KWB

Annual Report 2023

Welcome

Water is more precious and scarcer than ever. The water sector faces growing challenges in securing the quantity and quality of this valuable resource. These challenges are manifold and include adaptations to climate change, digitalisation, and preservation of existing as well as planning of future infrastructure and supply networks.

Prof. Dr. Christoph Donner (left)
Nicolas Zimmer (right)

To cope with these monumental challenges, innovative ideas, cooperation between many actors, and a strong desire to implement change are needed. This is precisely the sphere in which KWB operates. In applied water research, KWB is an important and central institution in the Berlin/Brandenburg metropolitan region, in Germany, and in Europe. It is an innovation laboratory, think tank and competent advisor for real-world applications. Its staff comprises forward-thinking individuals who not only share their expertise but also actively drive change.

There have been many exciting developments at KWB over the last 12 months. Former Managing Director Jochen Rabe left KWB after three years of successfully spearheading topics such as digitalisation, smart cities and hydroinformatics alongside the team. Prof. Dr. Martin Jekel is serving as the new, interim Managing Director. A preeminent expert whose dedication to water-related matters spans an unparalleled length and depth, especially within the Berlin community, he also played a pivotal role in the inception of KWB more than 20 years ago. With Prof. Dr. Jekel at the helm, a circle that serves as a solid foundation for tackling current and future challenges together with numerous local, national and international partners is now complete. As shareholders and research partners, we are staunch sponsors and supporters, with plans to intensify our collaboration even further in the forthcoming years.

Recognizing the qualities of KWB and its staff, we appreciate their commitment and willingness to actively contribute in the framework of the Climate and Transformation Fund, which enables multi-billion Euro investments in climate protection. Securing core funding for KWB would provide the Berlin/Brandenburg metropolitan region with reliable access to intellectual and human resources for addressing escalating water problems. The exceptional experts at KWB are not only dedicated team players, but also masterful at spearheading large collaborative projects with passion, and at acquiring the necessary grants and funding to benefit both their partners and the region as a whole.

We would therefore like to thank all employees for their extraordinary commitment and wish them continued success. We look forward to continuing to work together on exciting projects for our common future. KWB is indispensable.

Prof. Dr. Christoph Donner
CEO of Berliner Wasserbetriebe
Chairman of the Supervisory Board of KWB

Nicolas Zimmer
CEO Technologiestiftung Berlin (Technology Foundation Berlin)
Chairman of the Shareholders of KWB

Vision & Mission

We're delighted to present our refined vision and mission, meticulously developed through a collaborative effort with our dedicated staff. Our fresh vision and the mission it engenders serve as the core of our organisation, shaping our daily tasks and our drive.

Vision

Our expertise in applied research and practical solutions guarantees the sustainable management of the urban water cycle and a conscious approach to protecting our environment.

Mission

Thinking ahead
We tackle the urgent issues related to urban water management. These include responding to climate change, safeguarding the environment and resources, and embracing digitalisation. We achieve this by conducting thorough and practical research that generates innovative knowledge. Our work is inventive, grounded in solid scientific principles, and constantly pushing boundaries.

Sharing knowledge
We have strong collaborations with national and international partners in science, business, and administration. We operate independently and connect key players, stakeholders, and organisations in the water sector and beyond. By sharing our extensive knowledge and effectively communicating it, we aim to raise awareness about the vital significance of water.

Driving change
Our work, ideas, and solutions have a profound impact on society. The knowledge we share encourages open dialogue and empowers people to make informed decisions. Together, we are shaping a positive future.

Executive Summary

Managing Director
Prof. Dr. Martin Jekel

Dear Ladies and Gentlemen,

On 4 March 1999, I received an e-mail inquiry from Dr. Bodo Weigert, who was then the managing director of the Verein Wasserforschung e.V. in Berlin. It reached me while I was in the US for a research stay with Dr. Jörg E. Drewes, who was a postdoc at Arizona State University in Tempe. At the time, the Berlin Senate was in the midst of negotiating the partial privatisation of the Berliner Wasserbetriebe (BWB). One of the bidders Vivendi (now Veolia) expressed its interest in funding the establishment of an institute dedicated to water research in Berlin. In response, I developed a concept within a day that envisioned the creation of the Berlin Water Research Institute, or BWI. On 8 March, the concept was submitted directly to the Senate Administration for Science, Research and Culture as part of the sales negotiations. On 2 July 1999, the result of the negotiations with the bidders, including Vivendi, were publicly disclosed by the Governing Mayor, Eberhard Diepgen, who explicitly mentioned the establishment of the Center of Competence for Water. The speed with which this transition occurred, spanning only four months from conception to decision, is remarkable.

After almost three years of negotiations, the KompetenzZentrum Wasser Berlin was finally established as a gGmbH in 2001. I was able to accompany the founding phase of the KWB for six months as one of the two managing directors. At that time, the Technical University of Berlin, where I had held the professorship for water pollution control since 1988, was among the shareholders. During this period, we actively collaborated on several projects, such as the NASRI project, which focused on the analysis of trace substances in bank filtration.

Why am I sharing this? Despite my retirement, I was asked by Prof. Dr. Christoph Donner, the new CEO of BWB and Chairman of the Supervisory Board of KWB, to take over the management of KWB on short notice for a transitional period starting on 1 June 2023. I couldn't refuse this request, considering all my deep-rooted connections to KWB, its staff, and to BWB.

KWB has advanced very well thematically in its two decades of its existence, exploring new topics and research areas, and consistently expanding its staff. Our new annual report outlines exactly what I mean.

Our first article offers a glimpse into how after successful application of our innovative tool for ageing forecasts of wastewater and drinking water networks, SEMAplus, in Berlin, we are now implementing it in Lausanne (see from p.12). In the interview with representatives from the Service de l'eau de la Ville de Lausanne, you will learn more about how the city and its residents stand to benefit from SEMAplus, and how this partnership will enhance asset management practices in Lausanne.

The second article is about how water, cities, and public health are connected. Given the growth and densification of cities, increasing frequency of heavy rainfall events, and higher temperatures attributed to climate change, a paradigm shift in urban planning is imperative. Discover how our research contributes to addressing these pressing challenges on p.16.

As previously mentioned, BWB has a new CEO, Prof. Dr. Donner, whom you can get to know better starting on p.22. Explore his perspective on the role KWB will assume within the broader strategies of BWB and Berlin, how our future cooperation will take shape, and discover what significance water holds for Christoph Donner beyond his professional career.

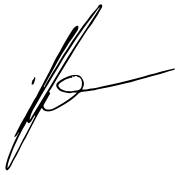
In the second section of the Annual Report, we swim out again and peer into the future. We begin with an article on climate neutrality within the water industry, which examines whether this is just a utopian dream - more on this on p.48. From p.54 onwards, we discuss which lessons could be learned from the recent gas shortage, which concerned us at the end of 2022 and beginning of 2023, for safeguarding Germany’s water supply.

Finally, in the last article starting on p.60, we introduce SWIM:AI, an innovative tool for predicting bathing water quality in rivers and lakes based on data-driven models. In the process, we’ll delve a little deeper into the technical details.

Water, often taken for granted as an essential resource for sustaining our lives, was insufficiently considered within the potential ramifications of climate change until 2018. Although forecasts based on various models for predicting water supply in the coming decades existed, reality has since outpaced these predictions. Five unusually dry years have transpired since then, and 2023 alone will not redress this balance, despite initially presenting itself as a year with relatively normal precipitation levels. The cumulative precipitation deficit, ranging from 500 to 700 mm, cannot be swiftly offset. Consider the mere 350 mm of precipitation recorded in Berlin-Dahlem for 2022, a figure similar to what may can be expected in arid steppe or desert regions. The entire eastern part of the Federal Republic is notably vulnerable, but other regions are also grappling with imbalances in their water resources. Multiple reports have underscored these challenges, as exemplified by a ZDF feature on August 14, 2023, titled "German Rivers in Distress - Distribution Struggle for Water," which brought this issue to the forefront of public awareness.

KWB is well positioned even amidst these uncertain times, and we look to the future with resourcefulness, courage and confidence. This positive outlook is rooted in several factors. Firstly, we've witnessed substantial economic growth at KWB throughout 2023, allowing us to secure increased project funding for the forthcoming years. Secondly, our optimism is fueled by our remarkable team of dedicated, highly skilled, and curious employees, eager to engage in cutting-edge national and international research projects on behalf of KWB. I would like to express my gratitude to the staff, who gave me a very warm welcome which enabled me to quickly get started.

I hope you enjoy reading our annual report. It is intended to inspire you and offer an insight into the numerous challenges at the intersection of water, urban environments, climate change, and digitalisation.
Join us in embracing a mindset of pragmatic optimism, and do not hesitate to contact us if you have any questions or issues related to water in urban environments.



Prof. Dr. Martin Jekel
Managing Director | October 2023

Immersion

Dive in and learn more about the latest developments in applied research at KWB. This includes ageing forecasts of wastewater and drinking water networks in Switzerland, the interplay of water, city, and health, and an interview with the new head of Berliner Wasserbetriebe.

Find out what kept us busy in 2023 in the following articles:

Boosting asset management *w*ith machine learning

SEMAplus in Lausanne

Dr. Nicolas Caradot

The city of Lausanne is taking a big leap into the future of water management with the introduction of SEMAplus, our innovative tool for forecasting the deterioration of sewer and water networks. Developed in close collaboration with Berliner Wasserbetriebe, this innovative software is set to transform the maintenance of sewer and water networks for future generations. It's already being used in Berlin to optimise the annual financial planning of over 10,000 km of sewer network.

The issue of ageing water and sewer networks requiring substantial investments for rehabilitation is finally being addressed in a new way with SEMAplus. This machine learning-based software solution provides rapid and accurate information to localise urgent rehabilitation needs and offers a solid foundation for long-term investment planning. With minimal inspection data required, SEMAplus streamlines the maintenance planning process.

In Lausanne, SEMAplus will be implemented and tailored to specific needs. Our main objective is to provide a comprehensive tool that integrates asset management, from data collection in the field (such as CCTV inspections of sewers or localising pipe failures), to prioritising pipe replacements. The tool will be further extended through a new module that automatically rates the conditions of the pipes based on sewer inspection reports by CCTV cameras. After model deployment, the result is a list of all inspected and uninspected sewer pipes, ranked and sorted by their immediate need for rehabilitation.

SEMAplus will also incorporate advanced machine learning techniques to enhance prediction accuracy. This is crucial, as accurate results can be immediately used to make on-site decisions regarding local construction. A specific module is also being developed for prioritising the rehabilitation needs of pipes according to the risks and consequences of failure. The underlying analysis is performed in close collaboration with experts from the French research institutes Institut national de la recherche agronomique (INRAE) and Institut National des sciences appliquées de Lyon (INSA). It will consider additional impact or vulnerability criteria to prioritise rehabilitation investment (e.g. under high-traffic streets or in resource protection areas).

On a strategic level, SEMAplus will simulate the future condition of Lausanne's network over the next decade. This simulation will provide valuable insights to justify the importance of proposed investments. Finally, we'll also upgrade and integrate the existing tool for asset management of the drinking water network in Lausanne into SEMAplus.

SEMAplus is poised to boost asset management in Lausanne, delivering fast and accurate information to identify urgent rehabilitation needs and lay the groundwork for long-term investment planning. ▶

Agnès Martinez

Networks Engineer at Service de l'Eau de la Ville de Lausanne | Drinking Water and Wastewater Disposal | Smart Cities

Perrine Ziegler

Engineer at Service de l'Eau de la Ville de Lausanne | Sustainable Water Networks

Dominique Zürcher

Deputy Head of Division, Networks & Hydraulic Engineering Unit Manager at Service de l'Eau de la Ville de Lausanne

We interviewed Agnès Martinez, Perrine Ziegler und Dominique Zürcher from Service de l'Eau de la Ville de Lausanne about their experience with SEMAplus, the collaboration with us, and the impact our solution will have in Lausanne:

How will the city of Lausanne and its people profit from SEMAplus? What is your future vision for the sewer network of Lausanne and how is it connected to SEMAplus?

SEMAplus will provide us with an efficient asset management tool for both of the networks we manage – drinking water networks and sewer networks. Thanks to this tool, we will be able to better target the renewal or rehabilitation of pipes. We believe the tool will allow us to increase the efficiency of the service we provide by improving our failure prevention policy while maintaining the same level of yearly investment. By doing so, we will optimise investments and therefore taxes on the customers, who will benefit from a drinking water network with a reduced risk of water cuts, and from rivers and the environment which are less affected by pollution resulting from defects of sewer pipes.

How did you first learn about SEMAplus?

We were part of the former European research project Care-W for asset management of the drinking water network. After 10 years of using this methodology, we were very satisfied with its results and wanted to develop a similar approach for sewer networks. We reached out to our contacts from the Care-W project (Yves le Gat from INRAE and Frédéric Cherqui from INSA) who told us about the methodology used in Berlin. We contacted Nicolas Caradot who introduced us to the SEMAplus tool.

What was the appeal of SEMAplus and how did you make the decision to apply it in Lausanne?

SEMAplus uses a similar approach as the one we have been using for the drinking water network: based on the data we have on our infrastructure and on the observations we make (CCTV inspection), we can estimate the condition of our entire infrastructure. Most of all, the flexibility of the tool and the possibility to adapt and develop additional modules provides us with a tool which can simultaneously be used for sewer and drinking water networks. Finally, we think KWB, as the developer of SEMAplus, has a the proper knowledge and skills for those topics.

Can you share some information about implementing SEMAplus in Lausanne? Which challenges do you face and how do you approach them?

In Lausanne, we face 2 main challenges. One is to develop a tool that can be used for sewer and drinking water networks. The other is to develop 5 additional modules that will be integrated into the existing SEMAplus tool. Our final goal (having one tool for the entire asset management of both networks) is ambitious, but we can rely on the research team (KWB, INRAE and INSA) who guide us and allow us to benefit from their great expertise in each area, and give great advice.

What are the next steps in of applying SEMAplus in Lausanne?

For the drinking water network, the next milestone is to finalise the implementation of our existing methodology in the SEMAplus tool. It means developing 2 specific modules: one to predict the probability of failure of each pipe, and the second to prioritise the renewal of each pipe using multicriteria analysis.

Sewer rehabilitation construction site in Lausanne

For the sewer network, the next milestone is the next step is to calibrate and validate our condition assessment method (aggregation of defects into a general defect rating) and to make the first run of the pipe simulator to get an idea of the condition of our whole infrastructure, including the pipes which have never been inspected.
These goals should be reached by the end of 2024.

Implementing SEMAplus in Lausanne involves close collaboration between 3 research partners KWB, INSA and INRAE. What are the advantages of this collaboration?

The advantage of this collaboration is the benefit from the expertise of each research partner: KWB in modelling the deterioration of sewer pipes and developing new modules for SEMAplus; INRAE in modelling the probability of failure of drinking water pipes and in their knowledge about uncertainty propagation; and INSA in developing methods to assess the conditions of sewer pipes and to use multicriteria analysis to prioritise renewal or rehabilitation, both in sewer and drinking water networks.

SEMAplus is being used in several utilities. What do you expect from the cooperation between the various cities? How can it help deploy SEMAplus and to improve asset management practices in Lausanne in general?

The cooperation between various cities is really interesting because even though the type of infrastructure or organisation of the utilities can differ, the challenges we face are often the same. Benefitting from the feedback of other utilities allows us to better apprehend our own challenges. It also creates synergies where utilities share the same needs, thus allowing us to share data and information to address these particular points. ●

What does urban water have to do with our health?

Lisa Junghans

Dr. Andreas Matzinger

Water is one of the most important resources for survival on our planet. Access to clean and sufficient water is not globally guaranteed, and due to climate change, more and more regions are affected by lack of access, including our own. The consequences of this are not only devastating for the environment, but also for our cities, for our society, and for our health.

"Drawing from numerous projects across the water cycle, our practical solutions are actively contributing to the creation of a sustainable and healthier world for generations to come."

This makes protecting our water resources and using them sustainably paramount. Only in this way can we strengthen our resilience and equip ourselves for impending future challenges. This is precisely where our applied research efforts make a significant impact. Drawing from numerous projects across the water cycle, our practical solutions are actively contributing to the creation of a sustainable and healthier world for generations to come. This can be seen in our work on blue-green infrastructure as well as on improving bathing water quality.

Green lungs for a healthy future: Blue-green infrastructure

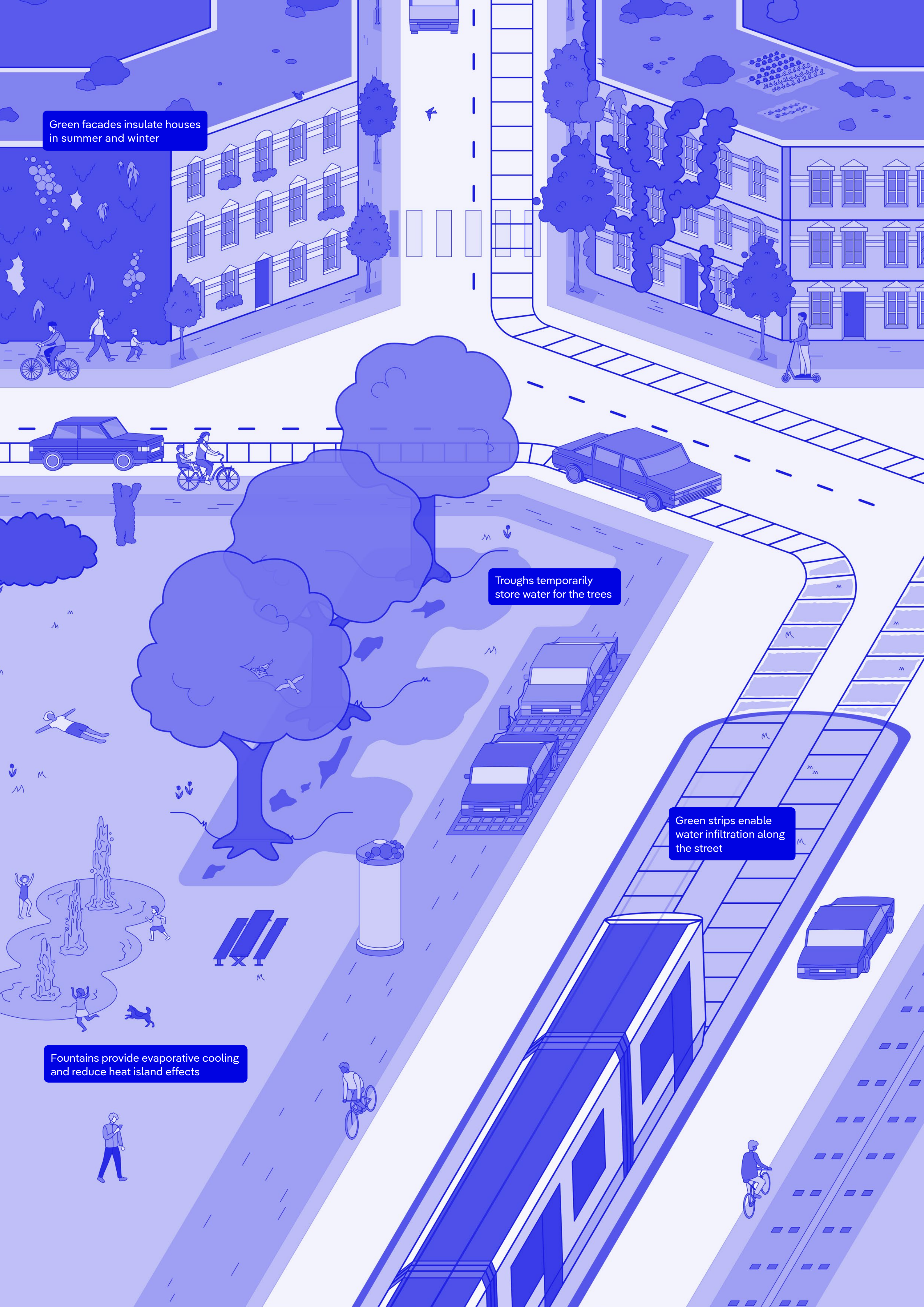
After heavy rainfall in July 2017, many streets, basements, and underground stations in Berlin were flooded. Rainwater accumulated mainly in low-lying areas of the city and caused damage to property and infrastructure. A year later, a heat wave and prolonged drought hit Berlin's inner-city districts particularly hard. The tall buildings and asphalt-laden streets retained heat even overnight, posing especially high health risks for young children and senior citizens.

