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Newsletter of the Chair of Urban Water Systems Engineering

ANNUAL REPORT OF THE CHAIR OF
URBAN WATER SYSTEMS
ENGINEERING
2025

Chair of Urban Water Systems Engineering

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Foreword

Dear friends of the Chair,

Climate change, epidemics, terrorist attacks, cyber threats, military defense, energy and water supply remained the focus of national and international attention in 2025, and resilience is considered key to overcoming these challenges. The EU Commission emphasized this once again with its new water resilience strategy in June last year. Resilience is the reactive adaptation to negative changes and crises, but at the same time it also means a high degree of flexibility, resistance, and sustainability. Contributing to this and developing new concepts was also at the center of our activities last year.

We are very grateful for a productive year at the chair. Once again this year, our employees were very active in publishing their scientific findings and sharing them with the national and international research community at conferences and lectures. We are delighted for Dr. Emil Bein, who was awarded the Mall Foundation Environmental Prize this year for his dissertation. We would also like to congratulate Dr. Panfeng Zhu, Dr. Mohammad Javad Bardi, Dr. Sebastian Knoll, Dr. Matthias Steindl, Dr. Michael Ahmadi, and Dr. Lea Rosenberger on the successful completion of their doctoral theses. Congratulations! Congratulations also to Prof. Helmreich, who received the Graduate School's Best Supervisor Award for her outstanding supervision of doctoral students.

I am also delighted to have been awarded the Willy Hager Medal in 2025 for scientific research into the fundamentals and processes of water treatment and wastewater purification. I see the latter as an award for all the staff at the chair for their tireless efforts.

In July 2025, we held the 52nd Wastewater Technology Seminar (ATS) in Garching, focusing on the topic of „Digitalization in Water Management“. The event was very well attended and featured exciting discussions.

In our „core business“ as well, the chair made significant contributions last year to the education of students in the bachelor's programs in environmental engineering and civil engineering, as well as in the master's programs in environmental engineering, civil engineering, and sustainable resource management. In addition to a large number of lectures, exercises, and internships, the chair's staff supervised numerous master's theses, student research projects, and bachelor's theses.

In December 2024, I took over as co-chair of the German Advisory Council on Global Change (WBGU). The WBGU is currently focusing on the topics of security and the environment for its next flagship report, which will be presented to the German government in the fall of this year.

On behalf of my colleagues, I would like to express my sincere gratitude for your support and interest in our students and our work. We are particularly grateful for the support of our Friends Association, which makes a very important contribution to the education of our doctoral candidates and students by financing trips to conferences and providing grants for research work.

I am delighted to present you with our 2025 annual report, which will give you a brief insight into our activities. In 2025, we were again strengthened by new employees, who introduce themselves to you in this annual report alongside their colleagues.

We would be very pleased if your donation this year would enable us to continue providing this support to our doctoral candidates and students.

We wish you confidence, a successful year, and much enjoyment reading this report.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'Jörg E. Drewes', written in a cursive style.

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Research Center

The mission of the research center at the Chair of Urban Water Systems Engineering is to provide support for process validations for both drinking water and wastewater treatment technologies at laboratory and pilot scale. In addition, we are conducting studies on new materials and processes and support research and development in close collaboration with industry partners, small and medium-sized enterprises, and public as well as regulatory agencies. The research center is comprised of a 400 m² pilot-scale facility and an adjacent research field, both with direct access to treated wastewater from the Garching Wastewater Treatment Plant (30,000 PE). This infrastructure enables us to conduct studies not only with drinking water but also to examine wastewater processes fed continuously with differently treated effluent qualities. For these studies, we can conduct experiments at laboratory and pilot scale with reactor volumes between 30 and 800 L in size. This provides opportunities to upscale and validate processes from laboratory to demonstration scale. Besides Zahn-Wellens-Tests to examine the biodegradability of wastewater samples (following DEV L 25), we also conduct activated sludge simulation tests (following DEV L 41).

Regarding advanced water treatment processes, the research center is equipped with test skids for chemical oxidation (ozone, UV irradiation with hydrogen peroxide, electrochemical oxidation) and membrane filtration (ultrafiltration, nanofiltration, reverse osmosis). Offered feasibility studies include removal of trace organic chemicals (according to EU UWWTD) and water reuse (according to EU water reuse regulation and DWA-M 1200).

In addition, the center is investigating and advancing treatment processes for urban stormwater and street run-off. For these investigations, we can utilize laboratory-scale test and soil column experiments of various sizes to examine the fate and transport of heavy metals and organic contaminants. Regarding urban run-off from copper roofs, a demonstration-scale test bed is available at the center, which is comprised of a large-scale copper roof and associated sampling and monitoring devices. The research center is directed by Prof. Brigitte Helmreich.



*Figure 1: Pilot-scale
nanofiltration test skid (80
L/min)*

Analytical and Microbiological Laboratory

The laboratory is a central facility of the Research Centre and the Chair of Urban Water Management. It is divided into the Analytical Laboratory, headed by Dr. Carolin Heim and Dr. Maren Haas, and the Microbiological Laboratory, headed by Dr. Christian Wurzbacher.

The Analytical Laboratory is equipped with the latest analytical equipment, which enables it to determine all standardised drinking water and wastewater-relevant parameters. In addition to the characterisation of water samples using sum parameters such as COD and BOD, organic compounds can be examined more closely using 3D fluorescence and UV spectroscopy and also quantified using the TOC analyser. Water-relevant anions, oxohalides such as bromate and chlorate as well as short-chain organic acids can be analysed using ion chromatography. A highly sensitive ICP-OES device is available for multi-element analysis using optical emission spectrometry with inductively coupled plasma. Individual elements can also be detected using classic atomic absorption spectroscopy with flame and graphite furnace AAS.

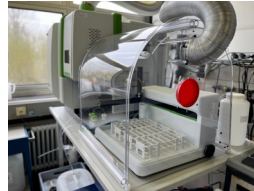


Figure 2: Multi-element analysis with ICP-OES by Perkin Elmer



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Figure 3: HPLC-MS/MS system for trace analysis

Trace substance analysis specialises in the characterisation and identification of organic molecules from aqueous samples in trace substance analysis (target screening) using chromatographic separation techniques coupled with highly sensitive mass spectrometric detection methods (LC-MS/MS). Among other things, perfluorinated alkyl substances (PFAS), pharmaceuticals and biocides can be reliably detected in the water cycle. In addition, for other analytes headspace GC/FID and thermal desorption pyrolysis GC/MS instruments are available.

The Microbiological laboratory uses conventional techniques to determine the microbiological water quality, as well as biosimetry protocols for viruses and bacteria to evaluate disinfection methods. We also count microorganisms using flow cytometry or analyse them individually using laser microdissection. In molecular biology, we work with the quantification of genes in the environment using digital and quantitative PCR, and the analysis of microbial communities and metagenomes using high-throughput sequencing.



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Research Group Urban Stormwater Management

This year, the research group focused on pollutants in stormwater runoff from sealed surfaces. A particular research topic was placed on monitoring pollutants in roof runoff. While the leaching of copper and zinc from metal roofs has been extensively studied, emissions from non-metal roofs have been insufficiently investigated. The leaching of chemical root barriers from bituminous roofing membranes, often used under green roofs, is more widely known. Unfortunately, water-relevant substances are also found in stormwater runoff from common roofing materials such as tiles, concrete roof tiles, treated wood shingles, and fibre cement. To minimize the entry of these substances into soil and groundwater, treatment systems are being developed in addition to pollutant monitoring: a decentralized treatment system for removing the chemical root barrier from bituminous roofing membranes, and improved substrates for infiltration basins to remove biocides and heavy metals from roof runoff.



Figure 4: Example for an extensive green roof. Photo: Brigitte Helmreich

This year, the rainwater research group successfully secured a collaborative project with the Universidad de los Andes in Bogotá, Colombia. A first workshop has already taken place in Munich. Another highlight for the group this year is the successful completion of doctoral studies by Panfeng Zhu, Sebastian Knoll, and Lea Rosenberger.

Implementing biochar in infiltration swales for stormwater treatment

Urban stormwater is a significant pollutant source that impairs the quality of water bodies and can affect human health and ecosystems. Implementing infiltration swales is a meaningful strategy for addressing this challenge. Additionally, they can provide various ecosystem services in cities including infiltration and evapotranspiration. However, while these systems can effectively remove sediments and particulate-bound pollutants, they can fail to remove dissolved pollutants reliably.

This project aims to improve the removal of dissolved heavy metals and biocides in infiltration swales by implementing biochar, a carbonaceous material produced from the pyrolysis of organic matter. For this goal, biochar has been tested both in isolation and in combination with two different soils in laboratory-scale adsorption and breakthrough experiments. Furthermore, meso-scale column experiments with biochar-amended soils under varying rain intensities and dry periods have been conducted.

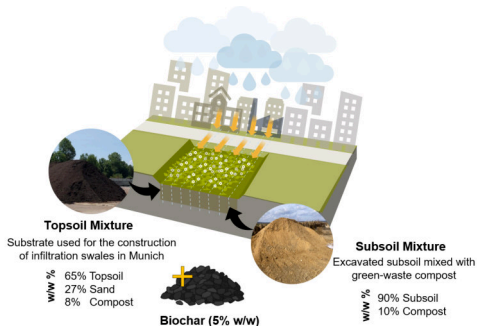


Figure 5: Conceptual framework of implementing biochar in infiltration swales

Current results from the column experiments with synthetic stormwater show that the addition of wood-derived, high-temperature (850 °C) biochar at a 5% weight rate has a significant effect on the removal of the biocides diuron, mecoprop, and terbutryn (>98%); in both tested soils and regardless of the wet-dry cycles. Furthermore, the addition of biochar lowered the bulk density of both soils and allowed the maintenance of sufficient drainage over the four-month watering period, in contrast to two unamended subsoil columns which showed signs of compaction and clogging. These results indicate that biochar is well-suited for both removing biocides and maintaining the hydraulic functionality of soils. This research is part of the interdisciplinary Research Training Group in Urban Green Infrastructure at the Technical University of Munich.



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Zeolite in infiltration swales to improve pollutant retention

Infiltration swales are popular infrastructure elements in cities. Not only do they have the ability to store and infiltrate rainwater, but they also purify it. Additionally, they provide an opportunity to increase biodiversity through their plantings. However, continuous exposure of the swales to pollutants poses a risk that these pollutants accumulate, and after a long period of time, they may break through the 20-30 cm topsoil layer of the swales, which could result in soil and groundwater contamination.

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Figure 6: Test setup, 2 weeks after application of the zeolite layer

To improve the retention of copper from stormwater runoff from copper roofs, zeolite is being tested as an additive in the topsoil zone. For this purpose, 18 infiltration basins were constructed on a semi-technical scale in various configurations. These swales feature different soil compositions, both with and without zeolite, and are complemented by various plantings. Additionally, the effectiveness of a pure zeolite layer on the vegetated soil zone is being investigated. Such a layer could be more easily replaced, regenerated, and reused after becoming saturated with copper. The semi-technical trials are being subjected to stormwater runoff from a nearby copper roof for a period of at least one year to capture seasonal variations.

Removal of water-relevant substances from green roof and facade runoff using a decentralized granular activated carbon (GAC) filter in technical scale

Green roofs are important tools for water-sensitive cities. Furthermore, these measures help mitigate the effects of peak runoff during periods of heavy rainfall, thereby counteracting the adverse impacts of extreme weather conditions. Despite the ecological advantages, green roofs also pose ecological risks: The resulting runoff contains a wide variety of water-relevant pollutants, including nutrients such as nitrate and ortho-phosphate, as well as heavy metals and pesticides present in the substrates, root protection layers, and facade coatings. These substances have the capacity to exert a substantial influence on aquatic ecosystems; as such, they should be removed in a targeted manner prior to being discharged into surface water or groundwater.

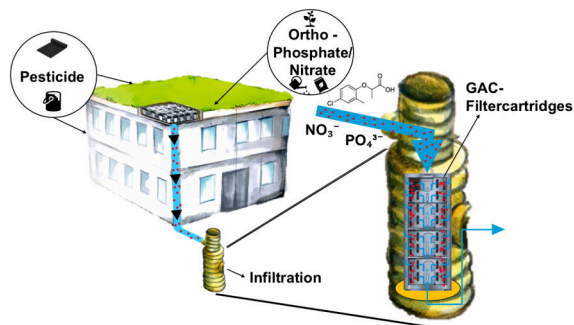


Figure 7: Pesticides and nutrients from green roof runoff are removed in the GAC-filter (adapted from Fränkische Rohrwerke Gebr. Kirchner GmbH & CO. KG, Optigrün International AG (2025)).

To minimize these emissions, a decentralized filter with GAC has been developed, which underwent laboratory trials and is currently being tested in technical scale at an 1,000 m² extensive green roof. The objective of this study is twofold: firstly, to achieve the efficient elimination of water-relevant substances, and secondly, to gain a deeper understanding of the behavior of runoff and the transport of these substances under varying precipitation conditions. It is evident that green roofs have considerable potential for sustainable urban development and climate adaptation. However, it should be mandatory to prioritize the retention of pollutants emitted by roofs in order to minimize ecological risks and ensure long-term water quality.



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FÖRDERUNG

COLLABORATION:

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Pollutants in stormwater runoff from non-metal roofs

In growing cities, an increasing number of surfaces are being sealed. This increases the contact of stormwater with materials, such as roofs, which can contaminate the runoff water with harmful substances. However, no clear or statistically significant statements can be made about pollutant emissions for most roof materials, as there are few studies, most of which are based on one-off random samples. General conditions, such as atmospheric influences or gutter material, are often not sufficiently described. There is a considerable need for research in order to make scientifically sound statements about pollutants in precipitation runoff from non-metal roofs.

The project serves to create a comprehensive and reliable database on the release of substances from non-metal roofs. Based on research of relevant products, laboratory and field tests are carried out. A standardized laboratory procedure is used to obtain building product eluates for estimating emissions. Outdoor tests are used to continuously investigate material emissions under real weather conditions.



Figure 8: Construction of the test roofs in the field

Results from laboratory tests show, among other things, that biocides such as terbutryn are washed out of concrete roof tiles and fiber cement panels, while treated wood shingles release large amounts of copper, boron, and ammonium. Sampling and evaluation of the field tests are currently underway. The data obtained enables a reliable assessment of material emissions and serves to derive recommendations for regulations. It serves as a basis for the development of decentralized precipitation water treatment plants in order to be able to make sustainable use of the run-off water from any pollutant-emitting building products under the challenges of climate change in urban areas.

Researching the path towards climate resilient and water-resilient cities: challenges, actions, and future



Figure 9: Tour of the Isar river restoration project in Munich as part of the first workshop

This project seeks to initiate a scientific collaboration between the Urban Stormwater Management research group from the Chair of Urban Water Systems Engineering of the Technical University of Munich and the Environmental Engineering Research Center (CIIA) at Universidad de los Andes to address the challenges of urban water management in the context of climate change and rapid urbanization. Both Bogotá and Munich face distinct yet complementary issues: Bogotá experiences frequent flooding due to heavy rainfall, coupled with water scarcity and high water stress, while Munich must manage heavy rainfall events, projected shifts in rainfall patterns, and droughts, as well as extreme heatwaves. The collaboration project aims to exchange knowledge, best practices, and real-world case studies in designing, implementing, and managing blue-green infrastructure, which integrates natural and engineered systems to enhance resilience and foster sustainable urban water systems. The collaboration includes a series of workshops to explore mutual research strengths, promote interdisciplinary dialogue, and identify opportunities for future joint initiatives. A particular focus will be placed on developing intercultural and interdisciplinary skills among doctoral candidates from both universities, equipping future decision-makers and water managers with the tools needed to address complex urban water challenges. The first workshop was in Munich in October 2025.



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Research Group Energy-neutral Wastewater Treatment

Wastewater treatment plants are still among the largest municipal electricity consumers, even though wastewater actually contains more energy than is required for its treatment. While compliance with legal limits in wastewater treatment remains the highest priority, our research group is exploring innovative approaches to reduce the energy demand of treatment and simultaneously recover more energy or other valuable resources from the wastewater.

I am delighted that in 2025, two members of our research group successfully completed their PhDs. Mohammad Javad Bardi, funded by the TUM SEED Center, successfully defended his dissertation in October. There is a good chance that he will remain affiliated with the chair, as he has submitted an application to the DFG for funding a subsequent postdoctoral phase. Also in October, Matthias Steindl, an external PhD student from the Bavarian State Institute for Agriculture (LfL), successfully completed his doctorate. He impressively managed to combine the practice-oriented research questions of the LfL with the academic requirements of the TUM including the publication of at least three peer-reviewed articles. We wish both all the best for their future careers! At the beginning of the year, David VoSSSchmidt started his work within the framework of the BMFTR-funded project Urban Heat Cycle. Unlike typical projects, this research does not focus on biogas production but rather on the targeted suppression of methanogenesis. The goal is to produce from sewage sludge not biogas, but organic acids and hydrogen as precursors for the production of a natural heating oil.

