forum 95

Newsletter of the Chair of Urban Water Systems Engineering

Annual Report of the Chair of Urban Water Systems Engineering

2024

Chair of Urban Water Systems Engineering

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Content

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Foreword

Dear friends of the Chair,

2024 was the warmest year since weather records began and this record is likely to be broken again in the near future. In addition, there are major geopolitical changes, the effects of which can only be partially assessed and which will make the search for sustainable solutions more difficult. However, there are also positive developments if we look at the resolutions of the last COP 29 negotiations, in which more than 100 countries agreed on a fundamentally realigned water agenda. In December 2024, the revised EU Urban Waste Water Directive (EU-WWWD) was adopted, which will completely change the water sector in the coming years and decades. This presents enormous opportunities and we look forward to supporting this change with new concepts.

We are very grateful for a productive year at the Chair. Once again this year, our staff have been very active in publishing their scientific findings and sharing them with the national and international research community at conferences and lectures. We are very happy for Dr.-Ing. Carolina Feickert Fenske, who was awarded the Johannes B. Ortner Prize of the Technical University of Munich for her dissertation this year. We also congratulate Dr.-Ing. Philipp Sperle, who received the TUM Department Prize for Civil and Environmental Engineering for his doctoral thesis. Furthermore, we congratulate Dr.-Ing. Christian Hiller, Dr. rer. nat. Lijia Cao and Dr.-Ing. Emil Bein on the successful completion of their doctoral theses. Congratulations to them!

In 2024, we organized the 33rd Water Technology Seminar with the topic 'The new Drinking Water Ordinance and its significance for drinking water supply in Bavaria'. The 51st Wastewater Technology Seminar (ATS) took place in Garching in July with a focus on the new EU Urban Wastewater Directive. Both events were very well attended with exciting discussions.

In our 'core business,' the Chair once again made significant contributions to the education of students on the Bachelor's degree courses in Environmental Engineering and Civil Engineering as well as the Master's degree courses in Environmental Engineering, Civil Engineering, and Sustainable Resource Management last year. In addition to a large number of lectures, tutorials and practicals, the Chair's staff supervised numerous Master's theses, student research projects and Bachelor's theses.

This year, I handed over my role as Academic Program Director for the Environmental Engineering course to my colleague Markus Disse. In addition to my chair duties, I am also involved with the International Water Association (IWA) and now as a co-chair of the German Advisory Council on Global Change (WBGU). This year, the WBGU presented its new main report 'Water in a Heated World' to the Federal Government.

On behalf of my colleagues, I would like to thank you very much for your support and your interest in our students and our work. In particular, we would also like to thank you for the support of our Sponsors' Association, which makes a very important contribution to the education of our doctoral candidates and students by funding travel to conferences and providing grants for research projects. I am very pleased to be able to present you with our 2024 annual report in this issue to give you a brief insight into our activities. In 2024, we were also strengthened by new employees, who introduce themselves to you in this annual report along with their other colleagues.

We would be very pleased if your donation could enable us to provide this support for our doctoral candidates and students again this year.

We wish you much confidence, a successful year and much pleasure in reading this report

Yours,

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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 m^2 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).

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

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

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. Tim Schlachta, 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, oxohal-ides such as bromate and chlorate as well as short-chain organic acids can be analysed using ion chromatography. For the analysis of metals, classic atomic absorption spectroscopy with flame and graphite furnace AAS is available as well as a highly sensitive ICP-OES device for multi-element analysis. Trace substance analysis specialises in the characterisation and identification of organic molecules from aqueous samples in trace substance analy-sis (target screening) using chromatographic separation techniques coupled with highly sensitive mass spectrometric detection methods (LC-MS/MS). Among other things, perfluorinated alkyl substances (PFAS) can be reliably detected in the water cycle. Volatile organic substances, such as plasticis-ers or volatile organic acids, can be detected using headspace GC/FID, and microplastic particles using thermal desorption pyrolysis GC/MS.

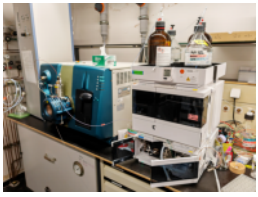

Figure 3: HPLC-MS/MS system for trace analysis

The microbiological laboratory uses conventional techniques to determine the microbiological water quality, as well as biodosimetry 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 topic of "water-sensitive cities" was also a focus of the working group. Climate change poses major challenges for settlement drainage due to the increasing frequency of extreme weather events such as heavy rainfall events and periods of drought. Adaptation strategies in response to the consequences of climate change are therefore becoming more and more important. When planning new areas or densifying settlements, it is important to integrate all actors of the grey, green and blue infrastructure into the planning right from the start. It should also not be forgotten that pollutants must be removed from the rainwater runoff from urban areas in order to avoid entering groundwater and surface water.

Figure 4: Biodiverse planting at an infiltration basin in Munich. Foto: Patrizia Eben

In 2024, we started the new research project "Pollutants in the stormwater runoff from non-metal roofs" together with Fraunhofer IBP in Valley. We were also able to successfully complete an order from the state capital of Munich on the topic of "Flowering infiltration swales in the city". An interdisciplinary project in which we also had the chance to sample long-standing infiltration basins in Munich in order to make statements about the operation of such infiltration systems. We were also able to examine infiltration swales with regard to the behavior of plants in waterlogging, long dry periods and also road salt. This year, the stormwater group was able to present its projects in Berlin as part of a scientific exchange with the Berlin Waterworks, the Berlin Rainwater Agency and the Berlin Water Competence Center on an excursion at the beginning of October. We were also able to visit an urban district in Berlin where water-conscious settlement planning has been implemented for many years.

Flowering Infiltration Swales in Urban Areas

Rapid urbanization is leading to high levels of densification in cities. The resulting increasing soil-sealing and reduction of inner-city green spaces inevitably leads to changes in the local water balance, intensification of effects such as the urban heat-island and a decline in biodiversity in residential areas. The climate change promotes more frequent extreme events such as heavy rainfall and drought periods and therefore, intensify the negative effects of missing open spaces in cities. Green, flowering infiltration swales are considered to be particularly promising ways of counteracting these challenges.

Figure 5: Semi-technical infiltration swales at the Chair of Water Systems Engineering

The aim of the interdisciplinary research project was to investigate the benefits that can be achieved in an urban infiltration swale through species-rich, native planting and an adapted substrate composition. In addition to the stress tolerance of the vegetation, drainage saftey, pollutant retention and insect diversity were investigated. At the Chair of Urban Water Systems Engineering, the pollutant load and stability of the infiltration swales were investigated on a semi-technical scale by feeding them with real traffic area runoff. In addition, pilot swales on a heavily trafficked road in Munich were monitored and the retention of heavy metals was analyzed. The risk of siltation of the topsoil in long-term operated infiltration swales was examined in Freiham and further, the accumulation of pollutants was evaluated regarding the soil-human impact pathway (in accordance with the BBodSchV). The one-year research project was successfully completed in December 2024. In the preceding research project on multifunctional infiltration swales, the publication "Multifunktionale Versicherungsmulden Handlungsempfehlung zu Planung, Bau und Betrieb" was published by the Bavarian Environment Agency (LfU) in September 2024.

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COLLABORATION:

CHAIR OF ENERGY EFFICIENT AND SUSTAINABLE DESIGN AND BUILDING (TUM), INSITUTE FOR REAL ESTATE ECONOMICS (IIÖ)

Accompanying research “Climate-friendly construction - model projects“

Creating affordable living spaces is challenging for developers, such as public or private investors. Adapting buildings to changing climate conditions is seen as an additional burden that further reduces the economic viability of construction projects.
The research project, a sub-project of the Centre for Urban Ecology and Climate Adaptation (ZSK) at TUM, provided scientific support for implementing ten model projects in Bavaria regarding urban climate adaptation and mitigation in residential construction. As part of the project, we evaluated climate protection and adaptation measures using a cost-benefit analysis. Side effects, such as health and environmental costs, were included in the assessment.

Figure 6: Brochure "Bezahlbar klimagerecht bauen"

By analyzing real model projects in subsidized housing construction, it was possible to show that the measures examined not only make an essential contribution to protecting against the effects of climate change but also make economic and social sense. We investigated this using the measures of tree preservation and replanting, outdoor ground coverings, infiltration systems, roof and façade greening, and sun protection.
Recognizing that long-term economic and social benefits can be achieved through increased investment costs is crucial. The early consideration of climate-friendly measures in the planning process creates the conditions for this to succeed. At the end of the project, the results were published in the brochure Bezahlbar klimagerecht bauen (in German).

Implementing biochar in bioswales for stormwater treatment

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Urban stormwater is a significant pollutant source that impairs the quality of water bodies and can affect human health and ecosystems. Implementing green infrastructure such as bioswales for urban stormwater management is a meaningful strategy for addressing this challenge, as it can provide various ecosystem services. However, although conventional bioswales can effectively remove sediments and particulate-bound pollutants, they can fail to remove dissolved pollutants in a reliable manner. This project aims to improve the dissolved pollutant removal in bioswales by studying the implementation of biochar. The main goal is to achieve a better understanding of the possible improvements in dissolved pollutant removal and long-term retention in biochar-amended bioswales, focusing on biocides and heavy metals. Biochar is being tested both in isolation and in combination with two different soils.

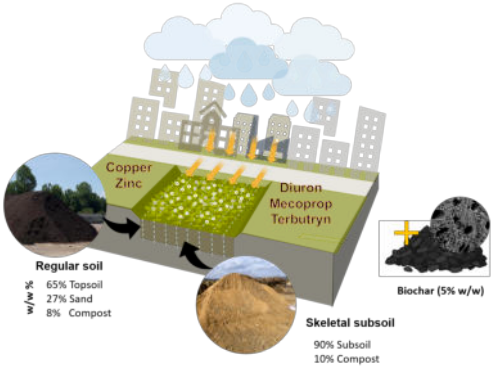

Figure 7: Conceptual framework of implementing biochar in bioswales

Preliminary results from laboratory-scale adsorption experiments with synthetic stormwater show that high-temperature (850°C) biochar from mixed forest residues has a removal of heavy metals and biocides comparable to granular activated carbon (GAC). In both tested soils, biochar can significantly enhance the removal of heavy metals (>80%) and biocides (>90%). However, its overall performance depends on the soil type. Small-scale permeability tests have shown that biochar can impact the soil's hydraulic conductivity, but the values still comply with the German regulations at the tested amendment rates. Currently, column experiments with biochar-amended soils under varying rain intensities and dry periods are being conducted.

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0°roofs - influence of contact time and water matrix on the release of Mecoprop from bitumen roofing membranes

In contrast to normal flat or green roofs, 0°roofs retain water and therefore offer many solutions for minimizing the consequences of climate change. However, green roof substrates are often built on bitumen roofing membranes with herbicides (Mecoprop) to protect buildings from root damage. Mecoprop (MCPP) is a water-relevant pollutant that is released in high concentrations from these bitumen roofing membranes. The aim of our research is to investigate and evaluate the influence of contact time and water matrix on the release, as these are very relevant for the release of MCPP according to the current state of knowledge. In particular, different roof structures contribute to the change in the water matrix due to the materials used. For this reason, three gravel, extensive and intensive roof structures were each constructed on a pilot scale in the experiments and tested for their MCPP release. The roofs were irrigated with 30 liters of synthetic rainwater. The roofs were left to soak for one to 12 days, then drained and the water matrix analyzed for MCPP.

Figure 8: Experimental setup of Mecoprop-release experiments from 0°- roofs

The aim of the research project is to demonstrate the hypothesized correlation between contact time, water matrix and MCPP release and thus to better characterize the MCPP release potential. This information will in turn be used to develop decentralized stormwater treatment systems for the MCPP release behaviour of green roofs in order to maximize the retention of MCPP. Furthermore, it is planned to issue a recommendation for action for green roof uses.

Pilot project former Bayern barracks: development of soils and substrates recycled from secondary raw materials and evaluation regarding water storage capacity, pollutant retention and plant compatibility

In the course of the site clearance at the former Bayern barracks the city of Munich plans to recycle approx.. 200,000 tons of excavated soil and processed demolition waste as plant substrates in landscaping. To minimize disposal and transport costs, as well as disposal related externalized costs such as urban traffic load and CO2 emissions, the city of Munich plans to utilize these materials on the spot.

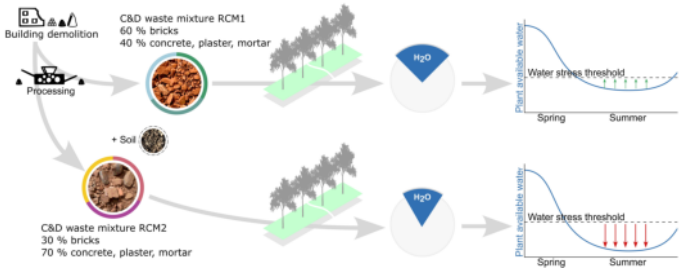

Figure 9: An increased ratio of bricks in the processed building rubble reduces the edaphic drought stress in summer months with little precipitation

The aim of the pilot project is to assess the non-hazardous re-use of these secondary substrates within the newly arising city quarter Neufreimann on the area of the former Bayern barracks. Also, potential benefits concerning water holding capacities will be investigated. For this purpose a field trial was established where different substrate mixtures will be investigated with regard to plant compatibility, soil water contents, emission of pollutants and retention of pollutants. Depending on the outcome, the recycling concept could be adopted for comparable building projects in Munich.

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COLLABORATION:

FRAUNHOFER INSTITUT FÜR BAUPHYSIK

Pollutants in stormwater runoff from non-metal roofs

In growing cities, more and more surfaces are being sealed. This increases the contact of stormwater with materials, e.g. on roofs, which can contaminate the run-off water with harmful substances. However, no clear or statistically relevant statements on pollutant emissions can be made for most roof materials, as there are hardly any 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 a 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 10: Construction of the test roofs in the field

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.

Research Group
Energy-neutral Wastewater Treatment

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Wastewater treatment plants are still the largest municipal consumers of electricity, although wastewater contains more than enough energy than is required for treatment. While wastewater treatment remains the top priority, considering the specified limit values, the working group is looking for ways to reduce the energy required for treatment and recover more energy from the wastewater, for example, by producing biogas from the sewage sludge.
The European Commission's new urban wastewater treatment directive (UWTD) sets new standards for the further development of wastewater treatment in the coming decades with the ambitious targets it formulates. The area of conflict between the required energy neutrality on the one hand and the additional requirements regarding further nutrient elimination and the (energy-intensive) removal of trace substances on the other will be particularly challenging. However, we are optimistic that we can make at least a small contribution to this with our work.
We want to pursue a promising approach in the necessary energy transition as part of the research project Microbiological methanation - Transition to commercial application (KomMeth) kindly funded by the Bavarian State Ministry of Economic Affairs, Regional Development and Energy (StMWi). Biomethanization provides an exciting opportunity to store energy as biomethane in times of surplus and to make it available again for wastewater treatment when required ("renewable drought"). With Christian Wenzel and Xaver Niebauer, we have two new doctoral students who will also be writing their dissertations as part of the project.
In the new year, a BMBF collaboration project entitled "Urban Heat Cycle - Sustainable, biogenic heating oil from municipal residual biomass" (UHC) will also start, in which we will - once again - be looking at the anaerobic degradation of sewage sludge. What is new this time, however, is that the focus is not on the production of methane but on the precursor substances, organic acids and hydrogen, for which methanogenesis must be suppressed entirely. While the hydrogen will serve as an energy store, the organic acids will be used as a substrate for oil yeasts, ultimately used to produce heating oil.
In addition, a doctoral network funded by the European Commission entitled "Leveraging Anaerobic Digestion through environmental stresses" (LeAD) will start in spring, in which Christian Wurzbacher and I will each supervise a doctoral student. Together with partners from Ireland, France, Italy, Denmark, Poland, and Turkey, we want to develop strategies to make the anaerobic digestion process even more resilient to external stress factors. Due to the interdisciplinary nature of this project, we hope to gain exciting insights into the microbial communities involved.

