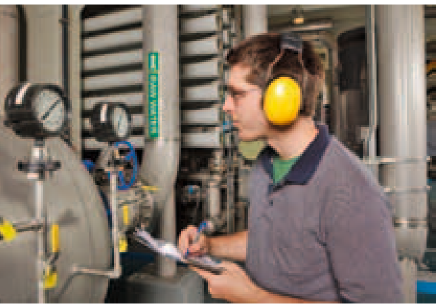
NaWaM
Sustainable Water Management

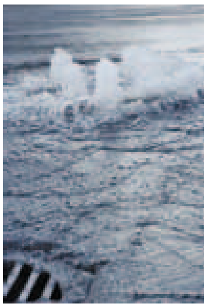
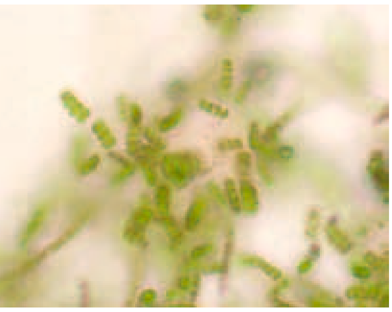
INIS

Smart and Multifunctional Infrastructural Systems for Sustainable Water Supply, Sanitation and Stormwater Management

Interim results from the INIS projects



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Smart and Multifunctional Infrastructural Systems for Sustainable Water Supply, Sanitation and Stormwater Management

Interim results from the INIS projects

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The BMBF funding measure INIS

Research for tomorrow's water infrastructures

RESEARCH FOR TOMORROW'S WATER INFRASTRUCTURES

The infrastructures for water supply and wastewater disposal in Germany are facing considerable challenges. As a consequence of climate change, demographic shifts and rising energy prices, the partially outdated systems require innovative upgrading and the development of new and more flexible solutions. This is the point at which water research must intervene to ensure that current quality standards are maintained into the future.

In view of these developments, the German Federal Ministry of Education and Research (BMBF) has allocated funds amounting to around 33 million Euros to its funding measure "Smart and Multifunctional Infrastructural Systems for Sustainable Water Supply, Sanitation and Stormwater Management" (INIS). This funding measure falls under the funding priority "Sustainable Water Management" (NaWaM), part of the BMBF Framework Programme for Sustainable Development (FONA).

In the period from 2013 to 2016, thirteen collaborative research and development projects are carrying out research into new approaches to water management, with the aim of developing innovative and feasible solutions for adapting water supply and wastewater disposal management to the changing conditions in Germany. In this brochure, each INIS research project is allocated two pages in which to present its most important interim results from eighteen months of collaboration with its partners.

TOPICS

The research projects cover a broad and diverse spectrum of topics within the following four thematic clusters:

» Integrated concepts for water, wastewater and energy
» Concepts and systems for a secure water supply
» Adaptation and optimisation strategies for urban drainage
» Processes for sustainable wastewater treatment

Table 1 shows the location of research projects within the thematic clusters. They are listed according to the main focuses of their research activities. In practice, the various project work programmes are often broader than the topics of a single cluster, and the classification is for guidance only.

Integrated concepts for water, wastewater and energy

Some of the research projects are focused on the development of integrated concepts for water, wastewater and energy utilisation. Within the development of integrated concepts, they deal with conditions of change to urban water infrastructures and seek ways to implement integrated system solutions. They analyse transformation processes and draw attention to the complexity of decision-making and planning processes in urban and rural areas. Alongside analysis of the environmental impacts of different options and cost/benefit analyses, the research agendas include issues of user acceptance, legal and institutional framework conditions and the necessary planning processes and management instruments. Some projects are developing simulation and decision-making tools to support the various target groups as they attempt to make appropriate use of their scope of influence. Of great importance is exemplary construction work on integrated solutions – including the further development and optimisation of infrastructure systems, technologies and processes – which take into account the specific conditions in diverse urban settings.

Concepts and systems for a secure water supply

A second thematic cluster consists of research projects that deal with safeguarding water supply. A reduction in the average consumption of drinking water, combined with stable or increased peak loads due to climate change, and a rise in flooding and dry-spell events present special challenges to water supply systems. Consequences include changes to water resources and water quality, due, for instance, to salt water intrusion into aquifers used for drinking water, as well as adverse effects on drinking water hygiene from longer retention of drinking water in water supply pipelines. Hence the projects are investigating strategies to ensure that drinking water supplies can meet these new challenges. They are also involved in the development of reliable stationary and mobile rapid detection and rapid warning systems for the inline monitoring of microbiological water contamination in raw and drinking water.

Adaptation and optimisation strategies for urban drainage

Other research projects are concentrating on the adaptation and optimisation of urban drainage systems. In these projects, the focus lies on the development and trial of concepts for sustainable rainwater management and on the operation, expansion or modification of urban drainage systems. They also investigate the ne-

Table 1: INIS collaborative projects in thematic clusters

Integrated concepts	**KREIS** **NaCoSi** **netWORKS 3** **SinOptiKom** **TWIST++**
Water supply	**EDIT** **NAWAK**
Urban drainage	**KURAS** **SAMUWA** **SYNOPSE**
Wastewater treatment	**nidA200** **NoNitriNox** **ROOF WATER-FARM**

gotiations required between planning instruments and organisational processes, for example in order to forge stronger links between urban development/ open space planning and urban drainage. A further focus is the improvement of databases for the planning and control of urban drainage systems.