We also welcome Nawaz Khan to our research group. Together with a PhD student from Dr. Wurzbacher's group, he is part of an EU-funded international doctoral network. Their research focuses on the interaction of archaea and bacteria in anaerobic biofilms.

The TUM SEED Center, together with the successful fellow Dr. Mohammad Javad Bardi, received a positive evaluation from the DAAD and was selected for a second funding period. In this new phase, two fellows will be affiliated with our chair, working on biogas production in rural areas one of them in Dr. Gondhalekars group. Hessam Shabanizadeh will join our group. In addition, we are pleased to welcome another postdoctoral researcher who has secured one of the highly competitive Alexander von Humboldt Fellowships: Dr. Guangze Guo is researching the combination of anaerobic wastewater treatment with nitrogen and phosphorus removal technologies.

Of course, we regularly present our research results at national and international conferences. Notable highlights include the ecoSTP conference in Stockholm, Sweden, where Christian Wenzel presented

impressive results on the restart behavior of the pilot reactor for biomethanation, and the Sludge Management Conference in Kyoto, Japan, where Xaver Niebauer presented his work on the removal of metabolically produced water using membrane-based processes. Both presentations received great interest from the international audience, demonstrating the high relevance of our research.



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THE GERMAN
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COLLABORATION:

TUM SEED
CENTER

Rural Biogas Generation

By 2030, the world population will reach 8.6 billion, increasing energy demand by 30%. This population growth will also amplify global organic waste production. To tackle these challenges, anaerobic digestion (AD) offers an innovative and resilient solution, treating organic waste streams while producing renewable energy in energy-rich biogas and digestate, a high-value-added bio-fertilizer.

In a recent study, we enriched the AD process with carbon dioxide to boost biomethane production and assess degradation kinetics and methanogenic pathway evolution. Carbon dioxide enrichment improved inoculum digestion, supplying additional energy for methanogenic archaea. The methane yield of blank inocula increased by 53% to 77% after carbon dioxide enrichment. Although further digestion of inoculum residues took longer, rapid adaptation increased the methane production rate and surpassed the lag phase. No antagonistic effects were observed with carbon dioxide enrichment after applying the feedstocks. Increased methane production and a significant reduction in chemical oxygen demand confirm the impact of carbon dioxide enrichment on inoculum digestion. Isotope analysis showed increased $\delta^2\text{H-CH}_4$ values by approximately 36 mU compared to non-enriched inoculum, implying enhanced hydrogenotrophic methanogenesis. Carbon dioxide enrichment significantly enhances biomethane production and digestion efficiency in anaerobic digestion, offering a sustainable solution for large-scale plant operations. Importantly, biogas plants already produce CO_2 , making this method both cost-effective and widely applicable, with successful trials on digestates from municipal wastewater treatment and agricultural feedstock.

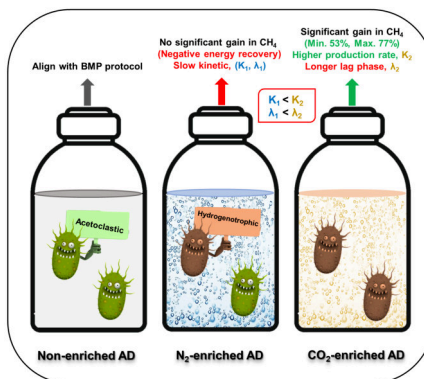


Figure 10: The intriguing effect of CO_2 enrichment in anaerobic digestion

ENCOVER: Energetic utilization of CO₂ to enhance the methane productivity and to reduce the residual methane potential

In the ENCOVER project, the potential of targeted CO₂ addition during the anaerobic digestion of renewable raw materials to enhance methane production and improve process stability was investigated. The objective was to utilize CO₂ as a reactive component within the fermenter to generate additional methane and to reduce the residual methane potential in the digestate. To this end, continuous long-term trials were conducted in two 35 L pilot-scale reactors using various substrates, including maize silage, organic residues, sugar beet pulp, and alfalfa. In the CO₂-enriched reactor (R_{CO2}), methane yields increased by 57 % compared to the control (R₀) at medium to high organic loading rates (> 6 kg_{VS}/m³üd). Moreover, an improved process resilience was observed: while the control reactor experienced a sharp pH drop and process disturbances at elevated loading rates, the CO₂-supplemented reactor remained stable for a longer period. Complementary isotopic and microbiological analyses provided new insights into the mechanisms of CO₂ utilization. The findings suggest that CO₂ was not only directly converted into methane but also facilitated a more efficient use of available reducing equivalents in the digestate. Isotopic measurements (¹³C and ²H signatures) further confirmed an increased contribution of hydrogenotrophic methanogenesis under stress conditions. The hydrogen isotopic signature (²HCH₄) and the metabolic quotient (MQ) proved to be sensitive early-warning indicators for process instability. An economic assessment indicated that the observed effect offers substantial efficiency potential for full-scale biogas plants. Assuming a 57 % increase in methane production, additional revenues of up to 80,000 per year could be achieved in typical agricultural biogas facilities. Building on these results, a follow-up project in collaboration with Fraunhofer IEE is planned to test CO₂ recirculation for the first time at pilot scale (40 m³ reactor).



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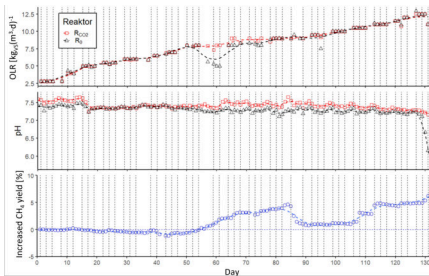


Figure 11: Long-term experiment using sugar beet molasses pellets as an example: OLR, pH, redox potential, and increase in CH₄ yield in R_{CO2} compared to R₀.



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Robust biofilm-based biomethanation after extended downtime: Optimized operation of Power-to-Gas systems at wastewater treatment plants

As part of the energy transition, renewable energies are set to play a central role in the German energy system in the long term. One promising solution for flexible and needs-based energy storage is the conversion of hydrogen (H_2) and carbon dioxide (CO_2) into methane (CH_4) using the so-called power-to-methane process. In this process, H_2 is produced from unused renewable electricity using electrolysis and CO_2 from wastewater treatment plants (WWTP), biogas plants or industry can be utilised directly where it is produced.

Biological methanation of H_2 and CO_2 in trickle bed reactors (TBR) is considered a promising technology for energy conversion, especially in the context of energy storage. To this end, a TBR with a reaction volume of 0.8 m³ was installed at the Garching WWTP to upgrade raw biogas from the local digester to synthetic natural gas quality (> 96 % CH_4). Following a period of uncontrolled dormancy lasting over 550 days, molecular biological investigations have indicated that it might be feasible to recommence the operation of the reactors, even following a highly protracted period of inactivity. Notably, adding digester supernatant, characterized by an NH_4+ concentration of 1,594 ± 166 mg/L, led to a substantial increase in methane production, reaching 96 % CH_4 in the product gas within few hours, without prior inoculation with fresh anaerobic sewage sludge. A methane production rate of 5.2 m³/(m³ reactor volume *d) was achieved in the pilot reactor, after a few days .

With the aim of testing the conversion technology as a holistic concept and under real conditions, the H_2 supply from gas bundles has now been replaced by the integration of an electrolyser. This coupling of electrolysis and methanation is intended to demonstrate the functionality of the overall process and identify and address any challenges that arise, for example with regard to the necessary intermediate storage of H_2 . In addition, various investigations are being carried out in parallel to further optimise methane productivity, process stability and the dynamic operation of the plant.

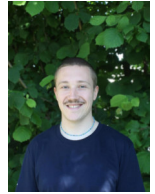


Figure 12: Pilot reactor at the Garching wastewater treatment plant.

Optimization approaches for the operation of a trickle bed reactor used for biological methanation of CO₂ and H₂

To ensure a sustainable and secure electricity supply based on a high proportion of volatile renewable energies, long-term, and demand-oriented energy storage technologies are required to stabilize the power grid in times of imbalance between energy production and demand. In Power to Methane PtM technology, electricity from renewable energy sources (in the form of green hydrogen) is converted into methane, which can be made available as short, medium- and long-term storage in the existing natural gas infrastructure. A critical aspect for an efficient use of the PtM technology is the ability to be operated in a demand-oriented (dynamic) manner.

The main objective of the KomMeth project is to advance the translation of the trickle bed reactor (TBR) concept for biological methanation further into commercial application. In addition to pilot-scale investigations, two existing technical-scale TBRs were recommissioned in July 2025 and are being operated in parallel. In these reactors, the effects of reducing the nutrient supply will be examined in more detail. In addition, various standby and restart strategies will be tested. To compare different packing materials for the reactors, a fed-batch test setup was also constructed. Initial preliminary tests have already been carried out. The entire project is also accompanied by microbiological monitoring in order to investigate the influence of different operating conditions on the composition of the microbiocenosis.



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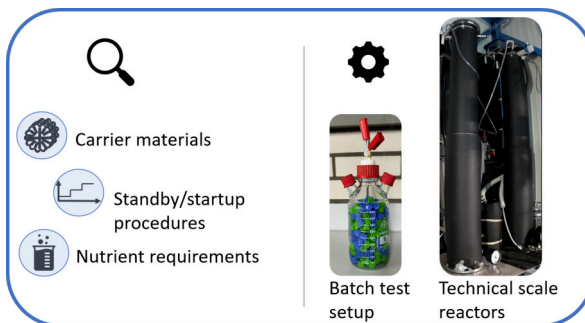


Figure 13: Overview of main topics investigated and experimental setups



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UrbanHeatCycle: Dark fermentation as a core component for the sustainable production of biodiesel intermediates from sewage sludge

Oil heating systems, with 3.9 million units in operation in 2024, remain a standard technology within the German building stock. Under the new Building Energy Act (GEG), the share of climate-neutral energy carriers in heating oil is to be gradually increased from 15 percent in 2029 to 100 percent by 2045. Although the market share of renewable heating systems continues to grow, oil-based solutions will remain relevant for many private households over the next 3040 years. Within the UrbanHeatCycle project, sewage sludge is used as a locally available resource for the fermentative production of intermediates such as hydrogen and acetic acid, serving as precursors for biobased heating-oil equivalents.

As part of a feedstock characterization, an appropriate and representative sewage sludge (primary or excess sludge) will first be identified and subjected to comprehensive chemical analysis. In addition to optimizing the enzymatic hydrolysis, the research focuses particularly on inhibiting methanogenesis, as it strongly influences the formation of volatile fatty acids (VFAs) and hydrogen. Through targeted process control or the addition of specific additives, the anaerobic degradation process is to be stopped after acetogenesis in order to maximize product formation. Both processes will be implemented at a technical scale (50 L) together with heavy-metal removal using algal biomass, forming the basis for subsequent upscaling to industrial scale.



Figure 14: Reactor system for the anaerobic fermentation of sewage sludge

Improved process resilience by enhanced anaerobic biofilm formation

Natural resources are being depleted at an alarming rate as energy consumption continues to increase rapidly, resulting in a significant rise in greenhouse gas emissions and exacerbating climate change. The world is shifting toward cleaner and more sustainable energy systems that include waste management to address the drawbacks of fossil fuels and meet the Sustainable Development Goal. Anaerobic Digestion (AD) is a promising technology capable of overcoming these challenges. It is a biological process in which various anaerobic microorganisms convert complex organic matter into methane (CH_4) and carbon dioxide (CO_2), along with other trace compounds. However, since most of the energy in the system ends up in the produced methane, the process is understandably prone to disturbance and inhibition.

Leveraging Anaerobic Digestion through Environmental Stress (LeAD) is an innovative and collaborative research project funded by the Marie Skodowska-Curie Doctoral Networks, focusing on improving AD technology. This project aims to tackle key challenges by using advanced microbiological and computational tools to study how syntrophic bacteria and methanogenic archaea interact within AD ecosystems under stress conditions. By understanding these interactions, we aim to develop strategies that enhance the robustness and reliability of AD systems under stress conditions.



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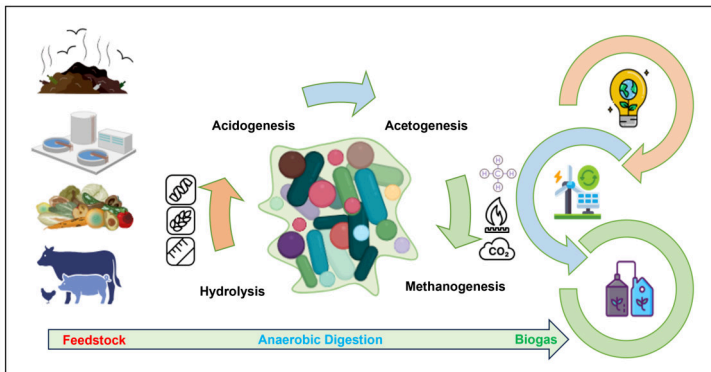


Figure 15: Schematic of conversion from organic feedstocks to biogas via anaerobic digestion steps



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Rural Biogas Generation

The TUM SEED Center fosters interdisciplinary collaboration between the Technical University of Munich (Germany) and ten leading partner universities across the Global South, including Bahir Dar University (Ethiopia), Kwame Nkrumah University of Science and Technology (Ghana), Bandung Institute of Technology (Indonesia), Indian Institute of Technology Bombay (India), Jomo Kenyatta University of Agriculture and Technology (Kenya), Makerere University (Uganda), Namibia University of Science and Technology (Namibia), Burkina Institute of Technology (Burkina Faso), Pontificia Universidad Católica del Perú (Peru), and Stellenbosch University (South Africa). Together, these institutions advance sustainable solutions at the intersection of energy, entrepreneurship, and development, contributing to SDG 7 Affordable and Clean Energy.

Within this collaborative framework, the Rural Biogas Generation project aims to develop resilient waste-to-energy systems for rural and remote communities. The research focuses on enhancing anaerobic digestion (AD) to increase biomethane yield and improve process stability. The concept aligns with the SEED Centers mission to create locally adaptable, sustainable energy technologies that strengthen rural economies and promote circular resource use.

The project benefits greatly from the SEED partner network, which provides access to diverse expertise, regional perspectives, and potential demonstration sites in different climatic and socio-economic contexts. A key collaboration is currently being established with Bahir Dar University (Ethiopia) to exchange knowledge. Further exchanges and workshops with other partner universities are envisaged to identify scalable approaches suitable for their respective regions. Through these institutional linkages, the project exemplifies the added value of the SEED network in connecting researchers, fostering innovation across continents, and translating academic knowledge into practical solutions for sustainable rural energy generation.

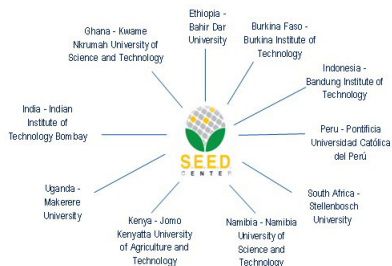


Figure 16: The SEED partner network

Research Group Advanced Water Treatment

The research group deals with the question how to manage the anthropogenic water cycle and material cycles to supply water in sufficient quality and quantity for a growing world population in view of an accelerating climate change and attributed challenges. In the research projects we develop approaches that reflect closed water cycles contrasting the traditionally linear take-make-waste paradigm of centralized water supply and waste water discharge. Hence, advanced water treatment may be employed on either side, wastewater treatment or drinking water purification. This paradigm change is also propelled by current regulative initiatives, e.g. revised EU Urban Wastewater Treatment Directive and EU regulation for agricultural water reuse. We are seeking to remove very different contaminants:

- trace organic chemicals at ng/L to $\mu g/L$ level (e.g. pharmaceuticals, personal care products, industrial chemicals) and in particular, persistent, mobile and toxic (PMT) substances (e.g. PFAS),
- pathogenic microorganisms (bacteria, viruses, protozoa), and
- antibiotic-resistant bacteria and resistance genes.

The developed hybrid treatment processes rely on different physical, chemical and biological removal mechanisms to offer multiple barriers against contaminants. Notably, we investigate hybrid treatment processes that combine separation and conversion. You can explore the current research projects on the following pages.



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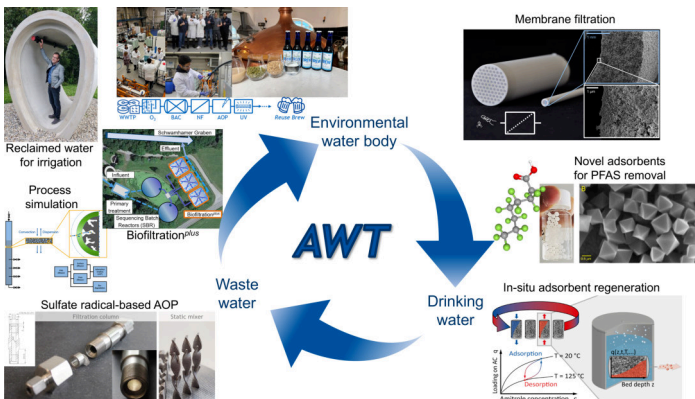


Figure 17: AWT research highlights



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Elimination of trace organic chemicals (TOrcs) at small scale wastewater treatment plants (<10,000 p.e.)