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COLLABORATION:

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ENCOVER: Energetic utilization of CO_2 to enhance the methane productivity and to reduce the residual methane potential

Burning fossil fuels is the primary source of greenhouse gases. In order to become carbon neutral by 2050, energy production must increasingly shift to renewable sources. Biogas plays a key role in this, as it can be stored, unlike other renewable energies. However, when raw and residual materials are fermented, a significant portion of the methane potential remains in the fermentation residue. Studies show that CO2 enrichment can increase methane production and improve process stability. The aim of this project is the energetic use of CO_2 to reduce the residual methane potential, especially for residues that have not been investigated much so far. These substrates are expected to be more efficient than sewage sludge. In addition to the quantification of methane production and stability, pH and redox measurements, isotopic analyses and microbiological investigations will be used to elucidate the mechanisms involved. This will be done in both batch and continuous pilot plant experiments. In the continuous tests with food waste, increased methane production was observed in the reactor enriched with CO_2 (R_{CO2}) (Figure 1A). By day 53, a methane increase of 96 L (+7%) was achieved compared to the control reactor (R_0) (black solid line). However, the effect of CO_2 enrichment only became apparent at increased room load, whereas before, both reactors showed comparable methane production. The vertical lines mark the time of feed stop in each reactor. Improved process stability was observed in R_{CO2}, as the reactor continued to run stably despite continued substrate feeding, while substrate feeding had to be stopped in R_0 due to the sharp drop in pH. Similar results were observed for hydrogen production (Figure 1B): About 0.2 L more H_2 was produced in R_{CO2} than in R_0. This indicates that not only was the existing H_2 efficiently converted, but additional H_2 was also produced. Therefore, CO_2 enrichment resulted in more methane, more hydrogen, and improved process resilience.

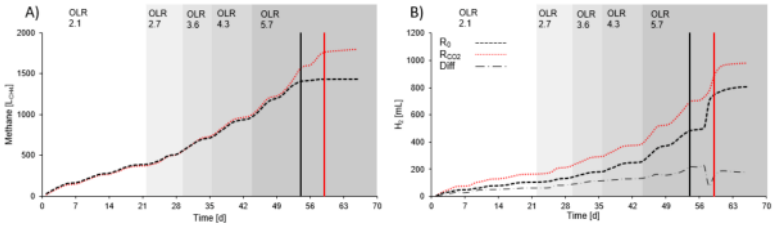

Figure 11: Cumulative volume of methane (A) and hydrogen (B).

Rural Biogas Generation

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THE GERMAN ACADEMIC EXCHANGE SERVICE (DAAD)

Collaboration:

TUM SEED CENTER

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 δ^2H-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.

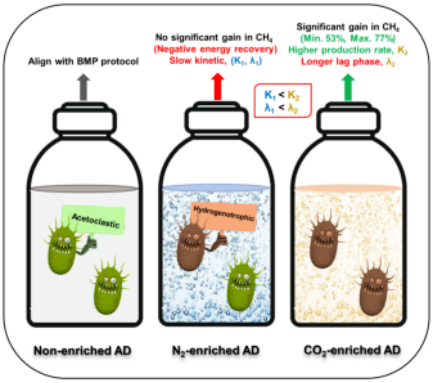

Figure 12: The intriguing effect of CO_2 enrichment in anaerobic digestion

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COLLABORATION:

BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LFL)

Technical Biogas Potential Bavaria

Biogas production from agricultural biomass is essential to the energy transition in Germany and Bavaria. Biogas is a storable energy source that can be seamlessly integrated into the existing energy infrastructure as upgraded biomethane. However, biomass is a limited resource, and energy production can compete with food or animal feed production. To expand biogas production, the EU Commission is therefore focusing on biomass not subject to competition for use in its REPowerEU plan.

The project "Technical Biogas Potential Bavaria" aimed to quantify the technical potential of agricultural biomass for biogas production in Bavaria. A high spatial resolution at the level of single municipalities was chosen to consider the low transportability of specific residues (liquid manure). In addition, the competition for the utilization of biomass was taken into account, as for the case of cereal straw, which can be used as bedding material for animals. A Monte Carlo simulation was used to address the uncertainty in the underlying statistical data, and a sensitivity analysis was carried out.

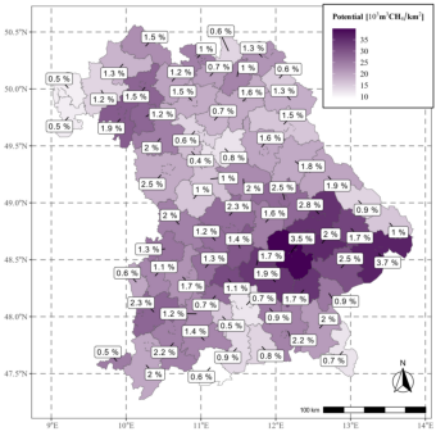

Figure 13: Concentration of the unused technical methane potential of biomass without competing use by county. Labels show the proportion of the total unused technical methane potential by county. Calculations at the level of municipalities were aggregated to the level of counties (NUTS-3).

The results show that the untapped potential from agricultural biomass without competition for use is still relatively high, and that around 12 percent of the natural gas consumed in Bavaria could be replaced. The results will be published in the Bavarian Energy Atlas of the LfU: www.energieatlas.bayern.de

Biomethanation as a building block of the energy transition at wastewater treatment plants

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Bavarian Ministry of Economic Affairs, Regional Development and Energy (StMWi)

Collaboration:

The Bavarian State Research Center for Agriculture (LfL)

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, biogas plants or industry can be utilised directly where it is produced.

The microbiological conversion of H_2 and CO_2 to CH_4 under anaerobic conditions by methanogenic microorganisms is known as a sub-process from biogas plants or digesters. A particularly efficient reactor concept is the gas-filled trickle bed reactor, in which the microorganisms are immobilised on growth bodies.

In the completed DemoMeth project, a pilot reactor with an active reaction volume of 0.8 m^3 was installed at the Garching wastewater treatment plant. Raw biogas from the digester's gas storage tank was used as the CO_2 source, enabling the biogas to be upgraded to feed-in quality (> 96 % CH_4) at the point of origin. A stable methane production rate of 6 $m^3/(m^3_{\text{reactor volume}}*d)$ was achieved in the pilot reactor.

After a 1.5-year shutdown period, the pilot reactor was fully repaired and put back into operation as part of the new KomMeth project. The first start-up tests in a cold start prove that the reactor can achieve stable methane production again within a short time, even after a longer shutdown.

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 14: Pilot reactor at the Garching wastewater treatment plant.

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COLLABORATION:

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Optimization approaches for the operation of a trickle bed reactor used for biological methanation of CO_2 and H_2

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 goal of the project KomMeth is to advance the translation of the trickle bed reactor (TBR) concept for biological methanation further into commercial application. Next to pilot scale investigations, two existing technical scale TBRs are recommissioned and will be used to evaluate different parameters and operation modes.

First, both reactors will be restarted and operated until a steady state is reached. To assess the current state of the microbiology in the reactor interior, samples of the microbiology were taken. The startup performances will be monitored and can provide insights into the reactor behavior after long standby periods (more than 1.5 years). Afterward, the focus of the investigation in the technical scale reactors will be on different standby-restart procedures as well as the detailed study of necessary nutrients and additives for an efficient operation. Furthermore, a (fed-)batch setup is planned to allow for a better comparison of different carrier materials.

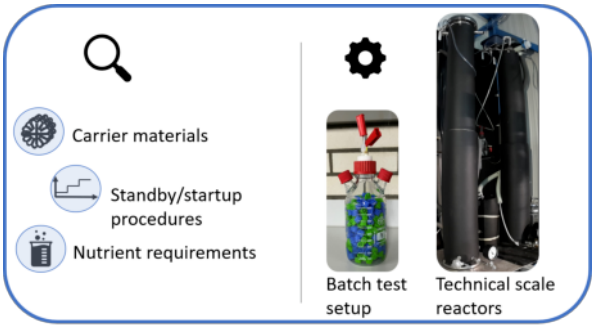

Figure 15: Overview of topics planned to be investigated and methods to be utilized

Research Group Advanced Water Treatment

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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.

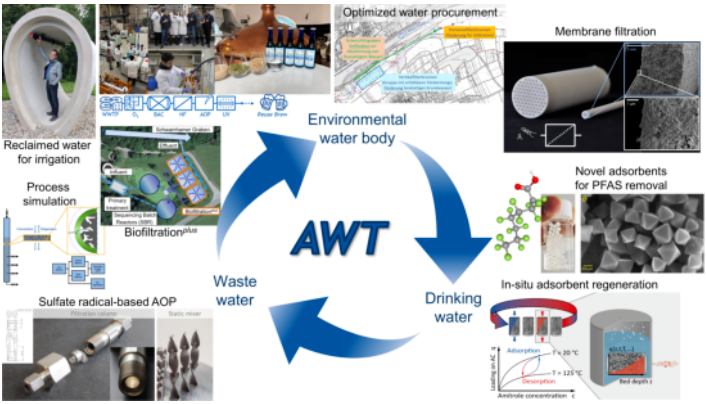

Figure 16: AWT research highlights

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BAYERISCHES LANDESAMT FÜR UMWELT (LFU)

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.

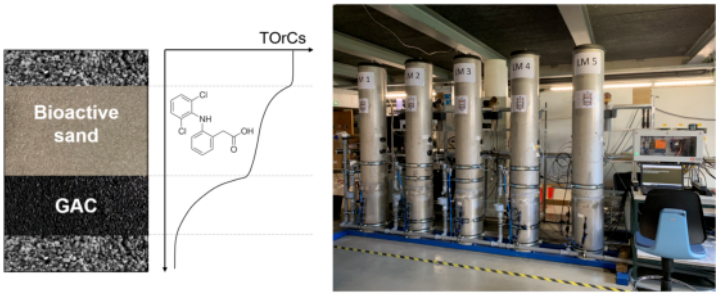

Figure 17: Biofiltrationplus principle (left) and experiments (right)

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 first phase of the project started in June 2022 and concludes with phase 2, which begins when the WWTP goes into operation and scientific monitoring of the large-scale technical Biofilter*plus* is started.

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

The overall objective of the project is to develop an alternative process for trace organic chemicals (TOrCs) removal that is based on the in-situ generation of sulfate radicals in a simple depth filter. Conventionally treated wastewater cannot be reused before removing TOrCs and dangerous microbiological elements, which can affect human, animal, and plant health. Sulfate radicals have been discovered to be more selective than hydroxyl radicals and possess a higher oxidation potential in removing trace organic chemicals. Homo- and hetero-genous metal and non-metal catalysts have been found to create radicals through electron interaction with peroxymonosulfate. This project expands on a novel catalytic filtration method through the activation of peroxymonosulfate (PMS) via a Manganese (II) Oxide catalyst immobilized on granular activated carbon (GAC), which is used to remove TOrCs. The project encompasses the design, validation, optimization and scale-up of a flow-through column system for TOrCs removal.

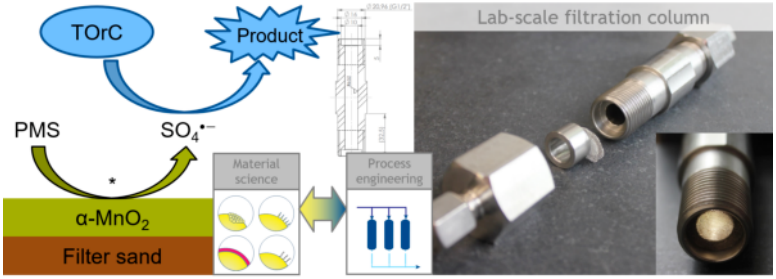

Figure 18: Catalytic filtration to remove TOrCs

The optimal conditions are first researched in a lab-scale setup with secondary wastewater effluent. This is, followed by a scale-up and installation in the Schweinfurt wastewater treatment plant to treat secondary wastewater as a comparable alternative to conventional treatment technologies. The last milestone consists of conducting a techno-economic analysis of this setup to determine its feasibility as a practical solution for the production of potable and nonpotable water.

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XYLEM WATER SOLUTIONS
HERFORD GMBH

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

Within the BMBF-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 STMUV-funded project „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 existing treatment train at the site will be expanded with a conveyance system (using pipe-in-pipe technology) and a storage reservoir in the northern part of the city.

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 risk management plan and long-term monitoring will be designed and implemented to preserve soil and groundwater quality as well as plant health. A cost-benefit analysis of the water reuse concept will be conducted to support the transferability of this practice to other municipalities.

Figure 19: Infrastructure of the water reuse concept in Schweinfurt

Basic research on treatment mechanisms of cement stone filters in the treatment of wastewater from the textile industry

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Textile wastewater poses a major challenge for wastewater treatment due to its contamination with dyes, electrolytes, softeners and dispersants. Particularly problematic are anionic dyes such as azo dyes, which are difficult and often expensive to remove using conventional processes. These high costs make it difficult to use the processes in countries where textile factories are heavily represented, such as in south Asia and India. For this reason, affordable alternatives are crucial for water protection.

In our project, we are developing adsorbents based on cement containing granulated blast furnace slag in order to evaluate their efficiency in removing dyes. The focus was on specific phases in the cement paste, especially those with layered structures that can bind colour molecules efficiently. The affinity of these materials for adsorption varies greatly depending on the pH value of the wastewater: monocarboaluminate showed an exceptionally high adsorption capacity of over 250 mg/g at a pH value of 5, which is related to the high zeta potential and thus a strongly positive surface charge.

Figure 20: Experimental setup for the decolourisation experiments

A key element of our method is a unique setup typically used in the pharmaceutical industry for tablet dissolution testing, which has been adapted for the study of adsorption processes (see Figure 1). This setup uses UV/VIS flow-through cells and allows continuous monitoring of decolourisation without interfering filter steps. The setup consists of a UV-VIS spectrometer with flow-through cells, which is connected to a peristaltic pump and the special setup. The granules are brought into contact with the dye solution in the metal basket. The measurements are carried out continuously in a closed circuit and enable detailed analyses of granulates and powders under realistic conditions. The research project is being carried out jointly with the Centre for Building Materials and Materials Testing (cbm) at the Technical University of Munich.

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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 will be published in yellow print in 2025.
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 start the new BMBF joint project 'Nutzwasser ' in 2021, which is developing concepts for safe water reuse for urban and agricultural irrigation on a demonstration scale. We will complete this project at the end of 2024. 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 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 BMBF, 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 as an alternative water resource for urban and agricultural irrigation

The region of Lower Franconia in Germany has traditionally suffered from water scarcity, where the effects of climate change are increasingly intensifying conflicts over resource usage. To address this issue, the *Nutzwasser (reclaimed water) Project* was initiated. The goal of this project is to develop practical management strategies for water reuse in urban and agricultural irrigation. These strategies are to be optimized in collaboration with practical partners through demonstration projects, enabling quicker implementation in other target regions.