Processes for sustainable wastewater treatment

The work of a fourth group of research projects centres on sustainable processes for wastewater treatment. A main focus of the research lies on decentralised and building-integrated wastewater treatment technologies that include processes to recover nutrients for use as fertilisers and to recycle wastewater for irrigation purposes. Here, too, hygiene issues are of major interest. This group is also working on possibilities for optimising the operations of central sewage treatment plants whilst reducing their energy requirements, maximising nitrate elimination and minimising environmentally detrimental emissions of nitrous oxide, nitrite and methane. The projects are involved with aspects of realisation that go beyond technical issues.

INIS IN PRACTICE

Characteristic of all the INIS research projects are their interdisciplinary approaches and the close collaboration between science and practice in model regions. Municipalities, utilities, special-purpose associations and other organisations involved in water management are responsible for carry out nearly half of the 98 sub-projects. Further partners from water management practice are integrated into the research consortia as associates or subcontractors. Figure 1 provides an overview of the 40 representative model regions, which are located throughout Germany and thus display a level of diversity. The trial of research results in municipalities and regions under different local conditions supports and strengthens their transferability.

CROSS-PROJECT ISSUES REGARDING INTEGRATION AND TRANSFER

Each of the INIS research projects is unique with regard to its objective and approach, yet the projects also display commonalities and points of contact. The most important crosscutting issues were jointly identified shortly after the commencement of the funding measure. The organised exchange between the INIS research projects and the subsequent synthesis of outcomes is centred on these issues, ensuring that the INIS funding measure as a whole is more than the sum of its parts. A number of the crosscutting issues facilitates an exchange with thematically related NaWaM funding measures, in particular RiSKWa and ERWAS, thereby fulfilling a bridging function. Others are overarching issues that are particularly useful to the internal INIS discussion of methods and their application. Finally, transfer-oriented crosscutting issues are of great relevance to practice, policymakers and the general public and thus support the synthesis and transfer of research results.

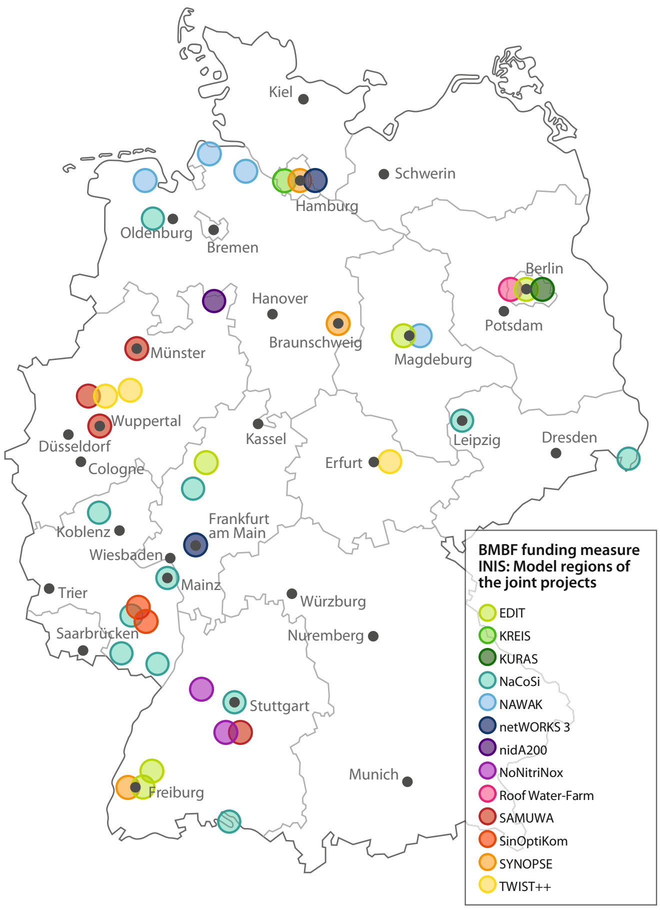

Figure 1: BMBF funding measure INIS – Model regions at a glance

Exchange with other NaWaM funding measures

Compliance with high health and environmental standards is required when implementing new water management system solutions. This applies particularly to **hygienic parameters and chemical trace substances**. In this context there are factors connecting INIS and another funding measure – RiSKWa – that falls within the remit of NaWaM. RiSKWa is dedicated to developing innovative technologies and concepts for the risk management of newly identified harmful substances and pathogens in the water cycle. At the heart of this exchange are analysis and monitoring standards that have been developed within the framework of the RiSKWa funding measure and are being continued by the relevant INIS projects.

The topic of energy efficiency and energy generation is also the subject of a special funding measure, ERWAS, within the framework of NaWaM. At the same time, this topic is the focus of smart system solutions and plays a correspondingly frequent role in projects supported by INIS. Various aspects of heat recovery from wastewater or from separated wastewater streams, the coupling of heat recovery with heat supply to residential areas and even the energetic optimisation of wastewater purification are being investigated. In some instances, specific questions are discussed, such as how to deal with the undesirable side effects of energetic optimisation of treatment processes. Particularly the latter point touches on the issue that is central to discussions surrounding the cross-cutting topic of the **water-energy nexus**, i.e. the interaction between economic viability, efficiency and performance dependability.

