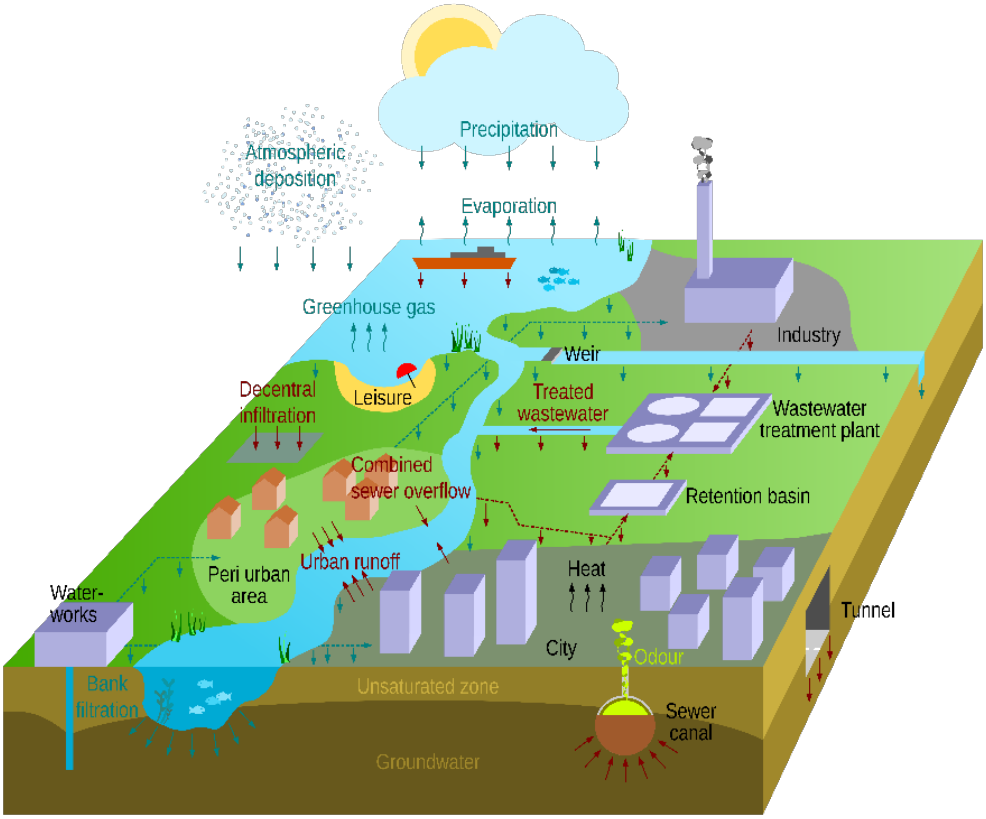
First International Conference on Urban Water Interfaces (UWI)

22 – 24 September 2020 (online)



Summary of Abstracts

A joint initiative of

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Table of content

Foreword

The First International Conference on Urban Water Interfaces, which will be held from 22 to 24 September 2020, was shifted from the vibrant city of Berlin, Germany to your (home) office. Owing to corona circumstances, we have the opportunity to explore a new conference format and will carry it out synchronously in two parallel sessions using a videoconference system.

For sure, this cannot replace the lively discussions we were expecting to have at the conference venue. However, considering the difficulties we are facing worldwide, we think that this is a reasonable alternative, which offers digital possibilities to present and discuss research results and exchange ideas, thus, letting the conference become a success.

This conference has been initiated by the Research Training Group 'Urban Water Interfaces' (UWI), which is a close collaboration of engineers and natural scientists of the Technische Universität Berlin (TUB) and the Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB), a member of the Forschungsverbund Berlin e.V. Being funded by the DFG (German Research Foundation) in the period 2015 - 2024, UWI educates three cohorts of thirteen doctoral students, respectively and two postdoctoral researchers. TUB and IGB have created a unique interdisciplinary platform for research on urban water interfaces. Together with associated partners from other research institutions, the water industry and local authorities we have established a stimulating research environment, facilitate international mobility, and provide support structures and assistance, all aimed at promoting the candidates' skill set required for successful scientific research (see www.uwi.tu-berlin.de).

Motivation

Interfaces in urban water systems play a crucial role in the urban water cycle but are still understudied. They connect a large number of compartments and subsystems and notably affect the overall system behaviour. The processes and fluxes of interfaces are highly complex due to, for example, steep physical and biogeochemical gradients, high numbers of micro-organisms and reaction rates, non-linear behaviour and feedback effects as well as heterogeneous and dynamic structures. Considerable knowledge gaps still exist - urgently requiring novel interdisciplinary collaboration of engineers and natural scientists. Under this collaborative perspective, we want to develop a new understanding and thinking on future urban water management being faced by multiple stressors such as climate and demographic change, ongoing urbanization and continuous growth of contaminations as well as multiple uses.

Main goals of the conference

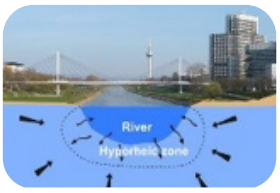
- The conference highlights progress, which has been achieved within the DFG Research Training Group 'Urban Water Interfaces'.
- The conference is a platform for presenting state of the art insights and novel findings from an international interdisciplinary community.
- At the conference contributions from the international scientific community, but also representatives from water engineering practice and administration are given.

Conference topics are: I n t e r f a c e s i n

urban watersheds

urban freshwater ecosystems

urban hyporheic zones



sewer systems

Keynote speakers

Prof. Ana Deletic
School of Civil and Environmental Engineering
UNSW Sydney, Australia
Stormwater management, urban modelling

Prof. Hayley Fowler
School of Engineering
Newcastle University, UK
Climate change impacts on water resources

Dr. Emma J. Rosi
Cary Institute of Ecosystem Studies
Millbrook, New York, USA
Human impacts on freshwaters

Prof. Daniele Tonina
Center for Ecohydraulic Research
University of Idaho, Boise, USA
Hyporheic exchange, greenhouse gases

Prof. Jes Vollertsen
Department of the Built Environment
Aalborg University, Denmark
Stormwater and wastewater

Further highlights of the conference are:

- An open forum discussion on the topics "Too much, or too little water, that is the question" and "Green cities: How can research help to develop future city concepts"
- Virtual excursions to selected laboratories and field sites
- Five awards for best presentations in the four conference topics and one for the most innovative online format
- Virtual networking

Organising committee

Prof. Reinhard Hinkelmann, TU Berlin
Prof. Birgit Kleinschmit, TU Berlin
Dr. Gwendolin Porst, TU Berlin
Nasrin Haacke, TU Berlin
Micaela Pacheco Fernández, TU Berlin

We are confident that the conference and this "Summary of Abstracts" will contribute to the advancement of knowledge on urban water interfaces and thus on a new understanding and thinking on future urban water management.

Conference statistics

This document includes abstracts of 53 presentations[1] of parallel sessions and of 5 keynote presentations coming from 10 countries and 5 continents. In this online format free of charge, we were able to open the conference to a broader scientific community. We received registrations of about 170 participants, while we would have been limited to about 80 persons in the conference location in Berlin.

Acknowledgements

First, we would like to sincerely thank the keynotes speakers, the presenters and the authors and co-authors of the abstracts. Secondly, many thanks to Tosca Piotrowski for her organisational support and Ralf Duda and Pavel Sneguir for their technical support. Thirdly, we acknowledge the DFG (German Research Foundation) for funding the Research Training Group 'Urban Water Interfaces' in the period 2015 - 2024 under reference numbers GRK 2032/1 and GRK 2032/2. Lastly, we thank the software developing enterprise Zoom Video Communications for using its videoconferencing system provided by the Technische Universität Berlin.

Reinhard Hinkelmann, Birgit Kleinschmit, Gwendolin Porst, Nasrin Haacke & Micaela Pacheco Fernández, all TU Berlin

September 2020

[1] This document does not include all abstracts of presentations given at the "First International Conference on Urban Water Interfaces (UWI)".

Programme

UWI International Conference

22nd - 24th September 2020

(via Zoom)

Day 1, 22nd September 2020

13:00	**Opening**	Prof. Reinhard Hinkelmann, UWI Speaker Prof. Christine Ahrend, Vice President TU Prof. Luc De Meester, Director IGB
13:30	**Keynote 1** Anthropogenic intensification of short-duration rainfall extremes: Implications for flash floods in urban areas (Interfaces in urban watersheds) *Session chair: Prof. Eva Paton*	Prof. Hayley Fowler, Water Resource Systems Engineering Group School of Engineering Newcastle University UK
14:15	**Keynote 2** The role of riverine hydromorphological and water quality quantities to predict hyporheic processes from reach to global scales (Interface urban hyporheic zones) *Session chair: Prof. Reinhard Hinkelmann*	Prof. Daniele Tonina, Center for Ecohydraulic Research University of Idaho Boise USA
15:00	Coffee break / Virtual networking	

	Parallel sessions	
	Session 1a *Interfaces in urban watersheds* Session chair: Prof. Birgit Kleinschmit	**Session 2a** *Interface urban hyporheic zones* Session chair: Dr. Jörg Lewandowski
15:30	Dr. Hamideh Nouri The impact of local climate on the greenness and water demand of large urban green spaces	Hanna Schulz The effect of stream flow dynamics on microbial metabolism and carbon dioxide production in a moving sandy streambed
15:50	Stenka Vulova A remote-sensing approach for assessing evapotranspiration of urban vegetation in a Berlin garden	Yuki Sorgler Transformation products of iodinated X-ray contrast media: formation and behaviour concerning sorption and biodegradability
16:10	Dr. Alby Duarte Rocha Inverse modelling of evapotranspiration of urban vegetation from thermal-optical remote sensing: a physically-based approach using SCOPE	Birgit Maria Müller Attenuation of dissolved organic matter and trace organic compounds in the hyporheic zone of an urban river
16:30	Lena-Marie Kuhlemann Using stable isotopes to quantify ecohydrological flux dynamics at the soil-plant-atmosphere continuum in urban green spaces	Niranjan Mukherjee Effect of different redox conditions on sediment microbial communities from a lotic hyporheic zone
16:50	Dr. Mikael Gillefalk Quantifying the effects of urban vegetation on water partitioning in complex cityscapes: the potential of isotope-based ecohydrological models	Anja Höhne Determining hyporheic removal rates using non-parametric conservative transport with multiple sorption models
17:10	Christian Marx High spatial and temporal resolution of stable water isotopes to investigate flow paths and water ages in the urban Panke catchment in the north of Berlin	Tabea Broecker Integral modelling approach for tracer transport in the hyporheic zone under neutral, losing and gaining streamflow conditions
17:30	Prof. Jochen Hack Analysis of the impact of different degrees of urbanization and urban green infrastructure on the water and energy balance using a spatially high resolved raster-based model	Vahid Sobhi Gollo Integral modeling of flow in and around a ventilated U-shaped chironomid burrow
17:50	Virtual networking	
18:05	End of day 1	

Day 2, 23rd September 2020

9:00	**Keynote 3** Planning nature based solutions for sustainable city futures (General overview) *Session chair: Prof. Dörthe Tetzlaff*	Prof. Ana Deletic, School of Civil and Environmental Engineering UNSW Sydney Australia
9:45	Coffee break / Virtual networking	
	Parallel sessions	
	Session 1b *Interfaces in urban watersheds* Session chair: Dr. Alby Duarte Rocha	
10:00	Dr. Basem Aljoumani Assessing the variation of evaporation from cobblestones and concrete slabs pavement	
10:20	Nasrin Haacke Survey of rain events: how to categorise and analyse individual storm events in high-resolution precipitation time series	
10:40	Omar Seleem Parsimonious hazard mapping for extreme urban pluvial floods: a case study for Berlin, Germany	
11:00	Simon Berkhahn Recursive artificial neural network approach for dynamic hot-spot nowcast of pluvial floods	
11:20	Lunch / Virtual networking	
	Parallel sessions	
	Session 1c *Interfaces in urban watersheds* Session chair: Dr. Basem Aljoumani	**Session 2c** *Interfaces in sewer systems* Session chair: Dr. Adrian Augustyniak
12:40	Wenyu Yang Evaluating the performance of green and grey infrastructures for the road-deposited sediment pollution removal	Prof. Andrea Cominola The ide3a project: a gamified digital approach to integrated modelling of urban critical infrastructure systems