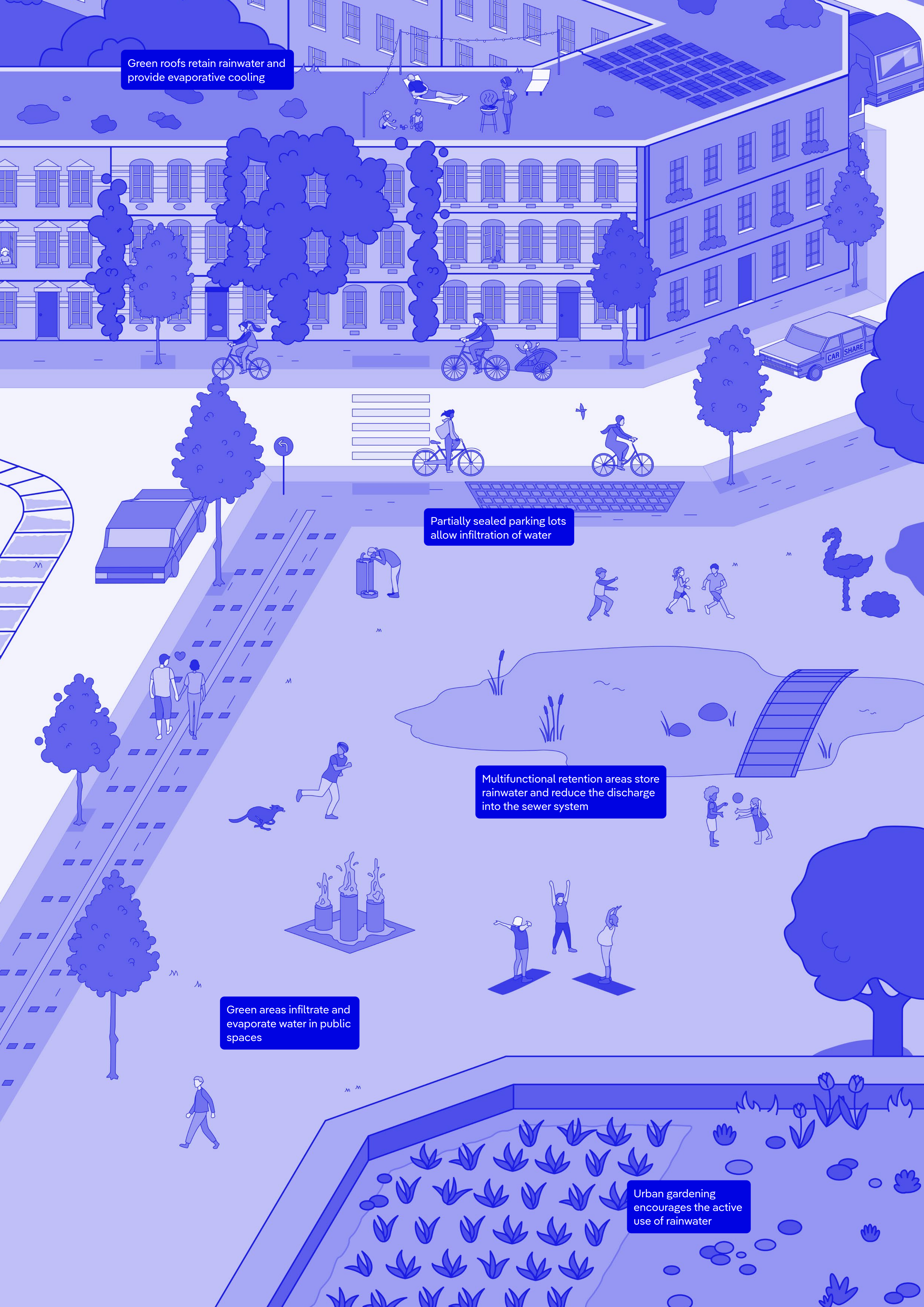
These two examples vividly illustrate the extent to which urban soil sealing, caused by the proliferation of roads and buildings, can give rise to heat islands and summertime flooding. Considering the ongoing urban expansion driven by the rising demand for housing, coupled with the escalating frequency of intense rainfall events and elevated temperatures resulting from climate change, a fundamental rethinking of urban planning is imperative.

An effective solution to address this is via adoption of climate-adapted and water-sensitive urban development strategies. This involves planning or redeveloping an area in a manner that allows rainwater to be retained, evaporated, infiltrated or used on site rather than being channelled away through conventional sewer systems. Such localised management can significantly reduce stormwater runoff, and evaporative cooling significantly reduces temperatures. The transition from runoff to infiltration or evaporation can be integrated into existing urban landscapes by incorporating blue-green infrastructure.

Blue-green infrastructure consists of both natural and man-made elements and aims to improve the natural environment in urban areas. We subsequently use a simplified definition according to the visibility of "green" and "blue", terms which have proven useful in planning, especially in stormwater management (Anterola et al., 2020). "Green" stands for elements such as green roofs, green areas or infiltration swales, while "blue" stands for water areas or water features.

Collectively, these components of blue-green infrastructure (Fig. p. 18-19) coalesce to create a sustainable approach for enhancing urban environments and elevating the overall quality of life for residents. ▶


Green facades insulate houses in summer and winter
Troughs temporarily store water for the trees
Green strips enable water infiltration along the street
Fountains provide evaporative cooling and reduce heat island effects


Green roofs retain rainwater and provide evaporative cooling
CAR SHARE
Partially sealed parking lots allow infiltration of water
Multifunctional retention areas store rainwater and reduce the discharge into the sewer system
Green areas infiltrate and evaporate water in public spaces
Urban gardening encourages the active use of rainwater

Better bathing *w*ater quality

In Germany, there are two sewer systems for wastewater disposal. In the separate sewer system, wastewater from toilets, showers and washing machines flows into a sewer and is transported to the wastewater treatment plant. Rainwater is directed to separate pipes and ultimately to bodies of water. In the combined sewer system, on the other hand, rainwater and wastewater flow into the wastewater treatment plant via a combined sewage system. In Germany, about half of the sewer systems are combined systems. The combined system is cheaper than the separate system, but during heavy rain events the system can overflow, causing untreated wastewater to be discharged into rivers. Such discharges into water bodies, called combined sewer overflow, can cause health problems for humans and animals.

Researchers at KWB have conducted extensive investigations into the fluctuations in hygienic load within the Havel River in Berlin following combined sewer overflows. Based on their findings, they have developed an innovative model named SWIM:AI for predicting whether swimming could be harmful. This statistical computer model is powered by real-time digital data encompassing water conditions and daily rainfall patterns in Berlin. Since 2019, it has been instrumental in keeping the public in Berlin informed about the current water quality at selected swimming locations (check out www.badestellen.berlin.de). Our hydroinformatics team is actively working on expanding SWIM:AI to water bodies beyond Berlin. You can read more about this on p.60.

"Considering the ongoing urban expansion driven by the rising demand for housing, coupled *w*ith the escalating frequency of intense rainfall events and elevated temperatures resulting from climate change, a fundamental rethinking of urban planning is imperative."

In addition to predicting bathing water quality, reducing pollution of public bathing waters in general is also critical. This is where blue-green infrastructure can make a significant contribution. Through evaporation and infiltration of rainwater, it can be partially or completely disconnected from the conventional sewer system. This directly leads to a reduction in combined sewer overflows during heavy rain events, thereby improving protection of health.

Less heat stress

It is widely recognised that high temperatures impact people's health and overall well-being. Due to climate change, heat waves occur with increasing frequency and intensity in many regions, which can lead to health-related issues and even death. In addition to the daytime heat, "tropical nights" with temperatures above 20 °C also impact public health.

"Climate-resilient urban development is indispensable for the health of urban populations."

The "Basic Report on Environmental Justice in the State of Berlin" examined how different population groups are affected by environmental pollution, especially heat, in more detail. Detriments to human well-being come in various forms, ranging from feelings of malaise and inattention, to a noticeable decline in overall performance. Prolonged or extreme heat exposure can escalate these adverse effects to a critical level, potentially resulting in organ failure or even death.

Blue-green infrastructure can help reduce heat stress in cities by changing land use and building characteristics. Properly watered trees and water features, such as ponds, can best alleviate daytime heat stress because they provide shade and induce a cooling effect through the process of evaporation. Unpaved surfaces, such as green or lawn areas, store less heat during the day and thus give off less heat at night, contributing to overall cooling. Incorporating greenery into buildings also converts heat into evaporative cooling, reduces heating requirements of buildings, and even positively influences the microclimate in the neighbourhood. Green and blue building components are thus an important component of health-centric urban development, as they can contribute to reducing thermally-induced health issues, especially among the elderly, sick, and very young people.

More beautiful cities

In addition to better bathing water quality and less heat pollution, blue-green infrastructure can also significantly improve the quality of life in other areas. Urban landscapes which are aesthetically pleasing can motivate people to exercise more. Simply looking at plants and vegetation helps reduce stress and positively affects physical well-being. The noise reduction and pollutant removal functions of blue-green infrastructures can also help reduce incidences of cardiovascular and respiratory diseases and subjective stress.

These examples show that water-sensitive and climate-adapted urban development is crucial in today's world, as climate change increases the frequency of extreme weather conditions such as heat waves and heavy rain events. Customised blue-green infrastructure solutions can help to counteract these problems.

Researchers at KWB are currently collaborating with other partners on developing intelligent planning tools to most efficiently use blue-green elements in urban planning, and are looking for ways to warn the urban population about heavy rainfall (read more about this on S. 42, where we introduce our Smart Water project). They are also investigating how the city can be turned into a forest, so to speak, by implementing blue-green infrastructure measures from the perspective of the water balance (you can find out more about our AMAREX project in last year's annual report or on our website).

While new research findings will make the use of blue-green infrastructure measures even more efficient and effective, cities should already be addressing this issue today. One thing is clear: sustainable urban development is not merely a means to enhance residents' quality of life or secure competitive advantages over other locations in the economic landscape by resilience to extreme conditions. Climate-resilient urban development is indispensable for the health of urban populations. Cities should therefore make every effort to initiate this transformation today if they aspire to maintain their relevance in the future. ●

Interview with Prof. Dr. Christoph Donner

Since the beginning of 2023, Prof. Dr. Christoph Donner has been the new Chairman of the Executive Board of our shareholder Berliner Wasserbetriebe and also the new Chairman of our Supervisory Board. The water specialist from North Rhine-Westphalia previously served as the Technical Managing Director for the Hildesheim Harzwasserwerke.

We interviewed Christoph Donner on future topics in the water sector, the role of research, and our future cooperation.

Looking at the water sector in Berlin, in Germany, and in Europe overall, which future issues will particularly concern us in the coming years?

The main challenges facing the water industry are securing quantitative and qualitative water resources, recruiting skilled workers, infrastructure, and, last but not least, financing necessary future investments in the lifecycle related reconstruction of existing infrastructure. There are also important concerns such as climate change, pandemics and economic crises. And of course, digitalisation in its entirety, from plants which could operate autonomously in the future, to smart city solutions, to new interactions with customers and charging models, is a key concern for managing our companies and resources efficiently and sustainably.

Challenges concerning supply chain changes, such as the ones for precipitants, can appear at first glance to not be very big. However, these challenges have manifold impacts concerning the resilience of processes and future treatment methods.

It will be crucial to rethink water management, potentially even in a completely new and radical way. For example, how can we convert urban landscapes to hold water instead of diverting it away? For which uses will we continue to provide drinking water quality, and for which can we switch to fit-for-purpose quality?

What role should research play in this?

For me, our researchers at KWB and in the research and development (R&D) department of the Berliner Wasserbetriebe serve a critical function: as sensors, as laboratories, as pioneers developing and testing ideas, and as drivers of innovation. The focus must always be on the practical relevance of our work in the water cycle. It is essential for the future viability of the Berliner Wasserbetriebe – and, by the way, also for the blue-green metropolis that we want to make Berlin into. For me, this also means that we must work together, hand in hand.

What needs to happen so that innovative solutions are put into practice more quickly?

As a founding member of the Water Innovation Circle (WIC) of the German Technical and Scientific Association for Gas and Water (DVGW) and the German Association for Water, Wastewater and Waste (DWA), I'm also particularly committed to implementing innovations faster, because we need much more innovation and transfer from other areas to solve the major issues of the future. KWB is already structurally very well positioned to do so, working together with the R&D department of the Berliner Wasserbetriebe, as well as with its network of scientific partners in the region and beyond.

We must harness this collective intelligence more effectively in order to elevate the synergy between applied research and practical collaboration to the next level of evolution.

Naturally, we must also secure the support of lawmakers to enact legislation and cultivate partnerships with public authorities to foster bolder and swifter adoption of innovative solutions. Unfortunately, the budget of the Federal Ministry of Education and Research (BMBF) has just been cut. Because we cannot rely on government funding for our innovation topics, we should establish a one percent turnover rule for R&D within the industry to secure and advance these projects, which are immensely important for our development. ▶

As a part of the water industry, we must accelerate our pace and embrace greater boldness in the adoption of innovations. Waiting for an extensive list of references will hinder our ability to achieve the required development speed promptly.

Back to Berlin: In many places, the transfer of knowledge works excellently. With the rapidly changing future demands on the Berlin-Brandenburg metropolitan region, we must craft water management infrastructures and utilisation practices that are not only sustainable for our generation but also for the benefit of generations to come. What a wonderful task and responsibility.

New Chairman of the Board and Strategies of Berliner Wasserbetriebe

You are the Chairman of the Executive Board of Berliner Wasserbetriebe since January 2023. Can you briefly tell us about the most important strategic approaches for the further development of BWB?

At the core of Berliner Wasserbetriebe's identity, I see us as a company that manages the region's water resources in an integrated manner – from raindrops to groundwater. I also envision us as a company that has established sustainable resource planning together with the Brandenburg utilities. This encompasses both drinking water and wastewater, as both are interdependent and cannot be viewed in isolation within a single federal state. My aspiration is to see us advance our digitalization efforts to the extent where AI supported tools are seamlessly integrated where they prove advantageous.
The Regenwasseragentur has accomplished significant milestones in its initial five years of operation, and is an integral component of this strategy, alongside Berliner Stadtwerke, the city's public utility company. We are working on many joint projects, for example equipping our factory roofs with photovoltaics or using heat from wastewater. I imagine even more possibilities in the area of geothermal energy, which I would like to expand under our new leadership.
Three things are particularly important to me in achieving these goals: Firstly, clarity in our investments: what do we need, what do we have to spend money on, what alternative solutions do we have? Secondly, clarity in our actions: Which tasks should we perhaps take on in the future to be able to manage our resources even more sustainably? Thirdly, efficiency: we must spend our energy and time on the things that are essential – and also do them in a certain amount of time. This is how we create added value.

"Because we cannot rely on government funding for our innovation topics, we should establish a one percent turnover rule for R&D within the industry to secure and advance these projects, which are immensely important for our development."

What role can KWB play in the context of your strategies for Berliner Wasserbetriebe and for Berlin overall?

First of all, I would like to say that Jochen Rabe successfully developed and set new priorities with the KWB team. I would like to thank him very much for this work and express my respect. The same applies, of course, to Prof. Dr. Martin Jekel, whom we were able to win over as interim managing director. In my opinion, there is no one in Berlin who has been working so intensively and for so long in the area of water – an absolute asset for KWB!
Today, KWB addresses nearly all pivotal facets of urban water management, functioning as both a think tank and an innovation laboratory while providing invaluable counsel to practitioners.
Following our groundbreaking research achievements, such as the notable SEMAplus initiative, I eagerly anticipate fresh inspiration for our company, particularly within the realm of digitalization. Regarding the concept of "wastewater as a resource," I look forward not only to building upon existing research but also to nurturing ongoing collaboration with KWB to further explore this subject.
KWB is a valuable partner for us, especially because of its international connections – for example in the digital-water.city project. At the same time, as the largest integrated company in the German water industry, Berliner Wasserbetriebe is the perfect practical laboratory for KWB, especially in connection with our inhouse R&D department. This is evident in projects such as IMPETUS and SmartWater, as well as netWORKS4, with important contributions to climate justice and resilience, or GeoSalz, from which we hope to gain important insights into the management of our groundwater.

"KWB is a valuable partner for us, especially because of its international connections. At the same time, as the largest integrated company in the German water industry, Berliner Wasserbetriebe is the perfect practical laboratory for KWB, especially in connection with our in-house R&D department."

What do you wish for the future cooperation between Berliner Wasserbetriebe and KWB?

I would like us to approach projects with focus and awareness of our respective strengths: together where it makes sense, alone where it takes us further. But under one strategic umbrella and always for the benefit of our city and its most important resource. In any case, I would like to celebrate the 25th anniversary of the KWB together in three years. Because we have a lot in common: Berlin, water, a never-ending enthusiasm for all topics related to the urban water cycle, and a lot of know-how with which we make the city a better place to live.

Do you also have a special relationship with water beyond your professional activities?

Of course. Water is my element! When I was a little boy, I built dams by the stream in the Sauerland and watched the water flow. That left its mark. My way to work takes me along the Spree every morning, as does my jogging route in the evening. I look forward to the day when swimming is possible there again. Until then, I do my laps in the indoor swimming pool on Fischerinsel.
But once again to return to our core topic: I would like to make my contribution to developing a clear picture of the future of water management together with the various stakeholders in Berlin-Brandenburg. To do this, we must anticipate the evolving framework conditions in the coming decades and discern the services that will fall under the scope of general interest. We need to collectively devise strategies for delivering these services and configuring the necessary infrastructure and processes. In doing so, adopting a modular mindset and remaining open to reevaluating our infrastructure and processes would be a prudent approach. ●

The interview was conducted by Moritz Lembke-Özer.

Selection of projects

- ULTIMATE
- AD4GD
- ABLUFT 2
- DIGIWAVE
- GEOSALZ
- SAFECREW
- SEMA BERLIN 3
- SMART WATER
- WATERMAN

ULTIMATE

Project volume
€16.6 million (total volume), financed by EU Horizon2020 – Grant agreement ID: 869318

Partners
KWR Water Research Institute; Eurecat Centre Tecnològic; Universita Politecnica delle Marche; Water Europe; The University of Exeter; Ethnicon Metsovion Polytechnion; Cranfield University; Strane Innovation; ESCI – European Science Communication Institute gGmbH; The Galilee Society – The Arab National Society for Health Research & Services (R.A.); Mekorot Water Company LTD; Greener than Green Technologies S.A.; Aquabio Limited; Aguas Industriales de Tarragona S.A.; Consorzio Aretusa; Agrobics LTD; West Systems S.r.l.; Alberta S.A.; SUEZ RR IWS Chemicals France; NTNU: Norges Teknisk – Naturvitenskapelige Universitet; Kalundborg Forsyning A/G; Novozymes A/S; X-Flow B.V.; Consorzio polo Technologico Magona

Contact
Dr. Anne Kleyböcker

▶ (1) A so-called electrostimulated anaerobic reactor (ELSAR™) is being built for this purpose, while the process is being tested and optimised in a corresponding pilot plant. The process enables bioelectrochemical reactions, which are e.g. capable to quickly degrade organic shock loads and thus contribute to a stable biogas formation process. The process is also characterised by a high methane yield.

Industrial *w*ater use for smart *w*ater management

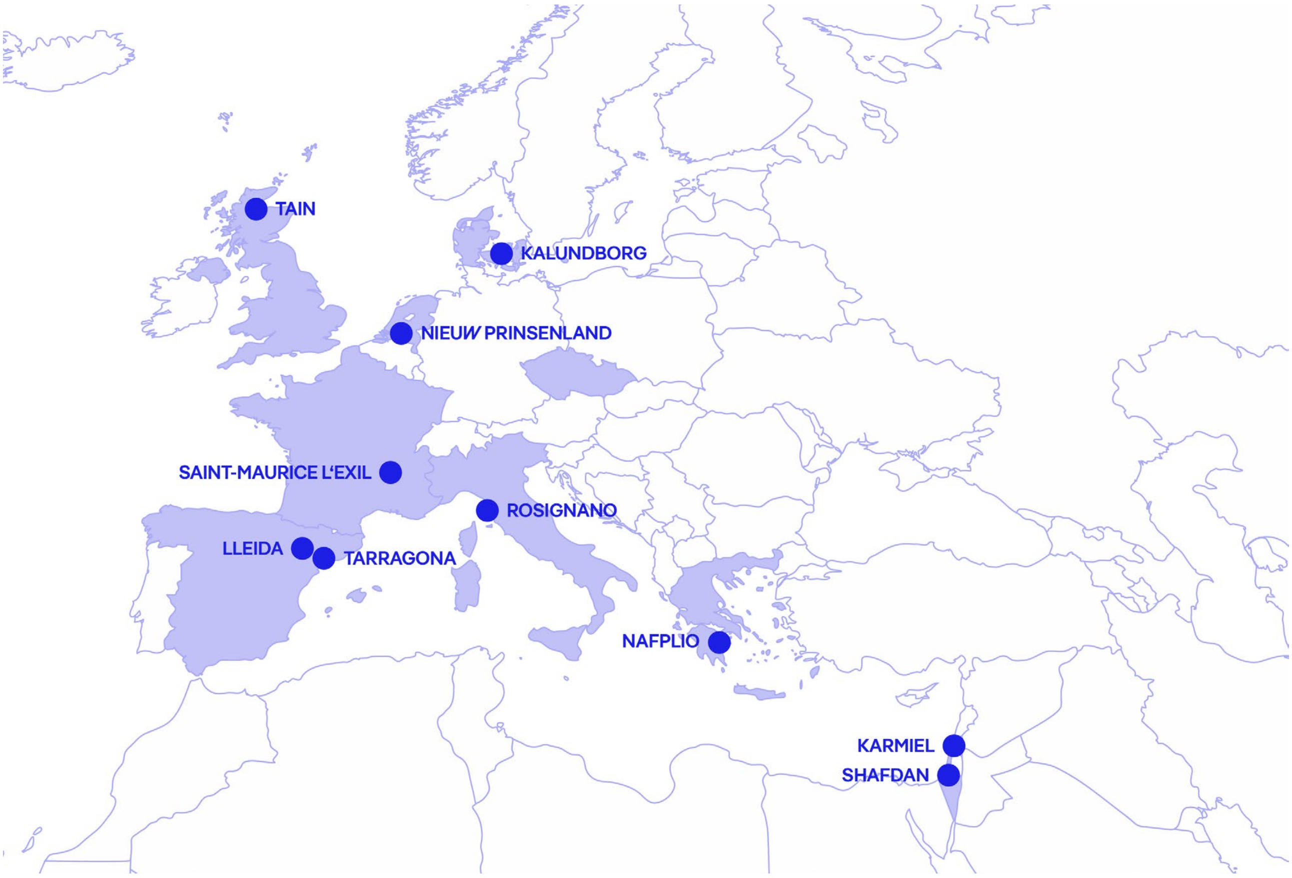
The European Commission's Green Deal is dedicated to fostering a sustainable European economy, with a key focus on advancing the concept of a circular economy. Within this framework, the industrial sector is a significant water consumer, second only to agriculture, and generates valuable wastewater as a byproduct. This wastewater holds the potential for recovering diverse materials and energy. Through the application of advanced technologies, it can also be treated and transformed into high-quality water suitable for industrial reuse. The project ULTIMATE establishes and promotes collaboration between and for the mutual benefit of the industrial and water sectors, creating a platform known as Water Smart Industrial Symbiosis.

