stormwater and snow melt treatment under northern climate conditions.

DYNAMICS OF PHYSICOCHEMICAL CHARACTERISTICS IN PAIRED MANGROVE AND SALT MARSH ECOSYSTEMS

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Mangroves and salt marshes are vital ecosystems that exchange nutrients, detritus, and contaminants such as trace metals with tidal water. Monitoring trace metals in sediment helps identify potential risks and highlight environmental factors associated with high concentrations, but typical assessments are ecosystem-specific. Here, we evaluated and compared the enrichment and ecological risk of fifteen trace metals in paired mangrove and salt marsh ecosystems in Australia. We also determined the relationships between trace metals (concentrations and indices) and other sediment physicochemical properties (i.e., pH, EC, total organic carbon, total nitrogen, acid volatile sulphide, percentage of sand, silt and clay). Metal concentrations differed significantly (for 11 of the 14 metals) between paired mangrove and salt marsh ecosystems, with higher concentrations typically found in mangroves. Se and Ni concentrations were above the lower limit of government guidelines, and contamination assessment indices – geo-accumulation index (Igeo) and contamination factor (CF) – revealed moderate pollution levels for As and Se concentrations, posing potential ecological risks. Sediment particle size correlated with most trace metals in mangrove and salt marsh sediment, whereby mangrove sediments with a high percentage of clay and silt accumulated more trace metals than the sandier salt marsh sediments. Despite their proximity and within the same watersheds, mangrove sediments had higher metal concentrations, suggesting that they are more likely to be affected by sediment pollution and require regular monitoring to avoid cascading effects in the ecosystem.

Keywords: Coastal wetland, environmental management, particle size distribution, contamination

BIO of Presenter:

Iresha is a PhD student at the Australian Rivers Institute/School of Environment and Science. She completed a Bachelor's and master's in environmental sciences at the Sabaragamuwa University of Sri Lanka. Her PhD focuses on the occurrence, bioaccumulation, and risk of contaminants in the mangroves and salt marshes of Southeast Queensland.

REDESIGNING PSVF WETLANDS: MEDIA AND DOSING OPTIMISATION FOR IMPROVED TREATMENT EFFICIENCY

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Abstract (Proposed Oral Presentation for WETPOL 2025)

Partially Saturated Vertical Flow (PSVF) constructed wetlands are a novel adaptation of traditional vertical flow (VF) systems, designed to enhance nitrogen removal without increasing the physical footprint or energy demand. These systems consist of single-stage filters (~900 mm deep) operated continuously, with only brief resting intervals between influent loadings. A key innovation in our PSVF design is the inclusion of a permanently saturated bottom layer containing pine woodchips, which serves as a solid carbon source to promote denitrification. To reduce the risk of clogging, coarse media such as gravel and zeolite are used, differentiating these systems from conventional sand-based VF wetlands.

The baseline performance of our four PSVF wetlands has been previously published (Singh et al., 2024) and was well received when presented at ICWS 2024 in Martinique. For WETPOL 2025, we propose an oral presentation that shares our four years of pilot-scale operational experience and learnings. We will outline key shortcomings identified in the original systems and describe how these insights informed the development of two optimised PSVF wetlands. Optimisation efforts focused on increasing the total media depth to extend hydraulic residence time within the saturated zone, and on refining the proportions of both inorganic and organic media layers. Waste cardboard, readily available in many regions and capable of faster carbon release, has also been trialed as an alternative carbon source. In addition, optimal intermittent wastewater dosing strategies have been identified for each media type. A performance comparison between the original and optimised systems will be presented, highlighting improvements in treatment efficiency.

<u>BIO of Presenter</u>:

Sukhjit Pal Singh has been a process engineer for eight years. He has a passion to do better for the environment through his work in water and wastewater projects. He is currently working towards a PhD in environmental engineering focusing on developing robust partially saturated vertical flow wetland treatments for domestic wastewater.

<u>References:</u>

Singh, S. P., Tanner, C. C., Sukias, J. P. S., Lay, M. C., & Glasgow, G. D. E. (2024). Multilayer partially saturated vertical flow wetlands for advanced small community wastewater treatment. *Ecological Engineering*, *209*(107390), 107390.

WOODCHIP BIOREACTOR IN ARCTIC AREA WATER PURIFICATION

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In the Arctic many anthropogenic processes, such as mining, municipal wastewater treatment and urban runoff, lead to nitrogen and/or heavy metal loads to recipient water bodies. In some situations, active water treatment units can be useful in arctic environments, but often nature-based systems, like wetlands, bioreactors etc., can be the most cost-efficient alternative. Woodchip bioreactors have been observed to be especially capable of purifying nitrate-nitrogen and metals from water through denitrification and sulphate reduction. These are microbial processes, which can be slower in cold climate conditions. The main aim of this study was to evaluate the ability of woodchip bioreactors to remove nitrogen and metals in Arctic conditions.

The woodchip bioreactor was constructed in Boliden Kevitsa multimetal mine, located in northern Finland, in the October 2022. Inside the bioreactor is 8.2 m^3 of woodchips (to a height of 1.2 m) and the volume of the bioreactor where the water flows is approximately 7.1 m^3. To facilitate water distribution, stone nests of 20–40 mm stone were implemented at the beginning and end of the bioreactor. The target flow rate is approximately 1.5 l/min (2.16 m^3/day), so that a residence time of approximately 2 days is achieved in the woodchip bioreactor, which has been found to be optimal in laboratory tests. From the water samples nitrogen fractions and metals were analyzed in an accredited laboratory. Monitoring has been done year-round from autumn 2022 until the present. Over the past 30 years (1991-2020), the average temperatures during the coldest and warmest months have been about -12 °C and 15 °C respectively.

The average total nitrogen (N_{tot}), nitrite+ nitrate nitrogen (NO_{2+3}-N) and ammonium nitrogen (NH_4-N) concentration in the inflow water were 36 mg/l, 31 mg/l and 0,04 mg/l, respectively. In the summertime the NO_{2+3}-N purification efficiency has been on average 67%, but in the wintertime the average was 20%. A smaller seasonal difference was seen with the N_{tot} removal efficiency, with the summertime purification efficiency being about 50% on average and about 20% in the wintertime. Increasing the hydraulic residence time in winter has been tested, and it appears to enhance nitrogen removal a small amount. The nickel, chromium and copper average inflow concentrations were 1.6 mg/l, 0.5 µg/l and 4.8 µg/l, respectively. The average nickel purification efficiency (about 60%) in October-November 2024 has been clearly better than earlier (average 6-7% in earlier winters). The same applies to chromium (removal in October-November closer to 90%, compared to 40–50% in earlier winters). The improvement in removal efficiencies over time is probably due in part to the fact that a sulfate-reducing bacteria community has had time to form in the bioreactor. Copper removal efficiencies have been 70% on average.

Based on current results it appears that denitrification and nitrogen purification can also occur in the wintertime, but it is only one third of purification efficiency seen in summertime. Decreasing the water discharge (increasing the hydraulic residence time) may enhance the purification efficiency, but this would need further study to confirm. Removal of metals occurs in the bioreactor, but there is some start-up period before it can be observed.

BIO of Presenter:
Postila has 19 years' experience from studies related of treatment wetlands purification efficiency, hydrology and hydraulics in the Nordic climate conditions and 12 years' experience other NBS/passive hybrid purification systems. NBS has treated runoff from peat extraction, urban, forestry and mining area and municipal wastewater treatment plant in polishing phase.

SEASONAL WATER QUALITY IMPROVEMENTS THROUGH A PILOT INFILTRATION TREATMENT WETLAND

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Most large-scale treatment wetlands for tertiary treatment involve free-water surface (FWS) wetlands. In areas with infiltrative soils, liners can make large FWS applications cost prohibitive. Additionally, operation of FWS wetlands is seasonally limited in cold climates. The City of Bozeman, MT and the Montana Dept. of Environmental Quality commissioned a study with researchers at Montana State University to test the feasibility of an infiltration wetland to provide water quality improvements in a cold climate. The infiltration wetland functions like a planted rapid infiltration bed, moving water down through the microbially dense wetland media and into the subsurface. This flow orientation has direct applicability to managed aquifer recharge (MAR) systems where water quality improvements are desired. Alternatively, systems may collect water in an underdrain for reuse or discharge. Full buildout of the pilot system would provide seasonal tertiary treatment for the City of Bozeman's Water Reclamation Facility, up to 14 MGD, before shallow aquifer recharge and discharge into the Gallatin River. The Gallatin is a blue-ribbon river with strict seasonal phosphorus limitations to protect the trout fishery and related economic sector. Seasonal utilization of a natural treatment system is currently estimated to be roughly 1/2 of the cost of a mechanical treatment upgrade.

The 450 ft^2 pilot system receives treated domestic wastewater from a five-stage Bardenpho-based treatment train after UV disinfection. The wetland system operated at water application rates varying between 4 and 12 inches of water per day, loading rates that are potentially two to six times higher than an equivalent FWS wetland. Operational data collection started in July of 2023, with weekly water quality sampling for nitrogen (N) and phosphorus (P) and chemical oxygen demand. The wetland system influent averages 5 mg L^{-1} total N and 0.2 mg L^{-1} total P. Warm weather removal rates have averaged approximately 80% for N and 75% for P. The system remained operational year-round, though treatment performance is significantly reduced during the winter months. In addition, participation in an EU-funded Multi-Source program enabled monthly assessments of over 140 contaminants of emerging concern (CECs) from December of 2023 to August of 2024. This presentation will outline operational data, seasonal nutrient removal rates, observed reaction rates for nitrate removal, and nine months of CEC data.

<u>BIO of Presenter</u>:
Christopher Allen, P.E., PhD is active researching and implementing natural systems (NS) for enhancing water quality. His research at Montana State University has centered on optimizing treatment wetlands for effective wastewater treatment, while investigating nutrient cycling and greenhouse gas emissions. He currently serves as Plummer's Natural Systems Design Practice Lead.

Keywords: nutrient removal, CEC removal, infiltration wetland, tertiary treatment

DESIGN OF VERTICAL FLOW CONSTRUCTED WETLANDS FOR GREYWATER TREATMENT

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Urban water scarcity and the urgent need for resource-efficient water management are driving the adoption of decentralized solutions, such as greywater recycling. Constructed wetlands (CWs) offer a robust, nature-based treatment approach; however, their widespread implementation, particularly in dense urban areas, is often limited by high area demands. This challenge is exacerbated by insufficient reliable design data for specific wastewater streams like greywater – in contrast to more extensively characterized municipal wastewater –, and by technical guidelines often failing to provide specific guidance for greywater treatment. This study addresses these limitations by presenting empirically derived design parameters from long-term investigations. Furthermore, it proposes crucial updates to technical guidelines to optimize CW sizing specifically for greywater treatment, using the German guidelines DWA-A 262 (2017) – *Principles for Design, Construction, and Operation of Wastewater Treatment Plants with Planted and Unplanted Constructed Wetlands for the Treatment of Domestic and Municipal Wastewater* – as a key reference.

Design values and operational limits were determined from over 500 days of monitoring eight pilot- and small-scale vertical flow CWs, utilizing Rhine sand and lava sand under various operational and structural modifications. This research yielded reliable per capita pollutant loads for light greywater and demonstrated high treatment efficiency, forming the basis for new sizing recommendations and evidence-based proposals for regulatory updates in Germany and elsewhere.

Key findings recommend the use of 85th percentile values for robust design as long as reliable greywater data remains scarce, implying a need for this approach until further research yields more comprehensive datasets. For mechanically pre-treated **light greywater** (predominantly from showers and handwash basins), derived design values are **55 L/(per·d)** for volume flow and for inhabitant specific **13 g COD/(per·d)** for COD load. These parameters support a reduced specific filter area requirement for VFCW treating light greywater of **0.4 m²/per**, a substantial improvement compared to the 4 m^2/per stipulated in DWA-A 262 (2017) for mechanically pre-treated municipal wastewater. Further proposed adaptations encompass: 1) Increased max. permissible hydraulic surface loading rates of **130 L/(m²·d)** and max. permissible COD loading rates of **32 g COD/(m²·d)** for light greywater treatment, validated by consistent high performance (e.g., >97% COD removal) in temperate climates like Germany. 2) Revised uniformity coefficient (U) criteria for alternative filter materials, such as U < 16 for zeolite-containing lava sand (compared to U < 5 typically required for fluviatile sand), reflecting successful long-term operation. 3) Confirmation of year-round nitrification capability in wetlands utilizing media with high cation exchange capacity (e.g., > 50 cmol$^+$/kg) at water temperatures down to 5°C. 4) Endorsement of fine screens or fine rakes (1–2 mm mesh/slot size) as effective pre-treatment for light greywater, simplifying overall system design.

This research provides data-driven design criteria for more compact, resource-efficient constructed wetlands treating greywater. The proposed enhancements to existing technical guidelines aim to improve design accuracy, encourage broader adoption of greywater reuse in diverse settings including urban environments, and advance sustainable water management by integrating wastewater-specific, empirically validated approaches into regulatory frameworks.

BIO of Presenter: Dr. Carlo Morandi currently works at the Department for Resource-Efficient Wastewater Technology at the RPTU University of Kaiserslautern-Landau, Germany, where he completed his PhD on the topic “Adapting Constructed Wetlands for Fit-for-Purpose Greywater Treatment and Impacts of Greywater Separation on Centralized Wastewater Treatment Plants”. Carlo holds degrees in Chemical Engineering and Environmental Engineering.

ASSESSING WETLAND WATER QUALITY IN CAPE TOWN, SOUTH AFRICA

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Wetlands are recognised as critical components of blue-green infrastructure, offering flood mitigation and sustainable urban stormwater management solutions. These systems not only regulate water quantity, but also water quality through the natural filtration of pollution and waste water. Wetlands within highly urbanised areas are however increasingly exposed to significant pressures, through both natural and human induced stresses. This review aims to examine the performance of wetlands within the Cape Town area, containing prominent wetlands such as Zeekoevlei, Rietvlei, and the Cape Flats wetlands, all of which form part of conservation areas and play critical roles in biodiversity and urban water management. In addition to thousands of estuaries that all feed into an extensive aquifer system, the area contains over 300 natural and heavily modified wetlands, often referred to as treatment wetlands. Particular focus is therefore placed on their capacity to improve water quality, while exposed to regular hydrological extremes. Consideration is also given to physical changes that reduce wetland treatment capacities. This includes the loss or permanent change to many of these systems through drainage or infilling (to facilitate urban development), stormwater diversion, pollution, social pressures and climate change. This study investigates water quality dynamics across 34 sampling points (within 29 wetlands) over a seven year period. These points provide continuous data consisting of key quality parameters, including E.coli, P04-P, N, DO, NH3, pH, EC, Chl and microscystin (cyanobacteria). Assessment and long-term trend analysis of these parameters, provides critical insights into water quality over time, which also highlights seasonal variations. From the analysis of water quality data, it is evident that pollution levels consistently report above acceptable threshold levels. Temporal trends and pressures from pollution caused by inadequate wastewater treatment, urban run-off and agricultural activities, result in extreme spikes for all of the water quality parameters considered. It is also evident that sampling points in close proximity to informal settlements, that lack basic sanitation services and solid waste management, have a higher vulnerability to deteriorating water quality. Findings reveal that, even though wetlands within this area provide considerable biodiversity and ecosystem services, contamination levels exceed wetland treatment capacities. Although the city's legislative framework provides for extensive wetland management and conservation strategies, water quality within these areas are likely to further deteriorate if current pressures and land-use management practices are not sufficiently addressed.

<u>BIO of Presenter</u>:
dr. Charné Theron is a researcher in climate adaptation. Her multidisciplinary background in civil engineering, environmental management and natural sciences provide her with extensive knowledge and experience in resilient urban design, sustainable development, water/waste management and climate resilience. Research focus areas include flood/drought risk, climate change impacts and resilient infrastructure.

ENHANCING DISSOLVED MICROPOLLUTANTS TREATMENT IN REED BEDS FILTERS WITH AN ADSORBANT MATERIAL: A LAB EVALUATION OF ADSORPTION EFFICIENCY AND MODELLING PARAMETERS

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Context and objectives

While the efficiency of vertical flow reed bed filters for the depollution of urban stormwater has been demonstrated, it has also been shown that their efficiency remains limited for the dissolved fraction of micropollutants which may remain superior to environmental quality standards in the treated water. The Life-Adsorb project aimed at evaluating an innovative reed bed filter which includes a layer of adsorbent material to retain dissolved micropollutants. The presentation will focus on the lab testing of this material, in order to assess its efficiency and establish the adsorption kinetic and isotherm parameters needed for the reactive hydrodynamic modeling of the filter.

Methodology

The adsorbent material considered (Rainclean®) is a commercial mixture (including zeolite, iron hydroxide, coco fibers, activated carbon, lime) available on the European market and specifically developed for stormwater treatment. Its' adsorption potential was characterized under batch tests for a range of mineral and organic micropollutants (As, Cd, Cr, Cu, Ni, Pb, Zn, V, BPA, OP, NP) and compared to sand and sediment present in the filter. The adsorbent was further tested under more realistic long term column tests, using water collected at the outlet of a conventional reed bed filter and spiked with micropollutants at a concentration level consistent with maximum values observed in urban runoff. Reactive transport in the column was modelled using Hydrus 1D, first based on batch results and then by inverse modeling based on column outlet concentrations.

Results

Batch results confirmed the very limited adsorption on sand and efficient adsorption of some micropollutants on Rainclean and on sediment. Based on Kd values, the adsorption efficiency could be ranked as follows, for Rainclean® : NP, BPA > OP, Cu, Pb, Zn > Cd >> Ni, As > V >> Cr, for sediment : NP, Cd >> Zn, Cu, Ni > Pb, OP > As, BPA, V >> Cr. Column studies confirmed good efficiency of Rainclean for Cd, Pb, Cu and Zn, and inefficiency for Ni, Cr, V and As but showed more limited efficiency then expected for BPA, OP and NP. Moreover, the dynamic flow conditions in the columns led to behaviors different from those modeled with Hydrus 1D based on batch parameters, with higher outflow concentrations and quicker breakthrough. New values of adsorption kinetic and isotherm parameters that fit column studies were obtained based on inverse modelling with Hydrus. These parameters will next be used to simulate long term behavior in the operational conditions of the reed bed filter (for a realistic chronic of inflow and concentrations). We should note however that the inversed modelling fitting results are sensitive to initial values of parameters and monitoring data available for the calibration: at least 5 monitoring points distributed over 2 to 3 weeks of continuous run of the columns are needed.

BIO of Presenter:

Ania Morvannou is a senior scientist at EcoBIRD who has been active in the field of treatment wetland modeling for the last 17 years. She owned a PhD degree from the UCL Louvain-la-Neuve, Belgium, and has previously been working at INRAE on several projects related to treatment wetlands.