13:00	Robert Sämann Pollution transport forecast during pluvial flood events: model and field experiments with a rainfall simulator	Mohammed Marzouk Modelling combined sewer network applications to the new admin city and new zaid city in Egypt
13:20	Hatice Seda Kilic Identifying faecal pollution sources in urban surface water resources to support water safety management	Abhinav Dixit Validation of air phase flow, mass transport and mass transfer in a sewer pipe
13:40	Jinghua Jiang A GPU-accelerated particle-tracking model for full-process modelling of nonpoint source pollutants in urban areas	Muhammad Waqar Tlime reversal technique for freshwater pipeline burst detection
14:00	Franziska Tügel Investigating the suitability of the Green-Ampt model with tabulated parameter values from literature by using a 2D hydrodynamic rainfall-runoff model	Wenyu Yang Integrated evaluation and improvement of urban drainage system sustainability through multi-criteria decision-making framework and green/grey infrastructures
14:20	Abu Sadath Analysis of feasibility and acceptability of rainwater usage to aeras of acute water scarcity in Rajshahi metropolitan city, Bangladesh	Ivo Daniel A data-driven approach to leakage identification in water distribution networks
14:40	Coffee break / Virtual networking	
15:00	**Keynote 4** Interfaces in urban freshwater systems: Examples from long-term research in Baltimore (Interfaces in urban freshwater ecosystems) *Session chair: Prof. Mark Gessner*	Dr. Emma J. Rosi, Cary Institute of Ecosystem Studies Millbrook New York USA
15:45	Virtual networking	
16:15	**Open forum discussion** *Discussion topics:* "Too much, or too little water, that is the question" "Green cities: How can research help to develop future city concepts" Discussion among doctoral students, invited national and international experts and all participants *Session chairs: Nasrin Haacke, Micaela Pacheco Fernández, Niranjan Mukherjee, Vahid Sobhi-Gollo*	
17:15	End of day 2	

Day 3, 24th September 2020

9:00	**Keynote 5** The smell of sewage (Interfaces in sewer systems) *Session chair: Prof. Matthias Barjenbruch*	Prof. Jes Vollertsen, Department of Civil Engineering Division of Water and Environment Aalborg University Denmark
9:45	Coffee break / Virtual networking	
	Parallel sessions	
	Session 1d *Interfaces in urban freshwater ecosystems* Session chair: Dr. Sabine Hilt	**Session 2d** *Interfaces in sewer systems* Session chair: Prof. Dietmar Stephan
10:00	Marvin Mayerhofer Modeling cyanobacteria at Lake Müggelsee	Dr. Katharina Teuber A three-dimensional model for H_2S mass transfer in sewers and its use cases
10:20	Benjamin Archer Urban greenhouse-gas dynamics: high frequency measurement of CO_2 and CH_4 in Berlin's surface waters	Daneish Despot Downstream nitrate dosing in pressure sewers for sulphide control: impact of residual nitrate on connecting gravity sewers
10:40	Jagriti Jain Urban wetlands: how can they mitigate the impacts of climate change	Kirsten Habicht Novel sensor technology for online monitoring of dissolved H_2S presents new opportunities for data driven H_2S management
11:00	Lena Heinrich Sulfur prevented the continuous effect of an iron amendment on sedimentary phosphorus retention: a case study at Lake Plötzensee in Berlin	Micaela Pacheco Fernández Determining the turbulent H_2S mass transfer coefficient across the liquid-gas interface in sewer systems
11:20	Giulia Friedland Sedimentary signatures reveal transition between mining and urban impacts along river Spree (NE Germany)	Maria Sielaff Biogenic sulphuric acid corrosion of concrete at sewer pilot plant Berlin
11:40	Anja Svane Petersen Can outlets handled by stromwater ponds still affect the sediment decomposition in receiving streams?	Virtual networking
12:00	Lunch / Virtual networking	

	Session 1e *Interfaces in urban freshwater ecosystems* Session chair: Dr. Mikael Gillefalk	**Session 2e** *Interfaces in sewer systems* Session chair: Prof. Andrea Cominola
13:00	Prof. Sara Egemose Runoff from urban and rural land-use has different impact on stream quality: a GIS-study	Dr. Adrian Augustyniak Bacteria from sewers and their potential to improve the sustainability of construction materials
13:20	Hellen Aziz The water challenges and proposed solutions for Ash Shakhlouba, the Egyptian Venice and El Burullus, the polluted lake	Tayebeh Zinati Shoa Assessment of urban sanitation concepts for sustainable wastewater management
13:40	Anna Lena Kronsbein Effects of benthic organisms on the fate of trace organic compounds during bank filtration	Luisa Reinhold Suitability of a differential scanning calometry (DSC) based method to identify and quantify two common microplastics polyethylene and polypropylene in wastewater samples
14:00	Dr. Giuseppe Francesco Cesare Lama Simulation of the effects of common reed riparian plants on the real scale water flow velocity fields of a vegetated reclamation channel	Smit Chetan Doshi Surface water and sewer network interface with the inlets
14:20	Dr. Elena Matta A review of recent applications of neurocomputing methods in urban hydraulics and hydrology	Farhana Afroz Wastewater treatment and effects of wastewater irrigation use in agriculture: a case study in Rajshahi city, Bangladesh
14:40	Dr. Soren Brothers Does urbanization increase or decrease carbon dioxide emissions from lakes?	Adnan Aldukki Detecting and minimizing water losses in a drinking water supply system: two case studies in Hurghada and El Gouna Cities, Red Sea Governorate, Egypt
15:00	Virtual networking	
15:15	**Virtual excursions to selected laboratories and field sites** *Session chairs: Birgit Maria Müller, Nasrin Haacke*	
16:00	**Awards and closing remarks**	
16:30	End of conference	

Summary of abstracts

Keynote 3

Planning nature based solutions for sustainable city futures (General overview)

Prof. Ana Deletic, School of Civil and Environmental Engineering, UNSW Sydney, Australia

Water Sensitive Urban Design (WSUD) is commonly employed to restore urban water systems back to pre-developed conditions and can provide multiple benefits. However, WSUD planning is a challenging task that involves multidisciplinary effort to deal with highly complex and uncertain futures. Hence, an integrated approach is required to address this task with a high level of scientific rigour. UrbanBEATS (Urban Biophysical Environments And Technologies Simulator) is an integrated modelling tool that supports planning and development of sustainable stormwater strategies. It was developed to plan WSUD stormwater infrastructure for management of runoff, pollution and stormwater harvesting, UrbanBEATS' ecosystem. It is currently being extended and includes, among others, three new modules; (1) uptake, needs and suitability assessment module for simulating the behaviour of the main actors in urban stormwater management to assess uptake, suitability and needs for WSUD technologies; (2) mapping of water pollution emissions, linking detailed information of the urban form and land use with stormwater pollution algorithms (allowing identification of pollution hotspots within the catchment to guide pollution management strategies); and (3) a novel cellular automata fast flood evaluation model known as CA-ffé for the rapid prediction of inundation extent, depths and flood risks in urban areas (including assessment of the WSUD benefits for reducing flood damages). The talk will particularly address the development of the fast flood model. UrbanBEATS boasts a wide variety of features to enable a group of stakeholders from different backgrounds, training and responsibilities to undertake collaborative planning exercise for urban areas. The model has been validated on a number of urban catchments in Melbourne, demonstrating its robustness for planning of stormwater management solutions.

Interfaces in urban watersheds

Keynote 1

Anthropogenic intensification of short-duration rainfall extremes: Implications for flash floods in urban areas

Prof. Hayley Fowler, Water Resource Systems Engineering Group, School of Engineering, Newcastle University, UK

Short-duration (1 to 3 hour) rainfall extremes can cause serious damage to infrastructure and ecosystems and can result in loss of life through rapidly developing (flash) flooding. Short-duration rainfall extremes are intensifying with warming at a rate consistent with atmospheric moisture increase (~7%/K) that also drives intensification of longer-duration extremes (1day+). Evidence from some regions indicates stronger increases to short-duration extreme rainfall intensities related to convective cloud feedbacks but their relevance to climate change is uncertain. This intensification has likely increased the incidence of flash flooding at local scales, particularly in urban areas, and this can further compound with an increased storm spatial footprint to significantly increase total event rainfall. These findings call for urgent climate-change adaptation measures to manage increasing flood risks, including rethinking the way climate change is incorporated into flood estimation guidance.

Session 1a

The impact of local climate on the greenness and water demand of large urban green spaces

Hamideh Nouri*[a], Sattar Chavoshi Borujeni[b], Pamela Nagler[c], Armando Barreto Munez[d], Kamel Didan[d]

a. Division of Agronomy, University of Göttingen, Göttingen, Germany
b. Soil Conservation and Watershed Management Research Department, Isfahan Agricultural and Natural Resources Research and Education Centre, Iran
c. U. S. Geological Survey, Southwest Biological Science Center, Tucson, AZ, USA
d. Biosystems Engineering. The University of Arizona, Tucson, AZ, USA

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Climate change and its impact on urban water cycles and water shortage are putting extra pressure on cities that are already vulnerable to water scarcity and drought. By recognition of environmental-social-economic values of green spaces, many cities are searching for solutions to maintain and expand their green spaces in the context of a changing climate and more competition for water. Adelaide, a city in a semi-arid climate, is facing mounting water scarcity pressure in most years, particularly in the summertime when demand is highest. Adelaide Parklands consisting of 29 parks covering approximately 780 hectares is one of the largest urban parks in the world. In this study, we assessed changes in the greenness of the Adelaide Parklands, and explored how local climate impacts the vegetation indices (VIs) and evapotranspiration (ET) of the Parklands on a seasonal scale. Trends of the VIs time series throughout the year showed how Parklands were affected by water limitation, resulting in minimum greenness in summer when benefits and services by green spaces are highly desired and valuable (e.g., cooling effect). The long-term intra- and inter-annual variations of VIs and ETs (2011-2018) revealed that while these annual changes are usually profoundly impacted by the local climate and green water availability (rainfall stored in soil and potentially available for uptake by plants), the restriction on blue water resources (surface and groundwater) may be also playing a role in the Parklands. Adelaide Parklands have been greatly dependent on blue water resources and must compete with other water-users in the State of South Australia. This means that maintaining the greenness of the whole parklands area year-round is not feasible; hence, the city council has chosen to allow a significant part of the grass areas to dry out in the summer for the park to survive. A possible solution is to maximize the drought-tolerant native species that have lower water demand in addition to applying the principles of water sensitive urban design (WSUD) to free up more blue water from the limited water resources to maintain (and possibly expand) urban green spaces.

Inverse modelling of evapotranspiration of urban vegetation from thermal-optical remote sensing: a physically-based approach using SCOPE

Alby Duarte Rocha*[a], Stenka Vulova[a], Michael Förster[a], Birgit Kleinschmit[a]

a. Geoinformation in Environmental, Planning Lab, Technische Universität Berlin, Germany

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Evapotranspiration (ET) is a measurement of mass or energy exchanged between surfaces and atmosphere, which combine evaporation and plant transpiration. Fields such as meteorology, hydrology and agriculture have developed different instruments and methods to estimate ET a local scale. However, ET estimations are necessary at a regional and global scale, which often rely on remote sensing data for upscaling. ET is challenging to model at broad resolution due to complex ecological processes in different scales. For instance, transpiration occurs at a cellular level and is directly measured at a leaf or plant level, but mainly modelled at the canopy or plot level. Direct measurements by remote sensing are still not possible, although many input variables for modelling ET are currently derived from optical and thermal sensors. Empirical models using spectral indices may be overly simplistic to fully capture soil-vegetation-atmosphere interactions to predict ET. Physical and semi-empirical models based on energy balance equations supported by remote sensing data are widely used, but they focus mostly on the atmospheric interface. The Soil-Canopy-Observation of Photosynthesis and Energy fluxes (SCOPE) model accounts for more surface-atmosphere interactions as it integrates radiative transfer and energy balance models. Although SCOPE has been successfully applied to predict ET, it assumes a landscape of homogeneous canopies without anthropogenic elements, which is rare in urban areas. To the best of our knowledge, no studies have used SCOPE for modelling water and energy fluxes of urban vegetation. This study aims to assess the possibility of a SCOPE model to predict ET accurately at different scales in urban vegetation. Biochemical and biophysical plant traits used for parametrising SCOPE were collected in a typical urban backyard garden in Berlin, composed by grassland, shrubs and trees, but surrounded by buildings and sealed surfaces. This data was combined with radiative and turbulence fluxes from an eddy flux tower to run forward models using SCOPE. For inverse modelling, UAV-based multispectral and thermal images were captured between April and September of 2019. The results were validated at canopy level using LI-6800 measurements of leaf transpiration and at plot level using eddy flux measurements of latent heat flux.