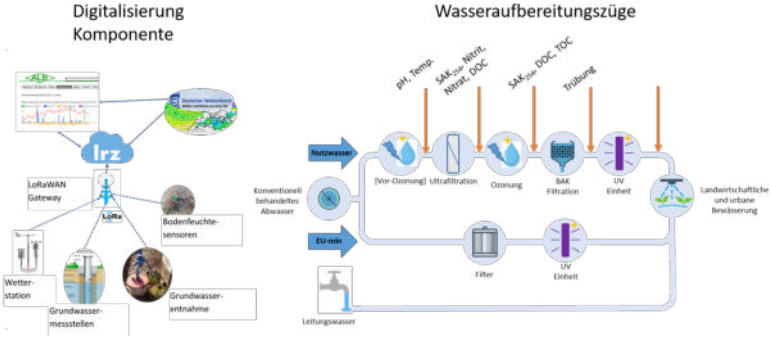

Figure 21: Digitalisierungskomponente und Wasseraufbereitungsstrategien im Nutzasser Projekt

Work packages (05.2021-12.2024):

- Development of requirements for the regulatory approval of a non-potable water reuse application
- Definition of water quality standards for various irrigation methods
- Development of digital solutions for the automated collection and documentation of irrigation demands
- Implementation of innovative multi-barrier treatment strategies for the effective removal of microbiological and chemical contaminants
- Design of an automated and demand-driven supply of non-potable reclaimed water
- Development of customized operating models
- Integration of the project into an interactive stakeholder process
- Establishment of an innovative platform for public engagement

Webseite: www.nutzwasser.org

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BERLINER WASSERBETRIEBE, BRANDT GERDES SITZMANN (BGS) UMWELTPLANUNG GMBH, CARL VON OSSIETZKY UNIVERSITY OF OLDENBURG

Development and optimization of an innovative treatment approach for indirect potable reuse in urban water cycles

During the TrinkWave joint project, which was completed and funded by the BMBF (Federal Ministry of Research and Education), new multi-barrier treatment processes for water reuse based on sequential managed aquifer recharge technology (SMART) were developed. The aim was to assess multidisciplinary monitoring approaches for innovative process combinations of water reuse to support the drinking water supply.

The subsequent joint project TrinkWave Transfer (funded by the BMBF), is now testing the large-scale implementation of the SMART process in collaboration with the Berliner Wasserbetriebe, the University of Oldenburg and BGS Umwelt GmbH. This is taking place at the former Berlin-Johannisthal waterworks site, where the process will be demonstrated in its optimized form with integrated high-infiltration trench technology and active hydrological control in the subsurface. The knowledge gained from the previous project and from the SMARTplus technical pilot system will be incorporated into the planning and implementation.

Since mid-2023, the Berlin demonstration plant has infiltrated drinking water to establish a local oxic redox zone in the aquifer. In 2024, the first infiltration of treated and wastewater-impaired bank filtrate occurred. The bank filtrate, previously enriched with atmospheric oxygen, flows through the subsurface and is sampled and analyzed at several depths and positions along the flow path. Analysis results for anthropogenic trace organic substances during approximately six months of operation are available and are currently being evaluated. The evaluation of the behavior of individual trace organic substances and the assessment of the performance of the demonstration field will take place in the coming months. We plan to publish the results in the spring of 2025.

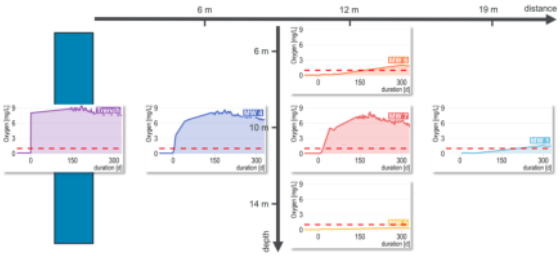

Figure 22: Timeline and establishment of an oxic redox zone in the subsurface of the demonstration plant, with the high-rate infiltration trench on the left and several monitoring wells in the central flow area and depths of the demonstration field.

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 hydrodynamics and particle deposition mechanisms 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 spatial and temporal evolution of biofouling on surface-patterned membranes, we perform accelerated biofouling experiments with semi-synthetic feed water. A pre-defined protocol allows conducting biofouling experiments in a reproducible manner.

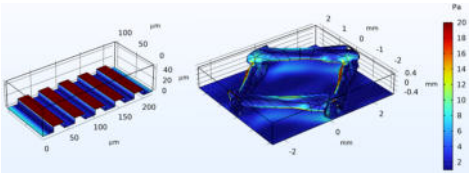

Figure 23: Shear stress distributions in surface pattern geometry on micrometer scale (left) and feed spacer geometry on millimeter scale (right).

In parallel to this experimental approach, we investigate the hydrodynamics in assemblies of feed spacers and membrane surface patterns by CFD Modeling with COMSOL Multiphysics 6.2. We hypothesize that these assemblies have synergistic effects on the hydrodynamics in a feed channel and hence lead to substantially enhanced anti-fouling propensity compared to one of the geometric features alone. In our CFD models, we investigate e.g. wall shear stresses (cf. figure) to understand the respective hydrodynamics.

Recently, we published a critical review of the state-of-the-art of surface-patterned membranes. In this article, we placed a particular focus on assessing experimental and numerical methods employed to test membrane performance and identified key areas for future research.

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WATER4ALL 2024 JOINT TRANSNATIONAL CALL

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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 groundwater recharge. 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, biocides and pesticides, 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 such as reclaimed water or rainwater runoff for groundwater recharge.

In a first step, the infiltration of water from various pretreatment processes (ultrafiltration, ozonation, etc.) is tested in column experiments. Thereby, it is determined how the microbiological community and its functionality adapts and establishes itself as a function of the different water qualities. As soon as the microbiology has reached a steady state in the column tests, the ability of the various microbiomes to degrade trace organic chemicals is analyzed. In addition, the stationary operation of a field-scale site for groundwater recharge will be investigated concerning trace substance degradation. The final work package will test how trace organic chemical degradation can be improved through biostimulation.

Figure 24: Column experiments to investigate the degradation of trace organic chemicals during groundwater recharge

Sequential Managed Aquifer Recharge Technology (SMART) for water reuse

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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.

There are two approaches: Firstly, the construction of a homogeneous SMART-Plus sand tank (WaterHub project, South Africa), similar to the existing SMART-Plus tank in Garching, and secondly, the use of a heterogeneous aquifer (TrinkWave Transfer, Berlin). The SMART tank can be installed almost anywhere and offers a reliable flow and thus the possibility of continuous biodegradation of trace substances. However, the flow in a heterogeneous aquifer can also be controlled by a seepage trench in combination with wells. Both projects aim to achieve constant water quality for reuse. There are open research questions regarding the required redox conditions and the development of the microbiome that degrades the trace substances.

Figure 25: SMART Projects at the Chair with SMART-Biofilters and 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

TRANS-SAHARA: Novel WEFE Nexus-based approaches towards agroforestry management in the Greater North African Region

TRANS-SAHARA will establish a groundbreaking approach for leveraging agroforestry systems to support African communities in their fight against climate change. This innovative approach is based on the well-established Water-Energy-Food-Ecosystems (WEFE) Nexus approach. This project emphasizes the primacy of ensuring water security when designing, installing and managing agroforestry systems. The translation of this conceptual agroforestry management approach into real-world applications is supported by an array of technical and non-technical innovations. The efficacy of the novel approach and supporting innovations will be rigorously tested and validated through a series of large-scale pilot demonstrations set to take place in key locations across Africa, including Tunisia, Ghana, and Ethiopia. Expected outcomes will contribute to bridging the agroforestry data gaps in Africa, increased crop yield, doubling of farmers annual incomes, and the creation of new carbon sinks across previously degraded territories. Innovation adopters will significantly enhance their communities resilience to threats posed by the climate emergency, and stimulate highly sustainable socio-economic development across their region. The Chair of Urban Water Systems Engineering is collaborating with the Professorship of Ecoclimatology and the Institute of Forest Management as well as 14 funded and 6 associate partners. The project duration is from 01.11.2024-31.10.2027.

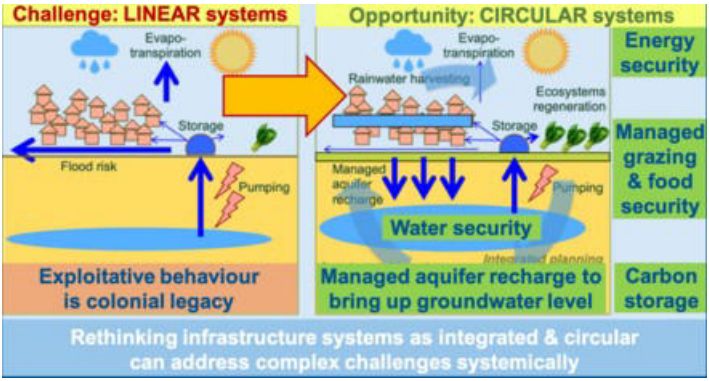

Figure 26: Integrated Water-Energy-Food-Ecosystems (WEFE) Nexus approach

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Federal Ministry of Education and Research (BMBF)

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

The project is developing alternative development scenarios in the village Dar es Salaam in the Dosso Region in Niger using suitable technology options as a basis for a participatory multi-stakeholder discussion, in order to facilitate a co-creation-process of a Nexus pilot project with the local community. In parallel, the project aims to build local capacities in order to anchor sustainable use of water in the region as part of a climate change adaptation strategy. In particular, the project analyses how the recharge of the groundwater aquifer using rainwater (managed aquifer recharge) can sustainably raise groundwater levels. This would enable the solar energy that is necessary to pump groundwater and that is being introduced through the pilot project to be partially used for other productive uses, thereby supporting socio-economic development. Furthermore, it is being analyzed how the soils can be regenerated using a managed grazing and a grassland restoration approach in order to enable the soils to store more moisture. This in turn would augment food security. As such, the project integrates water-, energy- and food security with regeneration of ecosystem services, thereby supporting social security. In addition, the project integrates climate change mitigation and adaptation in a holistic approach.

Part of the preliminary results of the project activities: A socio-economic survey of 124 out of a total of 400 households was carried out, which showed that, in addition to energy security, water security is the top priority. In Dar es Salaam, water security is only guaranteed for a few months of the year. However, an analysis using Geographic Information Systems and historical rainfall data determined that if rainwater were collected in 65 % of the area within the perimeter of the village, this would be sufficient to meet the annual water demand of the population.

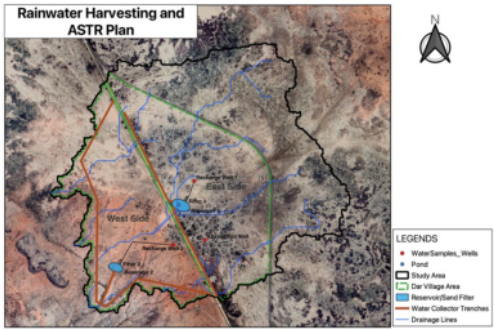

Figure 27: Rainwater Harvesting and ASTR Plan

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

SEED Himalaya aims to support remote communities in the Indian Himalayas in their transformation into environmentally resilient and economically empowered communities. This is to be achieved through community-based, decentralized energy supply as well as local value creation in agriculture. The inclusive bottom-up Community Development Plan, covering both green infrastructure as well as socioeconomic structures, is tailored to the local resources, capacities, and needs. This ensures the sustainability of the project and enables the replication of its approach in other Himalayan communities.

Firstly, all 140 households of Jabri in Jammu and Kashmir have been equipped with PV modules and battery storage for basic power supply. The second project phase couldn't be executed as originally planned in Jabri due to its limited accessibility caused by its location next to the Line-of-control.

Figure 28: The project community Jabri in Jammu and Kashmir (India)

Therefore, the community Simalta in Uttarakhand has been selected for the second phase and a Community Development Plan has been created jointly with the community members based on their needs for reliable electricity supply, improved water supply in agriculture, value addition in agriculture, and clean drinking water supply. In the final project year, this plan will be implemented jointly with a democratically elected Village Development Committee, who will manage and operate the newly installed infrastructure for electricity and water supply, as well as with a women Self-Help Group, who will launch, manage and operate a micro-enterprise processing agricultural goods aimed for high-priced markets.

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

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BAVARIAN STATE MINISTRY OF THE ENVIRONMENT AND CONSUMER PROTECTION (STMUV)

COLLABORATION:

UNIVERSITY OF CAPE TOWN, WESTERN CAPE GOVERNMENT

Water-Hub project in Western-Cape Province, South Africa

The Water-Hub project is a pre-feasibility study that applies an integrated Water-Energy-Food-Ecosystems (WEFE) Nexus approach to examine appropriate nature-based technologies for sustainable development of a (peri-)urban environment in a semi-arid region. TUM is collaborating with the University of Cape Town (UCT), South Africa, who has established The Water-Hub, a research site in Franschhoek, Western Cape, South Africa, in 2017, where the project is located. The project is supported by the Western Cape Government, Department of Environmental Affairs and Development Planning (DEA & DP) as a close partner and funded by the Bavarian State Ministry of the Environment and Consumer Protection (StMUV) in Germany.

The project expands the scope of the current activities at the Water-Hub to recover reclaimed water from a stream that is highly contaminated by surface run-off and discharge of untreated wastewater by an informal settlement further upstream. The nature-based treatment technologies (biofilters) have been modified to a multi-media horizontal-flow biofilter with a subsequent aeration and infiltration into an engineered bioreactor to establish an adaptation of the Sequential Managed Aquifer Recharge Technology (SMART) developed at the Chair of Urban Water Systems Engineering.

Figure 29: SMART-System at the Water-Hub in Franschhoek, South Africa

Higher removal of trace organic contaminants and pathogens leading to an increased final water quality are expected. Monitoring of water quality and the effectiveness of individual process steps are key focus points, which are essential for reuse applications. The project will assess the potential for energy recovery through anaerobic co-digestion of locally available feed stocks, from businesses (restaurants, farms, supermarkets, etc.) and households. This will support the development of business plans for entrepreneurship opportunities from organic (food) waste-to-energy streams, nutrient recovery (organic fertilizer) etc., and serving local markets. Knowledge dissemination and capacity building among project partners and stakeholders will be fostered through the Living Lab concept of the Water Hub. The project will contribute to improving water, energy, and food security in the Western Cape Province while protecting the environment and regenerating ecosystem services, contributing to achieve the UN sustainable development goals (SDGs). The project's Nexus approach will use WEFE as the starting point, but explicitly includes other relevant sectors such as waste and ecosystem services as a basis for a just transition to a circular economy.

Integrated Forest, Water, Prosperity Project Tunisia. Convergence

The Integrated Forest, Water, Prosperity Project Tunisia. Convergence project is a feasibility study funded by the Bavarian State Ministry of the Environment and Consumer Protection (StMUV) to characterize the scientific, geographic, climatic, technical as well as socio-economic starting points in Tunisia and use these as a basis to carry out stakeholder participatory-based reforestation that will have a lasting positive impact on the water balance and ecosystem regeneration in a sustainable manner. As part of the preliminary results from project activities: Previous reforestation projects in Tunisia were assessed and the targeted interventions of these projects were identified to highlight the lack of intersectoral interventions implemented which may have reduced potential socio-economic impacts. A

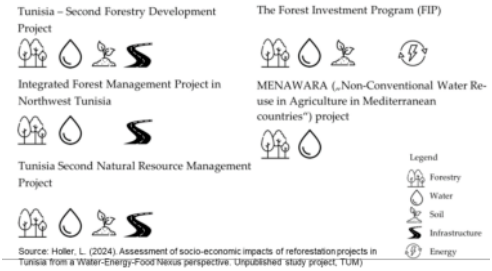

Figure 30: Review of major forestry projects in Tunisia (Holler L, TUM)

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) ranking was used to identify types of materials, vehicles and irrigation methods with the lowest carbon footprint for the implementation of sustainable reclaimed water irrigation infrastructure to support reforestation activities. In the next phase of project activities, groundwater availability will

Table 1. Carbon footprint rankings the least (1) to the most (9) for different pipe materials

DN (mm)	150				200				
Material	CS	CS, recycled	GFR-RTP	CF-RTP	GRE	CS	HDPE	PVC	DI
Ranking	7	1	5	6	4	8	3	2	9

Legend: Carbon Steel (CS), Recycled (50%) CS, Glass Fiber Reinforced Thermoplastic Pipe (GFR-RTP), Carbon Fiber Thermoplastic Pipe (CF-RTP), Glass Reinforced Epoxy (GRE) in DN150 and High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC) and Ductile Iron (DI)

Table 2. Carbon footprint rankings the least (1) to the most (8) for different truck options

Figure 31: TOPSIS-Ranking of the carbon footprint of different irrigation materials (Yildiz B, TUM))

be modelled, and a socio-economic survey will be designed and implemented. As well, an analysis of the potential for generation of carbon credits from forestry projects in Tunisia will be conducted.