Figure 2: Greywater recycling plant in the residential complex "Block 6" in Berlin. Photo: E. Nolde/Flickr

Methodological issues

Multi-criteria evaluation is a key element in the implementation of smart and multifunctional infrastructural systems. Whether the objective is the management of future risks, the choice between different system solutions and technical options or the optimisation or control of plants and processes, there is always a component of registering and measuring a multitude of factors and weighing them against each other. Various procedures are used in the research projects. The objective is often to find the "most sustainable" solution, while in some cases the aim is to further develop evaluation procedures. At the forefront of discussions are the selection and weighting of the criteria, the appropriateness of differing evaluation methods, the involvement of decision-makers into the evaluation process and the guarantee of transparency in implementing the procedures, in order to strengthen understanding and acceptance with regard to new system solutions.

Both **simulation** models and **scenarios** help us look into the future to assess and evaluate the effects of particular decisions or measures. They can assist in validating the design and construction of infrastructures that will be necessary in the future. Moreover, they represent an instrument of communication between different stakeholders. Socio-scientific and mathematical engineering inputs, as well as qualitative and quantitative methodologies are discussed within the framework of the crosscutting topic. The issue of how to handle uncertain future developments and clarification of the pertinent terms of reference and input data are on the agenda. The opportunities and limits of participative procedures are debated, as are the possibilities of visualisation and its importance in the decision-making process.

The **separation of wastewater** into several streams (black, brown, yellow and greywater) facilitates the **treatment** of water, which can be recycled to save drinking water, and also the targeted recovery and utilisation of nutrients. Until now, it has been difficult to compare research results with operational experience using diverse process technologies, due to the dissimilarity of the original products and the absence of standards. One important objective of joint discussions is therefore to achieve an alignment of experimental analysis and design to better enable comparison of research results. A further joint aim is a more far-reaching chemical, physical and microbiological characterisation of separated streams. Finally, in addition to a continuous exchange on operational experiences with different process technologies, it is intended to pursue the development of use-related quality requirements for process water.

Transfer-related issues

The realisation of smart and multifunctional infrastructural systems requires a prior debate about the **institutional framework** of water supply and wastewater disposal. In this context, institutions are understood to be particular patterns of activity or regular interactions between stakeholders. This would include both formal rules in the form of laws, technical standards, etc. and also informal rules, in particular social conventions. Against this background, this crosscutting topic discusses the extent to which institutional change is accompanied or must be accompanied by novel infrastructure solutions, and what preconditions are necessary for this to happen. Since the "institutional framework" cannot be considered without reference to financing options, the focus also includes the financing of system innovations.

The crosscutting topic **urban and open space planning** focuses on the importance and consequences of the necessary conversion of water infrastructures for the towns and cities of the future. It discusses ways to mesh more closely the institutions and content of urban water management and urban development concepts, as well as viable planning instruments. Approaches to the sustainable use of space, energy and water resources within the framework of urban and open space planning are on the agenda, as are concepts for the multiple use and integration of different infrastructure systems such as water, wastewater, waste and energy. This topic grasps the opportunity offered by INIS for pioneering the integration of urban water management and urban development and planning.

The transformation towards novel infrastructure systems of water supply and wastewater disposal which INIS is working on requires efforts to achieve acceptance by potential users of the systems, whether these be municipal decision-makers, plant operators or private households. For this purpose, INIS outcomes need to be adapted for, and communicated to, specific target groups. This is the challenge facing the crosscutting topic **acceptance and communication**, which discusses and connects interfaces between the overall communications approach of the integration and transfer project INISnet and the individual activities in the collaborative projects, and engages stakeholders in considerations relating to transferability of research results.

THE INTEGRATION AND TRANSFER PROJECT INISnet

The research projects of the BMBF funding measure INIS are supported by the integration and transfer project INISnet. Its principle tasks involve publicity activities for the funding measure, strengthening dialog and cooperation between the research projects and facilitating the synthesis and transfer of results into research and practice.

INISnet is a joint project led by central multipliers of the municipalities and the German water industry, the German Institute of Urban Affairs (Difu), the Research Centre of the German Technical and Scientific Association for Gas and Water (DVGW) at the Hamburg University of Technology (TUHH) and the German Association for Water, Wastewater and Waste e.V. (DWA).

This brochure offers a first impression of the results achieved by the INIS collaborative projects to date. For more information on the BMBF funding priority NaWaM, the funding measure INIS and the various INIS research projects, please visit the funding measure's website:

www.bmbf.nawam-inis.de/en

Figure 3: INIS Status Conference in January 2015 at the Bürgerhaus Wilhelmsburg in Hamburg. Photos: INISnet

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Project period: 01/2013 – 06/2016

INIS collaborative projects

Integrated concepts

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KREIS

From disposal to supply

Linking renewable energy production with innovative urban wastewater drainage

BACKGROUND

KREIS investigates and develops innovative concepts and processes for the supply of water and disposal of wastewater in urban areas, starting with an inner-city residential area of Hamburg. The German acronym KREIS stands for Linking Renewable Energy Production with Innovative Urban Wastewater Drainage. The project seeks to develop i.a. ways of generating electricity and heat from wastewater and biogas.

The goal of KREIS has always been to provide scientific support for the large-scale implementation of the Hamburg Water Cycle® (HWC) in the district of Jenfelder Au. It supports planning and construction processes, the commissioning of technical systems through preparatory research and the development of methods for the integrative evaluation of economic, ecological and sociological aspects.