Using stable isotopes to quantify ecohydrological flux dynamics at the soil-plant-atmosphere continuum in urban green spaces

Lena-Marie Kuhlemann*[a,b], Doerthe Tetzlaff[a,b,d], Birgit Kleinschmit[c], Stenka Vulova[c], Chris Soulsby[d,c,a]

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b. Department of Geography, Humboldt-University Berlin, Germany
c. Technical University Berlin, Germany
d. Northern Rivers Institute, University of Aberdeen, Scotland, UK

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Urban areas, more than many experimental catchments, are characterized by a markedly heterogeneous distribution of land covers, with different degrees of permeability that radically vary partitioning of precipitation into evapotranspiration ("green" water fluxes) and runoff and groundwater recharge ("blue" water fluxes). While the quantification of ecohydrological fluxes using stable isotopes in water as environmental tracers has been an established method for many years, surprisingly few studies have been applied to the highly complex urban water cycle. To determine the effects of representative urban green space "types" on water partitioning, we carried out plot-scale studies at a heterogeneous field site in Berlin-Steglitz that integrates climate, soil moisture and sap flow data, with isotope sampling of precipitation and soil moisture on a regular basis. Soil moisture and isotope measurements were conducted at different depths and under contrasting soil-vegetation units (grassland, trees, shrub) with different degrees of permeability. Our investigations revealed uniformly decreasing soil moisture content during the dry summer of 2019, with only temporary re-wetting of the uppermost soil layers despite heavy convective precipitation events. Soils under trees were driest, whilst grassland soils were wettest, with shrubs intermediate. Isotope-based modelling indicated that this was the result of greater interception, transpiration and – surprisingly – soil evaporation from forest sites. The isotope signatures of soil water also revealed stronger "memory effects" of summer drying in forest soils, which persisted until the major re-wetting of the system in autumn allowed drainage from the soil profile to contribute to groundwater recharge. Modelling showed that recharge under grasslands could be over 3 times higher compared to under trees and shrubs. Upscaling these findings with large-scale isotope studies of surface and groundwater across Berlin highlights the importance of the vegetation in urban green spaces to water partitioning in heterogeneous city landscapes and the need for careful integration of vegetation management in urban water and land use planning.

Quantifying the effects of urban vegetation on water partitioning in complex cityscapes: the potential of isotope-based ecohydrological models

Mikael Gillefalk*[a,b], Dörthe Tetzlaff[b,c], Reinhard Hinkelmann[a], Lena-Marie Kuhlemann[b], Aaron Smith[b], Fred Meier[d], Chris Soulsby[a,b,e]

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e. Northern Rivers Institute, University of Aberdeen, Scotland, UK

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The continued global acceleration of urbanisation increasingly requires sustainable, adaptive management strategies for land and water use in cities. Although the effects of buildings and sealed surfaces on urban runoff generation (via storm drains) and local climate (through the urban heat island effect) are well known, much less is known about how these artificial influences integrate with water partitioning in more natural urban green spaces. In particular, little is quantitatively known about how different types of urban green spaces (lawns, parks, woodland etc.) regulate the partitioning of evaporation, transpiration and groundwater recharge. To address this crucial issue, we integrated field observations with advanced, isotope-based ecohydrological modelling at the plot scale in the urban area of Berlin, Germany. Measurements of soil moisture, sap flow, and stable isotopes in precipitation, soil water and groundwater have been made over the course of one growing season. Additionally, an eddy flux tower at the site Rothenburgstraße in Berlin-Steglitz continuously collects hydroclimate data by measuring temperature, precipitation, radiation, humidity and wind speed at high temporal resolution. These data (30-min averages) have been used as input to, and for calibration of, the process-based ecohydrological model EcH2O-iso. The model also tracks stable isotope ratios and water ages in various stores (e.g. soils and groundwater) and fluxes (evaporation, transpiration and recharge). EcH2O-iso has successfully been used to describe the effects of vegetation cover on water partitioning in a number of studies but this is the first implementation in an urban setting. It shows that ecohydrological water use by vegetation type increases in the order trees > shrubs > grass, mainly through higher interception and transpiration. Accordingly, trees can reduce groundwater recharge by >50%, but provide cooling latent heat transfers to the atmosphere. Similarly, ages of stored water and fluxes are generally greater under trees than grass. The results, which form the basis for ongoing upscaling study, show that urban green spaces play an important role in urban hydrology and in Berlin there is a trade-off between moderating the urban heat island effect and maintaining groundwater recharge. Consequently, it is clear that vegetation management needs to be considered in sustainable water and land use planning in urban areas to build resilience in cities to climatic and other environmental change.

High spatial and temporal resolution of stable water isotopes to investigate flow paths and water ages in the urban Panke catchment in the north of Berlin

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Ongoing urbanization takes place worldwide and is affecting critical zone processes in the hydrological cycle, from atmosphere, to the soil – vegetation interface, down to the groundwater. A complex system of natural and artificial flows, infiltration on different land uses and "low impact development" as mitigation technique for storm water runoff makes it important to understand routing processes on a larger, urban scale. Stable water isotopes are commonly used as tracers for an identification of flow paths in hydrology, we will use those to understand the "urban karst" and the effect of urban greenspaces on the runoff generation. We will present stable water isotope data from the Panke catchment in north Berlin for surface and groundwater, which was taken synoptically to understand spatial and seasonal distributed patterns and to identify different water sources for the receiving water. Naturally, the Panke headwater is mainly groundwater dominated, while downstream the isotopic imprint of a wastewater treatment plant is dominating. Additionally, we will present a high temporal resolution data set (between daily and event-based sub-daily time steps) to demonstrate the effect of preferential flow paths on water ages for base flow conditions as well as during and after storm events. The high resulted data allows to differentiate between the effect of storm water overflows and the natural-urban dynamics of the catchment. In addition to surface, precipitation and groundwater samples, the research project is investigating spatial distributed soil water contents in the upper soil layer and stable water isotopes in soil for different greenspaces around and inside the catchment, which will be supplemented by moisture and sap flow data from the Steglitz research site, for achieving an holistic approach to understand urban hydrology. This preliminary work will be extended for at least the year 2020 and will be provided to hydrologic models for quantifying travel time distributions and how urban land use and change affects groundwater recharge.

Analysis of the impact of different degrees of urbanization and urban green infrastructure on the water and energy balance using a spatially high resolved raster-based model

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A principal objective of Green Infrastructure is to mitigate negative impacts of urbanization on the hydrological and energetic balance. This work examines the suitability of the conceptual model Surface Urban Energy and Water Balance Scheme (SUEWS) to quantify the mitigation effect of Green Infrastructure. The evapotranspiration as linking component of the hydrological and the energy balance was modelled on the basis of essential meteorological data and specific site characteristics of a study site in Costa Rica. A high resolution land cover classification was created and used to categorized different degrees of urbanization to evaluate the results in their spatial variety. A sensitivity analysis was executed to approximate the impact of different model variables. Finally, two scenarios were created within SUEWS, one representing the current state of the study site, the other representing the study site with Green Infrastructure elements implemented. The extent of the impact was evaluated, by analysing the deviations of the generated results spatially and statistically. The results show the suitability of SUEWS to model land cover changes and also its limitations to demonstrate the hydrological effects of Green Infrastructure elements.

Session 1b

Assessing the variation of evaporation from cobblestones and concrete slabs pavement

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Pavement, as a soil-atmosphere interface of urban surfaces, plays a key role as part of the urban water interface, determining the transformation and transport processes of water, energy, and matter between the soil and atmosphere in urban areas.

This study was carried out in two weighable lysimeter covered with different pavement-sealing types: cobblestone and concreate slabs. Both are commonly used for sidewalks in Berlin, Germany. Statistical models were applied to estimate the variation of evaporation. Hourly observations of both soil volumetric water content and soil temperature were gained by capacitance soil moisture sensors. The measurements started in June 2016 and have been carried out for one year. The time series consists of hourly measurements of evaporation and climate data. The data set was used to assess the variation of evaporation and how it is affected by the pavement type and environmental factors.

For data interpretation, generalized additive models (GAMs) were used to explore the complex behavior of evaporation by considering linear and nonlinear environmental trends. The modeling approach shows that the hourly evaporation from cobblestone pavers is higher compared to concrete slab pavers. This behavior can be explained by different biophysical processes above and below the pavement. For cobblestones, a linear dependency between the relative humidity was observed, and a decreasing evaporation rate with increasing relative humidity. However, the evaporation processes for concrete slabs increase the relative humidity of its surrounding, which decrease the evaporation potential nonlinearity. The model results could be improved significantly by considering the cumulative precipitation of 9-hour intervals as a predictor. In both lysimeters, the evaporation increases sharply, when the cumulative precipitation exceeds 10mm. The data also shows that the effect of soil temperature on evaporation is more pronounced for concrete slabs pavers than for cobblestones. The evaporation increases positively from its mean as the solar radiation increases.

Survey of rain events: how to categorise and analyse individual storm events in high-resolution precipitation time series

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Analysing frequency shifts in precipitation data is hampered by the dilemma of the duration-amount-intensity relationship. If we look at daily rainfall data, we do not know if a certain amount fell within 30 minutes as a convective high-intensity storm or within 8 hours as a drizzle. Conversely, if we analyse 10-minute resolution data and we select an individual 10-minute period with a very high intensity, we do not know in which 'context' it fell.

To overcome this dilemma, we developed a framework that enabled individual storm events to be categorised based on two methods: 1. grouping by key attributes (rainfall duration, amount, average and maximum intensity) and 2. grouping by storm effect, as predicted by hydrological modelling (e.g. does the storm generate a significant amount of infiltration and runoff on a hypothetical surface or mostly interception). Such categorisation can then be used for multiple applications in both ecology and urban drainage, for example, to analyse long-term changes in storm frequency that have the potential to generate urban flash floods or that contribute to the water supply of plants.

The study enables a new way of visualizing and analyzing trends of rainstorm types, which is presented here for the three general groups 'convective rainfall', 'continuous rainfall' and intermediate storms by analyzing their occurrences over the summer months in the last 25 years for several climatic zones in Germany. We show that using temporal bar plots with the three groupings offers a simple and effective starting point for further analysis.

Parsimonious hazard mapping for extreme urban pluvial floods: a case study for Berlin, Germany

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Urban pluvial floods are increasingly recognized as a ubiquitous hazard. They are caused by short and intense rainfall, followed by rapid runoff concentration. But while flood hazard maps for rivers have been widely implemented under the EU Flood Directive, corresponding efforts for pluvial flooding are rare, yet: pluvial floods are not to the existence of a river channel. They could occur anywhere, subject to the existence of minimal areas for surface runoff generation and concentration. That concentration could be dominated by small features of urban landscapes, which makes identification of flow paths uncertain even with highly-resolved digital elevation models (DEM) and full hydrodynamic simulations (which are computationally expensive). At the same time, sub-surface sewer and drainage systems – an additional complication in an already complex environment – will typically be subject to overcharge for extremely heavy rainfall events. That, however, allows us to focus on the surface in order to assess the hazard from such events. In the present study, we present a low-(computational)-cost approach to identify areas at risk of pluvial flooding. Common GIS operations are used to detect flood-prone depressions from a high-resolution 1m x 1m DEM, identify contributing watersheds, and represent runoff concentration by a fill-spill-merge approach. The approach is applied to a study area in Berlin, which has been repeatedly subject to pluvial flooding in the past years.

Recursive artificial neural network approach for dynamic hot-spot nowcast of pluvial floods

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Pluvial flooding in urban watersheds is one hazard with increased occurrence in the future, due to climate change. Induced by short term heavy rain events, the lead time for an urban flood is very short. Fast physically based models are still too slow for the usage in real-time forecasting. Data driven models were often used in the literature to overcome this problem. These models usually have simplifications and limitations. Some models do have a fine spatial resolution but no time distributed forecast. Others do have forecasts with time distribution for single points in an urban catchment.

In the present study we tested an artificial neural network based approach for time distributed nowcast of water levels for an area of interest. Water levels are predicted with a 5 minutes time resolution. The area of interest is a street corner with an area of several hundred square meters. The training data base for the neural network training was generated with a physically based hydrodynamic 2D model. The tested rain events are natural events collected from gauge data in region of the test area. We are able to show first promising results. We also want to propose a way to include uncertainty of rain forecasts in our model.

Pollution transport forecast during pluvial flood events

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High water levels in urban areas due to strong rainfall events and flooding of streets and places lead to an increased potential of the emission of pollutants in single spill events. These pollutants can be washed into the drainage water and spread widely in pipe systems and on surfaces. To take actions against spreading substances, a fast forecast of the transport path is needed. Within the EVUS project (https://www.pluvialfloods.uni-hannover.de) a model for real-time prediction of pluvial floods and induced water contamination was developed to nowcast water levels and contamination within a few minutes.