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Research Group Urban Microbiology

The Emmy-Noether Junior Research Group Microbial Systems focuses on the investigation of microbial processes in aquatic and technical systems ranging from biological wastewater treatment to surface water ecosystems. Microorganisms are tiny, yet crucial organism that cycle our planets resources and keep our biosphere balanced, and thus provide vital ecosystem services. We are interested in the microbiomes of engineered and natural water treatment. Our overall aim is to develop tools that specifically measure and qualitatively assess microbes and their functions in water systems. We perform hypothesis-driven and explorative research that allows us to link microbes to ecosystem services.

Our research hereby focuses on the interaction and diversity of organisms within microbial biofilms with a focus on fungi and their function. Fungi produce very efficient exoenzymes that can transform difficult-to-degrade organic substances. Of particular interest are the largely unexplored aquatic fungi (so-called dark fungal taxa) and their diverse functions in the environment. We are also interested in the detailed characterization of the taxonomic and functional diversity of microbial communities with specific capabilities, e.g., microbial degradation or antibiotic resistance genes in the water cycle. Most recently, we started to explore the potential of biomarkers in raw wastewater as a source of information, which started in by quantifying biomarkers from the SARS-CoV-2 virus, and is now extending to other informative biomarkers, such as antibiotic resistances and pharmaceuticals.

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

Since the onset of the SARS-CoV-2 pandemic, wastewater-based epidemiology (WBE) has emerged as a valuable tool for tracking infectious disease outbreaks by quantifying human biomarkers in wastewater. A harmonized workflow, encompassing all stages from sample collection to data visualization, is critical for ensuring reliable results.

To achieve this, we developed a GIS-based data model that integrates the entire WBE process, from sampling to data visualization. This system, created in collaboration with public health authorities, has demonstrated its effectiveness in pandemic response efforts. Given the natural variability of wastewater data due to the complex dynamics of sewer systems, we incorporated an automated quality control algorithm designed to filter out potential outliers based on predefined criteria.

A key focus of our research is understanding the influence of sewer system characteristics and sampling strategies on biomarker concentrations. We hypothesize that community size and sewer network length significantly impact the diurnal variability of biomarker levels. To test this, 48-hour sampling campaigns were conducted in seven communities across southern Germany, measuring SARS-CoV-2 biomarkers and additional surrogate parameters, such as indicator viruses and chemical tracers, to explore normalization strategies. Results suggest that smaller communities exhibit greater diurnal variability in biomarker concentrations, likely due to shorter retention times within the sewer network.

Additionally, our methodology is being expanded to include new biomarkers, such as antibiotic-resistance genes. This extension aims to broaden the scope of WBE within a One Health framework, enhancing its potential for comprehensive public health surveillance.

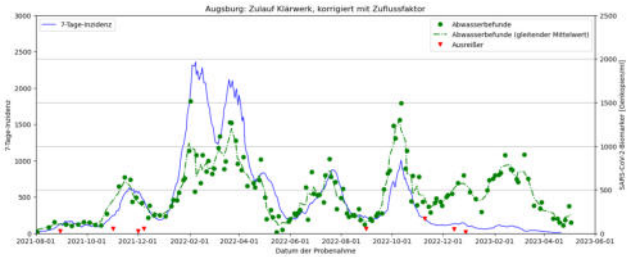

Figure 32: SARS-CoV-2 biomarker course compared to 7-day incidence rate from Robert Koch-Institute (RKI), Augsburg wastewater treatment plant influent.

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GERMAN RESEARCH FOUNDATION (DFG)

COLLABORATION:

EPFL VALAIS WALLIS, ALPINE AND POLAR ENVIRONMENTAL RESEARCH CENTER (ALPOLE)

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

Freshwater ecosystems are among the most impacted on Earth, having high rates of biodiversity loss due to ongoing climate change and anthropogenic pollution, such as industrial wastewater effluents and urban and agricultural runoff, among others. The current rates of species loss across many organism groups imperils the maintenance of the ecosystem services they provide, including nutrient recycling, carbon sequestration and water purification. Microbial decomposers, particularly aquatic fungi, are known to play a vital role in ecosystem dynamics in freshwater forested streams, relying on the energy input from allochthonous sources, such as leaf litter. This group is the main contributor to carbon and nutrient cycling, by producing and secreting extracellular enzymes that: (i) break down polymeric and recalcitrant organic matter into smaller, assimilable molecules and (ii) cycle nutrients, such as nitrogen and phosphorus. Despite their pivotal role in freshwater ecosystem functioning, the taxonomic and functional diversity of these fungi is currently poorly understood and characterized. The lack of knowledge on this group is even more striking when considering their genetic diversity, particularly their potential to remove recalcitrant compounds and pollutants. In order to help fill in these knowledge gaps, this project aims to: (I) develop strategies for identification and characterization of unknown aquatic fungi in different aquatic environments, (II) gain insight into aquatic fungal diversity and functioning in pristine and impacted aquatic environments , across distinct alpine zonations and (III) Understand the community dynamics of genetic expression during the degradation process, using a model system. To enable these analyses, the development and optimization of standardized workflows for rapid characterization and isolation of fungal isolates (single cells and pure cultures), (meta-)barcoding, and metatranscriptomics of aquatic fungi are sought.

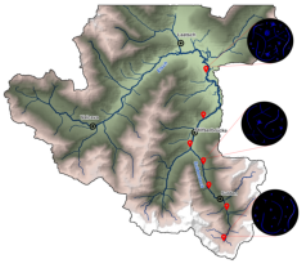

Figure 33: Aquatic fungal diversity across an altitudinal gradient in a glacier-fed stream.

Aquatic fungi in biofilms of water treatment systems: Abundance, dependencies and function of *Cryptomycota*

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FUNDING

COLLABORATION:

COLLABORATION

Fungi are known to be dominant in terrestrial systems, performing biological breakdown of organic carbon, which is crucial for the carbon cycle. However, their role in the aquatic environment is largely uninvestigated. Different environmental and diversity studies show their presence in a brought spectrum of aquatic habitats and highlight the lack of knowledge of this kingdom. In the last years even a whole new phylum, the *Cryptomycota*, was discovered and proven to be present in almost every water sample taken. Especially in engineered biological systems, it is crucial to consider the fungal kingdom during investigations to understand and optimize the work considering the whole microbial community. The superordinate objective of this research is to gain insight into and a better understanding of the fungal community in WWTPs in general with a focus on *Cryptomycota*. To enable this, existing molecular biological methods needed to be adjusted, leading to the development of a specific and reliable qPCR protocol targeting *Cryptomycota*. After this achievement, the microbial community in down-flow hanging sponge (DHS) reactors is used as a model community to get insight into the abundance and interactions of fungi and other microorganisms involved in wastewater treatment. The reactor performance was analysed and comprehensive quantitative and qualitative (Illumina sequencing) DNA and cDNA studies over reactor height and operation time were carried out. This gives insight into the diversity and abundance of microorganisms. To observe the function of *Cryptomycota* in those complex communities, correlation analyses are executed.

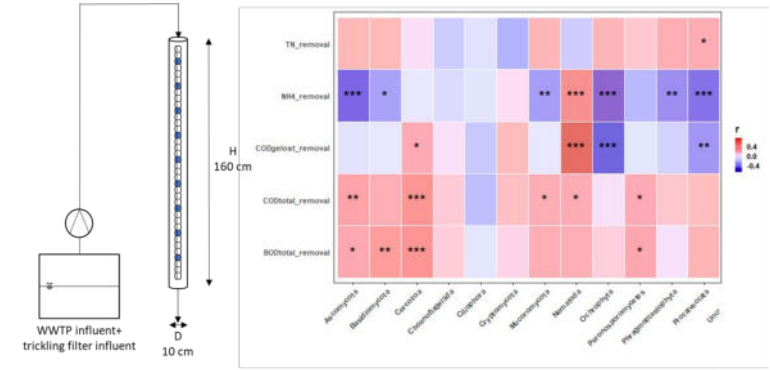

Figure 34: DHS reactor sketch and results of Spearman correlation between measured water parameters and 18s cDNA based classification.

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GERMAN SCIENCE FOUNDATION (DFG) EMMY NOETHER PROGRAM

COLLABORATION:

LEIBNIZ INSTITUTE OF FRESHWATER ECOLOGY AND INLAND FISHERIES (IGB), UNIVERSITY OF VIENNA, UNIVERSITY OF OXFORD

Shedding light into fungal dark matter: Ecology and genetic potential of Rozella sp. in lake Fuchskuhle

Aquatic fungi are vital components of aquatic ecosystems and food webs, yet a large portion of their diversity and ecology remains unexplored, termed fungal dark matter. The fungal group Cryptomycota / Rozellomycota, abundant in terrestrial and aquatic habitats, represents a significant portion of this unknown diversity. In this project, we investigate the ecological significance and evolution of a Cryptomycota representative using modern molecular methods. Our study focuses on a member of the Cryptomycota identified through metagenomic studies in the lake Grosse Fuchskuhle, a shallow and acidic bog lake in northern Germany, in collaboration with the Leibniz Institute of Freshwater Ecology (IGB). Using sequential water filtration and quantitative PCR, we localized the highest abundance of the organism in the water column at a depth of three meters. An 8.5-year time series of lake samples, provided by IBG, revealed seasonal abundance fluctuations **(a)**, with peak presence in the upper lake layers during winter months and positive correlations of the abundance with increased nutrient concentrations, especially nitrate and ammonium **(b)**. For genetic and evolutionary analysis, we isolated single Cryptomycota cells using laser dissection microscopy. DNA extraction and subsequent whole genome sequencing yielded a fungal genome size of 15 megabases, and allowed to place the organism in the evolutionarily early diverging subgroup of LKM46 Rozellida fungi. Ongoing genome analyses aim to uncover cellular structures linked to fungal evolution and adaptation to aquatic environments, processes related to phytoplankton degradation, and the organisms role in lake nutrient cycling.

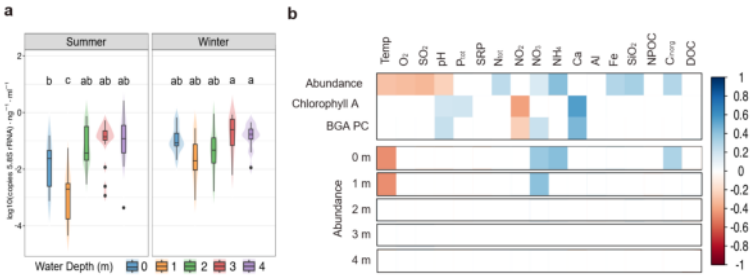

*Figure 35: **a)** Cryptomycota abundance in summer and winter at different depths. Letters: significant differences (ANOVA). **b)** Spearman correlations: abundance, chlorophyll a, phycocyanin (BGA PC), and physicochemical parameters across depths. Color intensity shows significant correlations ($p < 0.05$), from positive (blue) to negative (red).*

The fungal contribution to the carbon cycle of Subarctic and Arctic permafrost areas

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SWEDISH RESEARCH COUNCIL (VR)

COLLABORATION:

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Climate change is causing the thawing of Artic permafrost, which stores twice the amount of carbon than the atmosphere. The thawing process leads to the collapse of the landscape and the formation of thaw ponds that receive this organic matter (OM) and thus are considered hotspots for the carbon cycle. Microorganisms are responsible for breaking down organic compounds, which results in greenhouse gases (GHG) emissions. A massive release of previously frozen OM could not only threat Artic ecosystems but accelerate climate change globally. Therefore, there is an urge to understand how this OM is processed by microbial communities in thaw ponds, to further evaluate the impacts of a thawing Arctic. While there is a lot of ongoing research on this topic, a group of microorganisms is largely understudied: the aquatic fungi. Despite their role as decomposers of the OM in soil, we barely know about what fungi can do in water. Here I present my postdoc project aims to study the functional potential and carbon cycling activity of aquatic fungal communities in Arctic thaw ponds. Water and sediment from the ponds will be analyzed and combined with metagenomic data, fully sequenced fungal isolates, dissolved OM quality data, single cell sequencing, carbon assimilation assays (DNA stable-isotope probing) and metatranscriptomics to: a) analyze the functional potential, in terms of carbon degradation, of aquatic fungi across a thaw gradient (from pristine to degraded sites Figure 1); and b) conduct an in-depth functional analysis of the fungal community from a Swedish permafrost site significantly impacted by thawing. The degraded sites concentrate more terrestrial (allochthonous) OM, whereas the pristine sites present higher proportions of autochthonous dissolved OM, derived from primary production. These changes in OM were tightly linked to the taxonomic diversity of fungal species, and we have hypothesized that the functional potential of genes involved in carbon compounds breakdown would also be highly correlated with the quality of the OM. However, results showed weaker correlations, and thus, indicate functional redundancy of the fungal communities. Our next step now is to evaluate the activity of these genes through metatranscriptomics and stable isotope experiments. This project will increase the understanding on the role of aquatic fungal communities in carbon cycling in thaw ponds, an important step to better estimate the impacts of climate change in permafrost areas.

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Visiting Scientists

The uptake potentials of inorganic functional nanomaterials for environmental microplastics

The challenge of environmental microplastics (enMPs) in ecosystems has become a serious global concern. This is because the transport of enMPs has been known as a precarious culprit in depleting ecosystems, likely decreasing life expectancy, reducing the quality of human life, and threatening the future survival of fauna and flora. This menace is seriously threatening the continued existence and well-being of all biomes. Hence, this research attempts to provide a panacea to this global environmental issue through the application of Santa Barbara Amorphous silicas/zeolite composite (SSZC) for the removal of polystyrene microplastics (PMPs) from water and wastewater. This research showed that the adsorption capacity of SSZC for PMPs was 2.41 mgůg1. This was achieved by chemisorption between SSZC and PMPs via electrostatic attraction and hydrophobic interactions, such as covalent bonding, noncovalent aromatic -system, and electron donoracceptor interactions. The surface morphology of SSZC showed that CH, CO, CC, NH, AlO, SiOSi, and SiOH were the functional moieties present on its surface and available for adsorption.

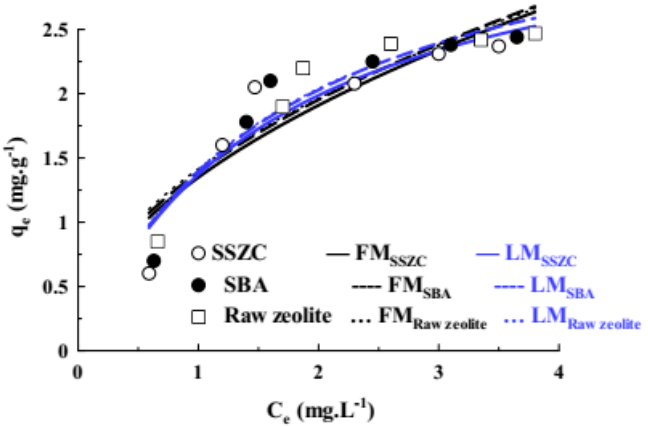

Figure 36: Nonlinear equilibrium plots of qe (mgůg-1) against Ce (mgůL-1) for the adsorption of PMPs by SSZC, SBA and raw zeolite.

