Report by UWI doctoral researcher Birgit Maria Müller (H1)

Project number: H1

First and last name of doctoral researcher: **Birgit Maria Müller**

(Working) title of doctoral project: **Fate of trace organics in the hyporheic zones of urban rivers**

Name of supervisors: Dr. Jörg Lewandowski (IGB), Prof. Ferdinand Hellweger (TUB), Dr. Anke Putschew (TUB), Prof. Reinhard Hinkelmann, Prof. Okke Batelaan (Flinders University, Adelaide, Australia)

2. Description of doctoral project and research results planned to date:

State of the art

River water and groundwater interact with each other in the hyporheic zone (HZ) [Orghidan, 1959]. This interface is located within the upper parts of a riverbed where groundwater infiltration or exfiltration take place [Fohrer et al., 2016]. It is characterized by heterogeneous physico- and biogeochemical conditions as well as gradients due to the mixing of groundwater and surface water [Fischer et al., 2005, Storey et al., 2001]. Comparing those two waters, one of the most significant differences in their chemistry is the oxygen concentration, usually being low in groundwater and high in river water.

Another example for chemical dissimilarities are anthropogenic pollutants. These mainly occur in surface water, with trace organic contaminants (TrOCs) being a major group [Luo et al., 2014] among them. The main source of TrOCs are the effluents of wastewater treatment plants (WWTPs) [Kasprzyk-Hordern et al., 2008, Petrie et al., 2015]. Being released into the environment, TrOCs may undergo natural removal processes such as microbial degradation, photolysis or sorption onto sediment [Li, 2014] in different compartments of the water cycle. For the attenuation of TrOCs, the HZ was found to play an important role due to diverse biological, chemical and physical processes occurring in it, with microbial metabolisation having the biggest influence [Boano et al., 2014, Lawrence et al., 2013]. As microbial activity is highly depending on temperature [Kaplan and Bott, 1989], seasonal temperature variations might be an important aspect for TrOCs degradation during a year's cycle. Among the other factors determining TrOCs attenuation in the HZ, dissolved organic carbon (DOC) seems to be one of the controlling parameters as it serves as a (co-)substrate for microbes metabolizing TrOCs [Drewes et al., 2014, Hoppe-Jones et al., 2012, Maeng et al., 2011, Rauch-Williams et al., 2010].

Motivation, scientific project relevance and research idea

The fate of TrOCs in the HZ is far from being completely understood. It is an important ecosystem service which can mitigate anthropogenic contamination of water resources. Therefore, a profound comprehension of underlying processes is needed and can improve management practices. My dissertation aims at gaining further knowledge on the attenuation of TrOCs in the HZ, with special focus on the role of seasonal variations and DOC. To achieve this, field campaigns in Berlin, Germany and Adelaide, Australia will be conducted and evaluated. All work will be done within the framework of the DFG (German Research Foundation) project Urban Water Interfaces at the IGB (Institute of Freshwater Ecology and Inland Fisheries) and the TU (Technische Universität) Berlin, in cooperation with the Flinders University, Adelaide, Australia.

Planned work steps

1) Parallel fate of TrOCs and DOC – Field sampling campaign at River Erpe, Berlin, Germany

Aim:	Investigate the fate of TrOCs parallel to the one of DOC with a Lagragian experiment following a water parcel into the HZ with electric conductivity (EC) as a conservative tracer.
Novelty:	High frequency observations of TrOCs and DOC concentrations within one water parcel along the flow path in the HZ, consideration of TPs and sediment analysis.
Hypothesis:	The attenuation of TrOCs in the HZ of the River Erpe is positively correlated to the one of DOC removal and TP appearance.

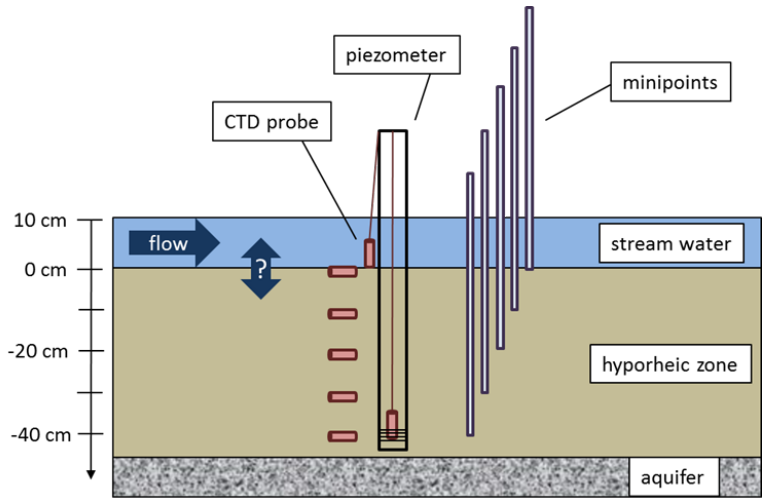

Figure 1: Setup of high frequency sampling campaign at the River Erpe. The actual depth to the aquifer is yet to be investigated

Description:
With a high frequency sampling campaign in a side channel of the River Erpe, TrOCs and DOC concentrations will be analyzed in different sediment depths (Figure 1) every hour over a period of 20 hours. In the same depths as the sampling points, CTD probes will measure EC to track individual water parcels using the dial EC pattern induced by the WWTP discharges. Redox conditions in the sediment will be investigated using indicators such as nitrate, $Fe^{2+/3+}$ and $Mn^{2+/4+}$. To analyze overall flow conditions, the hydraulic head at -40 cm depths in a piezometer and at the surface will be compared.