Figure 1: Testing point to monitor incrustations in the vacuum system. Photo: HAMBURG WASSER

INTERIM RESULTS

To fit in with the building schedule for the district of Jenfelder Au, KREIS project started at the end of 2011 – considerably earlier than all other INIS projects.

The preparatory phase KREIS (1) will be concluded shortly. Its ten most important outcomes are:

» The design and construction of technologies for the disposal and treatment of grey and blackwater to be implemented during the building project was facilitated. Diverse sampling points for black and greywater as well as digestates (media duct), and testing points for monitoring incrustations in the vacuum system were set up to facilitate other research (see Figure 1). In addition, construction conditions were established for a mobile feed unit for co-fermentation of secondary bio-resources and diverse sample withdrawal points were created.

» The novelty of the HWC, with its vacuum system for blackwater drainage, affects all stakeholders and requires close coordination between those planning and those implementing the Jenfelder Au construction project. In order to avoid faulty construction work with the ensuing need for rectification and to ensure comfortable living conditions in the long term, a manual entitled "Qualitätssicherung der Unterdruckentwässerung in Wohngebäuden der Jenfelder Au" [Quality Assurance of the Vacuum Drainage System in Residential Buildings at Jenfelder Au] was compiled.

» Diverse options for heat and electricity supply, including utilisation of biogas from blackwater and bio-resource fermentation, were dynamically simulated and a detailed evaluation was undertaken (see Figure 2).

» In order to expand knowledge about the characterisation and treatment of greywater, concentration, outflows and temperatures were measured for three different greywater systems in Germany and population-specific loads ascertained. A sampling system specially adapted for sample withdrawal in the immediate vicinity of the wastewater's point of origin was used. Greywater can now be significantly better characterised.

» Grass cuttings and greasy water have been identified as secondary bio-resources (co-substrates). These can be collected in the surrounding area and used for energy generation by anaerobic fermentation. Options for their pre- and co-treatment have been tested and reported.

» Stable anaerobic treatment of blackwater with or without co-substrates proved possible in both continuous flow stirred-tank (CST) reactors and upflow anaerobic sludge blanket (UASB) reactors (see Figure 3). However, considerably higher gas yields, based on the input of organic solid substance, could be achieved with the UASB process.

» Since too little is known about the anaerobic decomposition/conversion of pharmaceuticals, substances to be investigated were initially selected according to relevance. The results of the decomposition trials reveal differences in behaviour de-

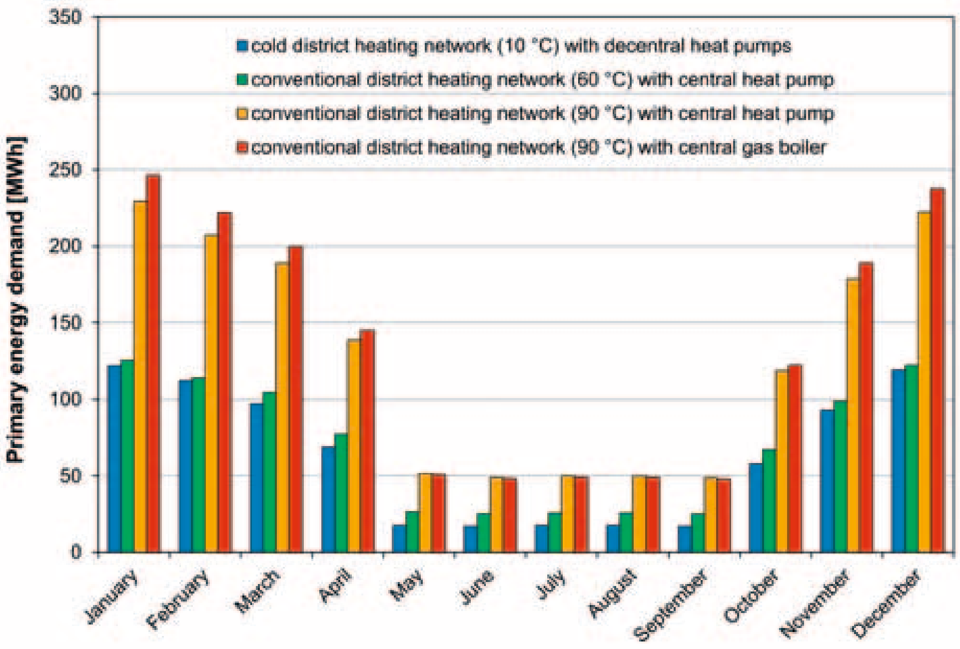

Figure 2: Primary energy requirements of different concepts for heating supply to the Jenfelder Au district. Graphics: Solar- und Wärmetechnik Stuttgart

pending on the reactor system (UASB better than CST), substrate mixture and hence volumetric loading. A new treatment design could be derived from the outcomes.

» Principles were established for balancing and evaluating both the HWC realised through the construction project and the systems developed by the KREIS research project. Initial theoretical calculations for the energy concept and the use of food waste grinders will need to be tested in practical operation. The odour assessment in the construction area clearly shows a prior level of pollution caused in particular by a yeast factory and catering enterprises in the surrounding areas.
» The project has been well publicised through intensive public relations efforts, ranging from exhibitions, posters and papers published in the national and international press and presentations, to national and international conferences and a strong online presence.
» The management of the research collaboration has proved effective and has contributed in no small measure to the achievement of project objectives, although it was relatively complex due to new procedural methods.

