Institute of Hydrochemistry
Department of Chemistry
Technical University of Munich

Annual Report 2015

Institute of Hydrochemistry

Chair of Analytical Chemistry

IWC group leaders preparing for the traditional Christmas dinner 2015

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Editor: Dr. Thomas Baumann

Editorial

Dear colleagues and friends!

These days the course will be set for the German Excellence Initiative II. For us, the question arises, whether and where the sought “excellence clusters” can be implemented among the respective disciplines in analytical chemistry and hydrochemistry. According to the database of the most cited publications, the hottest topics in hydrochemistry, one part of our business, are *water disinfection*, *membrane separation*, and *nanoparticle technology*. Top scorers in the field of analytical chemistry are *nanoparticle-assisted spectroscopy*, *imaging technologies*, and *chip-based DNA/RNA detection*. Assuming that the frequency of citations is related to the relevance, these topics might serve as a benchmark for the performance of research institutions and research initiatives.

As you will see in this annual report, there is a significant overlap between these hot topics and the research performed in our institute. Remember some ten years ago, when we implemented the first Raman microscope to investigate soot samples? Since then this technique served as a nucleus for a series of research projects. Today, the institute is well known for Raman microspectroscopy focussing on environmental samples. Applications include the unambigious characterization of microplastic to detect and avoid sampling artefacts, the identification of coatings on nanoparticles, the use of nanoparticles as analytical tools and tracers, and the identification and characterization of microorganisms. With Raman microscopy, a rapid identification of bacteria in its natural aqeous environment is possible. Also the status (live/dead) of bacteria is accessible, which is of paramount importance for the selection of countermeasures in case of an infection.

Complementary to Raman microscopy, we were the first to show exemplarily the on-chip isothermal nucleic acid amplification for the multiplex amplification and detection of viral and bacterial DNA by a flow-based chemiluminescence microarray. The completely automated platform was developed by our institute. The latest success story is our technology for the rapid detection of more than 15 subtypes of *Legionella pneumophila* strains and species with one single microarray, including the preconcentration of larger volumes of surface water already integrated into the system.

Beyond that, there is a significant number of "routine" examinations which, not for the first time, pinpoint problems, that might look simple at first glance. Scalings in geothermal systems are such an instructive example, causing high costs for repair and compensation of downtimes. Over the past years, we gained more insight into the involved mechanisms: degassing of excess methane and nitrogen leads to a stripping of dissolved carbon dioxide from the thermal water and a shift in the carbonate equilibrium, leading to carbonate scalings.

Whether we are excellent or not, is up to the scientific community to decide. But looking back on my 25 years at the institute, it seems that we are successfully competing with the best of the respective disciplines.

Thank you very much!

Reinhard Niessner

Hydrogeology and Hydrochemistry (PD Dr. T. Baumann)

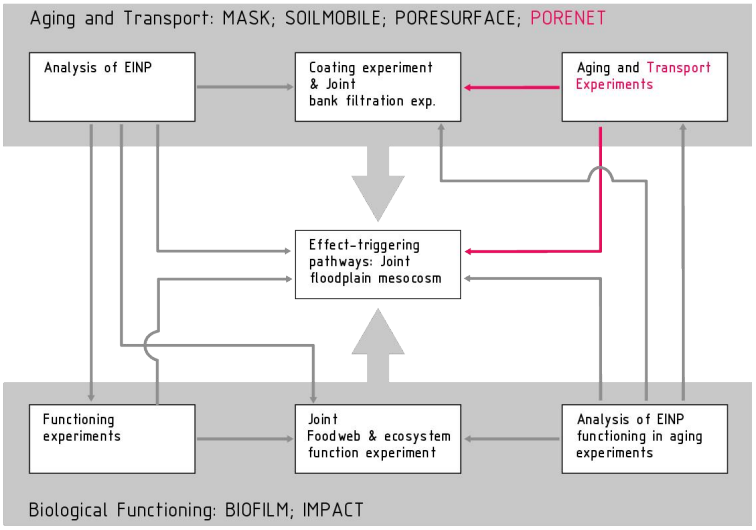
Changes of Nanoparticles Along Their Life-Cycle

Funding: DFG (Deutsche Forschungsgemeinschaft)
Cooperation: DFG Research Unit InterNANO (FOR1536)

Nanoparticles (NP) in the environment undergo changes which alter their mobility and toxicity. For instance humic substances increase the colloidal stability of NP while sulfidic coatings on Ag nanoparticles limit the release of Ag^+. After emission into the environment natural organic matter (NOM) seems to form a stable coating around Ag nano-particles immediately. The coating possibly replaces the original stabilizing agent (i.e. citrate), which can be deduced by the presence of the specific SERS signal of NOM obtained in the first phase. However, the formation of coatings along the life cycle is hard to measure. Due to analytical limitations a monitoring of the changes of coatings around NP has not yet been addressed.

Current measurement technology offers limited access to the formation of coatings (e.g. EXAFS for inorganic coatings) but virtually no time resolution. In the first phase Raman microspectroscopy (RM) was applied to gain information about coatings on Ag nanoparticles. Some relevant coatings can be distinguished (i.e. different humic substances, soil extract) easily if the potential coating agent is a strong Raman scatterer. Changes in the spectral features of NOM attached to Ag nanoparticles indicate a change of the structure of NOM and suggest an aging of the coatings. It has also be shown that the coating might become patchy if the environmental conditions are changing, i.e., if the concentration of the coating agent is decreasing. This suggests that the coating is reversible. This might also happen during sample preparation for off-site analysis techniques.

Based on the results obtained in the first phase of InterNANO the coating of EINP seems to be of paramount importance to assess and understand the fate of EINP in natural environments. The objectives for phase two of our research within the research unit are to characterize and measure the changes of the coatings on Ag nanoparticles under different, dynamically changing environmental conditions, to develop and apply a method to characterize and measure the coatings on TiO_2 nanoparticles using RM and SERS, to measure the effect of EINP on the local chemical environment, and to develop a model to describe the fate of EINP coatings.



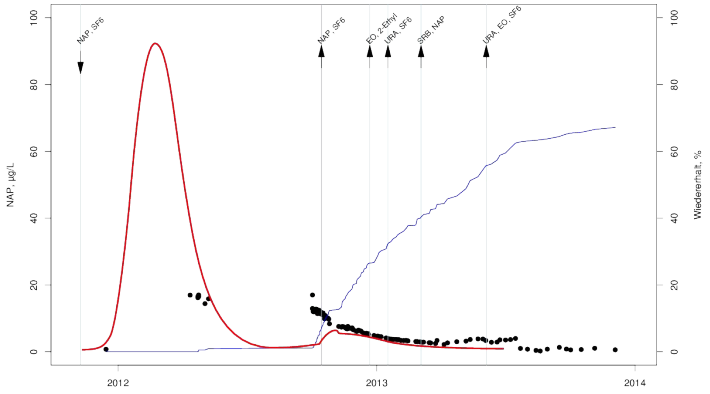
Cooperation matrix for phase II of the research unit InterNANO

S. Amininejad, M. Kühn

Quantification of Heat Mining in the Bavarian Molasse Basin

Funding: BMWi (Federal Ministry for Economic Affairs)
Cooperation: IEP GmbH, Pullach; Erdwerk GmbH, Munich; Aquasoil GmbH, Berlin

With high temperatures, high transmissivities, and low salinities the Malm Aquifer in the Bavarian Molasse Basin offers ideal conditions for the exploration of geothermal energy. In 2011 the Pullach geothermal facility was extended with a third geothermal well to account for the increasing heat demand. In the course of this extension an injection well was converted to a production well. Hence, for the first time in the history of geothermal exploration (not only) of the Malm Aquifer, data became accessible from the surrounding of an injection well which has been in operation for more than 5 years. This data, together with data from a push-pull tracer test started 9 months before the conversion, allows unique access to the processes at the injection well and sets the baseline for an assessment of the long term behavior of geothermal heat and power plants in the Molasse Basin.



Measured and simulated breakthrough of Na-Naphthionate

The development of the production temperatures went faster than expected, after 4 years of production the initial temperatures have almost been reached. This can only be explained with a vertically heterogeneous distribution of the transmissivity. In this setting, the cold water forms a thin disc which extends much further from the injection well. Thus, the effective area of the heat exchange with the matrix of the aquifer is larger than in a homogeneous setting. The breakthrough of the tracers was affected by an unexpected delay of the start of the production. The regional flow led to a shift of the injected tracer pulses with the innermost tracer pulse being entirely transposed downstream of the injection well. The recovery rates mirror the sorption coefficients of the individual tracers as determined in batch tests and column tests. It became apparent, that the stagnation phase led to a bias towards sorption with slow kinetics and diffusion-limited matrix interactions.

The hydrochemical data showed a significant increase of the concentrations of calcium, magnesium, and bicarbonate indicating a dissolution of dolomite. The dissolution overcompensates the effects of the increased viscosity of the injected cold water. Modeling results indicate that lower temperatures and different lithostratigraphy are contributing to the dissolution. These processes would also occur if the water would be produced from a dolomite and injected into a limestone, which explains why most facilities in the Molasse Basin have recorded decreasing injection pressures.

M. Lafogler, T. Baumann

Scalings in the Geothermal Cycle

Funding: BayMWi (Bavarian State Ministry for Economy), Geothermie-Allianz Bayern
Cooperation: Operators of geothermal facilities in the Bavarian Molasse Basin

Scalings are a widespread problem for geothermal plants which exploit the Malm Aquifer in the Bavarian Molasse Basin. They affect the technical and economic efficiency of geothermal plants and cause costly revisions of the geothermal cycle. Observed scalings mainly consist of different $CaCO_3$ polymorphs and are found at the motor, in the pumps and pipes and throughout the groundlevel facilities including the heat exchangers.

There are two main processes leading to a disruption of the carbonate equilibrium and causing these scalings: local temperature peaks and degassing of less soluble gases due to local pressure drops. While the increase of the temperature leads to a local supersaturation at the hot surface of, e.g., the motor of the submersible pump, the formation of gas bubbles strips all soluble gases from the solution according to the Henry equilibrium constants, thus shifting the carbonate-equilibrium. In order to prevent the formation of scalings, these processes have to be quantified and controlled.

In the scope of the Bavarian Geothermal Alliance, the scalings in all sections of the geothermal cycle at different geothermal facilities in the Malm Aquifer will be addressed.

So far, scalings from four different combined heat and electricity geothermal plants, which produce water with temperatures between 100 and 150 °C were taken. At all sites, samples were taken from the particle filters in front of the heat exchangers. At three plants, samples from the evaporator were available, one site provided scalings from the injection section and at another site we could recover samples from the pump, the motor and the production tubes (every 11 m) until ground level.

The samples were characterized by REM-EDX, XRD, Raman Spectroscopy and image processing to assess the elemental composition, mineralogical composition, crystallinity, phase transformations, and possible fluid inclusions. The thickness, porosity and bulk density were measured to assess the mass of the deposits and to calculate the kinetics of the formation.

Accumulated scalings inside an evaporator

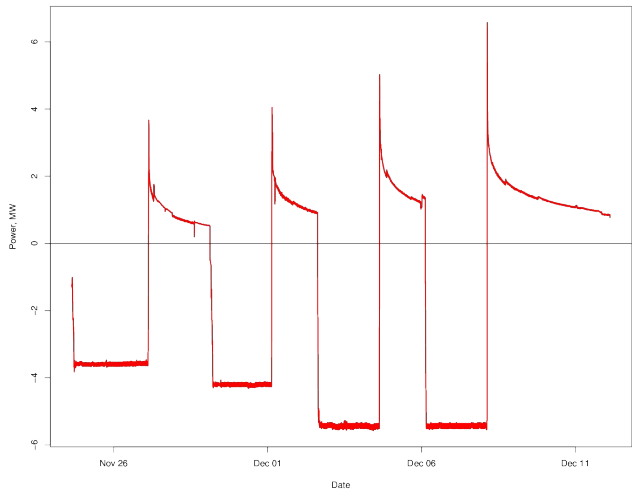
Scalings in the production pipes showed a unique pattern, with higher thickness above the pump and close to ground surface, indicating degassing in the pump. Scalings at the withheld in the filters contained fragments of aquifer materials produced after powering the pumps and ground level scalings after filters often consist of fragments of smaller scalings mobilized somewhere else.

B. Köhl, M. Herbrich

High-Temperature-Aquifer Storage

Funding: BMW (BayINVENT)
Cooperation: TUM Hydrogeology; Erdwerk GmbH, Munich; Aquasoil GmbH, Berlin

Combined heat and power plants (CHP) are efficient and environmentally friendly, because excess heat is used for heating purposes. However, the power demand remains rather constant throughout the year, whereas the heat demand shows a seasonal variation. In a worst case scenario, the heat production in winter is not sufficient, while the power production in summer has to be ramped down, because the excess heat cannot be released to the environment. Therefore, storage of the excess heat of CHP is highly beneficial from an economic and an ecological point of view.



Loading of the high temperature aquifer storage

Aquifer storage systems use the water from an underground reservoir to store energy and benefit from the vast amount of energy that can be stored, and the low heat capacity and heat conductivity of the rock matrix which then serves as an insulator. Small scale aquifer storage systems have been implemented in well secluded shallow groundwater aquifers as well as in some deeper reservoirs. While very few systems are designed for higher temperature levels (> 110 °C) and higher energy amounts, none of the latter systems has been implemented in a reactive aquifer like limestone or dolomite.

Here, hydrochemical reactions in the reservoir could severely affect the long-term efficiency of the aquifer storage system and process safety. Therefore, a testing site was established to run a pilot study at one of the production plants of BMW in the Northeastern Molasse Basin.

Hydraulic tests at the research borehole showed an unusual high transmissivity and the investigation of the cores from the boreholes indicated a high porosity. However, neither the evaluation of the hydraulic tests nor the hydrogeological model were able to predict the observed mixing of the injected water in the reservoir correctly. While the results of the hydrochemical monitoring suggest either mixing or a contribution of reservoir water from deeper strata not affected by the injection, the tracer results remove this ambiguity and clearly indicate that mixing in the vicinity of the borehole has to be taken into account. Energy recovery increased with each of the four loading cycles performed in the preliminary tests. The hydrochemical monitoring indicated that dissolution and precipitation processes can be controlled. All together the results support the setup of a large scale high-temperature aquifer storage system which will be set up starting in 2016.

M. Ueckert

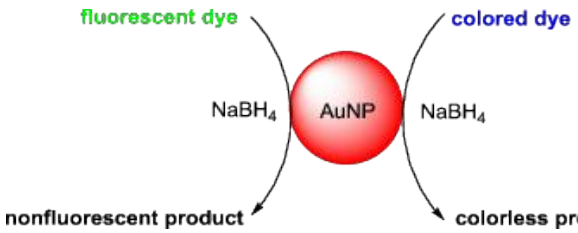
Bioanalytics (Apl. Prof. Dr. D. Knopp)

Gold Nanoparticle-Catalyzed Uranine Reduction for Signal Amplification in Fluorescent Assays

Funding: IWC, China Scholarship Council

Gold nanoparticles (AuNPs) received increasing interest due to their distinct physical and chemical properties. They are frequently modified with different molecules, like fluorescent dyes, proteins, and DNA to construct specific nanoprobes, which are then utilized for the detection of various analytes. To achieve high assay sensitivity, different strategies are used, e.g., enzymatic or DNA-based signal amplification. In addition, the catalytic properties of colloidal gold themselves can be utilized. For example, AuNPs can catalyze the reduction of organic compounds.

In this project, a multifunctional fluorescence platform has been constructed based on AuNPs-catalyzed uranine reduction. The reaction was conducted in aqueous solution using AuNPs as nanocatalyst and sodium borohydride as reducing agent, which was monitored by fluorescence and UV-vis spectroscopy. AuNPs may act as an electron relay system where electron transfer takes place between uranine and BH_4^- through the AuNP. $NaBH_4$ not only serves as reducing reagent, but also controls the solution pH value. Kinetic studies demonstrated that the concentration, size and dispersion state of colloidal gold greatly affect the reaction rate. When it was aggregated, its catalytic ability decreased. This was used to develop a label-free fluorescent assay for the detection of melamine in milk. In addition, a fluorescent immunoassay for aflatoxin B1 (AFB1) was established using the catalytic reaction for signal amplification based on target-induced concentration change of AuNPs, where AFB1-BSA coated magnetic beads (MBs) and anti-AFB1 antibody-conjugated AuNPs were employed as capture and signal probe, respectively. The assay can be accomplished in 1 hour and was successfully applied to milk and maize samples. It could be applied to other compounds because of attractive features like (a) AuNPs can be functionalized with affinity ligands such as antibodies or aptamers; (b) making full use of the catalytic activity of AuNPs as well as the high fluorescence quantum yield of uranine, the assay strategy exhibits high sensitivity, (c) the usage of MBs reduces incubation time and the formed AuNPs-MBs immune-complexes can be easily removed owing to efficient magnetic separation.