CIRCULAR NATURE-BASED SOLUTIONS TO MITIGATE UNTREATED MICROPOLLUTANT EMISSIONS: A CROSS-BORDER APPROACH TO PROTECT THE UPPER SÛRE LAKE

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The implementation of water policies, such as the revised Urban Waste Water Treatment Directive (UWWTD), has sparked concerns over the impact of Combined Sewer Overflow (CSO) discharges on surface water quality, leading to the proposal of stricter control measures. These discharges not only contain solids, organic matter, nutrients, and pathogens, but also release large quantities of micropollutants, making post-treatment solutions alone insufficient for effective pollution control even if important. At the catchment scale, a more integrated approach that considers all emission sources is essential to inform and support regulatory and policy-making processes.
The Interreg Greater Region-funded QualiSûre project has the ambition to address this complexity via the definition of a master plan for maintaining and protecting the water quality of the Upper Sûre Lake .
With a total storage capacity of 60 million m³, the Upper Sûre Lake not only supplies a hydroelectric power plant but also serves as Luxembourg’s largest drinking water reservoir, currently meeting 43% of the country’s annual demand and supplying 79 out of 102 municipalities. These factors highlight the critical importance of protecting the lake’s water quality and its overall functionality. The reservoir's catchment area spans 428 km², with two-thirds located in Wallonie, Belgium. 40 WWTPs and 60 rainwater systems are nowadays discharging into the Sûre, of which 6 WWTPs are located in Wallonie. Consequently, pollutants enter the Sûre from both the Belgian and Luxembourgish sides, emphasising that any significant improvement in water quality can only be achieved through coordinated cross-border collaboration.
Aligned with the strategic goals of the Greater Region, Nature-based Solutions (NBS) have been chosen to reduce punctual pollution loads, particularly when applied at key emission hotspots on the Sûre catchment. These solutions are designed to be fully integrated into the landscape while supporting biodiversity. Priority has been given to using locally sourced materials (i.e. sand-based substrates) or those admixtures produced in accordance with circular economy principles (i.e. biochar from cellulose or waste material such as plant residues), thereby reducing transportation costs and negative environmental impact.
Six Soil Filters (SF1: Rhine sand, 20 % CaCO3, 15% granular activated carbon (GAC); SF2: Rhine sand, 20 % CaCO3, 15% biochar from plant residues activated biologically (AC); SF3: Mosel sand, 20 % CaCO3, 15% AC; SF4: Mosel sand, 20 % CaCO3; SF5: Lavasand; SF6: Expanded sand, 15% AC) were designed based on granulometry, chemical composition (i.e. proximate analysis, alkaline saturation etc.) and bioavailability (i.e. Ion/cation exchange capacity and elemental composition) of a large number of potential substrates initially identified in the Greater Region. The configurations were tested at mesocosm scale (25 L volume with an initial Hydraulic Loading rate of 30 L/m2 day) with synthetic wastewater (Chemical Oxygen Demand=70 mg/L, Total Nitrogen=10 mg/L, Total Phosphorous= 3 to 6 mg/L, Ammonia=6 mg/L etc.) spiked with 5 µg/L of 18 micropollutants, which were selected considering those reference parameters for untreated wastewater and CSO (i.e. ibuprofen and paracetamol), surface and street run off (i.e. 1,3-Diphenylguanidine (DPG), Hexamethoxymethyl-Melamine (HMMM), PPD-Quinone), diffuse pollution from agriculture (i.e. Metolachlor). Preliminary results show more than 92 % elimination for the 18 compounds and suggest promising substrates to be tested at pilot scale under real conditions. The study intends to provide decision support criteria for selecting the appropriate NBS design tailored to the geographic location (i.e. resource availability) and water quality to be treated if CSO or WWTP effluent.

BIO of Presenter: Silvia Venditti is a Research scientist at the University of Luxembourg since 2017. She has 15 years of experience in the treatment of emerging contaminants from wastewater effluents. Her interests are in the circular economy, collaborative projects and translating science into policy for a better environment.

PLANT REMOVAL AND TRANSFORMATION OF PERSISTENT, MOBILE AND TOXIC CONTAMINANTS FROM SYNTHETIC GREYWATER IN A HYDROPONIC EXPERIMENT.

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Introduction

The presence of persistent, mobile, and toxic (PMT) substances in aquatic environments is a growing concern due to their resistance to conventional wastewater treatment processes. This study investigates the role of plants within nature-based solutions (NBS) for the removal of PMTs from greywater.

Methodology

The 16 hydroponic channels were watered twice a week during a month with synthetic greywater, spiked with PMTs. The eight selected PMTs were the Benzotriazole-1H (BTH), Ditolylguanidine (DTG), Melamine (MEL), Metformin (MET), Phenazone (PHN), Tris(2-chloroethyl) phosphate (TCEP), Trifluoroacetic acid (TFA), and Perfluorobutyric Acid (PFBA). The nine plant species selected were *Artemisia ludoviciana, Carex flacca, Centranthus ruber, Festuca glauca, Hypericum perforatum, Lythrum salicaria, Nephrolepis cordifolia, Salvia rosmarinus,* and *Vinca major*. Water samples were collected weekly, and PMT concentrations were quantified via liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS). In addition, non-target screening was initiated for DTG and PHN to investigate potential transformation products formed. Plant health and biomass changes were also monitored throughout the experiment.

Results and discussion

The removal efficiencies of PMTs varied markedly between unplanted and planted hydroponic systems. Unplanted systems exhibited limited removal (<15%) for most PMTs, confirming their persistence and mobility. In contrast, planted systems achieved significantly higher removal rates, but with species-specific differences. *Lythrum salicaria* consistently outperformed other species, demonstrating high potential for phytofiltration. *Festuca glauca* and *Vinca major* also showed substantial removal for certain compounds, while other tested species showed moderate efficiency.

Conclusion and future work

This study underscores the potential of NBS into urban water management systems, particularly as a decentralized approach to mitigating micropollutant loads. However, the variable effectiveness across species and substances suggests that plant selection is critical to optimizing PMT removal. Further research should explore the mechanistic pathways of uptake, transformation, or sorption involved and assess long-term performance under real-world conditions.

Acknowledgement

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<u>BIO of Presenter</u>:

Henry Beral is a plant biologist dedicated to nature-based solutions for water treatment. He investigates how plants can remove micro-contaminants from runoff, greywater and wastewater through systems like bioretention, green walls and constructed wetlands, bridging plant physiology and environmental engineering.

UNVEILING EMERGING CONTAMINANTS IN STORMWATER RUNOFF: A COMPREHENSIVE STUDY FROM LUXEMBOURG'S URBAN AND INDUSTRIAL WATERSHEDS

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Stormwater runoff significantly impacts receiving water bodies, with its quality degraded by chemicals from pesticides, biocides, urban infrastructure, automotive wear, industrial discharges, and urban sources. Environmental monitoring focuses mainly on 'known' pollutants, leaving many unregulated and undetected due to gaps in stormwater surveillance. The European Union (EU) addressed these challenges by revising its priority substances list in 2022, adding 25 emerging contaminants, while the 2023 Urban Wastewater Treatment Directive enforces stricter monitoring and treatment of emerging pollutants. This issue is particularly critical in Luxembourg, with a high population density of ~260 inhabitants per km², where rapid urbanization, extensive impervious surface coverage, and industrial activities contribute to increased stormwater runoff volumes and pollutant loading. To address these challenges, our project STORMland, funded by the Luxembourg National Research Fund (FNR), aims towards (i) developing a comprehensive stormwater monitoring approach of stormwater runoff, (ii) analyzing the distribution of stormwater contaminants in dissolved and particulate fractions across various particle sizes, and (iii) design a novel constructed stormwater wetland (CSW) with tailored substrates for targeted pollutant removal. Two monitoring sites have been selected for STORMland: (i) Raemerich, located at the Luxembourg-France border, which exclusively collects stormwater runoff from a motorway, and (ii) Grass-Steinfort, situated at the Luxembourg-Belgium border, which receives runoff from both urban roads and rooftops. Field campaigns are planned to be conducted in both winter and summer to collect first-flush stormwater runoff samples using autosamplers. Initially, samples were analyzed for conventional water quality parameters, followed by a comprehensive analytical approach combining both target and non-target screening methodologies to ensure the detection of a broader range of contaminants that conventional analyses might overlook. So far, winter stormwater runoff samples have been collected and analyzed for conventional water quality parameters, with non-target analysis underway. Preliminary results from the Raemerich site indicate that first-flush stormwater runoff is heavily contaminated. Conductivity levels varied between 641–3870 µS/cm, chemical oxygen demand ranged from 0–175 mg/L, total suspended solids varied between 2–1378 mg/L, and volatile suspended solids (VSS) were measured between 5.2–154.56 mg/L. The lowest values were consistently observed during dry periods, while peak concentrations occurred during runoff events. The inorganic pollutants of the runoff was also significant, with elevated concentrations of Na^+ (24.8–689.3 mg/L), Cl^- (28.8–1271 mg/L), SO_4^{2-} (38.44–4444.3 mg/L), Ca^{2+} (18.51–604.2 mg/L), Br^- (0.263–3.99 mg/L), and Mg^{2+} (0.1642–44.81 mg/L). The highest concentrations were detected during runoff periods, while dry-period concentrations were substantially lower. The high levels of Na^+, Cl^-, and Ca^{2+} likely originate from de-icing salt applications, while elevated SO_4^{2-} concentrations may be attributed to acid rain. The presence of Br^- could be linked to dibromoethane additives in gasoline. However, further insights into specific pollutants will be obtained through the combined target and non-target screening approach. Additionally, microbial analysis revealed high contamination levels of total coliforms and *Escherichia coli*. The observed pollutants in this study surpass previously reported stormwater runoff data from high-traffic areas, highlighting the significant pollution load from urban runoff. Findings from STORMland will enhance our understanding of stormwater contaminants, guiding the development of more effective treatment strategies for urban runoff.

BIO of Presenter:

Yamini Mittal is working as an Postdoctoral researcher at University of Luxembourg. She has expertise in biological wastewater treatment using constructed wetlands, constructed wetland integrated bio-electrochemical systems (CW-MFCs/electroactive wetlands). She has 11 publications in SCI indexed journals, one granted patent, two-time recipient of Indo-German Fellowship, and honored with the Best PhD Thesis Award for her contribution in research.

INNOVATIVE HYBRID INTENSIVE-EXTENSIVE TECHNOLOGIES FOR WASTEWATER TREAMENT IN SMALL COMMUNITIES: INTEXT PLATFORM

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BACKGROUND

Decentralized wastewater treatment technologies play a pivotal role in delivering sanitation in rural areas. LIFE INTEXT project, led by Aqualia, proposes the reduction of extensive technologies (*e.g.*, constructed wetlands) footprint through the INTensification of EXTensive treatment systems into innovative INTEXT technologies. The present communication describes the innovative intensive-extensive technologies installed on the INTEXT platforms.

INTEXT TECHNOLOGIES

INTEXT platform solutions are shown in Figure 1. Some of the technologies are operated in combination, to evaluate the best wastewater treatment performance and treat onsite the produced sludge.

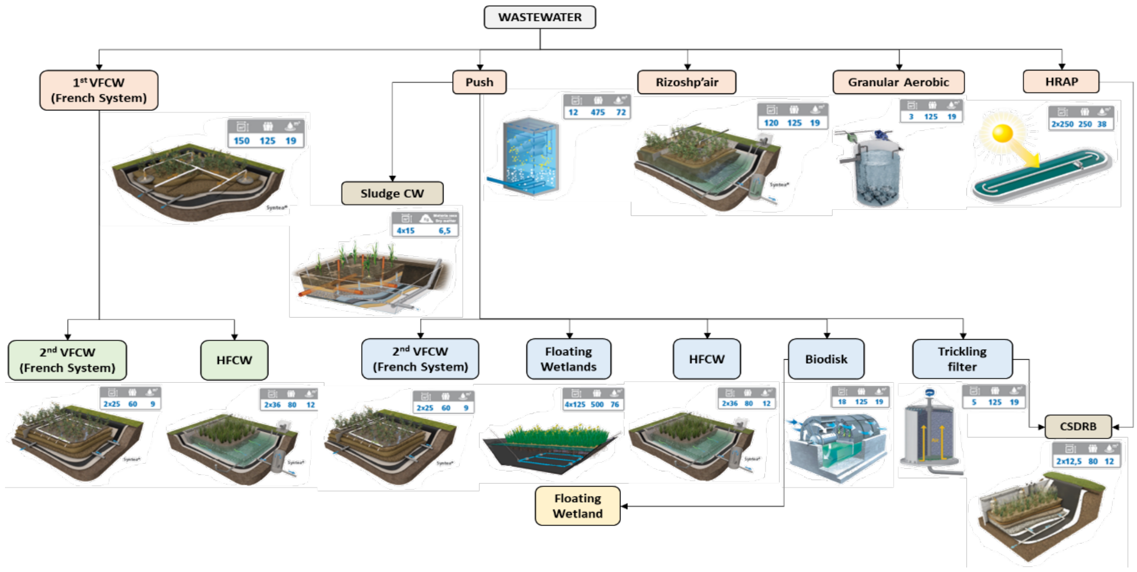

Figure 1. Diagram of the stages, equivalent population, capacity, and surface area of the INTEXT technologies.

FINAL REMARKS

Effluent from the INTEXT technologies receives further treatment for: (i) Phosphorus recovery with adsorbent materials, (ii) solar-based disinfection, (iii) water reclamation and reuse with smart irrigation control. The fact that the technologies are operated in different climatic conditions (Continental & Mediterranean) allows to determine accurate operating and design parameters. During the conference, the authors will present results data from the Continental INTEXT platform.

BIO of Presenter:

Enrique Romero-Frasca works as a Researcher at FCC Aqualia Department of Innovation and Technology. He holds a Ph.D. in Environmental Engineering and has 5+ years of experience working with microalgae-based treatment technologies. Enrique currently manages H2020 NICE project in Aqualia to promote NbS in the Spanish water utility sector.

MICROPOLLUTANT REMOVAL IN AN INNOVATIVE EARTHWORM-ENHANCED SLUDGE TREATMENT REED BED

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Abstract

The contamination of sewage sludge with organic micropollutants (MPs) presents significant environmental challenges, particularly for its reuse in agricultural applications. This study investigates the effectiveness of an innovative earthworm-enhanced sludge treatment reed bed (W-STRB) in mitigating MPs. The pilot-scale experiment evaluated the synergistic effects of *Eisenia fetida* earthworms and *Arundo donax* plants on the degradation and retention of MPs. Over the course of a year, 69 MPs were monitored in both sludge and leachate across various treatment setups (worm-planted, planted, worm-only, and control units). The findings revealed that earthworms notably improved the reduction of MPs, especially in the upper sludge layers, with compounds like caffeine and losartan showing reductions of 66% and 99%, respectively. However, certain MPs such as amisulpride and citalopram exhibited resistance to degradation, with only 10% and 26% reductions, respectively. The final resting phase further diminished the MPs, lowering their potential for release. These results underscore the promise of W-STRB systems as sustainable, nature-based solutions for sludge management, supporting circular economy goals and reducing micropollutant risks.

Keywords: organic micropollutants; nature-based solutions; sewage sludge; constructed wetlands

BIO of Presenter:

Amir Gholipour is a post-doctoral researcher at Aarhus University, specializing in environmental engineering. He completed his Ph.D. at the University of Lisbon in 2025, focusing on innovative sludge treatment methods. His research interests include Nature-Based Solutions, constructed wetlands, and the circular economy.

TURNING WASTE INTO SOLUTIONS: ENHANCING NUTRIENT REMOVAL IN BIORETENTION CELLS WITH REPURPOSED MATERIALS

Irina S. Pitropova[1,2,3,], Theis R. Andersen[2], Ditte A. Søborg[2], Magdalena Gajewska[4], Magda Kasprzyk[4], Søren Storm[c], Kamilla Aggerlund[3], Troels E. Raabjerg[3] & Jes Vollertsen[1]*

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Bioretention cells have gained prominence as nature-based solutions for runoff control in urban areas. While effective in peak flow reduction and particulate matter retention, removing dissolved phosphorus (P) and nitrogen (N) remains challenging. Therefore, this study examined the innovative use of repurposed waste materials as soil amendments for improved removal of nitrates (NO_3-N) and P.

Three pilot-scale rain gardens (1 m², 80 cm depth) were tested: a control using pumice and coconut fibers, one amended with crushed concrete (0–4 mm), and another with iron-coated granulate (0–11 mm) obtained from a Danish drinking water treatment plant – see Figure 1. Systems were irrigated three times weekly with synthetic stormwater spiked with PO_4^{3-} and NO_3^-. Water samples were collected from mid-depth and bottom outlets and analyzed for P and NO_3^- concentrations. After four months of operation, soil samples were also analyzed for P accumulation.

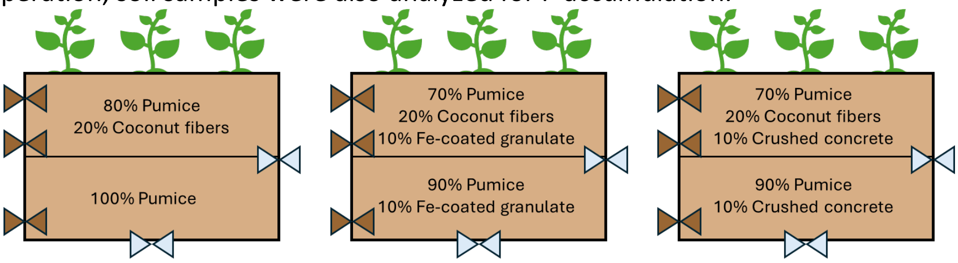

Figure 1 Pilot scale bioretention cells (blue valves - water sampling points; brown valves – soil sampling points).

Results showed better mid-depth nitrate removal in the amended systems, likely due to iron-supported denitrification. Yet, in deeper layers nitrate removal declined, possibly due to limited carbon, high pH, and competition from sulfate (SO_4^{2-}) and ferric iron (Fe^{3+}) reduction processes. Phosphorus removal was also significantly higher in the amended systems. Iron-coated sand achieved 88.8% P removal at mid-depth, compared to 69.6% for crushed concrete and 49.7% for the control. At greater depths crushed concrete outperformed both, reaching 97.1% P removal, compared to 92.6% for iron-coated sand and 69.8% for the control. This was, however, accompanied by a substantial pH increase (from 8.3 to 10.9), raising practical concerns. Results on P accumulation in the soils will be presented at the conference.

Amending bioretention cells with crushed concrete and iron-coated sand enhanced phosphorus and nitrate removal. However, material side effects, such as shifts in pH, must be carefully managed. Synergistic interactions between iron availability, carbon limitation, and nitrate removal underline the need to consider multiple treatment processes when designing bioretention systems.

<u>BIO of Presenter</u>:
Irina Pitropova is a PhD student at Aalborg University, working on optimization of bioretention cells for removal of nutrients and heavy metals from runoff. The PhD has been focused on experimental work executed in collaboration with BG Byggros, VIA University College and the Polytechnical University in Gdansk, Poland.
This abstract is submitted for an oral presentation.

PERFORMANCE EVALUATION USING NUMERICAL SIMULATION FOR VERTICAL FLOW WETLANDS WITH THE HYDRUS WETLAND MODULE

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[2] University of Natural Resources and Life Sciences, Vienna, Department of Land, Water and Institute of Sanitary Engineering and Water Pollution Control, Muthgasse 18, 1190 Wien, Austria
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Abstract

Two-stage treatment wetlands provide an advantage in the treatment performance and reduce the required surface area. Thereby, depending on the design (e.g. selection of filter media and water level), aerobic and anoxic conditions can improve the total nitrogen removal. In this study two different systems are under investigation. The first system is a French VF wetland in classical configuration. The second system is a stacked system using the same materials as the French VF wetland but with in impounded level at the bottom to provide denitrification (Figure 1). Influent and effluent concentrations for COD, NH4-N, NO3-N TN and TP were analyzed for both systems over a period of two Month (n=8).