At nine sites in Spain, Scotland, the Netherlands, France, Denmark, Italy, Greece, the Czech Republic, and Israel, the water sector is collaborating with the agri-food, chemical, petrochemical, biotechnology and beverage industries as part of ULTIMATE. 24 different pilot plants are being developed and optimised to recycle water, materials, and energy.

There are now 21 successfully operating pilot plants. The industrial pilot plant for the recovery of sulphur from flue gas of a hazardous waste incinerator and a large-scale plant for the production of biogas from brewery wastewater are still under construction. The biogas plant uses a new process that is being implemented at large scale for the first time ever in Lleida (ES). ▶ (1)

In Lleida (ES), Tarragona (ES), and Kalundborg (DK), ULTIMATE has already successfully produced high-quality water from brewery wastewater, petrochemical wastewater, and biotechnological/pharmaceutical and municipal wastewater, which can be used as cooling water. Plans for large-scale implementation in Tarragona and Kalundborg are under development. Pilot-scale optimisation is simultaneously continuing, and technologies for treating concentrates from reverse osmosis, such as membrane distillation, are being tested.

In Nafplio (EL), a solar reactor was successfully used to effectively degrade organic compounds from fruit juice production. In Nieuw Prinsenland (NL), greenhouse wastewater is treated for reuse in irrigation. The challenge here is to remove the high salt content. For this purpose, electrodialysis was successfully tested for the first time. The advantage of this process is that it uses only a quarter to a tenth of the energy of reverse osmosis.



Locations of ULTIMATE case studies

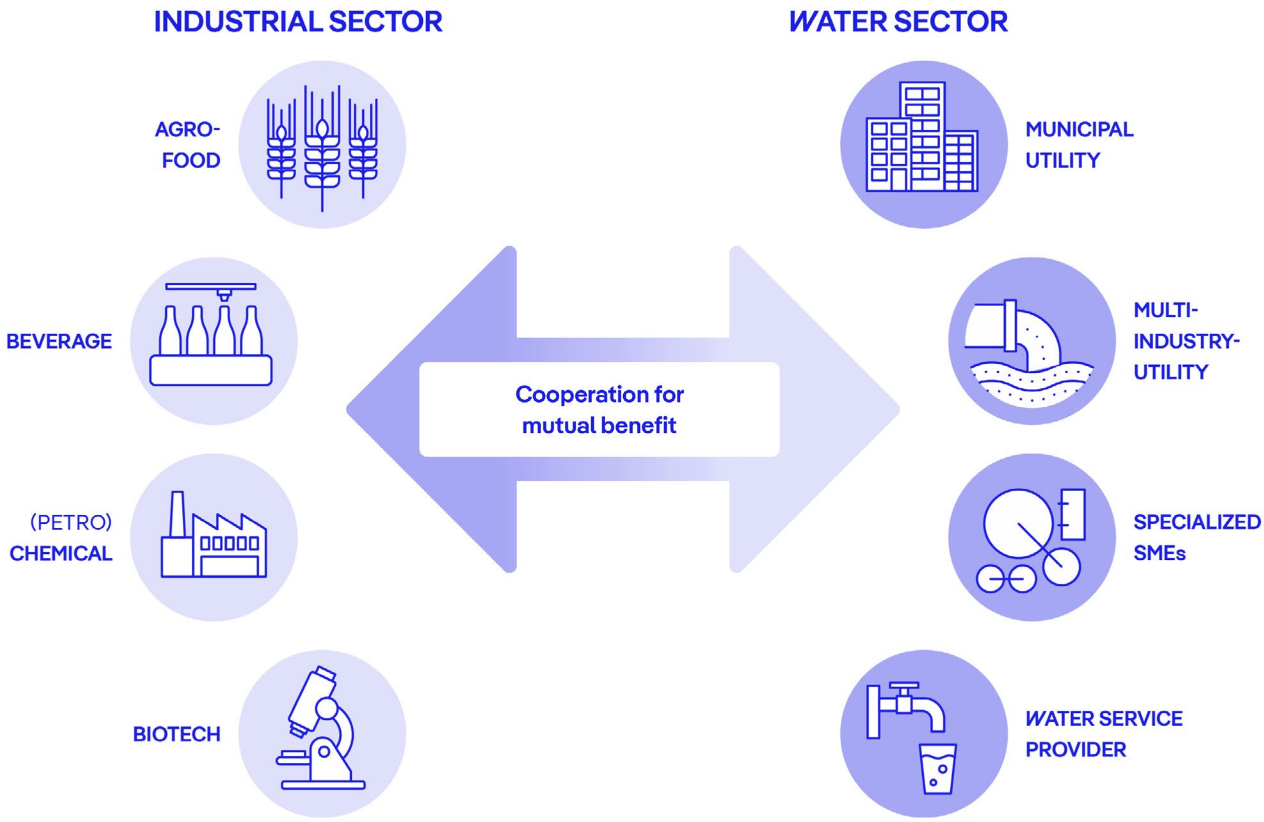
In Italy, the high salt content in wastewater also poses a challenge for its reuse in industry and agriculture. Seawater intrusion into the sewage system can lead to high salt loads, especially for chloride. For this purpose, a complex monitoring system was implemented, and with the help of a "matchmaking" system, different water flows will be combined with each other so that high salt contents can be avoided and reuse in agriculture and industry can be enabled.

In Scotland, high-quality fertilisers in the form of struvite and diammonium sulphate are successfully produced using whisky distillery wastewater. In this way, phosphorus and nitrogen are removed from the wastewater as a pretreatment to further recover fit-for-purpose water and to enable its reuse in industry.

In Israel, various anaerobic processes to treat seasonal high organic loads from olive oil production are being tested while recovering biogas as an energy source. Olive mill wastewater also contains polyphenols that can inhibit the methanogenic microorganisms responsible for the biogas formation process. Through an innovative adsorption/extraction process, the polyphenols are recovered as a high-value product to avoid process disturbances in the biogas reactor.

Lea Conzelmann (left) and project manager Dr. Anne Kleyböcker (right) in front of the ELSAR plant under construction in Lleida (Spain)

As part of the ULTIMATE project, we are developing an online knowledge platform called "Water Europe Marketplace" together with other H2020 projects. This platform will present our case studies, explain the technologies we have developed, and summarise all project results in the long term. The platform is hosted by Water Europe and will be available for presentation to users and to new projects after the end of ULTIMATE. Learn more about the platform at https://mp.watereurope.eu/.



Intelligent symbioses between the water and industrial sectors

AD4GD

Project volume
€4.14 million (total volume), financed by EU Horizon 2020

Partners
Centre de Recerca Ecològica i Aplicacions Forestals; Open Geospatial Consortium Europe; European Centre for Medium-Range Weather Forecasts; Fraunhofer Institute for Applied Information Technology; ATOS IT Solutions and Services Iberia SL; European Centre for Certification and Privacy; Instytut Chemii Bioorganicznej Polskiej Akademii Nauk; Mandat International; Design Terminal; IoT Lab; Aston University

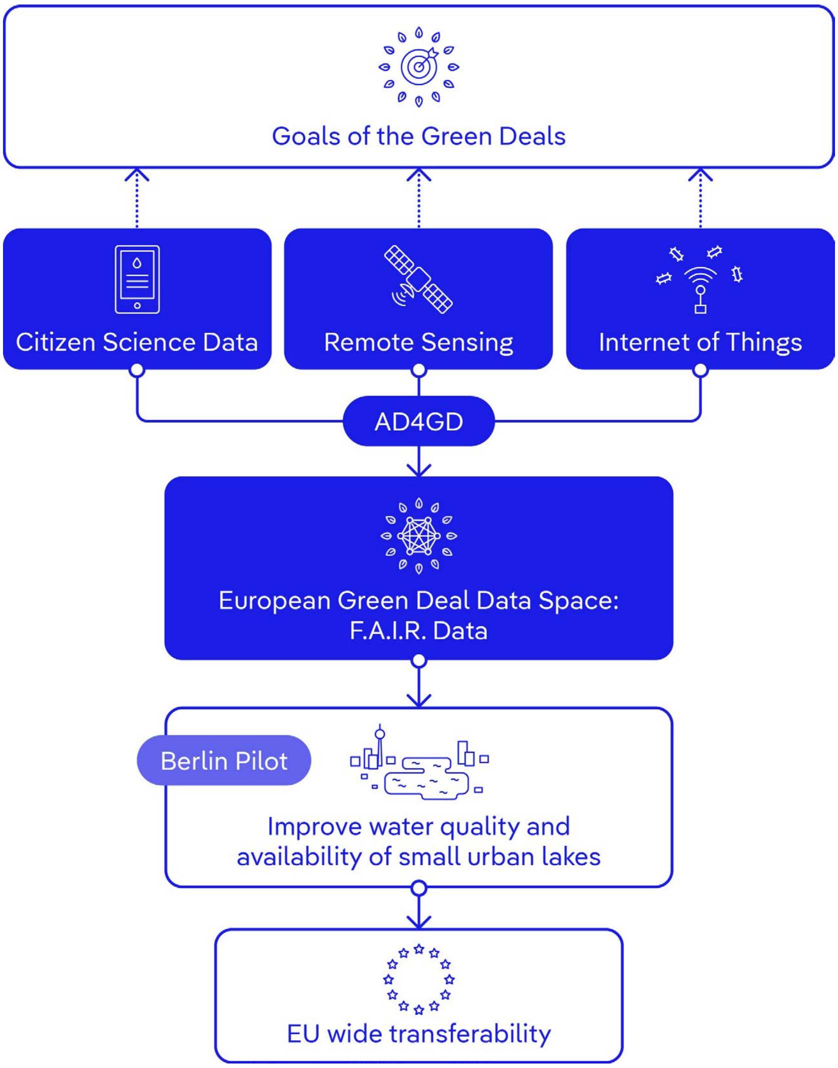
Contact
Malte Zamzow
Dr. Andreas Matzinger

Data for the Green Deal

Europe has set the ambitious goal of being the first climate-neutral continent by 2050. The European Commission's Green Deal aims to preserve biodiversity and reduce the impact of climate change and pollution. The complexity of environmental challenges often requires linking different data types collected in increasing amounts as a result of digitalisation. However, their use is limited, as they are often part of many small, decentralised networks, and are therefore difficult to find and access.

The AD4GD project aims to create a pan-European data space (Green Deal Data Space - GDDS), in which data relevant to the Green Deal and services related to the data are available according to the FAIR principle. FAIR stands for "findable", "accessible", "interoperable" and "reusable". The development of smart tools at local and global levels will ensure an efficient linking of remote sensing data, sensor data (Internet of Things), socio-economic data, and citizen science data. To overcome semantic and technological gaps, existing data standards will be integrated, and new interoperability concepts will be developed.

Fig. A: Illustration of the development of a Green Deal Data Space in the AD4GD project along the Berlin pilot study on small lakes



AD4GD is far beyond a conceptual project. It is developing three pilot projects focused on biodiversity, climate change and zero pollution, the latter of which is KWB's responsibility. The pilot project is about the water quality and availability of small urban lakes in Berlin. According to the EU Water Framework Directive, monitoring is not mandatory for lakes smaller than 50 hectares. Accordingly, little information is usually available about these water bodies. In urban areas, however, they are important places for biodiversity, counteract heat islands, and increase the quality of life as recreational spaces.

There are several hundred small lakes in Berlin whose water quality is strongly influenced by urban catchment areas. Water availability depends, among other things. on the degree of paved area and the drainage system. The pilot project aims to transfer the existing knowledge about a few regularly sampled lakes to other water bodies to be able to react to current and future challenges regarding water quality and availability. The condition of the lakes will be recorded and evaluated as automatically as possible to cover the large number of lakes even with limited staff. Among other things, we are investigating the use of satellite data ▶ (1) to describe changes in water quality and water volume in small lakes, the involvement of local residents in monitoring, and the use of rainwater runoff from urban areas to prevent small lakes from drying out without significantly affecting water quality.

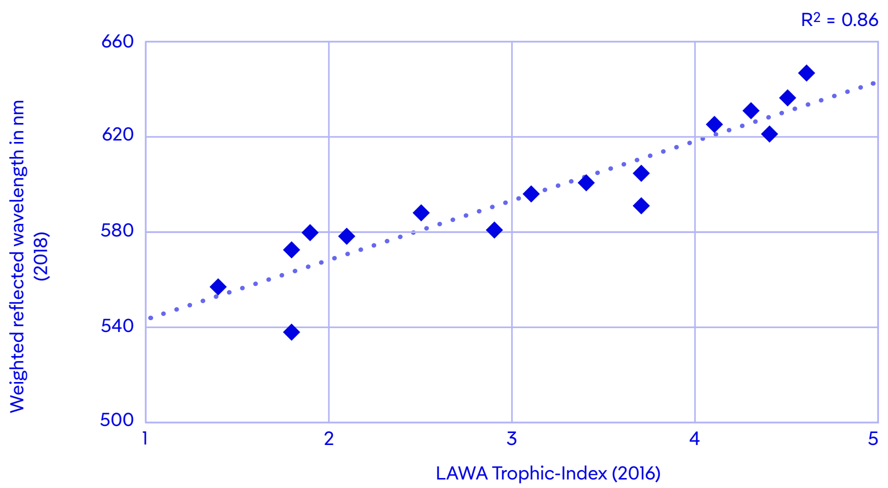
▶ (1) Remote sensing data for assessing the water quality of small lakes

The satellites of the ESA Sentinel-2 programme measure the reflection of specific wavelengths at various locations around the world every five days. In addition to visible light, wavelengths in the near infrared range are also recorded. The colour of the water and thus also the reflection change depending on the water contents. In principle, turbid waters reflect waves in the near-infrared range and the colour red more strongly than blue and green. In large bodies of water, this is already used to estimate the chlorophyll content or turbidity. For small lakes, however, only a few pixels of satellite images are available because the resolution of the satellite images is up to 60 x 60 m, depending on the wavelength. Statements on concrete concentrations are therefore highly prone to error and are considered unreliable.

To describe long-term trends of a water body, it's not required to have precise chlorophyll or turbidity values. Estimating the trophic index as an accumulating parameter for water bodies would already be helpful. The trophic index describes the nutrient content of a water body and includes several measurements, such as phosphorus concentration, chlorophyll *a* content, and the turbidity of a water body. It ranges from 0 (very nutrient-poor or oligotrophic) to 5 (very nutrient-rich or polytrophic).

Therefore, it was first investigated whether the information from a single pixel averaged over a year correlates with the trophic index. The reflected wavelengths of a pixel were combined as a weighted average to form an average wavelength (weighted reflected wavelength). Subsequently, 15 lakes in Brandenburg for which a calculation of the trophic index from 2016 was available were identified. The comparison of the trophic index data with the satellite data from 2018 suggests that there is a clear correlation (R^2 = 0.85) (▶ Fig. B). Next steps include optimisation of the procedure, its transferability to small lakes, and determination of the sensitivity using time-averaged satellite data.

Fig. B: Correlation between trophic index and reflected wavelength



ABLUFT 2

Project volume
€190,600, financed by Berliner Wasserbetriebe

Partner
Berliner Wasserbetriebe

Contact
Jonas Hunsicker
Dr. Ulf Miehe

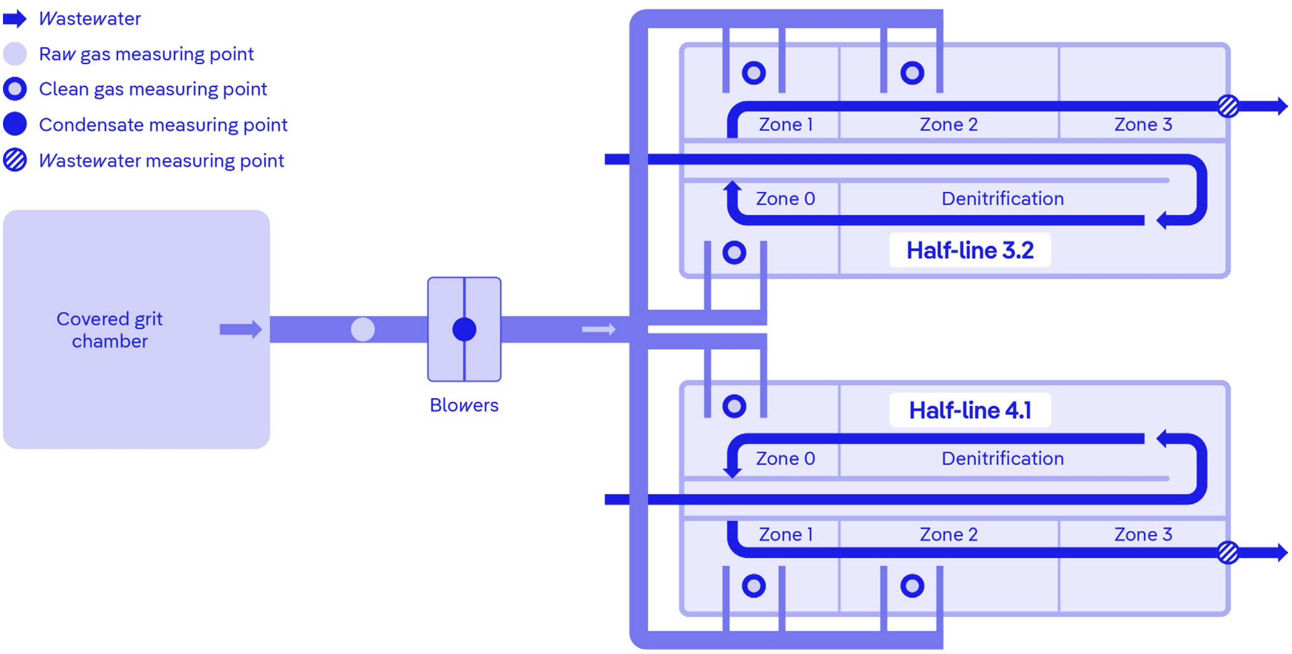
▶ (1) Compared to other processes such as chemical H_2S absorption in a chemical scrubber, or H_2S adsorption in activated carbon filters, no chemicals or activated carbon are needed for exhaust air co-treatment. The energy used to feed the exhaust air into the aeration basins (depending on the efficiency of the blower) can even be partly saved during the subsequent, normal aeration of the basin, as the oxygen content in the exhaust air is practically the same as in the ambient air.

No rotten eggs

Hydrogen sulphide (H_2S) is a colourless, toxic and very malodorous gas (beware of the rotten egg smell!). It is a by-product of the decomposition of organic materials with sulphur-containing compounds. This can occur in swamps, septic tanks or when biological material rots. This can also happen when wastewater remains in the sewer system for long periods of time. H_2S is corrosive, flammable and highly combustible. At high concentrations above 250 ppm (0.025%), humans cannot detect its odour anymore, and inhalation can be fatal at elevated concentrations above 500 ppm (0.05%).

Long retention times of wastewater in the sewer network, which are typical for Berlin, result in wastewater with high concentrations of dissolved H_2S at the inlet to the wastewater treatment plants (WWTP). At the Schönerlinde WWTP of the Berliner Wasserbetriebe (BWB), H_2S is gassed out in the inlet structure with turbulent flow and in the aerated grit chamber of the first (mechanical) treatment stage. To avoid odour nuisance and endangering employees, the H_2S-containing air (exhaust air, in German "Abluft") above the aerated grit chamber is removed and treated.

In the Abluft 1 project, KWB conducted preliminary tests on co-treatment of exhaust air in the aeration basins of the Schönerlinde WWTP. ▶ (1) We scientifically proved that when the exhaust air from the sand trap is blown into the aeration basin, the corrosive and toxic H_2S is oxidised into non-toxic sulphate (SO_4).