OUTLOOK

The "preparatory phase", KREIS (1) finishes in February 2015. In addition to the obligatory final reports of the individual partners, a composite report will be drawn up that will summarise the objectives, procedures and main outcomes of the collaborative project. The composite report will be translated into English and published on the project's homepage.

An application will be made for funding to continue the scientific support for the demonstration project. In this "operational phase", KREIS (2), the focus will be on optimising and further developing the combined energy supply and wastewater disposal concept, as well as investigating economic feasibility, ecological evaluation and societal acceptance. The outcomes should comprise insights and experience that can be exploited directly in the Jenfelder Au district and are also transferable to similar projects of the HAMBURG WATER Cycle® at home and abroad.

Figure 3: Status of trial on the anaerobic decomposition of pharmaceuticals from blackwater. Photo: Bauhaus University, Weimar

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Project period: 11/2011–02/2015

NaCoSi

Sustainability controlling for urban water systems – risk profiles and control instruments

BACKGROUND
Climate change, demographic shifts and rising energy prices present new challenges to municipal water management enterprises. Political considerations and legislative targets at the European and national levels give rise to changes in the specifications for technical design and construction and for enterprise organisation.

Any developments which could limit future performance or threaten sustainability, whether they be internal or external in origin, strongly affect the viability of water utilities. These are the issues of interest to the BMBF collaborative project NaCoSi – Sustainability Controlling for Urban Water Systems – Risk Profiles and Control Instruments. The aim of the project is to develop sustainability monitoring as a control instrument for municipal water management. The initial products of the INIS project NaCoSi are tools and guidelines for the implementation of sustainability monitoring in urban water utilities. Encouraging openness and comparison between enterprises will stimulate an internal, risk prevention-related learning process within the sector.

INTERIM RESULTS
The controlling tools under development will help service providers in the municipal water management to systematically identify and analyse enterprise-specific sustainability risks and to evaluate them with regard to necessity to act. The key question is how well enterprises are equipped to deal with these risks. Methodological principles for sustainability controlling will be developed in the course of the project.

The sustainability controlling consists of a set of tools that provide information from different perspectives. They monitor the enterprises performance, provide information main sustainability risks by help of risk matrices and risk profiles. Furthermore, planning games allow for developing future action. Eleven utility partners, being responsible for drinking water supply and/or wastewater disposal, are testing this range of tools in the pilot phase.

Fundamental to sustainability controlling is a target system for sustainable municipal water management that has been developed by projects participating in the collaboration. Systemisation of the sustainability objectives is based on the water industry's "Five Pillar Model", created by the German Technical and Scientific Association for Gas and Water (DVGW) and the German Association for Water, Wastewater and Waste (DWA), and on basic sectoral sustainability concepts. A total of fifteen objectives are divided into five categories that cover the long-term and sustainable development of both drinking water suppliers and wastewater disposal enterprises (see Figure 2).

These sustainability objectives offer a starting point for the identification of sustainability risks. As part of a qualitative risk identification process, possible risks for municipal water management enterprises were collected in the form of exposure pathways. Taking into account the probability of occurrence and extent of damage, the risks arising from the exposure pathways are being specified for each enterprise involved by help of a survey.

The first data survey took place in autumn/winter 2014. The required data and indicators were collected from the eleven participating utility partners using the "aquabench online platform". The survey was launched with information events for the utility partners in Mainz on 10 October 2014 (see Figure 1), and in Leipzig on 6 November 2014. All eleven partners participated in the information events with great enthusiasm.

Figure 1: Participants in the Introduction to Data Collection event held in Mainz on 10 October 2014.
Photo: NaCoSi research collaboration