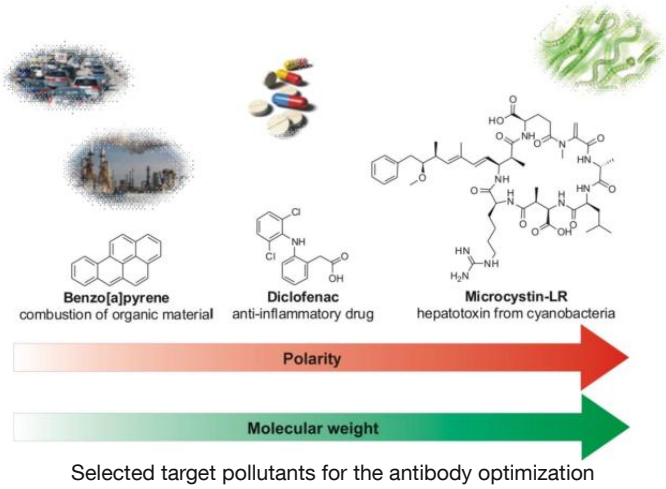
Schematic representation of AuNP-catalyzed reduction of dye by $NaBH_4$

X.Wang

Nanoscaled Architectures for Highly Sensitive Biosensing of Small Molecules

Funding: DFG (Deutsche Forschungsgemeinschaft)/ANR (Agence Nationale de la Recherche)
Cooperation: Université Pierre et Marie Curie, Paris, France, Prof. Dr. S. Boujday, Prof. Dr. A. Proust, Prof. Dr. C.-M. Pradier

Rapid and accurate detection of undesirable and toxic substances in human environment has become a major concern of our modern society. Therefore, biosensors which combine biological materials with physicochemical transducers are now becoming part of the daily routine. They are the key to fast, selective, and highly sensitive detection of the target molecules, even in demanding matrices.



Selected target pollutants for the antibody optimization

In this project, taking advantage of the complementary expertise of the involved teams, efforts have been made to improve the sensitivity of immunosensors, especially for the detection of targets of low molecular weight, like polycyclic aromatic hydrocarbons, algae toxins and pharmaceuticals. As the availability of highly affine antibodies was indispensable to achieve the main objective of the project, great efforts have been taken to prepare the first monoclonal antibodies (mAbs) against the non-steroidal anti-inflammatory drug diclofenac (DCF).

Recently, DCF was added in the EU watch list of emerging aquatic pollutants together with 17-beta-estradiol and 17-alpha-ethinyl-estradiol in order to gather Union-wide monitoring data. The proposed limit value for wastewater treatment plants is 100 ng/L for DCF.

However, DCF is detected in concentrations between 1 and 10 µg/L in wastewater treatment plants, mainly because the conventional activated sludge treatment is inefficient with regard to the removal of DCF.

To foster a quick monitoring of wastewater treatment plants, well-characterized mAbs against DCF were generated and highly sensitive immunological assays (ELISA on microtiter plate and microarray-based assay on glass slides) were developed.

Our best antibody to date is highly affine (K_D = 1.5 x 10^{-10} M), insensitive to potential matrix interferences such as pH values in a range of pH 5.2 - 9.2, Ca^{2+} concentrations up to 75 mg/L, and humic acid concentrations up to 20 mg/L. The LOD and IC_{50} of the ELISA calibration curve were 7.8 and 44 ng/L, respectively. The working range was defined between 11 and 180 ng/L. The assay was successfully applied for the determination of DCF at the low ppt range in river, lake water and wastewater influents and effluents.

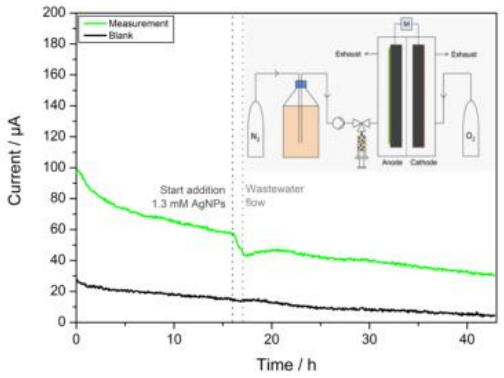
M. Hübner

Non-targeted Toxicity Testing of Nanoparticles by a Two-compartment Microbial Fuel Cell

Funding: IWC
Cooperation: Max von Pettenkofer-Institut, LMU, Dr. A. Wieser, Prof. Dr. S. Schubert

Toxic components for the bacterial cultures in wastewater treatment plants are as various as antibiotics, heavy metals and disinfectants. Scientific attention is increasingly paid to nanomaterials and their inhibitory effects on microbial growth. In industry, different nanoparticles like silver (AgNP), titanium dioxide (TiO_2NP), silicon dioxide (SiO_2NP) and zinc oxide (ZnONP) are used, e.g., for microelectronics and semiconductors, catalysts, and personal care products. As a consequence of the different uses the occurence and concentration of nanoparticles in industrial and municipal wastewater vary depending on the season and the time of the day.

Microbial fuel cells (MFC) have been proposed as a self-sustainable biosensor for wastewater quality monitoring. For example, a direct correlation between the biological oxygen demand (BOD) and the current output is established. MFCs are bioelectrochemical devices which can convert organic matters, for example in wastewaters, to electricity by exoelectrogenic bacteria growing on the surface of the anoxic anode. Using this effect, we present a method to assess the impact of nanoparticles on the microbial by measuring the efficiency of power generation in a two-compartment microbial fuel cell (TCMFC). Wastewater cultures were used as source for exoelectrogenic bacteria and wastewater as carbon source. The bacterial population used for TCMFC were cultivated and different species identified by MALDI-TOF before and after measurements, revealing a complex and diverse composition of the bacterial colonization. First experiments with different bactericidal and bacteriostatic agents like ethanol, NaN_3 and formalin gave rise to the hypothesis that the progression of the responding current signal depends on the killing mechanism of these chemicals. However, signal changes upon interaction with nanoparticles were low compared to those induced by NaN_3, ethanol, or formalin. One reason might be the distribution of the nanoparticles inside the biofilm. Nanoparticles are impeded from entering into the biofilm and hardly reach the base level of the biofilm where electron transfer predominantly occurs. DLS measurements revealed a wide size distribution of the used particles systems, ranging from 30 nm to 6 µm; hence, it can be assumed that at least the larger particles hardly reach the base layer of the biofilm.



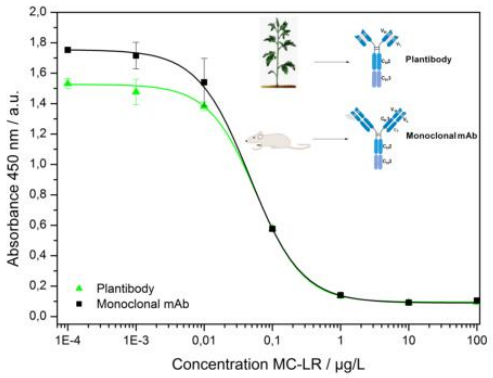
Effect of AgNPs on the current generation

C. Hartmann, A.-C. Neumann

Plant-produced Antibodies for the Depletion the Most Toxic Cyanotoxin Congener Produced by Blue Algae

Funding: DFG (Deutsche Forschungsgemeinschaft)/FWF (Fond zur Förderung der wissenschaftlichen Forschung)
Cooperation: University of Natural Resources and Life Sciences (BOKU), Vienna, Austria, Prof. Dr. E. Stoeger

Although the use of genetically modified plants for bioremediation, or the in situ cleaning of contaminated sites, has been known for quite some time, little attention has so far been paid to the production of antibodies in plants and their *ex vivo* application in selective depletion. However, the production of antibodies in genetically modified plants presents a lot of advantages compared to commonly used methods, namely low cost production, simple upscaling, and the abdication of laboratory animals. In the presented project the *ex vivo* depletion of a widespread hepatotoxin named microcystin-leucine-arginine (MC-LR) with selective immunofilters based on plant-produced antibodies (plantibodies) will be demonstrated.



ELISA dose-response curves established with a monoclonal mouse antibody and the new plantibody

Climate change and an intensified agricultural use, causing water eutrophication, has caused an increase of the distribution of cyanobacteria in inland waters even in higher latitudes over the last few years. The World Health Organization recommendation for the concentration of free and cell bound MC-LR in drinking water is 1 µg/L. However in raw water this value is often 10-100 times excelled, especially in eutrophic surface waters, so that there is an evident need for the quantitative depletion of MC-LR. Plantibody production was operated by the infection of *Nicothiana benthamiana* with *Agrobacterium tumefaciens* which carried a transformation vector with the sequences for the VL und VH region of the MC10E7. After a cleaning step with protein A the received plantibodies were first tested by enzyme-linked immunosorbent assay (ELISA).

It was possible to generate a highly affine and specific plantibody (IC_{50} value of 58 ± 4 ng/L) which is insensitive to humic acids, high ionic strength (Ca^{2+}), acidic pH-values, and organic solvents (MeOH and acetonitrile). During the course of the project the plantibody will be immobilized by encapsulation in a glass matrix. For tests with monoclonal MC10E7 breakthroughs for MC-LR at 1200 ng (for column preparation: 0.5 mg antibody encapsulated in 0.5 g matrix) and total binding capacities up to 74% regarding the theoretical binding capacity of 0.5 mg antibody (assuming bivalent binding) were achieved.

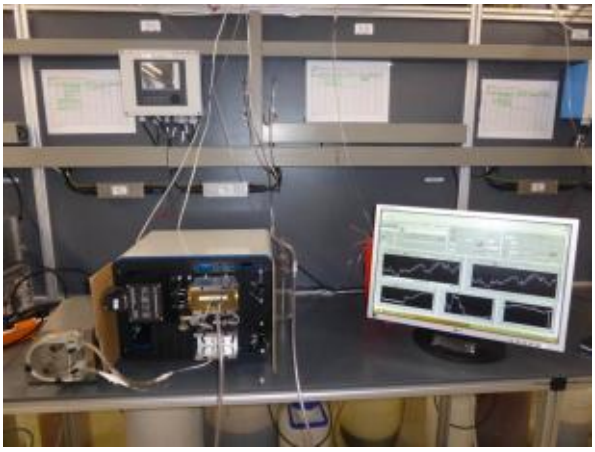
A.-C. Neumann

Applied Laser Spectroscopy (PD Dr. C. Haisch)

Sampling and Detection of N_2O in Wastewater Treatment Plants

Funding: International Graduate School of Science and Engineering (IGSSE)
Cooperation: TUM, Chair of Urban Water Systems Engineering, Prof. Drewes

Nitrous oxide (N_2O) is a strong greenhouse gas with a significantly higher global warming potential than carbon dioxide. N_2O is produced by wastewater treatment plants during the biological nitrogen removal process. Due to the lack of comprehensive monitoring approaches, available data is limited to establish quantitative relationships between nitrous oxide emissions and process parameters of biological nitrogen conversions. The goals are to develop novel monitoring and control strategies for N_2O employing photoacoustic (PA) laser spectroscopy. That will enable a tight control of contemporary nitrogen removal processes as well as new ways in harvesting N_2O for enhanced energy recovery from waste streams.



Setup of the N_2O-monitoring system

Together with the Chair of Urban Water Systems Engineering, an appropriate gas capture and handling system has been developed. Gas samples from multiple test-reactors are pumped continuously to the central PA-based detection unit, where N_2O is measured sequentially.

Additionally, a novel sample device comprised of a gas permeable membrane, which is submerged in the mixed liquor reactor, will allow reliable gas phase measurements with the same PA unit after optimization. Here, the task is to extract the dissolved N_2O gas from the liquid phase. A highly selective membrane is needed, which has to be permeable to N_2O and impermeable to water. First experiments with different silicone membranes show promising results. Dimensions of the gas permeable membrane, as well as the gas flow have to be optimized, and potential aging due to biofilm growth will be investigated. Comparison of the PA-data with routine analytical methods (e.g. gas chromatography) is implemented. Degassing by pressure reduction using a syringe pump show promising results. Additionally several gas extraction methods will be tested and compared to the membrane extraction.

Tests under real conditions and long-term measurements at waste water treatment plants are planned for next year. A complete characterization of N_2O emission during nitrogen removal process will be shown to the end of the project.

K. M. Thaler

A Novel Plasmaspectroscopic System for Online Monitoring of Siloxanes in Biogas

Funding: IWC

Due to rising energy consumption and the drive to renewable energies, biogas is increasingly used as an energy source. The number of biogas plants has more than quadrupled in the last ten years in Germany. Depending on the energy utilization, determination of the composition and in some cases the removal of certain components is required.

Siloxanes are undesirable trace components, which can be found in varying concentrations in biogas from wastewater treatment. If these organosilicon compounds reach the combustion engines, they get oxidized to silicon oxide, which gets deposited in form of a white precipitate on parts of the engine. The crystalline SiO_2 can clog valves and cause overheating of motor parts, since the deposits act as a thermal insulator. Also SiO_2 particles accumulate in the engine oil and cause additional wear. Therefore, operators of landfills and sewage treatment plants must ensure that the siloxane concentration in combustion gas remains below the limits recommended by the engine manufacturer.

The goal of this project is the quantification of these compounds in biogas. A novel method based on plasma emission spectrometry is used. A gas discharge, generated by high voltage, serves as a plasma source. The advantage of this approach is that it is relatively cheap to generate plasma in this form compared to other analytical methods e.g. laser-induced breakdown spectroscopy (LIBS). The optical emission of the plasma is detected by a spectrometer. Quantification of the silicon concentration takes place by the observation of the atomic silicon emission line intensity at 288.16 nm. By comparing several measuring cells, optical devices, and high-voltage sources, low detection limits are achieved.

Gas discharge plasma sensor as used for siloxane monitoring

A mobile measurement system has been built and tested under real world conditions. Problems caused by the humidity of the biogas need to be overcome. New possibilities to generate plasma with higher energy are verified. The use of microwave radiation is tested to improve the atomization of the compound in the biogas.

K. M. Thaler

Laser Photofragmentation for the Detection of Nitro-PAHs in Combustion Engine Exhaust

Funding: DFG (Deutsche Forschungsgemeinschaft)

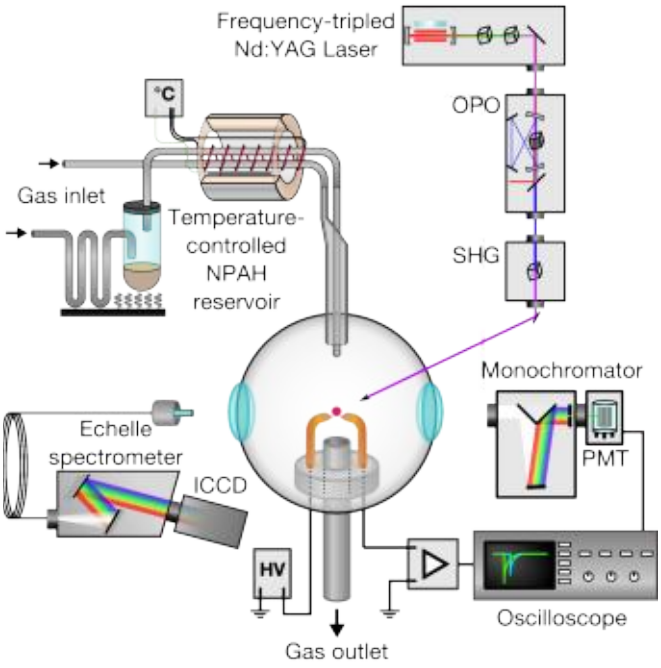
Nitrated polycyclic aromatic hydrocarbons (NPAHs), together with their parent compounds, PAHs, are probably the abiotic class of substances which is most harmful for human health, not only in the atmosphere, but in every environmental compartment. More than a third of the mutagenic potential of ambient air is attributed to NPAHs.

Our aim is to employ photofragmentation (PF), the process of breaking chemical bonds through interaction with one or multiple photons, as a means to investigate NPAHs in the gas phase as well as adsorbed on aerosol particulate matter. High sensitivities in the low ppb or even ppt range for PF-based gas phase analysis can be achieved.

Different modalities can be distinguished, regarding the fragmentation mechanism and the way of fragment detection. Resonant fragmentation allows for a rather straightforward system setup; a single laser pulse can be employed for fragmentation and photoionization. Depending on the photon energy employed, the fragments can be generated in an excited state, which relaxes by optical emission.

For nitrated aromatic compounds, a fragmentation process including elimination of nitrogen dioxide (NO_2) in an excited state and consecutive decay to excited atomic oxygen and excited nitric oxide (NO) is known. The excited NO molecules optically relax to the ground state.

A frequency-doubled optical parametric oscillator pumped by the third harmonic of a pulsed Nd:YAG laser is used as a light source with a broad continuous tuning range in the ultraviolet as well as visible spectral range. An intensified CCD camera (ICCD) coupled to an echelle spectrometer allows for time-resolved broadband spectral analysis. In order to achieve higher light sensitivities, grating monochromators and photomultiplier tubes are used. Simultaneously, photoionization current between two pointed copper electrodes can be detected.



