Karlsruhe Institute of Technology

Topics in Water Chemistry and Water Technology

Annual Report of the Chair of Water Chemistry and Water Technology and the DVGW Research Center at the Engler-Bunte-Institut 2022

Dear colleagues and friends,

following the "tradition" started in 2021, our editorial combines the views of two persons of our group regarding the water research at EBI. This year is sadly marked by the war in the Ukraine and its consequences in terms of loss of lives, suffering and destruction, but also in terms of global security, international economy and energy supply. 2022 will be also remembered for the extremely high summer temperatures and severe drought. The average temperature in Europe for August 2022 was by far the highest on record for August, at 1.72 °C higher than the average for the last 30 years. Climate change is a fact, which influences our entire life and the future. The application of renewable energy sources is one of the pillars to reduce carbon dioxide emissions. In this difficult context, our work in the area of water management for green hydrogen and Power-to-X (PtX) products generation and Lithium recovery became more relevant than ever before. You can find more information about our work in the area of water treatment and management for PtX on pages 2 and 3.

One highlight of this year was our two days retreat in Bad Herrenalb. After 3 years of Covid-restrictions, the main aim of the retreat was to strengthen the relationships between new and old members and to grow as a group. With a nice mix of a resume of the last 3 years, team building activities, scientific presentations, hiking and get together time, the retreat was a great success and something we can benefit in the long term. We hope we can meet again next year.

In 2022, five PhD students defended their doctoral theses and new PhD students joined our group. Most of the new PhD students are working in topics directly or indirectly related to renewable energy sources, such as CO_2 capture from sea water and sea water electrodialysis.

Two of our guest scientists left our group (Prof. Marta Gmurek, Poland; M. Sc. Hessam Addin Nadernia, Iran). And we warmly welcome our new guest researches Na Li, guest PhD student from China, and Prof. Isam Sabbah, visiting professor from Israel.

Moreover, after 3 years we could successfully organize and run the Advanced Biofilm Course with PhD students from 7 European Countries.

With the focus on water-energy, we coordinate the project *KoalAplan – Biorefinery Büsnau: Municipal waste water as a source of ammonium nitrogen, hydrogen and bioplastics* started by the end of 2021. The project is funded by the European Regional Development Fund (ERDF): Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, co-financed by the European Union within the program "Bioeconomy – Biorefineries for the recovery of raw materials from waste and waste water". In this project, the potential for using particulate organic carbon compounds from municipal waste water by converting them into higher-value products (biopolymers and hydrogen) will be demonstrated. Three products will be recovered from the waste water: ammonium, hydrogen and polyhydroxyalkanoates (bioplastics).

As you will see on the following pages, the water-energy nexus became a fix part of our research.
Enjoy reading our contribution to the future!
All the best for 2023!

Florencia Saravia Harald Horn

H_2Mare PtX-Wind: Offshore Generation of Hydrogen and Power-to-X Products Using Wind Energy – Water Management in Offshore PtX Processes

Florencia Saravia

Yair Morales

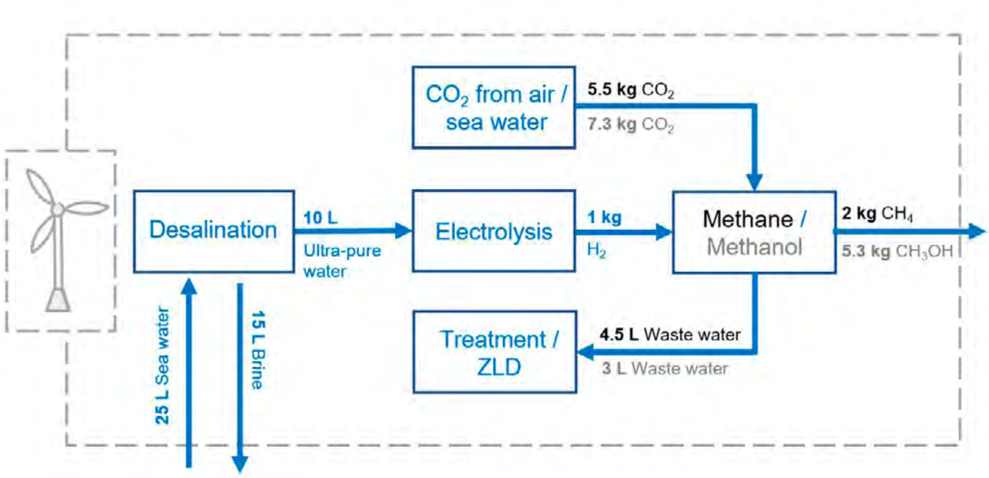
Prantik Samanta

The increasing anthropogenic emissions of greenhouse gases, mainly carbon dioxide (CO_2), and their accumulation in the atmosphere are one of the most important current challenges. The urgent need for decarbonization and a more sustainable energy supply has led to the promotion, development and research of renewable energy and alternative fuels such as Power-to-X concepts in recent years. Power-to-X consists of using renewable energy sources to produce hydrogen and downstream products (e.g. methane, methanol).

Hydrogen can be produced by water electrolysis, among other methods, and the energy required can come from sustainable sources. In water electrolysis methods such as proton exchange membrane and alkaline electrolysis, the water molecule is split into hydrogen and oxygen using high electrical voltages. For the production of one kg hydrogen, an ultra-pure water requirement of approx. 10 kg is assumed. Desalination of sea water by means of reverse osmosis plants typically achieve yields of 40 % (see figure). This means that 25 kg (L) of sea water must be treated to produce one kg of hydrogen. However, this also produces 15 L of concentrated brine, which contains, in addition to the higher concentration of salts, chemicals such as antiscalants.

The production of synthetic methane and methanol from hydrogen also requires CO_2. This can be captured by direct air capture or electrodialysis method. For example: 1 kg of hydrogen and 7.3 kg of CO_2 will yield in 5.3 kg of methanol.