Following the adoption of the revised EU Urban Wastewater Treatment Directive in November 2024, national legislation must also be adapted in Germany, focusing on an advanced wastewater treatment step. This is intended to reduce water pollution with trace organic chemicals (TOrcs). Processes for the removal of TOrcs have so far proven to be particularly effective in medium to large scale wastewater treatment plants (WWTPs). However, TOrcs removal can also be considered for smaller WWTPs in the 2,000-10,000 PE range, as these often discharge into very small and sensitive water bodies.

This project involves the development and testing of cost-effective and low-maintenance solutions for the TOrcs removal at small wastewater treatment plants. The Irschenberg WWTP (7,000 PE) was selected as a case study for the implementation of the project. As part of a new construction, the WWTP will be equipped with a process designed by us: The Biofilter^{plus} is a vertical filter (VFCW) that contains a mixture of sand and granular activated carbon (GAC) to eliminate TOrcs.

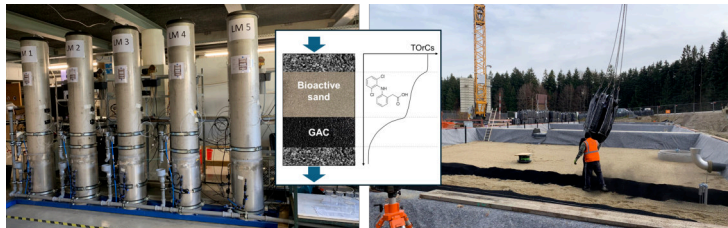


Figure 18: Biofiltration^{plus}: Experiments (left), principle (middle) and large-scale filter during filling with GAC during construction phase in Nov. 2025 (right)

For the simulation of the vertical filter at the Irschenberg WWTP, column experiments are carried out at the technical center of the chair. Based on these experiments, recommendations for the filling and operation of the filter in Irschenberg can be derived. Variables to be tested are, for example, the feeding regime (surge vs. continuous), the saturation state (saturated vs. unsaturated), the hydraulic residence time, and the elimination performance. Our filter design aims at creating selective pressure for the removal of TOrcs through the combination of biofiltration and adsorption, and to generate a long service life for the activated carbon.

The WWTP is planned to go into operation in May 2026 and simultaneously scientific monitoring of the large-scale technical Biofilter^{plus} is started.

Nano-Enabled Water Reuse: Water decontamination through sulfate-radical oxidation in a nano-enabled catalytic filtration process for non-potable and potable water reuse

Growing regional and local water stress can be mitigated through water reuse, whether direct or indirect. However, in addition to minimum removal limits from the EU Urban Wastewater Treatment Directive, chemical and biological contaminants must be extensively removed before the water can be reused. The project presents an alternative technology to remove Trace Organic Chemicals (TOCs) using in-situ generation of sulfate radicals from peroxymonosulfate (PMS) in a simple depth filter containing a catalyst: MnO_2 immobilized on sand and granular activated carbon. The project will design, optimize, scale-up and evaluate the performance of this modular technology to treat secondary wastewater effluent in the Schweinfurt wastewater treatment plant. Optimization of the process was initially conducted through using spiked tap water and passing it through columns containing catalysts with in-line dosing of peroxymonosulfate.



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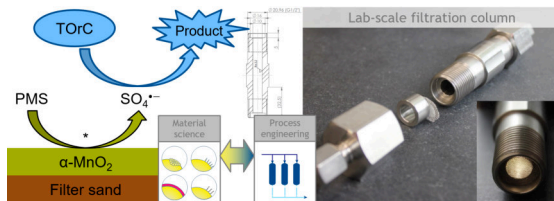


Figure 19: Catalytic filtration to remove TOCs

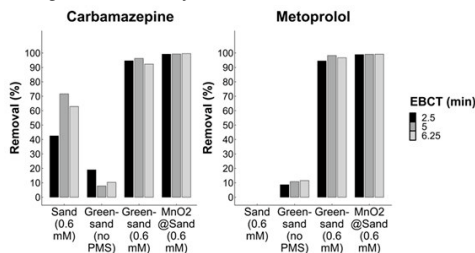


Figure 20: Catalytic Removal of Carbamezapine and Metoprolol in 3 different operational settings

Initial results indicate increased removal for TOCs when MnO_2 and PMS interact. Furthermore, reducing the Empty Bed Contact Time (EBCT) to 2.5 minutes does not impact TOCs removal (Figure 4). The shortest feasible EBCT and ideal PMS dosage for wastewater effluent will be evaluated before these settings are applied at the Schweinfurt WWTP.

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Water resilience - Innovative management and operating concepts for future-proof and resilient water infrastructures

Climate change is not only altering water availability, but also water usage at an increasing rate. As a result, the previous assumption of temporal stationarity for planning processes and water supply no longer applies. The objectives of the BMFTR project „Water Resilience,“ include forward-looking groundwater management with energy optimization based on artificial intelligence (AI) and the development of optimized, proactive well operation to improve raw water quality in bank filtration. In addition, an integrated management concept for the alternative water resource „Nutzwasser,“ for non-drinking water purposes in urban and rural areas is being developed in order to conserve drinking water resources. To evaluate the various approaches, new quantitative resilience indicators are being developed in addition to life cycle assessment and cost accounting, which will allow the increase in operational and strategic resilience to be evaluated.

In the first steps, a monitoring campaign was launched to observe the water quality in the Main River and in the adjacent bank filtration wells. With the help of monitoring, it is possible to assess the influence of seasonal changes, such as dry periods, on water quality. The main focus here is on the influence of treated wastewater on raw water quality, which is detected by analyzing the occurrence of trace organic chemicals. Based on these observations, various well management concepts were developed to ensure very good raw water quality even during low discharge periods of the Main. These concepts involve targeted temporary shielding of the river-side groundwater or a temporary increase in the land-side inflow without the need for structural measures.

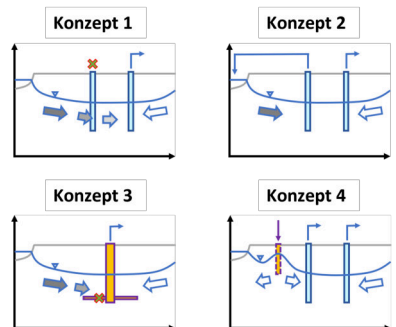


Figure 21: Depiction of the well management concepts

Water resilience - Innovative management and operating concepts for future-proof and resilient water infrastructures

Traditional approaches to water management have long been based on the assumption of stationarity, enabling the long-term management of water resources. However, this assumption is increasingly being called into question due to climate change. More frequent extreme weather events and rising temperatures impact water availability and quality. At the same time, changes in water demand lead to further uncertainty for water suppliers and engineering firms.

In particular, areas that rely heavily on riverbank filtration for their drinking water supply are affected by reductions in water quality during low-water periods in rivers during the summer months. Various water management strategies, both with and without structural measures, are therefore being devised to improve the quality of raw water. These strategies aim to protect riverbank filtration and increase groundwater levels inland.

Groundwater and transport models are used to represent complex subsurface processes, such as the interaction between surface water and groundwater, and substance transport processes. These models are used to investigate the impact of the developed well management concepts on raw water quality.

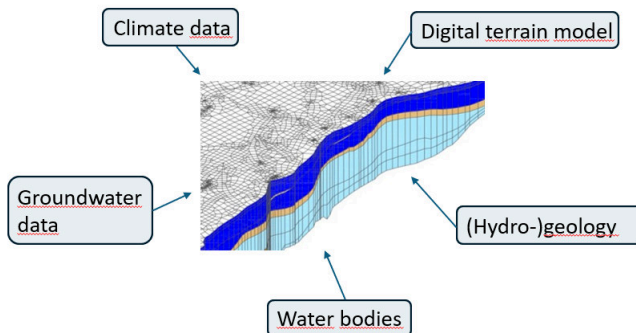


Figure 22: Structure and required input datasets for a groundwater model



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PFASelect: Selective PFAS removal from aqueous media through novel and regenerable ion exchange materials

Perfluorinated and polyfluorinated alkyl substances (PFAS), also known as forever chemicals, are classified as (very) persistent with some being toxic and in addition either bioaccumulative or (very) mobile. The classifications as PBT, PMT or vPvM therefore pose a far-reaching risk to humans and ecosystems. The aim of the EU according to the Green Deal is therefore to reduce the exposure of humans and ecosystems, e.g. through the Chemicals Strategy for Sustainability, the Regulation on Persistent Organic Pollutants, the REACH Regulation, the Drinking Water Directive and the new editions of environmental quality standards and Groundwater Directive. The transboundary nature of environmental problems and water bodies such as the river Inn makes cross-border cooperation indispensable.

In particular, the entry into the environment via contaminated process and waste water as well as uptake via contaminated groundwater and drinking water must be avoided. Current treatment and remediation processes, such as adsorption on activated carbon, are inefficient for certain PFAS (especially short-chain ones) and problematic if competing substances such as dissolved organic substances and anions (e.g. chloride, sulphate) are present. Furthermore, activated carbon can only be regenerated to a limited extent, which makes it a disposable fossil product.

The development of highly efficient, highly selective and regenerable ion exchange materials based on perfluoroalkyl chains represents a promising solution. In a novel approach, a macroporous, amino-modified alkyl-based polymer is to be grafted with fluoroalkylated substances based on imidazole (grafting-to). The aim is to use a dual deposition mechanism that synergistically couples electrostatic and fluorophilic interactions. A comparison with commercially available materials (activated carbon, ion exchangers) will be carried out. Characterization and process engineering process development and simulation are to be carried out. The high-performance resins are to be regenerated by elution and oxidation using non-thermal plasma. High-performance PFAS analysis will be established. Hydraulically optimized granulates will be produced and the most promising materials will be scaled up in pilot tests. Pilot sites on both sides of the program area (i.e., Bavaria/Germany and Tyrol/Austria) will be selected and pilot plants will be developed, built and operated. The success of the project should help to raise awareness of the PFAS problem among experts and the public and present available solutions.

StaySafe - Safe intermittent agricultural irrigation

Increasing water scarcity caused by climate change requires the use of treated water for agricultural irrigation, even in regions that previously had sufficient freshwater supplies. However, there are fundamental gaps in our knowledge regarding the fate and regrowth of pathogens in the distribution system, i.e., during transport and storage. Due to highly fluctuating irrigation requirements and diverging precipitation patterns, numerous irrigation systems experience stagnation phases that last from a few days to several weeks. This project team, therefore, focuses on the dynamics of pathogens and antimicrobial resistance (AMR) during the transport and storage of further treated water. Experimentally, different treated water qualities are compared and tested under dynamic operating modes and (post-)disinfection strategies. The project team has three objectives: first, to suppress recontamination with pathogens; second, to determine the most suitable disinfection strategies under transient operating conditions; and third, to prevent the spread of antimicrobial resistance.



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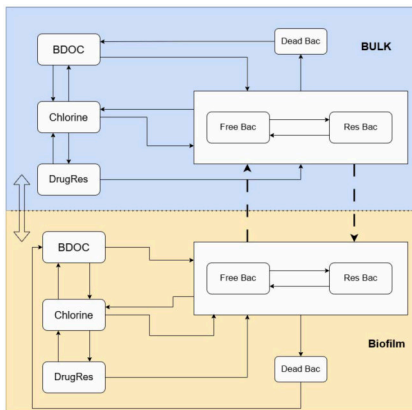


Figure 23: Schematic representation of the exchange between the water phase and biofilm, as well as the interactions between the most important parameters in the tank model: antibiotic residues (Drug), biodegradable dissolved organic carbon (BDOC), residual chlorine (Chlorine), non-resistant bacteria (Free Bac), bacteria with resistance genes (Res Bac), antibiotic residues (DrugRes), and dead bacteria resulting from lysis (Dead Bac).

First, modeling is used to determine the optimal system configurations for microbial and physicochemical water quality. The model is then validated by means of laboratory tests. This optimum is demonstrated on a pilot scale in Schweinfurt in order to ensure safe water quality under highly dynamic operating conditions.



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Research Group Water Reuse

Water recycling and reuse can overcome water resource problems efficiently and sustainably by creating an alternative source of high-quality local water supply and thus partially replacing already scarce freshwater resources. In particular, the reuse of qualitatively impaired surface water or further treated (municipal) clear water can effectively mitigate the challenges associated with increasing water use conflicts. In May 2020, the EU published a new regulation on minimum requirements for water reuse for agricultural irrigation for the first time. This also came into force in Germany in June 2023 and is currently being transposed into national law. In addition, the DWA has for the first time drawn up a set of technical regulations for water reuse (DWA-M 1200), which was published in July 2025 in yellow print.

Due to this development, but especially due to the noticeable consequences of climate change, there is now also a great need for action for water reuse in Germany. Based on a feasibility study in Lower Franconia, we were able to complete the new BMFTR joint project "Nutzwasser" in 2024, which was developing concepts for safe water reuse for urban and agricultural irrigation on a demonstration scale. Based on the findings of this study, the city of Schweinfurt will be the first city in Germany to implement the use of industrial water for urban greenery in the city. We are very grateful for the follow-up funding from the Bavarian Ministry of the Environment.

In addition, water reuse is an interesting support option for artificial groundwater recharge. Also funded by the BMFTR, we have been testing the concept of sequential managed aquifer recharge technology (SMART) on a former waterworks site together with Berliner Wasserbetriebe as part of the 'TrinkWave Transfer' project since 2022. We are also able to continue this project with European partners in the 'MARSURE' project thanks to follow-up funding from an EU program. We are also investigating the SMART concept for decentralized water reuse as part of an international project in South Africa funded by the Bavarian Ministry of the Environment.

Nutzwasser: Demonstration of reclaimed water use for the irrigation of urban green spaces

Within the BMFTR-funded Nutzwasser project (completed in December 2024), innovative flexible and demand-oriented management strategies for water reuse for urban and agricultural irrigation were designed and optimized at demonstration scale.

The subsequent project, funded by the Bavarian State Ministry of the Environment, „Nutzwasser for Urban Green Spaces“ is now testing the large-scale implementation of the reclaimed water applications for irrigation within the City of Schweinfurt. This project will be the first in Bavaria and Germany to establish the use of an alternative, drought-proof water resource for the irrigation of urban green spaces at a city scale.

The investigations focus on establishing a dynamic and demand-oriented management system for the irrigation infrastructure and ensuring appropriate water quality for the provision of Nutzwasser. Additionally, a lysimeter study and long-term monitoring are designed and implemented to preserve soil and groundwater quality as well as plant health. Based on the obtained findings and the results of a systematic cost-benefit analysis, recommendations will be provided to facilitate the transfer of this practice to other municipalities.



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SOLUTIONS
HERFORD GMBH

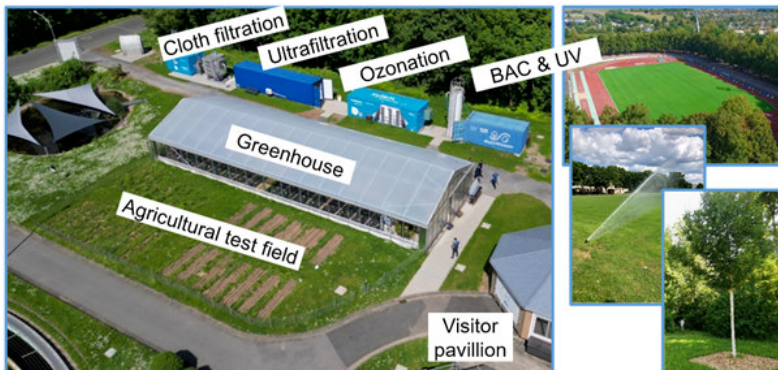


Figure 24: Water reclamation facility and urban applications of Nutzwasser in Schweinfurt



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FreeSpace: Fundamental research to exploit hydrodynamic effects to reduce membrane fouling by introducing special arrangements of novel feed spacer geometries in combination with non-regular membrane surface-pattern

In this DFG-funded research project, we investigate synergistic influences of membrane surface patterns and feed spacers on flow characteristics, concentration polarization, and biofouling in the membrane feed channel. This research will promote our understanding of fundamental design criteria that determine the overall module performance. Using this knowledge, we strive to optimize the geometric arrangement of feed spacers and membrane surface patterns to ultimately reduce membrane fouling and assure higher process efficiency.

Biofouling, the accumulation of microorganisms and subsequent biofilm growth on the membrane, is of particular concern in Reverse Osmosis systems. Therefore, in order to understand the evolution of biofouling on surface-patterned membranes, we perform accelerated biofouling experiments with semi-synthetic feed water. We assess spatial and temporal biofouling dynamics by direct observation (cf. figure 25), online measurement of the feed channel pressure drop, image-derived quantitative fouling indicators, and post-experiment biofilm analysis.

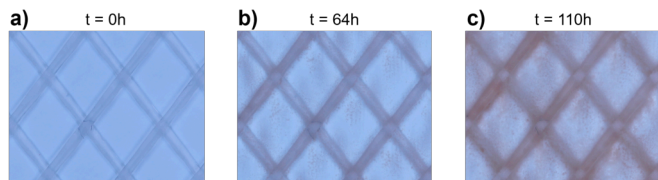


Figure 25: Camera images of different stages of biofilm growth in accelerated biofouling experiments at $t = 0h$ (a), $t = 64h$ (b), and $t = 110h$ (c).