Phenotypic and genetic evaluation of susceptibility to antibiotics and heavy metals of isolates of gram-negative bacteria from the Laguna de Tramandai

DNA extracted from water samples from 14 lagoons of Rio Grande do Sul, Brazil, is being used to perform qPCR, a technique that allows quantifying the abundance of antimicrobial resistance genes (blaOXA, blaVIM and ampC). In addition, the student will improve her bioinformatics skills by focusing on metagenome analysis of isolates to investigate the diversity of antimicrobial resistance genes in samples from 14 lagoons in Rio Grande do Sul, Brazil. These findings will be used to contribute to our research in Brazil on the project of microbial communities of shallow lakes in Brazil (Laboratory of Immunology and Microbiology, Faculty of Health and Life Sciences, Pontifical Catholic University of Rio Grande do Sul, PUCRS, Porto Alegre, Brazil.).

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Innovative anaerobic solutions towards defossilization

Anaerobic digestion is a key process for producing methane-rich biogas from organic waste effluents. This biogas can either be used on-site to generate electricity and heat or upgraded to grid-quality biomethane (>97 % methane content) for injection into the gas grid. Maximizing the production of grid-quality biomethane is particularly important to achieve the REPowerEU plan's objective of producing 35 billion cubic meters (bcm) of biomethane within the European Union by 2030.

During his research stay at SWW TUM, Dr. Sergi Vinardell collaborated in a review article exploring the ambivalent role of graphene oxide in enhancing biogas production during anaerobic digestion. This review was recently published in the journal Bioresource Technology: DOI:10.1016/j.biortech.2024.\\131663.

The stay also laid the foundations for future collaboration on Power-to-Gas projects focused on biomethane production, building upon the collaborative efforts initiated in a prior study: DOI: 10.1016/j.enconman.2024.118\\339.

In addition to research, Dr. Vinardell participated in teaching activities by taking over lectures in courses on Anaerobic Processes and Wastewater Treatment. This experience enriched both his academic engagement and the knowledge exchange with students.

Research Project

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(M.Sc.)

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Funding:

Coordination of Improvement of Higher Level Personnel (Capes-Brazil)

Although current environmental monitoring programs or experiments generate substantial amounts of data, these datasets remain underutilized due to challenges in statistical analysis and interpretation. This issue is particularly significant given the rapid technological advancements that yield increasingly large and complex datasets. Alongside data collection, modern computational advancements enable the processing of vast amounts of information. Machine learning (ML), a field of artificial intelligence focused on creating systems capable of learning and improving automatically from data and experience, has become a valuable resource in this context. In the modeling of environmental processes, ML demonstrates significant potential. ML provides tools for enhancing processes, developing predictive models, and detecting faults in complex environmental systems, leading to better decision-making and more efficient management. A large number of algorithms is available for diverse tasks (Figure 1), such as numerical or categorical prediction, data clustering, time series modeling, and determining variable importance.

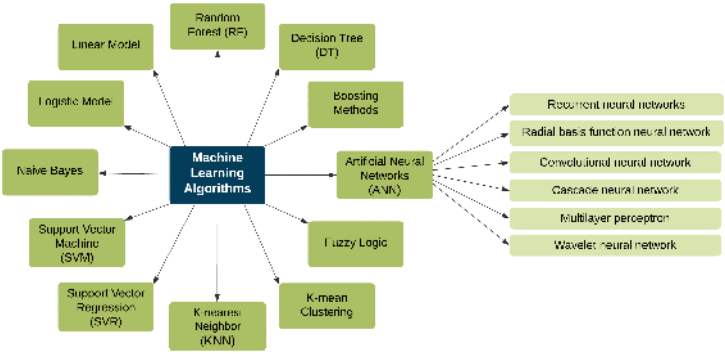

Figure 37: The most widely used ML algorithms

Marina Muniz de Queiroz, an external PhD student from Brazil, conducted her research for four months at TUM under the supervision of Prof. Dr. Konrad Koch. She focused on modeling data related to arsenic removal using membrane technologies and also initiated the modeling of data from experiments on microbiological methanation in a trickle bed reactor, conducted by Dr. Carolina Feickert Fenske. Her work illustrates the potential of ML to model environmental processes and enhance the understanding of their mechanisms.

International Collaborations

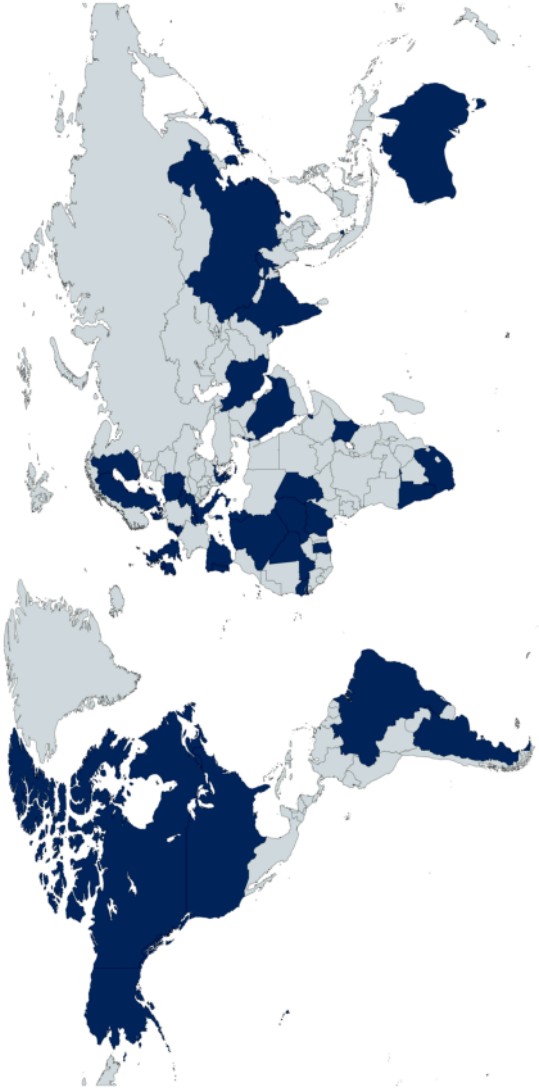

Figure 38: Map of international collaborations

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	Vienna University of Technology
Barbados	Eartland Global
Belgium	Ghent University
	ZABALA Brussels
Brazil	Universidade Federal de Minas Gerais
	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
Czech Republic	University of Chemistry and Technology
Denmark	Aalborg University
	Aarhus University
Djibouti	Ministry of Environment and Sustainable Development (GGW Country Office)
Ethiopia	Bahir Dar Institute of Technology
Finland	Aalto University
	Kemira Oyj
	Oulu University
Ghana	Kwame Nkrumah University of Science and Technology
	West African Science Services Centre on Climate Change (WASCAL)

Country	Institution
Greece	National Technical University of Athens
Hong Kong	City University of Hong Kong
	The University of Hong Kong
India	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
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
Poland	Pozna University of Technology
Portugal	University of Minho

Country	Institution
Saudi Arabia	King Abdullah University of Science and Technology
Senegal	Cheikh Anta Diop University of Dakar (UCAD)
	Senegalese Agency for Reforestation and GGW (GGW Country Office)
Singapore	National University of Singapore
South Africa	University of Cape Town
	Vaal University of Technology
South Korea	National Institute of Environmental Research
	Ulsan National Institute of Science and Technology
Spain	Catalan Institute for Water Research
	CSIC (Consejo Superior de Investigaciones Científicas)
	ICREA (Catalan Institution for Research and Advanced Studies)
	Polytechnic University of Catalonia
	University of Barcelona
	University of Girona
Sweden	Lund University
	University of Gothenburg
Switzerland	Agroscope
	Ecole Polytechnique Fédérale de Lausanne
	Swiss Federal Institute of Aquatic Science and Technology (EAWAG)
	Swiss Federal Institute of Technology
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

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. In 2024, the IWA LET took place in Germany for the first time.

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). 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 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". .

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", a

subcommittee of the German Water Chemistry Society. The group develops the current state of knowledge and perspectives for dealing with pathogens in the water cycle.

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. **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). Furthermore, he is a guest editor of the following special issues:

- Biogas - Actual Research and Application in „Bioresource Technology“
- Nutrient removal and resource recovery in „Water Research X“
- 18th IWA World Conference on Anaerobic Digestion in „Bioresource Technology“

33rd Water Technology Seminar and 51st Wastewater Technology Seminar

In 2024, we organized the 33rd Water Technology Seminar with the topic ”The new Drinking Water Ordinance and its significance for drinking water supply in Bavaria”.

The 51st Wastewater Technology Seminar (ATS) took place in Garching in July with a focus on the new EU Urban Wastewater Directive. Both events were very well attended with exciting discussions.

The 52nd ATS is planned for next year on July 16, 2025 in Garching with the title ”The digitalization of the water industry”

IFAT 2024

Once again this year, the Chair of Urban Water Systems Engineering and the Research Center had a booth at IFAT. As before, we were again at the Bayern Innovativ joint booth. Many company visitors and students were interested in the Chair's research activities and services (e.g. feasibility studies, analytics) and used the personal discussions to find out more. The tasting of Reuse Brew attracted particular attention!

Services: https://www.cee.ed.tum.de/en/sww/service/

Contact: Dr.-Ing. Benedikt Aumeier

Figure 39: IFAT group picture

Figure 40: IFAT presentation by Prof. Jörg E. Drewes at the Blue Stage

Figure 41: IFAT booth ready to begin

WEFE Nexus at IFAT 2024

A cross-sectoral multi-stakeholder event on Water Security in Africa - An integrated Water-Energy-Food-Ecosystems (WEFE) Nexus perspective at the IFAT Munich 2024 was hosted by the WEF Nexus Research Group in collaboration with the Bavarian State Ministry of the Environment and Consumer Protection (StMUV) and the Bavarian Research Alliance (BayFOR). Invited international speakers from government, academia, NGOs, and funding organizations addressed Challenges & Opportunities of an integrated WEFE Nexus approach to improve water security in Africa during a panel discussion with words of welcome from Dr. Melanie Habelitz-Wollgam (Bavarian State Chancellory) and moderated by Dr. Klaus Arzet (StMUV). Key questions were:

1. Why is the WEFE Nexus a valid approach to augment water security in Africa?
2. What are the key technologies (e.g., nature-based solutions) to support water retention in ecosystems through groundwater recharge locally, as a key Nexus opportunity?
3. How can the Nexus approach be strengthened in the context of academia, NGOs, policy, and industry to facilitate Nexus-based ecosystem regeneration?

In a following open-to-the-public workshop with approx. 60 participants Implementation & Transfer of Solutions on the topic were debated in a round table discussion. The session was kicked-off by Prof. Dr. Martin Grambow and moderated by Dr. Klaus Arzet (StMUV) and Dr. Thomas Ammerl (BayFOR) and focused on:

1. The applicability of Nexus approach? What are the major challenges/gaps in implementation, and how can these be used as opportunities based on prior successful experiences?
2. How can an effective and impactful transfer of solutions be facilitated?
3. How can continuity/financial issues leading to unsustainable short-term projects be overcome?

Outcomes of the event were consolidated in a White Paper that reflects the importance of embracing the WEFE Nexus approach with collaborative multi-sectoral partnerships that address water-security in a transdisciplinary approach to generate new solution-oriented knowledge and focusing on participatory community engagement (co-design and co-creation) from an early stage.

Figure 42: Panellists (left to right): Dr. Daphne Keilmann-Gondhalekar (TUM), Toni Rinaudo (World Vision), Dr. Elias Nkiaka (UNCCD consultant), Dr. Ambe Emmanuel Cheo (UNU-EHS), Prof. Dr. Akica Bahri (Former Minister of Agriculture, Water Resources and Fisheries, Tunisia), Gottlieb Arendse (Western Cape Government, South Africa), Dr. Peter Renner (Allianz Foundation for Development and Climate), Prof. Dr.-Ing. Jörg E. Drewes (TUM).

Figure 43: Participants at the workshop Water Security in Africa - An integrated Ecosystems WEFE Nexus perspective: Implementation & Transfer of Solutions at IFAT Munich 2024.

Figure 44: Meeting with the State Minister Thorsten Glauber (left to right: Dr. Sihem Jebari, Kwadwo Asamoah, Dr. Pascal Finkbeiner, Prof. Dr. Kevin Winter, Prof. Dr. Akica Bahri, Toni Rinaudo, Dr. Daphne Keilmann-Gondhalekar, Thorsten Glauber, Gottlieb Arendse).

Convergence Symposium on May 13, 2024 TUM, Garching

As part of the project activities for the Integrated Forest, Water, Prosperity Project Tunisia. Convergence research project a symposium was organized by the Water-Energy-Food (WEF) Nexus Research Group in collaboration with the Bavarian State Ministry of the Environment and Consumer Protection (StMUV) and the Bavarian Research Alliance (BayFOR). The aim was to bring together key Bavarian and African stakeholders from government, non-governmental organizations and academia as well as international experts to share research and practice experiences and facilitate a dialogue on the role of forests in improving water security, ecosystem regeneration and socioeconomic development.

Participating in the hybrid symposium were representatives of the Bavarian State Ministry of the Environment and Consumer Protection (StMUV), - Germany, Technical University of Munich (TUM), Germany, National Research Institute of Rural Engineering, Water and Forests (INRGREF), Tunisia, Western Cape Government (WCG), South Africa, University of Cape Town (UCT), South Africa, Kwame Nkrumah University of Science and Technology (KNUST),Ghana as well as international experts such as Right Livelihood Award winner Tony Rinaudo (Principal Climate Action Advisor, World Vision Australia) who pioneered the Farmer Managed Natural Regeneration technique for reforestation that has been successfully implemented in 20 countries, Akiça Bahri (Agricultural engineer and former Minister of Agriculture in Tunisia), Anastasia Makarieva and Andrei Nefiodov (Russian physicists) who are leading researchers on the Biotic Pump Theory for ecosystem regeneration.

In the first part of the symposium, participants gave presentations on their research on topics including the Water-Energy-Food-Ecosystems (WEFE) Nexus approach, valorization of non-wood forest products, ecoclimatology and ecosystem regeneration. This was followed by a roundtable discussion to deliberate on research results presented and the relationship between the sectors forest, water and ecosystems. Key conclusions from the roundtable discussions include the following:

1. Increasing trust in the WEFE Nexus approach can be achieved by incorporating the approach in research projects and data collection, as well as model validation using collected data.
2. The WEFE Nexus approach has the potential to increase resilience of ecosystems.
3. WEFE Nexus projects should include incentives (especially socioeconomic) for vulnerable communities to facilitate better adoption

of actions that support the WEFE Nexus approach.

4. More research is needed concerning ecosystem regeneration, especially its chances for success in different local climatic contexts?

The symposium allowed for multi-sectoral deliberations on how the WEFE Nexus approach can be leveraged to maximize the positive impacts of forests on water security, ecosystem regeneration and socioeconomic development.

Figure 45: Convergence Symposium 2024

Figure 46: Convergence Symposium 2024

Excursion to track Munichs drinking water sources in the valley of Mangfall

On 22 November 2024, as part of the Water and Wastewater Treatment Engineering lecture, numerous students on the Master's degree program in Environmental Engineering went on an excursion to the water extraction plants in the Mangfall Valley, the source of Munich's drinking water. Did you know that Munich's water supply is unparalleled anywhere in the world? The water gushes out of the mountain slopes in the Mangfall Valley, mostly by gravity. It then travels by gravity to Munich, where the water is usually supplied to consumers untreated (!). Why untreated? Because it is already of the best quality and requires no chemical treatment. Only occasionally is UV disinfection carried out to be on the safe side. For a metropolis with almost 2 million inhabitants, this is quite unique in the world! How does it work? Thanks to the existing geology coupled with the abundant groundwater recharge in the foothills of the Alps. And above all, because the catchment area is well protected. Sustainable forestry and organic farming play a key role here: good forest, good soil, good water. Jochen Vogel, responsible for the water extraction plants at Stadtwerke München, explained all this to us in a clear and lively manner. But not everyone is so enthusiastic about Munich's water supply. Some local residents are more interested in opening up and developing the area: roads, the establishment of businesses, increasing agricultural yields... Then the historic water rights are sometimes contested by petition. One possible background: without a reform of German federalism, trade tax is often the only option for municipalities to bring money into their sometimes strapped municipal treasuries. And some farmers would probably prefer to engage in intensive farming in the belief that they are missing out on income - despite compensation payments for not using organic fertilizers from Stadtwerke München. This conflict is symbolic of numerous conflicts over water that are being waged energetically in many other places in Germany and elsewhere. Speaking of energy: on the way to Munich, the water is used to produce electricity using hydropower. Jochen Vogel is beaming again as he explains the technical aspects. And that is catching. The students were able to experience all of this - sugared up by the first snow of the year.