The synthesis of methane and methanol produces waste water as a by-product. For the production of 1 kg hydrogen, 4.5 L (methane) or 3 L (methanol) of waste water can be expected. In current research, there is little data available on the exact composition of these waste waters. Addressing the treatment of these effluents is necessary to gain insight into which treatment technologies are applicable to meet discharge limits or whether sustainable approaches such as Zero-Liquid-Discharge (ZLD) can be implemented.



Flow diagram of an offshore PtX platform powered by wind energy for the production of methane or methanol (modified from gwf-Wasser/Abwasser 06/2022).

Funding:
Federal Ministry of Education and Research (BMBF)

H_2Mare PtX-Wind: Offshore Generation of Hydrogen and Power-to-X Products Using Wind Energy – Recent Progress in Subprojects

Michael Wagner

Florencia Saravia

Mehran Aliaskari

Szilárd A. Bucs

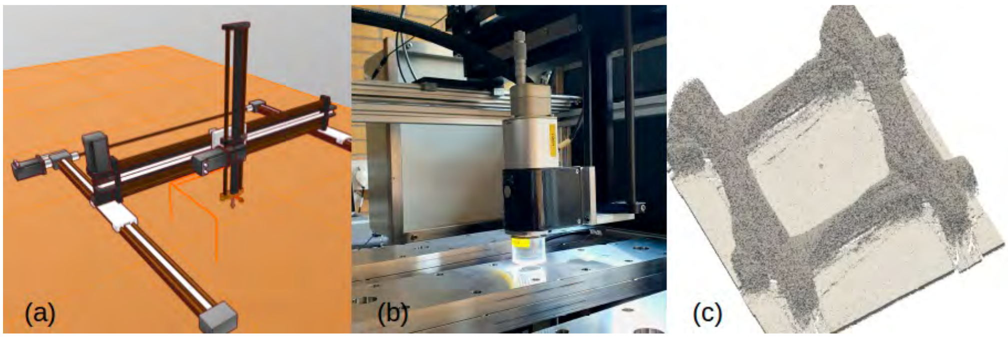
Vasco Welter

We are contributing to several subprojects within *H_2Mare PtX-Wind*. Short progress reports can be found below.

CO_2 extraction from sea water
We are investigating the possibility of obtaining CO_2 as educt for PtX products from sea water. CO_2 is thereby extracted from sea water using an electrodialysis bipolar membrane setup. In initial experiments a model water with characteristics close to North Sea water was used. The electrical current increased at higher voltages leading to a decreasing pH value. Results revealed that a voltage of ≥ 15 V is required for complete conversion of bicarbonate to CO_2 (i.e., pH value ≤ 4).

Sea water electrolysis
Together with the project partner Technical University Berlin (TUB), we aim to characterize and optimize fouling development in sea water electrolysis cells used for green hydrogen production. Optical coherence tomography is used to acquire three-dimensional datasets of fouling accumulating on parts of bipolar plates developed by TUB. A prototype electrolysis cell has been manufactured for lab-scale fouling experiments. First experiments are going to be conducted in the last quarter of 2022.

Monitoring in reverse osmosis desalination plants
An experimental setup consisting of four high pressure reverse osmosis flow cells, a robotic platform for positioning (x, y, z) the optical coherence tomography scanning probe, and related peripherals such as pumps, flow and pressure sensors have been installed (see figure). The system will be developed further in order to establish an automated imaging-based biofilm monitoring pipeline evaluating fouling parameters in reverse osmosis flat sheet membrane units on-line in time and space.



Automated OCT image acquisition setup: (a) three axis robotic arm for positioning the OCT scanner, (b) OCT scanner and flow cells with side windows, and (c) 3D OCT scan of the flow channel.

Partners:
Institute for Micro Processing Engineering (IMVT), KIT;
Institute of Chemistry, Catalysis and Materials Engineering Group, TU Berlin;
DVGW Research Center, Gas Technology at the Engler-Bunte-Institut, KIT;
DECHEMA e. V., Frankfurt am Main; Helmholtz-Zentrum, Geesthacht;
EnBW Energie Baden-Württemberg AG; EnviroChemie GmbH, Rossdorf;
INERATEC GmbH, Karlsruhe; Siemens Gamesa Renewable Energy GmbH & Co. KG, Denmark;
and other partners from universities, research institutions and companies in Germany

Funding:

Federal Ministry of Education and Research (BMBF)

Gesellschaft der Freunde des Engler-Bunte-Instituts

Reactor Concepts for Bioelectrochemical Applications

Andrea Hille-Reichel

Johannes Reiner

Max Hackbarth

Maximilian Miehle

Andreas Netsch

Jonas Ullmann

Funding:

Federal Ministry of Education and Research (BMBF)

Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg

Several projects are currently investigating the application of different microbial electrochemical technologies (METs) either as a pre-step of or for the direct production of value-added chemicals and/or hydrogen. Various novel and scalable bioelectrochemical reactor concepts are developed and tested:

1. The aim of the project *ContiBio-Elect* is a continuous, anaerobic oxidation of organic substrates for the production of value-added chemicals. The reactor is designed as a fixed-bed reactor (with the option of fluidization) with a packing (1.6 L) of graphite-polymer granules as anodic material. Electroactive bacteria are supposed to form biofilms on these granules and oxidize glucose to acetoin. Electrons are discharged via the packed bed and, at the counter electrode, reduce the protons produced during the oxidation to hydrogen.

2. In the project *BROWSE (Biopolymers from Waste)*, a 10 L rotating disk bioelectrochemical reactor (RDBER) is operated as microbial electrolysis cell to selectively oxidize individual acids of a hydrolysate from a dark fermentation of food waste while producing hydrogen at the cathode. The effluent is to be used together with the CO_2/H_2-mixture generated in the RDBER for the synthesis of 2,3-butanediol in a membrane biofilm reactor.

3. A similar microbial electrolysis cell is investigated within the project *PeePower* for a bioelectrochemical hydrogen production from urine and will be installed for 6 months in a specially designed toilet facility at the Federal Garden Show (BUGA) 2023. The pictures below show the 100 L RDBER (a) and the arrangement of the rotating anode discs and the cathode (metal screen) (b).

Rotating disc bioelectrochemical reactor (RDBER) (a) and arrangement of electrodes (b).