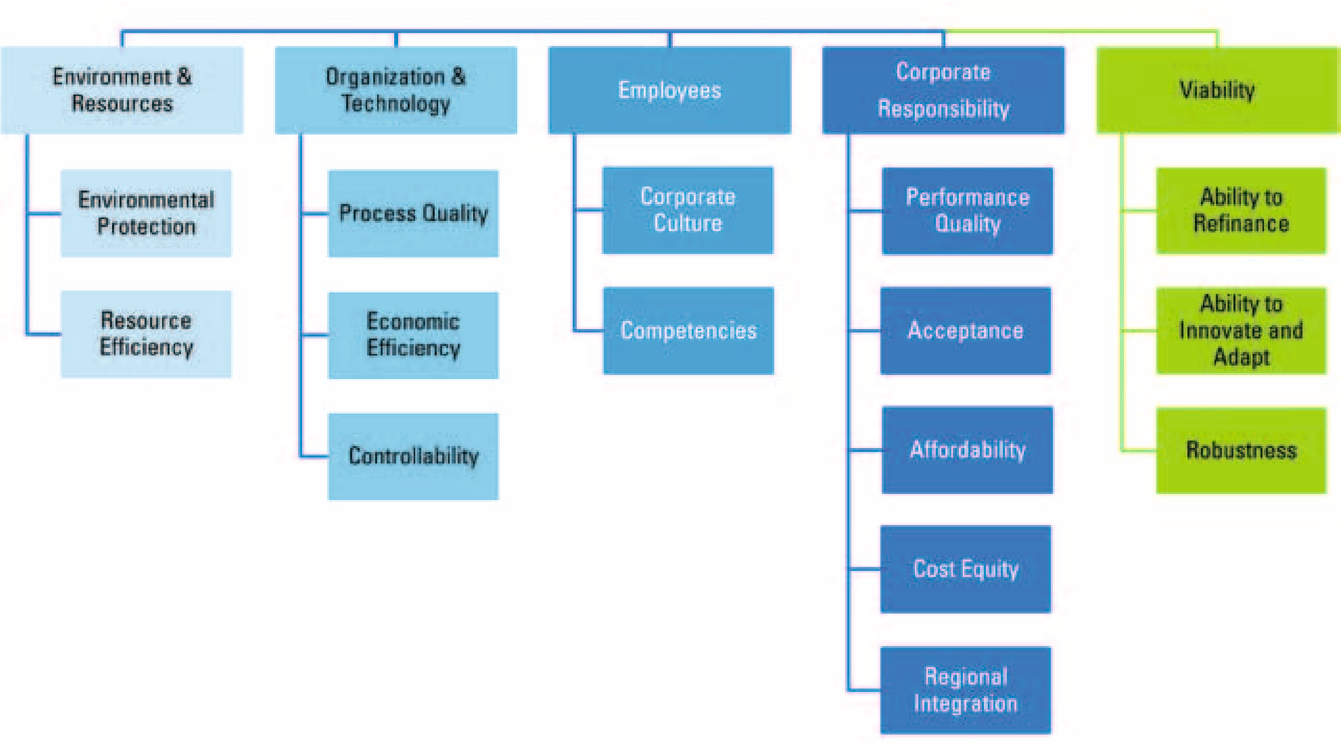

Figure 2: Clustered sustainability goals as foundation for developing a sustainability controlling for the domestic water sector (own illustration by NaCoSi project)

The tools introduced above are used to analyse and evaluate the risk information further. In the moment, indicator-based systems to monitor deviations from the objectives are under development as well as enterprise-specific risk matrices and risk profiles. Options for future action are to be explored using planning games to test their effectiveness in risk reduction.

OUTLOOK

Data collection from the utility partners will continue until the beginning of 2015. The data will then be evaluated using the methods developed, and enterprise-specific risk profiles drawn up for the partners.

The results of the data analysis will be evaluated in cooperation with the partners in scenario-based planning games starting in spring of 2015. The aim of a series of related workshops is for research and utility partners to jointly identify relevant dynamics in relation to sustainability risks and to draw plausible future scenarios taking into consideration their reciprocal effects. Building on this, problem-oriented and enterprise-specific options for risk prevention are to be identified. Potential options cover the full range, from technical and operational to communications measures.

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Project period: 05/2013–04/2016

netWORKS 3

Intelligent integrated water management solutions in Frankfurt am Main and Hamburg

BACKGROUND

The providers of municipal water supply and wastewater disposal face great challenges in adapting infrastructural systems to meet the challenges brought about by climate change, rising energy costs and demographic changes. Innovative, novel systemic solutions that could be applied are not yet in common or widespread use because of societal and institutional barriers and difficult decision-making processes. The objective of netWORKS 3 is to support municipalities and the water management sector as they attempt to convert their urban water management systems.

INTERIM RESULTS

Identification of pilot areas and their possible future system variants

Suitable areas in the pilot regions of Frankfurt am Main and Hamburg were identified by typification of specific urban areas from netWORKS 2. Suggestions for areas from the competent authorities were analysed and tested. Suitable criteria for selection proved to be: good marketability, location and new residential housing, as well as stakeholders and their status in respect of use and interests, and land tenure.

The Hamburg pilot areas comprise the Struensee Quarter (site of a school due for restructuring) and the Tucholsky Quarter (development area due for redensification). In Frankfurt, the business district Niederrad (site of offices due for conversion), the "Innovation Quarter" (conversion area) and the Rödelheimer Landstraße (trading and industrial estate with increasing residential use) were selected. All of these are marginal inner city areas with a moderate to high momentum for development. At the same time, the complexity and expense of transformation is classed as low to moderate.

For each pilot area two alternative systems with novel systemic solutions were identified in addition to one conventional wastewater infrastructure reference system (see Figure 1). Of the seven system variants available, those most suitable with regard to local conditions were chosen for the pilot areas.

Residents' experiences with greywater recycling and heat recovery

In order to find out how much experience residents already have with greywater recycling and heat recovery, 45 households from four Berlin housing complexes utilising greywater and partial heat recovery were surveyed using semi-structured interview techniques. It was revealed that from the point of view of the residents, the plant functioned unobtrusively and was, by and large, regarded and assessed positively. For most of those interviewed, the quality of the water to be used for flushing the toilets was acceptable. For them, the ecological advantages of the plant play a considerably more important role than the potential for financial savings. However, some of those interviewed would like more background information on both aspects.

The interviews also show that the interest, needs and assessments of the residents with regard to the different wastewater systems are very heterogeneous. Moreover, the results indicate that ecologically oriented building associations show great willingness to implement innovative wastewater systems.

Scope for action by urban water management stakeholders

The focus is on the scope for decision-making and action available to stakeholders who play a part in infrastructural transformation, new strategic options for municipal water management enterprises and the need for coordination in achieving novel systemic solutions.

Before novel systemic solutions can be applied, mental, organisational and also institutional barriers to innovation must be overcome. Where this is achieved, it may be expected that a greater diversity of technologies and participants who work together in new ways will influence water management infrastructure.