Process diagram of the system for exhaust air co-treatment in the aeration basins

Gas hood on zone 0 of half-line 3.2 in Schönerlinde (clean gas measuring point)

Exhaust air co-treatment in the WWTP's aeration basins was implemented for the first time at full scale at the Schönerlinde WWTP, and KWB oversaw the internal testing at the WWTP for one year starting in June 2022. Measurements of all relevant substance flows (gas, wastewater, condensate) were planned in detail in advance and coordinated with BWB. This is where KWB's expertise in both the sampling of these substances and in the WWTP process understanding came into play. ▶ (2)

Now we are continuing our work in Schönerlinde. Data from the measurements will continue to be evaluated, presented, and used to plan future testing. This enables us to improve our understanding of the process of exhaust air co-treatment in aeration and identify optimisation potentials for WWTPs.

▶ (2) Due to the long experimental period, the performance of WWTP in summer and winter operations could be observed. To comprehensively evaluate the risk for employees, and to evaluate and minimise the cleaning performance of the WWTP, we also tested extremely unlikely operating states of the WWTP, such as emergency operation, or when the maximum amount of exhaust air would be input into the aeration basin.

DigiWaVe

Project volume
€1.2 million (total volume), sponsored by Federal Ministry of Education and Research

Partners
Xylem Services GmbH; Stadtwerke Bad Oeynhausen AöR; Masasana GmbH; Schölzel Consulting

Contact
Jonas Hunsicker
Dr. Ulf Miehe

▶ (1) Explainable Artificial Intelligence (XAI) refers to methods and techniques in artificial intelligence where the results of decision making are clearly understandable to humans. Basically, it is the opposite of black box AI, where decision making processes and parameters are often unclear and incomprehensible. Explainable AI is crucial for increasing trust in AI systems and promoting their adoption in different sectors, enabling users to understand the AI's decision-making processes and, if necessary, to question or control them.

▶ (2) Bad Oeynhausen is a town in the district of Minden-Lübbecke in northeastern North Rhine-Westphalia. The town was founded as a spa in the 19th century after a thermal spring was established on its territory. It subsequently developed into a health resort of supra-regional importance, with a spa park originally designed by Peter Joseph Lenné. Bad Oeynhausen is the second largest town in the district, with just under 50,000 inhabitants. It is situated between the Wiehengebirge mountains in the north and the Lipper Bergland hills in the south in the valley of the Werre, which flows into the Weser River in the Rehme district.

Irrigation of urban green spaces: Digital solutions for *w*ater reuse

Irrigation of urban green spaces is becoming more and more difficult in many regions of Germany. Longer and hotter dry periods require more intensive irrigation, especially of younger trees, while water shortages are increasing, especially in the summer months. The introduction of water reuse measures and the thereby enabled decoupling of green space maintenance from possible bottlenecks in drinking water supply are therefore becoming increasingly important.

The DigiWaVe project, coordinated by KWB, aims to combine digital and analogue solutions for improved water reuse. At the project site in Bad Oeynhausen ▶ (1), tools to support municipalities in planning and implementing water reuse will be developed. To achieve this, we're working together with the following partners: Stadtwerke Bad Oeynhausen, the local wastewater treatment plant operator and water supplier; Xylem Services, a manufacturer of ultraviolet light (UV) disinfection systems; Masasana, a software consultancy specialising in AI solutions; and Schölzel Consulting, an independent engineer with practical experience.

Building on KWB's previous work on water reuse, four digital solution modules will be developed and tested in DigiWaVe to support water reuse in municipalities:

1. A real-time prediction model of the disinfection performance of UV systems for water reuse: KWB is testing different prediction algorithms for real-time prediction of microbial water quality. These are intended to support operators of a water reuse facility in implementing technical risk management measures in accordance with the new EU Regulation on water reuse, the water reuse factsheet series of the German Association for Water, Wastewater and Waste (DWA), which are still in draft form, and the German DIN 19650 on hygienic quality of irrigation water. The aim is for the model to be as comprehensible as possible, and at the same time, ensure safe compliance with the quality objectives ("explainable AI" ▶ (2)).

2. A cloud-based data management for urban water reuse: The networking and automation of plants and processes as well as the optimisation of the provision and exchange of data will be addressed by KWB and Xylem. Merging data from different data sources into one platform is challenging, especially if they should be used for real-time forecasting, or if they contain information about critical infrastructure.

3. A model of the irrigation needs of urban green spaces: The model will exclusively use existing data sources, such as weather data, vegetation data from the parks and recreation department, and satellite images from the European earth obser-

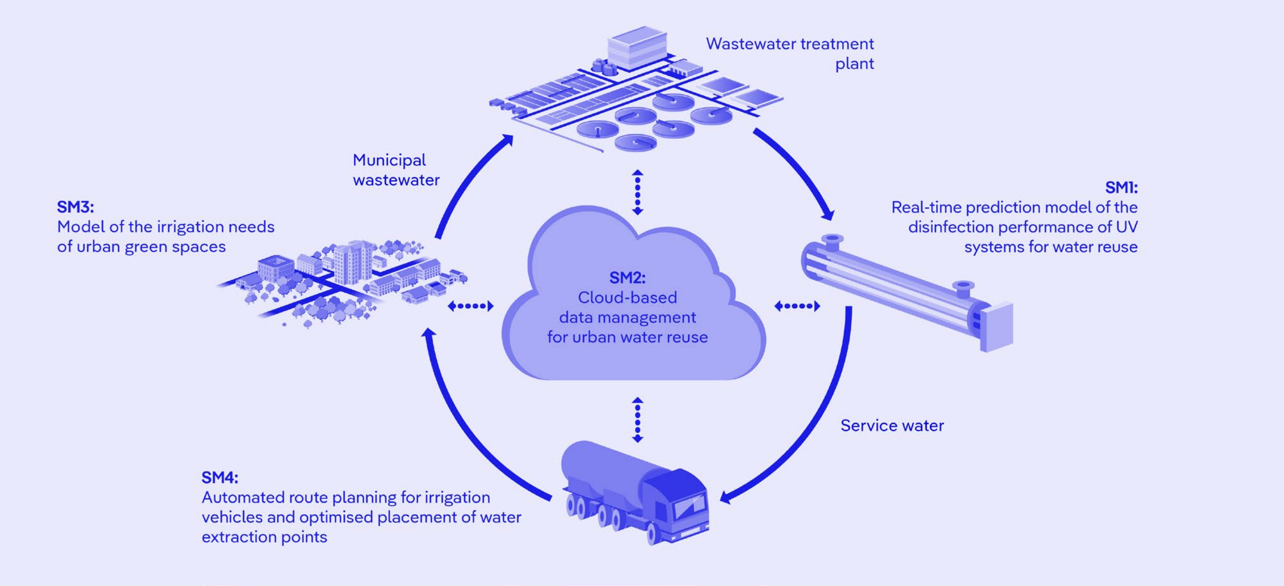


Diagram of the interaction of the solution modules (SM) in the DigiWaVe project

vation programme Copernicus. To validate the model, soil moisture measurements will be taken at five reference plots distributed throughout the city. A water demand forecasting model without sensor networks is a novelty for urban parks and recreation management, and is intended to increase reusability in other cities. A web interface for visualising the results of the model will be developed in close cooperation with the users.

4. Automated route planning for irrigation vehicles and optimised placement of water extraction points: A route planning tool which automatically creates route plans for irrigation vehicles will be developed. The forecasted irrigation needs from solution module 3, among other data, will serve as the basis for this tool. The complex problem of finding the fastest route when there are several options (the travelling salesman problem) is the challenge here. Our approach will reduce the complexity by clustering or merging irrigation areas without compromising the quality of the route plans. Furthermore, the optimal distribution of water extraction points along a possible pipeline through the urban area will be determined.

The cooperation of the project partners and the use of new technologies make the inter- and transdisciplinary project DigiWaVe a promising way to meet the challenges of water scarcity and climate change for the irrigation of urban green spaces.

GeoSalz

Project volume
€345,000, financed by Berliner Wasserbetriebe

Partners
Berliner Wasserbetriebe

Contact
Dr. Christoph Sprenger
Dwight Baldwin

Managing the saltwater deep beneath Berlin's wells

Deep beneath the city of Berlin, as well as throughout a significant portion of the North German basin, lies groundwater imbued with extraordinarily high salinity from the remnants of ancient oceans. In most cases, this hyper-saline water remains separated from the fresh groundwater by thick layers of impermeable clay. However, in certain regions of Berlin, these impermeable barriers have gaps or are insufficiently thick, which enables the saltwater to mix with the freshwater above and ascend to the surface.

To ensure the provision of drinking water for the city, Berlin relies on up to four interconnected aquifers, known as the freshwater complex. Induced bank filtration and groundwater augmentation techniques complement these reservoirs. In most cases, the freshwater complex is shielded from the underlying saltwater complex by a geological layer called the Rupelian Clay, the thickness of which ranges from 80 to 100 meters. However, breaches in the Rupelian Clay, such as glacial erosion channels, can facilitate the upward movement of highly concentrated saltwater, which results in contamination of freshwater reserves. While this process occurs naturally, local extraction of groundwater can exacerbate the situation by mobilising saline deep waters, as is the case in Berlin and Brandenburg.

Groundwater sampling at an observation well

During groundwater sampling, physicochemical parameters (pH, temperature, conductivity, oxygen, redox potential) are measured in a flow-through cell.

Elevated levels of sodium chloride have been identified in individual wells within five of the nine waterworks managed by the Berliner Wasserbetriebe (BWB), the city's water utility. Furthermore, historical data reveals instances of salinization phenomena occurring at hydraulic discharge areas over a century ago, even before groundwater was utilised for drinking purposes. Extensive investigations are underway to better comprehend the intricate relationship between deep saline groundwater and groundwater utilised by the city's wells. As part of the GeoSalz project, measurement chains have been installed to detect the inflow of salt in drinking water wells ▶ (1) which are particularly vulnerable to geogenic contamination. Wells are regularly sampled and monitored, and saltwater intrusion is being simulated on different scales by numerical models ▶ (2).

The GeoSalz project aims to model saltwater migration and develop innovative concepts for monitoring salinity levels in wells which are particularly prone to saltwater intrusion. By deepening our understanding of the contributing factors to salinization and predicting future scenarios, this project plays a crucial role in establishing sustainable management practices for wells, thereby minimising the future upsurge of saline water.

▶ (1) Monitoring saltwater migration

In the GeoSalz project, the temporal and spatial dynamics of geogenic salinity are observed through water sampling at several observation points at different aquifer depths. Using a special probe, we measure the variations in temperature, electrical conductivity, and pressure along observations well in depths up to 100 m below ground surface. On-site measurements of electrical conductivity and pH are done using a flow cell. Water samples for further analysis are taken, focusing on hydrochemical composition as well as isotopic signatures - specifically isotopes of oxygen and hydrogen ($\delta18O$ and $\delta2H$). The hydrochemistry of groundwater reveals information about geochemical reactions occurring within the aquifer like salinization or refreshening, and stable isotope ratios give information of the mixing proportions of different waters.

▶ (2) Modelling saltwater migration

The modelling in the GeoSalz project comprises two approaches: (i) the adaptation and extension of the existing numerical model of BWB, and (ii) a conceptual model for the near-well area to represent essential structural and hydrogeological parameters, their variation, and evaluation of the effects of intensive groundwater management on the potential of the saltwater to rise. Using this model, we can better understand how to protect drinking water wells from qualitative impairments and as a result, optimise the extraction of drinking water in areas already under the influence of saltwater upwelling.

SafeCREW

Project volume
€4 million (total volume), financed by the European Union

Partners
DVGW Deutscher Verein des Gas- und Wasserfaches – Technischwissenschaftlicher-verein e.V.; Politecnico di Milano; BioDetection Systems B.V.; Fundacio Eurecat; Umweltbundesamt; Helmholtz-Zentrum für Umweltforschung GmbH - Ufz; Consorci Concessionari d'Aigües per als Ajuntaments i Industries de Tarragona; Tutech Innovation GmbH; Metropolitana Milanese Spa; Multisensor Systems Limited

Contact
Dr. Christoph Sprenger
Dr. Ulf Miehe

▶ (1) Ultrafiltration is an effective technique for separating particles from liquids based on their size. When sampling with ultrafiltration, the water is pumped through a filter membrane with a defined pore size. This pore size makes it possible to retain microorganisms, such as bacteria and viruses, while the cleaner water flows through the membrane. The retained organisms can then be further examined to identify various microbiological indicators. Ultrafiltration sampling offers several advantages: It allows effective concentration of organisms, and analysis and detection of microorganisms, especially at low concentrations. Additionally, the method is simple and inexpensive, making it a viable option for regular water quality monitoring.

▶ (2) Conducting a quantitative microbial risk assessment (QMRA) for natural water treatment is a scientifically sound method for assessing the risk of microbial contamination to drinking water supplies, identifying knowledge gaps and, if necessary, developing risk mitigation measures. It supports decision-making and policy development to ensure safe drinking water supplies. This is a method for assessing the microbiological risk posed by pathogenic microorganisms, i.e. pathogens. Pathogens can enter the aquifer, for example, through pollution from agriculture or via faecally contaminated surface waters. In a QMRA, relevant data on the concentration ranges of pathogens in the raw water are first collected. The removal of microorganisms is determined along the entire drinking water treatment chain, from raw water to drinking water. Mathematical models are then used to calculate the potential risk of ingesting pathogens via drinking the water. These calculations are used to estimate the probability of infections and the severity of disease outbreaks.

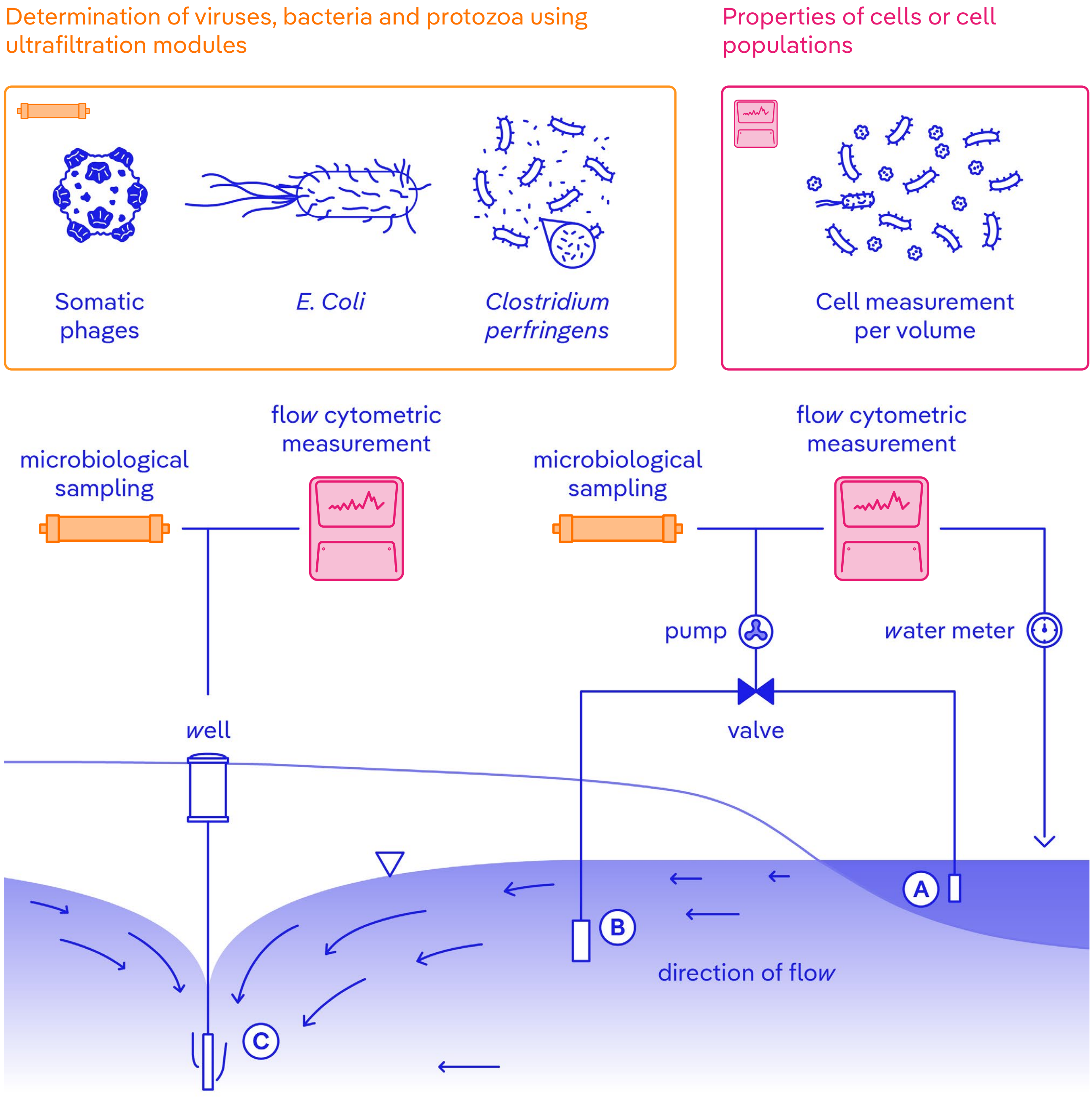
Nature based drinking *w*ater production under the microscope

The microbiological safety of drinking water is crucial for preventing the transmission of diseases via drinking water. A common drinking water disinfection method is chemical treatment before and during distribution in the drinking water network. However, this method leads to the formation of disinfection byproducts (DBPs), some of which are a threat to human health. Studies reveal that of the more than 600 DBPs currently known, more than 100 have been shown to be genotoxic (DeMarini, 2020). Drinking water production through bank filtration or groundwater augmentation is a nature based method to ensure the microbial safety of drinking water. Sufficiently long residence times of the infiltrate in the aquifer ensure microbiologically impeccable quality. In Berlin, about 70 % of the drinking water is abstracted and treated in this way.

The SafeCREW project investigates both approaches, the technical and the nature based, to safeguarding water quality to consider possible future risks related to climate change. In two case studies in Spain and Italy, the focus is on the investigation of known and previously unknown DBPs, the influence of plastic materials for pipe maintenance on DBP formation, and the modelling of DBP formation in the drinking water network under different boundary conditions. The third case study focuses on Berlin and Hamburg. In both German cities, technical drinking water treatment occurs via aeration and rapid sand filtration without any chemical disinfection. Here, possible influences of climate change which could question the previous decision not to use chemical disinfection are being investigated. These include changes in water composition, temperature, or the subsurface.

The subsurface in particular plays an important role in Berlin, as it is the most important hygienic barrier for microbiologically safe drinking water during bank filtration and groundwater recharge. However, taking microbiological measurements in the aquifer is challenging, as conventional methods often fail to detect the indicators after even a short residence time. KWB will apply an onsite sampling method for the recovery of bacteria, viruses and parasites from large volume water samples by using ultrafiltration ▶ (1), which was developed by the TZW: DVGW-Technologiezentrum Wasser (Karlsruhe, Dresden) and Blue Biolabs GmbH (Berlin). This allows for a better estimation of the retention of pathogens in the subsurface and will lead to a reassessment of health risks using quantitative microbiological risk assessment (QMRA) ▶ (2).

The SafeCREW project will help prepare the European water industry for the challenges of climate change and strengthen the protection of drinking water for consumers in the EU. KWB will carry out methodological extensions and data collection in the field to support risk management for sites with natural water treatment for drinking water.



Sketch of the measurements and sampling in the field. On-site measurements with flow cytometry and sampling using ultrafiltration modules.

SEMA Berlin 3

Project volume
90,000 €, financed by Berliner Wasserbetriebe

Partner
Berliner Wasserbetriebe

Contact
Lukas Guericke
Dr. David Steffelbauer
Dr. Nicolas Caradot

CIPP lining - a long-term rehabilitation strategy?

To evaluate the service life of CIPP liners, the project focused on damages that could shorten their service life and how they could be avoided. A total of 21 interviewees mentioned curing deficiencies (approx. 48 %), wrinkling, flushing damage, damage to the inner liner, problems with connections (approx. 24 % each), underfitting (approx. 19 %) and bulging/deformation (approx. 14 %) (multiple answers were possible) as problems.

Curing deficiencies are a common problem when installing CIPP liners. Although synthetic fibre liners with heat-initiated curing (by hot water or steam) were used in the past, increasing use of glass fibre liners with UV-initiated curing has been seen since the 2000s. This has led to a change in the control parameters of the curing process. New parameters such as the light intensity, temperature, and speed of the lamp pull increase the complexity of ensuring a fully cured liner, and therefore the uncertainties in predicting the service life. The interviews revealed a need for more comprehensive quality assurance of the installation process (approx. 33 %), especially for a curing test to measure the residual styrene content (29 %).

CIPP liners are designed for a service life of 50 years, but with good installation quality and consideration of the other influencing factors shown in Figure B, they could exceed this amount. Based on these prerequisites, 71 % of respondents estimated the service life to be longer than 50 years, with 33 % assuming a service life of 70 years or longer. 24% of respondents compared the service life of CIPP liners with that of new PVC pipes, which according to Folkman (2014), Meerman (2008), and Whittle and Tennakoon (2005) should last over 100 years. The studies indicate that a scientifically sound and robust review of the service life of 50 years originally stated by the manufacturers and adopted into the codes is needed.