In parallel to this experimental approach, we investigate the flow characteristics and concentration polarization in assemblies of feed spacers and membrane surface patterns by CFD Modeling with COMSOL Multiphysics 6.2. In our latest publication, we found that the well-known, individual effects of surface-patterned membranes and feed spacers on membrane performance and anti-fouling propensity are perpetuated and complement each other in spacer-pattern assemblies. Currently, we conduct an optimization study for the geometry of surface-patterned membranes in a spacer-filled feed channel in order to maximize anti-fouling propensity and permeate flux while minimizing concentration polarization.

MARSURE - Hybrid Managed Aquifer recharge as an adaptation tool to ensure a resilient and sustainable groundwater management

The transnational MARSURE research project aims to develop hybrid processes for managed aquifer recharge (MAR). The hybrid approach combines the pretreatment of the water to be infiltrated and subsequent hydraulically controlled infiltration into the groundwater body. This is intended to create ideal conditions for retaining various chemical contaminants (e.g. antibiotic residues, industrial chemicals, etc.) and biodegrading them during the retention time in the subsoil. The hybrid process combination is intended to create a resilient option for utilizing alternative water resources for groundwater recharge (e.g. reclaimed water).

We investigate two hybrid MAR experimentally:

In Schweinfurt, reused water is differently pretreated (ultrafiltration, ozonation, etc.) and infiltrated in groundwater mimicking columns. The aim is to investigate how the microbiological community in the column adapts to the different water qualities and how this affects the biological degradation of organic trace substances (Figure 4, left).

At the test site in Berlin, the Sequential Managed Aquifer Recharge Technology (SMART) is implemented in a heterogeneous aquifer at field scale a. The test field was set up as part of the „TrinkWave Transfer“ project, enabling now to gain deeper insights into its long-term operation, biological trace substance degradation and the microbiological community in the field (Figure 4, right).

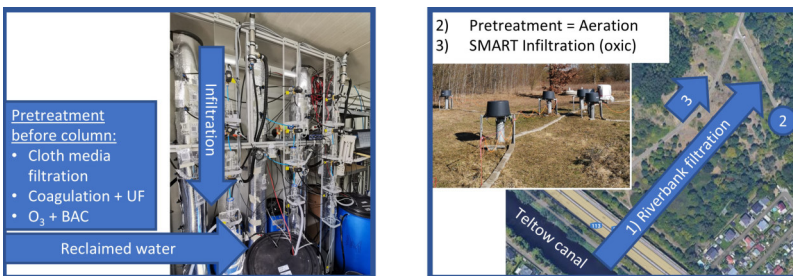


Figure 26: Schematic experimental setup for Schweinfurt (left) und Berlin (right)



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The Water Hub: Water reuse in Franschhoek, South Africa

The Water Hub in Franschhoek, South Africa, is a pilot water treatment facility and research site where nature-based technologies are applied to treat and reclaim polluted river water for irrigation. The project follows a Water-Energy-Food-Ecosystem-Nexus approach to improve and expand the water treatment train and to create on-site entrepreneurship opportunities for energy (biogas and PV) and crop production for local markets.

The nature-based water treatment system, as shown in Figure 5, consists of two multi-media horizontal-flow biofilters, followed by aeration and a secondary treatment step. This step applies sequential managed aquifer recharge technology (SMART) in an engineered bioreactor to create high-oxygen, low-carbon conditions and to establish a microbiome which further removes trace organic contaminants and pathogens, creating a high-quality effluent safely reusable for irrigation. Applying SMART in a closed reactor optimizes the required footprint, offers well-controlled and reliable flow conditions, and simplifies potential replication at other sites.

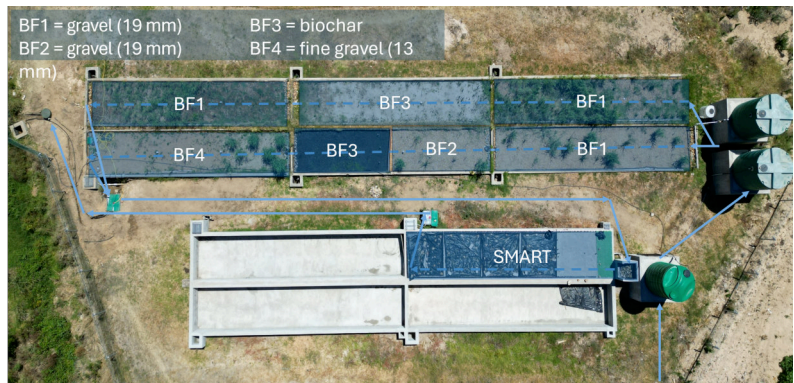


Figure 27: Sequential water treatment using biofilters and SMART

The project is supported by the Western Cape Government, Department of Environmental Affairs and Development Planning (DEA & DP) as a close partner and is funded by the Bavarian State Ministry of the Environment and Consumer Protection (StMUV) in Germany. As such, a main research goal of this project is to advance this low-cost and low-input (in terms of energy, chemical additives, and logistics) water treatment technology for knowledge transfer to other sites not only in the Western Cape but also in the State of Bavaria.

Insights into a black box methods to unravel environmental processes in managed aquifer recharge

Managed Aquifer Recharge (MAR) is a method of storing water underground and making it available at a later date to meet demand. With increasing demand for water and longer periods of drought, this is an important approach for future water supplies. At the same time, water quality must be maintained to protect groundwater and to ensure water quality for applications such as agricultural irrigation.

Sequential groundwater recharge (SMART) combines a first infiltration to break down easily degradable organic matter with a second infiltration after aeration under low-carbon, high oxygen conditions. The advantage of the second infiltration is the degradation of some organic trace substances. It also requires less space and has faster flow rates than a conventional MAR. Treated wastewater treatment plant effluent or bank filtrate is used as the water source.

However, many questions remain regarding the optimal conditions for the biodegradation of organic trace substances. A pipeline approach was developed to apply machine learning based on existing SMART experimental data. Of all the models, random forest performed best, and the model results showed a good fit to the observed data. However, as there was very limited data available, the results have limited explanatory power regarding the conditions that influence biodegradation. Nevertheless, the developed workflow can be applied to other water quality experimental data or future SMART experimental data.

Other currently applied approaches include in-situ measurements of biofilm in the aquifer to closely monitor the environmental processes influencing biodegradation. Combining reactive groundwater models with online monitoring data can improve our understanding of subsurface processes. The aim of these approaches is to reveal the effect of environmental processes on biodegradation in the subsurface, moving from a black box towards a grey box understanding. Overall, this could facilitate the transfer of the SMART approach to new locations.

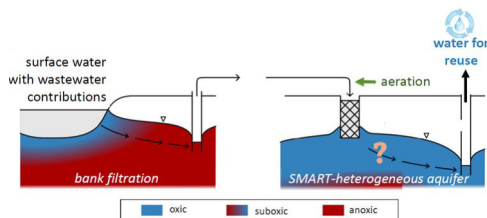


Figure 28: Sequential Managed Aquifer Recharge Technique at a heterogeneous aquifer



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Research Group Water-Energy-Food-Ecosystem (WEFE) Nexus

With ongoing economic growth, urbanization and industrialization, demand for natural resources such as water, energy and food continue to rise worldwide, especially in cities. The result is serious environmental challenges and climate change. Integrated urban planning to leverage on potential synergies of climate change mitigation and adaptation approaches and measures urgently needs to be developed and implemented by 2030 to avoid disastrous climatic change.

The Water-Energy-Food (WEF) Nexus approach is one integrated urban planning way for cities to devise more sustainable development pathways. The approach advocates that supplying water to cities takes much energy, and that much water is also needed to produce energy and food. Planning these three sectors in an integrated manner can support water, energy and food security and achievement of the United Nations Sustainable Development Goals (SDGs). Water reclamation with integrated resource recovery is a key synergy opportunity for the operationalization of the WEF Nexus approach. However, so far, few examples exist where this has been implemented at urban scales. More case study development and pilot projects are urgently needed in order to test the viability of this approach. Further, such development needs to be embedded from the outset in a participatory multi-stakeholder process.

Within the TUM Nexus Lab initiative (Nexus@TUM) founded by Dr. Gondhalekar in 2021, the Urban WEF Nexus Research Group uses the Nexus approach as an integrated urban planning framework to analyze the interactions between the sectors water, energy and food, as well as other related sectors such as mobility, solid waste, health and ecosystem services, and devises alternative future urban development scenarios to support the development of pilot projects at urban scales. Nexus@TUM aims to build on an environmental engineering perspective by integrating all three pillars of sustainability and connecting these to social, institutional, legal, political, and economic aspects, in an equal manner. Nexus@TUM further acknowledges that the issue at hand pertains equally to contexts in developing as in developed economies. The research group works in several case study locations including Germany, Ghana, India, Niger, South Africa and Tunisia.

For more information, please visit www.nexus.wasser.tum.de

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Water-Energy-Food (WEF) Nexus pilot project in the Reto Dosso Region, Niger

The aim of the project is to use a holistic approach to increase water, energy, and food security in the Dosso region of Niger. Through a participatory multi-stakeholder process, the project aims to contribute to long-term socio-economic development and social security in the region.

In the first phase of the project, socio-economic surveys were conducted at the project site, the village of Dar es Salam, to assess the resource demands of households. These surveys revealed that improving the water supply is particularly important to the residents. Therefore, further analysis focused on how the groundwater level can be sustainably raised by using rainwater for Managed Aquifer Recharge (MAR). The solar energy which is needed to pump the groundwater saved by this process could be partially used for other productive purposes. Currently, a comprehensive survey of several stakeholder groups (households, community leaders and well keepers) is being conducted to evaluate the socio-economic impact that has already been achieved through an improved resource availability.

Based on the studies conducted in Dar es Salam, the measures are now being implemented in the municipality of Barkiawal Beri, a suburb of the capital Niamey. The aim is to balance water availability for households and agricultural irrigation throughout the year using a MAR system for rainwater infiltration. Groundwater quality will be ensured through appropriate pre-treatment. The local ecosystem will be regenerated through the creation of demi-lune terraces to reduce soil erosion and store rainwater on the slopes, thereby contributing to climate adaptation in the greater Niamey area. In addition, the installation of an irrigation system is planned to enable the cultivation of agricultural land beyond the rainy season, thereby strengthening local food production and the associated value chain.



Figure 30: Location of the new project site Barkiawal Beri, 20 km east of Niamey

Integrated Forest, Water, Prosperity Project Tunisia. Convergence

This two-and-a-half-year pre-feasibility study adopted the Water-Energy-Food-Ecosystems (WEFE) Nexus approach for the planning of an afforestation/ reforestation project with an end goal to improve the socio-economic conditions of the local population in a water scarce country such as Tunisia as a means of climate change adaptation and to help reduce climate migration. To achieve project objectives, extensive desktop literature reviews were conducted, paired with findings from remote sensing analysis and fieldwork from a WEFE Nexus socio-economic survey and measurements of plant water balance.

This pre-feasibility study concluded by establishing a baseline for the current state of the incorporation of the WEFE Nexus approach in previous afforestation/ reforestation in Tunisia, identifying potential alternative water sources to support agroforestry projects, identifying a suitable project site and tree species for implementation (remote sensing analysis was conducted to determine the long term climatic effects of different plant species on local water balance). The challenges of forest fires and lack of access to long-term financing through the carbon markets were also investigated.

The conclusions of this study are now to be applied through collaboration by project partners from TUM and INRGREF in the European Union funded TRANS-SAHARA project (Grant Agreement NŽ: 101182176) from November, 2024 to October, 2027.

Long term field measurements are being conducted with Tunisian partner INRGREF using the LI-600 Porometer/ Fluorometer from LICOR for combined measurements of stomatal conductance and chlorophyll a fluorescence to present a more complete picture of a plant's physiological state and make investigations into the plant water balance in agroforestry trees in Tunisia.

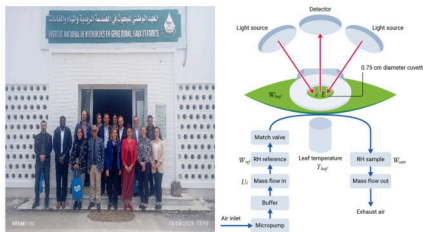


Figure 31: Left: Project closing meeting at INRGREF, Tunisia Right: Operation of the LI-600 @LICOR



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Water-Energy-Food-Ecosystems (WEFE) Nexus & Biogas Generation Potential in Urban Areas

This project will consider multiple interconnections between the WEFE Nexus elements to augment water, energy and food security and enhance ecosystem health in the following manner: first, the project will estimate the generation potential of biogas energy from human sewage/septage, animal manure and organic food and industrial waste using anaerobic co-digestion technology from different sources including households, from markets, commercial areas, companies, institutions and landfills in the urban context of the city Kampala in Uganda. Doing so constitutes a key opportunity to harvest and capture methane, a key climate gas that determines the rate of global warming and which is grossly underleveraged in the urban context. Capturing these waste streams systematically is expected to significantly curb water pollution, thus supporting the access to safe drinking water. Further, bi-products such as bio-slurry from the anaerobic co-digestion process can serve as organic fertiliser for soil nutrient nourishment in urban farms and green spaces, thereby enhancing soil health and soil carbon sink capacity. Briquettes for energy from carbonisation of bio-slurry & black soldier fly larva to be used as birds/fish and other urban farm feedstocks . As such the study will have far-reaching implications in terms of WEFE Nexus security and sovereignty in Uganda and beyond.

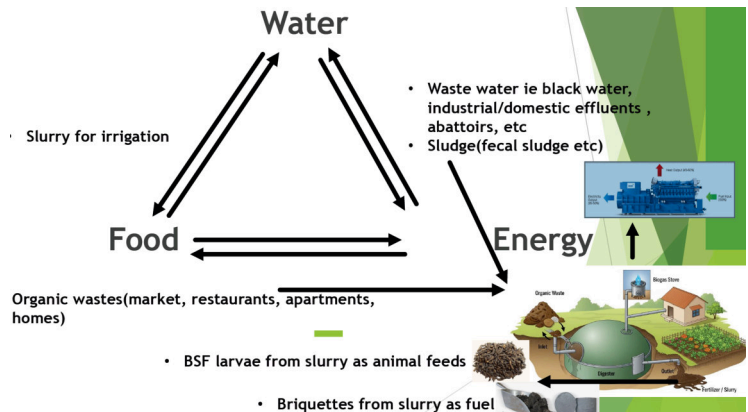


Figure 32: WEFE Nexus & Biogas Generation Potential Synergy

SEED-Himalaya: Sustainable Energies, Entrepreneurship and Development in rural Kashmir

The SEED Himalaya project, which was completed in August 2025, supports remote communities in the Indian Himalayas in their development into ecologically and economically sustainable communities through decentralized, community-based energy supply and local value creation in agriculture. In the first phase of the project, all 140 households in the Jabri community in Jammu and Kashmir were equipped with PV modules and battery storage systems for a basic power supply. Due to the limited accessibility of the original location directly on the Line of Control with Pakistan, a new project location had to be selected for the second phase of the project. The community of Simalta in Uttarakhand was chosen.



Figure 33: The project community Jabri in Jammu and Kashmir (India)

There, a community development plan was developed together with the residents based on local needs such as reliable electricity supply, clean drinking water and better water supply, as well as agricultural value creation. It was planned to implement these measures together with a democratically elected Village Development Committee, which would be responsible for managing the new infrastructure in the future. In addition, it was intended that a women's self-help group would establish a micro-entrepreneurial model for processing agricultural products for high-price markets. Due to the early onset of the monsoon, parts of the construction work were delayed. Nevertheless, the project was able to create sustainable added value, particularly in the form of the integrative bottom-up community development plan that was developed, which combines green infrastructure with socio-economic structures. It enables the community of Simalta to continue the initiated measures independently beyond the project period. At the same time, the concept serves as a blueprint for other communities in the Himalayas and can thus promote sustainable and socially just development in the region in the long term.

This project was funded by the Federal Ministry for Economic Affairs and Climate Protection (BMWK, 2022-2025) under the International Climate Initiative Programme (IKI).



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Research Group Urban Microbiology

The Emmy Noether Junior Research Group Urban Microbiology investigates microbial processes and indicators in aquatic and technical systems, from biological wastewater treatment to ecosystems in surface waters. Microorganisms are tiny but vital organisms that recycle our planet's resources, keep our biosphere in balance and thus provide important ecosystem services. We are interested in microbiomes in an urban gradient ranging from urban to pristine environments. Our overarching goal is therefore to develop concepts that can be used to specifically evaluate microbes and their functions in water systems. We conduct hypothesis-driven and descriptive research that enables us to link microbes to ecosystem services.