New operators of decentralised or semi-centralised plants will enter the arena and existing water management operations and enterprises will face new tasks and coordination requirements. With regard to the separate collection of material streams, new demands for coordination can be expected, for example at the interface between the public sewerage system and home installation. More importance is also being attached to cooperation between the wastewater, energy, waste and housing industry sectors. In coming years, strategic options are seen primarily in the context of energy efficiency, and, in particular, energy generation from wastewater.

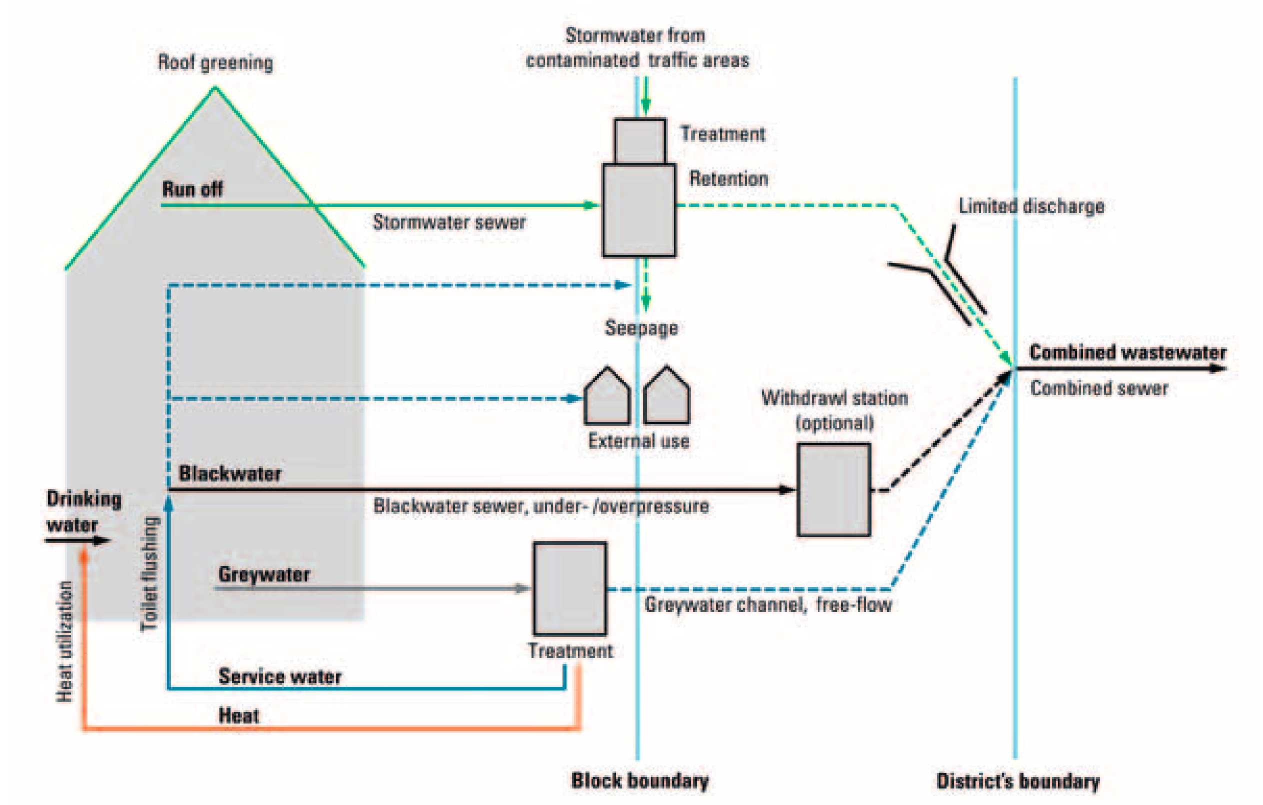

Figure 1: One of the two innovative system variants being investigated as part of the project in the Tucholsky Quarter, Hamburg's pilot area. Graphics: ISOE – Institute for Social-Ecological Research

Groundbreaking ceremony at the construction project in Frankfurt

Practical implementation, starting with a block in Frankfurt's Bockenheim district, began with a groundbreaking ceremony on 16 July 2014 (see Figure 2). Here, ABG FRANKFURT HOLDING is building a passive house with 66 rented apartments and a child day-care facility.

The project includes technologies for greywater recycling and heat recovery from various domestic wastewater streams which are being researched by the collaboration.

Figure 2: Construction work on the passive house started with a symbolic groundbreaking ceremony attended by, among others, Engelbert Schramm (ISOE, left) and the architect Jo. Franzen (2nd from left), Mayor Olaf Cunitz (3rd from left) and Frank Junker (MD of ABG FRANKFURT HOLDING, 2nd from right). Photo: ISOE

OUTLOOK

The next steps will see the evaluation of system variant suitability for the pilot areas together with the stakeholders active in the areas and the development of approaches to overcome identified social and institutional barriers. Outcomes, together with experience gained from implementation in Frankfurt and feasibility studies in Hamburg, will be drawn up in the form of guidelines and made available to municipalities and the water sector.

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Project period: 05/2013 – 04/2016

SinOptiKom

Cross-sectoral optimisation of transformation processes in municipal infrastructures in rural areas

BACKGROUND

In many rural regions, aging populations and diminishing population densities are threatening the economic operation and maintenance of existing water supply and wastewater disposal systems. The collaborative project SinOptiKom is seeking differentiated adaptation and transformation strategies for rural water infrastructures. The partners in the collaboration are developing prototype software that assists municipalities and decision-makers as they update systems. They do this by analysing and developing future intelligent system structures, and by finding the best strategies for the implementation of planning, technical and municipal/financial policies in their actual chronological sequence.