Partners:
[1] Eisenhuth GmbH & Co. KG, Osterode am Harz;
[1,2,3] Institute of Technical Microbiology, Hamburg University of Technology;
[2] Environmental Process Engineering, University of Bremen;
[2] EnBW Energie Baden-Württemberg AG;
[2] Institute of Organic Chemistry, Material Science Center, KIT;
[2] Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg

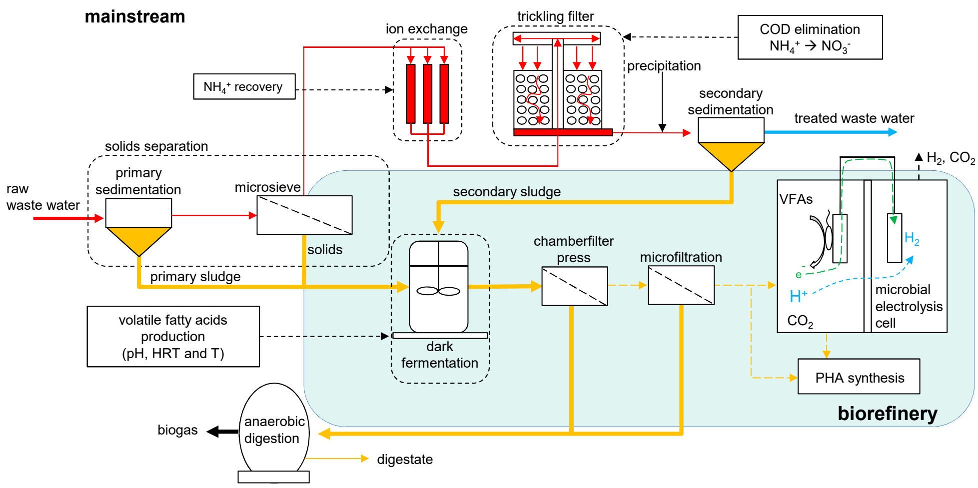
Municipal Waste Water as a Source of Ammonium Nitrogen, Hydrogen and Bioplastics – the Büsnau Biorefinery (*KoalAplan*)

The project aims to develop a viable replacement for a typical municipal waste water treatment plant (WWTP) by significantly and effectively modifying the treatment of incoming pollutant loads in the form of carbon, nitrogen, and phosphorus through enhanced recovery. In general, a municipal WWTP aims at removing and/or recovering these pollutant loads through physical, chemical and biological processes. Common WWTPs offer a suitable pathway for removal, but are poorly positioned in terms of energy requirements (aeration requirements for carbon and nitrogen removal), as well as carbon and nitrogen recovery. Especially carbon recovery in the form of biogas further contributes to greenhouse gases emissions. This is circumvented in this project by having a rigorous solids separation step, which opens a route for recovery of nutrients and meeting discharge limits by replacing energy intensive steps along with the recovery of organic carbon in the solids (primary and secondary sludge plus solids separated from the effluent of primary sedimentation by microsieving) through hydrogen and bioplastic production. These changes aim to reduce greenhouse gas emissions, provide alternatives for fossil fuel-based chemicals used in plastics production, and substantially reduce the energy demand.

The biorefinery part of the project deals with the recovery of organic carbon from the solids stream. In the first and most important step, the solid stream is hydrolyzed to volatile fatty acids (VFA) by dark fermentation (DF) (see figure). For optimization of the hydraulic retention time (HRT), experiments were performed at semi-continuous feeding conditions, pH-value of 6, and uncontrolled temperature (23 – 25 °C). Results show that HRT has a notable impact on VFAs production, and that maintaining a low HRT of 12 h seems beneficial for a high VFAs release while strongly inhibiting methanation.

Andrea Hille-Reichel

Nikhil Shylaja Prakash



KoalAplan process scheme.

Co-funded by the European Union

Baden-Württemberg

Partners:
CUTEC Clausthal Research Center for Environmental Technologies, TU Clausthal;
Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB), Stuttgart;
Institute of Technical Microbiology, Hamburg University of Technology;
Umwelttechnik BW GmbH, Stuttgart;
Treatment Plant for Education and Research at the University of Stuttgart

Funding:
European Regional Development Fund (ERDF): Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, co-financed by the European Union

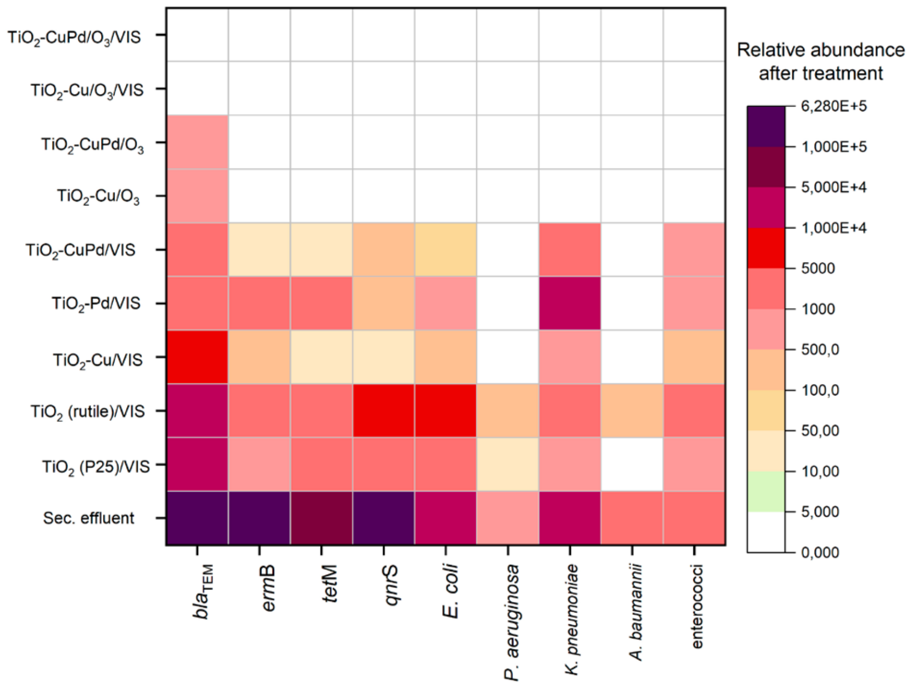
Comparative Removal of Antibiotic Resistance Genes and Facultative Pathogenic Bacteria during Advanced Oxidation Processes