In the present study, the treatment performances of both wetland systems were simulated to gain better in depth understanding of the processes affecting their treatment performance. HYDRUS was used to numerically solve variably saturated water flow and solute transport. In the wetland module the CW2D model formulation is used to describe the biochemical transformation and degradation processes. In a first step the water flow is simulated using the matrix flow model and the van Genuchten-Mualem soil hydraulic model, for both the systems including a cover layer on the top and a drainage layer at the bottom using different gravel sizes. With the fitted water flow, the wetland module is used to describe the biokinetic transformation and degradation of the wastewater constituents. In order to fit measured and simulated effluent concentrations several parameters needed adjustments. With the calibrated model insights of the performance are analyzed. The Understanding how the new configuration influences the treatment can help us to optimize the system and achieve the desired output concentration.

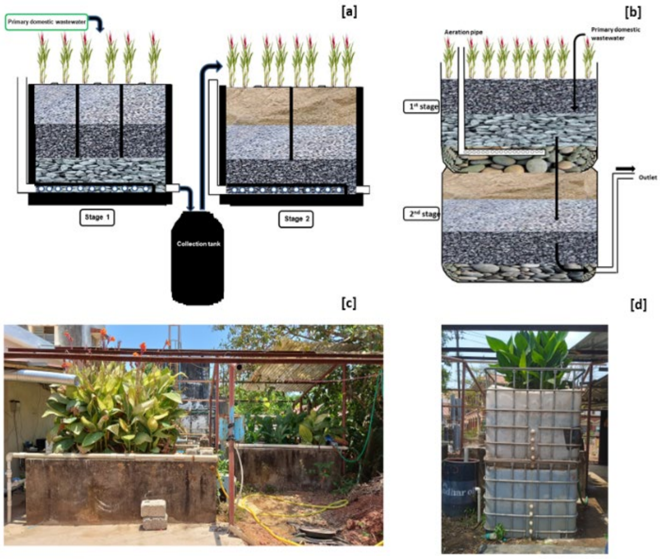

Figure 1: Investigated wetland configurations

<u>BIO of Presenter</u>:

Ravikiran Shet holds a PhD in Environmental Science. His research focuses on development of a hybrid non-sewered sanitation (NSS) system that integrates electrochemical treatment with constructed wetlands for decentralized wastewater management.

DEVELOPMENT OF BIOCHAR–CaO_2 COMPOSITES FOR LONG-TERM PESTICIDE REMOVAL IN AGRICULTURAL RUNOFF: A SYNERGISTIC ADSORPTION–OXIDATION APPROACH

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Nature-based solutions, including constructed wetlands, biofilters, and buffer zones (vegetated strips between agricultural fields and water bodies), have been widely implemented to mitigate agricultural runoff pollution. However, the performance of these systems often remains inconsistent due to variable climatic and hydrological conditions that influence pollutant transport dynamics and microbial degradation efficiency. Therefore, it is essential to develop substrate materials that exhibit stable and reliable pollutant removal performance under fluctuating environmental conditions.

Biochar has gained attention as a sustainable and cost-effective adsorbent because of its high porosity and large specific surface area. However, relying solely on adsorption is insufficient for long-term pollutant removal, as adsorbed contaminants may eventually desorb and re-enter the environment. Importantly, biochar also possesses catalytic properties, enabling electron transfer reactions and promoting the formation of reactive oxygen species (ROS), which can degrade organic pollutants more thoroughly.

Advanced oxidation processes (AOPs), such as the Fenton reaction, have demonstrated high efficiency in removing organic contaminants by generating potent ROS, including hydroxyl radicals (•OH) and superoxide radicals (O_2•–). However, the application of conventional AOPs in agricultural contexts is limited by the necessity for precise chemical dosing, stable hydraulic conditions, and potential risks of soil degradation or crop damage. Consequently, there is an urgent demand for innovative remediation materials suitable for dynamic agricultural environments.

To address these limitations, a multifunctional composite material was developed combining biochar and calcium peroxide (CaO_2), a solid oxidant that slowly releases hydrogen peroxide and has applications in soil amendment and aquatic oxygenation. By integrating CaO_2 with biochar, the hybrid material synergistically couples adsorption with in-situ oxidative degradation, enhancing remediation effectiveness under varying hydrological loads and low contaminant concentrations. To evaluate performance, 30-day static incubation experiments were conducted using biochar-CaO_2 composites at five different ratios. The composite materials achieved up to 76.8% removal of tebuconazole, a commonly used fungicide, through combined adsorption and oxidative degradation processes. Throughout the 30-day incubation period, tebuconazole concentrations and associated degradation products continuously changed, confirming sustained oxidative activity and ongoing degradation. In contrast, CaO_2 alone exhibited significantly lower removal efficiency (12.4%), underscoring the critical role of biochar in improving pesticide remediation performance. Interestingly, ROS generation did not significantly differ among the tested materials with or without biochar, suggesting biochar facilitated a more targeted removal of tebuconazole upon adsorption onto its surface. Additionally, increasing biochar content in the composites regulated CaO_2 consumption, ensuring a more sustained release of reactive oxygen species and enhancing overall remediation effectiveness. Functional group analysis further confirmed progressive oxidation on the biochar surface, providing clear evidence of active and continuous ROS generation on the surface. These findings demonstrate the promising potential of biochar-CaO_2 composites as a robust and adaptable strategy for pesticide remediation in agricultural runoff under dynamic environmental conditions.

BIO of Presenter:
Jingyu Wang: PhD candidate in Department of Agroecology, with a research focus on functional biochar for environmental remediation. Her work explores the design of biochar-based materials for adsorption and catalytic degradation of persistent pollutants

ADSORPTION-DRIVEN SUPPORT FOR WETLAND PURIFICATION: MGV_6O_{16} NANOFIBERS FOR CONTAMINANTS REMOVAL ACROSS VARIABLE PH CONDITIONS

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Understanding the mechanisms that govern the transport, transformation and removal of pollutants in wetland environments remains a significant scientific challenge. Diffuse pollution, which originates from sources such as agriculture, pharmaceuticals and urban runoff, enters aquatic systems and accumulates there in the form of persistent, chemically complex substances. Although wetlands can retain and degrade a variety of substances through biological, chemical and physical processes, their natural capacity may be insufficient when pollutant loads are high or the contaminants are particularly resistant. Consequently, research has increasingly focused on molecular-level strategies to support pollutant removal in wetlands. Among these, adsorbent materials stand out for their ability to enhance and complement the natural purification processes in such ecosystems.

Vanadium bronzes represent a promising group of compounds for adsorption-based water purification. Despite their potential, they remain relatively understudied and have only recently begun to attract growing scientific interest. This work aims to establish a novel synthesis approach that enables precise control over the microstructure and morphology of this compounds, thereby optimizing their adsorptive properties for environmental applications. To address this challenge, we developed a one-step method known as Liquid-Phase Exfoliation with Ion Exchange (LPE-IonEx) [1].

Using this synthesis route, we obtained nanofibrous magnesium vanadate (MgV_6O_{16}). Its physicochemical properties were then thoroughly examined using a range of analytical techniques, including XRD, XPS, SEM, TEM and UV-Vis DRS. The adsorption performance of MgV_6O_{16} was evaluated using selected cationic model contaminants. The results revealed a strong dependence of adsorption efficiency on pH, with markedly higher performance observed under acidic conditions. These findings are particularly novel as they suggest that the synthesised material has a high affinity for cationic species in acidic environments, which is contrary to the commonly reported trends for similar materials in the literature.

References:

[1] Nadolska-Dawidowska, M., Szkoda, M., Trzciński, K., Niedziałkowski, P., Ryl, J., Mielewczyk-Gryń, A., Górnicka, K., & Prześniak-Welenc, M. (2022). Inorganic Chemistry, 61, 9433-9444.

BIO of Presenter:

I am a Materials Engineering master's student at Gdańsk University of Technology. My research focuses on adsorption and the photocatalytic degradation of pollutants, as well as sensor technologies for water monitoring. This year, I also won the university stage of the Red Rose competition in the 'Best Student' category.

WETPOL 2025
GDAŃSK TECH, Gdansk, Poland

AUTONOMOUS SYSTEM FOR CLEANING HYDROCARBON AND BIOLOGICAL CONTAMINANTS FROM WATER BODIES - SKIMMER

Sebastian Parzych [1*], *Patryk Rybicki* [2], *Marek Chmielewski* [2], *Adam Augustyniak* [3]
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[2] Faculty of Applied Physics and Mathematics, Gdańsk University of Technology, Poland
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Increasing pollution of surface waters, particularly from hydrocarbons and biological agents such as cyanobacteria, poses a serious threat to ecosystems, water usability, and public health. Traditional water treatment methods are often reactive, costly, or difficult to deploy in dynamic or remote aquatic environments.

In response, we present an autonomous purification system specifically designed for effective removal of contaminants from natural and artificial water bodies. The system consists of compact, floating units that operate independently or in a coordinated group, targeting oil-based pollutants and cyanobacterial blooms. The system features a high level of autonomy, supported by real-time sensor data (GPS, ultrasonic radar), onboard decision-making algorithms, and the ability to navigate aquatic environments independently.

Each unit is equipped with a modular cartridge system tailored to the type of pollution. Hydrocarbon cartridges absorb oils and fuel residues, while biological cartridges collect floating cyanobacteria and organic debris. The design allows for fast, tool-free replacement of cartridges, ensuring continuous operation and minimal downtime. Units can operate individually or collectively in a swarm mode, coordinated by a base station that assigns tasks and optimizes group efficiency, making the system highly scalable depending on contamination severity.

Key purification features include:

- Targeted surface skimming of pollutants using optimized intake geometry
- Real-time analysis of water quality parameters (e.g., turbidity, pollutant concentration)
- Autonomous navigation and obstacle avoidance to reach and treat contaminated zones
- Swarm coordination, allowing multiple units to efficiently cover large or complex areas
- Scalable response, adaptable to pollution level and location (ports, lakes, rivers, coastal zones).

The units are powered by onboard batteries with a minimum of 1.5 hours of autonomous operation, and the system supports both rapid recharging and battery exchange. Additionally, eco-friendly materials and renewable energy sources are prioritized to reduce environmental impact during operation and maintenance.

Designed with flexibility, efficiency, and sustainability in mind, this system addresses both accidental and chronic pollution. It holds strong potential for deployment by public authorities and private stakeholders, contributing to cleaner water ecosystems and supporting tourism, recreation, and ecological resilience.

BIO of Presenter:
Sebastian Parzych is a student at GUT in faculty of Electronics, Telecommunications and Informatics. Currently he is working on Skimmer project which is presented in the abstract above. His work focuses on modernizing floating units to adapt more controllers for navigating polluted waters.

IN PLANT TRANFORMATION OF ORGANIC MICROPOLLUTANT IN CONSTRUCTED WETLAND PLANTS

Selina E. Ilchmann[1,2], Rumyana Karlova[2], Stefan van Leeuwen[1,3], Nora Sutton[1], Thomas Wagner[1]*
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Constructed wetlands (CW) can be used as a low-energy-consuming post-treatment strategy for wastewater treatment plant effluent for additional organic micropollutant (OMP) removal. Currently, the removal of OMPs by biodegradation and sorption in CWs is relatively well studied and progress has been made to engineer CWs to increase the OMP removal efficiency of these mechanisms. In contrast, the uptake of OMPs by plants and subsequent in-plant transformation has received less scientific attention. For a selection of OMPs, it is known that plants in CWs can take them up through their roots, relocate them, and most likely transform them. Plants possess a sophisticated metabolism system, meaning there are many questions remaining regarding OMP uptake, in-plant transformation products (TP), and accumulation of OMPs and TPs in the plant. My PhD-research will elucidate the fate of OMPs in plants and the underlying mechanism for plant uptake and transformation. To do so, the uptake and transformation of fifteen OMPs with different chemical properties and structures, e.g. metopropol, benzotriazole, carbamazepine and diclofenac, will be investigated using the model plant *Brachypodium distachyon* and typical CW plant *Phragmites australis*. Additionally, plant enzymes and endophytic (microorganism living in plant material) activity will be studied. To achieve this, extraction and analytical methods will be optimized for low concentration screening and will be tested on plant material grown in small scale CWs fed with real wastewater treatment plant effluent. Together, this will improve our understanding of plant-mediated OMP removal in CWs as well as providing valuable insights for food safety research.

With this **poster**, I will present the objective and experimental set-up of my first PhD-research experiment. In a hydroponic greenhouse experiment, *B. distachyon* will be exposed to selected OMPs. Root and shoot tissue will be analyzed for OMP (TPs) after extraction by target and non-target mass spectrometry screening. The non-target data will be analyzed using the online platform Global Natural Product Social Molecular Networking 2 (GNPS2) as well as the non-target data analysis tool patRoon. Incorporated database access improves molecule identification, annotation of structural related molecules, and statistical analysis. Combined, they enable the identification of TPs and the observation of overall plant metabolic changes. This explorative approach allows to investigate in plant formation of TPs while keeping an eye on plant physiological changes, potentially indicating active transformation pathways. It is hypothesized that each OMP has unique TPs but their transformation mechanisms are similar across OMPs. Hence, modifications e.g. glycosylation can be observed with various OMPs and their TPs. After TPs identification, tissue specific investigation can be started addressing the question of transportation pathways and final storage compartment. The obtained results will also be used for method development for targeted TP screening that can be used to determine the uptake and metabolization of OMPs in full-scale CWs, providing improved insights in the accumulation of OMP (TP) in the biomass.

BIO of Presenter:
Selina Ilchmann is a plant physiologist doing a PhD in a collaborative project between the Department of Environmental Technology and Laboratory of Plant Physiology at Wageningen University. Her research focuses on the fate of micropollutants after plant uptake and the in-planta mechanisms of OMP transformation and translocation.

ENHANCING AMMONIUM OXIDATION THROUGH HYDROLOGICAL ZONING: A CASE STUDY IN GUANJINGGANG CONSTRUCTED WETLAND

Weidong Wang[1,2], Yu Su[1,2]*
[1]Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, China
[2]University of Chinese Academy of Sciences, Beijing, China
* wdwang@rcees.ac.cn

Constructed wetlands often feature spatial heterogeneity in hydrology and redox conditions, which in turn influence microbial nitrogen cycling. In this study, we explored how structural optimization of a plant-bed/ditch system affects ammonium oxidation in the Guanjinggang Constructed Wetland (GJG-CW), with particular focus on microbial functional zonation and ammonia-oxidizing communities.

Field investigations and rate measurements demonstrated that ditching the original plant-bed significantly increased ammonium oxidation activity—most notably at two key microzones: the ditch center and the plant-bed fringe. Post-intervention oxidation rates rose by 2.13 and 1.76 times respectively in these areas, increasing from 1.07 ± 0.30 to 1.22 ± 1.27 mg N kg^{-1} d^{-1} overall. This spatial enhancement reflected a shift from uniform to highly heterogeneous activity patterns, suggesting the emergence of oxidation "hotspots" following hydrological modification.

Ammonia-oxidizing bacteria (AOB) and archaea (AOA) displayed distinct ecological niches: AOB activity was dominant in the ditch zone, while AOA remained more active in the plant-bed. Ditching markedly stimulated AOB activity, which was linked to elevated ammonium oxidation. Interestingly, no direct correlation was found between AOB abundance and oxidation rates, indicating functional activity rather than population size drove the response. Phylogenetic analysis of *amoA* genes revealed a shift in AOB community composition from predominantly *Nitrosospira* in the original system to a mixed dominance of *Nitrosospira* and *Nitrosomonas* after ditching. AOA community composition also shifted, indicating broader microbial succession induced by structural change.

These results highlight the importance of spatial hydrological zoning in optimizing microbial nitrogen transformations in constructed wetlands. Targeted enhancement of microbial functional hotspots may provide a practical strategy to improve ammonium removal efficiency in engineered ecosystems.

Keywords: Constructed Wetland, Ammonium Oxidation, Ammonia-Oxidizing Bacteria (AOB), Ammonia-Oxidizing Archaea (AOA), Plant-bed/Ditch System

BIO of Presenter:
Weidong Wang is a professor at the Research Center for Eco-Environmental Sciences of the Chinese Academy of Sciences, focused on the structure, function, and restoration of wetlands and land/inland water ecotones, as well as the ecological drinking water source protection.

RETHINKING SOIL HEALTH AND WATER QUALITY FROM A MOLECULAR ECOLOGY PERSPECTIVE: THE DANISH "MINI-WETLANDS" AS A PATH4MED CASE STUDY

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Since 2015, wetland restoration has been promoted in Denmark as a solution for improving water quality. Initiatives such as "mini-wetlands," supported under the Green Growth Agreement, aimed to reduce nutrient emissions into open water sources by 1,130 tons of nitrogen and 30 tons of phosphorus per year (Nissen, 2015).
Ten years later, within the framework of the European project Path4Med (https://www.path4med.eu/), we are evaluating one of the "mini-wetland" systems built in 2015 to assess whether its treatment capacity for agricultural runoff is still effective. The knowledge about challenges to water quality and soil health has evolved. Micropollutants are now recognized as widespread in aquatic environments, accumulating in seawater receptors and impacting ecosystems. At the same time, molecular functional techniques, such as metatranscriptomics, have become increasingly affordable and accessible. Moreover, the concept of soil health — and the impact of pollutant loads on ecosystem functioning — remains under discussion, as does how we should measure and monitor it. Our research questions thus extend beyond nutrient buffering to include micropollutant accumulation, DNA and RNA-based molecular profiling of the filtering beds, and the system's ongoing capacity for water purification. Yet once we generate such complex datasets, what are the right questions to ask? What does "soil health" and "water quality" really mean — from a water treatment perspective, or from the viewpoint of agricultural practices? What types of ecosystem services are these systems expected to provide, and how can we measure them?
By using total RNA sequencing (capturing both functionality and the presence of aquatic and terrestrial microbial communities, including eukaryotes), along with assessments of nutrient buffering and micropollutant degradation, we aim to propose and explore several key research questions through an integrative analysis of the datasets. Some of the specific points we address include:

- Structural biodiversity (in comparison with classical markers)
- Animal faecal contamination indicators
- Phytoplankton relative distributions
- Antibiotic resistance genes
- Functional genes involved in nutrient cycling
- Rhizosphere dynamics

At the conference, we will present more detailed information about our working hypotheses, together with preliminary analyses and perspectives on integrating molecular and analytical techniques for wetland assessment.

Nissen, A.L., 2015. Landowner Participation in Wetland Area Projects (Master thesis dissertation, University of Copenhagen).

BIO of Presenter:
Alba Martinez I Quer is a postdoctoral researcher at the Department of Environmental Science, Aarhus University. She researches within the intersection of environmental chemistry and microbiology in constructed wetlands using analytical chemistry and molecular microbiology to understand biodegradation pathways and actors.

Biomimetic Constructed Wetland for Microbial Degradation of Caffeine, Paraben, and Triclocarban in Synthetic Wastewater

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[3]Biotechnology Center of Silesian University of Technology, B. Krzywoustego 8, 44-100 Gliwice, Poland.
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Abstract
Constructed wetlands (CWs) provide an eco-friendly, integrative platform for wastewater remediation by leveraging physical, chemical, and biological processes. This study presents a novel biomimetic CW prototype using 30 L aquarium-based systems equipped with porous media, controlled aeration, and macrophytes to replicate natural wetland environments. The system incorporates targeted microbial treatments—fungal (*Trametes versicolor*), bacterial (*Pseudomonas aeruginosa*), and their consortia—to enhance the degradation of selected micropollutants: caffeine, paraben, and triclocarban (TCC), each introduced at 1 mg/10 mL concentration in synthetic wastewater. Over a three-month operation, we assessed system dynamics including microbial growth, plant health, and pollutant removal, with Nuclear Magnetic Resonance (NMR) employed for degradation monitoring. Fungal and bacterial treatments each achieved near-complete caffeine removal (99–100%) within seven weeks, while the combined microbial consortium reduced this time to just four weeks. Paraben exhibited a similar degradation profile. In contrast, TCC removal remained inconclusive due to poor solubility in the chosen solvent system. The findings highlight the effectiveness of microbial consortia in CWs for accelerated biodegradation of emerging contaminants and propose a scalable framework for advanced wastewater treatment. Future research should optimize solvent systems and microbial synergies to address compounds with lower bioavailability.