Our research focuses on the interaction and diversity of organisms within microbial biofilms in the urban gradient. In terms of microorganisms, our focus is on fungi and their function. Fungi produce highly efficient exoenzymes that can convert organic substances that are difficult to degrade. Of particular interest are the largely unexplored aquatic fungi and their diverse functions in the environment. We are also interested in the detailed characterisation of the taxonomic and functional diversity of microbial communities with specific abilities, e.g. microbial degradation or the transfer of antibiotic resistance genes in the water cycle. Recently, we have begun to explore the potential of biomarkers in raw sewage as a source of information. This began with the quantification of biomarkers from the SARS-CoV-2 virus and is now being extended to other informative biomarkers such as antibiotic resistance, pharmaceuticals, or indicators of stressors.

Evolving Wastewater-Based Epidemiology: From Pandemic Surveillance Towards One Health

Since the SARS-CoV-2 pandemic, wastewater-based epidemiology (WBE) has proven to be an effective tool for monitoring infectious disease dynamics. To generate reliable results, a harmonized workflow covering all steps from sampling to data visualization is essential. In our research, the following methodological components were investigated:

(I) Development of a GIS-based data model that integrates the entire WBE process. It was implemented in collaboration with public health authorities and has proven effective in pandemic response. The system enables standardized collection, processing, and visualization of WBE data. An automated quality control algorithm was added to identify and filter potential outliers based on defined criteria.

(II) Investigation of the impact of sewer system structure and sampling strategy on the collection and interpretation of biomarker concentrations. In seven municipalities, various sampling strategies were tested over 48 hours to analyze diurnal variability and suitable normalization approaches. The results show that smaller communities experience greater fluctuations due to shorter residence times in the sewer system.



Figure 34: Datenmodell WBE

In parallel to methodological harmonization, WBE is being expanded to include new markers and epidemiological applications. This includes: (III) Investigation of the wastewater microbiome in relation to antibiotic resistance genes, and (IV) Development of multiplex assays for gastrointestinal pathogens and antibiotic resistance genes within an international project in Uzbekistan. The aim is to support methodological implementation and knowledge transfer in the participating laboratories and to strengthen WBE approaches in the LMIC context.



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Biodiversity and ecology of aquatic fungi in pristine and impacted surface waters

Freshwater ecosystems are undergoing rapid biodiversity loss as a result of ongoing climate change and anthropogenic pollution. This affects many organism groups, putting at risk the ecosystem services they provide. Freshwater fungi play a key role in leaf litter decomposition in stream ecosystems by producing extracellular enzymes capable of breaking down diverse complex carbon compounds. However, despite their recognised importance, the diversity of these fungi and the specific enzymatic strategies they employ during litter decomposition remain poorly understood.

To help fill these knowledge gaps, our projects aim to: (I) develop methods for identifying unknown aquatic fungi, (II) gain insight into fungal diversity across an elevational gradient, and (III) understand fungal community succession and enzymatic activity during leaf litter decomposition.

In the first project, we developed a multiphasic workflow that combines microdissection of fungal conidia with molecular biology and bioinformatic approaches. This workflow also serves as support for the objectives of the other two projects.

The second project investigated fungal biodiversity across an elevational gradient (2700 - 600 m) using samples collected during field campaigns in August and September 2025. These campaigns were conducted in three glacier-fed streams in the European Alps: Zwieselbachferner in Austria, and Suldenferner and Lysferner in Italy.

The third project was carried out in the benthic flumes at WasserCluster Lunz, Austria (April to November 2025). In this experiment, leaf bags containing alder, beech, and larch were incubated either as controls, placed on top of gravel, or buried in sediments, and were sampled throughout leaf decomposition.



Figure 35: Schematic overview of the PhD project, from development of fungal identification methods to biodiversity assessments in vulnerable aquatic systems and analyses of enzymatic activity during leaf litter decomposition.

Aquatic fungi: from methodological challenges to case studies

Since my PhD, my research has focused on the ecological role of fungi in aquatic ecosystems. Specifically, I am interested in their ability to degrade organic compounds derived from Arctic permafrost that is thawing due to climate change. To address questions about the functional potential of these fungal communities, I rely on metagenomic data from environmental samples. Retrieving micro-eukaryotic sequences from shotgun sequencing is often a challenging task. Unlike the situation with prokaryotic sequences, assembled micro-eukaryotic sequences are typically shorter and much more fragmented. In addition, these organisms, including aquatic fungi, are underrepresented in current databases. This makes it difficult to classify sequences taxonomically and annotate their genes, which in turn hinders ecological interpretation. During my last year of postdoc, my efforts have focused on developing pipelines to get the most out of this type of data. This started with building a comprehensive database, benchmarking multiple tools for the annotation of eukaryotic sequences, and developing scripts to automate this process. We are now close to publishing the pipeline and making publicly available a customized database of micro-eukaryotes.

In parallel, I have been expanding my research projects and becoming involved in initiatives in South America. Together with the Urban Microbiology group, I collaborate with teams in Brazil and Uruguay to study the microbial ecology of subtropical coastal shallow lakes. A successful workshop was held in Brazil to launch an international research network on these lakes. These lakes are part of a unique system that extends for over 1,000 km along the coastline. They experience different anthropogenic pressures and span gradients of eutrophication and salinity. Subtropical lakes are greatly underrepresented in the literature, making this a valuable opportunity to fill key research gaps in these ecosystems.



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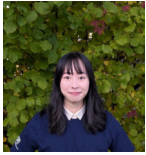
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Leveraging Anaerobic Digestion through Environmental Stress (LeAD)

The central scientific objectives of LeAD are to understand and mitigate the effects of environmental stressors on the syntrophic relationships between syntrophic bacteria and methanogenic archaea, and further develop resistant and resilient technologies for the efficient production of value-added products from waste through anaerobic digestion. The syntrophic relationships will be thoroughly investigated using advanced omics-based techniques and modelling approaches (Projects 1-3). The design will use both top-down conventional bioreactor acclimation techniques and bottom-up modelling approaches (Projects 4-9). We will reveal the response and adaptation mechanisms of established ecosystems under stressed environmental conditions, such as shock loading, or free ammonia/sulphate inhibition (Projects 1-14). Based on the clarified response and adaptation mechanisms, strategies will be developed to improve system stability for methane production or enhance the production of other value-added products (Projects 10-14).

This project is a collaboration with the National University of Ireland, Galway, Ireland; the Universiteit Gent, Belgium; the Politechnika Poznaska, Poland; the Danmarks Tekniske Universitet, Denmark; the Institut National de Recherche pour L'Agriculture, L'Alimentation et L'Environnement (INRAE), France; the Politecnico di Torino, Italy, and the Middle East Technical University, Turkey.

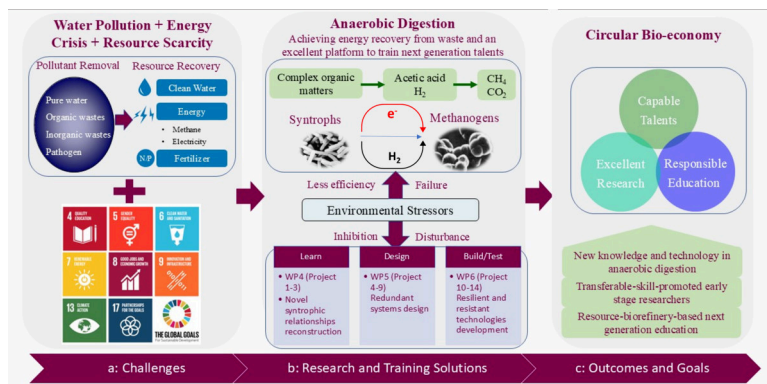


Figure 36: The concept of the LeAD Project: Training 14 doctoral candidates through 14 tailored projects based on the design-build-test-learn cycle. (<https://www.universityofgalway.ie/lead/>)

Visiting Scientists

Advanced energy and phosphorus recovery of organic sludge by the integration of a high-solid AnMBR and HAP-based PN/A process

Conventional treatment systems are strained by increasingly complex organic residues. A paradigm shift is needed to transform wastes into feedstocks for integrated biorefineries by coupling anaerobic carbon capture, autotrophic nitrogen conversion, and mineral-based phosphorus recovery under low-carbon conditions. My research aimed to establish an energy-generating, low-carbon resource recovery system suitable for the reclamation of concentrated organic sludge. The system consisted of (1) high-efficiency anaerobic digestion using a high-solid anaerobic membrane bioreactor (AnMBR) and (2) nitrogen removal and phosphorus recovery using a hydroxyapatite (HAP)-based one-stage partial nitrification and anammox (PN/A) process. The high-solid AnMBR was continuously operated to investigate bioenergy production, and digestion efficiency was enhanced by optimizing the solid retention time (SRT). The degradation efficiency of the substrate improved from 36 % to 52 %, and the biogas yield increased from 0.37 to 0.51 L/g-VS when the SRT was extended from 30 to 60 d. The HAP-based one-stage PN/A reactor operated at a nitrogen loading rate of 0.73 kg-N/m³/d, achieving a nitrogen removal efficiency of 81.6 %. Phosphorus removal efficiency was significantly enhanced by calcium addition, and a maximum value of 73.2 % was achieved when the influent Ca/P ratio was 2.7. The energy recovery rate reached 100.2 kWh/m³, and the system's energy self-sufficiency rate was 173 %. This research advances the development of an innovative "AnMBR+" technology, addresses existing challenges, and promotes the decarbonization of sludge treatment plants and promising resources production.



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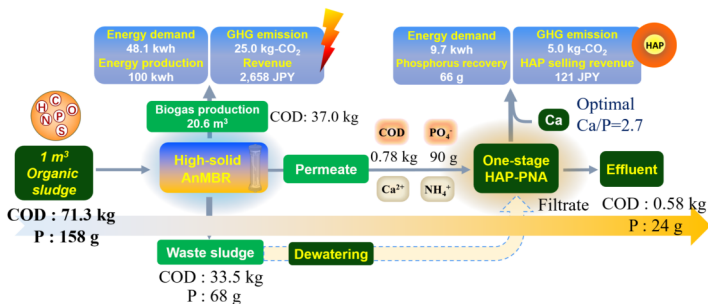


Figure 37: System-level energy and mass flow diagram of the integrated AnMBRPN/A platform



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COLLABORATION:

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Innovative technologies and practices for the sustainable management of wastewater treatment plants: carbon recovery and reduction of greenhouse gases

Driven by the European Green Deal's focus on a circular economy, this research project addresses the inefficiency of Conventional Activated Sludge (CAS) processes in wastewater treatment plants (WWTPs). CAS systems are energy-intensive and mineralize valuable organic carbon. This project aims to improve the management of organic carbon by investigating technologies that minimize its consumption on the water line and maximize its capture and upgrading on the sludge line for resource recovery. The research was structured around three primary tasks focused on High-Rate Contact Stabilization (HiCS), acidogenic fermentation of sludge from decentralized wastewater treatment (DWWT), and hydrothermal carbonization (HTC) as a pre-treatment for fermentation.

1. Optimization of the HiCS Process for Carbon Recovery

A lab-scale HiCS reactor was optimized by reducing its Sludge Retention Time down to 0.8 days. This strategy proved highly effective for carbon capture, successfully redirecting 39% of the influent organic carbon to the sludge stream for potential valorization.

2. Valorization of Sludge from Decentralized Wastewater Treatment (DWWT)

Following initial batch tests, long-term semi-continuous fermentation of DWWT sludge demonstrated stable VFA production with yields of 0.33 gVFA/gCOD. The produced VFAs were then proven to be a viable substitute for costly external carbon sources in denitrification. Plant-wide modeling confirmed that integrating this fermentation process is the most favorable operational strategy for a real WWTP, reducing external carbon dependency by over 30%.

3. Optimization of HTC Pre-treatment for Carbon Recovery as VFAs

This study first identified optimal HTC conditions (180 °C, 60 min) to maximize sludge biodegradability. Subsequent long-term fermentation successfully produced a valuable VFA mixture enriched in longer-chain acids, ideal for biopolymer synthesis. Although VFA conversion efficiency was moderate (30%), a comprehensive techno-economic analysis revealed the process is highly profitable, with a 3-6 year payback period. This feasibility is critically dependent on an integrated biorefinery model, where value is derived from the high-value VFAs, energy recovery from the biodegradable hydrochar co-product (containing 55% of the initial carbon), and massive savings from avoided sludge disposal.

The Uptake Potential of Inorganic Functional Nanomaterials for Environmental Microplastics.

Dr Martins Omorogie was a visiting scholar at our chair from December 1, 2022, to May 30, 2025, as part of an Alexander von Humboldt Fellowship, where he furthered his research in the field of environmental microplastics. The challenge posed by environmental microplastics in ecosystems has developed into a serious global problem. The transport of environmental microplastics is a significant contributor to ecosystem damage and poses a serious threat to the survival and well-being of all biomes. Therefore, his research aims to provide a solution to this global environmental problem by using Santa Barbara Amorphous Silica/Zeolite Composite (SSZC) to remove polystyrene microplastics (PMPs) from water and wastewater. This can be achieved through chemisorption, mediated by electrostatic attraction and hydrophobic interactions, including covalent bonds, non-covalent aromatic systems, and electron acceptor-donor interactions. Martin's Omorogie was very successful during his time with us, and he published ten scientific papers in peer-reviewed journals. He also secured an Alexander von Humboldt Return Fellowship in 2025 to support his return to his home university, the Redeemer's University in Nigeria.



**MARTINS
OMOROGIE**

(Ph.D)

Solar Catalytic Degradation of Environmental Microplastics in Water by Bismuth Tungstate and Vanadate

Rubaiyana Taskin was at our Chair from September 2024 to March 2025 as a DAAD-KOSPIE fellow. She has written her Master's thesis to complete her Master of Technology degree in Environmental Engineering at the Indian Institute of Technology (IIT) Bhubaneswar, India. The topic of her thesis was 'Solar Catalytic Degradation of Environmental Microplastics in Water by Bismuth Tungstate and Vanadate'. Additionally, she published an article in collaboration with Martins Omorogie, who was an Alexander von Humboldt fellow at the Chair, and Brigitte Helmreich, titled 'Trends in the applications of biochar for the abatement of microplastics in water' in Bioresource Technology Reports.



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ERASMUS+

Teaching innovation and research exchange

Dr. Sergi Vinardell (Universitat Politècnica de Catalunya (UPC)) visited SWW TUM in July 2025 as part of an Erasmus+ fellowship aimed at promoting teaching activities and fostering the exchange of experiences and best practices in teaching innovation. This fellowship provided a framework for academic mobility, enabling interactions with faculty members and participation in ongoing teaching-related activities. During his stay at SWW TUM, Dr. Vinardell delivered a seminar for the Chairs PhD researchers focused on the application of techno-economic evaluation tools, and participated in teaching activities by taking over the lecture in the Anaerobic Processes and Energy Recovery course. His participation introduced complementary techno-economic perspectives, giving insights into how economic evaluations can guide technology selection. In addition, the stay was also a relevant opportunity to lay the foundations for future research collaborations and to explore potential joint initiatives in both research and teaching.



ZHIYAO WANG

(PH.D)

TUM-UQ Workshop Grant: Pathways to Resource Recovery from Wastewater in the Net-Zero Era

This visit served as a strategic follow-up to the successful joint workshop held at UQ in 2024. The primary objective was to deepen the collaboration established under the TUM-UQ Workshop Grant Project. The visit focused on solidifying our joint research agenda regarding the circular economy, greenhouse gas (GHG) mitigation, and advanced resource recovery technologies in the wastewater sector.

I engaged in detailed knowledge exchange with David Voßschmidt and Xaver Niebauer. We discussed on: Biogas Upgrading Reviewing TUMs latest methodologies for increasing the calorific value of biogas and removing impurities. Resource Recovery: novel pathways for recovering nutrients and energy from wastewater streams. Site Visit: A highlight of the visit was a guided tour of the adjacent Wastewater Treatment Plant (WWTP) and research facilities. This provided an opportunity to observe pilot-scale implementations of the biogas and resource recovery technologies discussed during the meetings.

This visit successfully maintained the momentum of the TUM-UQ partnership.

Antimicrobial resistance genes and biodiversity of bacteria and archaea in digestate from biogas plants

I had the pleasure of visiting the Chair of Urban Water Systems Engineering from 30 June to 5 July 2025. During my stay, I had the opportunity to present the scientific interests and ongoing projects of my team from the Department of Applied Bioeconomy at Wrocław University of Environmental and Life Sciences. At the same time, I became acquainted with the Chair's activities and potential opportunities for further collaboration. Courtesy of doctoral researcher Matthias Steindl, I was pleased to visit the Bayerische Landesanstalt für Landwirtschaft (LfL), where I learned about current trends in modern agriculture and became familiar with ongoing research, including, among others, biogas production and farm animal welfare (Fig. 1).



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Figure 38: Figure 1: Research station at LfL

I also had the opportunity to visit the LfL microbiology laboratories and learn about research conducted on anaerobic fungi. From a more technological perspective, I was shown around a local agricultural biogas plant in Eitting by its owner. My short stay concluded with another interesting technical tour of the wastewater treatment plant (WWTP) in Schweinfurt. The internship was financed by the Polish National Science Centre under project number 2024/08/X/ST8/00592.