Marta Gmurek

The widespread use of antibiotics results in their continuous release into the environment and the development of antibiotic resistant bacteria (ARB) and antibiotic resistance genes (ARGs). Despite attempts to reduce antibiotic consumption, global resistance has increased significantly. None of the currently applied methods guarantees the complete removal of ARGs and ARB in effluents of waste water treatment plants. To counteract this severe problem, more effective solutions to ensure the ecological safety of the discharged effluents are needed. The aim of the study was to investigate the potential of mono- and bimetallic (Cu/Pd) rutile-loaded nanoparticles for photocatalytic-based disinfection of ARGs and ARB from conventionally biological treated effluents. It was found that despite an insufficient ARGs removal (but still more than 1 log), photocatalysts can significantly remove facultative pathogenic bacteria (FPB) when applying Cu/Pd photocatalysts in the visible light. Photocatalysts that contain Cu metal, that has antibacterial properties, lead to higher ARGs and FPB removal compared to TiO_2-Pd. However, bimetallic catalysts lead to the best performance.

The application of the hybrid photocatalytic technology with ozone resulted in almost complete ARGs and FPB removal from waste water effluents, while just photocatalytic inactivation decreased significantly ARGs and FPB abundance (see figure). Samples showed bacterial regrowth after 24 h of dark storage when applying only catalysts, whereas after photocatalytic ozonation, the regrowth was strongly inhibited even after 72 h.

It was shown that photocatalytic ozonation has the greatest potential for the removal of FPB and ARGs. Especially, photocatalytic ozonation with the application of Cu/Pd-TiO_2 due to the synergistic effect between Pd and Cu. It is suspected that Pd nanoparticles increase the generated charge carriers while Cu nanoparticles prolonged their lifetime, which leads to acceleration of ozone – catalysts reaction.



Heat map of the relative abundance of ARGs and FPB after different treatment strategies.

Funding:
Alexander von Humboldt Foundation
Karlsruhe Institute of Technology (KIT)

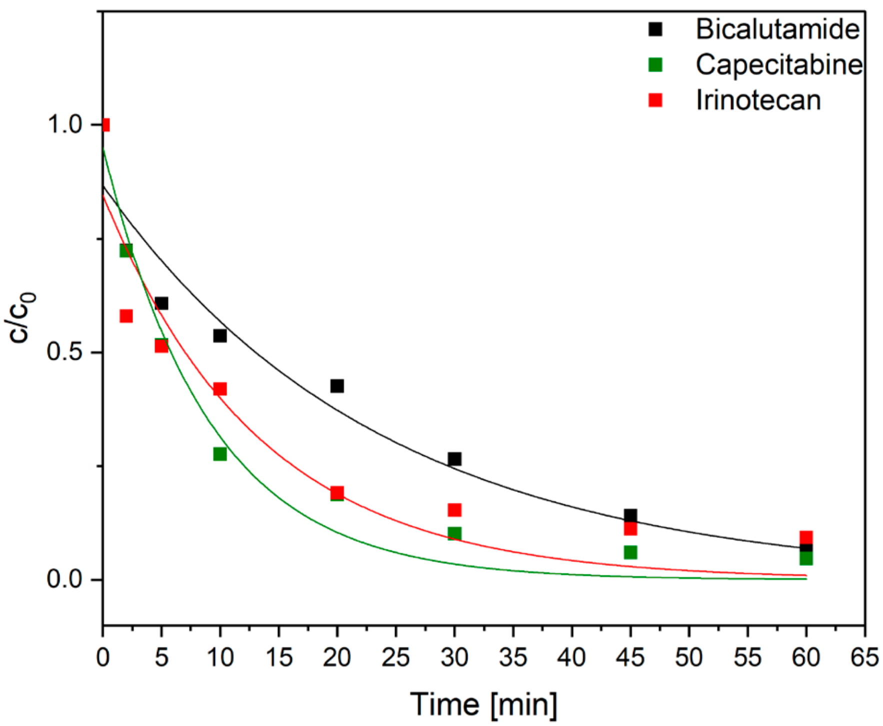
Partners:
Prof. Thomas Schwartz, Institute of Functional Interfaces (IFG), KIT;
Department of Environmental Technology, University of Gdańsk, Poland

Fate and Degradation of Micropollutants in the Aquatic Environment

The behaviour of pharmaceuticals in the aquatic environment and the effectiveness of treatment processes to decrease their environmental concentrations are important topics within the field of micropollutant (MP) research. Therefore, the aim of our investigations was to study the fate of antibiotics (ABs) in the environment and the removal of anti-cancer drugs (ADs) during oxidative processes.

While the determination of degradation kinetics of ADs during oxidative processes in pure water can be important to estimate the removal efficiency of these processes, it has been shown that the constituents of real water samples may heavily influence that efficiency, for example in waste water. In order to be able to test the ability of the UV, ozone and ozone/UV-processes for the degradation of ADs in a real water matrix, a solid phase extraction (SPE)-method was developed and validated for waste water effluents. This tool, in combination with a previously developed liquid chromatography tandem mass spectrometry (LC-MS/MS) method, allows us to test the degradation efficiency of these processes for three ADs at environmental concentrations (see figure).

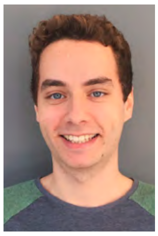
To study the fate of ABs in the aquatic environment, we performed a lab-scale mesocosm experiment. Our mesocosm experiment consisted of five 10 L reactors filled with river sediment and water. Up to four processes were studied in parallel during the experiment: adsorption to river sediments, biodegradation, hydrolysis and photodegradation with visible light. We changed the condition in the five reactors with respect to exposition to sunlight, presence of sediment, and presence of sodium azide (to inhibit microbial activity) to differentiate between the different processes. After spiking, ABs were monitored over a period of 42 d in the water phase. We could show that adsorption and biodegradation are the main attenuation processes for ABs.