BIO of Presenter:
I am Bhautik Dave, a 4^{th} year PhD student at the Silesian University of Technology, Gliwice, Poland. My research is focused on microbial degradation of different pollutants. I work on my individual idea of microbial degradative wetland where I enhance the microbial degradation inside the biomimetic wetland. The whole idea based on self-cleaning phenomenon of water medium.

UNDERSTANDING ARBUSCULAR MYCORRHIZAL FUNGI'S CONTRIBUTION TO HEXABROMOCYCLODODECANE METABOLISM: PATHWAYS AND ECOLOGICAL IMPLICATIONS IN CONTAMINATED ENVIRONMENTS

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Hexabromocyclododecane (HBCD), a persistent organic pollutant, poses significant ecological risks due to its toxicity and bioaccumulation potential. Phytoremediation is a promising strategy to mitigate HBCD contamination, yet its effectiveness is limited by the compound's adverse effects on plant growth and soil microbial communities. Arbuscular mycorrhizal fungi (AMF) form symbiotic relationships with plants, potentially enhancing their resilience and bioremediation capabilities. This study investigates AMF's role in HBCD metabolism and its ecological implications in contaminated environments. A pot experiment was conducted using *Iris pseudacorus* L. inoculated with *Rhizophagus irregularis*, subjected to HBCD exposure. Treatments included AMF-inoculated and non-inoculated plants, with and without HBCD. Plant growth parameters, oxidative stress indicators (e.g., malondialdehyde, superoxide anion, peroxidase, superoxide dismutase), HBCD isomer concentrations, and rhizosphere microbial communities were assessed. Results revealed that HBCD induced oxidative damage and inhibited plant growth. AMF inoculation significantly mitigated these effects by enhancing antioxidant defenses, reducing oxidative damage, and promoting growth. Furthermore, AMF accelerated HBCD isomer degradation, with rates following the order β-HBCD > γ-HBCD > α-HBCD. Microbial community analysis showed that AMF enriched rhizosphere bacterial taxa linked to HBCD degradation, potentially upregulating genes associated with its metabolism. These findings underscore AMF's dual role in alleviating HBCD stress in plants and enhancing its biodegradation through microbial modulation. By improving phytoremediation efficiency and reducing ecological risks, AMF offer a valuable approach for managing HBCD-contaminated sites. This research advances our understanding of AMF-mediated bioremediation and supports the development of sustainable strategies for wetland restoration.

BIO of Presenter:
Dr. Zhongbing Chen is an associate professor at the Czech University of Life Sciences Prague, and his main research focus is the fate of organics and heavy metals in constructed wetlands. Currently, he is interested in the application of arbuscular mycorrhizal fungi in constructed wetlands.

HARNESSING BIOGENIC MANGANESE/IRON OXIDES IN CONSTRUCTED WETLANDS FOR ENHANCED ORGANIC MICROPOLLUTANT REMOVAL

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Groundwater constitutes the primary source of drinking water in the Netherlands, accounting for 60% of the national supply. However, the sustainable management of aquifer recharge faces significant challenges from organic micropollutants (OMPs) originating in surface water systems. To address this issue, Dutch water authorities are re-engineering natural infiltration systems through an innovative pretreatment strategy: constructed wetlands (CWs). Conventional CW designs, while effective for conventional contaminants like COD and nutrients, do not remove all OMPs sufficiently. To overcome this limitation, we propose integrating biological MnO_x as substrate in CWs for better OMPs removal.
This novel CW utilizes biologically formed manganese oxides ($BioMnO_x$) for OMPs removal. $BioMnO_x/FeO_x$ is generated as a byproduct in groundwater-based drinking water plants, where microbial oxidation of dissolved Mn^{2+} and Fe^{2+} forms manganese/iron oxide coatings on silica sand particles. These biogenic oxides exhibit three possible mechanisms for OMP removal: 1) Chemical oxidation through electron transfer from OMPs to the highly reactive MnO_x matrix, 2) Biodegradation mediated by manganese-oxidizing bacteria (MnOB) embedded in the biofilms, and 3) High adsorption capacity, characterization reveals that $BioMnO_x$ possesses a δ-MnO_2 crystalline structure with flower-like microstructures observed via scanning electron microscopy, providing enhanced surface area compared to synthetic counterparts.
To disentangle the 3 OMPs removal mechanisms (Fig 1), batch experiments will be performed using controlled mixtures $BioMnO_x/FeO_x$ and sand from mature CWs under two conditions (Fig 2): (1) inhibited systems (4°C) isolating abiotic processes (adsorption + oxidation), and (2) biotic systems enabling all three mechanisms. All setups will also be tested in strict aerobic or anaerobic environments. Net OMPs removal will be tracked over 28 days, and non-target screening will be used to identify the formation of transformation products (TPs).
By performing these batch experiments, we will be able to: 1) determine the contribution of $BioMnO_x/FeO_x$ sand to the overall OMP removal efficiency; 2) identify the contribution of biodegradation, adsorption, and chemical oxidation; 3) determine the formation of TPs; 4) distinguish TPs formed by chemical oxidation and biotransformation

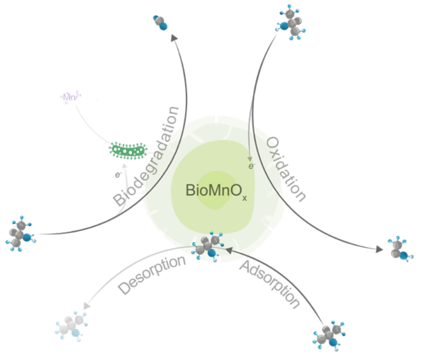

Fig 1. Possible OMPs removal mechanisms conducted by biogenic MnO_x/FeO_x.

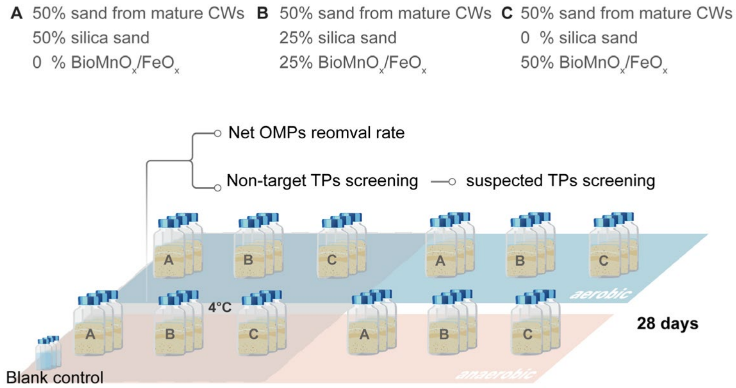

Fig 2. A batch study to identify the role of biogenic MnO_x/FeO_x in OMPs removal as an oxidant, adsorbent, and bioaugmentation.

<u>BIO of Presenter</u>:
Han Liu, a PhD researcher at Wetsus/WUR, pioneers $BioMnO_x$-mediated constructed wetlands for organic micropollutant removal in drinking water pretreatment. His research spans adsorption capacity decay of black carbon in sediment (China Pharmaceutical University) and a quick bioluminescent detection method of plant-derived nitrification inhibitors (University of Copenhagen).

LASER-ACTIVATED 3D-PRINTED BIODEGRADABLE ELECTRODES FOR ELECTROCHEMICAL DETECTION OF PHARMACEUTICALS IN WATER

Aleksandra Tober [1,2], Maja Daroszewska [1,2], Marta Kamińska [1,2], Jacek Ryl[1]*
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In the face of increasing threats to freshwater quality—particularly the presence of pharmaceuticals and their metabolites—the development of effective detection methods has become a key challenge of the 21st century. Modern electrochemical sensors, thanks to their high sensitivity, selectivity, and miniaturization potential, offer a promising tool for real-time monitoring of such contaminants. This study presents the development of innovative, environmentally friendly 3D electrodes fabricated using additive manufacturing techniques from a biodegradable PLA/TPU polymer blend enriched with conductive carbon black and a plasticizer. This approach enables low-cost production of sensors that can be implemented even outside specialized laboratory settings.

To enhance the electrochemical performance of the obtained electrodes, laser surface activation was applied. Material modification was carried out using two types of lasers—CO_2 (IR) and UV—under varying power and pulse duration parameters. The aim was to expose the conductive pathways within the composite structure and achieve localized surface modification without the need for chemical reagents. The study evaluated how different laser ablation strategies influenced the physicochemical and electrochemical properties of the electrodes, such as conductivity, internal resistance, and electrochemically active surface area. Comparing both activation methods allowed for the identification of the most effective laser treatment in improving the key parameters relevant for future sensor applications aimed at detecting trace levels of pharmaceuticals in aquatic environments.

<u>BIO of Presenter</u>:

A graduate of the Nanotechnology program at the Faculty of Technical Physics and Applied Mathematics. Currently pursuing a Master's degree in Biomedical Engineering at the same faculty. Chair of the Interfaculty Scientific Association RedOx.

CONSTRUCTED WETLANDS FOR REVERSE OSMOSIS CONCENTRATE TREATMENT – INSIGHTS ON LONG-TERM PERFORMANCE AND NOVEL PILOTS

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Constructed wetlands are widely used for a variety of treatment applications of domestic, agricultural, drainage, and industrial effluents, as well as an extra polishing step of Wastewater Treatment Plants (WWTPs). However, the use of constructed wetlands to address the pressing issue of reverse osmosis concentrate (ROC) management has only more recently been proposed (Scholes et al. 2021[1]) and reported (Chakraborti and Bays 2020[2]). Consequently, the aim of this study is (i) to provide evidence for the performance of constructed wetlands for ROC treatment, and (ii) to report on the results for improved design of wetlands for ROC treatment.

This study reports on the performance of a full-scale 1-ha horizontal subsurface flow (HSSF) constructed wetland planted with willows (*Salix spp.*). The system was implemented by Aquaduin, a drinking water utility in Koksijde, Belgium, to treat ROC from a UF-RO unit receiving treated municipal effluent from the nearby WWTP. Gravel was used as substrate with a smaller zone (~10%) where only wood chips were used. Since 2022, performance monitoring of the wetland influent and effluent has been conducted monthly (flow, conductivity, temperature, COD, TN, NH_4^+, NO_3^-, NO_2^-, TP). During March 2024 – April 2025, a continuous monitoring campaign has provided higher resolution data via daily samples composited weekly. In Spring 2025, a pilot system replicating the full-scale HSSF wetland consisting of four 1 m^3 units is currently being used to test treatment performance in alternative substrate materials: (i) gravel (benchmark), (ii) woodchips (to supply biodegradable carbon for enhanced nitrogen removal), (iii) biochar (to improve removal of COD and micropollutants), and (iv) seashells (to enhance phosphorus removal via $CaCO_3$-adsorption).

The monitoring results of the 1-ha wetland revealed limited removal efficiencies: ~10% for COD (183±148 to 162±128 mg O_2/L), ~30% for Total Nitrogen (15±4 to 10±3 mg TN/L), and only 2–5% for Total Phosphorus (3±1 to 2±1 mg TP/L). Moreover, no reduction in conductivity was observed (4001±794 to 4082±765 µS/cm). The COD fraction appears to be largely non-biodegradable, likely to explain the poor removal. Nitrogen removal showed seasonal variability, with summer efficiencies reaching 40–50%, linked to higher microbial activity and carbon availability. Phosphorus removal shows to have declined over time, likely due to substrate saturation. Micropollutant monitoring, focused on pharmaceuticals and selected herbicides, revealed detectable levels of compounds such as atenolol and gabapentin (0.2–10 µg/L), with variable but promising removal (~70-90%). Results of the four pilot wetland designs will reveal where dedicated substrate selection can improve the treatment performance.

In conclusion, this research highlights the complexity of applying wetlands for ROC treatment, including its limitations to remove recalcitrant COD, N, P and salt content, providing also valuable data on long-term performance and supporting the development of tailored treatment wetlands for circular water systems.

BIO of Presenter:
Catarina Baptista is a bioengineer, specialised in biological wastewater treatment and constructed wetlands, working as researcher on topics such as mainstreaming Nature-based Solutions and circular systemic solutions across Europe. As science communicator, she has organized and participated in several events to bridge the science-policy-society interface and boost impact through knowledge.

Disclaimer: An oral presentation is preferred. The pilot research is currently ongoing, therefore by the date of the conference more detailed data can be presented regarding this section of the work.

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(1), 7–17. https://doi.org/10.1021/acsenvironau.1c00013

OPTIMISING WETLAND-BASED SOLUTIONS FOR IMPROVED MICROPOLLUTANT TREATMENT EFFICIENCY FROM WASTEWATER TREATMENT PLANT (WWTP) EFFLUENT: THE WE-TREAT PROJECT

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Micropollutants (MPs) such as pharmaceuticals and industrial chemicals in water bodies are receiving growing attention due to their persistence and potential risks to both aquatic ecosystems and human health. Conventional wastewater treatment systems often fail to effectively remove these substances, resulting in their accumulation in aquatic environments. This buildup can disrupt ecosystems and negatively affect the health, behaviour, reproduction, and survival of aquatic organisms, eventually making its way into the food chain.

In response to these concerns, the European Union has updated its Urban Wastewater Directive (Council Directive 91/271/EEC), now requiring wastewater treatment plants (WWTPs) to achieve at least 80% removal of MPs like pesticides and pharmaceuticals. While post-treatment technologies such as activated carbon filtration and ozone oxidation are commonly used, they tend to be energy-intensive and rely on fossil-based materials. To reduce environmental impact and energy consumption, there is a pressing need for more sustainable and eco-friendly alternatives for advanced wastewater treatment. Constructed wetlands (CWs) offer a nature-based solution by combining biodegradation, sorption, photodegradation, and phytoremediation processes to remove MPs and other contaminants.

The We-Treat project (Grant Agreement n°101060874), funded under the theme "Aquatic Ecosystem Services" of the Water4All call 2023, aims to drive innovation by optimising phytoremediation systems using elite wetland plant ecotypes and their associated rhizosphere microbiomes.

We-Treat grounds on a multidisciplinary and intersectoral consortium including agronomists, biologists, engineers, chemists, and biotechnologists from Portugal (PT), Italy (IT), Luxembourg (LU), and the Netherlands (NL) with ambitious objectives. Several species have shown the capacity to uptake MPs within CWs, thus, their optimised propagation (Objective 1) and fundamental understanding of their physiology (Objective 2) when exposed to MPs can lead to an increased efficiency of wastewater treatment (Objective 3).

This integrated, multidisciplinary approach supports the development of sustainable water treatment solutions that enhance water quality, safeguard ecosystems, and protect public health and the environment.

BIO of Presenter: Henry Beral is a plant biologist dedicated to nature-based solutions for water treatment. He investigates how plants can remove micro-contaminants from runoff, greywater and wastewater through systems like bioretention, green walls and constructed wetlands, bridging plant physiology and environmental engineering.

Poster presentation

EVALUATION OF CHANGE IN BIOCHAR PROPERTIES DERIVED FROM ERAGROSTIS TEF STRAW AND PYROLYSIS TEMPERATURE FOR ENVIEONMENTAL APPLICATION

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ABSTRACT

The agricultural wastes must be treated in a way that maintains environmental sustainability. In the current research study, we introduce the possible application of Teff straw (Eragrostis tef straw), which is one of the most prevalent agro-wastes in Ethiopia and East Africa, to environmental pollution. As Teff straw contains high levels of hydroxyl groups, we explored the utilization of its biochar through pyrolysis, focusing on its prospects for environmental application. Teff straw biochar was made at temperatures of 400 °C, 500 °C, and 600 °C, and it was analyzed using X-ray diffraction(XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), and Fourier transform infrared (FTIR) spectroscopy, as shown in Figure 1. The findings suggest that the temperature of pyrolysis dictates the surface microstructure and physicochemical characteristics of biochar. Brunauer-Emmett-Teller (BET) surface area of Teff straw increased from 2.61 m²/g, with a maximum value of 18.44 m²/g at 500 °C; while below and above temperatures, i.e., 400 °C and 600 °C, respectively, provided lower surface values of 11.12 m²/g and 17.45 m²/g, respectively. It can be concluded from these results that the optimal pyrolysis temperature for the maximum surface area and maximum potential uses of Teff straw biochar is 500 °C. Phosphate recovery, soil remediation, carbon sequestration, wastewater treatment, and other environmental applications can effectively utilize this biochar, contributing to a circular economy.

Keywords: Teff straw: waste valorization: optimum pyrolysis temperature: environmental application: circular economy

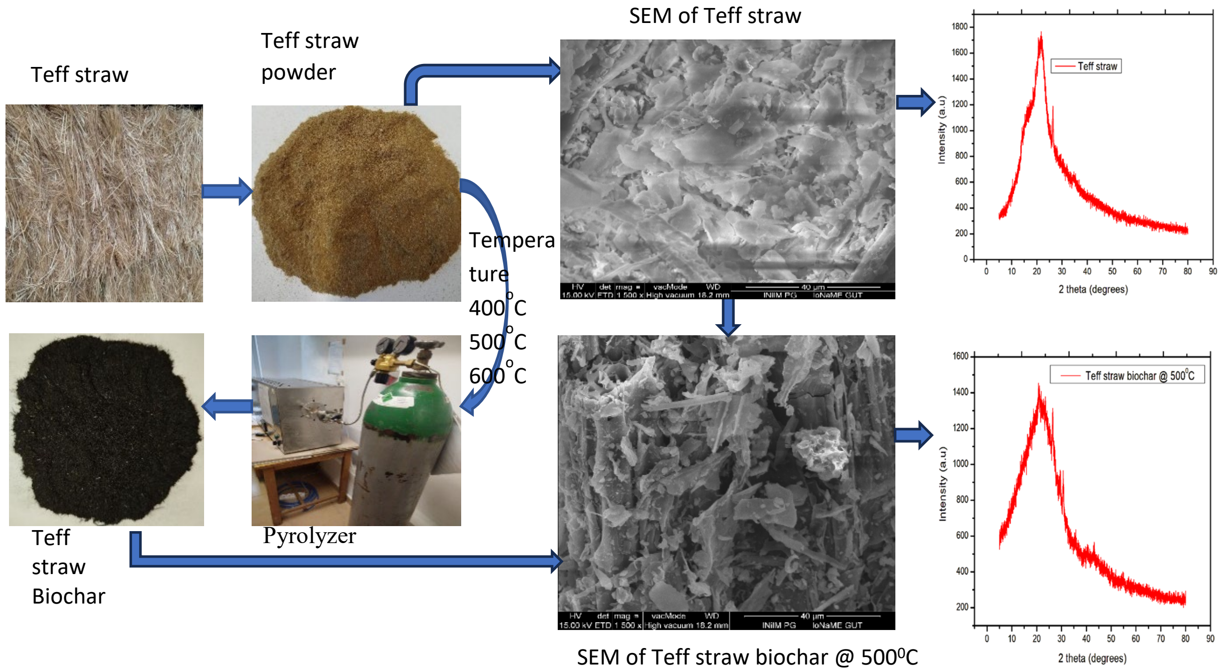

Figure 1. Teff straw biochar production and its characterization

BIO of Presenter:

Abreham Bekele Bayu is a PhD fellow at Gdańsk University of Technology, specializing in environmental engineering, mining, and energy. His research focuses on waste valorization, nutrient recovery, and agricultural wastewater treatment. He has authored several peer-reviewed articles and frequently presents at international conferences on sustainable technologies and ecological resource management.