Discussion about the service life also raises questions about possibilities for subsequent renovation. This topic, as well as detailed damage analyses, preventive measures, a literature review, and data evaluation, will be addressed in the project report slated for publication in December 2023. Through research on the service life of CIPP liners, KWB is actively contributing to the development of innovative solutions for sustainable rehabilitation strategies.

Non-disruptive sewer rehabilitation – no excavation pits or road closures

The sewer network has the important task of conveying wastewater and stormwater safely to treatment plants and discharge points. Like any other infrastructure, sewers have a limited service life. Trenchless rehabilitation of damaged sewers saves both time and money in comparison to traditional open trench rehabilitation methods. Sewer lining has emerged as the fastest growing rehabilitation method among trenchless technologies (Berger et al., 2020). In this process, a flexible tube made of carrier material soaked in reactive resin is inserted into the deteriorated sewer via manholes and cured in place (see Fig. A). This creates a plastic pipe within the sewer pipe (CIPP = Cured in Place Pipe). This method was first used in London in 1971, and has since been widely used for over 50 years (Bueno, 2021).

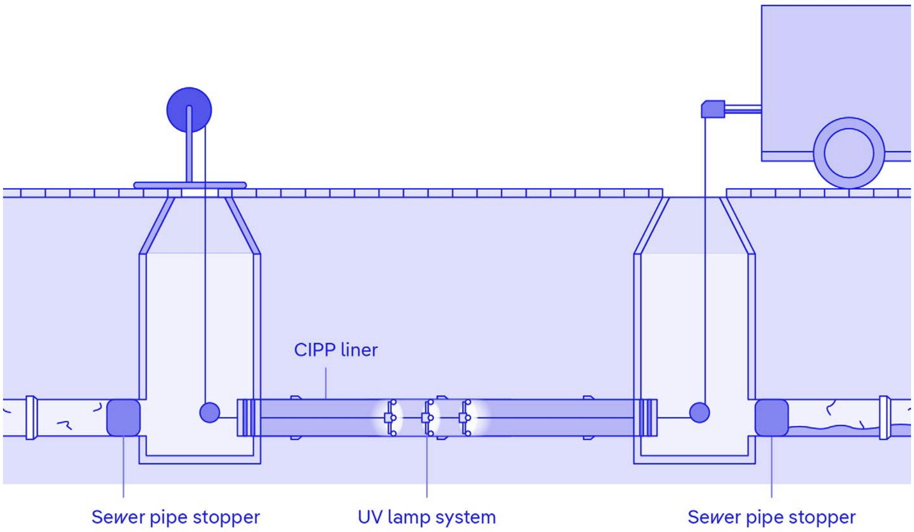


Fig. A: Curing of a CIPP liner during the installation process using a UV lamp system

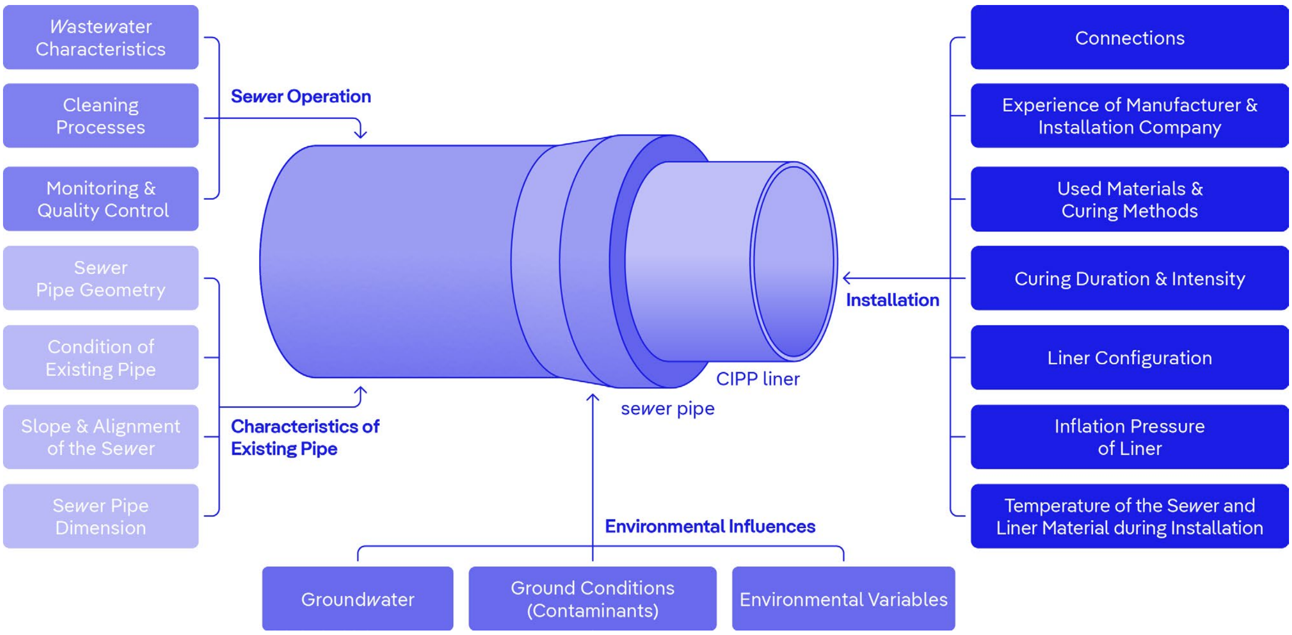
The increased adoption of this technology is yielding promising sewer renovation results. However, it also raises questions about the potential service life. According to manufacturers and the German Association for Water, Wastewater and Waste (DWA), the current technical service life assumption stands at 50 years. The materials and installation methods used have developed continuously over the past 30 years. Therefore, a 30-year-old sewer liner can only be compared to a 5-year-old one to a limited extent. Given the uncertainties surrounding the actual service life of sewer liners, a thorough investigation and, if necessary, reassessment of the service life specified in the regulations is imperative.

To ascertain the service life of CIPP liners, damage that shortens it and measures to ensure a long service life must be explored. In the SEMA Berlin 3 project, which is closely connected to and complements our SEMAplus tool ▶ (1), we address these issues with the help of three methods: a literature review, an analysis of damage to installed liners, and an interview campaign with operators of urban drainage systems, manufacturers of sewer liners, research institutes, consulting firms, and testing laboratories to gather information on their experiences and insights.

The investigation revealed a large number of influencing factors that impact sewer liners and their service life. The influences on a CIPP liner shown in Figure B include installation processes, environmental and operational factors, as well as decision-making processes related to strategic asset management. The service life of liners depends primarily on the quality of the installation. Ensuring a defect-free installation enhances the prospects of an extended service life for sewer liners. Just like with newly constructed sewers, CIPP liners should only be installed by trained and experienced installation companies, and comprehensive quality assurance should be carried out.

▶ (1) SEMAplus is a solution that uses statistical methods as well as machine learning techniques to create forecasts on the inventory and condition of sewer networks. By simulating different rehabilitation strategies for the development of the condition of the sewers, a customised and optimised rehabilitation concept can be created according to individual requirements. SEMAplus was developed by the KWB in close cooperation with Berliner Wasserbetriebe for practical use, has been in operational use in Berlin since 2019, and is currently also part of a research project in Lausanne (see also p.12).

Fig. B: Influences on the service life of an installed CIPP liner within a sewer pipe



SMART WATER

Project volume
€2.4 million (total volume), financed by the Federal Ministry for Housing, Urban Development and Building (BMWSB) and Kreditanstalt für Wiederaufbau (KfW)

Partners
Technologiestiftung Berlin; Berliner Wasserbetriebe; Senate Department for Urban Mobility, Transport, Climate Action and the Environment; Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen

Associated Partners
Bezirksamt Pankow, Stadtentwicklungsamt; Bezirksamt Friedrichshain-Kreuzberg, Straßen- und Grünflächenamt; Berliner Regenwasseragentur

Contact
Lisa Junghans
Franziska Knoche
Paul Schütz
Dr. Andreas Matzinger

Blue-green infrastructure

Blue-green infrastructure combines natural and artificial elements to improve the environment in urban areas. "Green" refers to green roofs, green spaces and infiltration swales, while "blue" refers to water surfaces and water features.

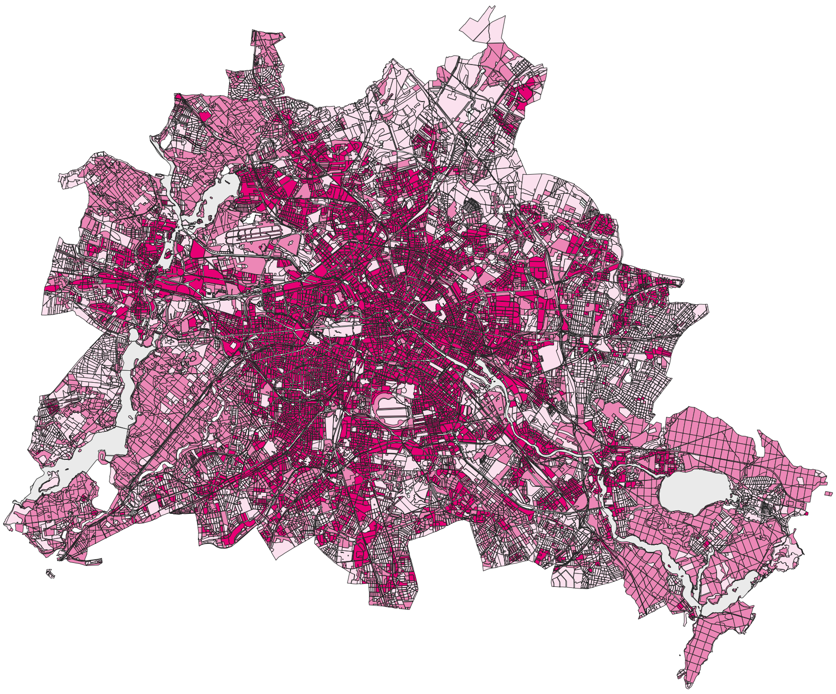
By implementing blue-green infrastructure, urban areas can be made more climate resilient and the quality of life of the population can be improved simultaneously. This is of great importance for future-oriented urban development.

Digital tools for a climate resilient city

Recent international climate negotiations quite clearly indicate that despite the efforts of many countries, implementation of agreed climate targets is being stalled. At the same time, the effects of climate change are becoming increasingly apparent. This is particularly true in cities, where the effects of climate change are further exacerbated by increasing urbanisation.

As a result, many cities and municipalities have developed climate change adaptation plans to strengthen the resilience of urban infrastructures and thus improve the quality of life of their populations. A key issue here is water: on one hand, there's flooding and water pollution caused by heavy rainfall, and on other hand, persistent heat and drought come from lack of rain. At the same time, local use of rainwater can mitigate the effects of climate change: blue-green infrastructure, for example, can increase evaporative cooling in the summer, reducing temperatures of surrounding neighborhoods. Such structures also result in less stormwater runoff into the sewer system, instead making the runoff available for irrigation of trees and plants.

The project Smart Water aims to address this disconnect. As part of Berlin's Smart City Strategy "Gemeinsam Digital: Berlin", Smart Water will enable the city's Senate and district administrations to integrate climate adaptation measures into planning processes. The goal is to speed up implementation of blue-green infrastructure developments and ensure buy-in by citizens.



The Berliner Wasserbetriebe, the Technology Foundation Berlin as well as the Senate Department for Urban Development, Building and Housing, and the Department for Mobility, Transport, Climate Protection and the Environment, are active project partners. The districts of Pankow and Friedrichshain-Kreuzberg, as well as the Berlin Rainwater Agency, also support the project. The funding is provided through the "Smart Cities Model Projects" programme, which is financed by the German government. In this project, KWB is developing three digital prototypes – a planning tool, a visualisation tool and a digital communication concept:

1. The planning tool will support the state and district administrations in integrating blue-green infrastructures in cities. These are intended to help contain heat islands and reduce water pollution and flooding of roads during heavy rain events. To accomplish this, a map-based web application showing locations with increased heat stress and high-risk flood zones during extreme rainfall events will be designed. Based on that, the tool will propose various blue-green infrastructure options and evaluate their feasibility, e.g. with regard to land availability, preservation concerns, gas pipelines and sewer networks, as well as the traffic-related suitability of areas. By providing this information, the tool can be used in strategic planning as well as in implementing specific blue-green infrastructure concepts.

2. The second tool is an instrument to both visualise and raise awareness about climate adaptation measures among residents, especially about blue-green infrastructure. It is likely to be applied, inter alia, in citizen engagement processes to ensure buy-in from citizens for various blue-green measures, and to encourage active involvement of residents to improve their neighbourhoods.

3. Finally, we are also developing a concept for improving digital communication during heavy rainfall events. On the one hand, we are planning to offer location specific information regarding flood risks and guidelines for how to protect houses during extreme rainfall events. On the other, we will be looking at a tool to improve operative communication between firefighters, police, and other first responders during heavy rainfall events.

All three prototypes are based on an interoperable data platform that links existing and newly generated data with models. This platform will be developed along with the prototypes and delivered to the administration at the end of the project. With our Smart Water project, we and our partners are making a decisive contribution to mitigating the effects of climate change in Berlin and making the city a smart and climate-resilient metropolis.

WaterMan

Project volume
4.4 Mio. € (total volume), financed by Interreg – Baltic Sea Region Program (European Union)

Partners
Region Kalmar County; Kalmar Municipality; Kalmar Water, Vastervik Municipality; Braniewo Municipality; Association of Polish Communes Euroregion Baltic; Gdansk University of Technology; Economic Chamber „Polish Waterworks"; Bornholms Water A/S; Bornholms Wastewater A/S; Association „Kleipeda Region"; Administration of Kleipeda District Municipality; Kleipeda University; Kurzeme planning region; Saldus Municipality

Contact
Elisa Rose
Pia Schumann
Dr. Ulf Miehe

▶ (1) In June 2023, we held our first workshop with the project partners. The workshop covered various options for water reuse and suitable treatment technologies, life cycle analyses, and risk assessment and management. Representatives from all six WaterMan partner countries attended the workshop in Schweinfurt, Germany, and visited the "Nutzwasser" research project of the Federal Ministry of Education and Research, which is coordinated by the Chair of Urban Water Systems Engineering at the Technical University of Munich. The participants gained insights into how municipal wastewater treatment plant effluent is further treated for reuse in irrigation of plants and sports fields, and benefitted from a lively exchange with experts from the TU Munich and the local water utility Stadtentwässerung Schweinfurt on experiences with local decision-makers and end users, as well as on risk management, acceptance, and demand for water reuse.

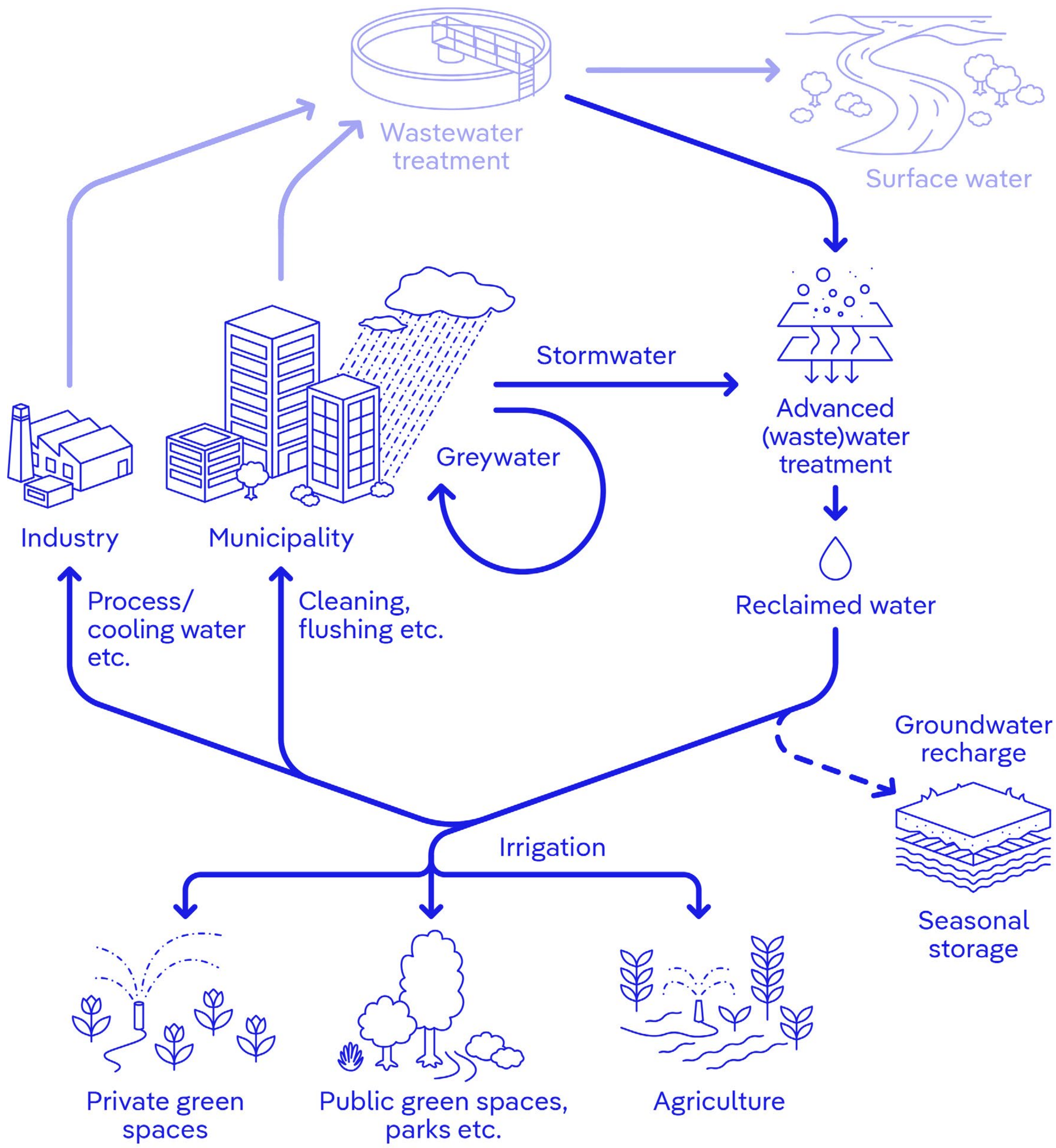
Fit for the future via *w*ater reuse – local capacity building in the Baltic Sea Region

Climate change effects pose major challenges to water management in the Baltic Sea region. Extreme weather events are becoming more frequent and are increasingly restricting water availability, while droughts limit water usage, particularly for irrigation purposes. Water scarcity is predicted to become even more severe in the future. In this context, water reuse is a key solution for reducing pressure on water resources, and is becoming increasingly relevant to local, regional, and even transnational stakeholders.

Along with 15 partners in the WaterMan project, KWB promotes water reuse as a new element of water management to make water supply more climate resilient in the Baltic Sea region. Although there are isolated examples of the use of alternative water resources, such as treated wastewater and urban stormwater runoff, broad application thereof is a long way off in this region. The primary actors for water reuse are local authorities and water and wastewater companies. WaterMan aims to build the knowledge and capacities of these key actors in this relatively novel topic.

The capacity building process in the WaterMan project, funded by the Interreg Baltic Sea Region program and coordinated by the Region Kalmar County in Sweden, involves a transnational peer learning process. Municipalities and water and wastewater companies from six countries collaborate to co-create exemplary water reuse strategies tailored for specific model regions. WaterMan combines measures for the reuse of treated wastewater, the use of rainwater and urban stormwater runoff, and promotion of stakeholder and consumer acceptance. Specific solutions for typical applications will be tested and validated in nine complementary water reuse pilot measures and case studies in Denmark, Poland, Latvia, Lithuania, Sweden, and Germany. Research institutions and domain experts will provide their knowledge and facilitate the capacity building in a series of workshops and trainings.

KWB supports the project partners in executing their pilot measures and developing future-oriented water reuse strategies. In pursuit of this goal, we are jointly developing guidance on established methods and available tools for application in the water reuse context. This will help local stakeholders to determine their local need for water reuse, to conduct an appropriate chemical and microbiological risk assessment, and to select suitable environmentally friendly water treatment technologies ▶ (1). The project will eventually develop a comprehensive and practical guideline for other local authorities and water and wastewater companies.