In this framework a particle based transport model is set up to keep track of solute pollution. Advective transport and mixing are considered as well as exchange fluxes between the surface and the pipe network. The transport model can be used for one, two and three dimensional domains. It is designed to serve the demand of low numerical dispersion during the simulation run whilst producing results for real-time forecasts. Pollutions are treated as non-reactive and completely dissolved in the drainage water in order to achieve fast computation times. The goal is to forecast transportation paths and transportation times. Based on a two hour lead-time precipitation forecast an ensemble of similar rain events is chosen from a database of pre-calculated hydrodynamic simulation results. The ensemble contains dynamic velocity fields in pipes and on streets as well as surface inundation with a temporal resolution of 5 minutes.

This presentation will give an overview about the outcomes of the research project with focus on contamination transport prediction and an overview of the workflow of the forecast process. The model is applied to a rain induced flood in an urban district of 5km².

The transport model works with pre-calculated flow field results from SWMM (only pipe domain) and HYSTEM EXTRAN 2D (pipe and surface). The model is available under MIT license for download at https://github.com/rsaemann/GULLI.

A GPU-accelerated particle-tracking model for full-process modelling of nonpoint source pollutants in urban areas

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Nonpoint source (NPS) pollutants play a critical role in urban surface pollution, and different approaches have been proposed and implemented to address this issue, such as sustainable drainage systems (SuDS). Modelling provides an indispensable tool and essential information to inform the development of NPS pollution mitigation approaches. However, current modelling approaches are empirically based and neglect the details of the underlying wash-off and transport processes of NPS pollutants across the urban surfaces and thus unable to provide enough information to support engineering designs. A few attempts have been made to develop physically based models to predict the wash-off process of NPS pollutants. But these models are developed in a grid-based Eulerian framework and unable to depict the sources and transport pathways of pollutants. To overcome the limitations of the current models and provide detailed information to inform the design and implementation of SUDS or other mitigation measures, this work presents a novel coupled hydrodynamic and Lagrangian particle-tracking numerical scheme to simulate the full process (i.e. wash-off and transport) of NPS particulate pollutants driven by rainfall-runoff and overland flows. A particle-based approach is adopted to represent physically the detachment and deposition of particulate pollutants. The transport of pollutants is simulated by a random walk particle-tracking model that directly predicts the trajectories of particles and hence traces out the detailed pathways of pollutants. However, particle-tracking scheme is computationally very demanding, and models considered in this work have no exception. It limits the model's applications in real project. The Graphic Processing Units (GPUs) are explored to accelerate the coupled hydrodynamic particle-tracking model for wider applications. GPUs are highly parallelized, which makes it suitable for accelerating scientific computing algorithms like particle tracking.

The new accelerated coupled NPS pollutant model is validated against an experimental test to demonstrate its capability in accurately simulating the wash-off and transport processes of NPS particulate pollutants in urban areas.

Investigating the suitability of the Green-Ampt model with tabulated parameter values from literature by using a 2D hydrodynamic rainfall-runoff model and field experiments with a rainfall simulator

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The Green-Ampt model is one of the most commonly used approaches to consider infiltration in rainfall-runoff models, which can be either conceptual catchment models as well as 2D hydrodynamic models. The so-called Green-Ampt parameters and the initial water content are needed as model input. Often, the Green-Ampt parameters are not directly measured in the field but are determined by calibration if observed runoff data is available. However, in some cases, a calibration of the Green-Ampt parameters is not possible due to a lack of measurements, and the parameters can only be assumed based on tabulated average values from the literature depending on the dominant soil texture class. This study aims to use a coupled shallow water flow and infiltration model to investigate if the Green-Ampt parameters could be appropriately assumed based on these tabulated values. To investigate the general suitability of using the tabulated values, different small-scale test cases with available data for calibration are shown, where two of them are laboratory experiments and one is a field experiment on a small plot in Senegal. Finally, a case study on flash floods in a desert region in Egypt is represented. The results show that in the laboratory experiments, the infiltration rates with average Green-Ampt parameters are underestimated, while for the field experiment in Senegal infiltration rates are overestimated. For the study case in Egypt, infiltration with Green-Ampt parameters from literature as well as with measured infiltration rates from double-ring infiltrometer tests is strongly overestimated in the model. It is planned to conduct plot-scale rainfall-runoff experiments with a rainfall simulator to better represent the natural conditions during heavy rainfall. Furthermore, the microtopography should be recorded by several digital photographs to create a high-resolution digital elevation model by using photogrammetry. With the gathered data, the field experiments can be simulated by the coupled shallow water and infiltration model to better estimate the Green-Ampt parameters for the study area. Effects, that could lead to an inappropriate representation of infiltration with tabulated Green-Ampt parameters can be studied, such as surface clogging, sub-grid rill-flow, and coarse resolution of the digital elevation model (DEM).

Analysis of feasibility and acceptability of rainwater usage to areas of acute water scarcity in Rajshahi metropolitan city, Bangladesh

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Rainwater harvesting for saving drinking water has acquired tremendous significance as modern sanitary water-saving technique. This study investigated the viability and acceptability of harvested rainwater, using easy and low-cost technology, in rural communities in Bangladesh as well as Metropolitan City like Rajshahi. A field-based questionnaire survey was conducted on two water scarce slum areas in Rajshahi city. The survey was conducted for randomly selected 197 participants to avail some details such as the socio-economic status for those slum dwellers and family details, housing situation, sanitation status, health condition, economic condition, current water supply condition, awareness about rainwater, willingness to accept rainwater, etc. Yield after spillage (YAS) and yield before spillage (YBS) models were established to know the real availability and storage conditions of rainwater that were used to explain the effective size of the tank. Survey findings and models' output was used to conduct cost-benefit analysis and feasibility analysis. In addition, a sensitivity analysis was carried out to test the appropriate parameters against the device implementation. The results showed that cost was the most sensitive parameter (54.3 percent), roof area (28.4 percent) was the second highest sensitive parameter, and demand was the lowest sensitive parameter (1.8 percent). The study successfully analyzed a tentative low-cost rainwater harvesting technique was feasible and acceptable as the only possible alternative source of safe drinking water for slum dwellers.

Interfaces in urban freshwater ecosystems

Keynote 4

Interfaces in urban freshwater systems: Examples from long-term research in Baltimore

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Freshwater ecosystems that drain urban landscapes have a unique suite of stressors. Urban freshwater systems are fundamentally altered relative to those that drain less developed catchments. As a consequence of draining urban landscapes, urban freshwater system interface with unique settings which can alter the hydrology, chemistry and biology of these freshwater ecosystems. In this talk, I will highlight the major drivers of change of urban freshwater ecosystems, focusing on alterations at the interface with riparian, sewage, and drinking water systems. Drawing on examples from the long-term research by Baltimore Long-term Ecological Research Study and elsewhere, this talk will shed light on the how the interfaces in urban freshwater systems manifest in ecosystem health, how restoration and installed infrastructure can influences these dynamics, and ultimately how these resilience of these systems may be constrained by dynamics at the interface of urban freshwater systems.

Session 1d

Effects of benthic organisms on the fate of trace organic compounds during bank filtration

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Trace organic compounds (TrOCs) such as personal care products and highly prescribed pharmaceuticals can reach surface waters via treated sewage effluents and occur in streams in the ng/l to µg/l range. TrOCs are of particular concern in water bodies used for bank filtration because they are only partly attenuated on their flow path through littoral and aquifer sediments to drinking water abstraction wells. Bank filtration is increasingly applied to meet water demands in urban areas such as Berlin where approximately 60% of the drinking water are supplied by bank filtration. As a consequence, some of Berlin's surface waters are part of a semi-closed water cycle in which water is being abstracted via bank filtration from water bodies receiving treated wastewater.

Research on the fate of TrOCs during bank filtration usually focuses on the influence of abiotic parameters. We hypothesize that benthic organisms such as mussels and macrophytes can significantly affect redox conditions at the sediment-water interface and thus can also influence the attenuation of TrOCs.

In our study, we focus on two invasive benthic organisms that have strongly increased their abundance in temperate freshwater ecosystems in Europe during recent decades: the quagga mussel (*Dreissena rostriformis bugensis*) and Nuttall's waterweed (*Elodea nuttallii*). In an extensive column experiment simulating bank filtration of water containing TrOCs we test the influence of quagga mussels and Nuttall's waterweed on the fate of pharmaceuticals (carbamazepine, gabapentin, metoprolol, oxipurinol, valsartan), an artificial sweetner (acesulfame) and X-ray contrast media (diatrizoate, iopamidol, iopromide, 2,4,6-triiodobenzoic acid). Planar oxygen optodes and oxygen microsensors are used to measure oxygen at the sediment-water interface with a high resolution. In addition nitrate, sulfate, manganese and iron concentrations are monitored to characterize redox conditions because it is well-known that attenuation of many TrOCs is much higher under oxic to suboxic conditions than under anoxic conditions.

Urban greenhouse-gas dynamics: high frequency measurement of CO_2 and CH_4 in Berlin's surface waters

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Urban environments provide physico-chemical conditions that promote high microbial CO2 and CH4 production rates in freshwaters. When released from freshwaters, these gases impact regional and global climate as so-called greenhouse gases (GHG). Global urbanisation subjects an increasing number of freshwater bodies to these conditions, potentially affecting the global CH4 and CO2 budgets. Despite this, few studies have investigated urban freshwater GHG emissions in detail, although a first assessment has been presented for Berlin's freshwater system. However, the data resolution from this and a small number of other investigations has been constrained by the measurement techniques available and the challenges involved in sampling urban areas, making GHG budget estimations imprecise. To narrow this gap, the present study develops and pilots an open-source and inexpensive sampling chamber, capable of measuring CO2 and CH4 fluxes at a temporal resolution not possible with traditional closed-chamber methods. A key feature is the versatile operation of automatically ventilating chambers with either low-cost CO2 and CH4 sensors or Cavity-Ring-Down-Spectroscopy (CRDS). The technique enables high-frequency GHG flux measurements in urban environments, where frequently lost sampling equipment must be replaceable and low investment, whilst remaining mobile and inconspicuous. Seasonal sampling at 5 lakes and 5 ponds across the city of Berlin, Germany, involved GHG flux measurements for 15 minutes at a rate of twice per hour using stand-alone automatic chambers. These measurements were accompanied by traditional CRDS measurements and water sampling for physico-chemical analyses at monthly intervals. Results from one summer season, so far, demonstrate the robustness and effectiveness of the chambers operating at water surfaces. GHG dynamics are not spatially homogenous within urban lakes but are habitat specific, and the inclusion of fluxes from the littoral zone can have a notable influence on whole-lake GHG budgets. Furthermore, GHG fluxes in urban freshwaters are temporally variable within days, over the diel cycle, among days, and, to some extent, depending on environmental drivers. The increased resolution of the data will facilitate more accurate and more constrained budget calculations for the city of Berlin, and could ultimately contribute towards the establishment of an effective climate mitigation policy.

Sulfur prevented the continuous effect of an iron amendment on sedimentary phosphorus retention: a case study at Lake Plötzensee in Berlin

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The internal phosphorus (P) precipitation by iron hydroxide and nitrate in Lake Plötzensee was part of a set of management measures around the year 2000. Thereafter, the eutrophic status improved by means of lower total P concentrations during spring, higher Secchi depths and less (but still high) oxygen depletion. 20 years later, we investigated whether the iron (Fe) amendment had a continuous effect on the P retention in the sediment and led to the formation of redox stable Fe bound P.

By a µXRF line scan, we identified an Fe-rich layer in 10 cm depth below the present sediment-water-interface as today's position of the Fe surplus. In this layer and in reference layers below and above, we analyzed P binding forms by sequential extraction and the total P content. We found that the Fe-rich layer did not contain a higher total P content in comparison to the reference layers. In addition, the P-fractions indicating redox sensitive Fe bound P and redox stable Fe bound P were small. By XRD, no crystalline Fe-P minerals, e.g. vivianite, were identified.

In contrast, we found an enrichment of sulfur, S, in the Fe-rich layer and proved by XRD that the extra S was bound by iron as pyrite, FeS2. By comparing the molar S/Fe ratios one year (0.1) and 20 years (1.8) after the Fe application, we conclude that S did not precipitate with Fe immediately but S was bound to Fe later on. According to the lake's mean sulfate reduction rate of 200 mg/(m2· d), the Fe surplus was potentially consumed by pyrite formation within 9 years.

We conclude that S reacted preferentially with the Fe surplus in the sediment and prevented an ongoing effect of the Fe amendment on P fixation. In order to achieve a long-term effect of an Fe treatment, the dose calculation must take into account not only the amount of P to be fixed but also the expected sulfate reduction over a long period.