Degradation of ADs in treated waste water by UV irradiation.

Ewa Borowska

Amélie Chabilan



Stephan Zimmermann

Funding:

Baden-Württemberg Stiftung

Karlsruhe Institute of Technology (KIT)

Biological Nitrogen Removal from Waste Water by Partial Denitrification Combining with Anammox Process

Rui Du

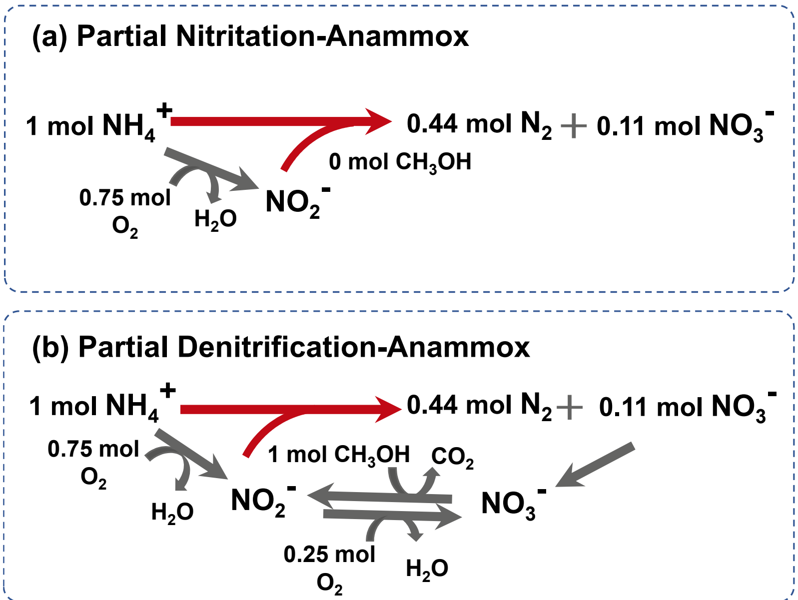
Na Li

The discovery of anaerobic ammonium oxidation (anammox) opens a new window for turning the energy-intensive mainstream municipal waste water treatment to energy self-sufficient or even energy-positive. Currently, anammox processes are mainly performed based on partial nitrification (PN) providing nitrite, while it highly depends on the operating conditions as well as on strictly process control for the continuous suppression of nitrite-oxidizing bacteria (NOB). Partial denitrification (PD), the reduction of nitrate to nitrite, was recently demonstrated to be another pathway of nitrite production for anammox with strong robustness, high efficiency, and easy control.

In this project, a novel integration of PD and anammox process is designed (see figure) and developed in a sequencing batch reactor, aiming to remove ammonia and nitrate from low-strength waste water. Performance of nitrite production and nitrogen transformation kinetics of PD process with different organic carbon sources and nitrate loading were investigated. Moreover, the production and extensive use of antibiotics have led to the widespread presence of various antibiotics in waste water. The co-effect of multiple antibiotics on the efficacy of PD process was also explored.

Results indicated that the PD displayed a relatively stable nitrite accumulating performance during 6-months operation. The nitrate-to-nitrite transformation ratio (NTR) achieved over 80 % with a nitrate concentration of 70 mg L^{-1} in the influent. The organic carbon source has an important impact on the PD reaction rates. Acetate was found to achieve the highest specific nitrate reduction and nitrite accumulation rates, followed by propionate and glucose. High NTR with different carbon sources demonstrated the independence of PD capability on electron donor.

It offers a new avenue in going for mainstream nitrogen removal with enhanced anammox contribution with efficient nitrite generation and diverse electron donor.



Biological nitrogen transformation pathways in anammox combining with (a) partial nitrification and (b) partial denitrification processes.

Funding:

Alexander von Humboldt Foundation

Karlsruhe Institute of Technology (KIT)

China Scholarship Council (CSC)

Partners:
College of Architecture and Civil Engineering, Beijing University of Technology, China

New and Ongoing Research Projects

WATER QUALITY		
Hessam Addin Nadernia	Synthesis of Nanophotocatalysts for Removal of Micropollutants in Water using Sunlight *	German Academic Exchange Service (DAAD), KIT
Ulrike Scherer	*ESI-CorA* – Systematic Surveillance of SARS-CoV-2 in Waste Water	Emergency Support Instrument (European Commission)
WATER TECHNOLOGY		
Ali Sayegh Florencia Saravia	*NextGenRoadFuels* – Processing of Hydrothermal Liquefaction Products with Membrane Technologies *	European Commission – Horizon 2020 www.nextgenroadfuels.eu
Giorgio Pratofiorito Florencia Saravia	*ProBioLNG* – Innovative Process Chain for the Resource-Efficient Production of Liquified Biogas	Federal Ministry of Education and Research (BMBF)
Michael Sturm	Microplastic-Free Sea Salt Production – Development of a Methodological and Technological Process for the Reduction of Microplastic Pollution during Sea Salt Extraction *	German Federal Environmental Foundation (DBU) German Federal Ministry for Economic Affairs and Energy (BMWi) through the provision of ZIM
Prantik Samanta Florencia Saravia	*KompaGG-N* – Complete Treatment of Manure and Digestate Process - Development by Taking into Account Regional Material Flow Concepts for Nutrients and Pollutants	Federal Ministry of Education and Research (BMBF)
Andreas Netsch Michael Wagner	*DEMO-BioBZ* – Development and Demonstration of an Energy-Efficient Bio-Electrochemical Waste Water Treatment	Federal Ministry of Education and Research (BMBF)
BIOLOGICAL INTERFACES		
Michael Wagner	Visualization of the Mesoscopic Biofilm Structure by Means of Optical Coherence Tomography	Helmholtz Association
Szilárd A. Bucs	Development of Tools for the Characterization of Biofilms with Specific Spectroscopic Methods (MR, NMR) - Conception and Realization of Specific Reactors	Gesellschaft der Freunde des Engler-Bunte-Instituts
Isam Sabbah	Nano- and Microplastics in Aquatic Systems; Processes in Engineered Biological Systems; Water and Waste Water Treatment	Sabbatical at EBI, KIT Home: BRAUDE College of Engineering, Karmiel, Israel
WATER RESEARCH NETWORK, BADEN-WÜRTTEMBERG		
Ulrike Scherer (Coordination Office) Harald Horn (Spokes Man)	The scope of the *Water Research Network* is to enhance the collaboration across disciplines and locations in Baden-Württemberg in order to meet the future challenges of water research. Partners: Universities in Baden-Württemberg	Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg Karlsruhe Institute of Technology (KIT)

*completed in 2022

Farewell

Dr. Birgit Gordalla retired in February 2022. We wish her good health and many exciting activities for this new chapter in her life. Our farewell is connected with warm thanks for her dedication and excellent work and her tremendous motivation for the various projects she has worked on, especially on standardization for methods for the examination of water, waste water and sludge.