FULL-SCALE CONSTRUCTED WETLAND WITH IRON-OXIDE-COATED SAND FILTER FOR DOMESTIC WASTEWATER TREATMENT

Jente Lezy [1], Wouter Igodt[1], Stijn Van Hulle[2], Diederik Rousseau[2]*
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In the municipality Ledegem (West-Flanders, Belgium) domestic wastewater from a rural residential area (70 P.E.) is being treated using a full-scale nature-based treatment plant. The biological treatment step involves a 140 m^2/m^3 VFCW with flowering vegetation, applying a hydraulic loading rate of 0.06 $m^3.m^{-2}.d^{-1}$. Solid-settlers are employed in the pre-treatment phase, while a novel post-treatment step captures phosphates from the VFCW effluent. In this final step, 2.5 ton of a granular iron-based byproduct from potable water production, known as iron-oxide coated sand (IOCS), is utilized to capture phosphates. This process is both cost-effective, since no energy is necessary and no sludge gets produced. Continuous sensor monitoring, ensures accurate system performance by tracking effluent water quality, water flow, energy usage, and weather conditions. This long-term and still ongoing research also aids in identifying trends, such as the necessary starting phase and seasonal effects on treatment performance.

The system has proven to be a robust option for domestic wastewater treatment, complying (2022-2024) with the Flemish discharge standards that normally apply to 100 000 P.E. plants. After a brief start-up period of about three months, it achieved average removal efficiencies of 90 % for COD, 96 % for TSS, 75 % for total nitrogen and 90 % for total phosphorus. Phosphorus-polishing—often the bottleneck in small, unmanned biological plants—was particularly effective: effluent concentrations averaged 0.4 ± 0.3 mg P L^{-1} (Figure 1.). The IOCS filter proved to be a rapid, reliable way to capture phosphorus in a decentralized setting, needing only an annual media change. Despite these high treatment levels, the hybrid system operates at just 0.15 kWh m^{-3} - two to ten times less energy than conventional plants.

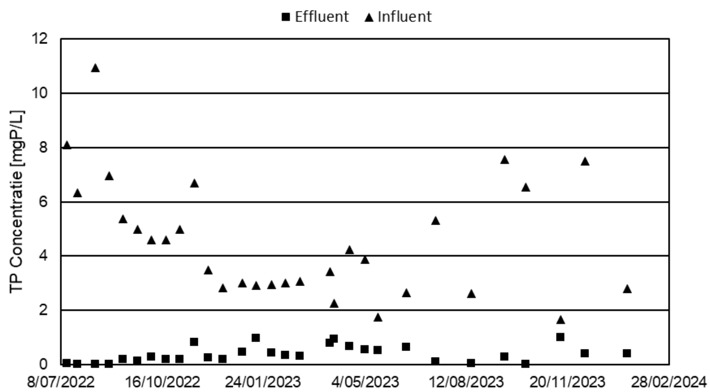

Figure 1. Periodic sampling outcomes of the decentralized treatment plant include influent (sample after solid settlers) and effluent (after post-treatment) measurements total phosphorus.

BIO of Presenter: After graduating as an Environmental Ind. Eng., I started working as a water researcher for UGent on the EU Interreg project I-Qua. Today I apply that experience in R&D at HelloWater, where I continue to work closely with UGent's LIWET group to translate academic insights into practical solutions.

WHERE DOES THE PHOSPHORUS GO? TRACKING FATE AND CYCLING IN TREATMENT WETLANDS

Ayisha Affo Souleymane [1], Gabriela Dotro,[1,2], Robert Grabowski[1], Tao Lyu[1],*
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Surface-flow treatment wetlands play an increasing role in achieving phosphorus (P) compliance targets under nature-based solutions frameworks, yet the internal cycling of phosphorus across compartments remains poorly resolved. This study investigates phosphorus fate and transformation pathways across three full-scale wetlands in the UK receiving secondary and tertiary effluent with differing upstream chemical dosing regimes.

Water, sediment, and vegetation samples were analysed for total and fractionated phosphorus, supported by mass balance modelling. Dissolved phosphorus (DP) was the dominant form at all sites, accounting for >70% of total phosphorus in final effluent. Sediment analysis showed that Fe/Al-bound P contributed most significantly to retention; however, statistical comparisons revealed no significant difference in sediment P storage between ferric-dosed and undosed sites, challenging assumptions about chemical enhancement of long-term binding in wetland sediments.

Root-zone plant uptake was found to contribute minimally to system-level P removal (<3%), though evidence of Fe plaque formation suggests sorptive roles may be underrepresented in current models. A large residual sediment P fraction remained unclassified by standard extraction protocols, highlighting the need for improved methods to characterise long-term P stability.

To further understand internal P cycling, two upcoming experiments will be integrated in summer 2025: (i) a 24-hour high-resolution sampling campaign to capture diel variability in phosphorus species and redox-sensitive conditions, and (ii) algal biomass and phosphorus content sampling across cells to assess the contribution of algae to phosphorus uptake and transformation. These efforts aim to quantify the temporal and microbial components of phosphorus cycling, and better align process understanding with real-time performance fluctuations observed in operational wetlands.

Findings from this study will provide actionable insights for wetland design, monitoring, and adaptive management, particularly under regulatory pressure to achieve low phosphorus discharge concentrations while maintaining ecosystem co-benefits.

BIO of Presenter:
Ayisha Affo Souleymane is a PhD researcher at Cranfield University, focusing on phosphorus and carbon dynamics in surface-flow treatment wetlands. She has academic and industry experience in wastewater treatment and is currently collaborating with UK water utilities on constructed wetland use for nutrient removal and other co-benefits.

NATURAL PROMOTER-ENRICHED ACTIVATED CARBON FROM TANNERY WASTE: A DUAL ROLE IN METAL ADSORPTION AND HYDROCARBON REFORMING CATALYSIS

Beata Barczak [1], Ewa Klugmann-Radziemska[1], Katarzyna Januszewicz[1]*
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Growing environmental pressures and the need for sustainable waste management strategies have prompted intensive research into converting residual biomass into value-added materials for environmental and energy applications. In pursuing sustainable technological solutions, increasing attention is being directed toward utilising waste biomass materials derived from various sectors of daily life and industry. This study investigates the potential of tannery shavings—representing the largest fraction of solid waste generated in leather processing—as a precursor for the production of a dual-functional material: first, as an adsorbent for the removal of heavy metal ions from water, and subsequently, as a catalyst support in the dry reforming of hydrocarbons (DR).

Tannery shaving biomass produced highly porous activated carbon through pyrolysis, followed by chemical activation with potassium hydroxide (KOH). In the first stage, model adsorption experiments were carried out to evaluate the material's capacity to remove nickel (Ni^{2+}) and cobalt (Co^{2+}) ions from aqueous solutions. The influence of key parameters such as pH, contact time, and ion concentration on the adsorption efficiency was examined. The results confirmed a high sorption capacity of the material (97.5% and 94.7% removal of Ni^{2+} and Co^{2+} after 180 min, respectively), indicating its promise as an effective adsorbent for heavy metal removal, one of the critical environmental challenges of the 21st century.

In the second stage, the spent activated carbon, loaded with metal ions after the adsorption process, was utilized as a catalyst in the dry reforming of methane. Before catalytic testing, the material underwent calcination and reduction to convert the adsorbed metal ions into their metallic forms. The performance of the resulting catalyst was compared with a conventional Ni-Mo/Al_2O_3 catalyst. The activated carbon-based catalyst exhibited satisfactory catalytic activity - 67% CH_4 conversion, compared to 84% for the conventional catalyst. An additional advantage of the bio-based catalyst was the natural presence of mineral elements such as sodium (Na), potassium (K), and magnesium (Mg), which are known to act as catalytic promoters. Their inherent presence in the biomass may contribute to reduced coke deposition, enhanced catalyst stability, and prolonged catalyst lifetime by mitigating deactivation mechanisms.

The results of this study demonstrate that waste-derived activated carbon can serve a dual role as both an efficient adsorbent and a promising catalyst support in energy conversion processes. This approach aligns with the principles of the circular economy, contributing to waste reduction, environmental protection, and more sustainable resource utilization. Furthermore, the presented findings are in line with current trends in the search for alternative energy sources and represent preliminary research into the potential use of carbon-supported catalysts in reforming processes of the volatile fraction from the pyrolysis of plastic waste.

BIO of Presenter:
Beata Barczak, MSc Eng, is a PhD student at the Faculty of Chemistry, GUT. Her research focuses on valorisation of residual plant and animal biomass via thermochemical conversion (mainly pyrolysis and activation) for application in adsorption, electrochemical and catalytic processes like DMR or SMR.

ENHANCING CARBON SEQUESTRATION AND WATER PURIFICATION TO SUSTAIN WETLAND ECOSYSTEMS

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Introduction: Wetlands are crucial for carbon sequestration and water purification however; they face increasing pressures from human activities. All wetlands sequester carbon from the atmosphere through plant photosynthesis and by acting as sediment traps for runoff. Wetlands are some of the largest stores of carbon on the planet, but when disturbed or warmed, they release the three greenhouse gases that contribute the most to global warming: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) [2]. This study aims at enhancing carbon sequestration and water purification to sustain wetland ecosystems.

Methods: A mixed research method approach was used. The study measured and estimated N_2O and CH_4 gas emissions from the wetland and induced net sequestration rates. Other data was collected using questionnaires among wetland users, specialists, field observations and secondary data from weather stations.

Results: Wetlands have grossly lost their carbon sink and increasingly carbon stored in them is released. There is an observed increase in CO_2 concentrations in the atmosphere are up to 46% per year. Rates of C sequestration and CH4 emissions are dependent upon the height of the wetland above the water table. Some wetlands have been under extraction and emitting 0.24 Tg -1 of Co2. The biomass of aquatic wetland plants (hydrophytes) exhibits the ability to sequester up to 0.7 Gt of carbon. Fluxes of soil carbon resulting from oxidization due to the degradation and loss of wetlands. Phosphorus retention value among surveyed wetlands ranged from -.03 to .051 g/m2/year while Nitrogen retention among ranged from -.44 to .56 g/m2/year.

Conclusion: Carbon sequestration potential of wetlands and water purification once well managed through a multi-stakeholder engagement can sustain wetland ecosystems.

Key words: Carbon sequestration, Wetland ecosystems.

BIO of Presenter:
Nassolo Ritah is a well-rounded research expert with wide span of experience in strategic program design and implementation. She has Collaboratively worked with many research and academia institutions in the areas of applied research. Ritah holds an MSc. in Environment & Natural Resources and she is a member of the Uganda EvaluationAssociation (UEA).

INNOVATIVE GREEN SOLUTIONS: SLUDGE-DERIVED FERTILIZERS FREE FROM PFAS AND ANTIBIOTICS (FERTIPAS)

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Abstract

The FERTIPAS project aims to address the contamination of excess sludge from wastewater treatment plants with per- and polyfluoroalkyl substances (PFAS) and antibiotics, which hinder its sustainable use in agriculture. Utilizing Sludge Treatment Reed Beds (STRB), a nature-based technology, the project seeks to convert sludge into high-value agricultural fertilizer while ensuring it is free from hazardous chemicals. The project will explore two biotechnological innovations: the integration of earthworms and bio-electrochemical systems to enhance the control of PFAS and antibiotics in sludge. FERTIPAS will measure the presence of these contaminants in full-scale STRB systems in Denmark, study their transformation processes, and investigate a novel hybrid microbial-fuel cell configuration with earthworms. Additionally, machine learning will be employed to identify patterns and forecast reactor performance. The goal is to provide a comprehensive assessment of both the problem and potential solutions for hazardous chemicals in sludge, contributing to environmental protection and circular economy.

Keywords: Nature-based solutions; Sludge; Sludge Treatment Reed Beds (STRB); Earthworms; Circular economy

BIO of Presenter:

Amir Gholipour is a post-doctoral researcher at Aarhus University, specializing in environmental engineering. He completed his Ph.D. at the University of Lisbon in 2025, focusing on innovative sludge treatment methods. His research interests include Nature-Based Solutions, constructed wetlands, and the circular economy.

OPTIMIZING SINGLE-STAGE AND HYBRID CONSTRUCTED WETLANDS FOR WASTEWATER TREATMENT AND REUSE

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Constructed Wetlands (CW) represent a sustainable solution for wastewater management, as they use naturally occurring processes to treat various wastewater sources. Different CW types have been developed over the years depending on the number of stages and flow path. Generally, hybrid CW systems, i.e., systems with two or more treatment stages, have been found to possess a higher treatment capacity. Although singe-stage and hybrid CW are already applied worldwide, there is still need for improved designs and enhanced performance, especially considering effluent standards for reuse in agriculture.

With this in mind, this project develops various pilot-scale CW systems towards the optimization of the various designs. The pilot CW have been installed at the municipal wastewater treatment plant of Chania (WWTP). Specifically, two hybrid CW (Hybrid A and Hybrid B) have been constructed to treat raw municipal wastewater after the screening stage. Each hybrid system consists of one Vertical Flow CW unit per stage. Additionally, two other single-stage vertical flow CW (PG and PGB) treat primary municipal wastewater collected from the primary sedimentation. Each unit is an IBC tank of 1 m^3 volume. The various beds have different construction and operation parameters, such different and novel substrate media (recycled HDPE, biochar, medium and small gravel, sand) up to 70 cm depth, different vegetation species (*Phragmites australis and Arundo Donax*) and varying applied hydraulic loading rates. All CW systems operate at an average HLR of 0.19 m/d (daily inflow of 200 L/d) so far and the water level varies across the units to provide partial saturation (40 cm in the second stage of the hybrid CW).

Regular samplings and analyses in the influent and effluents of all CW units take place for the determination of a series of physicochemical parameters and micropollutants. The pilot units are in their first year of operation. So far, all systems demonstrate a high performance across all examined parameters (nitrogen, phosphorus, COD, BOD_5, pathogens, etc.). This work will present the overall results of the pilot units after the first operational year.

Acknowledgement

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BIO of Presenter:

Emmanuela Karefylaki graduated from the School of Environmental Engineering at the Technical University of Crete and is currently pursuing a PhD in Ecological Engineering. Her research focuses on constructed wetlands towards developing innovative and optimized designs for wastewater treatment and reuse.

NBS4AQUAMISSION: MONITORING THE FIRST RHIZOSPH'AIR SYSTEM IN DENMARK

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Abstract
Anthropogenic activities, particularly pollution by pharmaceuticals, are a major driver of biodiversity loss in aquatic ecosystems, with freshwater species seeing a significant decline. Concerns about pharmaceuticals pollution in aquatic ecosystems and human health were raised over 20 years ago, and current policy approaches for managing pharmaceutical waste are considered inadequate to protect water quality and aquatic ecosystems. Better, sustainable water treatment systems are necessary, especially as pharmaceuticals consumption steadily increases. Cocktails of pharmaceuticals are released after human consumption, often present in WWTP effluents at concentrations exceeding predicted non-effect concentrations (PNEC), representing a high risk to biota and causing ecological consequences, even at low levels. Therefore, there is an explicit need for more effective strategies to minimize pharmaceuticals pollution and ensure healthy aquatic ecosystems.

The NBS4AQUAMISSION project aims to leverage nature-based systems (NbS) in a combined triad solution of treatment wetlands, innovative materials (like bio- and hydrochars), and bioaugmentation (using active microbes) to mitigate the impacts of pharmaceuticals pollution on aquatic biodiversity. The project adopts a transdisciplinary approach, assembling expertise from various fields including biological, environmental, chemical, economic, educational, and anthropological, to understand the relationships between biodiversity, ecosystem services, and social systems. The research plan stands out by intertwining chemical-ecotoxicological approaches to address the challenge of pharmacological products on biodiversity, aligned with the latest calls from the BIODIVERSA+.

The Danish case study in the NBS4AQUAMISSION project will be centered around the Rhizosph'air system in Hvidkilde, an eco-village in the northern part of Zealand. The system designed to treat the domestic wastewater from 125 PE, is the first Rhizosph'air system built in Denmark by Kilian Water. This specific site does not use a septic tank as a pre-treatment step; instead, both the sludge and the water are treated together within a single system. Following treatment, the water is not discharged to surface water but is infiltrated into the ground, thereby recharging the groundwater. We aim at monitoring this 1,5-year-old system for the next 2 years for classical pollutants and pharmaceuticals and different ecotoxicological assessments with the support of our international partners.

A poster will present the concepts behind the project, the Danish case study and we aim to bring the first screening results for pharmaceuticals.

BIO of Presenter:
Pedro N. Carvalho is Associate Professor in environmental chemistry with an extensive research activity in water treatment technology. He has more than 17 years of experience working with organic micropollutants in the environment and more than 14 years dedicated to micropollutants occurrence in wastewater and their fate in treatment wetlands.

STUDY ON MICROBIAL COMMUNITIES IN VERTICAL FLOW CONSTRUCTED WETLANDS REMOVING PERSONAL CARE PRODUCTS FROM LIGH, MEDIUM AND DARK GREYWATER

Fernanda Cristina MUNIZ SACCO[1], Silvia VENDITTI[1], Paul WILMES[2], Cedric Christian LACZNY[2], Tuesday LOWNDES[2], Zainab ZAFAR[2], Heidrun STEINMETZ[3], Joachim HANSEN[1]*

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Microbial communities have already demonstrated their benefits in increasing yields in the recovery of valuable products from wastewater, such as biodiesel from accumulated lipids by *Microthrix parvicella* in urban sewage sludge (Muniz Sacco et al., 2023) and biodegradable polymers of polyhydroxyalkanoates (PHA) by the PHA-producing bacteria, such as the genera *Zoogloea*, *Dechloromonas*, *Acinetobacter* and *Clostridium* in residual streams from fruit juice industry and urban excess sludge (Laumeyer et al., 2025).

Here, we investigate the microbial communities involved in the recovery of the most obvious product from wastewater: water, more precisely greywater (GW), which represents wastewater from households, excluding the toilet fraction. We use vertical-flow constructed wetlands (VFCWs) filled with innovative substrates: zeolite and biochar from plant residues and from sewage-cellulose mixed with expanded clay to remove personal care products (PCPs) from GW (Muniz Sacco et al., 2024). Our hypothesis is that microbial communities improve the overall removal efficiency of macropollutants (e.g., chemical oxygen demand (COD), total nitrogen (TN) and total phosphates (PO4-P)) and micropollutants (e.g., PCPs) in VFCWs. To resolve the microbial community composition, DNA was extracted from substrate samples using an optimized protocol based on DNeasy PowerMax Soil Kit (Qiagen, Germany). DNA quality and quantification were checked using Qubit dsDNA HS Assay Kits (Thermo Fisher Scientific, USA), and the full-length 16S rRNA gene was sequenced using a MinION sequencer (Oxford Nanopore Technologies).

Preliminary characterization of the unused substrate with sewage-cellulose biochar revealed *Alkalibacterium* (48%) and *Planococcus* (25%) as the most abundant genera. These genera were used to biologically activate the biochar, confirming the efficacy of our extraction and characterization framework. This framework will be applied to study how the microbial composition changes upon GW treatment (lightly, moderately and heavily polluted), as well as due to operational parameters such as hydraulic and organic loading rates.