Sedimentary signatures reveal transition between mining and urban impacts along river Spree (NE Germany)

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Waters and sediments in riverine systems of urban areas are threatened by different contamination sources such as road deposits, impact of treated waste water and nutrient and pesticide loads from upstream agricultural areas. As a result of the open-cast lignite mining in Lusatia (Eastern Germany), additionally, large quantities of iron and sulphate are fed into small streams discharging into the Spree river system, which finally flows through the urban area of Berlin. The high sulphate concentrations challenge the compliance of the Drinking Water Ordinance in Berlin by withdrawing bank filtrate at Lake Müggelsee.

We aim to identify urban and mining impacts as sedimentary signatures by analyzing the sediments in the river-lake-system Spree from Spreewald (Brandenburg) down to its outlet into river Havel, including a reference site in Bautzen. Therefore, we sampled surface sediments (upper 0-3 and 3-6 cm) of the river and interconnected lakes using a gravity corer at 20 sites. The sediments were analyzed for total C, N using an elemental analyzer, and various elements (incl. Fe, S, Mn, Al, P, heavy metals) by ICP-OES after digestion with hot aqua regia. Characteristic sediment signatures were examined by a Principal component analysis (PCA).

We revealed strong positive correlations between the elements Fe, Ni (and Co) as well as between Zn, Cu, Pb (and Cr) in the sediments. The latter are characteristically increased in sediments of urban areas, thus also in the area of Berlin and Fürstenwalde. The former are characteristic for the impact of lignite mining and are elevated close to the mining area. Mining-impacted sediments are visible between Spreewald and at least Hangelsberg, only 30 km prior to Lake Müggelsee. With increasing distance from mining, Fe, Ni, and Co are decreasing towards Berlin together with an increasing sedimentary molar S:Fe ratio and varying iron mineral forms. The changing sedimentary characteristics in river Spree probably also have an impact on the availability of P and the carbon turnover.

Session 1e

Runoff from urban and rural land-use has different impact on stream quality: a GIS-study

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Runoff from point sources and diffuse sources affect stream quality in various ways. Examples of sources are drainage water from agriculture, stormwater from separate sewer catchments and overflows containing wastewater from common sewer systems. Effects can be due to the hydraulic load and/or substances contained in the water (nutrients, organic matter, xenobiotics etc.) leading to e.g. erosion, withdrawal of animals and plants, oxygen depletion and eutrophication in receiving waters.

To evaluate environmental effects depending on land use, a detailed and comprehensive GIS study was carried out. The studied area covers 937 km^2 in the south western part of Denmark. The included data was land use, outlet types, typography and stream quality (physical, chemical and biological). It includes e.g. invertebrate data from 468 stream stations and data 319 from point sources (stormwater).

The comprehensive GIS study, did not surprisingly, revealed a positive impact on stream quality both biological (measured as the Danish Water Fauna Index - DVFI) and physical (measured as the Danish physical Index - DFI), when the catchments contained nature areas, whereas agricultural areas influenced negatively.

Stormwater had both positive and negative effects on stream quality depending on sewer type and eventual treatment before discharge to the recipient, even though stormwater discharges often represent a minor part of the catchment area. Streams located in catchments containing urban areas with separate sewer systems generally had better ecological quality compared to streams located in urban catchments with common sewer systems.

The study can very importantly conclude that any specific stream must have a catchment area with a minimum of 20-30% without agriculture or urban areas to obtain good ecological status; when focusing only on the riparian zone (10 m on each side of the stream), a minimum of 40-55% is needed to create a good ecological status. Therefore, management focus on the entire catchment is very important.

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The water challenges and proposed solutions for Ash Shakhlouba, the Egyptian Venice and El Burullus, the polluted lake

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Ash Shakhlouba is a village located in Kafr Al-Sheikh governorate in Egypt surrounded by water. It is inhabited by a community of fishermen who are low income inhabitants and is located on the Southern Coast of El Burullus Lake in the Delta. El Burullus lake is identified as one of the five Mediterranean coastal lakes in Egypt. It extends along the northern parts of the Egyptian Nile Delta and is the second northern lake in size (El-Zeiny and El-Kafrawy 2017, p1). In addition, it is considered as one of the most polluted lakes along the Delta's coastline (El-Zeiny and El-Kafrawy 2017, p1) because of the directly disposed pollutants in the water from the urban landscape residents of the village and the industries and agriculture land in Kafr El Sheikh. Due to the lack of proper waste management on the macro and micro scales, the agricultural, industrial and domestic solid waste and sewage have caused a decrease in the freshwater supply and fish in addition to the increase of health risks, further deteriorating the quality of life of the village residents. The resulting visual and odour pollution has also hindered the village's touristic potential, impacting its economic development. This paper studies the current situation of Ash Shakhlouba village and the lake's pollution as a result of urban activities. Existing academic proposals and funded projects addressing the water pollution of the lake on the macro level were studied. Accordingly, an integrated water management process on the micro level of Ash Shakhlouba Village was proposed to engage the relevant stakeholders; NGOs, the inhabitants and the government through participation, awareness and actions that include sewage treatment and waste management. This research was done as part of the water management module within the urban development master program in TU Berlin campus El Gouna. It is important to note that this paper is a continuation of a previous research and proposal done by the authors to propose a solid waste management for Ash Shakhlouba.

Modeling cyanobacteria at Lake Müggelsee

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The concerns on cyanobacteria blooms rise globally. The increased eutrophication, rising CO2 concentrations, and global warming are factors that enhance these blooms. The consequence of a rising cyanobacteria population has a tremendous effect on biodiversity, food webs, and water use. To work on current problematic situations and to prepare for the anticipated expansion of cyanobacteria, further research into mechanisms that determine toxin production, species composition, and species interaction is needed. To address these issues, we will use a newly developed mechanistic big-data model. "Mechanistic Microbial Ecosystem Model Inference" (short MMEMI) is the first model that uses a purely mechanistic approach for long-term data analysis. A unique feature of MMEMI is, that it can integrate a huge amount of data and still deliver reasonable and understandable outputs. The model software is applied for the case study lake Müggelsee. Lake Müggelsee is a eutrophic polymictic lake that experienced fundamental ecological changes during the last decades. Long and continuous time series of species and nutrients provide a solid foundation for MMEMI to investigate interaction and behavior patterns in lake Müggelsee. Current focus is the phytoplankton-zooplankton interaction. In the future this model can be a tool to give new insights and contribute to solutions controlling cyanobacteria blooms.

Simulation of the effects of common reed riparian plants on the real scale water flow velocity fields of a vegetated reclamation channel

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Leaf Area Index (LAI) of vegetation distributed along bottom and banks of vegetated river is a key parameter for calculating the hydraulic resistance and cross sectional velocity fields of vegetated channels, as well demonstrated by many experimental and modeling studies. We simulated a vegetated reclamation channel located in colonized by a community of senescent Common reed plants, by employing the Riparian Vegetation Simulation Module (RVSM) in the freeware HEC-RAS software.

The RVSM simulated the phenological development of riverine vegetation inside the vegetated reclamation channel located in a drainage network located a lowland belonging to the Migliarino-San Rossore-Massaciuccoli Regional Natural Park, located in northern Tuscany (Italy). More in detail, the software module has been employed in order to estimate the change in vegetative hydraulic resistance coefficients over time under unsteady water flow simulations. The riparian zone has been modeled by discretizing it into a specific vegetation computation mesh.

The LAI of the Common reed plants have been retrieved during an experimental field campaign carried out in November 2018. The results of the RVSM simulations have been compared with the experimental outcomes in terms of water flow velocity cross sectional distributions and Manning's hydraulic roughness coefficients. The water flow velocity measurements have been carried out by employing an acoustic Doppler velocimeter (ADV). The evidences of the comparative analysis between experimental and simulated parameters are discussed by taking into account the different predictive models implemented in RVSM for evaluating their capability in predicting the real-scale effects of the hydrodynamic interaction between water flow and riparian vegetation in vegetated water bodies.

A review of recent applications of neurocomputing methods in urban hydraulics and hydrology

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Neurocomputing methods represent nowadays an attractive alternative to physically based hydro-numerical models, mainly due, on the one hand, to their cheaper computational costs and high performance, and, on the other hand, to their lower requirement of physical and topographical data. Besides, in comparison with the traditional statistical models, stochastic methods, and empirical formulations, such techniques have a larger potential in providing accurate and reliable predictions (Zounemat-Kermani et al., 2020), fostered by the growing availability of sensor data and current straightforward open-source technology available. In our contribution, we will present some recent hydrological and hydraulic applications of neurocomputing methods, with a particular focus on applications in urban contexts. In detail, we will review some recent works dealing with the prediction of water level and rainfall-runoff, flood and risk assessment, sediment transport, odours in sewage systems, and water demands in the urban surface waters. In fact, most neurocomputing applications in urban water environment available in the literature deal with modelling and/or prediction of rainfall-runoff, streamflow, and flood risk assessments (e.g., Mosavi et al., 2018; Kim and Han, 2020). For instance, identifying the risk of extreme rain events in real-time plays an enormous role in hydraulic engineering and water management, especially in the urban environment. Furthermore, the prediction of surface water levels in urban waterways supports the logistics of navigation and monitors climate change effects. Also, the prediction of sediment transport is of great importance to avoid high amounts of deposition/erosion, obstructions in the canals and for water quality control. Finally, recent works deal with challenges related to the prediction of odours and corrosion in urban sewage systems, as well as of water demands, to inform the design and optimal management of water distribution systems through the deployment of smart meter technologies (e.g., Cominola et al., 2015). As an outlook for future research, further testing of neurocomputing methods with optimization approaches (e.g., Salomons et al., 2007) is needed to assess their usability in integrated models and account for the effect of their uncertainties.

Keywords: neurocomputing methods, big data, urban waters, applications, review

Does urbanization increase or decrease carbon dioxide emissions from lakes?

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Some recent studies have argued that urbanization and anthropogenic disturbances in general can increase carbon dioxide (CO2) emissions from local lakes by increasing the loading of organic carbon, whereas other studies have argued that increased concurrent nutrient loads are instead leading to net declines in lake CO2 emissions. Understanding the net effects of anthropogenic disturbances on watershed carbon cycling is necessary for future climate-conscious planning. I will present CO2 flux data from a heavily impaired lake in the western USA (Utah Lake, UT), and discuss the broader (and often overlooked) considerations linking watershed anthropogenic activities and aquatic greenhouse gas emissions, including groundwater fluctuations, desiccation, and methodological considerations.

Interfaces in urban hyporheic zones

Keynote 2

The role of riverine hydromorphological and water quality quantities to predict hyporheic processes from reach to global scales

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Riverine corridors have water flowing as surface water above streambeds and as hyporheic water below and besides streambeds through the interstitial pores of granular sediments or fracture rocks. Hyporheic flows stem from several mechanisms that drive stream water in and out of the sediments. This exchange forms a band of sediment mainly saturated with surface water, whose biochemical signature changes through the sediment due to hyporheic residence times (how long the surface water stays in the sediment) and the biogeochemical environment encountered by the water laden reactive solutes. Consequently, hyporheic exchange may impact both surface and subsurface water quality. Here, we summarize the main hydromorphological mechanisms that drive hyporheic exchange and we applied hyporheic models based on these hydromorphological mechanisms to show the impact of hyporheic exchange on nitrous oxide (N2O), a 300 times more potent greenhouse gas, emissions from riverine environments in natural, urban, and agricultural streams. We then upscale this information to predict N2O emissions at the global scale. The world view of N2O riverine emissions helps us understand and quantify the important role played by the hyporheic zone within riverine corridors.

Session 2a

The effect of stream flow dynamics on microbial metabolism and carbon dioxide production in a moving sandy streambed

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Streams cover only a small area of earth's surface but play a significant role in global biogeochemical cycles. Streambeds are known biological hotspots and serve as bioreactors for the transformation and removal of nutrients, organic matter, and pollutants. Streams are subject to natural and anthropogenic discharge fluctuations caused by natural precipitation events and man-made infrastructure, such as wastewater treatment plants (WWTPs) and hydro power plants (HPPs). These fluctuations influence water fluxes, sediment movement, and microbial activity. Despite the fact that the interactions between stream flow and bed migration are well known, most studies that focus on microbial activity and biogeochemical processes ignore the fact that soft sediments are almost constantly in motion.

The influence of three different discharge regimes on microbial metabolism, CO2 production, and bedform movement was investigated within a recirculating indoor flume. These discharge regimes are: 1) constant discharge (e.g., downstream of HPPs and irrigation abstraction), 2) sinusoidal discharge (e.g., downstream of HPPs and WWTPs), and 3) natural flood discharge (e.g., free flowing rivers). The microbial response to flow regimes was determined using measurements in the water column and streambed. Oxygen-, CO2-, and pH- sensitive planar optodes were used to measure their distributions in the hyporheic zone. Sensors for oxygen, CO2, pH, and turbidity logged continuously within the water column, and a floating CO2 flux chamber was used to measure CO2 emission from the water column to the atmosphere. Streambed morphodynamics were observed using high-frequency timelapse photography and a surface elevation sensor.