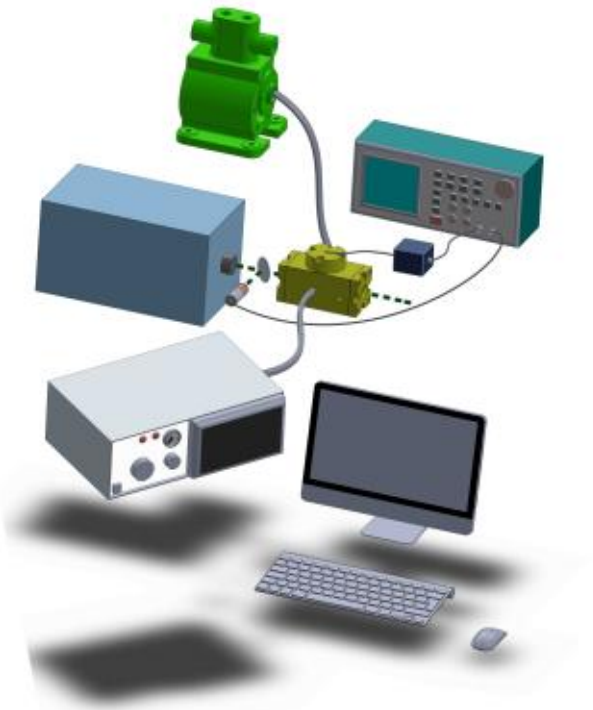
Setup of the photofragmentation system

S. Schneider

Pulsed Laser Photoacoustic Spectroscopy

Funding: DBU (Deutsche Bundesstiftung Umwelt)

The investigation of soot requires methods and devices not only for quantitative as well as qualitative analysis. Photoacoustic (PA) spectroscopy is known as a sensitive and suitable method for trace gas analysis. However the significance of PA spectroscopy is even bigger for soot analysis. The reason



Schematic of the experimental setup for pulsed photoacoustic spectroscopy

of this is the optical properties of aerosols, of course, including soot. The light which travels through the aerosols is not only absorbed but also scattered. In consequence, the typical extinction measurement methods are not applicable to measure the absorption coefficient of soot, thus providing quantitative information.

An ordinary PA soot detection setup or device consists of laser, pump, lock-in amplifier and resonance cell. However, the device, which operates in resonance mode, is sensitive to environmental fluctuations. Management of this problem requires sophisticated techniques and supplementary devices, making the instruments even more complex. Therefore, there is a high demand for simpler, non-resonant PA systems. Using pulsed lasers as a light source likely provides suitable pulse energy for non-resonant PA spectroscopy.

In order to improve the time resolution of PA device, which is limited by the circulation time for the gases in the PA cell, we developed a simplified cell with a quite small volume.

For pulsed laser PA spectroscopy researches were Nd:YAG laser's second harmonic pulses (532 nm) used. The repetition rate of laser was 10 Hz, pulse duration at FWHM (Full Width Half Maximum) was 7 ns and the pulse energy was 5.5 mJ, which is sufficient for experiments. An average of 10 signals was used and a good compromise between signal quality and time resolution. Using lasers with higher repetition rate improved both, the devices' stability and the time resolution.

System response to change of soot or NO_2 concentration was evaluated using the peak to peak signal times of the PA signal and fast Fourier transformation. The linearity of the signal response was sufficient, however the overall system performance was still limited by the stability of the lases power.

A. Griauslys

Photoacoustic Spectroscopy in Mixed-phase Dispersions

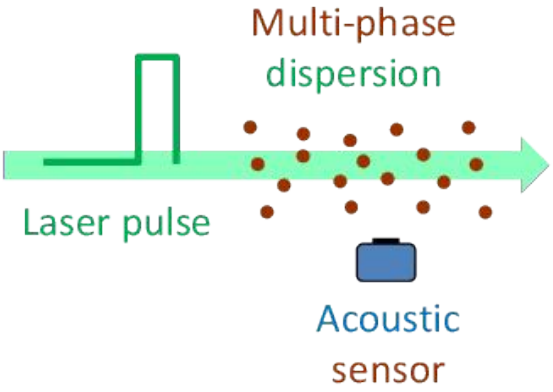
Funding: Alexander von Humboldt-Foundation
Cooperation: LMU LIFE-Centre Laser-Forschungslabor

Examples of mixed-phase dispersions include atmospheric aerosols or nanoparticles in suspension. These are systems in which particles are dispersed in a continuous phase of different composition. The presence of the particles causes light scattering, which limits the application of pure optical diagnostic techniques.

Photoacoustic spectroscopy is a photothermal sensing technique involving the conversion of absorbed light energy into sound energy and is ideal for studying mixed-phase dispersions because the results are not strongly affected by light scattering. Although photoacoustic spectroscopy has been successfully demonstrated in a variety of application areas, including gas detection and biomedical imaging, accurate quantitative measurements and analytical understanding of the photoacoustic effect are still limited to simple cases such as homogeneous gas sensing.

This project investigates the fundamental signal generation process in photoacoustic spectroscopy of mixed-phase dispersions. In contrast to the photoacoustic effect in homogeneous-phase samples where absorption of optical energy causes rapid local heating, thermal expansion, and acoustic wave generation, all in the sample phase, the case in mixed-phased dispersions is different in that the heating and thermal expansion do not occur locally in the particle that absorbs the optical energy, but also in the surrounding phase. Therefore, particle size, composition, and morphology can have an effect of the photoacoustic signal generation efficiency.

We performed a systematic series of photoacoustic experiments using suspensions of gold nanoparticles of different diameters. These nanoparticles are used as contrast agents in biomedical photoacoustic imaging and understanding the photoacoustic signal generation will enable quantitative imaging. Our experiments were carried out in a custom-made cuvette with a built-in acoustic sensor for detection of photoacoustic waves. The second harmonic of a pulsed Nd:YAG laser (532 nm) was used for photoacoustic illumination. To determine the



Schematic for photoacoustic sensing of a multi-phase dispersion

relationship between photoacoustic signal generation and absorbed optical energy in the different nanoparticle suspensions, the absorption and scattering coefficients were measured in an integrating sphere setup designed for measuring optical properties of scattering media.

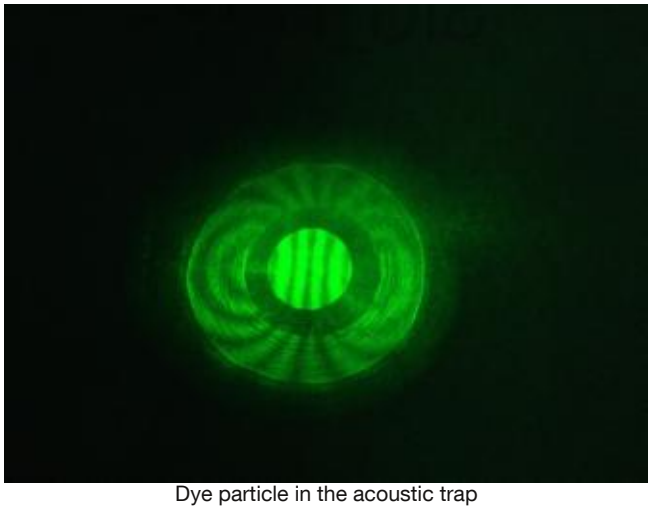
Parallel work involved investigations analyses of the relationship between photoacoustic signal generation and absorbed optical energy in other types of mixed-phased dispersions, such as atmospheric aerosols, where aerosol absorption measured using photoacoustic spectroscopy can aid atmospheric modelling.

G. Pang

Photoacoustic Spectroscopy on Single Optically Levitated Nanodroplets

Funding: International Graduate School of Science and Engineering (IGSSE) & Swiss National Science Foundation
Cooperation: Prof. R. Signorell, Johannes Cremer, ETH Zurich, Switzerland.

Photoacoustic spectroscopy is an established technique for the optical characterization of aerosol particle ensembles. However, applicability to single isolated aerosol particles has not been demonstrated yet. Single aerosol particles are best characterized when levitated in air using an optical trap. In this setting, the particle size



Dye particle in the acoustic trap

can be determined by elastic light scattering. We were able to demonstrate that photoacoustic measurements on optically trapped single particles provide a direct, widely applicable method to measure absorption with attoliter sensitivity.

In our experiments, single particles (500 nm to 10 µm diameter) of a yellow dye are immobilized by a trapping laser inside a specially designed acoustic resonator. The trapped droplet sits above a sensitive electret microphone and reveals a photoacoustic signal when illuminated by the excitation laser. The excitation laser was selected with a maximum emission wavelength matching the maximum absorption of the particle in the trap. The photoacoustic setup is used to study the influence of size-dependent focusing of light inside small droplets on photochemical reactions. The photoacoustic signal decreases exponentially as the absorber undergoes photolysis. The observed reaction rate does not scale linearly with particle size, since focusing of light inside small droplets leads to an enhancement of the overall light intensity and thus to an increased reaction rate. Nanofocusing of electromagnetic radiation inside aerosol droplets plays a crucial role in their absorption behaviour, since the radiation flux inside the droplet strongly affects the activation rate of photochemically active species. The nanofocusing only occurs in a certain droplet size range. For very small (20 nm) and very large (10 µm) particles, the effect is negligible.

We demonstrate the viability of this new method for the first time and showed its extreme sensitivity, enabling studies even of single nanodroplets (10 attolitres). The ability to measure and thus quantify the kinetics of the light-induced step in photochemical reactions in aerosol particles is of fundamental importance for atmospheric chemistry, where chemical processes are largely driven by sunlight.

K. M. Thaler

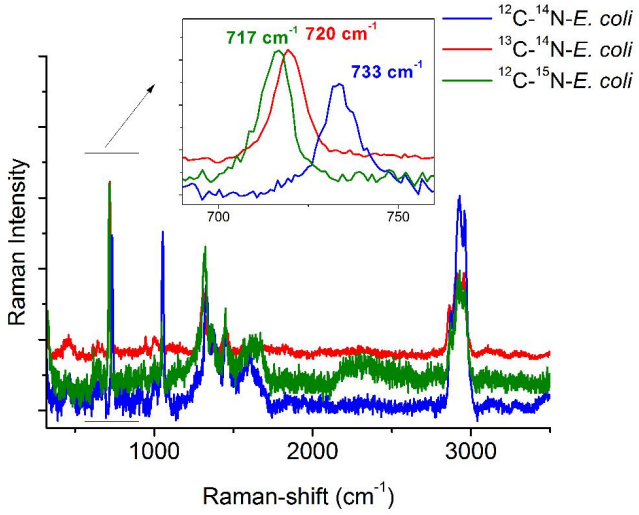
Raman Microspectroscopy (Dr. N. P. Ivleva)

Stable Isotope Resonance Raman Microspectroscopic Analysis of Groundwater

Funding: Helmholtz Zentrum München (Water Alliance)
Cooperation: Prof. R.U. Meckenstock, PD Dr. T. Lüders, Institute of Groundwater Ecology, Helmholtz Zentrum München

On our planet most microbial cells can be found in multicellular communities. They are usually embedded in a hydrogel matrix of extracellular polymeric substances (EPS). These multicellular communities of microorganisms are called biofilms. They play an important role in the degradation of pollutants in aquatic systems, but are very sensitive to changing boundary conditions. A rapid and non-invasive analytical tool for chemical characterization with high spatial resolution and sensitivity is therefore needed. Raman microspectroscopy (RM) is a powerful tool for an in situ nondestructive chemical characterization of biofilm matrix in the µm-range. However, due to the low quantum efficiency of 10^{-6} - 10^{-8} for the Raman effect, Raman spectroscopy has only a limited sensitivity. An enhancement of the Raman signal is needed and therefore surface-enhanced Raman scattering (SERS) is used. SERS occurs if a molecule is attached to or in immediate proximity of a nanometer-roughened metal (e.g. Ag, Au) surface. In combination with stable isotopes a better understanding of accumulation and/or degradation pathways on the single cell level can be achieved.

E. coli was used as a model organism to explore the possibilities of SERS in combination with stable isotopes (^{13}C- or ^{15}N-labeled compounds) at single cell level. The SERS analysis of bacteria cultivated with ^{12}C-, ^{13}C- or ^{15}N-compounds showed a very good reproducibility. Notably, a very sharp marker band at 733 cm^{-1} for ^{12}C-*E. coli* cells could be found. This band is significantly red-shifted to 720 cm^{-1} or to 717 cm^{-1} for ^{13}C-labeled and ^{15}N-labeled cells, respectively. This fact enables a direct comparison between bacteria with different stable isotope labels using stable isotope SERS. These results could open new possibilities in characterizing microbiological processes at single cell levels and should help in understanding the influence of biofilms on flux, turnover and fate of natural and anthropogenic pollutants.



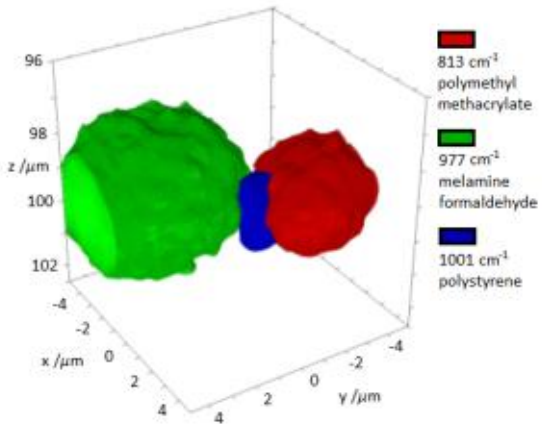
Spectra of *E. coli* cells labeled with ^{12}C, ^{13}C or ^{15}N with the red-shift of the adenine-related marker band

P. Kubryk

Raman Microspectroscopy for Non-invasive Three-dimensional Analysis

Funding: Helmholtz Zentrum München, Water Alliance, DFG (Deutsche Forschungsgemeinschaft)

Confocal Raman microspectroscopy (RM) enables a three-dimensional chemical characterization of transparent samples. This technique is of great use for the analysis of heterogeneous compounds and for a depth profiling of layered materials. Because RM is a minimal-invasive analytical method with little need for sample preparations, it is suited for sensitive samples like biofilms. Model experiments with artificial biofilms allowed a measurement depth of up to 500 µm, a lateral resolution of about 2 µm and a depth resolution of around 4 µm (λ_0 = 532 nm, Olympus LUMPlanFI 100×, NA = 1.0). As the figure shows even particles in close proximity can be separated with the spectroscopic data of the 3D RM. Furthermore, the resonance Raman signal of *Geobacter* cells could be detected in a measurement depth of 100 µm, suggesting the applicability of the 3D RM onto real samples.



3D Raman image of plastic particles inside an artificial biofilm (agarose gel) at a measurement depth of about 100 µm

Another important advantage of the RM is its ability to distinguish between different stable isotopes. Though most physical and chemical properties of substances change only slightly, the shifted Raman signals permit the conclusion about the exchange of isotopes. Already successful applied stable isotope probes can be analyzed three-dimensionally via the 3D RM. In a simple experimental setup the content of deuterated water in multiple stacked water layers with a thickness of about 15 µm could be correlated to the red-shifted Raman signal. The three-dimensional execution of the stable isotope RM (SIRM) with a high spatial allocation is sure to broaden the informative value of this analytical technique.

The detection and assignment of inclusions or the 3D examination of biofilms – just to name two examples for the scope of application – are possible with the 3D RM. Biofilms play an important role for the accumulation and degradation of substances, which are related to the water quality. Here, 3D SIRM features considerable potential for a detailed, time and spatially resolved analysis of the processes in this complex ecosystem, which is also a place for the development of pathogenic bacteria. The 3D characterization of biofilms might reveal essential insights into the flux and state of pathogens and pollutants.

R. Weiß, P. Kubryk

Raman Analysis of Soil Organic Matter for Improving the Water Holding Capacity

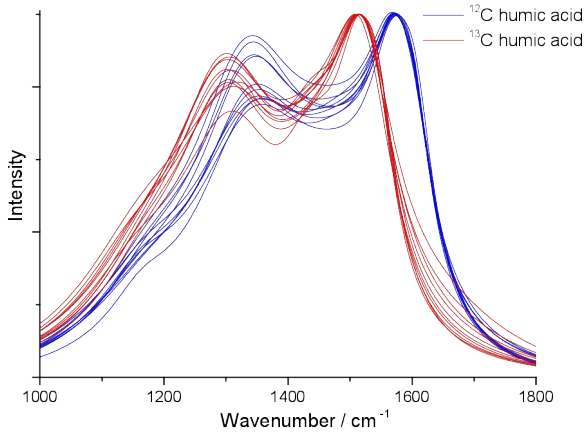
Funding: International Graduate School of Science and Engineering (IGSSE), TUM
Cooperation: Prof. Dr. I. Kögel-Knabner, Chair of Soil Science, TUM

Climate change will cause alternate rainfall patterns with more intense incidents with lower frequencies. This will result in higher draught risks in arid areas, whereas humid regions are endangered to flooding. In order to ensure a constant agricultural yield in the future it will become more and more important to create draught resistant soils.

Therefore, the soil has to capture and store the majority of the rainfall and allow the plant roots to penetrate the soil. A property of soil which is discussed to influence the available water capacity (AWC) is the soil organic matter (SOM). In order to understand the involved mechanisms studies with isotope labeled organic tracer substances have to be performed.

A suited analytical method for the evaluation of the complex and variable structure of soil is Raman microspectroscopy (RM), which is based on the inelastic scattering of light. RM enables a non-destructive analysis down to a spatial resolution of 1 µm with only low interference of water. RM allows the analysis of ^{13}C stable isotope labelled samples with a red-shift to lower frequencies due to the higher mass of ^{13}C. Since most of the SOM is stored in humic acids (HA), these are used as a model substance for validating the method. Artificial humic acid with various ^{13}C-ratios were produced by reaction of glucose with urea in boiling hydrochloric acid. The theoretically predicted linear relationship could be confirmed by the experiments.