References

Laumeyer, C. M., Zimmer, J., & Steinmetz, H. (2025). From fruit juice wastewater to biopolymer – How the mixed microbial culture and PHA content develop over time. Chemical Engineering Journal, 503, 158314. doi: 10.1016/j.cej.2024.158314.

Muniz Sacco, F. C., Frkova, Z., Venditti, S., Pastore, C., Guignard, C., & Hansen, J. (2023). Operation of a pilot-scale lipid accumulation technology employing parameters to select Microthrix parvicella for biodiesel production from wastewater. Bioresource Technology, 369, 128498. doi: 10.1016/j.biortech.2022.128498.

Muniz Sacco, F. C., Venditti, S., Wilmes, P., Steinmetz, H., & Hansen, J. (2024). Vertical-flow constructed wetlands as a sustainable on-site greywater treatment process for the decrease of micropollutant concentration in urban wastewater and integration to households' water services. Science of the Total Environment, 946, 174310. doi: 10.1016/j.scitotenv.2024.174310.

BIO of Presenter:
Fernanda Muniz Sacco is a doctoral researcher at the University of Luxembourg. She is an agricultural engineer with a master's degree in sustainable development, with over 10 years of experience in sustainable agriculture. Since 2021, she has been developing her career in circular economy applied to urban wastewater management.

OPTIMIZED TWO-STAGE VERTICAL FLOW CONSTRUCTED WETLAND SYSTEM INTEGRATED WITH MICROBIAL FUEL CELL AND MICROALGAL PHOTOBIOREACTOR FOR PIGGERY WASTEWATER TREATMENT AND RESOURCE RECOVERY

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Optimizing Nature-Based Technologies for Wastewater Management and Circular Economy

This pilot scale study presents an integrated nature-based solution to mitigate the negative environmental impacts of piggery wastewater, through the development, optimization, and integration of two-stage vertical flow constructed wetland (VFCW) with microbial fuel cell (MFC) and microalgal photobioreactors (PBR). In the first phase, five pilot-scale two-stage VFCW configurations (1VFCW, 2VFCW, 3VFCW, 4VFCW, and 5VFCW) along with a control wetland were evaluated based on their different aeration regimes, saturation levels, and plantation. Three VFCW configurations (1VFCW, 2VFCW, and 3VFCW) were unsaturated, while 4VFCW and 5VFCW were saturated in the second stage (up to 60 cm and 90 cm, respectively). The 5VFCW also featured a stacked configuration with no space between two stages. Passive aeration was applied selectively in 2VFCW, 3VFCW, 4VFCW, and 5VFCW, while plants were present in all the configurations except the control. Among these, saturated wetlands (particularly 4VFCW with 60 cm saturation and passive aeration) exhibited higher removal of NO_3^- (46.06 ± 45.96%) and total nitrogen (77.03 ± 16.24%), while unsaturated wetlands like 1VFCW showed the highest TAN removal (98.89 ± 0.33%). The stacked saturated system (5VFCW) achieved the highest COD (94.17 ± 4.85%) and TOC (86.35 ± 6.78%) removal and the control system (C), showed the highest removal efficiency for PO_4^{3-} (90.38 ± 6.52%). Overall, 4VFCW emerged as the most balanced and effective system for treating piggery wastewater, supported by an optimal combination of aerobic and anaerobic conditions that facilitated sequential nitrification and denitrification, along with an extended HRT due to saturation. In the second phase, the most effective VFCW design (4VFCW) was further enhanced by integrating an MFC system using low-cost stainless steel mesh (cathode) and aluminum mesh (anode) electrodes. Optimization of electrode zonation (60 cm anode, 20 cm cathode) yielded a peak open-circuit voltage (OCV) of 291.83 ± 13.53 mV at 2 L/day loading rate and 76 h 48 min HRT. The VFCW-MFC system achieved higher pollutant removal compared to control wetland—by 23.24% for COD, 27.43% for TOC, 33.05% for PO_4^{3-}, 13.51% for NO_3^-, and 8.14% for total nitrogen—demonstrating the synergistic effect of bioelectrochemical enhancement on microbial activity and pollutant degradation. The final effluent from the VFCW-MFC was used to cultivate indigenous mixed microalgae in a 5L bubble-column photobioreactor. The optimum microalgal growth was observed with a biomass yield of 21.32 ± 8.31 g/L (wet weight) under a 96 h retention period. This biomass can be further processed as biofertilizer and animal feed or used to produce biofuels, further contributing to a circular bioeconomy model. Overall, the integration of optimized VFCW configuration with MFC and microalgal photobioreactor represents a scalable and sustainable approach for decentralized piggery wastewater treatment and resource recovery, with high potential for application in rural or peri-urban areas where conventional infrastructure is often limited.

<u>BIO of Presenter</u>:

Karan N is a PhD scholar at BITS Pilani Goa, specializing in sustainable wastewater treatment. His research focuses on integrating constructed wetlands, microbial fuel cells, and algal bioreactors to develop decentralized, cost-effective technologies for resource recovery and environmental protection in rural and semi-urban areas.

HYDRAULIC MODELLING FOR PLANNING A SUSTAINABLE FLOOD RISK MANAGEMENT WITH SUDS: A CASE STUDY FROM CATANIA (SICILY, ITALY)

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Abstract

A promising strategy towards flood risk reduction involves the development of the so-called Sustainable Drainage System (SuDS), also commonly referred to Nature-Based Solutions (NBS), Green Urban Infrastructures (GUIs) and Water Sensitive Urban Design, that have gained recognition as win-win strategies for enhancing climate resilience. The flood risk analysis, at catchment scale, is pivotal to target the most affected areas at risk where the implementation of sustainable solutions for effective stormwater management is necessary and usually is conducted by using hydraulic models (i.e. HEC's River Analysis System, HEC-RAS).

In this framework, CARDIMED project aims to enhance Climate Resilience with a strong geographical focus in the Mediterranean region, implementing 9 demonstration sites to address climate change and circularity challenges. Italy's National Energy and Climate Plan (NECP) identifies Sicily as a priority for resilience actions due to extreme weather events. Among CARDIMED's nine demonstration sites, DEMO 4.1 focuses on urban flood risk, water scarcity, and upgrading grey infrastructure with SuDS. This study aims to identify areas with the highest hydraulic risk within an urban catchment located in the northern part of the municipality of Catania (Sicily, Italy) considering the "Tondo Gioeni" as basin outlet (110 ha), in which a retrofitting intervention (4400 m^2) will be realized integrating a bioretention system (rain gardens and infiltration wells) into urban landscapes (e.g., roundabouts) to mitigate flooding in the city's historic center.

The hydraulic modelling is carried out by using the freeware software HEC-RAS with a return period of 2, 5, 10, 50 and 200 years and allowed the editing of flood risk maps. These maps, derived from the integration of the potential damage map and the flood hazard map, emphasize the most critical areas (in terms of hydraulic risk), within the "Tondo Gioeni" catchment, that require prioritization for NBS implementation. In details, the area affected by each Italian risk factor category R1, R2, R3 and R4 (DPCM Sept. 29th, 1998) covers approximately 2,775 m^2, 15,584 m^2, 14,858 m^2 and 20,518 m^2, respectively. In the current scenario, the estimated peak flow values at the basin outlet were 2.1 m^3/s, 10.2 m^3/s, 16.9 m^3/s, 32 m^3/s, and 45.3 m^3/s for return periods of 2, 5, 10, 50, and 200 years, respectively. The total runoff volume (approximately 17,500 m^3), calculated for a 2-year return period, could be reduced by about 16% considering only the effect of the rain gardens, and by up to 40% when including the contribution of the infiltration wells. The hydraulic model proved effective in identifying high-risk areas that require SuDS interventions for flood risk mitigation and in estimating peak flow and runoff volume at the basin outlet, which are essential for the design and sizing of SuDS.

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Note: a **poster** presentation is preferred.

Acknowledgement

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WETPOL 2025
GDAŃSK TECH, Gdansk, Poland

ENHANCING SOCIAL ACCEPTANCE OF NATURE-BASED SOLUTIONS: THE CONTRIBUTION OF TREATMENT WETLANDS IN MEDITERRANEAN REGIONS

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Abstract

Given the increasing scarcity of water resources in the Mediterranean, the use of non-conventional water, particularly treated wastewater (WW), has become essential. Treated WW is available year-round and can be reused in agriculture after appropriate treatment. The case study is a hybrid treatment wetland (TW) located in Scicli (RG), Sicily, Italy that consists of three units arranged sequentially. Specifically, the first horizontal sub-surface flow unit is followed by a vertical sub-surface flow unit, and finally another horizontal sub-surface flow unit. This system is used to treat a portion of the WW leaving the primary sedimentation tank of the municipal WW treatment system. The treated effluent is subsequently used to irrigate a near experimental field cultivated with horticultural crops. Although the required technologies is well established and safety can be assured, planners and operators of such initiatives highlight consumer resistance. This barrier can be very limiting for the spreading of WW agriculture reuse, that is a need especially in Mediterranean regions. To the knowledge of the authors, few studies investigated the degree public acceptance of treated WW. This study evaluates the assessment of public perception and willingness to adopt Nature-Based Solutions (NBS) for the reuse of treated WW in agriculture in Mediterranean regions. The research investigates the importance of WW as an alternative resource in agriculture, potential barriers that could hinder the use of this resource with a specific focus on fear associated with reclaimed water in agriculture as well as perceived environmental benefits. The methodology adopted in this study followed a multi-dimensional and context-sensitive approach. A questionnaire was administered face-to-face to approximately 80 participants and was disseminated along the year 2023 during various awareness events organized within the TRESOR project (https://www.tresorprojet.eu/). The audience includes professionals, students, and local stakeholders. The questionnaire was structured into three main sections, combining closed-ended questions, designed to identify priorities and levels of knowledge with open-ended questions, aimed at gaining deeper insight into specific characteristics. The results show that notwithstanding the majority (54%) of respondents would purchase or consume agricultural products irrigated with treated WW, the rest highlight concerns about the consumption of raw products (23%), as well as about the irrigation technique that could allow or not the direct contact between the crops and treated WW (23%). These responses reflect a generally positive perspective, notwithstanding some concerns about food safety due to the recognition of the importance of water reuse as a strategic response to the severe water scarcity affecting Sicily.

BIO of Presenter:
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CONNECTING DISCIPLINES FOR TREATMENT WETLANDS: THE MONTREAL BIOSPHERE CASE STUDY

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The names of the many project stakeholders will be added following the discussion period scheduled for this summer.

Increasingly used for sustainable wastewater management, treatment wetlands are engineered systems that rely on complex biological processes. They require strong multidisciplinary collaboration from their design step to operation, but clear effective guidelines for coordinated planning and implementation remain limited. This gap is particularly evident in the province of Québec, Canada, where early implementation of treatment wetlands two decades ago—developed without a cohesive framework—led to underperforming systems and relative public distrust. As a new treatment wetland is set to be rebuilt at the iconic Montreal Biosphere, a landmark dedicated to art, science and socio-environmental citizen action, there is a unique opportunity to improve existing practices and adopt a more integrated approach. The system aims to be a scientific platform with replicated basins, while also serving a space for contemplative art and education. This presentation will identify key stakeholders, including municipal planners, engineers, scientists, landscape architects, maintenance personnel and citizens. It will outline a timeline for their involvement, with a particular emphasis on the early inclusion of often overlooked actors, yet essential to long-term performance and community engagement. In addition, numerous factors and challenges will be explored across the five major phases of project development: orientation, planning, implementation, maintenance and follow-up. By encouraging early collaboration and shared responsibility, this project aims to demonstrate a more integrated approach, one that ensures not only technical success and durability of the treatment wetland, but also wider benefits, such as education, artistic engagement and tourism, ultimately helping to rebuild public trust in this remarkable nature-based solution.

BIO of Presenter:

PhD student in biological sciences at the University of Montreal, I investigate the potential of treatment wetlands to remove human-derived pollutants, with a focus on the risks associated with microbial resistance transmission.

OPTIMIZING URBAN NATURE-BASED SOLUTIONS: INSIGHTS FROM GREEN INFRASTRUCTURE PATTERNS IN GDAŃSK, POLAND?

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Urbanization and climate change are intensifying environmental challenges in cities, necessitating innovative approaches to manage stormwater, mitigate urban heat, and enhance ecosystem services. Nature based solutions, such as green infrastructure (GI), have emerged as an effective solution to combat these challenges. The study explores how urban planning can optimize the distribution of nature-based solutions, particularly in addressing issues like flood management and heat island mitigation. This study investigates the spatial distribution of GI in Gdańsk, Poland, employing a grid-based analysis to understand its relationship with biophysical and sociodemographic factors. Data preprocessing included correlation and multicollinearity analysis to reduce redundancy in data. Spatial autocorrelation was assessed using Global and Local Moran's I statistics, revealing significant clustering patterns necessitating the use of advanced regression techniques. To model the relationships between GI density and its drivers, multiple regression models were applied, including ordinary, weighted, and generalized least squares, along with spatial lag, spatial error, and geographically weighted regression (GWR) models. Results indicate that the GI density is highest in the western and eastern regions occupying state forests. In contrast, low-density regions are found in northern, central urban areas, and parts of southern regions. Among biophysical and sociodemographic factors analyzed, impervious surface, land surface temperature (LST), NO_2, negatively impact GI density in Gdańsk while O_3 exhibits spatially varying effects. By highlighting spatial disparities in GI distribution, this study supports the integration of nature-based solutions, including constructed and urban wetlands, into spatial planning for improved stormwater management and pollutant attenuation in urban catchments.

<u>BIO of Presenter</u>:
I am a PhD student in Civil Engineering and Transport at Gdańsk University of Technology. My research, "**Flood Risk in Coastal Cities Under Climate Change**", involves the impact of urbanization and climate change on floods, employing machine learning methods to map flood-prone areas and integrating nature-based solutions for sustainable flood management.

ASSESSING SURFACE RUNOFF AND RETENTION IN URBAN CATCHMENTS USING RS-GIS AND SCS-CN: IMPLICATIONS FOR NBS PLANNING IN GDYNIA, POLAND

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Urban development and climate variability are increasingly altering surface hydrology, challenging cities to adopt sustainable stormwater strategies. To support the implementation of Nature-based Solutions (NbS), this study assesses the impacts of land use/land cover (LULC) changes on surface runoff and water retention in Gdynia, a rapidly urbanizing city on the Baltic coast of Poland, and its sub-catchment, the Kacza River basin. We integrated machine learning-based remote sensing (RS) with the Soil Conservation Service Curve Number (SCS-CN) hydrological model in ArcGIS Pro 3.4.3 to quantify runoff dynamics over multiple decades. Supervised classification was applied to Landsat 5, 7, and Sentinel-2 imagery to generate LULC maps for Gdynia (1985–2024) and the Kacza basin (1949, 2024, 2030). Six land cover classes were identified: surface water, forest, green area, cropland, bare land, and built-up area. Results show that built-up areas in Gdynia increased from 27.3 km² in 1985 to 41.1 km² in 2024, with simultaneous forest expansion and declines in green space, cropland, and bare land. In the Kacza basin, built-up area rose dramatically from 1.77 km² in 1949 to a projected 18.83 km² in 2030, accompanied by a major reduction in green area (39.85 km² to 11.41 km²). These LULC shifts have significantly reduced water retention and increased surface runoff. Our findings underscore the role of LULC-driven hydrological changes in amplifying urban flood risks and highlight the potential of RS- and hydrological model-supported assessments to inform NbS integration into urban planning. Future work will extend this framework by incorporating climate change projections and advanced hydrological models to evaluate compound impacts, with the goal of guiding urban resilience and wetland-informed NbS implementation. This study contributes to key WETPOL themes, including modeling runoff processes, leveraging remote sensing and AI tools for designing resilient green infrastructure.

Abdata Wakjira Galata specialized in Hydraulic Engineering is a PhD student at Gdansk University of Technology. He is focusing on urban land use and climate change, runoff modeling, and nature-based solutions. With experience in remote sensing and GIS, he integrates hydrological modeling to support sustainable urban planning and wetland conservation.

RECYCLED MATERIALS AND DIFFERENT MANAGEMENT FOR SUSTAINABLE ENHANCEMENT OF CONSTRUCTED WETLANDS AS DECENTRALIZED WASTEWATER TREATMENT SYSTEM

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Introduction

Constructed wetlands (CWs) are recognized as effective systems for the treatment of various wastewater types, including domestic effluents. Despite advancements enhancing their efficiency, CWs have limitations such as substantial land area requirements and the high costs associated with traditional substrates like sand, silt, and gravel. To address these challenges, the current research, carried out within Agritech project, aims to evaluate the feasibility of utilizing recycled materials as alternative substrates in pilot-scale constructed wetland for domestic wastewater treatment. The specific objectives of this study are: i) assessing the hydraulic properties of various recycled materials to determine their suitability as substrates in CWs; ii) comparing the pollutant removal efficiencies of different recycled substrates under different operational conditions, including both aerated and non-aerated configuration

Methods

The research activity was conducted in a vertical pilot constructed wetland (VF-CW), located in the parking area of the IKEA® store of Catania (Eastern Sicily, Italy). Onsite conventional wastewater treatment plant, a sequential batch reactor (SBR), is used to treat wastewater from toilets, kitchen and bar of the store. The VF-CW consists of 12 units (length 1.20 m, width 0.80 m, depth 0.85 m) functioning in parallel and are intermittently loaded with a portion of SBR effluent (six loadings per day) with a hydraulic loading rate of 65 mm/day. Three different recycled materials were used as main layer: i) pyroclastic deposits from Mt. Etna volcano (particle size 1-2 mm) classified as non-hazardous waste, common called "volcanic ash", whose management is very expensive for the local communities; ii) recycled material from construction and demolition activities; iii) crushed recycled glass. Six units have a classical VF management and six units are aerated (or intensified). In October 2024, *Iris pseudacorus* was planted at a density of 4 plants m^{-2} and has developed well. Six vertical flow constructed wetland (VF-CW) units were operated under conventional management, while six additional units were subjected to aeration (or intensified management). Each design configuration, defined by the primary substrate and management approach, was replicated in duplicate units to ensure experimental reliability. The removal efficiencies for COD, TSS, TN, NH_4, TP and the log reduction for *Escherichia. coli, total coliforms, Enterococcus spp., somatic coliphages* and *Clostridium perfringens* were calculated as mean value of two units with the same gravel configuration and the same management modality. The hydraulic proprieties of the VF-CW units have been monitored through measurements of hydraulic conductivity at saturation (Ks) and porosity carried out during the years 2024 and 2025.

Results and Conclusion

The hydraulic features of substrates tested in terms of porosity and hydraulic conductivity, carried out tree time at interval of 4/5 months, shown the potential as wetland substrates due to negligible variation after several months of operation. Preliminary results suggest that volcanic ash with aeration provides the most effective removal performance for the parameters investigated, followed, in order, by recycled glass and recycled building materials. This research endeavors to enhance the sustainability and cost-effectiveness of constructed wetlands by integrating recycled materials, thereby contributing to more accessible and environmentally friendly wastewater treatment solutions.

BIO: Dr. Marzo has about 20 years of experience in planning, designing and monitoring constructed wetlands for wastewater treatment. Her scientific activity is mainly focused on hydraulic properties of constructed wetlands, the use of constructed wetland for pollution control and for wastewater reuse in agriculture. She has been involved in many national and international research projects.