The WATER CHEMISTRY AND WATER TECHNOLOGY GROUP

Head of Chair

Prof. Dr. Harald Horn
Dr. Gudrun Abbt-Braun
Prof. Dr. Fritz H. Frimmel (retired)

DVGW Research Center

Dr.-Ing. Florencia Saravia	Deputy head, team leader research and development

Supervising Functions and Postdoctoral Positions

Dr. Ewa Borowska	Organic micropollutants (until January 2022)
Dr.-Ing. Szilárd A. Bucs	Visualization and image analysis of biofilms
Apl. Prof. Dr. Gisela Guthausen	NMR/MRI
Dr. Andrea Hille-Reichel	Biological interfaces
Dr. Johannes Reiner	Microbial electrosynthesis
Dr.-Ing. Ulrike Scherer	Water Research Network BW
Dr. Michael Wagner	Biofilm structure and function
Dipl.-Ing. (FH) Stephanie West	Head of the laboratory

DVGW Research Center

Dr. Birgit Gordalla	Standardization (until February 2022)

PhD Students

M. Sc. Mehran Aliaskari	Bipolar membrane electrodialysis
Dipl.-Ing. Fabian Brunner	Aerobic granules for waste water treatment
M. Sc. Amélie Chabilan	Antibiotics in aquatic environment
M. Sc. Max Hackbarth	Microbial electrosynthesis
M. Sc. Steffen Hertle	Aerobic metabolic degradation processes (TZW)
M. Sc. Oliver Kehl	Modelling the treatment performance of activated sludge plants
M. Sc. Lukas Lesmeister	Treatment processes for removal of PFASs (TZW)
M. Sc. Na Li	Biofilms in water distribution systems (Guest PhD Student)
M. Sc. Maximilian Miehle	Bioproduction using biocatalyst for electrode assisted fermentation
M. Sc. Hessam Addin Nadernia	Solar photocatalysis for water treatment (Guest PhD Student until April 2022)
M. Sc. Andreas Netsch	Energy-efficient bioelectrochemical waste water treatment
M. Sc. Nikhil Shylaja Prakash	Waste water treatment
M. Sc. Giorgio Pratofiorito	Membrane processes for organic acids concentration
Dr.-Ing. Florian Ranzinger	Visualization of water and biofilms in porous media (Dr.-Ing. since February 2022)
Dr.-Ing. Prantik Samanta	Treatment of manure by membrane processes (Dr.-Ing. since July 2022)
Dr.-Ing. Ali Sayegh	Membrane treatment of industrial waste water (Dr.-Ing. since June 2022)
M. Sc. Tim Schwarzenberger	Mono- and polychromatic UV disinfection (TZW)
M. Sc. Lara Stelmaszyk	PCR- and cultivation methods for antibiotic resistant genes (TZW)
Dr. Michael Sturm	Removal of microplastics from sea water (Dr. rer. nat. since July 2022)
M. Sc. Fadi Tantish	Design of water treatment processes (until March 2022)
M. Sc. Vasco Welter	Electrolytic production of green hydrogen from sea water
M. Sc. Stephan Zimmermann	Degradation of cytostatic drugs in water by oxidation processes

DVGW Research Center (Project Engineers)

M. Sc. Yair Morales	Electrolysis of sea water for hydrogen production
M. Sc. Jonas Ullmann	Microbially catalyzed hydrogen production from urine

Guest Researchers

Dr. Rui Du	Denitrification/anammox process in biofilms (Alexander von Humboldt Stipend)
Prof. Assoc. Dr. Marta Gmurek	Advanced oxidation processes for water treatment (Alexander von Humboldt Stipend until August 2022)
Prof. Assoc. Dr. Isam Sabbah	Physico-chemical and biological processes in natural and engineered aquatic systems

Technical Staff

Axel Heidt	GC/ECD, GC/MS, IC, AOX
Rafael Peschke	HPLC, LC/MS, IC
Matthias Weber	LC/OCD, DOC/TOC

DVGW Research Center

Ulrich Reichert	Operation of lab reactors
Reinhard Sembritzki	ICP-MS, AAS, ICP-OES, IC

Secretarial Office

Ursula Schäfer

DVGW Research Center

Sylvia Heck

Apprentices

Maya Frey
Julia Gretschmann
Tobias Grundwald (until February 2022)
Enrico Horst (until July 2022)

RECENT PUBLICATIONS

Peer-Reviewed Journal Publications

Chabilan, A., Landwehr, N., Horn, H., Borowska, E., 2022. Impact of log-(Kow) value on the extraction of antibiotics from river sediments with pressurized liquid extraction. Water (Switzerland) 14 (16), 2534.

Dueholm, M.K.D. et al. (*inter alios* Horn, H.), 2022. MiDAS 4: a global catalogue of full-length 16S rRNA gene sequences and taxonomy for studies of bacterial communities in wastewater treatment plants. Nature Communication 13, 1908.

Gmurek, M., Borowska, E., Schwartz, T., Horn, H., 2022. Does light-based tertiary treatment prevent the spread of antibiotic resistance genes? Performance, regrowth and future direction. Science of the Total Environment 817, 153001.