The water cycle with possibilities for non-potable water reuse

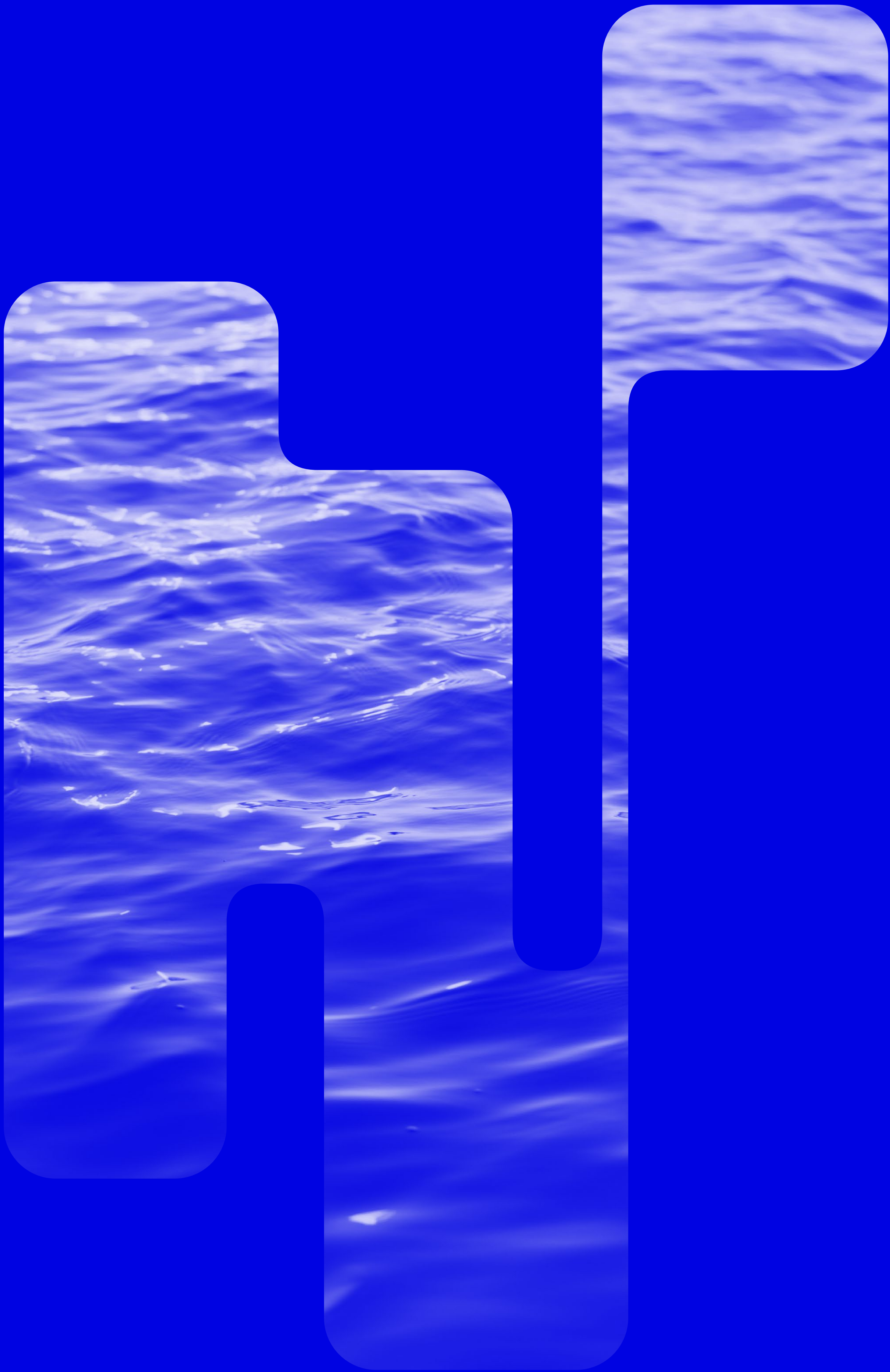
Leveraging our expertise in water reuse, knowledge exchange, and practical application of risk assessment and life cycle analysis, we are making an important contribution to alleviating strains on natural water resources and fostering climate-resilient water management in the Baltic Sea region through WaterMan.

Swimming out

For us, swimming out means taking a look into the future. Explore whether climate neutrality in water management is just a utopian vision, what insights water supply infrastructure can learn from the recent gas shortage, and how our SWIM:AI tool takes prediction of bathing water quality in rivers and lakes to a new level.

The following articles give
a glimpse into the future:

- ▶ Climate neutrality in water management
- ▶ Securing Germany's water supply through lessons learned from the natural gas shortage
- ▶ SWIM:AI



Climate neutrality in water management: realistic or idealistic?

Dr. Christian Remy

Human-induced climate change is one of the most pressing global environmental problems, as its detrimental impacts on humans and ecosystems are significant, diverse and difficult to assess. The warming of the atmosphere due to increased greenhouse gas (GHG) emissions also poses new challenges for water management, as both the availability and distribution of water will change significantly in the future. At the same time, the water sector itself also contributes to GHG emissions through the infrastructure construction and operation. Demands for climate neutral water supply and disposal systems are gaining momentum, prompting many enterprises in the water sector to incorporate climate neutrality to their strategic objectives and to strive to reduce their GHG emissions.

But what does climate neutral actually mean? Despite the widespread use of this term, a clear and concise understanding and definition of it is missing. Without a definition, it's difficult to record one's own GHG emissions, or to work out, implement and transparently report on concrete goals and suitable measures for emissions reduction. Furthermore, the question of whether the water sector is even capable of becoming completely climate neutral in the foreseeable future, and what action towards this might look like, also arises. So how realistic is the idea of a climate neutral water sector?

"Climate neutrality" – what does that actually mean?

The accounting of GHG emissions throughout a company's value chain is based on the internationally recognised Greenhouse Gas Protocol. (Bueno, 2021) This methodology specifies which GHG emissions are to be taken into account and how they can be recorded. By definition, all relevant GHGs are included, i.e. not only CO_2, but also nitrous oxide (N_2O), methane (CH_4), and other GHGs. Their effect on global warming varies, so all gases are assigned an effect factor relative to CO_2 ("CO_2 equivalents", also known as CO_2e) for calculation purposes. Nitrous oxide, for example, is 265x more intense than CO_2, and methane is 28x more harmful to the climate, related to a time horizon of 100 years (IPCC, 2023).

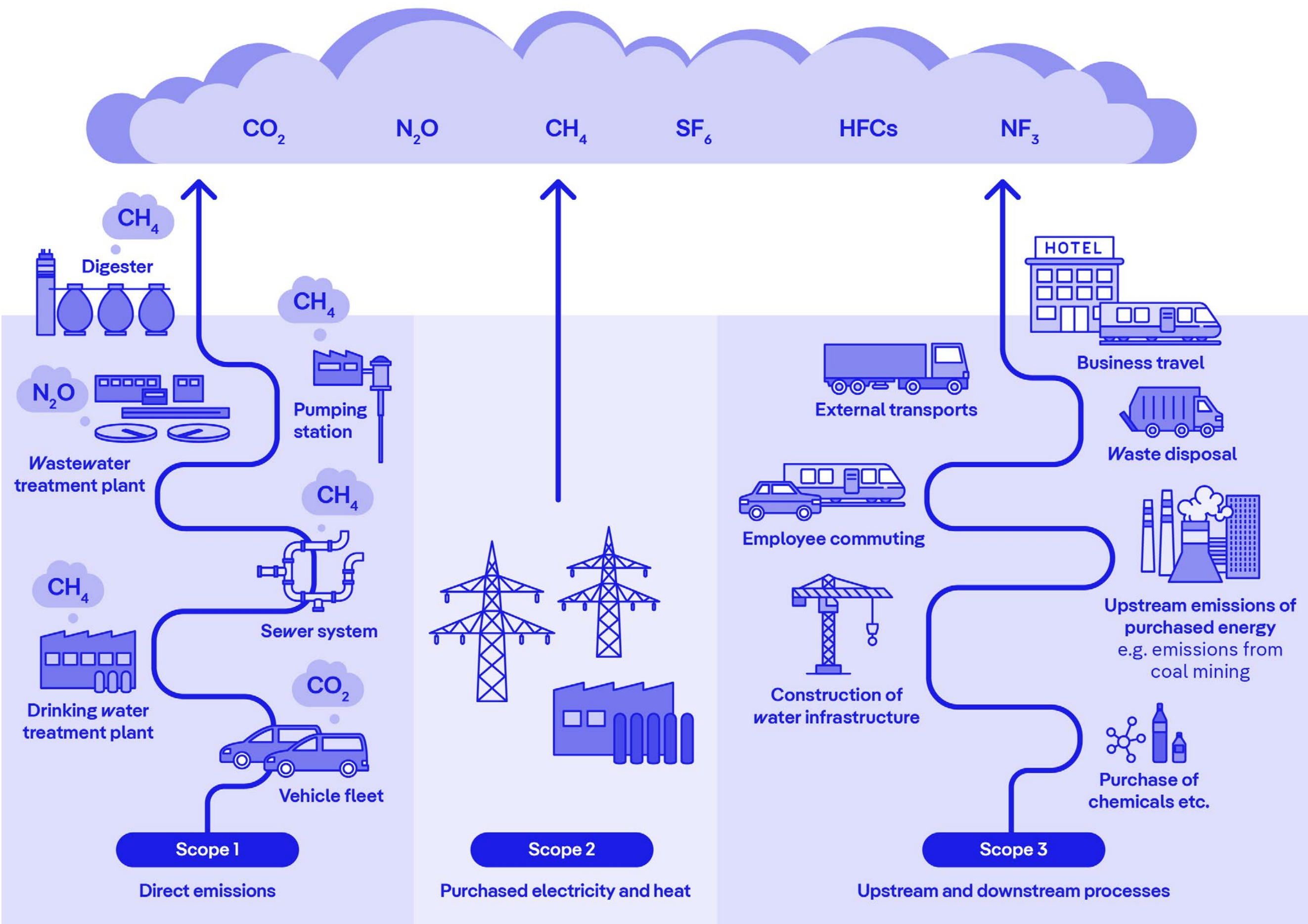
Another important requirement of the protocol is the division of the GHG balance into three distinct scopes (see Fig. A). Scope 1 describes the direct GHG emissions stemming from a company's own internal infrastructure operations on its premises. These are directly controlled by the company and can therefore be directly influenced. Scope 2 includes the indirect GHG emissions caused by procurement of electricity, heating or cooling. These include, for example emissions at a coal-fired power plant during the generation of grid electricity serving the company. Scope 3 represents all other processes and procedures related to business operations, extending both upstream and downstream of the company's core activities. This area is subdivided into 15 individual categories and ranges from purchased goods (e.g. chemicals or paper), to the construction of infrastructure, to waste disposal, to the commuting and business trips of the company's employees (WRI/WBCSD, 2013). Across these three areas, all activities relevant to and caused by the company's business activities are ultimately included in the GHG balance sheet.

To calculate a company's comprehensive GHG balance sheet, all three areas must be added up into a total sum. Only when the total sum of all activities balances out to zero can a company claim climate neutrality. This makes it clear that true climate neutrality is more than just the use of green electricity or the conversion of a vehicle fleet to e-mobility. The water industry is thus also dependent on many other sectors whose products or services are needed for water supply and disposal.

Scopes in *water* management

In terms of energy related GHG emissions (Scope 2), electricity consumption for the operation of water supply and wastewater disposal is by far the most important factor in the balance. Saving energy and using it as efficiently as possible is already a goal pursued by many companies and actively contributes to climate protection. Generating one's own electricity and heat, e.g. by using digester gas from sewage sludge treatment or operating one's own wind turbines, is also a good option for generating climate-neutral energy from renewable sources, and thus reducing the amount of energy drawn from the grid. Additionally, targeted purchasing of certified "green" electricity is also suitable for making energy consumption more climate-friendly and improving the carbon footprint. ▶

Fig. A: System boundaries of greenhouse gas emissions in the water sector for the three scopes of the Greenhouse Gas Protocol



As a result of the ongoing energy transition, grid electricity will be generated from wind, solar and other renewable sources in an increasingly climate-friendly way in the future, so that this factor will become less relevant for future climate balances. KWB has been able to show in studies that in the future, the release of processed digester gas as biomethane will be significantly more beneficial for climate protection than on-site electricity generation: this renewable "green gas" helps other sectors, such as heat generation or transport, to reduce their GHG emissions using a more climate-friendly fuel, and thus reduces the global climate footprint better than local generation of electricity (Remy et al., 2022).

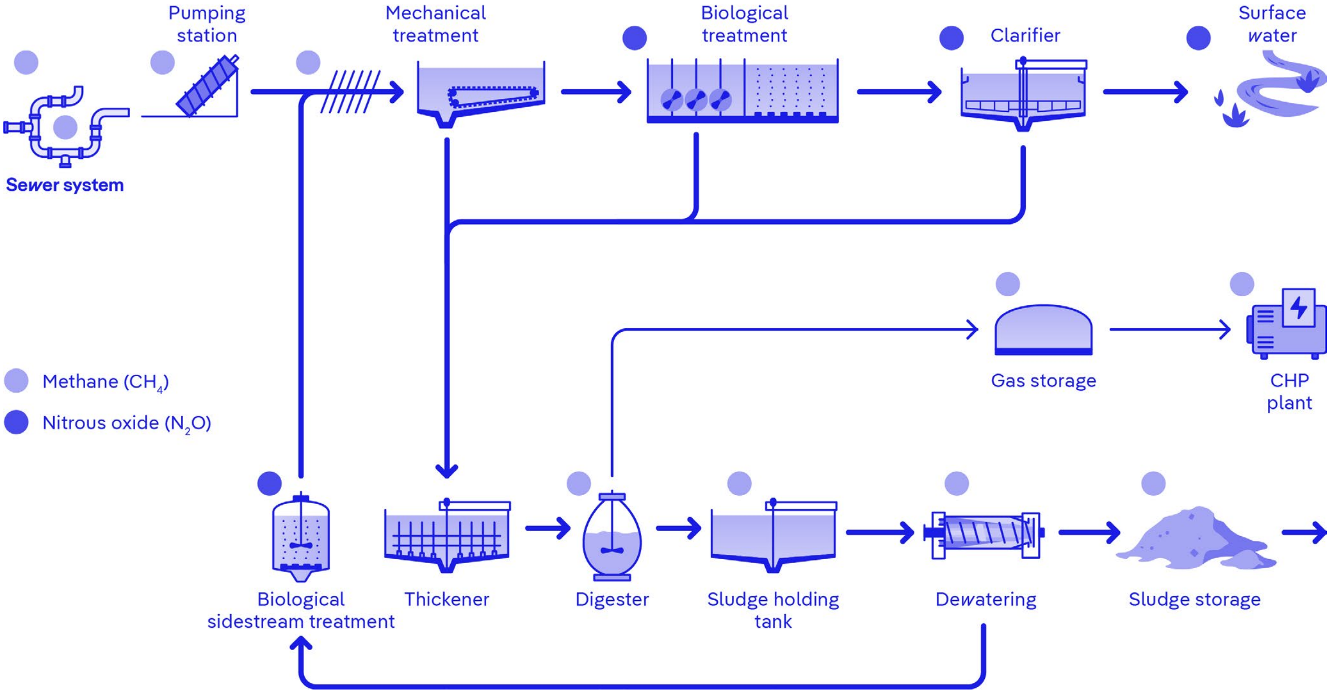
Another relevant contribution comes from direct GHG emissions from the operation of drinking water treatment plants, sewer networks and wastewater treatment plants (WWTP) (Scope 1). Nitrous oxide and methane, which are significantly more harmful to the climate than CO_2, play a major role here. Nitrous oxide can be produced during the biological conversion of nitrogen in wastewater treatment, when the bacteria involved become stressed due to changing conditions and produce nitrous oxide from the nitrogen in the wastewater. These mechanisms are now well researched, but the emission of nitrous oxide during operation of a WWTP can only be recorded and evaluated through targeted, long-term measurements. (EFRAG, 2022)

Since nitrous oxide emissions can vary greatly in terms of location and time, this is not an easy task. As part of the LASSO project, KWB is carrying out measurements of nitrous oxide at one of Berlin's WWTPs, and intensively exchanging information with other operators and researchers, including in the corresponding working group of the German Association for Water, Wastewater and Waste (DWA).

"The major goal of climate neutrality can only be achieved through co-operation with the other sectors and companies closely linked to the water industry via supply chains, construction services and energy procurement."

Methane can also form from the organic components of wastewater under low oxygen conditions, especially in the sewer network and during digestion of sewage sludge. Recording these diffuse methane emissions is also a challenge, but suitable measurement methods exist, and initial measures to prevent methane emissions have proven successful.

Fig. B: Potential sources of direct emissions of nitrous oxide and methane in wastewater treatment



Overall, however, direct GHG emissions from water management have not yet been systematically recorded and balanced. In the future, targeted and permanent monitoring will become necessary due to requirements in the revised EU Urban Wastewater Treatment Directive (UWWTD). In addition to recording emissions, suitable measures for reducing nitrous oxide and methane emissions can then be developed, tested and evaluated. However, it is important to keep in mind that from a national perspective, water management causes only a few percent of the total nitrous oxide and methane emissions, whereas other sectors (e.g. agriculture, waste) contribute significantly more.

"Ultimately, this major goal can only be achieved through cooperation with the other sectors and companies closely linked to the water industry via supply chains, construction services and energy procurement."

Upstream and downstream GHG emissions (Scope 3) have been generating more interest for some time now: however, due to the many different categories and actors involved, it's not easy for companies to record emissions in this area and balance them accordingly. For many aspects in the reporting, practical methods for collecting and evaluating both the necessary data from the company and the respective GHG factors are missing. KWB has been working on GHG balances for the water sector for a long time, and has comprehensively examined and evaluated procedures and concepts in many national and international projects. Together with Berliner Wasserbetriebe, we're currently working on a feasible methodology in the SCOPE3M project to record and report company wide GHG emissions in Scope 3. In the first step, it is important to define the essential categories and components, to harmonise the effort and benefit of calculating the carbon footprint and to align it with the goals, using questions such as do I need an initial, low effort assessment of my carbon footprint, or do I want to develop, report and monitor the impact of precise information, starting points for strategies, and climate protection measures? Various approaches can be developed to record the individual areas in a meaningful, comprehensive way, and to involve the company's employees. For purchased chemicals or waste disposal, for example, average values from databases or studies can be used if the relevant supplier or service provider cannot provide their own GHG assessment. In construction projects, the many different processes and actors make calculating a complete GHG balance difficult. Here, different levels of detail are helpful to provide involved parties with suitable options for climate-friendly construction, while keeping the effort of balancing manageable. A look beyond national borders is also helpful: in countries such as Denmark, England and France, comparable developments for GHG accounting in the water sector can provide a blueprint. In the long term, a more precise assessment can also lead to the development of suitable measures to significantly reduce GHG emissions in Scope 3. ▶

Not Utopia: climate neutrality in water management

Creating a comprehensive corporate climate balance is a task that should not be underestimated, and requires the appropriate amount of time and resources. In addition to suitable methods, cooperation between the different areas of a company is also important and must be prioritised from the beginning. We support this task with scientific know-how and practical methods for advancing climate protection in water management and anchoring it in daily operation. Future requirements for monitoring and reporting GHG emissions play a major role here, since this is now required in the EU's Sustainability Reporting Directive (EFRAG, 2022).

But what can we expect? Will the water industry become completely climate-neutral in the foreseeable future? And how can this happen? Ultimately, this major goal can only be achieved through cooperation with the other sectors and companies closely linked to the water industry via supply chains, construction services and energy procurement. It's important to include climate protection as a basis for operational decision-making on investments and strategies, and to use climate-friendly products, processes and infrastructures. Also, knowledge about one's own climate footprint and the impact of various measures and alternatives is crucial for companies to make informed decisions and thus actively contribute to climate protection. Suitable paths towards climate neutrality are already well established in the energy sector and are politically mandated via the energy transition. In the case of direct emissions of nitrous oxide and methane, recording and evaluation is still difficult, and suitable measures for reduction still need to be developed and reviewed. In the complex balancing of Scope 3, it makes sense to develop a sector-wide, coordinated balancing method and thus offer all companies in the water sector a comparable basis for their climate balances.