Preliminary results show that dynamic flow regimes cause a net increase in microbial activity based on oxygen consumption and CO2 production rates compared to constant flow regimes. Moreover, natural flood regimes cause a sudden release of CO2 from the streambed as high discharge causes high turnover of the sediment. Because the bed movement and hyporheic exchange respond to flow dynamics in a nonlinear way, further analysis is now being conducted to understand how flow regimes affect biogeochemical processes. This understanding is expected to improve existing models for analyzing nutrient transport under unsteady flow conditions and to inform us on how human-controlled flow in streams influences water quality.

Transformation products of iodinated X-ray contrast media: formation and behaviour concerning sorption and biodegradability

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Triiodinated X-ray contrast media (ICM) are found at much higher concentration than any other pharmaceutical compound in wastewater, surface water and bank filtrate (Putschew et al., 2000). Several studies have shown that ICM are persistent to deiodination in aerobic environments, but side chain transformations lead to various metabolites (Schulz et al., 2008). Field data from bank filtration transects indicate at least a partial deiodination in reducing soil-water environments with unknown mechanism (Grünheid et al., 2005). As a possible mechanism a corrinoid-mediated deiodination is proposed with i) a reaction rate depending on the number of bound iodine atoms and ii) a strong influence by the water matrix. The combination of both factors could be the reason for the incomplete deiodination during bank filtration (El-Athman et al., 2019). The behaviour of the (partly) deiodinated transformation products (TP) remaining during the bank filtration process and the subsequent drinking water treatment is not investigated yet. Thus, we will present results examining the behaviour of partly and complete deiodinated organic compounds regarding i) the sorption onto different materials (soil, filter sand and activated carbon) and ii) the biodegradability. Most of the experiments were batch tests, but also column tests have been carried out. The applied partly and completely deiodinated TP were produced by the abiotic corrinoid-mediated reaction which is stopped at different times to produce compounds with varying numbers of bound iodine atoms. The main analytical tools were LC-MS and LC-MS/MS.

The results show that the number of bound iodine atoms influences the sorption and the biodegradability. In general, the sorption is significantly enhanced if all iodine atoms are cleaved off. In case of soils, the sorption depends also on the soil composition (organic content, clay minerals) which can interfere with the impact of the number of the bound iodine atoms. The biodegradability depends on that, too and furthermore even the transformation pathways of the ICM. The results are very important for the prediction of the ICM fate in the aquatic environment and for managed ground water recharge.

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Attenuation of dissolved organic matter and trace organic compounds in the hyporheic zone of an urban river

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Urban rivers are characterized by strong anthropogenic influences on their flow regime, chemistry and biology. For example, the discharge of wastewater treatment plants leads to an increased input of dissolved organic matter (DOM) as well as high concentrations of trace organic compounds (TrOCs) in the river. The main attenuation processes for DOM and TrOCs are microbial and mostly take place in the hyporheic zone, i.e. the streambed. As DOM can serve as a co-substrate in microbial metabolism of TrOCs, the attenuation of TrOCs is influenced by DOM. The River Erpe, a sandy lowland river in the East of Berlin, Germany, receives treated wastewater from the wastewater treatment plant Muenchehofe. A sampling campaign was conducted at a side channel of the main river to investigate the simultaneous attenuation of DOM and TrOCs in the hyporheic zone and the surface water. Samples were taken at site A (surface water) and 850 m downstream at site B (surface and hyporheic pore water in 25 cm depth) every three hours over a 48 hours period. Sample analysis included 17 TrOCs (HPLC-MS/MS) and DOM composition (FT-ICR-MS). DOM data was processed semi-quantitatively by calculating the percentage share of each compound class of the total DOM composition. Changes in DOM compound classes between all sites did not exceed single digit percentages but were higher in the hyporheic zone. Mean TrOC concentrations ranged between an increase of 200 % to a decrease of 29 % in the surface water and between a decrease of 5 to 93 % in the hyporheic zone. Significant correlation with the concentration of at least ten TrOCs was found for condensed hydrocarbons and proteins in the surface water and for condensed hydrocarbons, lignin, tannins, carbohydrates and proteins in the hyporheic zone. While compound classes with high bioavailability were positively correlated to TrOC concentrations, compound classes with a limited bioavailability showed negative correlations. The present study shows that the hyporheic zone is more efficient in the attenuation of DOM and TrOC. Furthermore, the attenuation of DOM and TrOCs was found to be partly simultaneous, especially in the hyporheic zone.

Effect of different redox conditions on sediment microbial communities from a lotic hyporheic zone

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Redox gradients, which are found in both natural and technical water systems such as rivers, lakes and water treatment plants, have been shown to impact water quality, corrosion and microbial ecology. Hyporheic zones, which are a saturated transition zone between groundwater and surface water bodies, contain steep redox gradients and a dynamic biogeochemical environment. Hyporheic passage often results in the conversion of nutrients and attenuation of pollutants, which is why the hyporheic zone is known for its impressive purification capacity. This extraordinary environment hosts highly specialized organisms that support specific ecosystem functions and services. However, there are still gaps regarding the role of biodiversity of microbial communities and their influence on ecosystem functioning in hyporheic processes.

Our aim is to assess the effect of different redox conditions on microbial communities of hyporheic zone sediments of rivers.

For this study, we devised a bioreactor setup consisting of sediment columns extracted from the hyporheic zone of the river Erpe in Berlin. The columns were continuously fed with synthetic freshwater to simulate redox gradients in the river sediment, under controlled conditions. To characterize the degradation potential of the microbial communities, transformation of iodinated X- ray contrast media (iopromide) was analysed in the bioreactors. In parallel, batch experiments containing this sediment with defined aerobic and anaerobic conditions are being performed.

Our results showed that, almost all near-river concentration levels of iopromide were transformed within 27 cm of sediment with 5 mM of sodium acetate as supplemented organic carbon source. Within a month, 90 % of iopromide was transformed within 9 cm of sediment depth under the same conditions. Iopromide transformation was reduced to 37 % after terminating the addition of acetate.

It has been observed that iopromide was biologically transformed in the hyporheic zone and that its transformation was related to the presence of co-substrate sodium acetate. The results suggest that this transformation was a co-metabolic process. Complete deiodination of iopromide's tri-iodinated phenyl ring was detected under anaerobic conditions.

Determining hyporheic removal rates using non-parametric conservative transport with multiple sorption models

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Understanding the transport and reactive behaviour of solutes in freshwater streams is crucial in managing water resources sustainably. Particularly the hyporheic zone, an interface where surface water and groundwater mix in the streambed sediment, may possess significant pollutant removal capacities due to its myriad physical, chemical, and biological conditions. However, modelling approaches aiming at assessing the hyporheic zone's reactivity are either based on inappropriate assumptions, such as 1D transport, along with using only an average hyporheic residence time for removal rate predictions, or are computationally not feasible due to a too detailed system characterisation. Therefore, a novel modelling approach was developed for determining removal rates of pollutants in the hyporheic zone that considers the full range of hyporheic residence times and allows for parent and daughter reactions to be considered. The proposed model is based on the transfer function theory, namely the deconvolution method. In particular, mathematically deconvolving the input and output concentration time series of a conservative solute yields a non- parametric function that appropriately describes all physical processes occurring in the investigated system. Thus, the model approach captures the conservative transport without assuming a fixed model. This so-called transfer function can be modified so that it includes specific reactive processes. This modified transfer function can directly be used in a numerical model framework that takes the concentration time series of a reactive solute, for instance, a pollutant as calibration target. In that, only the reactive parameters need to be estimated. Having less parameters not only speeds up simulation time but also increases parameter identifiability. The proposed transfer function approach is demonstrated by deconvolving electrical conductivity time series as conservative solute and a suite of pharmaceuticals as calibration targets using two commonly used sorption models: one including retardation and one accounting for first order sorption kinetics. The proposed transfer function approach performed remarkably well for both sorption models considered and revealed significant variations for the hyporheic removal rate estimates. This result underlines the need for considering multiple sorption models when determining pollutant removal rates in the hyporheic zone.

Integral modelling approach for tracer transport in the hyporheic zone under neutral, losing and gaining streamflow conditions

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The exchange of water and solutes between surface and subsurface is important for hydrological, biogeochemical, and ecological processes. Driven by dune-shaped bedforms, flow and transport processes in the hyporheic zone were simulated with a novel integral modeling approach. The solver uses an extended version of the three-dimensional Navier-Stokes equations in combination with an implemented advection-diffusion equation for groundwater and surface water. The simulated spreading of a conservative dye tracer from the surface water into the pore water was compared to experimental results. Neutral, gaining and losing conditions were considered. The simulations agree well with the experimental observations and confirm the reliability of the novel integral approach. Next to the investigation of the transport processes, the simulations offer high resolution results of velocity distributions. Velocity and pressure distributions at the groundwater-surface water interface are significantly affected by groundwater flow (gaining, losing, neutral conditions). Under losing conditions the highest velocities in the sediment were found and consequently shorter residence times are expected compared to neutral and gaining conditions. The largest hyporheic exchange flow cells were observed under neutral conditions.

Integral modeling of flow in and around a ventilated U- shaped chironomid burrow

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Chironomids often dominate benthic communities in freshwater ecosystems with their high population density which strongly enhance sediment water exchange and impact biogeochemical processes at sediment-water interfaces. Tube-dwelling of invertebrate communities such as chironomid larvae can affect lake and river ecosystems in a variety of ways, including nutrient exchange across the sediment- water interface. Understanding of such processes is achieved by tracking the flow initiated by pumping activity of chironomid worms through and around burrows.

Unlike current numerical simulation efforts to model chironomid larvae pumping activity in U-shaped burrows which use coupled models of pipe and groundwater flow, we present a novel high-resolution integral formulation for the sediment-water domain which solves an extended version of the Navier- Stokes equations. The solver allows us to simultaneously simulate flow in both the burrow and the surrounding sediment with the same conceptual approach to get a deeper understanding of the processes at the interface burrow wall. Due to intense exchange processes between sediment and U-shaped burrows, such a step is required to simultaneously model flow through both sediment and burrow.

For simulations we applied the computational fluid dynamics model OpenFOAM. We used a similar model setup as the one from Brand et al. (2013) where a 3D U-shaped burrow is confined in a relatively large column of sediment. We performed similar scenarios of flow through burrow and sediment triggered by pumping in the center of the burrow according to Brand et al. (2013). For further validation of our approach, we compared the flow patterns resulted from our model with experiment results of Roskosch et al. (2010) and Morad et al. (2010) focusing on the flow of the inlet and outlet of the U-shaped burrow to the overlying water column as well as accumulation of flow in circular burrow. Overall, our results show a good agreement with the experiments mentioned and point out novelties (e.g. redistribution of the pressure) of our approach when compared to existing ones.

Interfaces in sewer systems

Keynote 5

The smell of sewage

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The common (wo)man does not love her sewer, neither does he hate it. He or she simply wants to ignore it. A sewer shall do its work of getting rid of annoying wastes without making a fuzz of itself. When this expectation is not met, both he and she get annoyed. They start making a fuss when the city stinks of sewage. They also make a fuss when sewers affect other aspects of life, like creating urban flooding or impacting surface water quality. The sensitivity to and acceptance of sewer nuisances is not an absolute but depends on where you are and who you are. Occasional issues in an industrial area might be acceptable, while even a small whiff or sight of sewage is a problem if you are sitting at a street café enjoying your café late, or taking a stroll in the park. Over the last decades, people have become increasingly less accepting of such annoyances. At the same time, sewer systems are getting larger and more complex, increasing especially the issues with respect to odor nuisances. Today's sewers often give of more off a stink than they did decades ago, intensifying the crash between sewers and the urban population. This presentation discusses these aspects and presents new catchment-scale approaches to assess and manage odor issues from sewers.

Session 2c

The ide3a project: a gamified digital approach to integrated modelling of urban critical infrastructure systems

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The world's urban population is expected to rise to over 9 billion by 2100. This growth, combined with urbanization, increasingly frequent extreme weather events, and ageing infrastructure, is going to exacerbate the stress on existing critical infrastructure assets, including water networks, energy grids, IT systems, and, in general, interconnected urban systems. The necessary transformation of the above systems along sustainability and climate change targets is increasing this stress significantly further. While IoT sensors and digitalization are opening up new opportunities for inter-sectoral communication and multi-scale modelling, data are often siloed and traditional tools for simulation and forecast modeling are usually developed within the boundaries of individual application sectors.

However, modelling the existing interconnections between water networks and other critical urban infrastructure systems would allow a more informed management and mitigation of cascading effects caused by extreme events (e.g., floods), along with supporting planning strategies for enhanced urban resilience.