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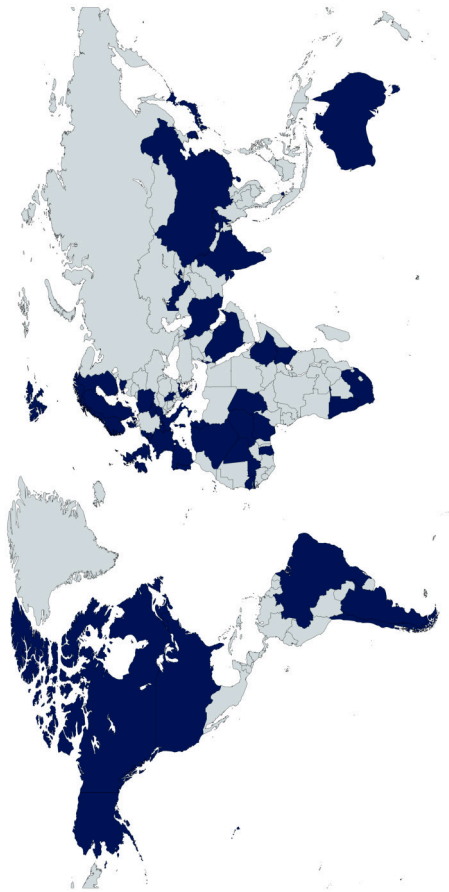
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Research internship KomMeth

From the 7th of April to the 22nd of August 2025, I conducted a research internship under the supervision of M.Sc. Xaver Niebauer as a visiting master student in energy and environmental engineering from INSA Lyon. The internship was part of the KomMeth project, which contributes to the field of Power-to-Gas technology, specifically optimizing the biological methanation of hydrogen and carbon dioxide. At the beginning I helped restarting the trickle-bed reactors by replacing some of the equipment and verifying that it worked. Afterwards I was in charge of taking samples of the process water and testing them for different concentrations. My primary focus was comparing the start-up phase of two trickle-bed reactors operating at thermophilic conditions (55 °C) and ambient pressure. The difference between both reactors was the state of the carrier material as the reactor 1 was filled with previously used carrier materials containing an established biofilm and reactor 2 was filled with new, virgin carrier materials. The goal was to determine if reusing colonized biocarriers could accelerate the start-up process, compared to establishing a new microbial community from scratch. The operation, which I could observe for over 30 days during my stay, yielded distinct performance differences between the two systems. Indeed, reactor 1 demonstrated superior efficiency, achieving stable methane production with high methane concentration within this period. On the other hand, reactor 2 (new biocarriers) struggled to establish a stable process and achieved significantly lower methane concentration and rate. It was concluded that reusing biocarriers with an existing microbial community significantly promotes a faster and more efficient start-up compared to new materials during this study period. Beyond the technical findings, this internship was a great opportunity for personal growth and building meaningful connections. I was warmly welcomed into the department's community, finding a sense of belonging through shared events and daily interactions in the lab. Therefore I feel particularly grateful for the people I met at the Chair and the experience I gained thanks to them.

International Collaborations



Created with mapchart.net

Figure 39: Map of international collaborations

Country	Institution
Algeria	Pan African University Institute of Water and Energy Sciences (PAUWES)
Argentina	Consejo Nacional de Investigaciones Científicas y Técnicas Universidad de Buenos Aires Universidad Nacional de Salta
Australia	Murdoch University University of New South Wales University of Newcastle University of Queensland University of Sydney World Vision
Austria	Technical University of Vienna University of Innsbruck University of Vienna Vienna University of Technology WasserCluster Lunz
adoss	Earthland Global
Belgium	Ghent University Katholieke Universiteit Leuven ZABALA Brussels
Brazil	Federal Center of Technological Education of Minas Gerais Pontifícia Universidade Católica de Minas Gerais Universidade Federal da Bahia Universidade Federal de Minas Gerais Universidade Federal de Viçosa
Canada	University of Alberta
Chad	National Agency of the Great Green Wall (GGW Country Office)
Chile	Universidad Andrés Bello
China	Beijing University of Technology Southwest Petroleum University Tsinghua University Wuhan Botanical Garden
Czech Republic	University of Chemistry and Technology
Denmark	Aalborg University Aarhus University Geological Survey of Denmark and Greenland
Djibouti	Ministry of Environment and Sustainable Development (GGW Country Office)

Country	Institution
Estonia	University of Tartu
Ethiopia	Bahir Dar Institute of Technology
Finland	Aalto University Kemira Oyj Oulu University University of Jyväskylä University of Turku
France	University of Bordeaux University of Poitiers
Ghana	Kwame Nkrumah University of Science and Technology West African Science Services Centre on Climate Change (WASCAL)
Greece	National Technical University of Athens
Hong Kong	City University of Hong Kong The University of Hong Kong
India	Aseem Foundation Birla Institute of Technology and Science Pilani Indian Institute of Science Bangalore Indian Institute of Technology Bombay Indian Institute of Technology Madras
Iran	Isfahan University of Technology
Ireland	University of Galway
Israel	Technion Tel Aviv University
Italy	Accademia Europea di Bolzano (EURAC) Politecnico di Milano University of Napoli Federico II University of Padua
Japan	National University Corporation Tottori University The University of Tokyo Tokyo University of Agriculture United Nations University Institute for Environment and Human Security (UNU-EHS) University of Wakayama
Kenya	Jomo Kenyatta University of Agriculture and Technology World Agroforestry Centre (ICRAF)
Mali	Rural Polytechnic Institute for Training and Applied Research (IPR-IFRA)
Namibia	Namibia University of Science and Technology
Netherlands	Delft University of Technology Environment Europe Foundation Erasmus University Rotterdam

Country	Institution
Niger	Abdou Monmouni University Niamey
Nigeria	Bayero University Bowen University Ekiti State University Federal University Dutse Obafemi Awolowo University Redeemer's University University of Ibadan University of Ilorin
Norway	Norwegian University of Science and Technology University of Oslo
Poland	Pozna University of Technology University of Warsaw
Portugal	University of Minho
Saudi Arabia	King Abdullah University of Science and Technology King Saud University Princess Nourah bint Abdulrahman University
Senegal	Cheikh Anta Diop University of Dakar (UCAD) Senegalese Agency for Reforestation and GGW (GGW Country Office)
Serbia	University of Belgrade
Singapore	National University of Singapore
South Africa	University of Cape Town Vaal University of Technology Western Cape Government: Department of Environmental Affairs and Development Planning (WCG DEA and DP)
South Korea	National Institute of Environmental Research Ulsan National Institute of Science and Technology
Spain	Catalan Institute for Water Research Catalan Institution for Research and Advanced Studies (ICREA) Centre for Advanced Studies of Blanes (CEAB) Consejo Superior de Investigaciones Científicas (CSIC) Institut de Ciències del Mar (ICM-CSIC) Polytechnic University of Catalonia University of Barcelona University of Girona University of Granada
Sweden	Lund University Swedish University of Agricultural Sciences University of Gothenburg

Country	Institution
Switzerland	Agroscope Ecole Polytechnique Fédérale de Lausanne Swiss Federal Institute of Aquatic Science and Technology (EAWAG) Swiss Federal Institute of Technology University of Applied Sciences Northwestern Switzerland
Tunisia	National Research Institute for Agricultural Engineering, Water, and Forestry (INRGREF) University of El Manar (UEM)
United Arab Emirates	Khalifa University of Science and Technology
United Kingdom	Cranfield University University of Oxford
United States	Massachusetts Institute of Technology National Science Foundation Northwestern University Stanford University University of Arizona University of California at Santa Cruz University of Colorado-Boulder University of Connecticut University of Massachusetts University of California San Diego
Uzbekistan	Committee for sanitary and epidemiological well-being and public health of the republic of Uzbekistan (SANEPID)

National and International Comitees

International Water Association (IWA)

In addition to **Jörg E. Drewes'** work on the IWA Strategic Board, he supports the planning and implementation of the IWA's flagship conference in the program committee of the IWA Leading Edge Technology (LET) Conference.

German Advisory Council on Global Change (WBGU)

Jörg E. Drewes was appointed to the Advisory Council by the Federal Government in 2024 for a further period (2024-2028). Since 2024, he has served as one of the two co-chairs of the WBGU. The WBGU published its main report "Water in a heated world" in 2024.

Drinking Water Comission (TWK)

Jörg E. Drewes is also involved in the Drinking Water Commission, which advises the UBA and the Federal Ministry of Health on all issues relating to the Drinking Water Ordinance. He is the deputy spokesman there.

DWA Working Groups

Brigitte Helmreich is actively involved in various DWA working groups. She is deputy chairwoman of the **DWA expert committee ES-3** „System-related planning“, spokesperson for the **DWA-ES-3.1** „Infiltration of rainwater“, member of the working groups **DWA-ES-3.11** „Multifunctional surfaces“, **DWA-ES-3.7** „Decentralized systems for stormwater treatment“ and **DWA-ES-1.2** „Substance inputs into drainage systems“. She is also an active member of the DWA technical committee **IG-2** „Sector-specific industrial wastewater and waste“.

Jörg E. Drewes is involved in the **DWA Technical Committee KA-8** „Advanced Wastewater wastewater treatment“, in the **DWA working groups Biz 11.4** „Water reuse“ and **KA-8.1** „Anthropogenic substances in the water cycle“ and **KA-8.4** „water reuse“. He played a leading role in the creation of the new DWA-M 1200 information sheet on water reuse.

Benedikt Aumeier is an active member of the **DWA working group KA-8.4**, which has recently published the DWA-M 1200 „Water reuse for agricultural and urban irrigation in Germany“ (yellow print) in three parts.

German Water Chemistry Society

Christian Wurzbacher is actively involved in the expert committee „Pathogens and Antibiotic-Resistant Bacteria in the Water Cycle“ and „Biological Processes“.

Felicia Linke is actively involved in the expert committee „Biological Processes“.

Benedikt Aumeier is actively involved in two technical committees of the German Water Chemistry Society: “Persistent, mobile and toxic (PMT) substances” and “Physical processes - membrane processes”.

Journals - Editors

Jörg E. Drewes is an Associate Editor for the international journal ACS Environmental Science Technology Water since 2020. **Christian Wurzbacher** has been a specialist editor of the journals MycoKeys and Biodiversity Data Journal (Pensoft Publisher) since 2016 and editor of the journal Fungal Biology (Elsevier) since 2022. **Konrad Koch** is editor and editorial board member of the journals „Bioresource Technology“ (Elsevier) und „Environmental Technology & Innovation“ (Elsevier).

52nd Wastewater Technology Seminar

The 52nd Wastewater Technology Seminar (ATS) took place on 16 July 2025 in Garching, focusing on digitalisation in water management.



Figure 1: Introduction to ATS 2025



Figure 2: Podium discussion at the ATS 2025

Event announcements 2026

34th Water Technology Seminar (WTS) 2026

On June 20, 2023, the new Drinking Water Ordinance (TrinkwV) came into force in Germany, implementing key elements of the new EU Drinking Water Directive. What needs to be considered now when implementing measures to comply with the TrinkwV limits? What should be done in the event of exceedances? How are concentrations of a few nanograms per liter measured? What is the status of our water resources, groundwater, and surface water? What should be done in the event of exceedances? How are concentrations of a few nanograms per liter measured? What is the status of our water resources, groundwater, and surface water? Which other PFAS substances that are not (yet) regulated are also relevant?

In our virtual seminar in February 2026, we therefore want to discuss the implementation and compliance with these requirements in practice with proven experts. The seminar is primarily aimed at municipalities, drinking water suppliers, health authorities, water management authorities, state institutions, planning offices, as well as consultants and experts.

53rd Wastewater Technology Seminar (ATS) 2026

The 53rd ATS is scheduled for 16 July 2026 in Garching, exploring the treatment of stormwater in separate and combined systems.

Chair of Urban Water Systems Engineering at IFAT 2026

IFAT 2026 will take place again in Munich in May 2026. As in previous years, the Chair of Urban Water Systems Engineering will be represented with a booth at the Bavaria joint booth. We are also very pleased that the ReUse Brew campaign will be back again. In addition, the Chair will participate in various events at IFAT. Current information on this will be available on our website in due course.

Company Outing 2025

This year's company outing was a challenging mountain hike. Starting in Bad Kohlgrub, we hiked 750 meters in altitude and 12 kilometers to the Hinteres Hörnle. The particularly motivated even climbed additional Hörnle peaks. Afterwards, everyone gathered for a snack at the Hörnlehütte. Finally, we descended into the valley and took the train back to Munich. Special thanks go to Dominik Meier, Marie Otte, and Rodoshi Ahmed for the great organization!



Figure 3: Company outing 2025 Hiking trip Hörnle



Figure 4: Company outing 2025 Hiking trip Hörnle

Scienclisten

In 2025, the employees of the Chair of Urban Water Management cycled a total of over 15181 km on their way to work. This corresponds to a CO₂ saving of around 2.2 tons compared to a car and 5.8 tons compared to an airplane (economy). Konrad Koch achieved the highest individual mileage this year, for which he was awarded the Chair's Scienclisten Cup.



Publications

Peer-reviewed Journal Articles

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- 2) Gondhalekar, Daphne; Baccalaro, Dario A.; Drewes, Jörg E.; de Vries, Walter T. (2025). TUM Nexus Lab (Nexus@TUM): TUM as a frontrunner university with a targeted research and teaching agenda on the Water-Energy-Food (WEF) Nexus. In: Filho, Walter L.; Newman, Julie; Salvia, Amanda L.; Trevisan, Laís V., Corazza, Lara: *World Sustainability Series: North American and European Perspectives on Sustainability in Higher Education*. 1st. ed. Springer, Cham., 397417.
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Conferences (Oral Presentations)

- 1) Aumeier, Benedikt M.; Ahmadi, J.; Drewes, Jörg E. (2025): Wasserwiederverwendung für die landwirtschaftliche Bewässerung in Deutschland - Chancen und Herausforderungen, KTBL-Tage Celle 2025, 26. - 27. March 2025, Celle
- 2) Aniol, J.; Greskowiak, J.; Hübner, U.; Sperlich, A.; Filter, J.; Bartels, Y.; Gerdes, H.; Ergh, M.; Linke, F.; Drewes, J.E. (2025): Sequential managed aquifer recharge with rapid infiltration trench for trace organic chemical removal in a heterogenous aquifer for potable reuse, 14th IWA International Conference on Water Reclamation and Reuse Conference, 16. - 19. March 2025, Cape Town, South Africa
- 3) Asamoah, K. Y.; Marful, A.; Amoah, M.; Ameyaw, J.; Gondhalekar, D. (2025) Leveraging a Water-Energy-Food-Ecosystems (WEFE) Nexus approach to facilitate climate-smart agroforestry systems to enhance water security and climate resilience in Africa. The International Climate Resilience Conference 2025 (iCARE25), 27. - 29. October 2025, Ludwig-Maximilians-Universität Munich (LMU)
- 4) Asamoah, K. Y.; Spektorenko, I.; Mengistie, K.; Berlanda, M.; Chuprikova, E.; Gardner, E.; Froehlich, N.; Gondhalekar, D.(2025): A novel Water-Energy-Food-Ecosystems (WEFE) Nexus modelling tool to bridge data gaps and aid decision-making in water scarce African regions. Advancing Earth and Space Science Conference, 15.-19. December 2025, New Orleans, Louisiana
- 5) Aumeier, Benedikt M.; Mieke, Ulf; Seis, Wolfgang; Ho, Johannes; Ahmadi, Javad; Drewes, Jörg E.; Wintgens, Thomas (2025): Validierungsmonitoring für Aufbereitungsanlagen zur Wasserwiederverwendung in Deutschland, 16th Aachener Tagung Wassertechnologie, 11. - 12. November 2025, Aachen
- 6) Aumeier, Benedikt M.; Thiel, Maria; Ahmadi, Javad; Drewes, Jörg E. (2025): Nutzwasser Implementierung der Wasserwiederverwendung für die landwirtschaftliche und urbane Bewässerung sowie Synergien mit der Spurenstoffentfernung nach EU-KARL, HUBER Abwassersymposium, 13. - 14. May 2025, Berching
- 7) Finkbeine, Pascal (2025): Sustainable implementation of a nature-based water treatment