The application of stable isotope RM (SIRM) on artificial humic acids showed promising results which were validated by Isotope-Ratio Mass Spectrometry (IR-MS). In future we plan to analyze mixtures of native soil samples with artificial humic acids and later on real samples, where isotope labelled organic matter is exposed to soil. The potential of RM to determine the detailed structure and isotopic composition of unknown samples with a high spatial resolution will be investigated. The comparison of optical images with maps containing information about the isotopic composition will lead to further conclusions on the depletion mechanism of the organic substances in soil and the incorporation of SOM.



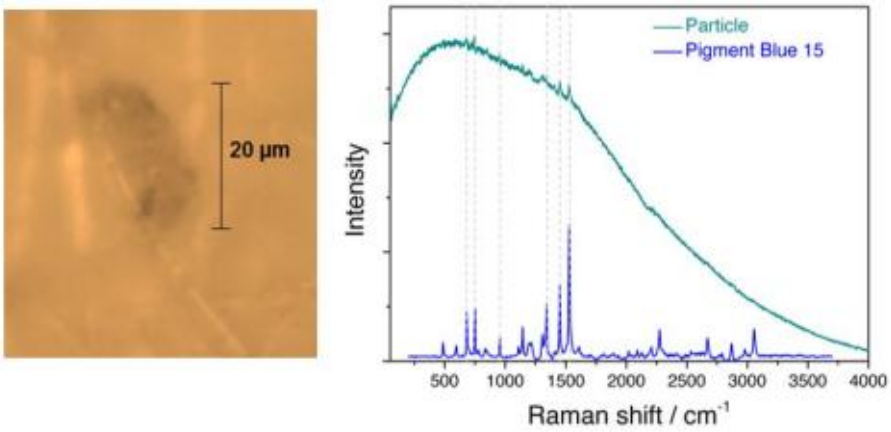
Fitted Raman spectra of ^{12}C and ^{13}C labelled humic acids. A redshift of the maxima around 1600 cm^{-1} can be seen.

A. C. Wiesheu

Qualitative and Quantitative Analysis of Microplastic and Pigment Particles in Freshwater

Funding: DFG (Deutsche Forschungsgemeinschaft)
Cooperation: University of Bayreuth, Prof. Dr. C. Laforsch, H. Imhof

In the last decades plastic became a ubiquitous material with applications in many fields where it is widely valued for its properties like inertness, formability and low costs. With the subsequent increase in plastic production, the quantity of plastic waste also increased to an alarming amount. Since plastic is degrading very slowly, an enrichment not only in marine ecosystems but also in freshwater bodies has to be expected. Recently, the risks for humans and environment provoked especially by microplastics (MP) attracted notice in the scientific community as well as the public media.



Small pigment particle found in Lake Garda and corresponding Raman spectrum with reference.

There is currently no standardized definition for MP, but it is generally used for particles and fibers from 1 µm to 5 mm. MP is either produced directly for the use in products e. g. in the cosmetic industry (primary microplastic) or derives from the breakup of larger plastic particles (secondary microplastic).

In a recent study, we analyzed microplastic particles from sediment samples in the subalpine Lake Garda, Italy. We separated and identified about 450 microplastic particles with a diameter down to 9 µm using the Munich Plastic Sediment Separator (MPSS) and Raman microspectroscopy (RM). The most prevalent plastic types were polystyrene, polyethylene and polypropylene. However, we found that the plastic types strongly correlate with the particle size. For very small microplastics (defined as 1 µm – 50 µm) mostly polyamides were found. Particles in this size can be ingested by organisms easily and accumulate in the food chain. They are expected to have severe consequences on human health and have been overlooked so far.

In addition to plastic particles, we found a high number of pigmented particles (e.g. from paint and coatings), which appear to be presently an ignored issue. ICP-MS analysis of these particles indicates that pigmented particles can contain high levels of heavy metals. The size distribution of these particles shows an increase with decreasing size, which suggests that even smaller pigment particles might be present (down to the nanometer-range) in the aquatic environment.

A. C. Wiesheu, P. M. Anger

Raman Microspectroscopic Analysis of Microplastic Particles in Bivalves Samples

Funding: Bavarian State Ministry of the Environment and Consumer Protection (Bayerisches Staatsministerium für Umwelt und Verbraucherschutz)
Cooperation: LfU Bavarian Environment Agency (Bayerisches Landesamt für Umwelt), Dr. J. Domogalla-Urbansky, F. Rager, Dr. H. Ferling, Dr. J. Schwaiger

The accumulation of microplastic (MP, 1 µm – 5 mm) debris in marine ecosystems is of increasing scientific and public concern. Recently, MP has also been found in freshwater ecosystems. The impact of MP on aquatic ecosystems is not yet fully understood, but there is an increasing number of studies reporting that MP particles are hazardous to aquatic organisms.

In particular, the negative impact of MP can be associated with the leaching of monomers and additives, since some of them are toxic, carcinogenic, or endocrine-disrupting compounds.

In cooperation with the LfU we investigate the accumulation of MP by fresh water organisms, e.g. indigenous bivalves (*Unio sp.*). The bivalves were exposed to MP either in the field or under standardized laboratory conditions. In the latter, organisms were exposed to various concentrations and particle sizes of polyvinylchloride (PVC) under flow through conditions. For the analysis of MP in bivalves we established a method including sample processing, as well as identification and quantification of MP down to 1 µm by means of Raman microspectroscopy (RM).

A sample of bivalve tissue is blended with MP-PVC. Nitric acid is added to the mixture and the solution is allowed to stand overnight. The next day fast heating to 100°C for two hours is followed by 1:10 dilution with hot water (80 °C). The solution is filtered and then analyzed by RM. Several filter materials were tested and polycarbonate (PC) was found to fit best with the requirements. The stability of the most abundant plastics (polyethylene, PE; polypropylene, PP; PVC; polystyrene; PS; polyethylene terephthalate, PET) in this treatment was verified.

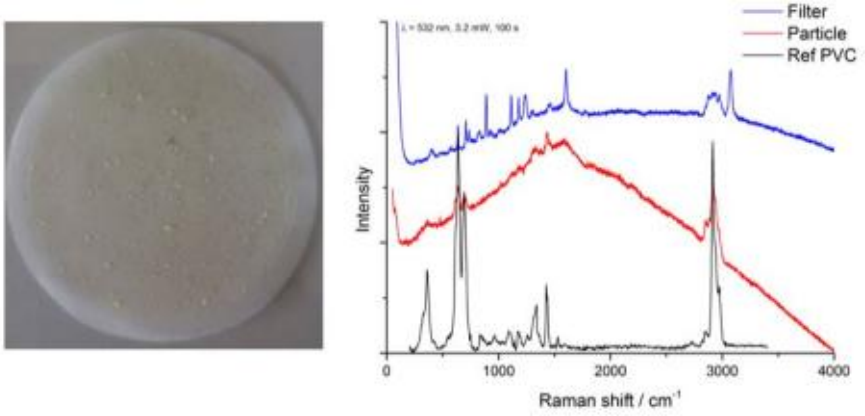


Photo of the PC filter after acid digestion of bivalves spiked with PVC and Raman spectra obtained from the filter, particles and reference PVC

Further RM studies will focus on the MP accumulation in fish exposed to MP containing food (e.g. PVC) under laboratory conditions. In parallel, possible adverse effects on fish health due to MP exposure will be investigated at the LfU.

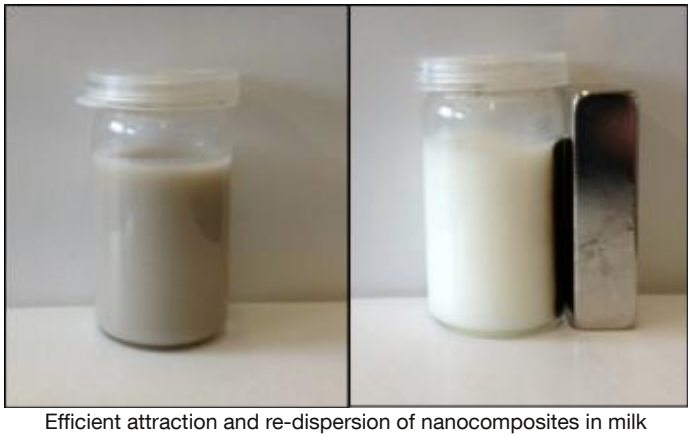
P. M. Anger, A. C. Wiesheu

Bioseparation and Microarray Technology (PD Dr. M. Seidel)

Culture-independent Quantification of Pathogens and Toxins in Complex Food Matrices

Funding: *BMBF (Federal Ministry for Education and Research)*
Cooperation: Chair of Hygiene and Technology of Milk, LMU Munich; Institute of Veterinary Food Science, JLU Gießen; R-Biopharm AG (Darmstadt)

The aim of the project is to rapidly identify hygienic relevant contaminations in the food supply chain. Fast and multiplexed analytical methods are developed to provide a rapid diagnosis and identification of proteotoxins (e.g. Staphylococcal enterotoxins, *Bacillus cereus* toxins) and pathogens (e.g. *Cronobacter sakazakii*, *Campylobacter ssp.*, *Clostridium ssp.* and *Klebsiella ssp.*) in complex food matrices (e.g. milk). Polyclonal and monoclonal antibodies developed by project partners from LMU Munich and FLU Gießen were used for their detection. Their performance on the MCR 3 as capturing and detection antibodies was evaluated in our group. Sensitive culture-independent quantification requires the concentration of large volumes of complex food matrices.



Efficient attraction and re-dispersion of nanocomposites in milk

Two methods are investigated. The first method is based on immunomagnetic separation (IMS). A synthesis approach of superparamagnetic iron oxide-based nanocomposites was developed. Magnetic nanocomposites were fully characterized by various techniques such as TEM, SEM, FT-IR, SQUID measurements, DLS, Raman and Moessbauer spectroscopy. First tests of the colloidal stability and magnetic separation of the bare nanocomposites in milk samples showed no agglomeration tendency and excellent and simple magnetic separation ability, even by using only a permanent magnet. After functionalisation of the magnetic nanocomposites with specific antibodies, IMS of proteotoxins is feasible directly in food matrices. For a sensitive quantification of proteotoxins in 100-mL milk samples, IMS will be inline-coupled with a flow-based sandwich microarray immunoassay (SMIA).

Alternatively, the monolithic immunoaffinity extraction (MIE) is examined. Epoxy-based macroporous monolithic columns were used capturing foodborne pathogens by immobilized antibodies. First experiments with *B. cereus* spores in 100 mL milk, could show that the combination of MAF and antibody microarray analysis on MCR 3 is a promising method. In the future, cultivation techniques could be replaced and the time for analysis of pathogens and toxins in food will be reduced from days to hours.

A. Nistler, A. Wunderlich, M. Adebar

Microreactor with Integrated Characterization for the Synthesis of Magnetic Nanoparticles (MiCSMaP)

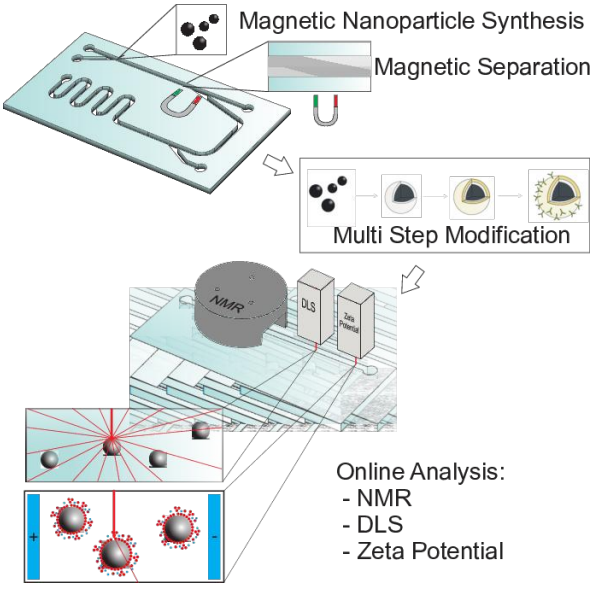
Funding: *TUM International Graduate School for Science and Engineering (IGSSE)*
Cooperation: Dr. B. Gleich, Dr. C. Rümenapp, TUM Central Institute of Medical Engineering (IMETUM)

Magnetic nanocomposites find a variety of applications in analytical chemistry. Most important are the selective preconcentration of analytes and the application in regenerable bioassays. The nanocomposites consist of a magnetic core, which is coated by a hydrophilic shell and a biocompatible polymer layer that is finally conjugated by selective receptors. Current limitations are the reproducible synthesis of magnetic nanoparticles with a narrow size distribution through a co-precipitation process and the formation of coatings with constant surface properties. The key issue is to avoid aggregation and unspecific binding of the receptors.

To overcome the stated limitations, this project is focused on the establishment of a multi-step synthesis procedure on a microfluidic platform. Microfluidics offer a great variety of reactor designs to flexibly adapt to different reactions. Many different operation conditions can be tested within short time. Furthermore, microfluidic reactors allow to precisely control mixing phenomena and reaction conditions such as temperature and compositions. The microfluidic reactors are fabricated in-house by a relatively practical approach of using double-sided adhesive tapes to form the microfluidic channels. The tapes are worked with a digital cutting plotter and a laser cutter, allowing for easy design adaption and fast processing.

After the chemical synthesis steps the particles are magnetically separated to remove unused reagents and side products. Therefore the particles are continuously transferred into a clean buffer stream by a mobile permanent magnet.

For quality control and online feedback, miniaturized analysis devices are integrated. They are used to efficiently characterize the synthesized composites in terms of their size by dynamic light scattering (DLS) and their surface charge by the measurement of the zeta potential. The magnetic nanoparticles are also counted for the first time by a device based on nuclear magnetic resonance (NMR).



Schematic of the multistep synthesis of coated magnetic nanoparticles with online analysis methods

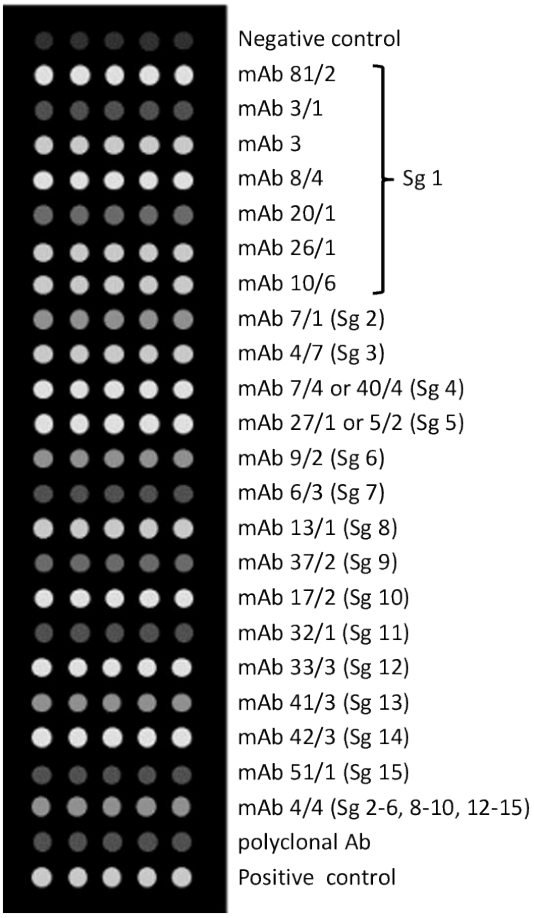
The analysis tools allow for a fast optimization of reaction conditions and to quickly adapt particle properties to a wide field of applications.

J. Bermetz

Culture-Independent Serotyping of *L. pneumophila* in Water, Aerosol, and Urine Samples

Funding: *BMBF (Federal Ministry for Education and Research)*
Cooperation: Technical University of Dresden, Dresden (TUD); Bayrisches Landesamt für Gesundheit und Lebensmittelsicherheit, Erlangen (LGL); GWK Präzisionstechnik GmbH, München

Many legionellosis outbreaks within the last years have shown, that a fast and sensitive detection method for Legionellae in different environmental samples is needed. In most cases like in Warstein 2013 outbreaks are caused by evaporative cooling systems. The legionellosis is mainly (90%) caused by *L. pneumophila*. All 15 serogroups are known to be potentially pathogenic for humans. An essential problem within this group is *L. pneumophila* serogroup 1 which were found in more than 85% of the cases recorded for legionellosis. The gold standard for the detection of legionella so far is the cultivation which takes 10 days for meaningful results. Therefore, there is an increasing need of rapid, uncomplicated, automated detection systems for the control of tap and process water as well as drinking water. For this reason a chemiluminescence sandwich microarray immunoassay for the detection and serotyping of *L. pneumophila* in real samples should be established on the MCR 3. A panel of 23 sensitive and selective monoclonal antibodies will be transmitted on a glass chip for definite and easy serotyping.



Schematic of a sandwich microarray immunoassay for the monoclonal subtyping of *L. pneumophila*

The microarray chip allows not only a differentiation of all serogroups of *L. pneumophila* (figure) within only 40 min. Furthermore a monoclonal subtyping of *L. pneumophila* Sg 1 will be possible. By enrichment methods like monolithic adsorption filtration and centrifugal ultrafiltration a culture-independent comparison of patients with environmental samples is feasible and will be a crucial improvement of the outbreak management because of the prompt detection and elimination of the source of infection.