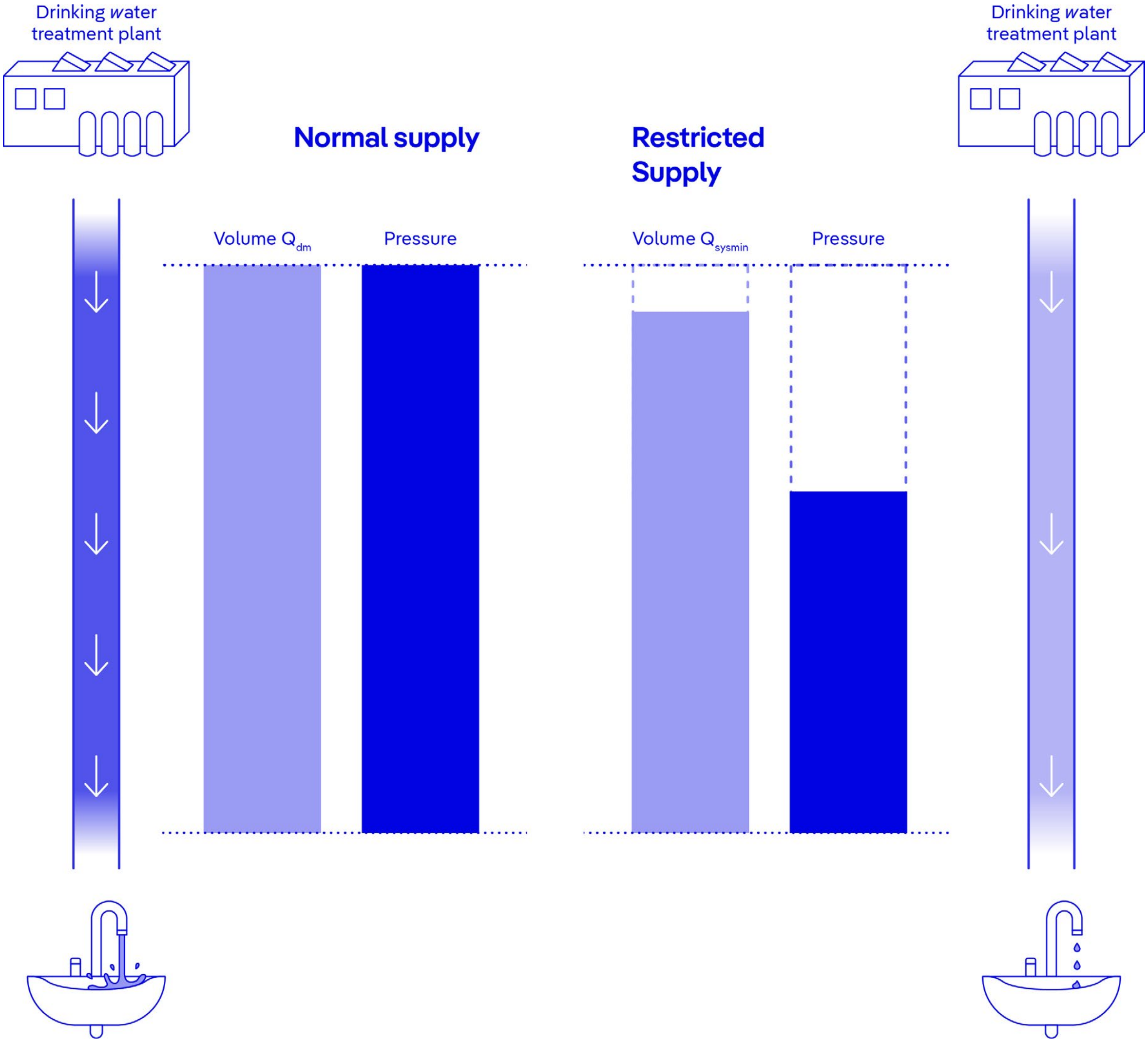
From today's perspective, complete climate neutrality in water supply and wastewater disposal still seems a long way off: even if green energy and climate-friendly chemicals become increasingly available in the future, the direct emissions of nitrous oxide and methane at WWTPs are much more difficult to record and probably cannot be completely avoided. Also, upcoming major undertakings to maintain and expand infrastructure in addition to increasing requirements, e.g. the quaternary treatment stage in wastewater treatment, will cause more emissions in the climate balance. Here, careful balancing of the different goals is important. Priority should still be given to the core task of sustainable water supply and disposal, but it should be as climate-friendly as possible. Ultimately, complete climate neutrality can only be achieved through the climate neutrality of all products and services used in the water sector. We will benefit from the joint efforts of all sectors to reduce the GHG emissions of their activities in the long term. In the end, unavoidable GHG emissions can then be neutralised in the balance sheet, through appropriate promotion of other climate protection measures via compensation. However, this should not be an excuse to neglect our own climate protection in the water sector: significant contributions towards a more climate-friendly water sector are already possible today via suitable measures. In addition to having a practical accounting method, regular and transparent monitoring and reporting also play a major role in clearly communicating a company's climate protection efforts. Climate protection is no longer "nice-to-have", but an essential task to enable a sustainable future for all of us on this planet! ●

Better safe than sorry

Securing Germany’s *water* supply through lessons learned from the natural gas shortage

Dr. Lisa Broß

Fig. A: Maintaining pipeline based drinking water supply



Once upon a time, there was a cold winter in Germany. Every day, people comfortably heated their apartments, and the economy thrived as usual. Fossil fuels were imported from afar in abundance and everyone enjoyed a carefree existence. However, this sense of security was shattered when reality struck with force. A nearby war disrupted supply chains, which led to a shortage of fossil fuels, and energy prices surged as the government hurried to secure natural gas for households. The repercussions for society were significant. The incident sparked a widespread call to transition from fossil fuels to renewable energy sources, with the shared aspiration of achieving a sustainable energy supply for Germany. The lingering question remains: Will this dream come true?

"To enhance the resilience and security of *w*ater supply systems, it is crucial to engage in appropriate emergency preparedness planning rather than relying on ad hoc coping responses."

The current energy supply situation in Germany is significantly more complex than the story above. The challenges and changes in the energy sector have been driven by various factors, such as the Paris climate targets, the gradual elimination of nuclear power, and the push for greater utilisation of renewable energy sources. However, the recent Russian aggression against Ukraine has brought energy security to the forefront, making it more relevant and crucial than ever before. Both the European Union and the German government have emphasised their commitment to achieving complete independence from Russian oil and gas supplies.

Human-induced climate change impacts the hydrological cycle and the availability of water resources. Padron et al (2020) revealed a spatial variation in the average water availability during the driest month of the year over the past three decades, compared to the first half of the twentieth century. Some regions, including in Europe, have experienced increased water availability, while others have witnessed a decrease. Presently, Germany is also facing challenges related to water resources. Falling groundwater levels, reduced groundwater recharge, low surface water levels, and increased water consumption during hot days are causing an imbalance in water resources and affecting storage capacity, as highlighted by La Jeunesse et al. (2016). This situation poses a threat to the security of the drinking water supply in certain parts of the country. Over the past six years, especially since 2018, German water utilities have encountered significant difficulties in ensuring public water supplies during the summer months. Several studies, including Ashoori et al. (2016), Toth et al. (2018), Manouseli et al. (2019), and Xenochristou et al. (2020), have demonstrated a positive correlation between water demand and temperature. A survey of 28 water utilities in Germany revealed that nearly 60 percent of them reported peak water deliveries during the summer of 2018, ranging from 100-150% of the average daily delivery for July and August, as documented by Simon et al. (2019). Additionally, one-third of the utilities experienced peak discharges between 150-200% of the average daily discharge for the two summer months. ▶

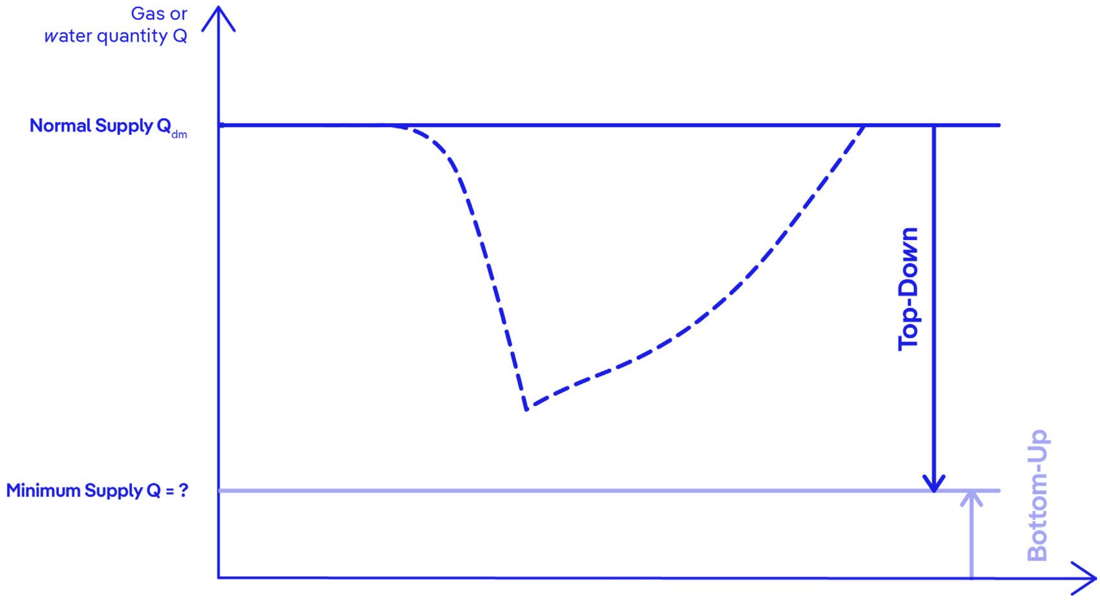


Fig B: Approaches for determining the amount of water required

Although driven by different factors, the gas and water supply sectors in Germany are confronting similar challenges, including decreasing supply, restrictions on consumption, and ensuring the provision of essential public services during emergencies. In the case of gas supply, the initial situation is characterised by a shortage of local gas resources, leading to heavy reliance on supplies from distant regions. One potential solution to address the shortage is to substitute gas with other energy sources, particularly renewable ones. This approach would help alleviate the shortage and reduce dependence on external gas suppliers. In the water supply sector, extraction typically occurs in close proximity to the local area. In the event of a shortage, replacing water extraction becomes a challenging task, requiring significant and costly infrastructural changes, the feasibility of which is questionable. However, measures can be taken to mitigate the impact of water scarcity: effective water-saving initiatives can reduce the demand for drinking water, or in some cases, lower quality water can be used for certain purposes.

To ensure reliable supply of water, it is essential to enhance the short-term resilience of water supply systems. The resilience of these systems is determined by the existing capacities to withstand damaging events and the availability of resources, which are not only finite but also distributed differently at local and regional levels. Resilience in critical infrastructures, such as gas or water supply, is often assessed using a performance-based resilience curve, as described in studies by Bruneau et al. (2003), Cimellaro et al. (2007), McDaniels et al. (2008), and Zobel (2010). When applied to a water supply system, this curve represents the average daily water demand (Qdm) that is typically delivered to consumers during normal operations. The curve can then depict the time course of impairment caused by a damaging event and illustrate its impact on the system's performance.

Ensuring *w*ater supply

Russia's gas supply to Germany fell significantly in 2022 and 2023. Both the European Commission and the German government are taking proactive measures in case of an acute gas emergency. The gas emergency plan of the European Community of States stipulates a 15% reduction of gas consumption among member countries. If voluntary savings are insufficient, in Germany, the Federal Network Agency can intervene in a regulatory capacity as the federal gas load distributor. Under this regulatory intervention, the withdrawals of non-protected customers are limited. Non-protected customers include those who do not fall into any of the three categories of protected customers: (i) household customers and small and medium-sized enterprises in the commercial, trade, and services sector, (ii) basic social services, and (iii) district heating plants that supply heat to the aforementioned customer groups and cannot switch fuel supply.

"To ensure safe *w*ater supply, establishing a registry similar to the gas platform, *w*here large *w*ater customers *w*ould be required to register their minimum *w*ater demand, *w*hich *w*ould managed by a central government authority, is recommended."

To assess the potential for savings among non-protected customers, the Federal Network Agency created a digital platform where all large gas consumers must register and provide their minimum gas requirements. This top-down approach helps determine the minimum technical quantities required to maintain a functioning system, as explained by Fekete et al. (2021). The data collected through this platform supports the Federal Network Agency in making informed decisions regarding necessary supply reductions during a crisis.

Determining the amount of water needed can be done using a bottom-up as well as a top-down approach (Figure B). The bottom-up approach focuses on identifying the minimum amount of water necessary to fulfill vital needs. This approach assumes that there is a lower limit below which consumers cannot function without sufficient water supply. On the other hand, the top-down approach aims to determine the acceptable losses in quantity or quality of water. It considers the minimum technical quantities of water required to maintain the overall system's functionality or to prevent reaching a critical "point of no return" (Bross et al. 2019). The bottom-up approach is thus based on the requirements of consumers, whereas the top-down approach is based on the requirements of the technical system, specifically on the water distribution network.

In drinking water supply, minimum supply standards are indicated by the amount of water needed for survival or medical care, particularly in the context of humanitarian aid (Sphere, 2018; UNHCR, 1992). In regular operation and under restricted supply scenarios, the German drinking water supply system operators are required to provide at least 50 litres per person and day through the grid-based supply (BMI, 2016). However, the volume required to maintain the gridbased drinking water supply depends on various factors, such as the structure of the supply network, the supply pressure, and the possibility of temporary disconnection of subareas (Bross et al., 2019). To ensure the safe operation of water supply systems in the face of climate change impacts, it is essential to identify minimum water volumes through a top-down approach. This involves utilising hydraulic models to analyse potential water-saving measures. Additionally, determining the minimum requirements for large consumers, especially critical infrastructures like hospitals, is crucial. ▶

To ensure safe water supply, establishing a registry similar to the gas platform, where large water customers would be required to register their minimum water demand, which would managed by a central government authority, is recommended. In Germany, the management should be entrusted to the highest water authority of the federal states, as the maintenance of the platform would benefit from their extensive knowledge of water supply systems during normal circumstances. When setting up the registry, it is essential to consider the intended use of the water to prevent wasting valuable resources. By incorporating this information, water utilities can access relevant parts of the database during periods of water scarcity. This enables them to make necessary adjustments to network supply and management, ensuring efficient and effective water distribution.

*W*e need change, *w*ithout delay

Considerable literature has been published regarding Europe's dependence on Russian gas and the potential consequences of developments such as the North Stream 2 pipeline construction (Balmaceda, 2013, 2021; Gustafson, 2020). However, only Russia's war of aggression against Ukraine and the subsequent sanctions imposed on Russia intensified the urgency for action. This increased pressure has led to a reduction in obstacles and a noticeable acceleration in the expansion of renewable energy generation. Nevertheless, political discussions concerning the increased use of coal-fired power plants and the extension of nuclear power plant lifespans indicate that the transition to a reformed energy generation system can only be achieved at the expense of significant setbacks in climate protection efforts.

Climate change will have significant direct impacts on water supply, affecting both the availability and quality of raw water as well as the functioning of supply infrastructure. While climate change has received attention in recent years, public focus can shift quickly when faced with more immediate crises such as Russia's aggression against Ukraine and subsequent gas shortages (Spisak et al., 2022). The crucial lesson to learn from this is that change should not be delayed until pressured by crisis escalation and media attention. Immediate actions are required to ensure a future-proof water supply, considering that the effects of climate change are already causing regional disruptions in water availability. To enhance the resilience and security of water supply systems, it is crucial to engage in appropriate emergency preparedness planning rather than relying on ad hoc coping responses (Bross et al., 2020). In this context, organisations like KWB contribute by developing research-based solutions directly applicable to practical challenges, addressing the acute need for solutions. ●

SWIM:AI

Machine learning and swimming for everyone!

Wolfgang Seis
Dr. David Steffelbauer

Access to environmental data is expanding due to digital services and open access data platforms. For example, the German Weather Service provides access to meteorological data, while Berlin's "Wasserportal" offers hydrological and water quality data. This increased availability of data paves the way for new digital services that can support real-time decision making in water management.

One such application is the use of data driven models to predict bathing water quality in rivers and lakes susceptible to episodes of short-term pollution. Studies have shown that data on rainfall, streamflow, and urban drainage system discharges (e.g. combined sewer system and stormwater) can accurately predict faecal pollution peaks. Unlike traditional laboratory methods that involve long wait times for results, model-based management allows for rapid response, enabling real-time monitoring and forecasting of pollution episodes. This timely information is crucial to protect swimmers from health risks caused by faecal pathogens.

Despite the benefits of model-based water quality management, widespread adoption is hindered by the need for programming and modelling skills. Recognising this challenge, KWB's Hydroinformatics group is dedicated to exploring new modelling approaches and data sources for water management while also developing user-friendly software solutions.

We're pleased to introduce SWIM:AI, a software already used in practice which is designed to facilitate the development and implementation of machine learning (ML) models for bathing water quality management. With SWIM:AI, users without advanced programming skills can train and evaluate their own ML models. The software also offers a flexible data transfer module, allowing prediction of daily water quality without additional programming effort.

SWIM:AI builds on KWB's expertise in bathing water quality management. This expertise was developed within the projects FLUSSHYGIENE, funded by the Federal Ministry of Education and Research (BMBF), the LIFE project iBathWater, and the H2020 project digital-water.city. Let's take a closer look at what makes SWIM:AI the go-to solution for protecting bathers' health.

Supporting informed decisions

SWIM:AI is dedicated to streamlining the process of creating and implementing ML models for authorities and managers in charge of bathing areas. Given informative historical datasets, these models can accurately predict pollution events in recreational waters. However, SWIM:AI does more than just predict water quality. It provides end-users with a comprehensive set of tools to manage data sources, develop prediction models, and generate recurring predictions for specific bathing waters.

It's important to note that the final decision on whether it's safe to swim still rests with the responsible authorities. SWIM:AI's role is to provide data-driven recommendations to support informed decisions.

Multiple services

SWIM:AI is a software package that provides users with multiple services:

Service 1: Modelling Engine and Content Management System (CMS)

With this service, users can tap into the predictive potential of ML models by extracting valuable insights from paired historical data. By inferring model parameters throughout the training process and visualising training results, we enable users to evaluate the predictive accuracy of a given configured model.

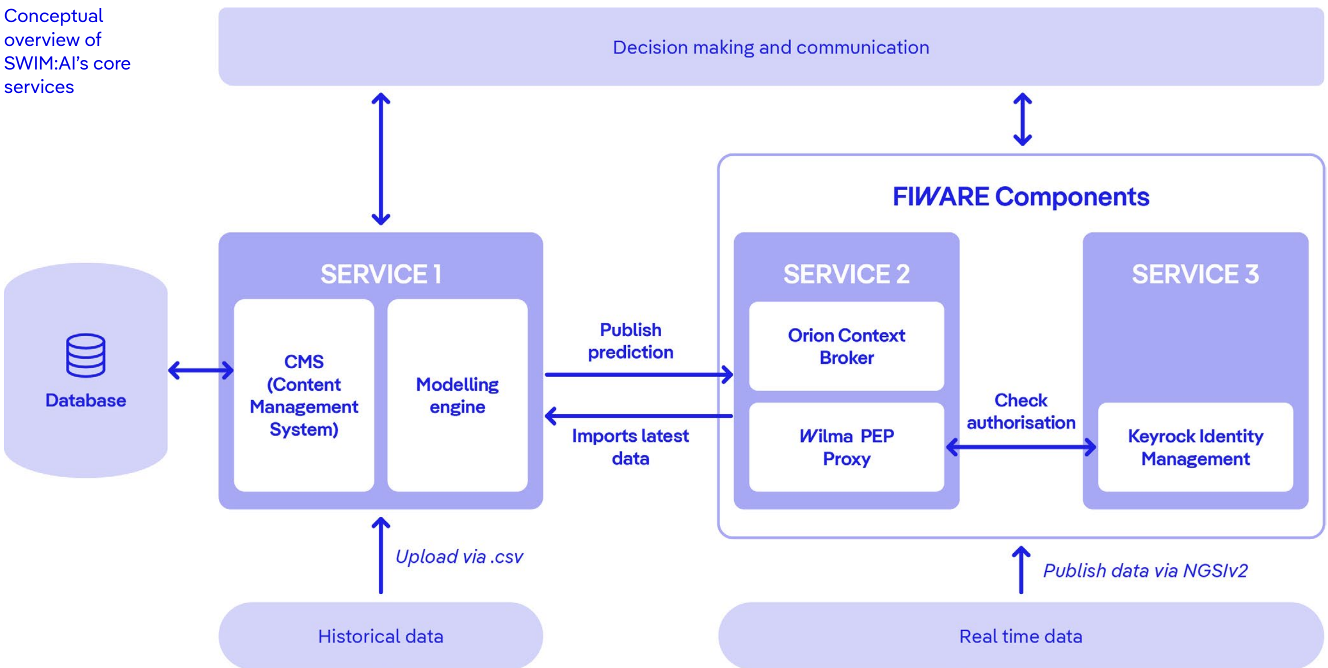
Our user-friendly graphical user interface (GUI) makes the training process a breeze. One can easily create, delete, and update sensors and data sources with a simple drag-and-drop feature on an interactive map. Data sources may either be classified as "BathingSpot" (target variable), or "FeatureData" (predictor variables). We focus on faecal indicator organisms as the target variable, while the predictor variables include hydrological quantities like antecedent precipitation, river flow, and discharges from wastewater treatment plants and combined sewer overflows. To upload historical data for training, the user can use a ".csv file", which will be securely stored in a PostgreSQL database.

Once the data is in place, the user can select various target and predictor variables and configure multiple candidate models. After model training the user is provided with multiple indicators for inspecting the quality of the fitted model. Model training is based on the scikit-learn library, with an extension to the skranger module, which implements a model type referred to as quantile random forest. Finally, the user has the flexibility of choosing between using a single model or multiple models for periodic predictions.

Service 2: The Data Transfer Module

Once the ML model is fully trained and deemed useful by the user, it needs fresh input data to make accurate predictions. This data is based on the predictor variables used during the training phase. To keep predictions up-to-date, it's crucial to integrate the latest data into the system. ▶

Conceptual overview of SWIM:AI's core services



In SWIM:AI, we've simplified this process by implementing a standardised API based on the FIWARE NGSI-v2 standard. FIWARE offers open source software components specifically designed for Smart City and Internet of Things (IoT) solutions. One of its key components is the Orion Context Broker, which facilitates the seamless exchange of data between data providers and users.

Our system eliminates the need for compatibility with various export formats, making data exchange hassle free. Data providers, such as water supply companies, always maintain full control over their data. They can decide which data is shared without the need for granting direct access to their IT systems. By publishing their data to the Orion Context Broker, they ensure data integrity.