- technology for reuse of highly contaminated surface water using a Water-Energy-Food-Ecosystems, 14th IWA International Conference on Water Reclamation and Reuse Conference, 16. - 19. March 2025, Cape Town, South Africa
- 8) Flad, V.; Weigoldt, M.; Müller, F.; **Koch, K.**; Polag, D.; Lebhuhn, M. (2025): CO2 addition as a solution to reduce residual methane potential? Exploring microbial community dynamics in biogas processes with and without CO2 supplementation. 5th International Conference on Biogas Microbiology, 26. - 29. May 2025, Galway, Ireland.
 - 9) Helmreich, B.: Niederschlagswasserbehandlung vor der Versickerung. 26. bdla-Bauleiter:innen-Gespräche, Bochum, 17./18.01.2025
 - 10) Helmreich, B.: Urbane blau-grüne Klimaanpassung, LMU Zentrum für Seniorenstudium, München, 07.01.2025
 - 11) Helmreich, B.: Multifunktionale Versickerungsmulden im Siedlungsraum Lessons learned. ZSK-Workshop Städte im Klimawandel: Lessons learned aus den ZSK-Projekten, München 31.01.2025
 - 12) Helmreich: DWA-A 138 -1 - Anlagen zur Versickerung von Niederschlagswasser - Teil 1: Planung, Bau, Betrieb, DWA-Grundstücksentwässerungstage, Fulda, 12./13.02.2025
 - 13) Helmreich: Vorstellung des Regelwerks DWA-A 138-1 Planung, Bau und Betrieb von Versickerungsanlagen. Seminar Anforderungen und technische Hinweise für die Regenwasserbehandlung in Baden-Württemberg, Pforzheim, 14.05.2025
 - 14) Helmreich, B.: Das neue Arbeitsblatt DWA-A 138-1 Erste Erfahrungen. DWA-RegenwasserTage, Hamburg, 24./25.06.2025
 - 15) Helmreich, B.: Blau-grüne Infrastruktur zur Klimaanpassung in der Stadt, LMU Zentrum für Seniorenstudium, München, 08.07.2025
 - 16) Helmreich: Blau-grüne Tools zum gezielten Regenwassermanagement in der wasserbewussten Stadtplanung. Seminar Regenwassermanagement und Bauwerksbegrünung, Bayerische Architektenkammer, München, 25.07.2025
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 - 19) Helmreich, B.: Schadstoffe im Niederschlagswasser urbaner Flächen. Challenge für die Behandlung. Innovationsforum 2025 - Intelligente Wasserkreisläufe für resiliente Städte von der Planung zur Praxis, KUBUS am Helmholtz-Zentrum für Umweltforschung Leipzig, 05.11.2025
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 - 22) Kau, Anna-Sonia; Aumeier, Benedikt M.; Drewes, Jörg E.; Hübner, Uwe (2025): Wie können Spurenstoffe auf kleinen Kläranlagen entfernt werden, um nachteilige Auswirkungen auf sensitive Gewässer zu vermeiden? 16th Aachener Tagung Wassertechnologie, 11. - 12. November 2025, Aachen
 - 23) Kau, Anna-Sonia; Hübner, Uwe; Drewes, Jörg E.; Aumeier, Benedikt M. (2025): Protecting Sensitive Waterbodies: Innovative TOxCs Removal at Small WWTPs (< 10,000 PE), GDCh Wasser 2025, Jahrestagung der Wasserchemischen Gesellschaft, 26. - 28. May 2025, Münster
 - 24) Khan, M. S.; Aumeier, Benedikt M.; Drewes, Jörg E.; Hübner, Uwe; Yashar, Omer; Yecheskel, Yinon; Zucker, Ines (2025): Nano-enabled Water Reuse (NEWR): Investigation into trace organic chemicals (TOxCs) removal through immobilized manganese (IV) oxide in a

- flow-through catalytic filtration system, IWA Advanced Oxidation Processes, 8. - 10. April 2025, Frankfurt
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 - 27) Koch, K. (2025): Determining the Residual Methane Potential (RMP) - Lessons learned in Germany so far. Workshop "Understanding the potential of Residual Biogas Potential (RBP) testing as a surrogate for digestate emissions quantification Department for Energy Security and Net Zero der Britischen Regierung, 10. - 12. March 2025, Cranfield, United Kingdom.
 - 28) Koch, K. (2025): Die energiepositive Kläranlage Synergie, Chancen, Herausforderungen. 36. Karlsruher Flockungstage Kreislaufwirtschaft und Klimaneutralität in der Abwasserbehandlung des KIT, 18. - 19. November 2025, Karlsruhe.
 - 29) Koch, K. (2025): Die energiepositive Kläranlage Synergie, Chancen, Herausforderungen. Tagungsband zum 52. Abwassertechnischen Seminar Die Digitalisierung der Wasserwirtschaft der TU München (ISSN 0942-914X), 16. July 2025, Garching.
 - 30) Koch, K. (2025): Little by little: Turning wastewater treatment plants into resource recovery facilities. Forum on Environment, Sustainability and Transformation, 21. February 2025, University of Galway, Ireland.
 - 31) Koch, K. (2025): Publish or perish: Meet the editor. 7th IWA International Conference on Ecotechnologies for Wastewater Treatment, 23. - 26. June 2025, Stockholm, Sweden.
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 - 33) Koch, K., Müller, F. Lebuhn, M.; Weigoldt, M.; Flad, V.; Polag, D. (2025). Energetische Nutzung von CO₂ zur Verringerung des Restmethanpotentials. 9. FNR/KTBL-Kongress Biogas in der Landwirtschaft Stand und Perspektiven, 08. - 09. September 2025, Stuttgart-Hohenheim.
 - 34) Koch, K.; Hafner, S.; Weinrich, S.; Astals, S. (2025): The dos and donts of BMP tests: A checklist. 19th IWA Conference on Sludge Management, 21. - 24. October 2025, Kyoto, Japan.
 - 35) Koch, K.; Hafner, S.; Weinrich, S.; Astals, S. (2025): The doand donof BMP tests: A checklist. 7th IWA International Conference on Ecotechnologies for Wastewater Treatment, 23. - 26. June 2025, Stockholm, Sweden.
 - 36) Linke, F.; Knabl, M.A.; Drewes, J.E.: Hybrid Managed Aquifer Recharge Effects of pretreatment on biodegradation of trace organic contaminants. EGU General Assembly, 27 April-2 May 2025, Vienna, Austria.
 - 37) Linke, F.; Knabl, M.A.; Drewes, J.E.: Hybrid Managed Aquifer Recharge- An experimental study on pretreatment effects on biodegradation of trace organic contaminants. 7th IWA International Conference on Ecotechnologies for Wastewater Treatment, 23. - 26. June 2025, Stockholm, Sweden.
 - 38) Linke, F.; Aniol, J.; Finkbeiner, P.; Drewes, J.E.: Engineering Sequential Managed Aquifer Recharge Technology (SMART) for water reuse and biodegradation of trace organic contaminants. GDCh Wasser 2025, Jahrestagung der Wasserchemischen Gesellschaft, 26. - 28. May 2025, Münster
 - 39) Niebauer, X.; Feickert Fenske, C.; Straub, J.; Sperle, P.; **Koch, K.** (2025): Membrane-based rejection of metabolic water in trickle bed reactors for biological methanation. 19th IWA Conference on Sludge Management, 21. - 24. October 2025, Kyoto, Japan.
 - 40) NieSS, D., Helmreich, B. Dezentrale Behandlungsanlage zum Rückhalt von gewässerrelevanten Substanzen aus Niederschlagswasser von Gründächern und Fassaden, Aqua Urbanica 2025, Rapperswil, Switzerland, 21.-23.09.2025

- 41) Paez-Curtidor, N., Meier, D., Helmreich, B. Auswirkungen von Nass-Trocken-Zyklen auf die Hydraulik und den Rückhalt gelöster Schadstoffe aus Niederschlagswasser in mit Pflanzenkohle angereicherten Böden, Aqua Urbanica 2025, Rapperswil, Switzerland, 21.-23.09.2025
- 42) Thiel, M. & Drewes, J. E. (2025): Implementing water reuse for urban and agricultural irrigation in Germany. 6th Global Water Operators Partnerships Congress, 27. - 29. October 2025, Bonn.
- 43) Thiel, M.; Ahmadi, J.;Schweikart, C.; Tiehm, A.; Scheyer, N.; Aumeier, B. M.; Drewes, J. E. (2025): Fate and regrowth of microorganisms and antimicrobial resistances in dynamically operated distribution systems for non-potable reuse, 14th IWA International Conference on Water Reclamation and Reuse Conference, 16. - 19. March 2025, Cape Town, South Africa
- 44) Thiel, M.; Aumeier, B. M.; Ahmadi, M.; Drewes, J. E. (2025): Nutzwasser als alternative Wasserressource für landwirtschaftliche und urbane Anwendungen. 6th Wilo Wassertage Adlersberg, 28 October 2025, Adlersberg.
- 45) Udvary, J., Schwerd, R., Helmreich, B. Der Beitrag von Nicht-Metalldächern zur Verunreinigung von Niederschlagswasser Untersuchungen zur Auslaugung verschiedener Dachmaterialien. Aqua Urbanica 2025, Rapperswil, Switzerland, 21.-23.09.2025.
- 46) Venus, T.; Steindl, M.; **Koch, K.**, Effenberger, M. (2025). Technisches Biogaspotenzial Ein neuer Bewertungsansatz. 9. FNR/KTBL-Kongress Biogas in der Landwirtschaft Stand und Perspektiven, 08. - 09. September 2025, Stuttgart-Hohenheim.
- 47) Wenzel, C.; Niebauer, X.; Munk, B.; **Koch, K.** (2025): Ex-situ biomethanation in the trickle bed reactor: A robust system as a component for an energy-self-sufficient wastewater treatment plant. 7th IWA International Conference on Ecotechnologies for Wastewater Treatment, 23. - 26. June 2025, Stockholm, Sweden.

Theses

Doctoral Dissertations

- 1) Ahmadi, Mohammad Javad (2025): Provision of reclaimed water as an alternative water resource for non-potable applications: multibarrier approach for pathogen control and chemical risk management
- 2) Bardi, Mohammad Javad (2025): Advancing Anaerobic Digestion - From Pre-treatment to Applying Additives: Investigating the Synergistic Effects of Hydrostatic Pressure in Ultrasonic Pretreatment, Biochar, Micronutrients, and CO₂ Enrichment
- 3) Knoll, Sebastian (2025): Circular Substrates: Reusing Demolition Waste for Sustainable Tree Planting in Urban Green Infrastructure
- 4) Rosenberger, Lea (2025): Quantitative Modeling in Water-Sensitive Urban Design under Climate Change Uncertainties: Tree Water Availability, Irrigation, and Long-Term Water Balance
- 5) Zhu, Panfeng (2025): Evaluating the interaction of heavy metals and biocides with dissolved organic matter in building runoff and their adsorption onto granular activated carbon

Masters Thesis

- 1) Gural, F. (2025). 0-Degree Roofs - Influence of Contact Time on the Leaching of Mecoprop from Bitumen Roofing Membranes with Different Constructions.
- 2) Förner, S. (2025). Modeling the Particle Deposition in Spiral-wound Membrane Modules Using COMSOL Multiphysics 6.2: The Influence of Spacer and Surface Pattern Geometries.
- 3) Kolb, A. (2025). Membrane Biofouling Assessment in Spacer-Filled Feed Channels Using an MFS: Systematic Parameter Analysis and Direct Observation of Patterned and Non-Patterned RO Membranes.

- 4) Baccalaro, D.A. (2025). Investigating Biogas Potential and Resource Recovery Opportunities in Franschhoek, South Africa.
- 5) Kolb, M. (2025). Biological effects of CO injection on the anaerobic digestion process using alfalfa and sugar beet molasse pellets as a substrate.
- 6) Otte, L.M. (2025). A Water-Energy-Food-Ecosystems Nexus-based climate-resilience framework for managing groundwater resources in data-scarce regions: The case of Dar, Niger.
- 7) Bashiri, Z. (2025). A System-of-Systems Approach Using Unified Architecture Framework for Urban Water Reuse in Irrigation.
- 8) Sulaimankhil, S. (2025). Insight into a Black Box Exploring Time Series of Sequential Managed Aquifer Recharge Technology (SMART) Experiments.
- 9) Manna, R.J. (2025). Performance Analysis of Large Scale Upflow Anaerobic Sludge Blanket BIODIGAT AS combined with Belt Thickener from Startup Phase to Fully Operational Phase.
- 10) MacDonald, S.P. (2025). How Off-Grid Electricity and Water Infrastructure for Commercial Consumers in a Remote Community in the Indian Himalayas Can be Planned and Sized to Improve its Economical Sustainability.
- 11) Elghamaz, A. (2025). 0-Degree- Roofs - Influence of Contact Time and Water Matrix on the Leaching of Mecoprop from Bitumen Roofing Membranes?.
- 12) Martin Zarate, D.S. (2025). Multi-Step Dynamic Modeling of Anaerobic Digestion Processes Using Recurrent Neural Networks and Random Forests.
- 13) Barbieri, G. (2025). Optimization of Polymeric Ultrafiltration and Ceramic Microfiltration Membrane Systems: Findings from Pilot Operations for Vitens Water Utility.
- 14) Taizeem Fayaz, (2025). Pretreatment of Brackish Water by Nanofiltration and Seeded Crystallization: Case Study in the Jordan Valley.
- 15) Zhu, Y. (2025). Investigation of different carrier materials for biological methanation in trickle bed reactors.

Study Projects

- 1) Djurdjevic, A. (2024). Impact of CO₂ Enrichment on Biogenic Methane Formation in Anaerobic Digestion by Analyzing Natural Isotopic Signature of Carbon Compounds.
- 2) Martin Zarate, D.S. (2024). Robust MPC of agricultural AD plant with uncertain substrate characterization - Prevention of constraint violation in a plant-model mismatch scenario.
- 3) Moritz, J. (2024). Retention Efficiency of Recycled Aggregates in the Vegetated Soil Zone of Infiltration Swales- Binding Behavior of Zinc and Copper Determined by Sequential Extraction.
- 4) Kolb, A. (2025). Implementation of an Automated Image-based Analysis Method for Fouling Detection in Flat Sheet Membrane Cells.
- 5) Hsu, W.-C. (2025). Optimizing Methane Production: A Study of Biocarriers Performance in Thermophilic Trickled Bed Reactors.
- 6) Giglberger, F. (2025). Design, implementation, and monitoring of decentralized wastewater treatment plants in Zambia.
- 7) Dev, A. (2025). Elimination of Trace Organic Chemicals with Biofiltrationplus: Determination of Water Quality, Oxygen Recovery, and Pressure Heads.
- 8) Nömer, A. (2025). Stakeholder Engagement in Water Reuse: International Insights and Recommendations for the TUM Nutzwasser Project.
- 9) Schletter, G. (2025). Biofiltrationplus: Biofiltrationplus: Water Quality Monitoring and Particle Characterization of the Integrated Granular Activated Carbon.
- 10) Zhu, Y. (2025). Experimental Approaches to Measure ReactionRate in Laboratory-scale Trickle Bed Reactors for Bio-methanation.
- 11) Jolly, M. (2025). Analysis on Leaching Behaviour of Bitumen Sheets in Green Roof Systems in Accordance with DIN EN 16637-2.

- 12) Fiedler, R. (2025). Recycling of residual waste fractions by pyrolysis and plasma gasification: Investigation of waste and the resulting synthesis gas.
- 13) Kolb, M. (2025). Methane production efficiency enhancement through CO₂ injection with sugar beet molasse pellets.
- 14) Singal, D.K. (2025). Mitigating Climate Change Impacts through Reforestation: Investigating the Comprehensive Feasibility of Reclaimed Water in Tunisia as an Alternative Water Source.
- 15) Dhoble, S. (2025). Monitoring small temporal changes in DOM using EEM-PARAFAC.
- 16) Jiang, L. (2025). Batch Evaluation of Multi-Media Filtration Systems for the Removal of Pollutants from Synthetic Stormwater.
- 17) Amin, M. (2025). Implementing Solute Transport in a Numerical Model of Flow in Nanofiltration and Reverse Osmosis Membrane Modules.
- 18) Elsheikh, M. (2025). Optimization of Methane Productivity Through CO₂ Enrichment Using Alfalfa as a Substrate: An Approach to Reduce Residual Methane Potential.
- 19) Tao, L. (2025). Modeling the water balance in biofilters using Hydrus-1D.
- 20) Rahimi, M.A. (2025). A Standardized Approach to Evaluating and Enhancing Energy Efficiency in a Large Municipal Wastewater Treatment Plant Using ENERWATER.
- 21) Barth, E. (2025). VExperiments to increase the efficiency of denitrification performance in the second biological stage of the Munich wastewater treatment plant Gut GroSSLappen of the Münchner Stadtentwässerung.
- 22) Seenath Raheem, S. (2025). Preliminary Assessment of a MnO₂-Based Sulfate Radical Oxidation System for Trace Organic Chemicals (TOCs) Removal in a Flow-Through Setup.
- 23) Sabea, R. (2025). Entwicklung eines experimentellen Protokolls zur Untersuchung und Bestätigung der katalytischen Aktivität von MnO₂@Sand mit Peroximonosulfat mittels Sulfatradikal-Oxidation in Batch-Systemen.
- 24) Alptüzün, Ö. (2025). Development of an Experimental Protocol to Test and Confirm the Catalytic Activity of MnO₂@sand with Peroxymonosulfate Through Sulfate Radical Oxidation in Batch Systems.
- 25) Andreeva, C. (2025). Evaluation of Hydraulic Properties and Pollutant Retention in Topsoil with the Addition of Biochar using Column Experiments.
- 26) Fetter, M. (2025). Design and Establishment of a Flow Through Column Experiment to Determine the Oxygen Consumption Potential of Aquifer Soil Samples.
- 27) Castano Candamil, J.A. (2025). Testing fungal growth substrates in a water treatment context: Laccase, peroxidase and -Glucosidase.
- 28) Wiese, H. (2025). Reallocation of microbial signatures from urban to pristine environments via trails.
- 29) Dutta, B. (2025). Feasibility Study for the Development of Fungal Photogranules as a Novel Bio-Granular System for Wastewater Treatment.