C. Kober, A. Wunderlich

Concentration and Detection of Waterborne Pathogens for the Inline-Monitoring of Drinking- and Raw Water

Funding: BMBF (Federal Ministry for Education and Research)
Cooperation: Helmholtz-Zentrums für Umweltforschung GmbH; Institut für Mikrosystemtechnik, Universität Freiburg (IMTEK); DVGW-Technologiezentrum Wasser Karlsruhe (TZW); R-Biopharm AG (Darmstadt); GWK Präzisionstechnik GmbH (München); Fraunhofer Anwendungszentrum Systemtechnik (Ilmenau); Berliner Wasserbetriebe (BWB)

The aim of the EDIT project is to design and construct a modular concentration and detection system for bacteria and viruses for the monitoring of raw and drinking water hygiene (Hygiene On Line Monitoring-system). Due to the high infectious potential of some waterborne pathogens, even small amounts have to be detected in large sample volumes of at least 1 m^3. Therefore, a parallel concentration of all pathogens is necessary prior to detection. In the HOLM-system, ultrafiltration and a monolith-based adsorption-elution method are used to concentrate pathogenic microbes in large-volume water samples to a few milliliters. This macro-concentration is combined with a lab-on-chip-based micro-concentration and nucleic acid extraction module.

The identification of pathogens within the HOLM-system is done by a DNA-microarray on the microarray platform MCR3. We have developed an automated assay which combines isothermal amplification and a subsequent chemiluminescence detection. For several water relevant microbes (HAdV41, PhiX174) the limit of detection was comparable to qPCR, while the measurement time was much shorter (~50 min). Moreover, it was possible to detect two viruses (HAdV 41, PhiX174) and the bacterium *E. faecalis* at the same time. Besides identification of pathogens by their species-specific genome, a life/dead-discrimination is implemented, revealing the infectious risk of the detected pathogens.

In a round robin test the waterworks in Berlin, Magdeburg and Marburg are currently using a benchtop-scale instrument which combines ultrafiltration and monolithic filtration for preconcentration of water samples prior their routine hygiene analytics. From the comparison of samples with and without preconcentration more acceptance and insights for the further process development will be generated.

Automated setup for the concentration of 1 m^3-water samples to a few milliliters by ultrafiltration (left) and monolithic adsorption filtration (right).

A. Kunze, D. Elsäßer

Quantification of *L. pneumophila* in Environmental Samples

Funding: Bayer. Landesamt für Gesundheit und Lebensmittelsicherheit (LGL) / IWC
Cooperation: LGL, München; Prof. Lück, TU Dresden

The latest Legionellosis outbreaks in Warstein (Germany), Vila Franca de Xira (Portugal) and New York (USA) have shown that the water operating cooling systems can pose a risk for public health. Surface water was used as process water for the cooling tower of an industrial plant in Warstein. The contamination with *L. pneumophila* Sg 1 was identified as source for the Legionellosis outbreak.

Bioaerosol sampling with Coriolis µ at wastewater treatment plants from different factories

Research on the contamination of *Legionella pneumophila* in the environment (surface water and air) and engineered water systems (waste water and process water) is needed. A new combined analytical process was developed that uses monolithic adsorption filtration (MAF) and centrifugal ultrafiltration (CeUF) to concentrate viable *L. pneumophila* prior detection by chemiluminescence sandwich microarray immunoassays (CL-SMIA) was developed for rapid quantification of *L. pneumophila* subtypes. A recovery of 99.8 ± 15.9% was achieved for concentrations between 1 CFU/mL and 1000 CFU/mL. The whole concentration and detection process takes 90 min instead of more than 10 days for culture.

Bioaerosols were collected by cyclone sampler Coriolis µ® and analyzed by SMIA consisting of a polyclonal antibody against *L. pneumophila* serogroup 1-12 and monoclonal antibodies against subtypes of *L. pneumophila* serogroup 1. Bioaerosol and water samples from waste water treatment plants of 12 factories with elevated temperatures of waste water were tested: 4 breweries, 2 dairies and 6 factories for paper production. Bioaerosol and water samples were analyzed by cultivation and PCR (*L. pneumophila*) as well as antibody microarray immunoassay (*L. pneumophila* serogroup 1). *Legionella spp*. were found in 10 of the 12 tested factories. The maximum concentrations were 3.3×10^3 CFU/mL for culture, 5.4×10^7 copies/100 mL for qPCR and 8.3×10^7 CFU/mL (*L. pneumophila* serogroup 1) for antibody detection on the MCR 3. The results show that under specific conditions, high Legionella concentrations may enter the environment by waste water treatment plant drains. In the case of an outbreak, waste water treatment plants should be involved in the casual research.

A. Wunderlich

Optimized Regenerable Immunochip for the Simultaneous Detection of Several Antibiotics in Milk and Environmental Samples

Funding: Hanns-Seidel-Stiftung

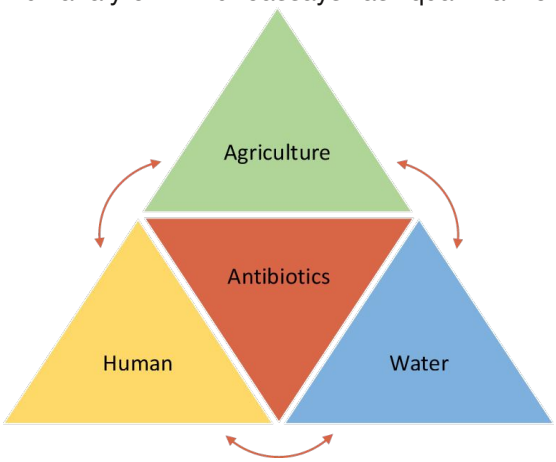
In animal husbandry, antibiotics are used to fight infections, and partly as growth promotors, too. Thus, they may be contained in food products of animal origin, or they entering into the environment by distributing or discharging manure and are, consequently, enriched in the surface water. As antibiotics cause dangerous resistances of bacteria, it is advisable to monitor and control the spreading of these pharmaceuticals, and to quantify them at the level of interest (maximum residue limit, if existing).

Using the automated flow-through analysis platform MCR 3 (GWK Präzisionstechnik, Munich), we have already established a regenerable chemiluminescence microarray immunoassay for the simultaneous detection of 13 antibiotics in milk. Now our work focusses on optimizing the microarray regarding signal stability and range of antibiotics, as the reproducibility of penicillin G has to be improved and tetracycline that is frequently used in veterinary medicine has to be integrated into the chip.

In a next step, we want to extend the range of samples being analyzed, such as meat juice or surface water from rivers or lakes, to broadly comprise contaminations from veterinary sources. Furthermore, possible or rather usual concentrations of antibiotics in surface water samples have not been examined yet.

It is also a big issue to detect metabolites as well. Comparing MS detection is used to assess the ratio of the antibiotics to its respective metabolites for samples of different origin.

Finally, the optimized regenerable multiplex immunochip has to be validated according to the Commission Decision 2002/657/EC of the European Communities. By this means, we suggest to accept multianalyte immunoassays as quantitative confirmatory methods as well, to benefit from the advantages of a fast automated method that doesn't need any pretreatment of the sample.



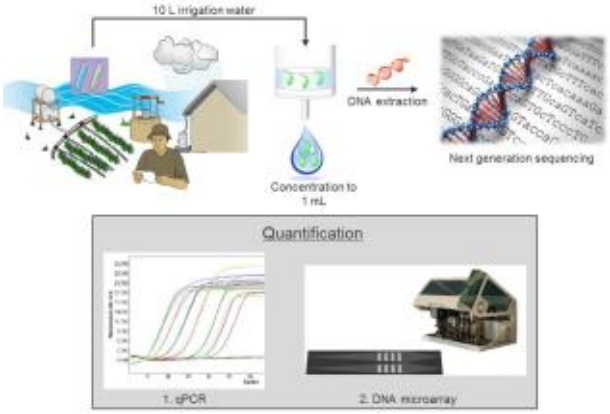
Assessment of antibiotics in environmental matrices

A. Wunderlich, V. Meyer

Analysis of Viruses and Antibiotic Resistant Bacteria in Irrigation Water by DNA Microarrays

Funding: BMBF (Federal Ministry for Education and Research)
Cooperation: Universitat de Barcelona (Barcelona, Spain), Universitat Politecnica de Valencia (Valencia, Spain), Universitat Rovira I Virgil (Tarragona, Spain), Bayerische Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), State General Laboratory (Cyprus), Technical University of Denmark (Copenhagen, Denmark)

An increasing number of epidemic outbreaks is associated with the consumption of fruits and vegetables. The World Health Organization (WHO) suspects that a reasonable explanation could be the irrigation with contaminated water. To date, there is no European guideline defining quality standards for irrigation water. To proctect consumer's



Schematic of the DNA microarrys

health as well as to ensure the production of safe food, screening, monitoring and controlling of microbiological hazard in irrigation water are highly needed.

Pathogens in water used for irrigation (surface and groundwater) are concentrated by monolithic affinity filtration (MAF). Bacteria and viruses are identified by species-specific genes via qPCR and DNA microarray. DNA microarray experiments are performed on the MCR 3 platform. In contrast to conventional methods based on cultivation, DNA microarrays enable a fast and multiplex analysis of different pathogens at the same time. During the project, three theme-related DNA microarrays will be synthesized. These arrays concern the detection of emergent pathogens, ESBL-producing bacteria as well as the trace back of fecal contaminations.

To achieve an European scale identification, experimental protocols are harmonized in all partner laboratories. Therefore, first TaqMan-based qPCRs for pathogen detection are already established on our real-time PCR-System. A sequence database containing information about gene segments of certain pathogens with species-specific primers and probes has been created.

To combine the concentration of pathogen and nucleic acids later on, a MAF-based nucleic acid extraction method will be established. First experiments with MAF-based materials proved their suitability for nucleic acid concentration. Prepared buffers show equivalent results as those of commercially available nucleic acid purification kits based on silica techniques. Application of MAF for nucleic acid concentration was shown in principle while further optimization of conditions is still going on.

Following the project workshop on pathogen concentration methods, partner laboratories of Spain and Denmark achieved promising results for viruses and protozoa concentration with our MAFs. The favored concentration method will be discussed at the beginning of 2016.

S. Schäfer

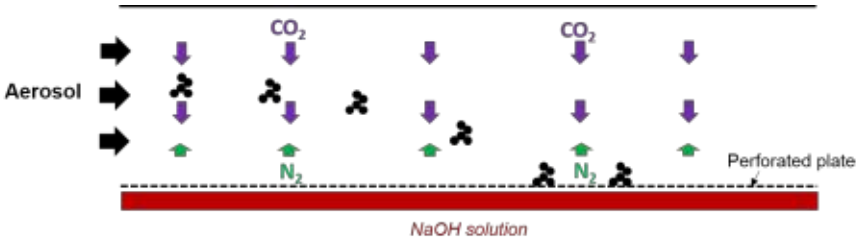
Aerosol Research (Prof. Dr. R. Niessner)

Diffusiophoresis ("Directed Diffusion") as Method for Aerosol Particle Sampling

Funding: IWC

Aerosol particles of anthropogenic and natural origin might be a threat to mankind and the environment. For risk assessment particles often need to be separated from the gas phase. Physical stress (shear forces, high temperatures) is usually part of the sampling process and might irreversibly change the particle properties. Additionally, in many cases the sampling efficiency for nanometer sized particles is below 10 %. One possibility to gently sample aerosol particles and to deposit small particles more effectively might be diffusiophoresis. In a nutshell, diffusiophoresis is the movement of particles in a concentration gradient. When used for sampling, the particle movement is directed towards a surface and results in particle deposition.

To evaluate whether this mechanism might be useful for particle sampling, a diffusiophoretic precipitator was constructed and tested with model aerosols. Spark discharge soot particles suspended in a mixture of air (27 %, v/v) and carbon dioxide (CO_2) were applied as a model aerosol. Within the precipitator the aerosol is guided over a surface of sodium hydroxide (NaOH) solution (see figure). CO_2 molecules diffuse from the aerosol stream (high CO_2 concentration) through a perforated plate in direction of the NaOH solution (zero CO_2 concentration above surface) and are irreversibly bound. Residual molecules (e.g. nitrogen), which are not absorbed, are accumulated near the surface of the NaOH solution and consequently diffuse to the opposite direction. While crossing the aerosol stream gas molecules collide with particles. Thereby the particles move in the same direction as the molecules with the higher concentration gradient and molecular mass. In the case being considered, this means that a certain percentage of particles is deposited in the NaOH solution.



Functional principle of diffusiophoretic precipitator

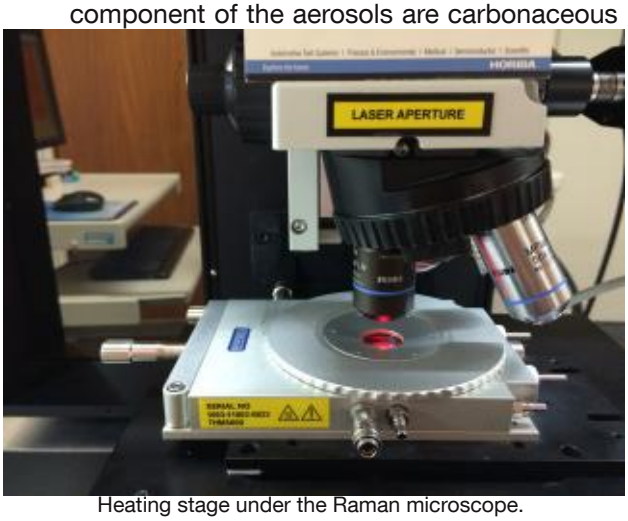
Measurements of the particle number concentration up- and downstream of the precipitator are used to determine the percentage of deposited particles. For particles with diameters of 30 nm and 70 nm a diffusiophoretic particle deposition of 20 % could be determined. This means that diffusiophoresis generally could be applied for gentle sampling of nanometer sized particles. Further investigations are needed to develop a setup that is applicable for living organisms.

B. Kiwull

In Situ Raman Microspectroscopic Analysis of Soot Samples With Different Organic Carbon Content

Funding: IWC
Cooperation: Dr. F.-X. Ouf, Institut de Radioprotection et de Sûreté Nucléaire (IRSN), Gif-Sur-Yvette, France; Dr. D. Ferry, Aix-Marseille Université, Marseille, France; Dr. E. D. Kireeva, Lomonosov Moscow State University, Moscow, Russia

Aerosols are ubiquitous in the environment, are of natural and anthropogenic origin and consist of many components in various compositions. Depending on their properties, aerosols can influence the climate, interact with radiation or cause diseases. One main component of the aerosols are carbonaceous materials generated by incomplete combustion. These carbonaceous aerosols can have different influences on the environment depending on their properties (e.g., hydrophilicity). One commonly used method to describe a carbonaceous aerosol composition is the characterization by thermo-optical methods to discriminate between the elemental carbon (EC, means unreactive carbonaceous material) and organic carbon (OC, highly reactive and volatile carbonaceous species) ratio. However, it is not clear whether the OC content in soot is related to differences in the soot structure and the changes during the oxidation.



Heating stage under the Raman microscope.

Therefore, soot generated with a diffusion burner at different air-to-fuel ratios is analysed by various methods for comprehensive characterization. With a thermo-optical method, the OC content is determined, transmission electron microscopy (TEM) and high resolution TEM (HRTEM) analysis provide the micro- and nanostructure of the soot, with Fourier-transform infrared spectroscopy (FTIR), functional groups on the soot are analysed and Raman spectroscopy gives information about the fluorescence of the sample as well as the nanostructure of the soot.

Furthermore, in situ Raman analysis of the changes in the soot nanostructure during the oxidation is performed in a heating stage at temperatures up to 600°C while analysing the soot nanostructure and fluorescent background at steps of 100°C to reveal the changes in to the organic coatings and the soot nanostructure of different samples during their oxidation in air.

With these results, we hope to get better insight into the composition and structure of soot samples of different OC content and improve the understanding of soot properties (e.g., reactivity and hygroscopicity) by linking the properties and information achieved by different methods.

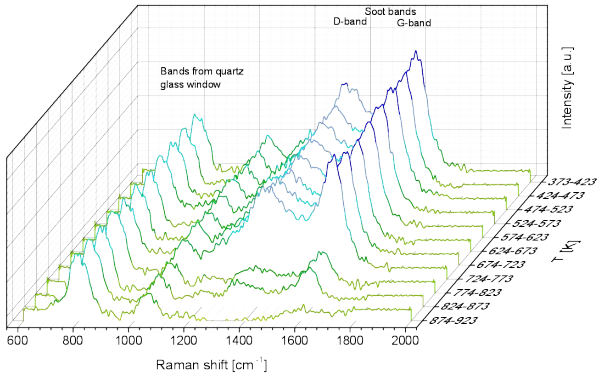
M. Eß, N. P. Ivleva

Combination of Temperature-Programmed Oxidation (TPO) and Raman Microspectroscopy (RM) for Diesel Soot Characterization

Funding: Audi AG, Ingolstadt

Aerosols can strongly influence the climate and the environment. One main source of anthropogenic aerosols are soot particles which are emitted by incomplete combustion e.g. by diesel engines. Because of the negative impact, particle emissions are limited by law. In order to reach the particle number concentrations set in the EU regulations for diesel cars and trucks, diesel particulate filters (DPF) are used to trap the soot in the exhaust. These filters have to be regenerated regularly, i.e., the soot has to be oxidized. As it would be favorable to perform this regeneration step at low additional energy demand, a reactive soot in the exhaust, which can be oxidized easily but controlled, would be desirable. As it is known that the reactivity of soot is also dependent on the soot's nanostructure, effective tools for the determination of the soot reactivity and nanostructure are necessary to allow a better soot characterization and consequent engine and fuel optimization.