Text: Dr.-Ing. Benedikt Aumeier

Organization: Prof. Dr.-Ing. Jörg E. Drewes

Figure 47: Excursion Munich's water supply

Company Outing 2024

This year, the weather finally cooperated and we were able to go on the canoe trip in the Altmühltal valley that had already been planned for 2023. We paddled along the Altmühl from Solnhofen in summery temperatures. We enjoyed the beautiful panorama and the cool water. After a few wild water battles, during which one or two of us went overboard, we fortified ourselves with a lunch break in the beer garden. After a few more kilometers on the Altmühl, our tour ended in Dollnstein. After a cool drink, we set off on our journey home.
Special thanks to Brigitte Helmreich and Felicia Linke for the great organization!

Figure 48: Company outing 2024 canoe trip Altmühl

Figure 49: Company outing 2024 canoe trip Altmühl

Scienclisten

In 2024, the employees of the Chair of Urban Water Management cycled a total of over 18,107 km on their way to work. This corresponds to a CO_2 saving of around 2.6 tons compared to a car and 6.9 tons compared to an airplane (economy). Daniel Nieß achieved the highest individual mileage this year, for which he was awarded the Chair's Scienclisten Cup.

Publications

Peer-reviewed Journal Articles

1) Anjorin, E. O., Alfred, M. O., Sotunde, B., Nnamani, E. A., Bayode, A. A., Unuabonah, E. I., Helmreich, B. and Omorogie, M. O. (2024). Overview of the Mechanism of Degradation of Pharmaceuticals by Persulfate/Peroxysulfate Catalysts. *ChemBioEng Reviews*, e202300079.

2) Arzabe, C., Pütz, P., Wurzbacher, C., Uchaikina, A., Drewes, J. E., Braun, U., Bannick, C. G., Obermaier, N. (2024). Wastewater-based Epidemiology: Deriving a SARS-CoV-2 Data Validation Method to Assess Data Quality and to Improve Trend Recognition. *Frontiers in Public Health*, 12, 1497100.

3) Bayode, A. A., Badamasi, H., Olusola, J. A, Durodola, S. S., Akeremale, O. K., Ore, O. T., Helmreich, B., Omorogie, M. O. (2024). One pot synthesis of ZnO-activated eggshell@kaolinite: Sorbents for phosphate capture in water. *Chemical Engineering & Technology*, 47(2), 375386.

4) Bayode, A. A., Emmanuel, S. S., Osti, A., Olorunnisola, C. G., Egbedina, A. O., Koko, D. T.; Adedipe, Demilade T.; Helmreich, B., Omorogie, M. O. (2024). Applications of perovskite oxides for the cleanup and mechanism of actionof emerging contaminants/steroid hormones in water. *Journal of Water Process Engineering*, 58, 104753.

5) Bayode, A. A.; Ore, O. T.; Nnamani, E. A.; Sotunde, B.; Koko, D. T.; Unuabonah, E. I.; Helmreich, B; Omorogie, M. O. (2024). Perovskite oxides; Syntheses and perspectives on their application for nitrate reduction. *ACS Omega*, 9, 1977019785.

6) Bein, E., Pasquazzo, G., Dawas, A., Yecheskel, Y., Zucker, I., Drewes, J. E., Hübner, U. (2024). Groundwater remediation by in-situ membrane ozonation: Removal of aliphatic 1,4-dioxane and monocyclic aromatic hydrocarbons. *Journal of Environmental Chemical Engineering*, 111945, 3.

7) Bhanye, J., Kloeffel, T., Beyers, M., Mabaso, M., Rajadirai, K., Winklmaier, J., Matamanda, A. (2024). Decentralised WaterEnergyFood (WEF) systems in Africa: space analysis, least-cost modelling of sack farming and establishment of renewable energy technologies in the Diepsloot slums of Johannesburg, South Africa. *Discover Global Society*, 2, 24.

8) Cao, S., Cheng, Z., Koch, K., Fang, J., Du, R. Peng, Y. (2024). Municipal wastewater driven partial-denitrification (PD) aggravated nitrous oxide (N2O) production. *Journal of Cleaner Production*, 434, 139916.

9) Drewes, J.E. (2024). More water through desalination and water reuse. Gwf Wasser Abwasser 165 (4), 106.

10) Dueholm, M. K. D., Andersen, K. S., Korntved, A.-K. C., Rudkjøbing, V., Alves, M., Bajón-Fernández, Y., Batstone, D., Butler, C., Cruz, M. C., Davidsson, Å., Erijman, L., Holliger, C., Koch, K., Kreuzinger, N., Lee, C., Lyberatos, G., Mutnuri, S., OFlaherty, V., Oleskowicz-Popiel, P., Pokorna, D.; Rajal, V., Recktenwald, M., Rodríguez, J., Saikaly, P. E., Tooker, N.; Vierheilig, J., De Vrieze, J., Wurzbacher, C., Nielsen, P. H. (2024). MiDAS 5: Global diversity of bacteria and archaea in anaerobic digesters. *Nature Communications*, 15, 5361.

11) Eben, P., Duthweiler, S., Helmreich, B., Knoll, S., Stinshoff, P., Pauleit, S. (2024). Thriving under multiple stressors: performance of drought-tolerant perennials and their suitability for infiltration swales. *Urban Forestry & Urban Greening*, 101, 128535.

12) Eben, P., Mohri, M., Pauleit, S., Duthweiler, S., Helmreich, B. (2024). Phytoextraction potential of herbaceous plant species and the influence of environmental factors a meta-analytical approach. *Ecological Engineering*, 199, 107169.

13) Ho, J.; Ahmadi, J.; Schweikart, C.; Hübner, U.; Schwaller, C.; Tiehm, A.; Drewes, J.E. (2024). Assuring reclaimed water quality using a multi-barrier treatment train according to the new EU non-potable water reuse regulation. *Water Research*, 267, 2024, 122429.

14) Ili, N., Tan, K., Mayr, F., Hou, S., Aumeier, B. M., Morales, E. M. C., Hübner, U., Cookman, J., Schneemann, A., Gagliardi, A., Drewes, J. E., Fischer, R. A., Mukherjee, S. (2024). MOF surface chemistry enables trace removal of PFAS from water *Advanced Materials*, 2413120.

15) Hübner, U., Ahmadi, J., Kubiak, S., Drewes, J.E. (2024): Reuse Brew. *Food Lab International*.

16) Knoll, S. Mindermann, S., Porter, L., Pauleit, S., Duthweiler, S., Prügl, J., Helmreich, B. (2024). The potential of processed mineral construction and demolition waste to increase the water capacity of urban tree substrates - A pilot scale study in Munich. *Sustainable Cities and Society*, 113, 105661.

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18) Mitranescu, A., Patel, M., Panglisch, S., Drewes, J. E., ElSherbiny, I. M. A. (2024). Critical Assessment of the State-of-the-Art of Surface-Patterned Water Separation Membranes and Future Research Needs *ACS ES&T Water*.

19) Mohapatra, S., Xian, J., Galvez-Rodriguez, A., Ekande, O., Drewes, J. E., Gin, K. (2024). Photochemical fate of quaternary ammonium compounds (QACs) and degradation pathways predication through computational analysis. *Journal of Hazardous Materials*, 465, 133483.

20) Nilsson, R. H., Jansson, A. T., Wurzbacher, C., Anslan, S., Belford, P., Corcoll, N., ... , Kristiansson, E. (2024). 20 years of bibliometric data illustrates a lack of concordance between journal impact factor and fungal species discovery in systematic mycology. *MycoKeys*, 110, 273-285.

21) de Oliveira, C., Sperle, P., Arcanjo, G., Koch, K., Viana, M., Drewes, J. E., Amaral, M.C. (2024). Successful application of photocatalytic recycled TiO2-GO membranes for the removal of trace organic compounds from tertiary effluent. *Chemosphere*, 362, 142730.

22) Omorogie, M., Helmreich, B. (2024). Exploring the potential of amino-functionalized zeolite series/H3PO4-biochar for environmental microplastics removal. *Industrial & Engineering Chemistry Research*, 63, 3947-3961.

23) Omorogie, M., Helmreich, B. (2024). The uptake potential of Santa Barbara amorphous silica/zeolite composite for environmental microplastics in wastewater. *ACS Environmental Science and Technology Water*.

24) Ponzelli, M., Koch, K., Drewes, J., Radjenovic, J., Vinardell, S. (2024). The ambivalent role of graphene oxide in anaerobic digestion: A review. *Bioresource Technology*, 414, 131663.

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28) Stinshoff, P., Henn, Y., Rommel, S., Helmreich, B. (2024). Heavy metal leaching from stormwater control measures Insights of field and lab prestressed media and road-deposited sediments. *Environmental Science: Water Research & Technology*.

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31) Vinardell, S., Fenske, C., Heimann, A., Cortina, J.L., Valderrama, C., Koch, K. (2024). Exploring the potential of biological methanation for future defossilization scenarios: Techno-economic and environmental evaluation. *Energy Conversion and Management*, 307, 118339.

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assessment, kinetic prediction and influence of inorganic anion. *Environmental Science & Technology*, 58(16), 7113-7123.

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Other Journal Articles and Book Contributions

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2) Cao, L., Garcia, S. L., & Wurzbacher, C. (2024): Profiling trace organic chemical biotransformation genes, enzymes and associated bacteria in microbial model communities. bioRxiv, 2024-03.
3) Eiler, A., Martin-Sanchez, P. M., Wurzbacher, C., Fontaine, L., Jimenez Lara, M., Juottonen, H., ... & Nilsson, H. (2024): Low determinism in pelagic fungal community assembly across climate zones in Scandinavian lakes. bioRxiv, 2024-06.
4) Mariz, J., Nawaz, A., Bösch, Y., & Wurzbacher, C. (2024): Exploring environmental microfungal diversity through serial single cell screening. bioRxiv, 2024-05.

Conferences (Oral Presentations)

1) Ahmadi, J., Ho, J., Hübner, U., Drewes, J.E. (2024, June 24-28). Ensuring proper removal of viruses & mobile genetic elements during water reclamation employing ceramic ultrafiltration combined with pre-ozonation & coagulation, IWA Leading Edge Technologies, Essen, Germany.
2) Aniol, J., Greskowiak, J., Hübner, U., Sperlich, A., Filter, J., Bartels, Y., Gerdes, H., Ergh, M., Drewes, J.E. (2024). Employing rapid infiltration trench technology to establish stable redox conditions in a heterogeneous aquifer for drinking water production. IWA Leading Edge Technology Conference, 24-28 June 2024, Essen, Germany.
3) Aumeier, B.M., Kau, A.-S.; Drewes, J.E. (2024, July 1). Optionen der Spurenstoffentfernung für kleine Kläranlagen, 51. Abwassertechnisches Seminar, Garching, Germany.
4) Aumeier, B.M., Tenberken, N., Wintgens, T. (2024, May 6-8). Size-exclusion ideal adsorbed solution theory for adsorption prediction of micropollutants of different molecular weight [presentation], Wasser - Jahrestagung der Wasserchemischen Gesellschaft, Limburg/Lahn, Germany.
5) Bardi, M., Koch, K. (2024, June 2-6). CO2 enrichment improves the efficiency of anaerobic digestion. 18th IWA World Conference on Anaerobic Digestion, Istanbul, Turkey.
6) Bein, E.,Yecheskel, Y., Zucker, I., Khan, S., Aumeier, B. M., Drewes, J.E., Hübner, U. (2024, June 24-28). A novel catalytic oxidation process employing peroxymonosulfate activation in a fixed bed catalyst filter, IWA Leading Edge Technologies, Essen, Germany.
7) Bösch, Y., Grossart, H. P., Woodhouse, J., Kluge, M., Baltar, F., Fischer, K., Breyer, E., Wurzbacher, C. (2024, August 11-15). Unveiling seasonal dynamics: shedding light on the functional potential of unexplored planktonic cryptomycota. IMC12, Maastricht, Netherlands.
8) Drewes, J. E., Ahmadi, J., Aumeier, B. M. (2024, May 6). Nutzwasser: Water Reuse for Agricultural Irrigation. DWA Innovation Forum Water Technologies for Water Reuse, IFAT, München, Germany.
9) Drewes, J. E., Ahmadi, J., Aumeier, B. M. (2024, May 6). Water Reuse for Agricultural Irrigation. 21th EWA International Symposium: "Water and Recovery of Resources", IFAT, München, Germany.

10) Drewes, J.E., Ahmadi, J. (2024). Considerations of integrating contaminants of emerging concern in the risk management of water reuse in Germany. JRC Water Reuse Technical Workshop, 26 January 2024.

11) Drewes, J.E., Helmreich, B., Aumeier, B., Wurzbacher, C., Koch, K., Gondhalekar, D. (2024). Rapid Change Adaptation Strategies in man-made Hydrosystems Securing Water in Towns and Cities of the Future. Water Cluster Symposium on RACE. 23 February 2024, Garching, Germany.

12) Drewes, J.E., Ahmadi, J., Aumeier, B. (2024). Erfahrungen mit dem Einsatz von Nutzwasser als alternative Bewässerungsstrategie im Gemüsebau. Gemüsebautage 2024, 26 February 2024, Oedheim, Germany.

13) Drewes, J.E., Ahmadi, J., Aumeier, B.,m Ho, J., Tiehm, A. (2024). Nutzwasserbereitstellung und Planungsoptionen für die urbane und landwirtschaftliche Bewässerung. Essener Tagung, 8 March 2024, Essen, Germany.

14) Drewes, J.E. (2024). Reuseful die Chancen. WassArena DVGW Water reuse notwendig oder überflüssig?, 26 April 2024, Berlin, Germany (Keynote).

15) Drewes, J.E. (2024). Water Reuse Benefits and Risks. EWA Workshop Water Reuse Chance or Meander? IFAT 13 May 2024, Munich, Germany.

16) Drewes, J.E. (2024). Klimawandel und Wassermanagement philosophische und ethische Aspekte. HfP Brennpunkte philosophisch-ethischer Debatten zur Nachhaltigkeit, 6 June 2024, Hochschule für Philosophie, München, Germany.

17) Drewes, J.E. (2024). Improving Implementation of Managed Aquifer Recharge (MAR) Systems by Utilizing Updated Pathogen Removal Knowledge. NGWA Webinar - Addressing the Risks of Viruses in Managed Aquifer Recharge. 20 June 2024 (Keynote).

18) Drewes, J.E., Ahmadi, J., Galjaard, G., Hoeijmakers, R., Clement, J. (2024). Integrated Alternative Source Management to address water scarcity. IWA Leading Edge Technology Conference, 24-28 June 2024, Essen, Germany (Keynote).

19) Drewes, J.E., Snyder, S.A. (2024). Reinventing the urban water infrastructure a U.S./German perspective. International Seminar Safeguarding the Planets Water Supply, Bayerische Staatskanzlei, 4-5 September 2024, Schloss Hohenkammern, Germany.

20) Drewes, J.E. (2024). Water Reuse: Needs, Opportunities and Treatment Requirements. IWA Large Wastewater Treatment Plants Conference. 9-11 September, Budapest, Hungary (Keynote).

21) Drewes, J.E. (2024). Nutzwasserbereitstellung und Planungsoptionen für die urbane und landwirtschaftliche Bewässerung (Nutzwasser als alternative Wasserressource). Abschlussveranstaltung der BMBF-FördermaSSnahme WavE, 7-8 October 2024, Frankfurt, Germany.