Acknowledgements

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FLOATING TREATMENT WETLANDS FOR WASTEWATER PURIFICATION: AN INITIAL LABORATORY STUDY

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Background information

The wastewater treatment plant with Wastewater Stabilization Ponds (WSPs) system in Sobótka, Poland, serves as the tertiary treatment stage. Treated wastewater flows from the secondary clarifier into the first WSP and then through the second pond (WP II) before discharge. The Hydraulic Retention Time (HRT) is approximately 8 days. The effectiveness of such WPs system was not sufficient, prompting for implementation of an additional Nature Based Solution (NBS) to improve effluent quality. An experimental setup with Floating Treatment Wetlands (FTWs) was developed and tested using artificial wastewater as a substitute of the effluent from WSP II.

Artificial wastewater was prepared according to OECD formulation. FTWs experiment was performed in climate chamber using 8 tanks: 2 control tanks, 2 tanks with FTWs plants (*Iris pseudacorus*) covered in 50% and 2 tanks with 100% plants coverage. Concentrations of water parameters including ammonium nitrogen, phosphates, Total Organic Carbon and pH were analysed.

Main results

Water in WSP II had high pollutant concentrations, with ammonium nitrogen (NH_4) levels peaking in summer (30.55 mg/dm³) and phosphates (PO_4) at 5.156 mg/dm³. Total Organic Carbon (TOC) median concentrations were 5.02 mg/dm³, and pH ranged from 6.53 to 8.13. Laboratory tests with FTWs started with pollution concentrations similar to WSP II, except NH_4, which reached the range at day 12 (median 17.21 mg/dm³). After 24 days, NH_4 concentrations decreased in all tanks: control tanks – 11.72 mg/dm³; 50% coverage – 5.38 mg/dm³; 100% coverage – 1.92 mg/dm³. After 41 days, NH_4 dropped to a median of 1.25 mg/dm³. PO_4 concentrations significantly decreased within the first 12 days in 100% coverage tanks (from 5.99 to 5.75 mg/dm³) and further dropped to 4.99 mg/dm³ after 41 days. TOC and PO_4 concentrations decreased significantly in 100% coverage tanks but TOC increased after 48 days. pH in control and 50% coverage tanks remained above 8.0, while in 100% coverage tanks it was lower than 8.0.

Conclusions

Within first 24 days start of reduction by rhizosphere-biofilm matrix and aerobic/anaerobic/anoxic processes allowing reduction of biogenic pollutants (NH_4, PO_4 and TOC) was observed. In initial days reductions could be result of bioaccumulation by plants. Higher rates of reductions were in tanks with 100% coverage. Control tanks showed significant reductions due to visible algae growth, which was also recorded in tanks with 50% coverage. Results of this experiment show promising results for future use of *Iris pseudacorus* in FTWs applications in conditions of Poland.

Keywords: nature based solution, wastewater, treatment efficiency
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BIO of Presenter:

Katarzyna Pawęska is a research scientist specializing in water and wastewater treatment in natural and semi-natural systems. Her research focuses on Nature-Based Solutions (NBS), including constructed wetlands, hydroponic systems, and artificial floating islands. She is particularly interested in the treatment of wastewater with complex physicochemical compositions, as well as the quality and revitalization of urban waters.

NEUTRAL4GS: CO-CREATING NATURE-INSPIRED URBAN WATER MANAGEMENT SOLUTIONS BRIDGING THE GLOBAL SOUTH AND EUROPE

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Abstract

Access to safe drinking water and sanitation remains a global challenge, with the Global South particularly affected. By 2040, one in four children worldwide is expected to live in regions facing extremely high water stress due to overuse, population growth, and climate change. NEUTRAL4GS, funded by the Marie Skłodowska-Curie Actions programme, addresses this crisis by fostering collaboration between six academic institutions, one SME, and one water utility bridging the EU and the Global South.

The project focuses on co-creating and co-designing sustainable, fit-for-purpose solutions for the treatment and reuse of urban waters, including stormwater, greywater, and wastewater. NEUTRAL4GS integrates nature-based solutions (NBS) such as treatment wetlands and green walls with supporting technological units, including membranes, lightweight porous media, nanofiber biomass carriers, graphene-based nanocomposites, and photocatalysis. These innovations aim to enhance sustainability, treatment performance, and resilience under diverse environmental and social conditions. Moreover, holistic sustainability and economic assessments are central to the project, ensuring that developed technologies are socially acceptable, economically viable, and environmentally sound.

The Aarhus University team, will be exploring the different combinations of advanced treatment with NBS for controlling micropollutants. Also the cost-benefit analysis of the different NBS and combination of technologies. We foresee dedicated experimental work via collaboration with project partners on new natural biosorbents, photocatalytic oxidation, and priming of microbial communities. Several activities from secondments, to webinars and in-person workshops will be used for knowledge exchange. We will be providing support on local stakeholders workshops and performing the economic assessment of the proposed solutions.

Initial case studies characterization, and conceptual designs on combination of technology will be presented in the conference, highlighting the collaborative pathway towards greener and more resilient urban water management.

<u>BIO of Presenter</u>:
Vaidotas Kisielius is a researcher specializing in environmental chemistry, with expertise in organic micropollutant monitoring and treatment technologies. His work focuses on advancing nature-based solutions and high-resolution analytical methods to improve urban water quality. He is currently based at Aarhus University.

RAIN GARDENS FOR STORMWATER TREATMENT

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Nature-based solutions (NBS) are cost-effective actions that provide environmental, social, and economic benefits and help build resilient ecosystems. Rain gardens are one of the NBS that can be implemented in cities to improve stormwater detention, retention, and its quality before infiltration. Rain gardens can effectively retain and utilise substantial amounts of stormwater that would otherwise be discharged into the sewer system.

An urban real lab rain garden constructed for the NICE project is located at Gdańsk University of Technology. This system was built with an additional purification step involving two-stage sedimentation followed by parallel filtration through three different media. The stages of the rain garden are as follows: an inlet with obstacles to intercept large objects, two sedimentation tanks, a filtration stage, and a retention basin.

In rain gardens, water is treated through the removal of large objects, sedimentation, filtration, adsorption, precipitation, ion exchange, microbial degradation and uptake, phytoremediation, and redox reactions.

Samples of stormwater have been collected since June 2024 at four sampling points, starting from the inlet and after subsequent stages of treatment. The first sampling point (1) is located just after the removal of larger objects. The second point (2) is at the end of the second sedimentation tank. Sampling points are located after each filtration medium (3A, 3B, and 3C). The filtration medium at point 3A was washed gravel with a grain size of 2–8 mm; at point 3B, it was biochar with the same grain size; and at point 3C, it was a substrate provided by Funke. The final sampling point (4) is a piezometer located in the retention basin.

The initial monitoring of the rain garden showed variable results. It is important to remember that the rain garden and the filtration media need some time to reach their full effectiveness. Comparing the amounts of total suspended solids at point 1 (range from 9.80 to 518.00 mg/L) and at point 3A (range from 4.25 to 39.33 mg/L) shows a significant improvement in water quality. Total nitrogen concentration values throughout the whole rain garden could not be considered high for surface runoff, but they were still lower; for example, at point 1, total nitrogen values ranged from 1.51 to 8.63 mg/L, and at point 3A, they ranged from 1.72 to 2.87 mg/L. PFAS were detected at the rain garden, they reached environmentally significant concentrations of a few ng/L. In most cases, the highest concentrations were at points 1, 2, and 4. The last section of the rain garden (sampling point 4) frequently had high pollutant concentrations, likely caused by the decay of organic matter and by wash-off of dust from the unsealed substrate.

This rain garden improves the quality of stormwater, but needs further monitoring to eliminate the influence of adaptation of the rain garden.

The investigation was carried out in the NICE project – "Innovative and Enhanced Nature-Based Solutions for Sustainable Urban Water Cycle" HORIZON 2020 project, grant agreement ID: 101003765.

BIO of Presenter:
Radosław Kujawski is a PhD student at Gdańsk University of Technology, focusing on environmental chemistry and water pollution. His research investigates the removal of PFAS from stormwater in a three-stage rain garden with different filtration media.

WETPOL 2025
GDAŃSK TECH, Gdansk, Poland

SWIPE RIGHT ON YOUR WETLAND: DECISION-SUPPORT MADE SIMPLE WITH NAT4WAT

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Nature-based solutions (NBS), including treatment wetlands, offer an effective and sustainable approach to managing water—including rainwater and diverse types of wastewaters—particularly in decentralized or small-scale contexts. These systems not only achieve pollutant removal but also deliver important co-benefits such as biodiversity support, climate regulation, and landscape integration. However, the wide variety of available NBS technologies—and the context-specific nature of their performance—can make it difficult for practitioners, especially non-experts, to identify the most appropriate solution.
To address this challenge, we developed Nat4Wat (nat4wat.icradev.cat), a web-based decision-support system (DSS) designed to help users select and compare NBS for wastewater treatment and stormwater management. Nat4Wat integrates a structured knowledge base with a multicriteria decision analysis (MCDA) framework, enabling transparent, evidence-based decision-making. The tool was co-developed with stakeholders, including researchers, public authorities, and technology providers, to ensure relevance, usability, and robustness.
Users begin by entering contextual information about their water scenario—such as pollutant concentrations, number of people served, land availability, and treatment goals. Based on this input, Nat4Wat filters suitable technologies from a catalog of over 50 NBS and estimates surface area and construction costs using a cascade of models: regression-based, mechanistic, or heuristic, depending on data availability. The MCDA component compares technologies using eight criteria: environmental impact, biodiversity, circularity, social benefits, removal performance, construction cost, space requirements, and operational constraints (Figure 1). Users can adjust the importance of each criterion through a transparent weighting system.
Nat4Wat presents results through an intuitive interface, including solution profiles with illustrations, technical parameters, performance data, and links to scientific literature and real-world implementation cases. A REST API is also available for advanced users or integration into planning workflows.
By combining technical rigor with accessibility, Nat4Wat lowers the barrier to adopting treatment wetlands and other NBS. It supports better-informed decisions, fosters stakeholder engagement, and promotes sustainable water management in both urban and rural contexts.

Figure 1. MCDA in Nat4Wat tool (nat4wat.icradev.cat). Comparison of 3 NBS for domestic wastewater treatment.

BIO of Presenter: Esther Mendoza, postdoctoral researcher at ICRA, currently focuses her research on greenwalls for greywater treatment. With a PhD in Water Science and Technology and degrees in Environmental Sciences, she specializes in emerging contaminants' behavior and water reuse through membranes and nature-based solutions, combining advanced treatment technologies with sustainable environmental practices.

Diversification of macrophytes within urban aquatic nature-based solutions (NBS) across European cities

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Aquatic nature-based solutions (aquaNBS) are increasingly recognized for their role in enhancing urban biodiversity and ecosystem resilience. This study, conducted across five European cities—Helsinki (Finland), Poznań (Poland), Antwerp (Belgium), Berlin (Germany), and Lisbon (Portugal)—examines the diversity and ecological drivers of macrophyte communities in 120 urban ponds and streams, representing a gradient of climatic, hydromorphological, and management conditions. A total of 103 aquatic plant species were identified, revealing high macrophyte richness and confirming the role of aquaNBS as urban biodiversity hotspots. Despite modest differences in overall diversity indices between site types, each category of aquaNBS supported distinct, species-specific communities. Ponds exhibited higher species richness and macrophyte cover than streams, while temporary water bodies hosted uniquely structured but less diverse communities than permanent ones. Species composition varied notably between lentic and lotic habitats and followed clear geographic and climatic gradients, with Lisbon showing the most distinct flora. While macrophyte assemblages were relatively homogeneous within countries, inter-country differences were significant. Key environmental drivers shaping community composition included substrate type—especially coarse substrates like gravel and stones—along with water temperature, conductivity, and elevation. These findings highlight the value of aquaNBS in supporting diverse urban aquatic flora and inform strategies for designing resilient, multifunctional ecosystems under urban stress.

Integration of Nature-Based Solutions (NBS) with the Spatial Planning System in Poland – The Gap Between Theory and Practice

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Nature-Based Solutions (NBS) are gaining significance as an integrated approach to environmental resource management, climate change adaptation, and supporting urban resilience. Their effectiveness has been confirmed in numerous studies and implementation projects across Europe and worldwide. Despite the growing popularity of this approach, its presence in Polish planning and strategic documents remains ambiguous and fragmented. Most often, proposed actions are of a technical nature, while references to environmental aspects, including biodiversity enhancement, are lacking. The aim of this study was to analyze the presence and character of Nature-Based Solutions in Polish planning and strategic documents.

In the context of intensifying climate challenges and the need for sustainable environmental resource management, the authors sought to assess the extent to which Polish national and local documents take NBS into account as tools for climate change adaptation and improving residents' quality of life. The analysis covered documents such as national development strategies, urban climate adaptation plans, municipal and regional strategies, and spatial planning documents. The evaluation focused both on the presence of terms directly referring to NBS and the scope and manner of their application in planning practice.

The study results indicate that although the concept of NBS is increasingly appearing in strategic documents, its implementation remains selective and unsystematic. The greatest activity in this area was observed in adaptation plans of large cities and in strategies containing green-blue infrastructure components. However, a lack of consistent definitions, integrated approaches, and sufficient implementation tools at the local and regional levels was noted. The authors highlight the need for further integration of the NBS approach into the spatial planning system and development policy, as well as the expansion of the knowledge base and practical guidelines for their design, implementation, and monitoring—also in the context of improving biodiversity in urbanized areas.

RETENTION SOIL FILTERS AT MESOCOSM SCALE: INFLUENCE OF SUBSTRATES ON REMOVAL OF ORGANIC POLLUTION

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Organic pollution from urban wastewater and combined sewer overflows (CSOs) poses growing risks to ecosystems and public health, as many contaminants like pharmaceuticals and detergents resist conventional treatment. Urbanization and climate-driven storm events make managing these diffuse sources a key challenge for sustainable water systems. Vertical-flow constructed wetlands (VFCWs) offer an effective, low-energy solution for treating complex wastewater, including WWTP effluents and CSOs. Their design supports pollutant-degrading microbes, and fits well into urban areas, providing decentralized treatment that strengthens and complements existing infrastructure. Substrate selection is key in VFCWs, affecting water flow, oxygen transfer, and pollutant removal. Factors like grain size, porosity, and chemical composition influence treatment efficiency and stability. Well-chosen substrates improve contaminant removal, oxygen distribution, and reduce maintenance, ensuring effective and sustainable treatment.

In this context, the QualiSûre project, funded by the Interreg Greater Region program, aims to assess the influence of substrate composition on the removal of organic pollutants. Six mesocosm-scale vertical-flow soil filters were constructed, each filled with a distinct combination of materials. The substrate mixtures varied in terms of sand origin, calcium carbonate content, and the inclusion of carbon-based additives such as activated carbon. These configurations were chosen to explore how factors like grain size, porosity, surface area, and chemical reactivity affect pollutant retention. To enhance treatment performance and mimic natural wetland conditions, all filters were planted with a combination of Phragmites australis and Iris pseudacorus. Each system was operated under intermittent loading conditions, with two loading cycles per day, each lasting 30 minutes, to simulate realistic treatment dynamics and promote sufficient oxygen transfer throughout the filter bed. The filters were subjected to a controlled organic loading rate (OLR) of 2.1 gCOD/m²/day. Synthetic wastewater was used for the experiments, and the data collected will be validated for use in future tests with pilot-scale systems. By systematically analyzing the performance of these diverse substrates under consistent operational parameters, the study aims to identify the most effective material combinations for maximizing the removal of organic contaminants in NBSs.

The experimental results demonstrated that all six vertical-flow systems achieved high removal efficiencies, with average COD removal exceeding 90% across the different substrate configurations. In addition, the systems achieved approximately 80% removal of PO_4-P and 99.9% removal of NH_4-N, highlighting their strong nutrient reduction capabilities. This consistently strong performance underlines the effectiveness of retention soil filters as a robust and low-energy treatment option for organic pollution in wastewater effluent and combined sewer overflow scenarios. These findings confirm that VFCWs, when optimized with appropriate substrate mixtures and operational settings, can serve as a reliable and sustainable nature-based solution (NBS) for improving effluent quality and protecting aquatic environments from organic and nutrient pollution.

BIO of Presenter:
Elaheh Faghih Nasiri is a Doctoral Researcher at the University of Luxembourg. She is an Environmental Engineer with a Master's in Civil and Environmental Engineering, and over 10 years of experience in water management and wastewater treatment, with a specific focus on the development and application of sustainable treatment technologies.

ADAPTING NORWEGIAN CONSTRUCTED WETLANDS FOR BETTER REMOVAL OF DISSOLVED NUTRIENTS: LESSONS FROM THE FIELD

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Norway has committed to achieving at least good ecological and chemical status in its water bodies, as required by the EU Water Framework Directive and the Norwegian Water Regulation. The intensification of agriculture has led to the loss of natural purification systems in watercourses. While mitigation efforts in Norway have traditionally focused on reducing phosphorus (P), dissolved nutrients such as phosphate and nitrogen are receiving increasing attention—especially considering climate change and more frequent runoff events. Subsurface drainage systems significantly contribute to dissolved nutrient loads, with studies showing that up to 90% of annual runoff in certain soils originates from drainage (Kværnø & Bechmann, 2010[1]; Bechmann et al., 2023[2]). As a result, **there is growing interest in more holistic measures to reduce nutrient losses from agricultural land**.

Constructed wetlands (CWs) are widely implement, and proven effective, in Norway (Blankenberg et al., 20216[3]; Krzeminska et al., 2023[4]). However, most Norwegian CWs were originally designed to trap particles (SS) and particle-bound P, with retention times often too short to effectively reduce dissolved nutrients. To address this, **there is a need to adapt existing CWs** —such as by introducing different filters—to enhance the removal of dissolved nutrients (e.g. Blankenberg et al., 2008[5]).

In our current project, we aim to operationalize the concept of modifying traditional CWs to better retain dissolved nutrients. In this project NIBIO, together with Norges Vel[6], is constructing the “pilot” CW in one of the fields in the South-Eastern part of Norway.

With this presentation we invite discussion and feedback on both the **successes and setbacks encountered throughout the adaptation process**. Specifically, we will present and further discuss following issues: (1) the filter concept—wood chips have shown promising results as a filter material (Roseth et al., 2023[7]; Hoffmann et al., 2019[8]), and are our current focus; (2) trade-offs between practicality, efficiency, and feasibility—we aim for a compact (5×10 m, 1.2 m deep), farmer-friendly filter design; and (3) our monitoring strategy, including sensor setup and trial timelines, designed to capture system performance under variable weather conditions.

BIO of Presenter:
Dominika Krzeminska is a researcher at the Soil and Land Use Department of NIBIO, with expertise in soil hydrology, soil stability, and nature-based solutions, focusing on challenges in agricultural catchments in Norway.