Therefore, a measurement device combining two commonly used effective soot characterization tools, namely temperature-programmed oxidation (TPO) and Raman microspectroscopy (RM) in one setup was designed. With TPO, soot is burned at a constant temperature ramp in a defined environment and the gaseous emission products CO and CO_2 are quantified by an FTIR sensor to determine and compare the reactivity of the soot. The setup consists of a flow cell, formed by a heatable steel block (up to 1000°C), on which a plate thermophoretically loaded with soot can be placed, an insulation and a quartz glass window above and can be connected to an FTIR gas sensor. With the water cooled aluminum frame, the outside of the cell is kept at a moderate temperature, which allows the placement under the Raman microscope. The parameters obtained by Raman analysis of the soot inside the cell t



Change in the soot nanostructure (Raman analysis) during TPO

hrough the quartz glass window are directly related to the soot nanostructure. Hence, the change in the soot nanostructure can be monitored in situ by taking Raman analysis of the soot during the TPO and synchronous monitoring of the emission products with FTIR.

By combination of TPO and RM in one setup for in situ measurements, comprehensive results will become accessible and a better understanding of the correlation of soot nanostructure and reactivity will be achieved in one experiment.

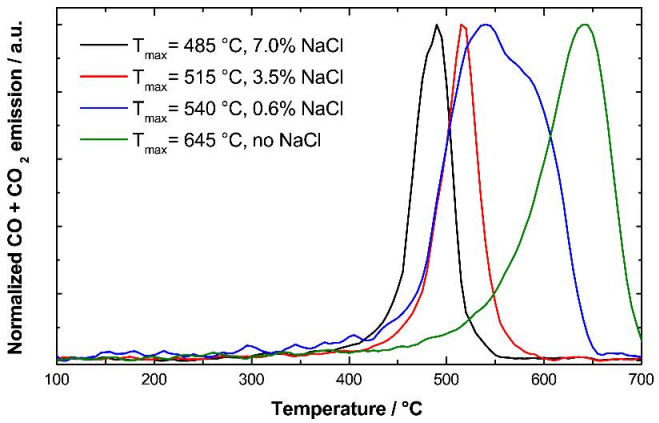
M. Eß, N. P. Ivleva

Production and Characterization of Internally-mixed Soot Aerosols

Funding: IWC

Diesel soot is one of the major pollutants in the world and is classified as carcinogenic by the WHO IARC. Soot/black carbon also has the second largest impact on global warming after CO_2. In North America and Europe, soot is mainly emitted by diesel engines.

To minimize emissions, particulate filters are used. Regeneration of the filter is done by oxidation (combustion) of the soot. Uncatalyzed oxidation requires temperatures > 600 °C in O_2, which results in poor fuel efficiencies. Additives enhance the soot reactivity during soot formation, leading to internally-mixed soot and possible oxidation temperatures under 400 °C. Previous results showed that besides oxides, also salts were able to lower the temperatures for soot oxidation significantly, which means that there must be some kind of interaction. Until then, only small amounts of soot were sampled, which were not enough for BET sorption measurements. Therefore, the propane/air diffusion burner was optimized for the controlled production of higher amounts of soot by introducing mass flow controllers, best possible conditions for maximum soot production and a thermophoretic precipitator for soot collection.



TPO profiles of 4 soot samples with different salt content normalized to soot mass

Ion Chromatography was used to characterize the salt content in the soot samples, Raman Microscopy was applied to analyze the graphitic soot structure and the presence of salts/minerals or hydrocarbons. It was found that there is no significant difference in the soot structure with and without salts, confirming previous results.

To simulate combustion in a Diesel particulate filter, temperature-programmed Oxidation was used. Soot samples were combusted in a defined atmosphere and temperature range. Combustion products were detected in an FTIR spectrometer. The temperature of maximum CO and CO_2 emission (T_{max}) was used as a benchmark for soot oxidation reactivity. Increased salt-contents lead to lower Tmax and lower ratios of CO/CO_2 at T_{max}. Both findings indicate that salts promote complete soot oxidation.

Another way to get insight on structural changes of solids is BET analysis, which is a method to determine specific surface areas. If there is an interaction between the salts and the primary soot particles and/or a change in the inter-layer spacing between the graphene planes, there should also be a change in the specific surface areas of the internally-mixed soots. First measurements with laboratory-produced soots and several salts were started.

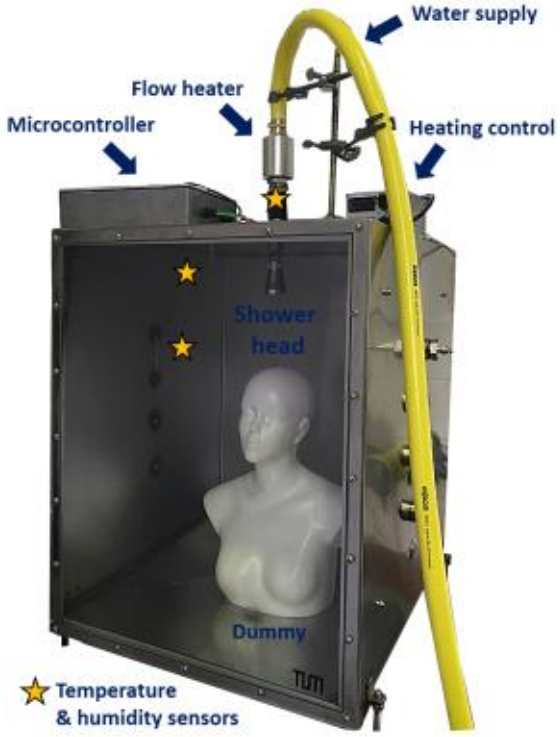
A. Rinkenburger

Generation and Analysis of Bacteria-Containing Shower Aerosols

Funding: Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), IWC
Cooperation: LGL

Legionellosis infections are often caused by inhaling bioaerosols containing pathogens like *Legionella pneumophila* serogroup 1. *Legionella* ssp. occur in the aquatic systems in company with or inside of protozoa in biofilms. Besides cooling towers, showers are also consistently considered as sources of contaminated aerosols. When flushing tap water through pipe systems, biofilm detaches from the walls and exits the piping for example through a shower head. This way, water and biofilm are sprayed and aerosols are generated. With the German Drinking Water Ordinance the legal limits for *Legionella* were set by law. Up to now only theoretical predictions exist to estimate the correlation of quantities of *Legionella* ssp. in tap water and the generated bioaerosols of the connected shower heads.

A miniaturized shower model (bioaerosol chamber) was constructed to experimentally determine the correlation between *Legionella* spp. concentrations in tap water and shower aerosol (see figure). It consists of a rectangular chamber (270 L) equipped with shower head and mannequin. Tap water is heated, artificially contaminated with defined concentrations of bacteria and transferred to the bioaerosol chamber. Several sensors are applied within the chamber to monitor temperature and relative humidity. To be able to work with biosafety level 2 microorganisms like living *L. pneumophila*, the shower model is encapsulated into a biosafety chamber. Aerosol particles can be sampled using sampling points at one side of the chamber at four different heights. Applying a wetted-wall cyclone sampler (Coriolis µ) the bioaerosol particles are concentrated into liquid medium and can easily be analyzed by a chemiluminescence sandwich immunoassay microarray based on a panel of monoclonal antibodies.



Set-up of Bioaerosol Chamber

B. Kiwull, A. Wunderlich

Assessment of the Air Quality in a Potential Health Resort

Funding: IWC
Cooperation: Tourismusverein Partschins; Chair for Public Health and Health Services Research, LMU

The Partschins falls are one of the highest and most impressive falls in the Southern Alps and a regional landmark. The basin formed by the water is kept as a natural resort. The spray from the water fall distributes far into the adjacent valley and causes a micro climate with higher humidity and lower temperatures. The presence of water aerosols are helpful for pulmonary diseases.

In preparation for an official recognition of the health effects of the Partschins falls a monitoring campaign was performed in Summer 2015. The results of the aerosol and particle measurements indicated that the micro climate is mainly controlled by the local temperature gradients, hence thermal convection. Particle numbers in gerneral were lower than in remote rural environments. There were no indications of pathogens cotransported with the aerosol.

The measurements were completed by a hydrogeological mapping and an analysis of potential risks originating from concurrent use. There are few alpine pastures, some of them combined with small taverns. Traffic is restricted and touristic activities are mainly limited to hiking and recreation.

There were no immediate or risks affecting the quality of the surface water above the falls, therefore there are no risks from inhaling the aersols. However, there were some minor nuisances, which have been included in an action plan. The detailed medical evaluation of the site underlined the potential with respect to positive health effects.

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M. Seidel, Analytische Microarrays: Herausforderungen und Potenzial. 9. Deutsches Biosensor Symposium,11.-13.04.2015 München, Germany.

M. Seidel, E. Linares, A. Gega, R. Niessner, Magnetische Immunfiltration und Mikroarray-Analyse: eine geeignete Kombination zur schnellen Bestimmung von pathogenen Mikroorganismen und Toxinen in Lebensmitteln, ANAKON, 23.-26.03.2015, Graz, Austria.

M. Seidel, Rapid detection of pathogens by flow-based chemiluminescence microarrays. 11. Workshop on Biosensors & Bioanalytical Microtechniques in Environmental, Food & Clinical Analysis, 26.-30.09.2015, Regensburg, Germany.

M. Seidel, Kulturunabhängige Detektionssysteme zur schnellen Risikobewertung anthropogen verursachten aerogenen Legionellenexpositionen (LegioTyper), VDI-Expertenforum „Legionellen aus Verdunstungskühlanlagen – Maßnahmen zur Risikominderung“, 13.11.2015, Bonn, Germany.

B. S. Tilley, D. S. Brady, M. Ueckert & T. Baumann, Pore dynamics and calcite solubility in carbonaceous aquifers used in energy storage applications, SIAM Conference on Mathematical and Computational Issues in the Geosciences, , 2.7.2015, Stanford University, Stanford, CA.

B. S. Tilley, D. S. Brady, M. Ueckert & T. Baumann, Pore dynamics and calcite solubility in carbonaceous aquifers used in energy storage applications, American Physical Society 68th Annual Division of Fluid Dynamics Meeting, 24.11.2015, Boston, MA.

M. Ueckert, R. Niessner & T. Baumann, Colloids in the River Inn, EGU General Assembly, 12.4.-17.4.2015, Vienna.

A. Wunderlich, C. Lück, M. Petzold, S. Walser, C. Herr, R. Niessner und M. Seidel, Screening auf Legionella pneumophila Serotypen in klinischen und Umweltproben mit Hilfe monoklonaler Antikörper als Basis für das Ausbruchsmanagement im Falle einer Epidemie, 9. Deutsches Biosensor Symposium,11.-13.04.2015 München, Germany.

A. C. Wiesheu, R. Niessner & N. P. Ivleva, Raman-Analysis of Stable Isotope Labelled Organic Substances in Soil, EuCheMS, International Conference on Chemistry and the Environment, ICCE 2015, 20.-24.9.2015, Leipzig.

A. Wunderlich, C. Torggler, R. Niessner, M. Seidel, Legionella pneumophila detection in clinical and environmental samples based on monoclonal subtyping, Workshop at Legionella Konsiliarlabor Dresden: Diagnostik und Prävention von Legionellen-Infektionen, 19.06.-20.06.2015, Dresden, Germany.

Poster Presentations

D. Elsässer, R. Niessner, M. Seidel, Enrichment of Microorganisms and Viruses from Large-Volume Water samples, International Workshop “Remediating the Human Water Footprint”, 22.-23.01.2015, Garching, Germany.

D. Elsässer, R. Niessner, M. Seidel, Monolithische Affinitätsfiltration: Eine schnelle und kostengünstige Methode zur Anreicherung und Aufreinigung von Mikroorganismen und Viren aus Wasserproben, Wasser 2015 - Jahrestagung der Wasserchemischen Gesellschaft, 11.-13.05.2015, Schwerin, Germany.

D. Elsässer, G. Dame, S. Hakenberg, C. Heese, M. Hügle, R. Niessner, M. Seidel, Makro- und Mikroaufkonzentrierung von wasserbürtigen Pathogenen aus Wasserproben großer Volumina, INIS-Statuskonferenz, 20.-21.02.2015, Hamburg Germany.

M. N. Ess, H. Bladt, N. P. Ivleva, R. Niessner, Reactivity of Biodiesel Generated Soot, ANAKON 2015, 23.03.-26.03.2015, Graz,Austria.

M. N. Ess, B. Grob, N. P. Ivleva, R. Niessner, Measuring Cell for Simultaneous Soot Characterization by Temperature Programmed Oxidation and Raman Microspectroscopy, ANAKON 2015, 23.03.-26.03.2015, Graz,Austria.

M. N. Ess, B. Grob, N. P. Ivleva, R. Niessner, Measuring Cell to Follow Structural Changes of Soot in Situ with Raman Microspectroscopy during Temperature Programmed Oxidation Experiments, 19th ETH Conference on Combustion Generated Nanoparticles, 28.06.-01.07.2015, Zürich, Switzerland.

M. N. Ess, B. Grob, N. P. Ivleva, R. Niessner, Measurement Cell for Soot Reactivity Determination and Simultaneous Observation of Changes in the Soot Structure by Raman Microspectroscopy, European Aerosol Conference (EAC) 2015, 06.09.-11.09.2015, Milano, Italy.

M. Hübner, R. Niessner, S. Boujday, D. Knopp, Simultaneous Detection of Micropollutants by a Microarray-based Flow-Through ELISA with Chemiluminescence Detection. Analytica Vietnam, 15.-16.04.2015, Ho Chi Minh City, Vietnam.

M.Hübner, K. Scholz, R. Niessner, J. Schwaiger, D. Knopp, Spezifische Antikörper für die empfindliche Rückstandsanalytik von Diclofenac in Abwasser, Oberflächenwasser und Fischgewebe, Jahrestagung der Wasserchemischen Gesellschaft, 11.-13.05.2015, Schwerin.

N. P. Ivleva, A. C. Wiesheu, P. M. Anger & R. Nießner, Selektive Analytik von Mikroplastik in Aquatischen Systemen, ANAKON 2015, 23-26.3.2015, Graz (Österreich).

B. Kiwull, A. Bergmann, R. Nießner, C. Haisch, Trends and Challenges in Exhaust Gas Analytics of Mobile Sources, Anakon 2015, 23.3.-26.3.2015, Graz, Austria.

B. Kiwull, R. Nießner, Aerosol Particle Sampling by Diffusiophoresis, Anakon 2015, 23.3.-26.3.2015, Graz, Austria.

B. Kiwull, J.-C. Wolf, R. Nießner, Evaluation of Volatile Particle Remover Devices for Exhaust Particle Quantification, 19th ETH Conference on Combustion Generated Nanoparticles 2015, 28.06.-01.07.2015, Zürich, Switzerland.

B. Kiwull, A. Wunderlich, R. Niessner and M. Seidel, Miniaturized Set-up for Generation and Sampling of Pathogenic Legionella Containing Shower Bioaerosols, EAC 2015, 06.09.-11.09.2015, Milano, Italy.

B. Kiwull, R. Nießner, Investigations on Diffusiophoresis as Aerosol Particle Deposition Mechanism, EAC 2015, 06.09.-11.09.2015, Milano, Italy.

P. Kubryk, S. Marozava, R. Nießner, R. U. Meckenstock & N. P. Ivleva, Stabilisotopen-Resonanz-Raman-Mikrospektroskopie und Stabilisotopen-SERS zur Analyse von Mikroorganismen in aquatischen Systemen, WASSER 2015, 11.-13.05.2015, Schwerin.

P. Kubryk, R. Nießner & N. P. Ivleva, Stabilisotopen-SERS zur Analyse von Mikroorganismen in Aquatischen Systemen, ANAKON 2015, 23.-26.3.2015, Graz (Österreich).

M. Kühn, N. P. Ivleva, S. Klitzke, F. v. d. Kammer, R. Niessner & T. Baumann, Surface-enhanced Raman spectroscopy (SERS) to detect natural organic coatings on silver nanoparticles, EGU General Assembly, 12.4.-17.4.2015, Vienna.

M. Kühn, N. Ivleva, R. Niessner & T. Baumann, Surface-enhanced Raman spectroscopy (SERS) to detect natural organic coatings on silver nanoparticles, ANAKON, 23.3.-26.3.2015, Graz.

A. Kunze, J. Otto, V. Blättel, S. Vosseler, M. Dilcher, B.A. Abd El Wahed, F. Hufert, A. Tiehm, R. Nießner, M. Seidel, Parallele Amplifikation und Detektion wasserbürtiger Pathogene, INIS-Statuskonferenz, 20.-21.02.2015, Hamburg, Deutschland.

A. Kunze, M. Dilcher, A. Abd El Wahed, F. Hufert, R. Niessner, M. Seidel, Automated, parallel amplification and detection of waterborne pathogens using a DNA microarray, International Workshop “Remediating the Human Water Footprint”, 22.-23.01.2015, Garching, Germany.