Service 3: Securing the Orion Context Broker
The Orion Context Broker does not provide authentication or authorisation out-of-the-box. To prevent unauthorised access to the Orion Context Broker, SWIM:AI implements additional FIWARE security components: KeyRock Identity Management and the Wilma PEP Proxy Server. Each data entity in the Context Broker's database is linked to a specific user or owner in the KeyRock Identity Management system. Therefore, only authorised users who are owners of a specific sensor have the ability to modify and update data sources. This safely counteracts unauthorised access.

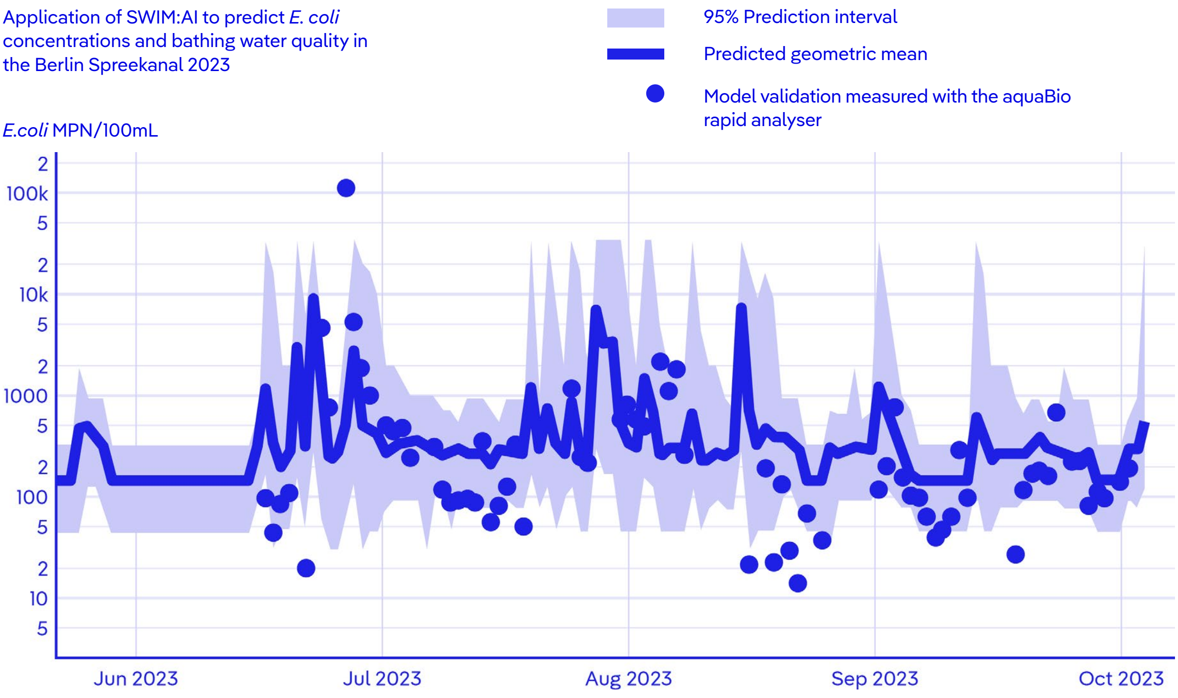
Together, KeyRock and Wilma enforce OAuth 2.0 standards for authentication and authorisation, ensuring that only authorised users can make changes.

Software architecture

When it comes to the programming language and software architecture, SWIM:AI was designed in Python. Python is not only easy to read, but it's also perfect for ML, general programming, and web programming tasks. For Python several excellent web frameworks exist, with Django, Flask and FastAPI being the most popular ones. Django was chosen for SWIM:AI. Why? Well, there are several reasons:

- Its monolithic software architecture simplifies deployment with a single code base;
- It prioritises security, offering protection against cross-site scripting and SQL injection;
- Working with geographical data is easy due to its GeoDjango capabilities;
- With a huge community (71,000 stars on GitHub), support and resources are never far away;
- The user friendly admin interface simplifies management and control;
- Finally, it supports multiple relational database backends, with a preference for the powerful PostGIS SQL backend, for long-term storage.

Application of SWIM:AI to predict *E. coli* concentrations and bathing water quality in the Berlin Spreekanal 2023



Components	General description	Programming language	Use
Django	Web framework	Python	Graphical user interface, backend services
PostGIS SQL	Database backend	SQL	Long term data storage
Orion Context Broker	C++ implementation of the NGSIv2 REST API	C++	Data exchange
Keyrock	Authentication and authorisation	Node.js / Javascript	Securing the context broker instance
Celery	Task queue	Python	Managing periodic tasks, predictions
Redis	Open source, in-memory data store used as message broker	ANSI C	Broker for managing periodic tasks
Ansbile	Automation software	Python	Deployment and maintenance

Table 1: Software components of SWIM:AI

From the very beginning, SWIM:AI was designed to be and built solely on open source technologies (Table 1), using tools like Django (web framework), Leaflet (mapping library), Celery (task manager), Redis (message broker), and the Orion Context Broker. It is publicly available on GitHub under General Public License, allowing for both private and commercial use as long as the resulting products remain public.

Successfully used in practice

The potential use cases for SWIM:AI are many. It has already been successfully tested at multiple river bathing locations in Germany and France, using hydro-meteorological data such as river flow, rainfall, discharges from wastewater treatment plants and discharges from combined sewer overflow outlets to manage bathing water quality. Currently, an adapted version of SWIM:AI is being utilised in Berlin, where predictive models are combined with real-time information about discharges from combined sewer overflows, flow-time models to estimate the during of predicted contaminations, and rapid E.coli analysis provided by the aquaBio system of the company ADASA. This combination was mainly developed during the project iBathWater, and continues to operate in cooperation with FLUSSBAD e.V., an organisation that aims to reactivate the Spree Canal as a recreational space in the heart of Berlin.

But the possibilities don't stop there. The backend developed for SWIM:AI can easily be adapted for other applications involving real-time monitoring and prediction algorithms. Whether it's controlling water treatment processes or ensuring data validation in digital twin applications, SWIM:AI's architecture may be used to support environmental decision-making in other fields of water management.

In the realm of bathing water management, SWIM:AI is constantly evolving. We're developing innovative algorithmic approaches that combine autonomous and incremental model training with risk-based decision-making approaches.

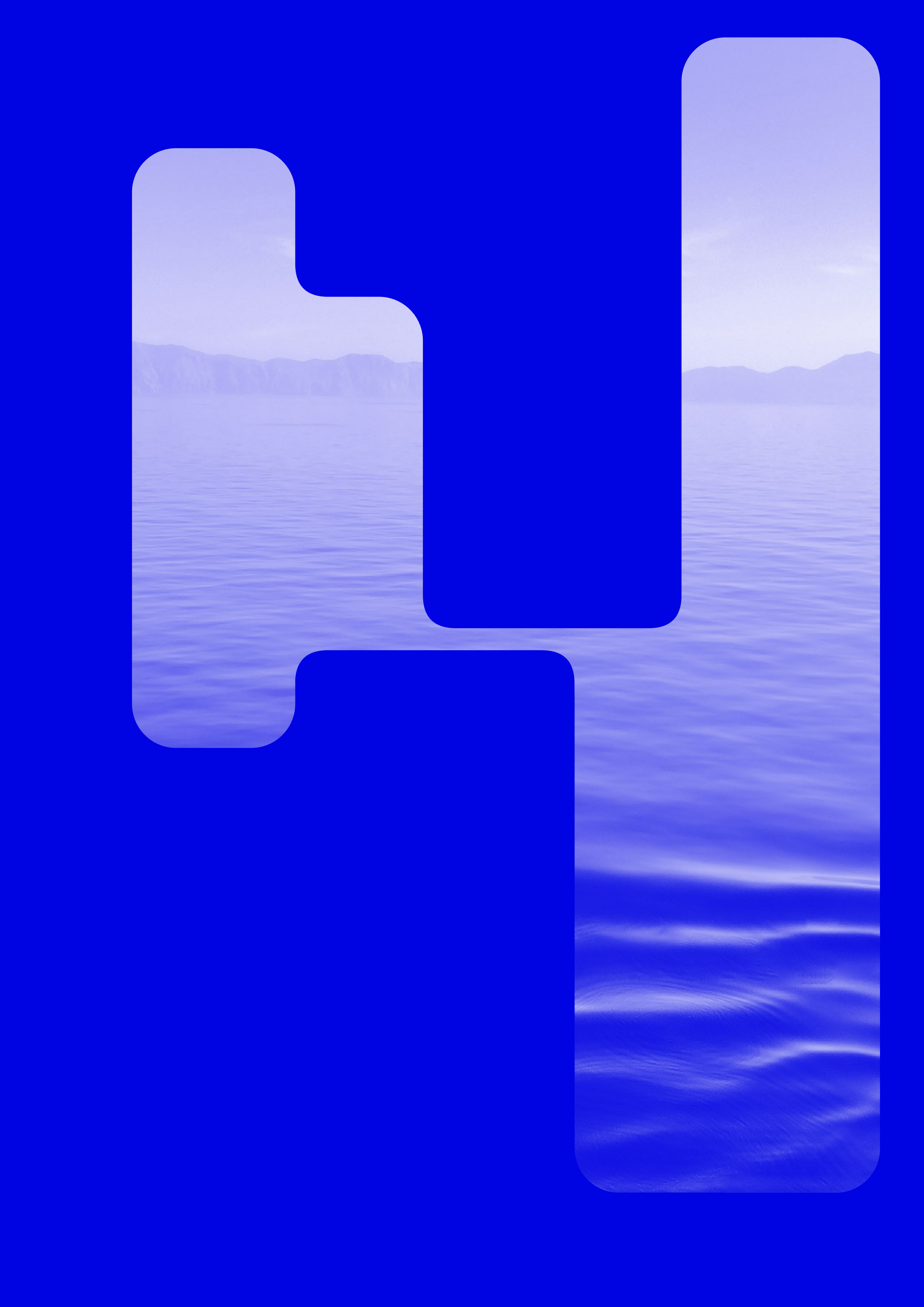
Our vision is to continue to effectively support decision-making processes in the field of public health and beyond with tools such as SWIM:AI. ●

Docking

After swimming out, we dock again. On the following pages, you'll meet our staff and get a look behind the scenes. You'll also get an overview of our ongoing projects and publications.

Back on land, the following awaits you:

▶ Team
▶ Behind the scenes
▶ Project overview
▶ Publications



Team

Dwight Baldwin
Researcher
Groundwater

Sandra Banusch
Head of Research &
Business Development

Viola Bender
Office Manager
Administration

Dr. Nicolas Caradot
Group Leader
Smart City & Infrastructure

Lea Conzelmann
Researcher
Energy & Ressources

Tobias Evel
Group Leader, Commercial
Manager, Administration

Lukas Guericke
Researcher
Hydroinformatics

Jonas Hunsicker
Researcher
Treatment Processes

Prof. Dr. Martin Jekel
Managing Director

Lisa Junghans
Researcher
Stormwater & Surface Waters

Jeannette Jährig
Researcher
Treatment Processes

Dr. Anne Kleyböcker
Researcher
Energy & Ressources

Lina Knaub
Dual Student
Administration

Franziska Knoche
Researcher
Stormwater & Surface Waters

Johannes Koslowski
Researcher
Energy & Ressources

Fabian Kraus
Researcher
Energy & Ressources

Moritz Lembke-Özer
Group Leader
Communications

Dr. Andreas Matzinger
Group Leader
Stormwater & Surface Waters

Dr. Ulf Miehe
Department Leader Process Innovation & Group Leader Treatment Processes

Kristine Oppermann
Project Controller
Administration

Francesco Del Punta
Researcher
Smart City & Infrastructure

Dr. Christian Remy
Group Leader
Energy & Ressources

Elisa Rose
Researcher
Energy & Ressources

Michael Rustler
Researcher
Groundwater

Franziska Sahr
Researcher
Smart City & Infrastructure

Rabea-Luisa Schubert
Researcher
Treatment Processes

Pia Schumann
Researcher
Energy & Ressources

Nikolaus de Macedo Schäfer
Researcher
Smart City & Infrastructure

Jan Schütz
Researcher
Treatment Processes

Paul Schütz
Researcher
Smart City & Infrastructure

Wolfgang Seis
Researcher
Hydroinformatics

Hauke Sonnenberg
Researcher
Hydroinformatics

Dr. Christoph Sprenger
Researcher
Groundwater

Michael Stapf
Researcher
Treatment Processes

Dr. David Steffelbauer
Group Leader
Hydroinformatics

Sonja Sterling
Graphic Designer
Communikation

Dr. Daniel Wicke
Researcher
Stormwater & Surface Waters

Malte Zamzow
Researcher
Stormwater & Surface Waters

Dr. Veronika Zhiteneva
Researcher
Treatment Processes

Trainees

KWB is supported by a wealth of up-and-coming talent from a wide range of specialisations. Not only are we proud of being able to provide them with support (such as by assisting them with their numerous final projects), we're also benefiting from their future-oriented ideas.

Elif Selin Adic
Technische Universität Berlin, Technischer Umweltschutz

Maria del Mar Alarcia Blanco
Technische Universität Berlin, Technischer Umweltschutz

Konrad Billian
Freie Universität Berlin, Geologische Wissenschaften

Finja Brendecke
Praktikum, Maschinenbau

Celine Cera
Hochschule Furtwangen, Angewandte Biologie

Annika Dankmeyer
Universität Duisburg Essen, Management and Technology of Water and Waste Water

Evelina Dietrich
Hochschule für Medien Kommunikation und Wirtschaft, Medien- und Wirtschaftspsychologie

Thomas Exner
Technische Universität Berlin, Technischer Umweltschutz

Sven Florian Fröhlich
Technische Universität Berlin, Technischer Umweltschutz

Johann Adrian Gamboa Carrillo
Technische Universität Berlin, Technischer Umweltschutz

Juliane Geißler
Technische Universität Berlin, Technischer Umweltschutz

Felix Gerhardt
Technische Universität Berlin, Technischer Umweltschutz

Sarah Gross
The University of Edinburgh, Chemical Engineering

Jonas Krohm
Technische Universität Berlin, Bauingenieurwesen

Deira Linke
Hochschule für nachhaltige Entwicklung Eberswalde, Global Change Management

Qiuyue Liu
Technische Universität Berlin, Bauingenieurwesen

Melina Meng
Technische Universität Berlin, Technischer Umweltschutz

Jette Michalski
Freie Universität Berlin, Biodiversity, Evolution and Ecology

Bruno Nadelstumpf
Universität Stuttgart, Umweltschutztechnik

Miriam Schelle
RWTH Aaachen, Umweltingenieurwissenschaften

Benedikt Schwehn
Technische Universität Berlin, Environmental Science and Technology

Vivian Pauline Stöckl
Humboldt-Universität zu Berlin, Geographie

Tasmina Bahadur Surma
Universität Duisburg Essen, Management and Technology of Water and Waste Water

Smilla Tettenborn
Hochschule für Technik und Wirtschaft Berlin, Kommunikationsdesign

Lea Alexandra Wantzen
Technische Universität Berlin, Technischer Umweltschutz

Sophie Wulf
Technische Universität Berlin, Technischer Umweltschutz

Behind the scenes

One moment in the office, the next out in the field: you can see why we're always talking about applied research. Here's a brief look at what our work beyond the desk looks like. For the EU Green Deal project PROMISCES, Franziska Knoche and Daniel Wicke, together with Fiona Rückbeil from the Berliner Wasserbetriebe, installed automatic samplers in two Berlin stormwater drains in March to monitor concentrations of per- and polyfluoroalkyl substances (PFAS) and industrial persistent, mobile and potentially toxic compounds (iPMT) in urban stormwater runoff.
With sensors that measure water level and flow, sampling is automatically initiated during rainy weather. Thanks to the data loggers which allow remote online access to the measurement data, we know exactly when to bring the stormwater samples to the laboratory for analysis.

Apropos "beyond the desk": In July, we all went hiking together in the Spreewald, accompanied by two friendly rangers from the Bundesverband Naturwacht. Of course, a trip on a Spreewald boat was included. We enjoyed a wonderful summer day all together.

Project overview

Overview projects 2023

Title	Subject	Funding sources	Duration	Project management	Department
Abluft-2/2.1	Evaluation of the treatment in the aeration tank (optimisation of exhaust air treat-ment and activation stage)	BWB	Nov. 18 - Jul. 23	Anne Kleyböcker	Process Innovation
AD4GD	All Data 4 Green Deal - an integrated, FAIR approach for the common european data space	EU Horizon Europe	Sep. 22 - Aug. 25	Malte Zamzow	Urban Systems
AMAREX	Adaptation of stormwater management to extreme events	BMBF	Feb. 22 - Jan. 25	Andreas Matzinger	Urban Systems
BluePlanet 22_23	Event series "BLUE PLANET Berlin Water Dialogues"	BMUV, SenWEB	Jan. 22 - Dec. 23	Moritz Lembke-Özer	Communi-cations
Circular Agronomics	Efficient carbon, nitrogen and phosphorus cycling in the European agri-food system and related up- and down-stream processes to mitigate emissions (circular agronomics)	EU H2020	Sep. 18 - Feb. 23	Fabian Kraus	Process Innovation
DASAM	Data-driven sewer asset management in Germany and Israel	BMBF	Oct. 23 - Sep. 26	Nicolas Caradot	Urban Systems
Data Governance	Data & smart city governance using the example of air quality management	Land Berlin	Nov. 22 - Sep. 25	Nicolas Caradot	Urban Systems
DeWaResT	Decentralized wastewater treatment and water reuse for regions with seasonal drought stress	BMBF	Aug. 21 - Jan. 24	Jeannette Jährig	Process Innovation
DigiWaVe	Digital solutions for resource-efficient and safe water reuse in urban areas	BMBF	Sep. 23 - Aug. 25	Jonas Hunsicker	Process Innovation
DWC	digital-water.city: leading urban water management to its digital future	EU H2020	Jun. 19 - Jan. 23	Nicolas Caradot	Urban Systems, Groundwater
FlexTreat	Flexible and reliable concepts for sus-tainable water reuse in agriculture	BMBF	Feb. 21 - Jan. 24	Michael Stapf	Process Innovation
GeoSalz	Dynamics of saline intrusion for early identification of endangered drinking water wells and quantification of the hydraulic potential	BWB	Aug. 21 - Jul. 24	Christoph Sprenger	Groundwater
HYSTA	Preliminary tests for thermo-alkaline hydrolysis and evaluation for Stahnsdorf wastewater treatment plant	BWB	Dec. 22 - Aug. 23	Fabian Kraus	Process Innovation

Title	Subject	Funding sources	Duration	Project management	Department
IMPETUS	Dynamic information management approach for the implementation of climate resilient adaptation packages in European regions	EU H2020	Sep. 21 - Mar. 25	Daniel Wicke	Groundwater / Process Innovation
iOLE	Intelligent online leakage detection	BMBF	Sep. 23 - Aug. 25	David Steffelbauer	Urban Systems, Hydroinfomatics
LASSO	Development of a measuring concept for the detection of nitrous oxide emissions from aeration tanks of wastewater treat-ment plants	BWB	Nov. 21 - Jul. 23	Anne Kleyböcker	Process Innovation
LIWE	Large-scale implementation of tertiary treatment and phosphate recovery in Lidköping, Sweden	EU LIFE	Jul. 18 - Jun. 23	Fabian Kraus	Process Innovation
PROMISCES	Preventing Recalcitrant Organic Mobile Industrial chemicalS for Circular Economy in the Soil-sediment-water system	EU H2020	Oct. 21 - Mar. 25	Veronika Zhiteneva	Process Innovation
R-Rhenania	Production of modified phosphate from sewage sludge ash for Bavaria	BMBF	Jul. 20 - Jun. 26	Fabian Kraus	Process Innovation
SafeCREW	Climate-resilient management for safe disinfected and non-disinfected water supply systems	EU Horizon Europe	Nov. 22 - Apr. 26	Christoph Sprenger	Process Innovation
SCOPE3M	Recording and balancing of company-wide, greenhouse gas (GHG) emissions in upstream and downstream processes	BWB	Oct. 22 - Dec. 23	Christian Remy	Process Innovation
Sema-Berlin 3	Investigation of the extension of the technical service life of pipe liners and further development of the SEMAplus posture simulator for the risk of posture damage by the extent of damage	BWB	Dec. 22 - Nov. 24	David Steffelbauer	Urban Systems
Smart Water	Agile planning of stormwater management with a focus on urban green and blue	Land Berlin	Nov. 22 - Sep. 26	Lisa Junghans	Urban Systems
ULTIMATE	Industry water-utility symbiosis for a smarter water society industry water-utility symbiosis for a smarter water society	EU H2020	Jun. 20 - May 24	Anne Kleyböcker	Process Innovation
WaterMan	Promoting water reuse in the Baltic Sea re-gion through capacity building at local level	EU INTER-REG	Jan. 23 - Dec. 25	Elisa Rose, Pia Schumann	Process Innovation

Abbreviations of funding sources:

BMBF	The Federal Ministry of Education and Research
BMUV	The Federal Ministry of the Environment, Nature Conservation, Nuclear Safety and Consumer Protection
BMWK	The Federal Ministry for Economic Affairs and Climate Action
BWB	Sponsoring Berliner Wasserbetriebe
EU H2020	EU Horizon 2020
SenWEB	Senate Department for Economics, Energy and Public Enterprises

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