22) Drewes, J.E. (2024). Trinkwave Transfer Projekt. Abschlussveranstaltung der BMBF-FördermaSSnahme WavE, 7-8 October 2024, Frankfurt, Germany.

23) Drewes, J.E. (2024). Aktuelle Herausforderungen und Chancen bei der Wasserversorgung und Wasserwiederverwendung. CDU/CSU Fraktionsausschuss Umwelt, Deutscher Bundestag, 15 October 2024. Berlin, Germany.

24) Drewes, JE., Ahmadi, J., Thiel, M., Aumeier, B. (2024). Nutzwasser in Schweinfurt - Implementierung als alternative Wasserressource. ReWater Braunschweig, 21-22 October 2024, Braunschweig, Germany.

25) Drewes, JE., Ahmadi, J., Thiel, M., Aumeier, B., Ho, J., Tiehm, A. (2024). Risikomanagement bei der Wasserwiederverwendung und Anwendung im Nutzwasser-Projekt. ReWater Braunschweig, 21-22 October 2024, Braunschweig, Germany.

26) Drewes, J.E. (2024). Latest Developments regarding the EU Urban Wastewater Treatment Directive. Ramboll Workshop, 3 October 2024, Stockholm, Sweden (Keynote).

27) Drewes, J.E. (2024). Wasser in einer aufgeheizten Welt. Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU). Vorstellung des Hauptgutachtens, 4 November 2024. Berlin, Germany.

28) Drewes, J. (2024). Herausforderungen und Möglichkeiten bei der Entfernung von Poly- und

perfluorierter Alkylsubstanzen in der Trinkwasseraufbereitung. WaBoLu Fortbildungstagung für Wasserfachleute. 6 November 2024, Berlin, Germany.

29) Drewes, J.E. (2024). Wasserverfügbarkeit tatsächliche und rechtliche Herausforderungen. 47. Jahrestagung der Gesellschaft für Umweltrecht, 7-9 November 2024, Leipzig, Germany (Keynote).

30) Drewes, J.E. (2024). Chancen, Synergien und Innovationen für die Etablierung der weitergehenden Abwasserreinigung in Deutschland. Oswald-Schulze Tagung, 12 November 2024, Münster, Germany.

31) Drewes, J.E. (2024). Towards Climate and Water Resilient Cities. Water EVER Lecture Series, Department of Sustainable Architecture, Technical University of Munich, 4 December 2024, Munich, Germany.

32) Drewes, J.E. (2024). Sustainable Urban Water and Wastewater Systems. TUM-UNESP Doctoral Summer/Winter School at TUM, 10 December 2024, Garching, Germany.

33) Gra, L., Hillebrandt, D., Aumeier, B.M., Palmowski, P., Wintgens, T. (2024, September 8-12). Biological degradation of micropollutants combining activated sludge systems and post-treatment activated carbon filters. The IWA 2024 Conference on the Design, Operation and Economics of Large Wastewater Treatment Plants, Budapest, Hungary.

34) Grüning, H., Helmreich, B. (2024, June 4-5). Baumrigolen Bedenken und Möglichkeiten. DWA-RegenwasserTage, Wiesbaden, Germany.

35) Helmreich, B., Stinshoff, P., Eben, B. (2024, June 4-5). Multifunktionale Versickerungsmulden im Siedlungsraum Schadstoffrückhalt und Biodiversität. DWA-RegenwasserTage, Wiesbaden, Germany.

36) Helmreich, B. (2024, October 14-15). Einführung in das neue Arbeitsblatt DWA-A 138-1. DWA-Seminarreihe Anlagen zur Versickerung von Niederschlagswasser, online.

37) Helmreich, B. (2024, October 16). Nachhaltiges Regenwassermanagement in der Siedlung - Den Folgen des Klimawandels entgegenwirken, 12. Kitzbüheler Wasser- und Energiesymposium, Kitzbühel, Austria.

38) Helmreich, B. (2024, October 14-15). Stoffliche Betrachtungen von Niederschlagswasser. DWA-Seminarreihe Anlagen zur Versickerung von Niederschlagswasser, online.

39) Helmreich, B. (2024, July 24). Umsetzung des Prinzips der wasserbewussten Siedlungsplanung für den Hochschul-Standort Neuburg. Ideenworkshop am 24. Juli am Campus Neuburg der THI im Rahmen des Projekts WaNdel!4, Neuburg, Germany.

40) Helmreich, B. (2024, October 14-15). Versickerung von Niederschlagswasser von stofflich stark belasteten von Dächern. DWA-Seminarreihe Anlagen zur Versickerung von Niederschlagswasser, online.

41) Helmreich, B. (2024, June 26). Wasserbewusste Siedlung Was ist zu erreichen, was ist zu beachte, Hochschule Weihenstephan-Triesdorf, PLV-Vortragsreihe der Fakultät Umwelttechnologie, Triesdorf, Germany.

42) Helmreich, B. (2024, March 12-14). Bau und Betrieb von Anlagen zur Versickerung von Niederschlagswasser was ist neu im Arbeitsblatt DWA-A 138? DWA-Kurs: Entwässerungssysteme und Wasserbewusste Stadtentwicklung, Kassel, Germany.

43) Helmreich, B. (2024, October 9). Blau-grüne Tools zum gezielten Regenwassermanagement in der wasserbewussten Stadtplanung. Seminar Regenwassermanagement und Bauwerksbegrünung, Akademie der Architektenkammer Nordrhein-Westfalen, online.

44) Helmreich, B. (2024, June 29). Blau-grüne Tools zum gezielten Regenwassermanagement in der wasserbewussten Stadtplanung. Seminar Regenwassermanagement und Bauwerksbegrünung, Bayerische Architektenkammer, München, Germany.

45) Helmreich, B. (2024, July 12). Blau-grüne Tools zum gezielten Regenwassermanagement in der wasserbewussten Stadtplanung. Seminar Regenwassermanagement und Bauwerksbegrünung, Bayerische Architektenkammer, München, Germany.

46) Helmreich, B. (2024, October 9). Versickerung von Niederschlagswasser das neue DWA-A 138-1, Seminar Regenwassermanagement und Bauwerksbegrünung. Akademie der Architektenkammer Nordrhein-Westfalen, online.

47) Helmreich, B. (2024, June 29). Versickerung von Niederschlagswasser das neue DWA-A 138-1, Seminar Regenwassermanagement und Bauwerksbegrünung. Bayerische Architektenkammer, München, Germany.

48) Helmreich, B. (2024, July 12). Versickerung von Niederschlagswasser das neue DWA-A 138-1, Seminar Regenwassermanagement und Bauwerksbegrünung. Bayerische Architektenkammer, München, Germany.

49) Helmreich, B. (2024, April 24). Vorstellung des Regelwerks DWA-A 138-1 Planung, Bau und Betrieb von Versickerungsanlagen. Seminar Anforderungen und technische Hinweise für die Regenwasserbehandlung in Baden-Württemberg, Heilbronn, Germany.

50) Kau, A.-S., Aumeier, B. M., Hübner, U., Drewes, J. E. (2024, June 16-20). Biofiltrationplus to remove TOrCs at small scale wastewater treatment plants. The 13th IWA Micropol & Ecohazard Conference, Taipei, Taiwan.

51) Kluge, M., Wurzbacher, C., Simone, D., Clemmensen, K.E., Stenlid, J., Garcia, S., Bertilsson, S., Peura, S. (August 2024, 11-15). Variation in functional potential of fungal carbohydrate-active enzymes across a thermokarst gradient in Arctic pods. IMC12, Maastricht, Netherlands.

52) Koch, K. (2024, August 24-30). Meet the Editor - Successful publishing in Engineering journals. TUM SEED Center - Annual Symposium 2024 at Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenia.

53) Koch, K., Feickert Fenske, C. (2024, September 2-4). Biological H2/CO2 methanation in trickle bed reactors Toward industrial application. International Conference Progress in Biogas VI, Stuttgart-Hohenheim, Germany.

54) Koch, K., Feickert Fenske, C., Drewes. J.E. (2024, July 3). Mit der Biomethanisierung zur Energieautarkie. Tagungsband zum 46. Abwassertechnischen Seminar Die neue EU-Kommunalabwasserrichtlinie und ihre Bedeutung für Bayern der TU München, Garching, Germany.

55) Koch, K., Feickert Fenske, C., Drewes, J. (2024, June 24-28). Ex-situ biomethanation as an energy buffer at WWTPs: Experiences from 450 days of operation at pilot-scale. 19th IWA Leading Edge Conference on Water and Wastewater Technologies, Essen, Germany.

56) Koch, K., Feickert Fenske, C., Strübing, D. (2024, November 12). Mit der Biomethanisierung zur energieautarken Kläranlage. Oswald-Schulze-Symposium "Technische Innovationen bei der Abwasserreinigung, Münster, Germany.

57) Koch, K., Hafner, S., Astals, S., Weinrich, S. (2024, September 2-4). Better BMP Free resources for improving the quality of biochemical methane potential tests. International Conference Progress in Biogas VI, Stuttgart-Hohenheim, Germany.

58) Koch, K., Hafner, S., Astals, S., Weinrich, S. (2024, June 2-6). Power and limitations of biochemical methane potential (BMP) tests. 18th IWA World Conference on Anaerobic Digestion, Istanbul, Turkey.

59) Koch, K., Macintosh, C., Sembera. C., Astals, S. (2024, October 16-17). Erfolgreiche Strategien zur energiepositiven Kläranlage Grüneck: Optimierte Belüftung und Co-Vergärung. 12. Kitzbüheler Wasser- und Energiesymposium, Kitzbühel, Austria.

60) Linke, F., Skodras, D., Leistert, H., Zimmermann, F., and Lange, J. (2024, April 1419). Biocides in urban groundwater modeling entry pathways at a district level, EGU General Assembly 2024, Vienna, Austria.

61) Linke, F.: Herausforderung Spurenstoffe im naturnahen Wasserhaushalt, 2024 Nov 21, 6. InDigWa Workshop Wasserknappheit, Online.

62) Mariz, J.; Nawaz, A.; Bösch, Y.; Wurzbacher, C. (2024, May 5-9). A novel approach for the identification and documentation of aquatic hyphomycetes diversity. 37th SIL 2024, Foz do Iguacu, Brazil.

63) Mitranescu, A., Drewes, J.E. (2024, June 24-28). Harnessing Hydrodynamic Effects of Assemblies of Surface-patterned Membranes and Feed Spacers to Reduce RO and NF Membrane Fouling: A Numerical Investigation, IWA Leading Edge Technologies, Essen, Germany.

64) Mitranescu, A., Drewes, J.E.(2024, September 8-12). Harnessing Hydrodynamic Effects of

Assemblies of Surface-patterned TFC Membranes and Feed Spacers to Mitigate Membrane Fouling: Euromembrane 2024, Prague, Czech Republic.

65) Müller, F.; Koch, K. (2024, June 16-19). Increased methane production through CO2 enrichment. Young Water Professionals European Conference, Kopenhagen, Denmark.

66) Müller, F.; Koch, K. (2024, June 2-6). Stimulation of methane production through CO2 enrichment. 18th IWA World Conference on Anaerobic Digestion, Istanbul, Turkey.

67) Munk, B., MöSSnang, B., Flad, V., Strübing, D., Koch, K., Lebuhn, M. (2024, September 2-4). Convergent microbiome development from different inocula in thermophilic biomethanation of H2 and CO2. International Conference Progress in Biogas VI, Stuttgart-Hohenheim, Germany.

68) Nie, D., Helmreich, B. (2024, September 22-24). 0ř- Dächer Einfluss von Kontaktzeit und Wassermatrix auf die Freisetzung von Mecoprop aus Bitumendachbahnen? Aqua Urbanica 2024: Urbanes Niederschlagswassermanagement: Herausforderungen Möglichkeiten Grenzen, Graz, Austria.

69) Nie, D., Helmreich, B. (2024, June 10-14). Leaching of Mecoprop from 0ř green roofs: How do extended water retention times and green roof materials influence the leaching of Mecoprop from bitumen sheets? 16th International Conference on Urban Drainage, Delft, The Netherlands.

70) Paez-Curtidor, N., Helmreich, B. (2024, September 22-24). Effekt von Biokohle auf die Adsorption von Schwermetallen und Bioziden in Bodenmischungen: Einblicke für begrünte Versickerungsmulden. Aqua Urbanica 2024: Urbanes Niederschlagswassermanagement: Herausforderungen Möglichkeiten Grenzen, Graz, Austria.

71) Paez-Curtidor, N., Porter, L., Helmreich, B. (2024, June 10-14). Insights on the pollutant removal resilience and implications on the hydraulic conductivity of biochar amendments in bioswales, 16th International Conference on Urban Drainage, Delft, The Netherlands.

72) Polag, D.; Müller, F.; Koch, K.; Keppler, F. (2024, September & October 30-02). Bioconversion of CO2 to CH4 during anaerobic digestion of Alfalfa indicated by 13CO2 labeling. Annual Meeting of the German Association for Stable Isotope Research, Darmstadt, Germany.

73) Polag, D., Müller, F., Koch, K., Lebuhn, M., Weigoldt, M., Keppler, F. (2024, June 2-6). Increasing CH4 productivity in anaerobic digesters by addition of CO2 The use of stable isotope techniques to identify the mechanisms. 18th IWA World Conference on Anaerobic Digestion, Istanbul, Turkey.

74) Rosenberger, L., Bechtel, D., Kleeberger, M., Helmreich, B. (2024, September 22-24). Klimagerechte MaSSnahmen im Wohnungsbau: Nutzenbewertung durch interdisziplinäre Betrachtung grau-grün-blauer Infrastruktur. Aqua Urbanica 2024: Urbanes Niederschlagswassermanagement: Herausforderungen Möglichkeiten Grenzen, Graz, Austria.

75) Rosenberger, L., Wood, R., Leandro, J., Helmreich, B. (2024, June 10-14). Water Demand and Availability at Urban Tree Sites: Impact of Climate Change Depending on Age and Tree Pit 16th International Conference on Urban Drainage, Delft, The Netherlands.

76) Steindl M., Venus J. T., Koch, K. (2024, June 2-6). The potential of agricultural residues for boosting biomethane production - A case study for Bavaria: 18th IWA World Conference on Anaerobic Digestion, Istanbul, Turkey.

77) Stinshoff, P., Helmreich, B. (2024, December 4-6). Treatment of road-deposited sediments from road runoff Experience and performance of infiltration swales. Tire Emissions Research Conference 2024, Munich, Germany.

78) Uchaikina, A., Maciossek, L., Wang, Q., Wurzbacher, C., Drewes, J. E. (2024, May 6-8). Wastewater-Based Epidemiology in the One Health Framework: Long-term analysis of potential and current biomarkers in Southern Germany, Wasser - Jahrestagung der Wasserchemischen Gesellschaft, Limburg/Lahn, Germany.

79) Uchaikina, A., Kahn, M.S., Wurzbacher, C., Mirshina, O., Mun, E., Pleshkov, B., Boklage, E., Drewes, J. E. (2024, April 26). Wastewater Surveillance System for COVID-19 in Tashkent, International Scientific and Practical Conference "Preparedness for Pandemic: Scientific Basics and Practical Solutions", Tashkent, Uzbekistan.

80) Vinardell, S., Feickert Fenske, C., Heimann, A., Cortina, J.L., Valderrama, C., Koch, K. (2024, June 16-19). Techno-economic assessment of implementing ex-situ biomethanation in wastewater treatment plants for grid-quality biomethane production. Young Water Professionals European Conference 2024, Kopenhagen, Denmark.

81) Weigoldt, M., Flad, V., Strübing, D., Koch, K., Lebuhn, M. (2024, September 2-4). Use of CO2 to reduce the residual methane potential Microbiology insights. International Conference Progress in Biogas VI, Stuttgart-Hohenheim, Germany.