A. Kunze, M. Dilcher, A. Abd El Wahed, F. Hufert, R. Niessner und M. Seidel, Chemilumineszenz-DNA-Mikroarray für die automatisierte, parallele Amplifikation und Detektion viraler Pathogene, ANAKON, 23.-26.03.2015, Graz, Austria (Poster Award).

A. Kunze, M. Dilcher, A. Abd El Wahed, F. Hufert, R. Niessner und M. Seidel, Entwicklung eines Chemilumineszenz-DNA-Mikroarrays für die automatisierte, parallele Amplifikation und Detektion wasserbürtiger Viren, Wasser 2015 - Jahrestagung der Wasserchemischen Gesellschaft, 11.-13.05.2015, Schwerin, Germany.

M. Moreno-Paz, A. Gómez-Cifuentes, O. Hofstetter, A. Maquieira, D. Knopp, V. Parro, A Multiplex Competitive Immunoassay for Organic Detection on Mars. Astrobiology Science Conference, 15.-19.07.2015, Chicago, IL.

A.-C. Neumann, C. Hartmann, C. Haisch, R. Niessner, D. Knopp, Non-targeted Toxicity Testing of Nanoparticles by Two-Compartment Microbial Fuel Cell. Analytica Vietnam, 15.-16.04.2015, Ho Chi Minh City, Vietnam.

A.-C. Neumann, C. Hartmann, C. Haisch, R. Niessner, D. Knopp, Microbial Fuel Cell – Toxicity Sensor for the Influent of Wastewater Treatment Plants. Jahrestagung der Wasserchemischen Gesellschaft, 11.-13.05.2015, Schwerin.

A.-C. Neumann, V. Ibl, R. Niessner, E. Stöger, D. Knopp, Depletion of Algal Toxin-Contaminated Water Using Selective Biofilters Based on Plant-Produced Antibodies (Plantibodies). ANAKON 2015, 23.-26.03.2015, Graz, Austria.

A.-C. Neumann, V. Ibl, R. Niessner, E. Stöger & D. Knopp, Herstellung und Charakterisierung von Plantibodies gegen Cyanotoxine zur selektiven Immunfiltration. 9. Deutsches BioSensor Symposium, 11.-13.03.2015, München.

M. Seidel, A. Wunderlich, C. Torggler, D. Elsaesser, R. Niessner, Microarray-based analysis of monoclonal subtypes of Legionella pneumophila in urine and environmental samples. Euroanalysis 2015, 6.-10.09.2015, Bordeaux, France.

M. Ueckert, R. Niessner & T. Baumann, High temperature aquifer storage, EGU General Assembly, 12.4.-17.4.2015, Vienna.

M. Ueckert & T. Baumann, Wärmespeicherung im Malm aquifer, Der Geothermiekongress, 2.11.-4.11.2015, Essen.

X. Wang, J. Pauli, U. Resch-Genger, R. Niessner, D. Knopp, Gold Nanoparticle-Catalyzed Uranine Reduction. ANAKON 2015, 23.-26.03.2015, Graz, Austria.

A. C. Wiesheu, L. Paetsch,C. W. Müller, I. Kögel-Knabner, R. Nießner & N. P. Ivleva, Stabilisotopen-Raman-Mikrospektroskopie als neue Methode für Studien zur Erhöhung der Wasserrückhaltefähigkeit durch Organische Substanzen im Boden, ANAKON 2015, 23-26.3.2015, Graz (Österreich).

A. C. Wiesheu, L. Paetsch,C. W. Müller, I. Kögel-Knabner, R. Nießner & N. P. Ivleva, Stabilisotopen-Raman-Mikrospektroskopie von organischen Substanzen im Boden zur Erhöhung der Wasserrückhaltefähigkeit, WASSER 2015, 11.-13.5.15, Schwerin.

A. C. Wiesheu, P. M. Anger, R. Niessner & N. P. Ivleva, Qualitative and Quantitative Analysis of Microplastic and Pigment Particles in Freshwater, EuCheMS International Conference on Chemistry and the Environment, ICCE 2015, 20.-24.9.2015, Leipzig.

A. Wunderlich. M. Petzold, C. Lück, R. Niessner, M. Seidel, Microarray-based sandwich-ELISA on the MCR 3 for a fast typing of Legionella pneumophila subgroups in environmental samples, ANAKON, 23.-26.03.2015, Graz, Austria

A. Wunderlich, D. Elsäßer, C. Torggler, C. Lück, R. Niessner, M. Seidel, Antibody-based microarray-analysis of Legionella pneumophila in surface water after monolithic affinity filtration (MAF) and centrifugal ultrafiltration (CUF), Wasser 2015 - Jahrestagung der Wasserchemischen Gesellschaft, 11.-13.05.2015, Schwerin, Germany.

A. Wunderlich, C. Torggler, D. Elsäßer, C. Lück, R. Niessner, M. Seidel, Rapid detection of Legionella pneumophila serogroups in environmental samples by monoclonal antibody microarrays on the multiplex analysis platform MCR 3, ESGLI Business Meeting 2015 London, 15.09-17.09.2015, London, Great Britain, First Poster Award.

Scientific Committees

T. Baumann, Fate and Transport of Biocolloids and Nanoparticles in Soil and Groundwater, EGU General Assembly, 27.4.-2.5.2015, Vienna (Convener)

D. Knopp, 9th International Conference on Instrumental Methods of Analysis: Modern Trends and Applications (IMA 2015), 20.-24.09.2015, Kalamata, Greece (Scientific Committee)

D. Knopp, BBMEC: 11th Workshop on Biosensors & Bioanalytical Microtechniques in Environmental, Food and Clinical Analysis, 27.-30.09.2015, Regensburg, Germany (Scientific Committee)

Invited Lectures

D. Knopp, Antibodies Against Polycyclic Aromatic Hydrocarbons: How to prepare and what they are good for? Leibniz-Institut für Analytische Wissenschaften (ISAS), 15.10.2015, Dortmund.

D. Knopp, Application of Immunological Methods for Food Safety Monitoring and Authentication. Analytica Vietnam, 15.-16.04.2015, Ho Chi Minh City, Vietnam.

D. Knopp, Bioanalytical Determination of Mycotoxins in Food Samples – an Overview of Current Concepts and Trends, 9th International Conference on Instrumental Methods of Analysis: Modern Trends and Applications (IMA 2015), 20.-24.09.2015, Kalamata, Greece.

D. Knopp, Food forensic (analysis) – Applicability of Immunological Methods, International Workshop Progress of Analysis on Agro-Food Quality and Safety. Oil Crops Research Institute, Chinese Academy of Agricultural Sciences (CAAS), 02.11.-09.11.2015, Wuhan, China

D. Knopp, X. Wang, D. Tang, Magnetic bead-based immunoassays for aflatoxins using functionalized gold nanoparticles: Some Pros and Cons, International Workshop Chinese Academy of Agricultural Sciences (CAAS), 02.11.-09.11.2015, Wuhan, China Progress of Analysis on Agro-Food Quality and Safety. Oil Crops Research Institute,

R. Niessner, New Technologies for Virus & Bacteria Detection: Microarray & Raman Spectroscopy, HKUST-TUM Water Workshop, 22.1.2015, IAS TU Munich.

R. Niessner, Characterization of Nanoparticles in Different "Spheres", Department of Mechanical Engineering, 13.5.2015, University of Minnesota, Minneapolis.

R. Niessner, Ways to Characterize Hydrosols, Department of Mechanical Engineering, 15.5.2015, University of Minnesota, Minneapolis.

R. Niessner, Interaction of Colloidal Matter with Light, Avogadro Colloquia 2015, Consiglio Nazionale delle Ricerche (CNR), 22.5.2015, Rom.

R. Niessner, Microarray Technology for Monitoring of Trace Contaminants, IAS, HKUST-TUM Water Workshop, 4.6.2015, Hong Kong University of Science & Technology.

R. Niessner, Chemical Online Measurement of Aerosols, Aerosol Summer School 2015, Department of Physics, 10.7.2015, Vienna University

R. Niessner, Modern Spectroscopy as a Tool for Aerosol Characterization, Aerosol Summer School 2015, Department of Physics, 10.7.2015, Vienna University.

R. Niessner, Particle Number Measurement in Diesel Exhaust, Aerosol-Technologie-Seminar, 28.9.2015, Palas GmbH, Karlsruhe.

R. Niessner, Microarray Technologies with Antibodies, Oligonucleotides, and Nanoparticles, Bundesanstalt für Materialforschung, 3.10.2015, Berlin.

R. Niessner, Microarray Technologies with Antibodies, Oligonucleotides, and Nanoparticles, Department of Chemical Engineering, 14.10.2015, Kyushu University, Fukuoka, Japan.

M. Seidel, Systems for rapid concentration and detection of pathogenic microorganisms and viruses to establish an inline hygiene monitoring system for raw and drinking water, TU Wien, 27.05.2015, Wien, Austria.

M. Seidel, Chemilumineszenz-Mikroarrays für die analytische Lebensmittelchemie, Universität Stuttgart, 02.06.2015, Stuttgart, Germany.

M. Seidel, Schnellaufkonzentrierungs- und Nachweissysteme zum schnellen Hygienemonitoring von pathogenen Mikroorganismen und Viren im Roh- und Trinkwasser, Fraunhofer IKTS, 07.10.2015, Dresden, Germany.

M. Seidel, Chemiluminescence Microarrays in Analytical Chemistry, ISAS, 27.10.2015, Dortmund, Germany.

M. Seidel, Research fields and current projects, Russian-German Bioeconomy and Biomedicine, Branch of Shemyakin and Ovchinnikov Institute of Bioorganic Chemistry, 16.11.2015, Pushchino, Russia.

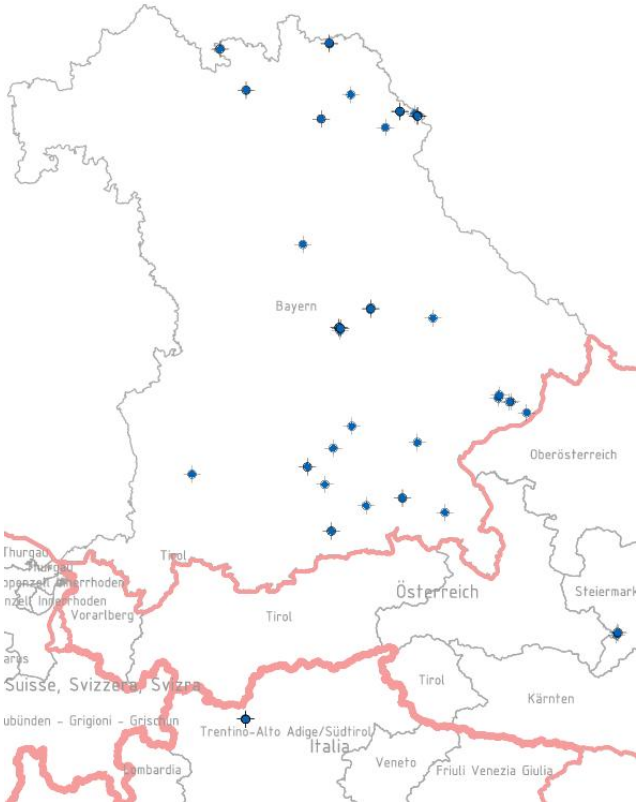
M. Seidel, Chemiluminescence Microarrays in Analytical Chemistry, School Conference for Young Scientists „Russian-German Biotech-2015“, Branch of Shemyakin and Ovchinnikov Institute of Bioorganic Chemistry, 18.11.2015, Pushchino, Russia.

Hydrochemical consulting

Mineralisation control analyses: Bad Abbach, Bad Aibling, Bad Birnbach, Bad Füssing, Bad Griesbach, Bad Gögging, Bad Reichenhall, Bad Rodach, Bad Staffelstein, Bad Wiessee, Bad Wörishofen, Bayreuth, Erding, Hölle, Kondrau, Neumarkt i. d. Opf., Sibyllenbad, Straubing, Weißenstadt

Hydrogeological and hydrochemical expertises (mineral water, spa water): Partschins, Ranten, Siegsdorf

Deep Hydrogeothermal Energy Exploration: Aschheim, Pullach, Sauerlach, Waldkraiburg



Theses

PhD Theses

MSc Chem. Maria Hübner: Development of Immunological Methods for the Detection of Micropollutants in Fresh Water Samples

Dipl. Bio. Carmen Kocot: Entwicklung eines Oberflächenplasmonenresonanz-Biosensors zum Nachweis von Faktor-VIII-Hemmkörpern in Plasma von angeborenen und erworbenen Hämophilie-A-Patienten

MSc Chem. Lu Pei: Monolithic adsorption filtration (MAF)-Based Methods for Concentrating Viruses from Water

MSc Chem. Michael Pschenitza: Untersuchung molekularer Wechselwirkungen von anti-Benzo[a]pyren-Antikörpern mit polyzyklischen aromatischen Kohlenwasserstoffen und Entwicklung einer immunologischen Bestimmungsmethode für Speiseöle

MSc Chem. Wang Xu: Magnetic bead-based Immunoassays for Aflatoxin B1 Using Biofunctionalized Gold Nanoparticles

M.Sc. Theses

BSc Matthias Edelmann: Development and Validation of a System for the In Situ Derivatization of Particle-bound Polar Organic Species Measured by GC-MS

BSc Catharina Kober: Development of a Chemiluminescence DANN Microarray for the Isothermal Amplification and Detection of Legionella in Real Samples on the MCR 3

Cand. Staats. Exam. Maryam Sandhu: Multiplex Chemilumineszenz Mikroarray Analyse der Staphylokokken-Enterotoxine A und B und der B-Komponente des Nicht-hämolytischen Enterotoxins des Bacillus cereus

BSc Stefan Schneider: Voruntersuchungen zur analytischen Nutzung der Photofragmentierung von Nitro-PAHs

BSc Maxine Tam: Development of Latex Membranes for Water Filtration: Fabrication and Properties

BSc Carmen Torggler: Combination of Monolithic Adsorption Filtration and Microarray-based Sandwich-ELISA for the Rapid Detection of Legionella Pneumophila in Large Volume Surface Water Samples

BSc Sebastian Weiker: Influence of the MEA on Start-stop Stability of a HAT-PEM Fuel Cell System

BSc Ruben Weiß: Raman-Mikrospektroskopie für zerstörungsfreie, dreidimensionale Analysen

B.Sc. Theses

Yunus Aynur: Detektion von Diclofenac mittels monoklonaler Antikörper

Philipp Baur: Analysis of Deposits in Engines with Neutron Activation Analysis

Daniela Hillebrand: Investigation on Aerosol Particle Deposition Applying Uranine

Tim Kratky: Determination of the Binding and Elution Behavior of Microcystin-LR-immunoaffinity Supports by Indirect Competitive ELISA

Lukas Kutschera: Development of a Detection Method for Staphylococcal Enterotoxin B in Milk by Means of Immunomagnetic Separation and ELISA

Qingbiao Lin: Concentration of Microorganisms and Viruses from Large-volume Water Samples by Cross-flow Ultrafiltration

Jessica Löprich: Detection of Microcystin-LR in Surface Water by a Magnetic Bead-based Colorimetric Immunoassay Using Antibody-conjugated Gold Nanoparticles

Jia Yu Quek: Evaluation of an Automated System for the Enrichment of Microorganisms and Viruses from Water Samples by Means of Monolithic Adsorption Filtration

Magdalena Strobl: N_2O-extraction of Water by Use of Ultrasonic-nebulization

Alexander Urstöger: Microarray-based Immunoassay for the Automated Detection of Emerging Pollutants in Water Samples

Institute Colloquia

Dr. Petr Skladal, Masaryk University, Department of Biochemistry and CEITEC RG Nanobio, Czech Republic: Electrochemical and Piezoelectric Immunosensors for Detection of Microorganisms (20.1.2015)

Dr. Peter Herzsprung, Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, Magdeburg: Molecular Formula Assignment by FTICR-MS Analysis (27.1.2015)

Prof. Dr. Schröder, Helmholtz Zentrum München, Research Unit Microbe-Plant Interactions: New Possibilities in Phytoremediation of Pharmaceuticals - relevant Metabolites and Final Products (4.2.2015)

Dr. Romana Schirhagl, Universität Groningen, Fakultät Medizinische Wissenschaften: Diamond Magnetometry for Biomedical Applications (7.4.15)

Dr. Stefan Rödiger, Brandenburgische Technische Universität, Cottbus-Senftenberg: A Planar Multi-substrate Microbead-Chip for the Real-Time Detection and Quantification of Biomolecules (15.4.2015)

Prof. Dr. Gerd Hamscher, Justus-Liebig-Universität Gießen, Institut für Lebensmittelchemie und Lebensmittelbiotechnologie: Challenges in the Analysis of Veterinary Drugs in Food, Biological Samples and the Environment (18.5.2015)

Dr. Günter Roth, ZBSA, Microarray Copying, Universität Freiburg: Microarray Copying – A Novel Way to Generate Unique Microarrays (1.6.2015)

Prof. Dr. Marchetti-Deschmann, Universität Wien, Institute of Chemical Technologies and Analytics: Mass Spectrometry Imaging – Visualising Molecular Distributions on Tissue and Biomaterial (9.6.2015)