Gretzinger, S., Schmieg, B., Guthausen, G., Hubbuch, J., 2022. Virtual reality as tool for bioprinting quality inspection: a proof of principle. Frontiers in Bioengineering and Biotechnology 10, 895842.

Klein, E., Weiler, J., Wagner, M., Čelikić, M., Niemeyer, C.M., Horn, H., Gescher, J., 2022. Enrichment of phosphate-accumulating organisms (PAOs) in a microfluidic model biofilm system by mimicking a typical aerobic granular sludge feast/famine regime. Applied Microbiology and Biotechnology 106, 1313-1324.

Lohani, S.P., Dhungana, B., Horn, H., Khatiwada, D., 2021. Small-scale biogas technology and clean cooking fuel: assessing the potential and links with SDGs in low-income countries – A case study of Nepal. Sustainable Energy Technologies and Assessments 46, 101301.

Netsch, A., Horn, H., Wagner, M., 2022. On-line monitoring of biofilm accumulation on graphite-polypropylene electrode material using a heat transfer sensor. Biosensors 12, 18.

Pratofiorito, G., Horn, H., Saravia, F., 2022. Differentiating fouling on the membrane and on the spacer in low-pressure reverse-osmosis under high organic load using optical coherence tomography. Separation and Purification Technology 291, 120885.

Ranzinger, F., Horn, H., Wagner, M., 2022. Imaging of particle deposition and resulting flow field during flocculation filtration within a granulated activated carbon filter. Separation and Purification Technology 292, 121033.

Samanta, P., Horn, H., Saravia, F., 2022. Removal of diverse and abundant ARGs by MF-NF process from pig manure and digestate. Membranes 12 (7), 661.

Samanta, P., Horn, H., Saravia, F., 2022. Impact of livestock farming on nitrogen pollution and the corresponding energy demand for zero liquid discharge. Water (Switzerland) 14 (8), 1278.

Samanta, P., Schönettin, H.M., Horn, H., Saravia, F., 2022. MF-NF treatment train for pig manure: nutrient recovery and reuse of product water. Membranes 12 (2), 165.

Samanta, P., Ungern-Sternberg Schwark, L. von, Horn, H., Saravia, F., 2022. Nutrient recovery and ammonia-water production by MF-vacuum evaporation treatment of pig manure. Journal of Environmental Chemical Engineering 10 (1), 106929.

Sayegh, A., Shylaja Prakash, N., Pedersen, T.H., Horn, H., Saravia, F., 2021. Treatment of hydrothermal liquefaction wastewater with ultrafiltration and air stripping for oil and particle removal and ammonia recovery. Journal of Water Process Engineering 44, 1024227.

Sayegh, A., Shylaja Prakash, N., Horn, H., Saravia, F., 2022. Membrane distillation as a second stage treatment of hydrothermal liquefaction wastewater after ultrafiltration. Separation and Purification Technology 285, 120379.

Sayegh, A., Merkert, S., Zimmermann, J., Horn, H., Saravia, F., 2022. Treatment of hydrothermal-liquefaction wastewater with crossflow UF for oil and particle removal. Membranes 12 (3), 255.

Schmieg, B., Gretzinger, S., Schuhmann, S., Guthausen, G., Hubbuch, J., 2022. Magnetic resonance imaging as a tool for quality control in extrusion-based bioprinting. Biotechnology Journal 17, 202100336.

Schroers, S., Eiff, O., Kleidon, A., Scherer, U., Wienhöfer, J., Zehe, E., 2022. Morphological controls on surface runoff: an interpretation of steady-state energy patterns, maximum power states and dissipation regimes within a thermodynamic framework. Hydrology and Earth System Sciences 26 (12), 3125-3150.

Sturm, M.T., Schuhen, K., Horn, H., 2022. Method for rapid biofilm cultivation on microplastics and investigation of its effect on the agglomeration and removal of microplastics using organosilanes. Science of the Total Environment 806, 151388.

Xiao, K., Horn, H., Abbt-Braun, G., 2022. "Humic substances" measurement in sludge dissolved organic matter: a critical assessment of current methods. Chemosphere 293, 133608.

Xiao, K., Horn, H., Abbt-Braun, G., 2022. Oversimplification of humic substances results in sewage sludge dissolved organic matter: potential pitfalls of the current presentation and interpretation. ACS EST Water 2 (10), 1625-1627.

Xiao, K., Abbt-Braun, G., Borowska, E., Thomagkini, X., Horn, H., 2022. Solid-liquid distribution of ciprofloxacin during sludge dewatering after Fe(II) activated peroxymonosulfate treatment: focusing on the role of dissolved organic components. ACS EST Engg. 2 (5), 863-873.

Publications Series of the Institute

Schriftenreihe Wasserchemie und Wassertechnologie, Engler-Bunte-Institut, Karlsruher Institut für Technologie:

Volume 83: Alvarado, A., 2022. Hydrolysis of particulate organic matter originated from municipal wastewater treated under aerobic and anaerobic conditions.

Volume 84: Ranzinger, F., 2022. Dynamic visualization of deposition processes within porous media by means of MRI.

Volume 85: Sayegh, A., 2022. Membrane technologies – adequate solutions for treatment of hydrothermal liquefaction wastewater.

Conferences (Selection)

Contributions at Biofilms 10 Conference, Leipzig, Germany, May 9 - 11, 2022: Du, R., Horn, H., Cao, S.: Novel integration of partial denitrification and anammox in biofilm systems: proof of concept from high-strength to low-strength wastewater treatment.

Miehle, M., Edel, M., Gescher, J., Hickmann T., Horn, H., Hille-Reichel, A.: Pilot reactor for anoxic biocatalytically assisted electrode-based oxidation of substrates for continuous production of value-added chemicals.