Bachelors Theses

- 1) Saglam, F. (2024). The Blue-Green City - Measures, Challenges and Role Models.
- 2) Huber, S. (2025). Analysis of pollutant release from a green roof substrate in the column percolation test according to DIN 19528.
- 3) Graml, J. (2025). Circular economy at the Gendorf Chemical Park: Evaluation of possible methods for phosphorus recycling.
- 4) Brisevac, B. (2025). Pollutants in Roof Runoff from Inclined Non-metal Roofs: A Comparison of Origin, Toxicity and International Limits.
- 5) Guzman Vargas, A. (2025). Investigation of water treatment as part of the nsoil washing for PFAS removal: Optimization potential for the REMEX soil washing system .
- 6) Zhang, Z. (2025). Literature Research on Heavy Metals, Biocides and Bisphenol A in Roof

Runoff from Inclined Non-metallic Roofs.

- 7) Pangerl, R. (2025). The removal of possible pollutants from water during Managed Aquifer Recharge. Conclusions from the literature on application projects and experiments.
- 8) De La Monja Lopez, A. (2025). Enhancing Coral Resilience Through Probiotics: An Approach to Combating Environmental Stressors.
- 9) Jiang, R. (2025). Reduction of the Artificial Supply of Nutrients and Trace Elements During Biological Methanation in the Trickle Bed Reactor.
- 10) Leitz Echeverria, N. (2025). Potential Analysis of Ammonia Streams from Wastewater Treatment for Electricity Generation and NO Emission Reduction.

Dissertations and Awards



Figure 5: Doctoral committee of Dr.-Ing. Matthias Steindl

Congratulations to Dr.-Ing. Matthias Steindl on the successful defense of his doctoral dissertation on October 1, 2025. His dissertation, entitled "Agricultural Residues and By-Products for Biogas Production," was reviewed by Prof. Dr. Konrad Koch and Prof. Dr. Andrzej Biaowiec of the Wroclaw University of Environmental and Life Sciences, Poland. The committee was chaired by Prof. Dr. Brigitte Helmreich.



Figure 6: Doctoral committee of Dr.-Ing. Mohammad Javad Bardil

Congratulations to Dr.-Ing. Mohammad Javad Bardil on the successful defence of his doctoral dissertation on 10 October 2025. His dissertation, entitled "Advancing Anaerobic Digestion - From Pre-treatment to Applying Additives: Investigating the Synergistic Effects of Hydrostatic Pressure in Ultrasonic Pretreatment, Biochar, Micronutrients, and CO Enrichment," was reviewed by Professor Konrad Koch, Yadira Bajón Fernández of Cranfield University, United Kingdom, and Professor Nigus Gabbiye Habtu of Bahir Dar University, Ethiopia. The committee was chaired by Professor Brigitte Helmreich.



Figure 7: Doctoral committee of Dr.-Ing. Michael Ahmadi

Michael Ahmadi also successfully completed his doctorate. Congratulations! He received his doctorate for his dissertation on the topic "Provision of reclaimed water as an alternative water resource for non-potable applications: multibarrier approach for pathogen control and chemical risk management." His examination committee on October 17, 2025, consisted of Prof. Dr. Konrad Koch (Chair) and the examiners: Prof. Dr. Jörg E. Drewes (TUM), Prof. Dr. Brigitte Helmreich (TUM), and Prof. Dr. Stuart Khan (University of Sydney, Australia).



Figure 8: Doctoral committee of Dr. Sebastian Knoll

Dr. Sebastian Knoll also received his doctorate for his dissertation on the topic "Circular Substrates: Reusing Demolition Waste for Sustainable Tree Planting in Urban Green Infrastructure." His defense took place on November 14, 2025. His examiners were Prof. Dr. Brigitte Helmreich, Prof. Dr. Stephan Pauleit (TUM), and Prof. Dr. Wolfgang Dickhaut from HafenCity University in Hamburg. The committee chair was Prof. Dr. Konrad Koch. Congratulations!



Figure 9: Doctoral committee of Dr.-Ing. Lea Rosenberger!

The last doctoral dissertation of the year was completed by Ms. Lea Rosenberger on December 15th. Her topic was "Quantitative Modeling in Water-Sensitive Urban Design under Climate Change Uncertainties: Tree Water Availability, Irrigation, and Long-Term Water Balance." Ms. Rosenberger's doctoral committee consisted of the chair, Prof. Roland Wüchner, as well as Prof. Brigitte Helmreich, Prof. Jorge Leandro (University of Siegen), and Prof. Dr. Ferdinand Ludwig (TUM) as reviewers. Congratulations to them as well!



Figure 10: Awardees of the Mall Environmental Awards Water 2025, from left to right: Dr. Emil Bein, Sandra Huber, Daniel Kick.

We are delighted that our Chair has won three Mall Environmental Prizes for Water 2025 this year. Dr.-Ing. Emil Bein received the Mall Environmental Prize for the best doctoral dissertation for his thesis entitled "Novel oxidative treatment processes for unselective removal of organic contaminants in groundwater remediation." Daniel Kick received the Mall Environmental Prize for one of the best master's theses. His topic was: "Analysis of the Long-term Treatment Performance of Different Engineered Substrates in Urban Bioswales - Results After Two Years of Operation." Mr. Kick completed his master's thesis in the Urban Rainwater Management research group. This same research group also produced the bachelor's thesis by Ms. Sandra Huber on the topic "Analysis of pollutant release from a green roof substrate in a column percolation test according to DIN 19528," for which Ms. Huber received the prize for the best bachelor's thesis.

Teaching

The Chair of Urban Water Systems Engineering offers a wide range of different courses for the Bachelor's study program Environmental Engineering and Civil Engineering as well as for the Master's programs in Environmental Engineering, Civil Engineering, Ecological Engineering, and Sustainable Resource Management. The emphasis of these courses is placed on water chemistry, advanced water treatment, energy recovery from wastewater, water recycling, as well as conceptual design for sustainable water supply and wastewater disposal systems for urban areas. In 2025, the following lectures were offered:

Summer term

Bachelor

- Kreislaufwirtschaft und Werkstoffe für nachhaltiges Bauen: Koch, Konrad
- Mikrobiologie: Wurzbacher, Christian
- Projektkurs Siedlungswasserwirtschaft: Drewes, Jörg
- Umweltanalytik: Helmreich, Brigitte; Linke, Felicia
- Umweltrecht: Spieler Martin (TUM-Lehrbeauftragter)

Master / PhD

- Advanced Water Treatment Engineering and Reuse: Drewes, Jörg; Aumeier, Benedikt
- Anaerobic Processes and Energy Recovery: Koch, Konrad
- Bewirtschaftung von Kanalnetzen und Regenwassermanagement: Helmreich, Brigitte, Rosenberger, Lea
- Doktoranden und Masteranden Kolloquium Proaktiv: Drewes, Jörg; Helmreich, Brigitte; Koch, Konrad; Wurzbacher, Christian; Keilmann-Gondhalekar, Daphne; Aumeier, Benedikt
- Hydrochemistry Laboratory: Helmreich, Brigitte; Heim, Carolin; Linke, Felicia; Koch, Konrad
- Industrial Wastewater Treatment and Reuse: Aumeier, Benedikt
- PhD Seminar SiWaWi: Aumeier, Benedikt; Drewes, Jörg
- Planning the Urban Water-Energy-Food Nexus, lecture & project: Keilmann-Gondhalekar, Daphne
- Wastewater Treatment: Linke, Felicia

Winter term

Bachelor

- Siedlungswasserwirtschaft Grundmodul: Helmreich, Brigitte; Koch, Konrad
- Verfahrenstechnik: Böhm, Bernhard (TUM-Lehrbeauftragter); Koch, Konrad
- Verfahrenstechnik Übung: Böhm, Bernhard (TUM-Lehrbeauftragter); Koch, Konrad

Master / PhD

- Aquatic Microbiology: Wurzbacher, Christian
- Design and Operation of Wastewater Treatment Plants: Athanasiadis, Konstantinos (TUM-Lehrbeauftragter); Böhm, Bernhard (TUM-Lehrbeauftragter)
- Doktoranden und Masteranden Kolloquium Proaktiv: Drewes, Jörg; Helmreich, Brigitte; Koch, Koch, Wurzbacher, Christian; Keilmann-Gondhalekar, Daphne; Aumeier, Benedikt
- Engineered Natural Treatment Systems: Aumeier, Benedikt; Linke, Felicia
- Gute Wissenschaftliche Praxis: Koch, Konrad
- Hydrochemistry Laboratory: Haas, Maren; Heim, Carolin; Linke, Felicia; Helmreich, Brigitte
- Hydrochemistry: Helmreich, Brigitte
- Unit Operations Lab: Aumeier, Benedikt
- Modeling of Aquatic Systems: Koch, Konrad
- PhD Seminar SiWaWi: Aumeier, Benedikt; Drewes, Jörg
- Planungs- und Genehmigungsverfahren nach deutschem und europäischem Wasserrecht: Spieler, Martin (TUM-Lehrbeauftragter)
- Water and Wastewater Treatment Engineering: Drewes, Jörg

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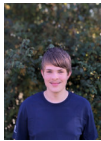


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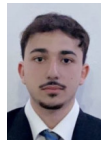


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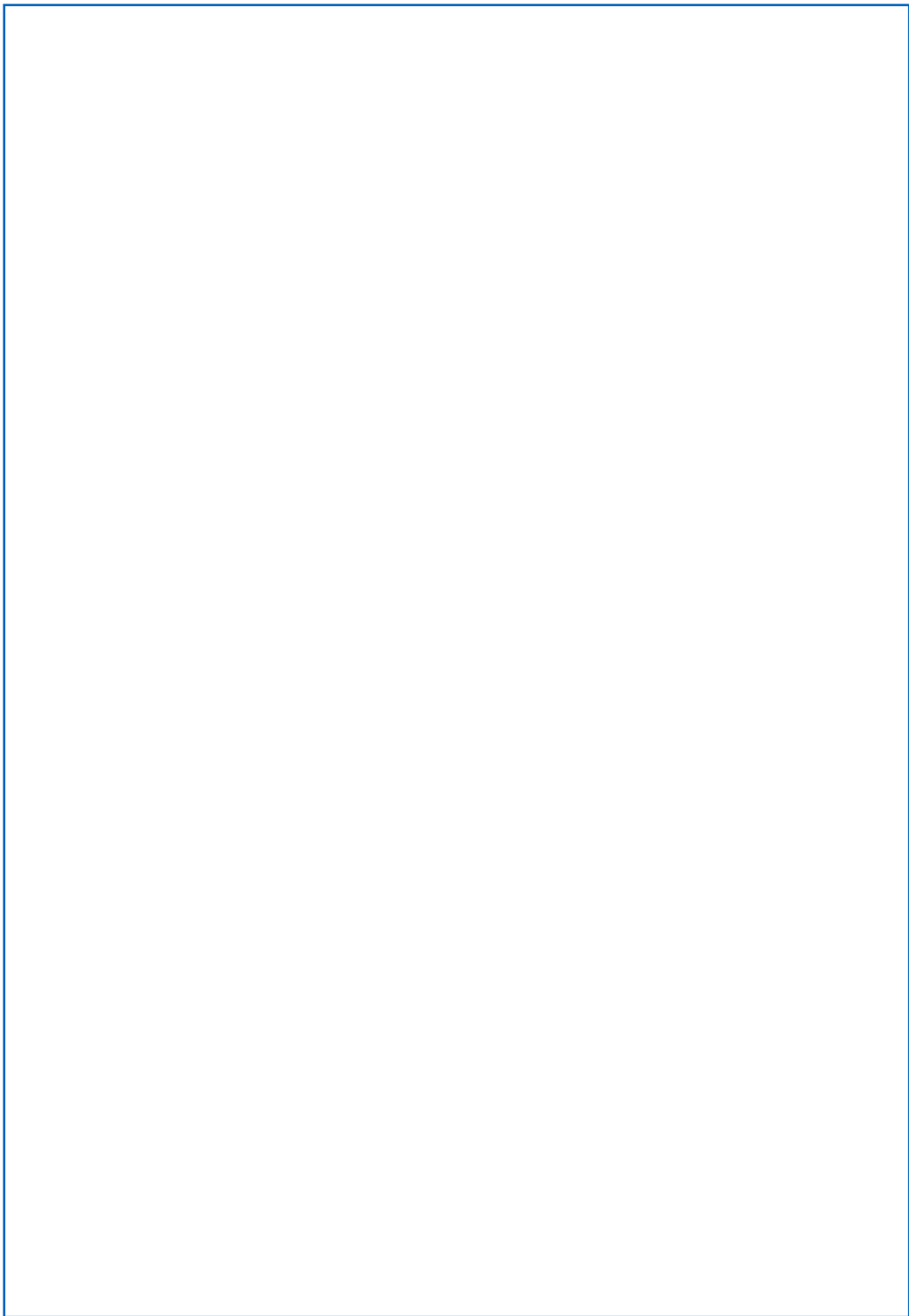


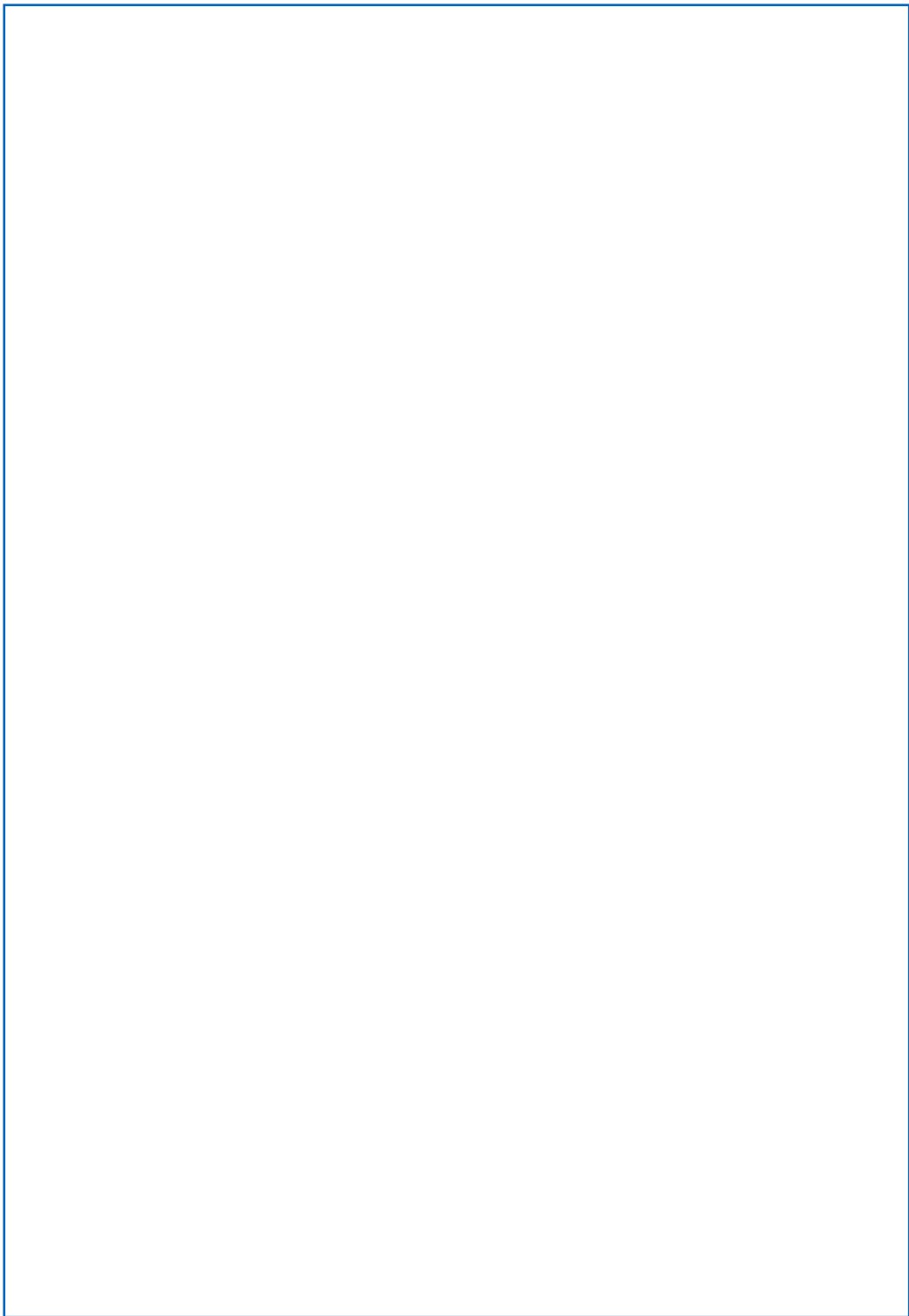
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