In this work, we present the ide3a approach to jointly model both the individual components of the critical urban infrastructure systems, and the interfaces among them. The ide3a project – international alliance for digital e-learning, e-mobility and e-research in academia – is a DAAD-funded project with the broad scope of developing a virtual campus where technologies for digital learning, research, and mobility are integrated to support collaborative efforts on the topic of "Critical Infrastructure & Digitalization". ide3a is contributed by a multidisciplinary and international consortium of five European partner universities, led by the Technische Universität Berlin. The core research of the ide3a is devoted to the development of ConnectiCity, a multi-layered digital, open source, serious game that integrates models of urban water distribution systems and sewer network with models of the other critical urban infrastructure systems. The main goal of ConnectiCity is to enable scenario analysis, simulation, and optimization of urban critical infrastructure systems under heterogeneous social, technical, and climate scenarios. Its gamified features will make it a suitable tool for university education and stakeholder engagement. In this presentation, we will introduce the ide3a project, the inter-sectoral challenges and interfaces driving the development of ConnectiCity, as well as preliminary showcase its features.

Validation of air phase flow, mass transport and mass transfer in a sewer pipe

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Hydrogen sulphide (H_2S) gas is formed by the bacterial decomposition of organic matter in the sewer under anaerobic conditions. H_2S gas is the major contributor to the odour and corrosion occurring in the sewer networks. These emissions not only increase the cost of maintenance but also pose a threat to human health of sewer workers. Optimal odour and corrosion management has been hindered by limited understanding of several of the key sewerage processes contributing to the problems, and the lack of tools and reliable technologies to support strategic decisions and cost-effective sewer operations (Rootsey et al. 2012). A significant step towards filling this gap is to develop a high-resolution three-dimensional model to understand and simulate the processes involved. This contribution advances the doctoral thesis of Teuber (2020) and concentrates on the validation of water-air flow in a sewer with a focus on air phase flow, mass transport and mass transfer occurring between the phases. The basis of this work is a three-dimensional water-air flow model developed within the framework of the open-source CFD platform OpenFOAM. First, simple plausibility tests with regard to water-air flow in a sewer pipe are investigated. Second, the modeling of water-air flow in a sewer will be validated using experimental studies of Bentzen et al. (2016) which aimed to improve the data basis for numerical modeling of sewer ventilation. Third, the mass transfer of H_2S and O_2 from the water to the air phase will be considered in stagnant water and air. Fourth, transport will be analysed by first injecting O_2 into the air phase and then also including H_2S. The transport and mass transfer of both tracers will be tested in a closed pipe (verification: functionality of the solver) as well as in a pipe with manholes (validation: experimental data).

Time reversal technique for freshwater pipeline burst detection

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Due to rapid increase in population and urbanization, freshwater pipelines are stressed. These stressed pipes are old and vulnerable to many defects such as leaks, blockages, pipe wall thinning and pipe bursts. Existing acoustics methods are inefficient to localize these defects because these methods rely only on the local characteristics of the defect. Waves, on the other hand, have potential to be used as diagnostic tool to not only diagnose physical systems but also to detect the defects. In particular, hydraulic transient waves (often known as waterhammer waves) can be used to diagnose water pipelines in both active and passive sense.

In this work, passive transient waves, generated by the natural pipeline bursts, are used to identify the origin of the burst via time reversal (TR) technique. TR technique relies on the time-invariant property of waves. This means that waves are able to retrace their past and converge back to their source when recorded, reversed and rebroadcasted. This technique has been successfully used in medical imaging to destroy the kidney stones and in Geophysics to localize the location of the earthquake source. In freshwater pipelines, however, this is the first time when TR techniques is coupled with passive transient waves signals to detect the pipe burst. This technique is more efficient than acoustics methods and much suitable for complex pipeline environment. The proposed method is first displayed via numerical simulations and then verified via laboratory experiments.

A data-driven approach to leakage identification in water distribution networks

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Infrastructure failures and water losses represent major challenges for the maintenance and management of water distribution networks (WDNs). Water losses due to leakages can amount to over 50% of the supplied water volume. In addition to the unnecessary loss of water, leakages lower the energy efficiency of WDNs, contribute to revenue losses, and can cause cascading effects, such as contaminant infiltration, or property damage. Furthermore, in a global context characterized by a rapidly growing population and increasingly scarce water resources, leak reduction becomes a key element of the strategies that utilities can adopt to increase the resilience of their infrastructural assets over the long-term. Hence, it is of crucial importance to proactively identify and promptly fix leakages, with the detection of leakages in WDNs being an essential and time-crucial prerequisite.

This work proposes a real-time and high-resolution data-driven algorithm for leakage identification. Our algorithm analyzes the pressure from SCADA data observed at different sensor nodes in a WDN and identifies leakage events. Firstly, our proposed model is trained on pressure data available from "normal" states of the WDN, i.e. before the leakages to be detected are present. Secondly, it is applied to detect these leakages on a time series that potentially include leak events. Finally, the reconstruction error from the model is analyzed to detect the anomalies, i.e. the leakages in the WDN. The model can be recalibrated to include each newly detected leak into the "normal" situation, enabling it to detect overlapping leakage states.

The underlying data to this work is a benchmark dataset released as part of the Battle of the Leakage Detection and Isolation Methods (BattLeDIM), an international competition organized for the purpose of comparing the performance of different leakage detection and localization methods. Relying on the BattLeDIM data, the leakage detection accuracy of the LSTM-based model is validated on a labeled set of anomalies. Numerical results were obtained at a resolution of 5 minutes and show that all labeled leakages could be identified with reasonable accuracy and time to detection.

Session 2d

A three-dimensional model for H_2S mass transfer in sewers and its use cases

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The talk gives an overview over a new three-dimensional mass transfer solver and its application field. Use cases apart from the solver's direct applications are being presented and necessary modifications are being outlined.

Within the open source software OpenFOAM, users can customize solvers to fit their own needs. In the dissertation of Teuber (2020), as part of the DFG Research Training Group "Urban Water Interfaces", a mass transfer solver has been extended to describe hydrogen sulphide (H_2S) mass transfer across the interface between wastewater and air in sewers. The aim of the developed model was to predict H_2S emissions in sewer systems.

The solver uses a volume of fluid formulation to account for two-phase flow. Haroun et al. (2010) defined a mass transfer formulation to account for species transport within the two phases and mass transfer between them. Following this formulation, mass transfer is limited by the Henry coefficient. The solver extensions made in Teuber (2020) include the description of the temperature dependency of the Henry coefficient, the equilibrium between H_2S and bisulphide ion (HS^-) in the water phase and the influence of the pH value on this equilibrium.

From the viewpoint of a water company, this solver shows the potential of being applied to a number of other use cases apart from sewers, which will be presented in this contribution. The first use case addresses H_2S emissions at the inlet of wastewater treatment plants (WWTPs) as well as mitigation strategies. At WWTP Schönerlinde in Berlin, exhaust air from ventilated grid chambers is being co-treated in the aerobic stage. The H_2S is then oxidized to sulphate. Modelling the H_2S uptake in the basin could give insights regarding requirements on air volumes and bubble structure. Further use cases address the quantification of greenhouse gases, for example emissions of nitrous oxide from WWTPs or methane emissions in pumping stations.

Downstream nitrate dosing in pressure sewers for sulphide control: impact of residual nitrate on connecting gravity sewers

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The addition of nitrate salts for sulphide mitigation in sewer systems is widely applied throughout Germany to date. Its availability and cost per sulphide removal make it an attractive product for sulphide control. However, dosing in uncontrollably excessive amounts will consume the easily biodegradable carbon source required for downstream wastewater treatment and could potentially result in the accumulation and release of nitrous oxide. One optimization strategy is to dose near the end of a pressure sewer to biologically oxidize the sulphide produced upstream. This work aims to evaluate the effectiveness of dosing 200m before the end of a pressure sewer and its impacts on the sulphur cycle in a connecting gravity sewer using the sewer pilot plant of the Berliner Wasserbetriebe (BWB). Calcium nitrate was injected 200m before the end of a pressure sewer with a diameter of 100 mm which then conveys the dosed sewage to a 25 m long gravity sewer (diameter: 400 mm). Flow proportional dosage in concentrations of 7.5, 14 and 28 mg N-NO3/L was used to simulate limited, optimal and overdosage scenarios. The effectiveness of the dosages was evaluated using online Hydrogen Sulphide (H_2S) gas measurements and key sewage parameters measured using online UV-Vis sensors installed in the gravity pipe. Furthermore, the rate of carbon source loss for each dosing concentration was computed and compared. To monitor the sulphur transformation in the gravity sewer due to nitrate dosing, a micro-electrochemical sensor capable of an amperometric detection of H_2S in wastewater was installed 2cm above the sewer sediments. Here an attempt was made to quantify the alternating anoxic sulphide oxidation and sulphate reduction (measured as sulphide produced) rates at the sediment – bulk wastewater interface of the gravity sewer receiving the dosed sewage from the pressure pipe. It was found that the residual nitrate concentration in the gravity sewers stimulated a synergistic relationship between the sulphate reducing bacteria (SRB) and sulphide-oxidizing nitrate-reducing bacteria (soNRB) which inevitably triggered sulphide production in the gravity sewer. Thus, it is important to ensure that the majority of nitrate added is utilised before exiting the pressure pipe when applying downstream nitrate dosing in pressure sewers.

Novel sensor technology for online monitoring of dissolved H_2S presents new opportunities for data driven H_2S management

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A novel and cost-effective electrochemical sensor technology, SulfiLogger, enables optimized hydrogen sulfide (H_2S) management in the wastewater industry by providing continuous, liquid-phase measurements of dissolved H_2S directly in untreated sewage.

Prevailing approaches to H_2S measurements in sewer systems presents a tradeoff between a direct but static overview of liquid-phase sulfide obtained via laboratory analysis of labor-intensive grab samples - or a dynamic but indirect overview of gas-phase H_2S as measured by gas loggers measuring in the headspace above the sewage. Using continuous, liquid-phase measurements, as enabled by the novel sensor technology, wastewater utilities gain access to full, dynamic overview of how H_2S travels in collection systems, enabling decision makers to prioritize H_2S mitigation activities on an informed basis.

As part of a demonstration project under the European Commission's Horizon 2020 framework, Unisense has successfully demonstrated the distinct advantages of online, liquid-phase H_2S monitoring using the novel sensor technology in demonstrations performed in cooperation with major European wastewater utilities. With the 2-year demonstration project ending in the Autumn of 2020, we will present results and findings from the project covering topics including:

- The fundamental advantage of liquid-phase H_2S measurements

  Demonstrations in the project have shown that gas loggers, when installed close to ground-level, primarily detect H_2S spikes commonly associated with odor issues, while liquid-phase measurements performed directly in the untreated sewage, or gas-phase measurements performed close to the sewage reacts faster to changes in the composition of the wastewater and are capable of detecting small variations.

- How continuous, liquid-phase measurements can optimize H_2S mitigation activities

  Wastewater utilities commonly dose neutralization agents for odor and corrosion control, but without a dynamic overview of the real-time composition of the wastewater, chemicals are often added in either insufficient or excessive dosages. In the demonstration project, a Danish wastewater utility adopted a H_2S sensor-controlled proportional dosing strategy for the dosing of ferrous sulfates. Using this approach, the utility managed to greatly optimize the effectiveness of the dosing system, and thereby increase the remaining lifespan of downstream sewer assets, while also using 50% less chemicals compared with a constant dosing strategy.

Determining the turbulent H_2S mass transfer coefficient across the liquid-gas interface in sewer systems

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Development of hydrogen sulphide (H_2S) in sewer systems poses a high risk to human health and sewer structures. H_2S is formed in the liquid phase, however, its effects are severe when released into the air. Therefore, studying the mass transport of H_2S from the liquid phase into the air phase is of great importance. In the presentation the turbulent transport of hydrogen sulphide from the liquid into the gas phase will be discussed. Turbulence can be used as a method to enhance H_2S-stripping in sewage systems before being locally treated with an exhaust air method. For this aim, a two-step setup has been planned, which investigates the mass transfer coefficient under laboratory and real conditions.

Laboratory experiments were carried out in a 52 L cylindrical reactor equipped with a four-blade stirrer, a pH and temperature sensor, and an OdaLog for the gas phase. Three stirring velocities were investigated: 300, 400 and 500 rpm. Oversaturated conditions in the liquid phase were created by adding sodium sulphide (Na_2S $3H_2O$, CAS 27610-45-3). The pH was stabilised at 7 by addition of hydrochloric acid (HCl). To avoid chemical interactions between oxygen and hydrogen sulphide, the reactor was purged continuously with nitrogen gas (N2). The H_2S decrease in the liquid phase was measured manually at regular time intervals (1, 2 and 10 min) using the H_2S-Analyser from ECH Halle. The Reynolds number was computed to quantify the turbulence level of the stirring rates as well as to provide comparability with other geometries. A general outcome is that the higher the turbulence level, the higher the K_La coefficient. In this work, the K_La values range between 1.5 and 4.9 h^{-1}. As a comparison oxygen values for this experiment range between 2.67 and 7.59 h^{-1}.