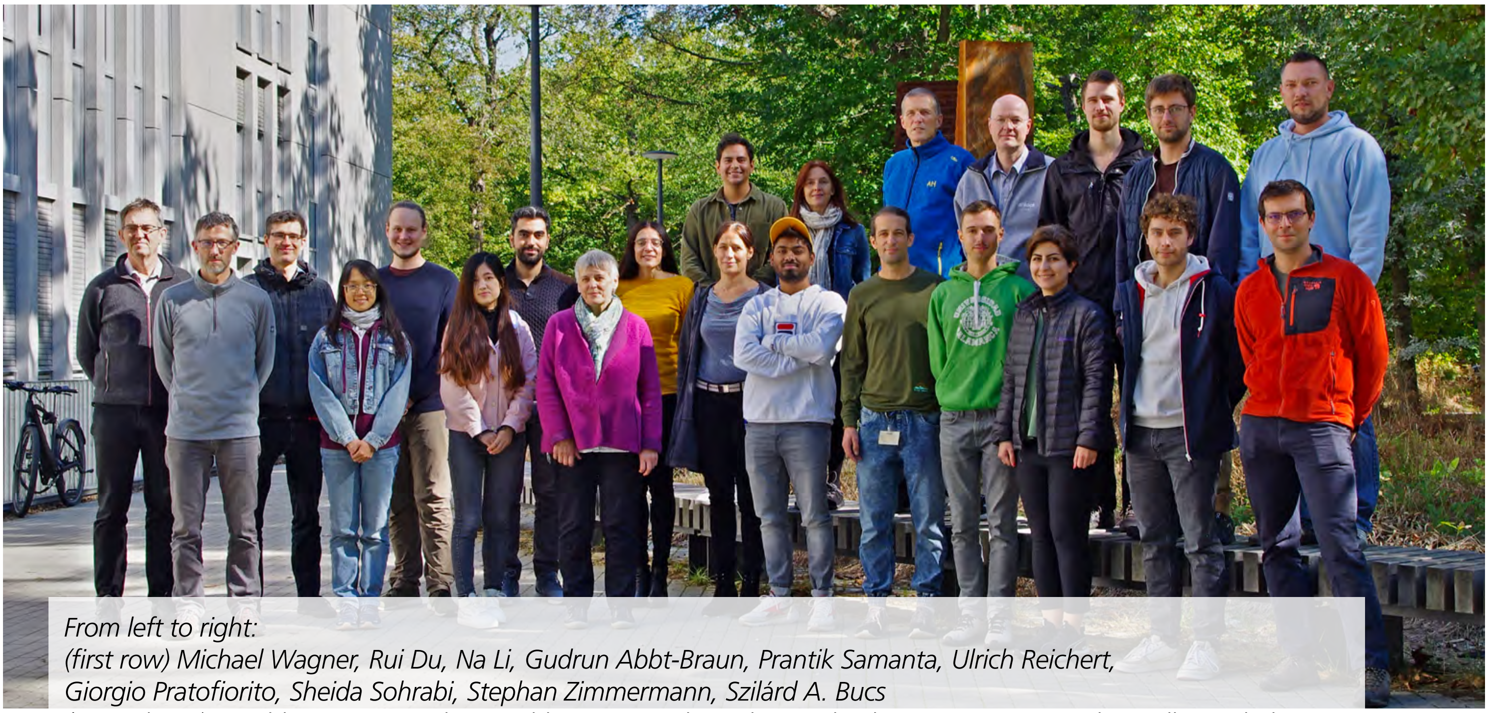
Netsch, A., Wagner, M., Horn, H.: On-line monitoring of biofilm accumulation on graphite-polypropylene electrodes applicable in bioelectrochemical systems using a heat transfer sensor.

Reiner, J., Hackbarth M., Horn H.: Scalable biofilm reactors as key component of a reaction cascade for the production of 2,3 Butanediol from food waste.

Wagner, M.: *Keynote lecture:* Biofilm imaging and its changes within the last decades.

Xiao, K., Pleitner, P., Abbt-Braun, G., Wagner, M., Horn, H.: Changes of ANAMMOX biofilm performance, organic components and microbial diversity under step-wisely increased ciprofloxacin stress.

Chabilan, A., Barajas Ledesma, D.G., Horn, H., Borowska, E., 2022. Fate of 19 antibiotics in aquatic environment - mesocosm experiment. 6th International Symposium on the Environmental Dimension of Antibiotic Resistance (EDAR 6), Gothenburg, Sweden, September 22 - 27, Poster.



From left to right:
(first row) Michael Wagner, Rui Du, Na Li, Gudrun Abbt-Braun, Prantik Samanta, Ulrich Reichert, Giorgio Pratofiorito, Sheida Sohrabi, Stephan Zimmermann, Szilárd A. Bucs
(second row) Harald Horn, Maximilian Miehle, Vasco Welter, Ali Sayegh, Florencia Saravia, Andrea Hille-Reichel
(third row) Yair Morales, Ulrike Scherer, Axel Heidt, Matthias Weber, Jonas Ullmann, Andreas Netsch, Rafael Peschke

FUNDING

We gratefully acknowledge the following institutions and associations for their financial support:

Karlsruhe Institute of Technology (KIT)

German Technical and Scientific Association for Gas and Water (DVGW)

The Land Baden-Württemberg

Helmholtz Association

Federal Ministry of Education and Research (BMBF)

Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg (MWK)

Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg

European Regional Development Fund (ERDF): Ministry of the Environment, Climate Protection and the Energy Sector Baden-Württemberg, co-financed by the European Union

European Commission – Horizon 2020

European Commission – European Support Instrument

Alexander von Humboldt Foundation

Baden-Württemberg Stiftung

Gesellschaft der Freunde des Engler-Bunte-Instituts

Chinese Scholarship Council (CSC), China

German Academic Exchange Service (DAAD)

German Federal Environmental Foundation (DBU)

German Federal Ministry for Economic Affairs (BMWi)

Water Chemistry Society (Division of the Gesellschaft Deutscher Chemiker e. V., GDCh)

The Umweltbundesamt (UBA)

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Duplication as digital and printed version:

Printed by Karlsruhe Institute of Technology (KIT), Karlsruhe (180 copies)
Topics in Water Chemistry and Water Technology, Number 28, published annually since 1995

The information printed in this newsletter is current as of October 31, 2022.

Issued by

Karlsruhe Institute of Technology (KIT)

President Professor Dr.-Ing. Holger Hanselka
Kaiserstraße 12
76131 Karlsruhe, Germany
www.kit.edu