82) Winklmaier, J. (2024, June 19-21). SEED Himalaya - An innovative blueprint for bankable rural electrification. InterSolar Europe Conference 2024. Munich, Germany.

83) Wurzbacher, C. (2024, August 11-15) Single cell genomics of aquatic fungi. IMC12, Maastricht, Netherlands.

84) Wurzbacher, C. (2024, September 20). Forschung, Erfahrungen und Perspektiven eines digitalisierten Abwassermonitorings auf kommunaler Ebene. AMELAG Kolloquium.

85) Yashar, O., Khan, M. S., Yecheskel, Y., Zucker, I., Aumeier, B. M., Drewes, J.E., Hübner, U. (2024, June 18-19). Water decontamination through sulfate radical oxidation in a nano enabled catalytic filtration process for non potable and potable water reuse, Status Seminar 2024 of the German-Israeli Cooperation in Water Technology Research, Koblenz, Germany.

86) Zimmermann, M., Hoffmann, M., Staaks, C., Aumeier, B.M., Wintgens, T. (2024, December 3-5). Introducing powdered activated carbon counter flow to an inline dosing membrane hybrid process - impacts on membrane performance, 19. Aachener Membran Kolloquium, Aachen, Germany.

Theses

Doctoral Dissertations

1) Bein, Emil Ferdinand: Novel oxidative treatment processes for unselective removal of organic contaminants in groundwater remediation.
2) Hiller, Christian Xaver: Optimization of the removal efficiency of antimicrobial resistance (AMR) by micro- and ultrafiltration treating WWTP effluents.
3) Cao, Lija: Biotransformation of trace organic chemicals in biofiltration systems and by microbial model communities.

Masters Thesis

1) Mraz, K. (2023). Biodegradation of labeled ozonation products: application of a novel labeling technique to elucidate biotransformation products and their removal in wastewater treatment processes.
2) Kleber, M. (2023). Influence of CO2 enrichment on the process parameters and system stability in anaerobic digestion.
3) Al-Areqi, A. (2024). Municipal Solid Waste Management and GHG Emissions in Singapore: Challenges and Opportunities for a Circular Economy.
4) Zhang, T. (2023). Batch adsorption tests to assess the potential of biochars as media amendments for biocides and heavy metals removal in bioswales.
5) Ajala, A. (2023). WEF Nexus Index and its application to energy generation: using Nigeria as a case study.
6) Gangal, A. (2024). Recommissioning and Optimisation of a Secondary Effluent Pretreatment Scheme for Sequential Managed Aquifer Recharge Technology plus (SMARTplus).
7) Deutsch, A. (2024). Exploring the Enhanced Hydrodynamics of Patterned Membrane Systems: A COMSOL Multiphysics Modeling Study.
8) Kunder, P. (2024). Azo Dyes in Textile Wastewater Occurrence and Removal strategies: A

Review.

9) Bertram-Mohammadi, P. (2024). Competitive comparison between ceramic and polymeric membrane fouling attributes affected by secondary effluent filtration under varying operational fluxes and coagulation doses applied.
10) Sultana, H. (2024). Enhancement of methane yield by increasing the digestibility of substrates and the inoculum residue by CO2 enrichment .
11) Appelmann, P. (2024). Execution of Column Experiments to Evaluate Treatment Performance of Different Substrate Mixtures on Removal of Various Pesticides from Green Roof and Facade Runoff .
12) Kick, D. (2024). Analysis of the Long-term Treatment Performance of Different Engineered Substrates in Urban Bioswales - Results After Two Years of Operation.
13) Zhang, X. (2024). The Relationship between Residence Time and Mecoprop Leaching Behavior from the Root Barrier Layer of Flat Roofs.
14) Wang, Q. (2024). Investigating the Spread of Antibiotic-Resistant Genes in Wastewater within the One Health Approach.
15) Steinhart, R. (2024). How do different root systems affect pollutant retention in soils from traffic area runoff? - Are deep rooters a no-go in near-natural treatment systems?.
16) Yldz, B. (2024). Investigating the feasibility of carbon footprint reduction in reclaimed water irrigation for reforestation initiatives: Tunisia as a case study.
17) Hilpert, A. (2024). WEF Nexus potential analysis of Lilongwe, Malawi using WEF Nexus software tools.
18) Brewster, G. (2024). Incorporating a climate-responsive leaf area index parameter in SWMM-UrbanEVA: Impact on the evaporation loss of an urban neighbourhood.
19) Rackl, R. (2024). Optimization of drinking water supply based on a regional structural assessment taking climate change into account.
20) Lermer, E. (2024). Development of a sponge city tool to support water-wise planning - Based on the evaluation of current guidelines, action plans and regulations.
21) Krebs, M. (2024). Seasonal Dynamics of Microbial Communities in Urban Wastewater: A Comparative Study of Augsburg and Munich Wastewater Treatment Plants .
22) Hwang, G. (2024). Assessment of the hydraulic conductivity and adsorption capacity of biochar-amended soil mixtures.
23) Mani, J. (2024). Evaluation of the desorption of heavy metals and biocides from biochar and granular activated carbon for urban bioswales for stormwater treatment.
24) Al-Areqi, A. (2024). Towards a Greener Future: Integrating Solid Waste Management and GHG Emissions Reduction in Singapore's Circular City Framework.
25) Siang, P. (2024). Investigation of Biogas Potential as Energy Supply for Franschhoek in South Africa Taking a WEF Nexus Approach.
26) Dastan, A. (2024). Influence of CO2 on methane production in a BMP test with different sodium carbonate concentrations as the CO2 source .
27) Djurdjevic, A. (2024). Identification of the Methane Production Pathway Using Natural Biogas Signature during Anaerobic Digestion of Lignocellulosic Biomass Treated with CO2 Enrichment .
28) Fung, J. (2024). A novel co-processing concept of anaerobic digestion and aerobic composting using food waste.
29) Ezzeddine, O. (2024). National Strategies in Lebanon: A Scenario Based Assessment of the Water-Energy-Food Nexus.

Study Projects

1) Krebs, M. (2023). Adaptation of cities to climate change the sponge city principle - Renovation of property drainage systems at the example of a single-family house in Munich.

2) Mani, J. (2023). Evaluation of the leaching behaviour of mineral and organic substrates for their use in urban bioinfiltration swales for stormwater treatment.
3) Kuz'menko, A. (2023). Assessment of Greenhouse Gas reduction potential in the food retail sector of Munich.
4) Stöhr, F. (2023). Data processing and situation assessment as basis for a restructuring concept of the sewer network of a wastewater association.
5) Zhang, T. (2024). The adsorption of biocides/heavy metals onto activated carbon and the influence of the presence of dissolved organic matter.
6) Baccalaro, D. (2024). A Comparative Analysis of Renewable Energy Potentials for Rural Communities in Zimbabwe Taking a Nexus Approach.
7) James, A. (2023). Analysis of the Leaching Behaviour of Green Roof Substrates using Column Test in accordance with DIN19528.
8) Ahmed, R. (2023). Developing a micro-scale experimental protocol for testing regeneration of Hydrophobic PFAS adsorbents.
9) Ezzeddine, O. (2024). Water for Sustainable Development in the Arab States: The Underlying Challenges & the role of the W-E-F Nexus.
10) Holler, L. (2024). Assessment of socio-economic impacts of reforestation projects in Tunisia from a Water-Energy-Food Nexus perspective.
11) Hessler, C. (2023). Development of an Experimental Protocol for the Evaluation of Planted Column Experiments.
12) Fung, J. (2023). Aerobic Composting-Anaerobic Digestion (ACAD) Co-processing System in Food Waste Management.
13) Rahman, M. (2024). Adsorption capacity and effectiveness of granular activated carbon for biocide removal from building runoff.
14) Lashkari, K. (2024). Trace organic chemicals extraction and analysis from edible crops irrigated with reclaimed water.
15) Förner, S. (2024). Assessing the human health risks after exposure to TOrCs by consuming the raw edible crops irrigated with reclaimed water.
16) Wang, L. (2024). Applying Analytic Hierarchy Process to Determine Optimal Circularity Strategy in Renewable Energy.
17) Anyosa Torres, L. (2024). Modeling of Particle Transport in Membrane Feed Channels with Feed Spacers and Surface-patterned membranes using COMSOL.
18) John, R. (2024). Kinetic Modelling of UV/H2O2 Advanced Oxidation Process using SUMO.
19) Ucar, I. (2024). Determination of hydraulic parameters required for the simulation of a vertical flow constructed wetland with integrated activated carbon designed for the removal of trace organic chemicals.
20) Meier, D. (2024). Integration of drought-responsive evapotranspiration in SWMM-UrbanEVA.
21) Krishna, A. (2024). Application of CO2 for enhancing anaerobic digestion performance.
22) Peng, S. (2024). Effect of CO2 enrichment on AD of different inocula.
23) Jain, S. (2024). Reducing Emissions through Energy Recovery from Organic Waste in Franschhoek, South Africa.
24) Brenner, L. (2024). Analysis of the material load of the Irschenberg wastewater treatment plant as a basis for the design of the advanced treatment step.
25) Varghese, N. (2024). Roof Rainwater Harvesting and Storage in Private Gardens Using Nature-Based Systems to Facilitate Public Green Space Irrigation and Mitigate Excess Runoff.
26) Chiang, I. (2024). Application of CO2 for enhancing anaerobic digestion performance.
27) Tasnim, N. (2024). Establishment of Sequential Biofiltration Column Setup and Assessment of Water Parameter to Predict Oxygen Demand for Removal of Trace Organic Chemicals.
28) Babu, N. (2024). Application of CO2 for enhancing anaerobic digestion performance.

29) Therese, A. (2024). Application of CO2 for enhancing anaerobic digestion performance.
30) Tailor, R. (2024). Understanding Biotransformation of Atenolol, Ibuprofen, and Sulfamethoxazole: an RDKit and KEGG-Analysis."
31) Dastan, A. (2024). Optimizing Methane Yields: The Impact of CO enrichment and substrate concentration in BMP tests using sodium bicarbonate.
32) Glocker, F. (2024). Energetic utilization of carbon dioxide to reduce the residual methane potential.
33) Pöll, L. (2024). Energetic utilization of carbon dioxide to reduce the residual methane potential.

Bachelors Theses

1) Sudjito, A. (2023). A Literature Research on Root-System Related Factors in Retaining Anthropological Contaminants from Stormwater in Swales.
2) Riedler, P. (2023). Adaptability of alternative concepts for advanced removal of trace organic chemicals under changing boundary conditions in small-scale wastewater treatment plants (2,000 - 10,000 PE).
3) Wiese, H. (2023). PCR-based analysis of biomarkers in wastewater current state of the art, potentials, and challenges.
4) Magnoni, M. (2024). Mitigation Approaches for Biofouling in Nanofiltration and Reverse Osmosis: A Literature Study.
5) Ettenberger, L. (2024). Literature study on the suitability of the Total Oxidizable Precursàrs Assay for the detection of unknown PFAS.
6) Fischer, M. (2024). Life Cycle and Sustainability Analysis in Industrial 3D-Printing for Manufacturing of Molds.
7) Federspiel, D. (2024). Literature Study: Numerical Simulations of Fouling in Nanofiltration and Reverse Osmosis Membrane Modules.
8) Pivetta, A. (2024). Energy balance of the wastewater treatment plant Friedrichshafen.
9) Papperitz, R. (2024). Precipitation and Combined Sewer Overflows into Surface Waters: An Evaluation of Current Regulations and Guidelines in the Context of Climate Change.
10) Dietrich, E. (2024). Effects of pharmaceutical residues in aquatic ecosystems.
11) Ramseger, R. (2024). Potential analysis of the urban water cycle to secure the water supply with the support of blue-green-grey infrastructure.
12) Hermann, E. (2024). Field investigations on the use of recycled aggregates in the vegetated soil zone of infiltration basins - retention of copper and zinc from urban traffic area runoff.

Dissertations and Awards

Congratulations to Dr.-Ing. Christian Hiller for the successful defense of his doctoral thesis on January 16th, 2024. His thesis entitled „Optimization of the removal efficiency of antimicrobial resistance (AMR) by micro- and ultrafiltration treating WWTP effluents“ was supervised by Prof. Dr.-Ing. Jörg E. Drewes, Mr. Prof. Dr.-Ing. Stefan Panglisch (Universität Duisburg-Essen, Germany) and Mr. Prof. Dr. Thomas Schwartz (Karlsruher Institut für Technologie, Germany) reviewed. The chairwoman of the commission was Prof. Brigitte Helmreich..

Figure 50: Doctoral committee of Dr.-Ing. Christian Hiller

Congratulations to Dr.-Ing. Emil Bein for the successful defense of his doctoral thesis on June 6th, 2024. The thesis, entitled „Novel oxidative treatment processes for unselective removal of organic contaminants in groundwater remediation“, was reviewed by Mr. PD Dr.-Ing. Uwe Hübner, Mr. Prof. Dr.-Ing. Jörg E. Drewes and Herrn Prof. Dr. Yunho Lee (Gwangju Institute of Science and Technology-GIST, Korea). The chairwoman of the commission was Prof. Brigitte Helmreich.

Figure 51: Doctoral committee of Dr.-Ing. Emil Bein

Congratulations to Dr. rer. nat. Lijia Cao for the successful defense of her doctoral thesis on August 2nd, 2024. Her thesis entitled „Biotransformation of trace organic chemicals in biofiltration systems and by microbial model communities“ was supervised by Mr. Dr. rer. nat. Christian Wurzbacher, Prof. Dr. Sarahi Garcia and Assoc. Prof. Dr. Lea Ellegaard-Jensen. The chairman of the commission was Prof. Dr. Konrad Koch.

Figure 52: Doctoral committee of Dr. rer. nat. Lijia Cao

Carolina Feickert Fenske was awarded the Johannes B. Ortner Award of the Technical University of Munich on 14 November 2024 for her dissertation entitled „Biological H_2/CO_2 methanation in trickle bed reactors - Toward industrial application “. Ms Feickert Fenske was able to demonstrate the successful methanation of H_2 and CO_2 in a trickle bed reactor on a pilot scale. With the construction of the pilot reactor at the wastewater treatment plant in Garching, it was possible to test its usability under real application conditions with biogas as a CO_2 source. With a height of 4.5 m and a reaction volume of 0.8 m^3, the pilot reactor is currently one of the largest anaerobic trickle bed reactors in the world. With the results of Ms. Feickert Fenske's research work, important strategies for stable reactor operation were developed and operation recommendations and optimization potentials for the implementation of the technology on an industrial scale were identified.
Since 2005, the Johannes B. Ortner Foundation has honored outstanding work by young scientists in the natural sciences and technology. The Johannes B. Ortner Award was presented at the TUM Award Dinner.

Figure 53: Dr. -Ing. Carolina Feickert Fenske Carolina Feickert Fenske (far right) was awarded the Johannes B. Ortner Prize of the TU Munich (©Gabriela Paleznica).

Teaching

The Chair of Urban Water Systems Engineering offers a wide range of different courses for the Bachelor study program Environmental Engineering and Civil Engineering as well as for the Master 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 2024, 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: Koch, Konrad
- Scientific Methods and Presentation Skills: Koch, Konrad

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
- Gute Wissenschaftliche Praxis: Koch, Konrad
- Hydrochemistry Laboratory: Schlachta, Tim; Heim, Carolin; Linke, Felicia; Helmreich, Brigitte
- Hydrochemistry: Helmreich, Brigitte
- Unit Operation 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)
- Scientific Methods and Presentation Skills: Koch, Konrad; Drewes, Jörg
- Water and Wastewater Treatment Engineering: Drewes, Jörg

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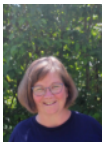

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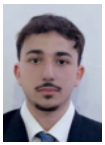

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