To validate the laboratory results, experiments under real conditions will be performed at a sewer pilot plant located in Berlin which is fed with wastewater from the Neukölln district. Turbulence will be enhanced in this case through a weir and through the addition of obstacles (e.g. stones) in the flow regime. The pumping flow rate can be adjusted between 1.5 and 10 m^3/h.

Biogenic sulphuric acid corrosion of concrete at sewer pilot plant Berlin

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Cementitious building materials such as concrete in sewer systems may undergo different kinds of chemical stress at different parts of the sewer system. At the interface of building material and sewer atmosphere, sulphur oxidising bacteria produce sulphuric acid under the presence of hydrogen sulphide (H_2S). In the case of cementitious building materials, the sulphuric acid may lead to a dissolution of the cement stone minerals as well as the formation of expansive corrosion products, thus resulting in the loss of stability or even failure of the constructional element and the need of its repair or replacement. The development of concrete with high resistance against biogenic sulphuric acid corrosion (BSC) is one option to reduce repair and replacement costs in sewer systems.

In 2010, the sewer pilot plant located in Berlin-Neukölln was built and put into operation by Berliner Wasserbetriebe, Kiwa MPA Bautest, and TU Berlin to investigate countermeasures against odour and corrosion in sewer systems. In January 2017, five concrete compositions were implemented into the air phase of the two gravity pipes of the sewer pilot plant. The concrete specimens are sampled biannually to track the progress of the BSC. The progress of corrosion is analysed using incident light microscopy, polarising light microscopy, and micro X-ray fluorescence analysis. The crystalline corrosion products are analysed using X-ray diffraction. The H_2S concentrations in the two sewer lines are influenced by H_2S reducing measures in the first sewer line and, since summer 2019, H_2S increasing measures in the second sewer line. The resulting H_2S concentration differences in the two sewer lines result in different corrosion progress of the concrete specimens. Differences in the corrosion progress are also found between the five concrete compositions indicating different resistances against BSC. The results are used to evaluate the applicability of different laboratory performance tests for concrete used in sewer systems, which are necessary for a fast and comparable evaluation of newly designed concrete compositions.

Session 2d

Bacteria from sewers and their potential to improve the sustainability of construction materials

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Sewer systems are rich in microorganisms. Bacteria, fungi, and protozoans can play an important role in pre-treatment of sewage before it is transported to the wastewater treatment plant (WWTP). They are transferred via sewer pipes together with water and particulate matter that forms sediment. While sediment is being transported in the pipe, some microorganisms can form a biofilm that may firmly stick to the surface of the pipe. The composition and quantity of biofilms in sewer systems depend on the flow rate, contaminations, dispersed nutrients and gases, and even material from which the pipe is created. Cementitious materials that are often used for the construction of sewage transport systems are susceptible to biodeterioration due to the biological production of sulphates. On the other hand, some microorganisms can produce urease, an enzyme that can break urea into carbon dioxide and ammonium that increases pH and protects the composite.

The aim of this study was to isolate urease-producing bacteria in environmental samples, including soil, activated sludge, and sewer biofilm, and describe their ability to withstand conditions associated with the surfaces on cementitious materials. The material consisted of environmental samples (sewer biofilm, activated sludge, soil). The samples were diluted and propagated on growth media. Sporulating, Gram-positive bacteria were sought and isolated in monocultures. Afterwards, the isolates were subjected to various environmental conditions including low or high pH (from 4 to 10) and high salinity. Urease production and biofilm formation abilities were also examined. The taxonomic affiliation was determined by the analysis of 16S rDNA analysis. Furthermore, the microbiomes of the studied environmental samples were studied via the nanopore sequencing. In total, 28 bacterial strains were isolated. Seven were urease-positive. Relatively high resistance to harsh environmental conditions was detected among strains. On the other hand, isolates expressed a low ability to form biofilms. The group was diversified and consisted of strains from genera Bacillus, Solibacillus, Lysinibacillus, Sporosarcina, and Brevibacterium. Apart from the relatively low biofilm formation abilities in the isolates, high resistance to high pH and salinity suggests that isolates have the potential to be used on cementitious materials. Further tests are necessary to validate this hypothesis.

Assessment of urban sanitation concepts for sustainable wastewater management

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Source separation sanitation alternatives are offering the separate collection and treatment of the various fraction of wastewater which is provided the efficient recovery of nutrients and recycling of treated wastewater and consequently increasing energy efficiency. Although the technical feasibility of source separation sanitation system in the different pilot project has been successfully proved (Larsen et al., 2009, Otterpohl et al., 2002, Zeeman et al., 2008), nevertheless there is still a lack of performance and databank to investigate resource-oriented sanitation system alternative for urban water. Visualization of these new concepts can contribute increasing system understanding for sanitation experts and urban planner. This study aims to provide a visualization on the existing source separation sanitation systems in the domestic sewer system and wastewater treatment process and assess the performance of material flow of this approach in comparison to conventional wastewater treatment method.

In order to comparatively assess these systems, conventional and source separated urban sanitation systems are compared in terms of their resource recovery potential including nutrient, energy and water demand in a settlement with 1,000,000 inhabitants in Germany. The evaluation has been done with sustainability indicators for resource demand and emission to air, water and soil.

A range of required wastewater treatment processes (emphasizing on processes, which lead to nutrient/energy production) is defined. The required parameter is set for each flow (including greywater, blackwater and urine) and corresponding processes.

The material flow model is set up using SIMBA# software and developing a new simulator tool for visualization of material flow of new sanitation system. The model is developed by transferring corresponding processes into mathematical equations. The model equations not only integrate mass and nutrients flow but also the sustainability indicator of various systems. The validation and calibration have been completed.

The simulated concepts involve the processing of different wastewater fraction, transport, and energy supply. The resulting substance flow model is evaluated with a set of indicators including nutrient recovery, effluent quality, and energy and water balance in investigated sanitation concepts.

Suitability of a differential scanning calometry (DSC) based method to identify and quantify two common microplastics polyethylene and polypropylene in wastewater samples

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The quantification of possible contaminants being released into water bodies is necessary to evaluate the possible risks for urban freshwater systems and watersheds. One recently highly discussed contaminant is microplastic which could be disposed in urban freshwater for example from combined sewer overflows, stormwater outlets or effluents of wastewater treatment plants. However, there are no standardized methods for the sampling and measurement of microplastic yet. In this study, a simple method based on differential scanning calometry (DSC) is tested for its suitability to identify and quantify the mass concentration of Polyethylene (PE) and Polypropylene (PP) in different wastewater samples with a complex unknown matrix. These two polymers are representing almost half of the plastic production and therefore they appear in high abundance.

The melting peak area in the DSC curve correlates with the mass of polymer in the sample. For all environmental samples, the amount of PE and PP was determined after hydrogen peroxide treatment with external calibration, standard addition method and the weight loss during the degradation temperature of PE and PP. Additionally, an artificial sample consisting of different polymers and rock flour was analyzed using the same procedure.

The artificial sample showed recoveries of 78% for PE and 57% for PP. For all environmental samples a melting peak in the temperature range of PE and PP melting temperature was detected after the treatment. It was found that the weight loss was significantly lower than the determined PE and PP concentrations derived from the melting peak with external calibration or standard addition. Additionally, in some cases, matrix compounds produced a peak in the DSC signal that was indistinguishable from the PE and PP melting peaks. This indicates that the method is suitable for pure polymer mixtures or single particles, as results of high recovery percentages for the artificial sample with an inorganic matrix show. However, a further sample preparation targeting the remaining organic matrix components is necessary for wastewater samples with a complex matrix. Repeating the measurements of the samples using a TED-GCMS can provide further insights into the remaining matrix compounds and the reliability of the measured values.

Surface water and sewer network interface with the inlets

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Increasing urban areas has resulted in the increment of the percentage of impervious area evidently modifying the surface runoff in terms of runoff increase and time to peak. In addition, the rainfall event is highly variable in both the magnitude and frequency of occurrence. This could result in a more devasting condition if the drainage system components such as storm drain inlets are not optimally utilized. Stormwater collection system is a critical component in infrastructure in order to reduce the impact of the flooding by interference with the surface water. Inlets collect the stormwater from the surface and transiting the flow into storm drains thereby maintaining an environment for the vehicular, pedestrian, goods and assets movement. In order to overcome the urban flooding problems an analysis that could define an urban drainage system is to be designed and build in order to decease the effect of rainfall runoff operation on the urban areas by preventing increase in depth and velocities in given catchment by maintaining the hazard criteria of maximum water depth and velocities in the urban streets. In order to achieve that, a study is carried out to investigate the optimum spacing between the inlets for the urban areas that could intercept the flow in the given catchment. To determine the behaviour of the spaced inlet the efficiency is to be determined by the potential law and later the hydrological model is built with certain assumption using HEC-HMS. The results obtained would let the stakeholder decide about the optimum spacing of the inlets and the hydrologic behaviour of the surface flow. This study answers the question regarding the optimal spacing of the inlet for a given return period of an event so that the flow transitions or the interface could be studied between the surface water and the sewer system.

Wastewater treatment and effects of wastewater irrigation use in agriculture: a case study in Rajshahi city, Bangladesh

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Cities in developing countries are experiencing exponential growth of coverage of water supply and sanitation which will continue to release of growing wastewater volumes. In Rajshahi city, domestic and industrial wastewater is either discharged directly into a sewer system, a natural drain or water body, a nearby field or an internal septic tank. Due to the limitation in the availability of fresh water for irrigation, wastewater is used for irrigation of agricultural fields, particularly sewage water. The treatment of sewage water has a significant effect on urban environments, agriculture, and the river system. This paper aims to identify the benefits, adverse effects, and long-term impacts of wastewater reuse in Rajshahi City's agricultural land and provide appropriate solutions to the problems. A questionnaire survey was conducted to collect data on the perception and responses of the farmers regarding agricultural, economic, environmental, and health issues. Also, waste water was collected and analyzed in the RUET laboratory prior to and after treatment. It is evident from the results that, Rajshahi City has no biological method of handling their wastewater. The water has been misused in agriculture and has posed possible threats to public health and the environment. The most important advantages of wastewater reuse were noticed as the availability of wastewater over all seasons. Farmer reported that this water's long-term exposure rapidly stimulates crop growth but drastically reduces grain yield. Finally, Interviews with key factors suggest that a long-term, permanent wastewater reuse system is not advantageous to the community and some suggestions have been put forward so that the treated waste water can be used without further treatment as irrigation water and discharge into the river.

Detecting and minimizing water losses in a drinking water supply system: two case studies in Hurghada and El Gouna Cities, Red Sea Governorate, Egypt

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Detecting and reducing the unaccounted for water (UFW) is an essential tool in water demand management in dev eloping countries. This study focuses on detecting and investigating UFW on a large scale in several areas in the Red Sea Governorate, Egypt.

In Hurghada City, with 200,000 inhabitants, the UFW in the networks of Alnagda district, which receives water from the Nile, and Almallaha district (an informal settlement), which receives water from Alyusr desalination plant, was estimated roughly to 60% and 49% respectively. To calculate the amount of UFW, Alqiadat district in NE of Hurghada with 6500 inhabitants, a modern residential community with exact known consumers and a complete connected system and Abutig district, a commercial and residential quarter located north of ElGouna resort were selected. The estimated water consumption in both districts is 200 l/d. Both selected areas receive water from desalination plants and their distribution networks are designed in combined system of loops and dead ends.

To detect and control the UFW in Alqiadat, District Metered Areas (DMA) were established to analyze the minimum night flow (MNF) in a continuous supply system. By installing flowmeters and measuring the input at the main inlet for each DMA for 37 days, the daily demand patterns and the hourly peak factor could be determined. The UFW was calculated with 60%. The main reason behind these high losses are the defective flowmeters and the illegal connections. Replacing the defective units and identifying the illegal connections r educed the UFW to 44%.

A butig area was divided into four DMA, each one was equipped with a flowmeter to analyze the MNF and the daily demand pattern. The resulted calculated UFW were 14%, 45%, 19% and 16%. The hourly peak fac tor in the DMA with the highest UFW was determined with 65% indicating leakage in the network. The measures introduced to reduce UFW included replacing the defective flowmeter, detecting and replacing the leakage points. The final calculated UFW reached 21%.