Prof. Dr. Dietrich Volmer, Institut für Bioanalytische Chemie, Universität des Saarlandes: Capturing Metabolic Signatures Using Advanced Mass Spectrometry Techniques (21.7.2015)

Dr. Thomas Härtling, Fraunhofer-Institut für Keramische Technologien und Systeme, Materialdiagnostik, Dresden: Optical Nanosensor Technology - From Basic Research to Industrial Applications (23.7.2015)

Prof. Dr. Andrea Robitzki, Universität Leipzig, Center for Biotechnology and Biomedicine (BBZ): Bioelectronic Sensor Array Platform for Real-time and High Content Screening in Life Sciences (26.11.2015)

External Tasks and Memberships

T. Baumann

Bayer. Fachausschuss für Kurorte, Erholungsorte & Heilbrunnen	Deputy Member
VBEW Arbeitskreis Wasserschutzgebiete	Guest Member
Arbeitskreis Spurenstoffe im Umweltcluster Bayern	Member
Network Innovative Landfill Techniques (iDetec)	Member
Science of the Total Environment	Guest Editor
Journal of Contaminant Hydrology	Guest Editor

C. Haisch

Kommission Reinhaltung der Luft im VDI und DIN - Normen-ausschuss: Unterausschuss Messen von Partikeln in der Außenluft - Bestimmung der Partikelanzahl	Member

D. Knopp

Chromatographia	Editorial Advisory Board
Ecotoxicology and Environmental Safety	Editorial Advisory Board
International Journal of Environmental Research and Public Health	Editorial Advisory Board
School of Chemical Engineering, National Technical University of Athens (NTUA), Greece. Election committee	Member

R. Niessner

Bayer. Fachausschuss für Kurorte, Erholungsorte & Heilbrunnen	Member
Heinrich-Emanuel-Merck Award	Jury Head
Hong Kong University Grants Committee, Theme-based Research Scheme, Selection Committee	Member
fms_ProcesNet-Gemeinschaftsausschuss Sensoren und Sensorsysteme (DECHEMA)	Member
Analytical Chemistry	Associated Editor
Analytical & Bioanalytical Chemistry	Advisory Board Member
Analytical Sciences	Advisory Board Member
Annual Review of Analytical Chemistry	Editorial Committee Member
Fresenius' Environmental Bulletin	Advisory Board Member
International Journal of Environmental Analytical Chemistry	Advisory Board Member
Microchimica Acta	Advisory Board Member
Talanta	Advisory Board Member
Toxicological & Environmental Chemistry	Advisory Board Member

M. Seidel

Kommission Reinhaltung der Luft im VDI und DIN - Normenausschuss: Unterausschuss Messen und Bewerten von Legionellen	Member
Kommission Reinhaltung der Luft im VDI und DIN - Normenausschuss: Arbeitsgruppe "Bioaerosole und biologische Agenzien – Luftgetragene Mikroorganismen und Viren"	Member
Spiegelgremium zur CEN/TC 264/WG 28 „Microorganisms in ambient air"	Member
Temporärer Arbeitskreis bei DECHEMA „Biosicherheit und biologisches Monitoring“	Head
Fachgruppe für „Viren und Parasiten“ bei der Wasserchemischen Gesellschaft in der GDCh	Member

Teaching

Chemistry (B.Sc./M.Sc.)

Hydrogeological, Hydrochemical and Environmental Analysis Seminar (Hydrogeologisches, Hydrochemisches und Umweltanalytisches Seminar); Niessner, Baumann, Haisch, Knopp

Graduate Course in Analytical Chemistry: Lecture in Organic Trace Analysis-Physical and Chemical Separation Methods (Nebenfach Analytische Chemie:Vorlesung Organische Spurenanalytik-Physikalisch-chemische Trennmethoden); Niessner

Graduate Course in Analytical Chemistry: Lecture in Organic Trace Analysis-Applications of Selective Receptors (Nebenfach Analytische Chemie: Vorlesung Organische Spurenanalytik-Nutzung selektiver Rezeptoren); Niessner, Seidel

Graduate Course in Analytical Chemistry: Lab in Organic Trace Analysis (Nebenfach Analytische Chemie: Kurspraktikum Organische Spurenanalytik); Niessner, Seidel

Graduate Course in Analytical Chemistry: Research Lab in Organic Trace Analysis (Nebenfach Analytische Chemie: Forschungspraktikum Organische Spurenanalytik); Niessner, Seidel

Trace Analysis Techniques (Spurenanalytische Techniken); Niessner, Knopp, Haisch

Industrial Chemistry (M.Sc.) GIST TUM-Asia

Bioengineering & Bioprocessing; Seidel

Hydrochemistry; Niessner

Chemical Engineering (B.Sc.) GIST TUM Asia

Biochemical Process Engineering; Seidel

Geosciences (B.Sc./M.Sc.)

Analytical Chemistry I: Instrumental Analysis for Geoscientists (Analytische Chemie I: Instrumentelle Analytik für Geowissenschaftler); Niessner
Analytical Chemistry II - Organic Trace Analysis for Geoscientists (Chemische Analytik II - Organische Spurenanalytik für Geowissenschaftler); Niessner
Contaminant Hydrogeology (Transport von Schadstoffen im Grundwasser); Baumann
Remediation Design (Erkundung und Sanierung von Grundwasser-schadensfällen); Baumann
Technical Hydrogeology (Technische Hydrogeologie); Baumann
Fluidflow in Porous Media Lab (Hydrogeologisches Laborpraktikum); Baumann, Haisch, Niessner
Hydrogeochemical Modelling (Hydrogeologische Modellierung II); Baumann
Hydrogeological Field Lab (Hydrogeologische Feldmethoden); Baumann
Hydrogeological Mapping (Hydrogeologische Kartierung); Baumann
Hydrogeological and Hydrochemical Field Trips (Hydrogeologische und Hydrochemische Exkursion); Baumann
Water Chemistry I (Wasserchemie I); Niessner
Water Chemistry II - Hydrocolloids, Micellar Systems and Photochemical Transformations (Wasserchemie II - Hydrokolloide, micellare Systeme und photochemische Umsetzung); Niessner
Hydrochemical Lab (Hydrochemisches Praktikum); Knopp, Baumann

Biosciences (B.Sc./M.Sc.)

Analytical Chemistry - Separation Techniques, Chemical and Biochemical Sensors (Analytische Chemie - Trenntechniken, chemische und biochemische Sensoren); Knopp
Biochemical and Molecular Biological Methods in Environmental Analysis I - Immunological methods; Sensor techniques (Biochemische und molekularbiologische Verfahren ind er Umweltanalytik I - Immunologische Methoden, Sensor Techniken); Knopp
Biochemical and Molecular Biological Methods in Environmental Analysis II - Enzymatic methods; DNA Probes (Biochemische und molekularbiologische Verfahren in der Umweltanalytik II - Enzymatische Methoden, DNA-Sonden); Knopp

Equipment

Hydrogeology

Two pilot scale tanks with flow lengths of up to 10 m allow transport experiments in a controlled environment while preserving almost natural conditions. Apart from studies on the transport behaviour of contaminants and colloids, these facilities are used for testing sensor prototypes and serve as a test bed for numerical models

Großhadern Unsaturated Zone field laboratory (10 m deep)

1 Analytical Autoclave, Büchi Midiclave for sorption experiments

Dioxin Laboratory

3 High security labs with locks, separate activated carbon filter and high-performance particle filter systems

Aerosol Research

1 Aerosol chamber (1 m^3)
1 Aerosol flow tube (10 L)
1 Ozone analyzer (UV absorption)
1 NO/NO_2 analyser (Chemiluminescence)
2 Aerodynamic particle sizers (0.5-25 µm)
1 Berner impactor (9 stages, 50 nm - 16 µm)
1 Electrical low-pressure impactor (12 stages, 30 nm - 10 µm)
2 Low-Volume filter samplers (PM 10, PM2.5)
1 High-Volume filter sampler (PM 2.5)
2 Differential mobility particle sizer systems (10-1000 nm)
2 Diffusion batteries (5-300 nm)
5 Condensation nucleus counters
3 Electrostatic classifiers (10-1000 nm)
2 Spark-discharge soot aerosol generators (polydisperse ultrafine carbon aerosol)
1 Berglund-Liu aerosol generator (monodisperse aerosols, 0.8-50 µm)
1 Floating bed aerosol generator (powder dispersion)
1 Rotating brush aerosol generator (powder dispersion)
1 Tube furnace
1 Cyclone Impinger (Coriolis µ, Berlin)
1 Micro soot sensor with dilution unit

Bioseparation

1 Crossflow-ultrafiltration unit (6 m^2-hollow fibre module, Inge-AG)
1 Munich Microorganism Concentrator (MMC 3)
1 Monolithic Affinity Filtration Unit

Molecular Biology

1 Biacore X100, General Electric
1 Real-time PCR (Light Cycler 480, Roche)

Microarray Technology

2 Chemiluminescence Microarray Reader (Immunomat, IWC)
4 Chemiluminescence Microarray Reader (MCR 3, GWK GmbH)
1 Ink-Jet Microdispenser (SciFlexarrayer 31, scienion)
2 Contact Microarrayer (BioOdyssee Caligrapher, BioRad)

Microbiology

1 Flow Cytometer (Cell Lab Quanta SC, Beckman Coulter)
1 Water Microbiology (Colilert-18 and Quanti-Tray 2000, IDEXX)
3 Clean benches
1 Microbiological Incubator (BD 53, Binder)
1 Autoclave (Century 2100, Prestige Medical)
1 Autoclave (SHP Steriltechnik)

Standard Lab Equipment

1 Lyophilizer (Alpha 1-4 LSC, Christ)
1 Washer Disinfector (DS 500 Lab, International Steel CO.SPA)
1 Ultrapure Water System (Direct-Q 3 UV, Millipore)
1 Refrigerated Centrifuge (Universal 320R, Hettich)
1 Climatic chamber (Memmert HCP 108)
2 Fluorescence reader systems, time-resolving
3 Photometric reader systems
1 384-channel washer, Biotek
1 Turbidometer (WTW GmbH)
1 Nanophotometer (Implen GmbH)

Chromatography and Particle Separation

3 GCs with FID, NPD, ECD, TEA, and AED
1 Orbitrap-based benchtop MS, Exactive/HCD-System, Thermo Fischer
1 GC/MS, VG Autospec
1 GC/MS, Shimadzu
1 Portable Micro-GC, MITEC
1 Asymmetrical Field-flow-fractionation system, Postnova
2 Concentrators for dynamic headspace analysis
4 HPLC, UV/VIS array detector, programmable fluorescence detector
1 Capillary electrophoresis system
1 Ion chromatograph, Dionex 4500 i
1 Ion chromatograph, Dionex BioLC (Photodiode Array Detector, Electrochemical Detector)
1 Ion chromatograph, Metrohm 881
1 LC system, ECONO
1 Preparative HPLC
1 Zetaphoremeter, SEPHY

Elemental Analysis

1 TXRF, Atomika EXTRA II a
1 Flame-Photometer, Eppendorf ELEX 6361
2 AAS systems with flame atomization, electrothermal atomization, hydrid system, Perkin-Elmer PE 3300, ELAN 4100
1 ICP-MS, Perkin-Elmer ELAN 6100

Laser

2 He/Ne-laser
5 Nd-YAG-laser, pulsed
1 Nd-YAG Laser 2 W cw, 532 nm narrow band
3 Nd-YAG-laser, cw
1 CO_2-laser
3 Dye-laser (tunable with frequency doubler)
5 N_2-laser
8 Diode-lasers (600-1670 nm; up to 2 W CW)
1 Laserdiode array with 10 diodes (0.8 µm - 1.8 µm)
1 Laserdiode with external resonator
2 Optical parameter oscillator (410 nm - 2.1 µm)

Optoelectronics/Spectrometer

1 Rowland spectrometer
2 Echelle spectrometer
1 ICCD spectrometer system
1 FTIR-Spectrometer, Thermo Scientific Nicolet 6700
1 Fluorescence spectrometer, Perkin Elmer LS-50
1 Fluorescence spectrometer, Shimadzu RF 540
1 Fluorescence spectrometer, Shimadzu RF 5301 PC
1 UV/VIS spectrometer, Beckman DU 650
1 UV/VIS spectrometer, analytic jena Specord 250 plus
1 UV/VIS spectrometer, analytik jena Spekol 1500
2 Boxcar integrator
4 Digital storage oscilloscopes (400 MHz, 500 MHz)
3 Optical multichannel analysators with monochromators, time-resolving
1 Wavemeter

SEM/Microscopy

1 SEM/EDX system, Zeiss Gemini
1 Polarisation microscope for phase analysis
1 Fluorescence microscope
1 Image analysis software for automated image processing
1 Inert gas glovebox
1 Laminar flow box

Raman-Microscopy

1 Laser Raman microscope, WITec alpha300R (532/633 nm)
1 Laser Raman microscope, Renishaw 2000 (514/633/785 nm)
1 Laser Raman microscope, Horiba LabRam HR (532/633/785 nm)
1 Temperature controlled stage (-196°C - 600°C, Linkam THMS 600)

Sum Parameters

2 Coulostat for C quantification, Coulomat 702
1 DOC analysator, UNOR 6 N
1 TOC analysator, TOCOR 2
1 AOX/TOX, Sigma

Staff 2015

Staff

Univ.-Prof. Dr. Reinhard Niessner
PD Dr. Thomas Baumann
PD Dr. Christoph Haisch
Dr. Natalia P. Ivleva
Prof. Dr. Dietmar Knopp
PD Dr. Michael Seidel

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Susanne Mahler
Cornelia Popp
Christine Sternkopf
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Sebastian Wiesemann

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PhD Students

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MSc Wasserb. Sayed Amininejad (10/15-)
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Dipl.-Biol.-Ing. Dennis Elsäßer
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MSc Chem. Maria Hübner (-7/15)
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MSc Chem. Catharina Kober (11/15-)
MSc Erdw. Bernhard Köhl (7/15-)
MSc Chem. Patrick Kubryk
MSc Chem. Andreas Kunze
MSc Ing. Hydrogeo. Mark Lafogler(-4/15)
MSc Chem. Verena Meyer (10/15-)
MSc Chem. Anna-Cathrine Neumann
MSc Pharm. Angelika Nistler (1/15-)
MSc Chem. Alexander Rinkenburger (5/15-)
MSc Bio. Chem. Sandra Schäfer (3/15-)
MSc Chem. Stefan Schneider (3/15-)
MSc Chem. Klemens Thaler
MSc Geol. Martina Ueckert
MSc Chem. Xu Wang (-12/15)
MSc Chem. Alexandra Wiesheu
Staatsexam. Leb. Chem. Anika Wunderlich

External PhD Students

MSc Chem. Michael Göttel (ABF GmbH München)
MSc Biol. Johannes Otto (DVGW-TZW Karlsruhe)
Dpl. Biol. Michael Schmalenberg (TUM/Klin. r. d. Isar)
MSc Biochem. Ruoyu Sun (TUM/Klin. r. d. Isar)

Diploma Students / Master Students

BSc Chem Nadine Berger (9/15-)
BSc Leb. Chem. Sebastian Dirndorfer (12/15-)
BSc Chem. Catharina Kober (4/15-9/15)
BSc. Geol. Wiss. Selina Muffler (4/15-11/15)
Cand. MSc Leb. Chem. Maryam Sandhu (-4/15)
BSc Chem. Stefan Schneider (-2/15)
BSc Chem. Carmen Torggler (-5/15)
BSc Chem. Ruben Weiß (4/15-11/15)
BSc Chem. Carina Wismeth (7/15-12/15)

External Master Students

BSc Chem. Matthias Edelmann (Hong Kong Univ. of Science and Technol., -7/15)
BSc Ind. Chem. Maxine Tam (TUM Asia-BASF Singapore, -7/15)
BSc Chem.-Ing. Sebastian Weiker (Elcore GmbH, -1/15)

Bachelor Students

Yunus Aynur (-1/15)
Philipp Baur (7/15-9/15)
Daniela Hillebrand (3/15-6/15)
Tim Kratky (-5/15)
Qing Biao Lin (6/15-7/15)
Jessica Löprich (5/15-8/15)
Ashariena Nur (11/15-)
Jia Yu Queck (6/15-7/15)
Florian Rager (
Ciny San (11/15-)
Magdalena Strobl (4/15-6/15)
Li Yan Tay (11/15-)
Alexander Urstöger (4/15-6/15)

Guests and Research Fellows

Daniel Brady, Worcester Polytechnic Institute (5/15-6/15)
Adomas Griauslys (2/15-)
Kentaro Kojima, Kyushu Univ. (3/15)
Dr. Genny Pang (Humboldt Stipendiate 4/15-)
Valentina Mazzucchelli, (3/15-8/15)
Florian Rager, LfU Augsburg (4/15-6/15)
Meng-Che Tu, Nanyang Technol. University Singapore
Dr. Jan-Christoph Wolf, ETH Zürich (11/15-)

Student Assistants

Steffen Amann (10/15-)
Philipp Anger
Jessica Beyerl (11/15-)
Bastian Striebel (7/15-)
Maximilian Walter (-1/15)
Carina Wismeth (-3/15)
Carolin Hartmann (-8/15)
Alexander Urstöger (10/15-12/15)