[1] *Kværnø S. & Bechmann M. 2010. Transport av jord og næringsstoffer i overflate- og grøftevann. Sammenstilling av resultater fra rutefelter og småfelter i Norge. Bioforsk rapport;5(30) 2010*
[2] *Bechmann M, Bøe F., Havranek I., Stenrød M. & Tveiti G. 2023. Kjelle avrenningsforsøk. Årsrapport 2021–2022 for jordarbeidingsforsøk på lav erosjonsrisiko. NIBIO Rapport; 9 (9)2023.*
[3] *Blankenberg A-G.B., Paruch A.M., Paruch L., Deelstra J., Haarstad K. 2016. Nutrients tracking and removal in constructed wetlands treating catchment runoff in Norway. In: Vymazal J. (ed) Natural and Constructed Wetlands. Springer International Publishing Switzerland, pp. 23-40. DOI 10.1007/978-3-319-38927-1_2*
[4] *Krzeminska D., Blankenberg A-G.B., Bechmann M., Deelstra J.2023. The effectiveness of sediment and phosphorus removal by a small constructed wetland in Norway: 18 years of monitoring and perspectives for the future. CATENA, 223.*
[5] *Blankenberg A-G.B., Haarstad K., Søvik A-K. 2008. Nitrogen retention in constructed wetland filters treating diffuse agriculture pollution, Desalination 226 (2008) 114–120.*
[6] https://www.norgesvel.no/
[7] *Roseth R., Skrutvold J., Vartdal I.V., Fjemstad H. & Barland T. 2023. E16 Bjørum–Skaret. Resultater for renseanlegg for nitrogen i 2022. NIBIO Rapport 9 (52) 2023.*
[8] *Hoffmann C. C., Larsen S. E. & Kjærgaard C. 2019. Nitrogen removal in woodchip-based biofilters of variable designs treating agricultural drainage discharges. Journal of Environmental Quality, 48, 1881-1889.*

EFFICIENCY OF THE INSTALLATION TO TREATMENT OF OUTFLOW FROM THE HYBRID CONSTRUCTED WETLAND SYSTEM AND POSSIBILITY OF REUSE OF TREATED WASTEWATER IN THE HOUSEHOLD

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Keywords: closed water circuit; hybrid constructed wetland system; pollution removal; water management; water protection; Polesie National Park

The purpose of this study was to determine the effectiveness of the operation of a novel installation for treating the outflow from a hybrid constructed wetland system and the possibility of domestic wastewater reuse. The study was carried out in 2022–2023 at a facility located in the Polesie National Park (PNP) in Poland. The analyzed installation for the treatment of wastewater discharged from the constructed wetland system is located in the basement of a single-family building and consists of a filtration system including: yarn, spun and carbon filters, and a UV lamp. In turn, the hybrid constructed wetland system from which the treated wastewater is recycled to the building consists of a 2-chamber primary settling tank and a system of two VF-HF type beds with common reed and willow. During the study period (October 2022 to December 2023), 14 series of analyses were performed, during which the values of selected physico-chemical and microbiological indicators were determined in the collected samples of treated wastewater. On the basis of the performed tests, it was found that the analyzed system provided an average efficiency of reduction of total suspended solids and BOD_5 at 46.8 and 45.8%, respectively. Smaller effects were obtained for the reduction of COD (22.7%), total nitrogen (4.9%) and total phosphorus (16.3%). In contrast, the average reduction effects of microbiological indicators were very high, amounting to 92.7 and 97.1% for Escherichia coli and enterococcus bacteria, respectively. The study showed that the effluent flowing out of the hybrid constructed wetland system after treatment in the analyzed installation could be reused for toilet flushing or green watering, as it usually did not contain microbiological contaminants. It was determined that the recycled treated wastewater could replace, on average, 18.7% of the good-quality water supplied by the mains water supply in the studied household.

CONSTRUCTED WETLANDS FOR DECENTRALIZED WATER REUSE IN AGRICULTURE

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Constructed wetlands (CWs) are sustainable, low-resource treatment technologies for controlling water pollution. Their relevance is increasing in the context of climate change, which is intensifying water scarcity across many regions of the world. In the Mediterranean area, particularly in Portugal and Spain, average precipitation has decreased by approximately 15% over the past two decades and is projected to decline by an additional 10–15% by the end of the century.

In Portugal, many small rivers and streams experience effluent-dominated flows. Although wastewater treatment plants (WWTPs) typically provide disinfection, water quality often deteriorates downstream, and the transport of treated water to agricultural fields adds logistical and energy burdens. Decentralized wastewater treatment systems, particularly nature-based solutions such as CWs, offer a promising alternative for local irrigation reuse.

A demonstration site was established near Lourinhã, a major horticultural region in central coastal Portugal, within the premises of the Zambujeira WWTP. The system treats screened municipal wastewater using a septic tank, a 4 m^2 horizontal subsurface flow CW, and a UV disinfection unit. The treatment train is designed to meet Class A water reuse standards, in accordance with Regulation (EU) 2020/741 and Portuguese Decree-Law 119/2019.

The treated effluent irrigates a 75 m^2 agricultural test plot, cultivated with seasonal crops such as cabbage and pumpkin. This plot is part of an agricultural field in operation near the WWTP and is divided into three sections, each receiving a different irrigation source: (i) CW-treated reuse water, (ii) WWTP-treated reuse water (sequencing batch reactor + UV), and (iii) potable water. From June to September, water quality is monitored weekly for COD, TSS, ammonia, nitrates, *E. coli*, total coliforms, and viruses. Harvested crops will be analyzed for microbial contamination (*E. coli*, total coliforms, and viruses).

This study aims to assess the feasibility of achieving Class A water quality using CWs and to evaluate their suitability for decentralized wastewater reuse in agriculture. Results will inform the development of resilient irrigation strategies in water-scarce regions and support the adoption of CWs as a viable alternative to conventional treatment and distribution systems

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BIO of Presenter:
Ana Galvão is an Assistant Professor at Instituto Superior Técnico since 2003. Her research interests are focused on Nature-Based Solutions for water reuse and circularity, including constructed wetlands and green walls for greywater treatment

USING DIFFERENT METHODS TO ASSESS NUTRIENT AND SEDIMENT RETENTION IN NORWEGIAN CONSTRUCTED WETLANDS

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Fresh water quality problems in Norway are largely caused by high phosphorus (P) inputs from the catchments. The need for measures in the agricultural landscape, such as constructed wetlands (CWs), are needed and the importance of the measures will most probably increase due to the consequences of climate changes.

In agricultural areas in South-Eastern Norway, several hundred small vertical flow CWs were established in the streams during the last two decades, to reduce downstream losses of sediments (SS) and nutrients. The focus of the CWs has been on reducing losses of P and SS, due to the naturally P-rich clay soils of marine origin in lowland areas. Whereas our study included 11 CWs altogether, we here present the data from the CW with the most intensive monitoring, i.e., the Skuterud CW, around 20 years after it was constructed. The catchment's total area was 450 ha with 61% agricultural land. The CW occupies 0.05% of the catchment area.

The methods included analyses of waterflow-proportional water composite samples, water grab samples, sensor monitoring (turbidity), bed sediments, and biological quality elements (invertebrates and benthic algae).

Analyses of three years of composite samples showed a retention of 47 % for SS, 41 % for total phosphorus (TP), 4.2 % for total nitrogen (TN), 0.8 % for ortho-phosphate, and a negative retention for nitrate (i.e., nitrate leaching).

Monitoring by turbidity sensors (correlations to SS and TP; $R^2 = 0{,}7802$) during a 5 - month period showed that retention during episodes of elevated water discharges was 26 % for SS and 11 % for TP.

Grab sampling gave more confusing results. It was revealed by the sensor monitoring that to assess the retention in CWs by grab sampling at the in- and outlet can be misleading, even if the sampling is done at the same time. The reason is the rapid variation in concentrations.

Bed sediments have been removed from the CW several times since it was established, and in total approx. 1140 tons of SS and approx. 1090 kg of particle bound P. However, it is difficult to assess the total amount of retention, as we did not know the extent of leaching of nutrients from the bed sediments over the years.

The analysis of invertebrates and benthic algae revealed that the ecological condition was better at the inlet and worse at the outlet (similar for five CWs). The reason is probably that the oxygen levels and substrate conditions are better at the inlet, where the running creek enters, whereas the outlet would have still-standing waters with lower oxygen contents and a clayey substrate. Moreover, this can be due to the method used, as the outlet area had fewer stones where the benthic algae could grow. Hence, it would be better to sample biology a bit more downstream, but that is often not practical, as the CWs often have their outlet into another stream or directly into a drainage system.

In summary therefore, our recommendation is to use composite sampling and/or sensor monitoring (combined with grab sampling for correlation purposes), to assess the retention capacity of a CW. However, for cost-effective assessment of the effect of sediments and particle bound nutrients, bed sediments are recommended.

BIO of Presenter:
More than 30 years of experience from national and international research and consultant activities in the fields Watershed Management and Ecological Engineering; Constructed Wetlands, Vegetated Buffer Zones, sludge dewatering in reed-beds, catchment action plans (WFD) and natural systems for wastewater management and treatment. Experienced in co-operating and guiding key stakeholders.

ASSESSMENT OF WETLAND DEGRADATION AND HEALTH FOR RIVERINE WETLAND CREATION, RESTORATION, AND MANAGEMENT

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Wetlands are experiencing significant degradation due to both natural and anthropogenic impacts, including a reduction in area, water quality deterioration, and loss of biodiversity. In response, the international community has emphasized the importance of wetland conservation and restoration as a nature-based solution for addressing the climate crisis and achieving carbon neutrality. Wetland health assessments serve as essential baseline data for developing restoration and management policies. Among various approaches for assessing wetland health, the Pressure-State-Response (PSR) framework has gained attention as an efficient and systematic approach that enables the clear definition and quantification of environmental pressures, current conditions, and human and natural responses. Alluvial deposits, formed by the accumulation of waterborne sediments such as sand, gravel, and silt, are characterized by high porosity and permeability and can be classified as wetlands in their natural, undisturbed state.

In this study, naturally occurring alluvial deposits were classified as undisturbed wetlands, and current land cover conditions were analyzed to identify wetland degradation. Subsequently, a wetland health assessment was conducted using the PSR framework utilizing various indicators, including wetland degradation. The pressure indicators included population density, urbanization rate, agricultural land ratio, sewage discharge, and livestock-related pollution. The state indicators comprised NDVI, water quality, aquatic ecosystem health, environmental ecological evaluation, flood trace index, and slope. The response indicators included wetland degradation rate and sewage treatment rate.

The study area was divided into 80 sub-watersheds, and each watershed was evaluated using a five-grade classification system. The results showed that 17 watersheds were assessed as Grade 2, 48 as Grade 3, and 15 as Grade 4. Based on the analysis of sub-watershed 30060101, it was evaluated as having a high potential for water pollution due to its Grade 4 ratings for both water quality and pollution load, along with the presence of five public sewage treatment facilities. Therefore, this sub-watershed is considered a suitable site for water purification-oriented wetland creation and restoration management aimed at improving water quality.

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BIO of Presenter:
Dr. Jaeseung Seo, Research Professor at Inha University since 2022, specializes in water quality and aquatic ecosystem health assessment.

CAN THE USE OF ELECTROCHEMICAL TECHNOLOGY PRINCIPLES IMPROVE WASTEWATER TREATMENT IN ON-SITE SOIL INFILTRATION SYSTEMS?

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Decentralised sanitation systems are used worldwide to protect the environment and human health from the contaminants in wastewater. The most popular type of systems used in Nordic countries, as well as in many other parts of the world, are septic tanks followed by a subsurface soil-based filtration system, i.e., sand filters or soil infiltration fields. Infiltration fields consist of perforated pipes which distribute the wastewater onto an underground layer of gravel (biofilm carrier material) followed by a layer of sand or local soil, but unlike sand filters, there is no drainage system to collect the infiltrating water and direct it to an outflow pipe discharging to surface waters or a well for further infiltration into soil. Regarding the efficiency of infiltration fields to treat wastewater, while organic matter removal is satisfactory, the removal of nutrients has been reported to vary, as well as their capability to retain micropollutants.

The combination of microbial fuel cell (MFC) principles into nature-based solutions for improved wastewater treatment efficiency has been suggested and is under development for applications such as the Metland® technology, where constructed wetland (CW) media, i.e., gravel, is replaced by electroconductive (EC) material. Published works commonly report the enhancement of organic biodegradation in METlands as well as nutrients and micropollutant removal compared to conventional CWs. In this study, the goal was to investigate whether the same principles could be applied to improving wastewater treatment efficiency in infiltration fields. A research plan was elaborated to test the hypothesis that by replacing the gravel layer in infiltration fields with an EC material (to act as the biofilm carrier media), treatment efficiency can be improved.

Triplicated vertical columns (diameter: 10 cm; height: 80 cm) are being used to test the hypothesis in pilot-scale experiments. Columns were filled with a top layer of soil (10 cm) followed by a layer (40 cm) of either gravel (reference) or EC biochar material (previously tested in Metland studies), and a sand layer (30 cm) at the bottom. Preliminary treated wastewater is introduced via a diffuse outlet 2-3 cm below the surface of the gravel/EC biochar layer. An outflow port was installed at the bottom of the columns to sample treated wastewater for analysis, and redox sensors were installed at different depths to monitor process conditions. Wastewater is fed (0.4 L/day) via multichannel peristaltic pumps in a pulse feed mode (3 x per day), replicating conditions commonly found in households. The systems are being sampled bi-weekly, and samples are being analyzed for chemical oxygen demand, nitrogen fractions, total phosphorus and suspended solids. The pH and temperature of the water are also being monitored. Systems operations started mid-April 2025, and the experiment period will last for 36 weeks. Samples will be sent for micropollutant analysis (pharmaceuticals and personal care products, 126 compounds) in weeks 12, 24 and 36. Biofilm developed onto gravel and EC biochar material will be collected and will be studied for microbial community analysis using DNA isolation, 16S rRNA gene amplicon and metagenomic sequencing. The experiment period ends before the conference, and therefore, full results will be presented.

<u>BIO of Presenter</u>: Elisangela Heiderscheidt is a docent in wastewater engineering with over 20 years of experience working with wastewater treatment systems and processes, including nature-based solutions. She works as a senior research fellow at the University of Oulu (Finland) where she manages several projects and supervises 8 doctoral candidates.

COMPACT RECIRCULATING SYSTEMS FOR WASTE-FREE REGENERATION AND REUSE OF WATER

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BeAquaAgain designs and implements compact systems for decentralized treatment of any type of used water and leachate. The natural processes employed in these systems integrate knowledge of microbial food webs with plant physiology and trophic interactions between aquatic and terrestrial ecosystems. In optimized conditions, such systems are waste-free. They regenerate healthy water for onsite reuse and groundwater recharging. These small-scale expandable systems imitate biostructures and hydraulic conditions in undisturbed aquatic ecosystems. The offered system solutions demonstrate a waste-free approach to the on-site treatment of residential sewage and contaminated water.

By applying principles of microbial food webs and utilizing natural materials such as biochar and zeolites, we engineer resilient, modular systems for the regeneration of healthy water in diverse climatic and socio-economic conditions. At the same time, phosphorus-accumulating bacteria are applied for the quantitative recovery of phosphorus and its reuse on land - a patent-pending technology.

We demonstrate how such systems bring transformative and regenerative changes to communities and ecosystems by increasing water-food security and environmental resilience.

Securing drinking water for farm animals has been low on governmental agendas. In an ongoing project in Sweden, we demonstrate how supplies of healthy water can be secured year-round. We convert problems into multiple benefits. The project is supported by the European Innovation Program (EIP AGRI). One of the important objectives of the project is the creation of educational guidelines for the commercial application of such modular solutions in the Baltic Sea catchment area.

BIO of Presenter:
Ph.D. limnology, Lund University. Decades of experience in international scientific and commercial projects on four continents. Interdisciplinary and holistic approach to water resources and ecosystem services. Specializing in natural small-scale and closed-loop solutions for the regeneration and reuse of water.

HABITAT ASSESSMENT FOR BIODIVERSITY NET GAIN VALUATION OF SURFACE FLOW TREATMENT WETLANDS IN THE UK

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The UK has traditionally preferred the use of single-species subsurface-flow treatment wetlands (reedbeds) as a secondary or tertiary stage in sewage treatment. However, in the past years, the UK Government's policy-driven push to address the biodiversity loss crisis and the need to remove phosphorus (P) and nitrogen (N) from sewage minimizing the use of chemicals have created the conditions for the use of surface flow (SF) wetlands. These are multi-species systems, with known habitat creation potential, are able to degrade organic matter, retain solids, convert nitrogen species and retain phosphorus in particulate and dissolved forms. While biodiversity benefits associated with treatment wetlands are typically claimed, they are seldom quantified, and this limits the wider deployment of this technology as a nature-based solution for sewage treatment. England has recently implemented a mandatory "Biodiversity Net Gain" (BNG; Defra 2023) assessment of any site where construction will take place, to try to revert nature loss. This study evaluated the retrospective use of the BNG tool on three SF wetlands, ranging between one and six years old. The methodology involved a combination of desk-based analysis of pre- and post-construction land use using various datasets, complemented with field surveys to document biodiversity at each site. The Defra BNG metric calculations yielded total post-construction BNG units of 39.2, 215, and 8.69 for a tertiary, chemically-dosed, a tertiary conventional, and a secondary treatment system, respectively. These results correspond to biodiversity net gains of 370%, 340% and 261%, respectively, significantly surpassing Defra's 10% net gain requirement for new developments, even when the initial site conditions were varied from poor (low baseline) to good (high baseline) quality. While a positive increase in BNG was anticipated, the magnitude of the observed increase significantly exceeded initial expectations. This substantial increase indicates that the implementation of SF wetlands can greatly exceeds BNG expectations, thereby demonstrating the potential of these systems to serve as effective nature-based solutions for sewage treatment *and* biodiversity enhancement. The findings of this study underscore the importance of quantifying biodiversity benefits to facilitate the broader adoption of surface flow wetlands in environmental management practices.

BIO of Presenter:
Dr Gabriela Dotro, ecological engineer and independent consultant at NbS Future, specializes in nature-based solutions for wastewater treatment. With 20+ years' experience and multiple international degrees, she led treatment wetland innovation at Cranfield University and Severn Trent Water. Expertise includes both grey infrastructure and green infrastructure pollutant cycling pathways.

APPLICATION OF NOVEL SUBSTRATES AND MANAGEMENT STRATEGIES TO ENHANCE CONSTRUCTED WETLAND PERFORMANCE FOR DAIRY WASTEWATER TREATMENT

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The considerable amounts of wastewater generated by dairy industries could constitute an environmental risk if not properly treated and discharged. Conventional treatment systems serving small and medium-sized farms, generally preliminary (i.e. degreaser) and primary (i.e. Imhoff tank) treatment systems, are often inadequate and costly in terms of operation and maintenance. Therefore, a viable and sustainable alternative is provided by natural treatment systems such as Constructed Wetland (CW). Nevertheless, a drawback of these full-scale systems could be the considerable surface area required. For this reason, the main objective of this research activity is to optimise a CW system for the treatment and reuse of dairy wastewater by reducing the surface area required. In this regard, innovative substrates and different management modalities (aerated and non-aerated system; partial recirculation and no-recirculation) have been tasted in a lab-scale CW system fed with synthetic dairy wastewater. The CW system is characterised by four identical hybrid CWs. Each CW consists of two treatment units connected in series: vertical flow (VF) and horizontal flow (HF). The VF systems are filled from bottom to top with five different inert materials: bio-balls, expanded clay, zeolite, perlite and dolomite. The HFs are filled with gravel and at the initial transect with expanded clay. The VFs are powered by timer-activated pumps, in contrast, the HF units are gravity-fed. The synthetic dairy wastewater is reproduced weekly, using powdered milk, fertilizers and chemical reagents. The removal efficiencies (Res) of the main contaminants (organic matter and nutrients) as well as hydraulic characterisation of the substrates were evaluated

<u>BIO of Presenter</u>:

Salvatore Barresi is a PhD student in Agricultural, Food and Environmental Science at the Di3A of the University of Catania. His research activity is focused both on the monitoring and management of full-scale CW systems and on the assessment of innovative substrates and different management techniques for lab-scale CW systems.