2) <u>Seasonal variation in TrOCs attenuation – Field sampling campaign at River Erpe, Berlin, Germany and modelling of attenuation rates</u>

Aim: Study seasonal variations in TrOCs removal in the HZ, compare it with temperature and redox zonation. Model TrOCs attenuation under different scenarios.
Novelty: In-situ measurement of seasonal variations of TrOCs removal in the HZ.
Hypothesis: TrOCs removal rates decrease in the order of summer > autumn > spring > winter.
Description: The same experimental setup as in the first project will be used for four sampling campaigns, one in each season. Statistical analysis will be based on the Kruskal-Wallis test a nonparametric test for significant differences between independent groups whose variables do not need to be normally distributed [Kruskal and Wallis, 1952]. Using a model like WASP8 or OTIS, TrOCs concentrations and attenuation rates will be modelled and up-scaled to the whole Erpe catchment. Another option would be analyzing “climate change”-scenarios for the attenuation rates under increased temperatures.

3) <u>In-river variation of DOC and TrOCs attenuation – Field sampling campaign at Sturt River, Adelaide, Australia</u>

Aim: Difference in TrOCs removal between river sediments with high and low DOC concentrations.

Novelty: In-situ comparison of TrOCs removal under different DOC conditions with close proximity of the study sites.
Hypothesis: TrOCs attenuation rates are higher under high DOC concentrations.

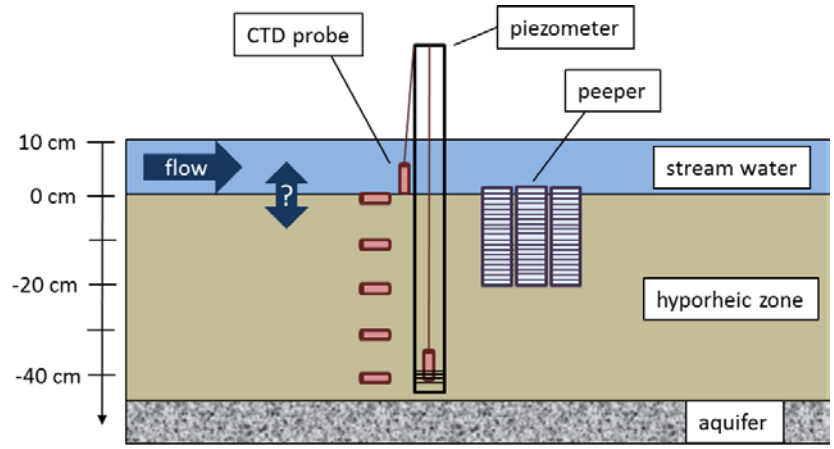

Figure 2: Setup for the Sturt River sampling campaign

Description:
Two sites at the Sturt River will be chosen which (ideally) only differ in their DOC concentration. At each side, peepers (dialysis membrane chambers [Hesslein, 1976]) will be inserted into the sediment (Figure 2) and integrate TrOCs concentrations for two weeks. CTD probes will provide EC time series of different sediment depths which will be used to gain information on travel times in the sediment and daily fluctuations of WWTP discharge.

Collaboration
Collaboration on pharmaceuticals removal in and their effects on the aquatic environment is planned with Anna Lena Kronsbein (UWI project F1). Due to connecting topics, further collaboration with Yuki Sorgler (H3) and Lukas Weise (H4) is aimed at.

The data obtained from work step 1 will be provided to Vahid Sobhi Gollo (UWI project H2) for model evaluation as well as calibration.

References

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3. Comments on the qualification programme and supervision strategy:

As UWI is an interdisciplinary program, it has the advantage of group consisting of doctoral students and supervisors coming from diverse backgrounds. Therefore, problems to solve are looked at from different points of views leading to elaborated solutions. In order to enable advanced communication and understanding between engineering, different natural science and modelling backgrounds, core courses will provide knowledge on a variety of topics covered by the 13 doctoral projects. To connect with the other doctoral students and their topics, regular meetings and summer schools are scheduled. Furthermore, elective courses offered by UWI will ensure personal and scientific development during the three years of the doctoral program.

I would like to point out the great effort of all UWI participants. Everything is remarkably well organized and if asking for information, it is always provided in a helpful and fast way. In combination with the unique mixture of different disciplines covered by UWI participants this forms a motivating and high level working environment.

Participation in the following Research Training Group events:

1. Core courses
    - I – Urban interface processes – fluxes, transport, interactions (3 ECTS)
    - II – Modelling and measuring concepts of interface processes (3 ECTS)
    - III – Urban freshwater ecology (3 ECTS)
2. Elective courses
    - Introduction to experimental design and basic statistics (IGB Berlin, 15.-22.10.2018)
    - Individual coaching on experimental design and statistics by Dr. Kirsten Pohlmann
    - Optimize your participation in scientific meetings and conferences (IGB)
3. Gender courses
    - Negotiation
    - Project management
4. UWI lectures: Participate in all UWI lectures
5. Other UWI events
    - Welcome workshop (05.07.2018)
    - Summer School and exposé presentation (18.-20.09.2018)

Research stays or internships at other research institutions both at home and abroad

- Field sampling campaign at Flinders University, Adelaide, Australia (October – December 2019)

Participation in conferences, congresses, etc., at home and abroad:

2019:

- EGU (07.-12.04.2019, Vienna, Austria)

2020:

- WASSER Berlin International (spring 2020)
- AGU Fall Meeting (07.-11.12.2020, San Francisco, USA)

2021:

- EGU (spring 2021, Vienna, Austria)