INTERIM RESULTS

The collaboratively developed structure of the decision-support and optimisation system consists of three main components. The collaborative partners are working in parallel on these three components (see Figure 1): a pre-processing tool which links databases, scenario management and different levels of decision-making; a mathematical optimisation model that is embedded in the overall decision-support model; and a so-called "interpretation tool".

In a first step, a stakeholder analysis was performed to establish and categorise the requirements of the software-based decision-support system. All persons or groups with an interest in the model under development are regarded as stakeholders.

A core element of the pre-processing tool is a knowledge and evaluation database for the management of innovative solutions and adaptation measures with their specific boundary conditions, as well as urban and water infrastructure data and evaluation criteria. The targeted collection and containment of the data and information needed was undertaken by means of a stakeholder survey, and the selection and composition of possible solutions closely coordinated with partners in practice and municipal partners. To this end, existing nature-oriented or innovative solutions were reviewed (see Figure 2).

The database server built upon the PostgreSQL platform can model dependencies, specifications and links with (database)

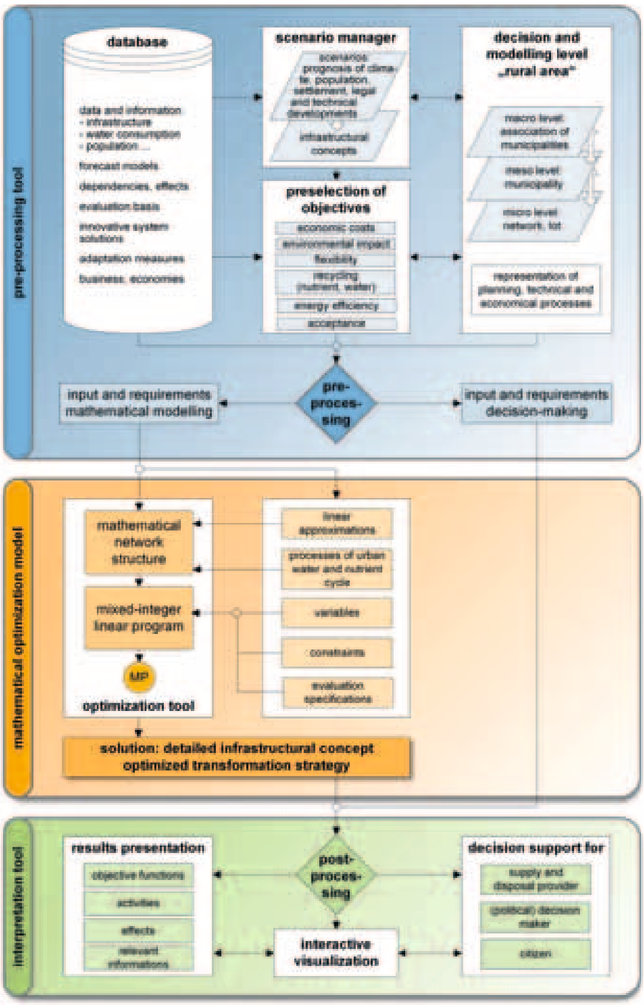

Figure 1: Model development and application progress in SinOptiKom. Graphics: University of Kaiserslautern

infrastructural objects, and has now grown into a data management system for all model-related data and information. Functionalities such as the generation of input for the mathematical optimisation model or the link to the scenario manager have already been implemented and road-tested.

Figure 2: Viewing several plants (St Alban constructed wetland for wastewater treatment, Palaterra® plant, Hengstbacherhof) during a project meeting in June 2014. Photos: igr AG, Rockenhausen

To take account of future developments in the modelling and decision-making process, chronological changes to different development factors and/or drivers are compiled into an observation scenario in the scenario manager. Potential development pathways are generated for each driver (e.g. demography, pricing, water and energy consumption, legislative framework) using different methodological approaches and techniques.

A mathematical model based on integral linear optimisation has been developed to determine optimised transformation strategies for water supply and wastewater disposal systems and energy provision. The contents of different drinking water and drainage components, for example, are viewed as flows in the mathematical network. Adaptation measures and transformation strategies are calculated taking objective functions into account. Objective functions are cost, ecological impact, flexibility, water and nutrient recycling, energy efficiency and acceptance. Until now, the subarea of urban drainage has been implemented in the mathematical model with its functional connections. The model represents the spatial and chronological progress of the transformation on several levels of decision-support and modelling.

The interpretation tool takes on a bridging function for the overall model and offers interactive visualisation options to all stakeholders. The results of the optimisation process will be presented to each stakeholder group with an adjusted degree of detail. The concept is focussed on an attractive, scalable design adapted to user requirements. To support cooperation and ensure maximum flexibility, in particular for decision-makers, the tool should be available for large multi-touch displays and for popular mobile devices like smartphones and tablets. For this purpose, a geographic information system (GIS) based on the open-source NASA World Wind Java SDK structure was integrated.

OUTLOOK

In the process modelling area, simplified material flow models are currently being developed for all the supply and disposal facilities and infrastructure components under consideration. To this end, transfer coefficients are being compiled for the observed flows in the mathematical model and stored in the database. For scenario development, a cross-impact analysis, including population predictions, factors influencing urban development and an expert survey, is to be used to establish consistent urban development scenarios. The first expert survey to assess probable urban and economic structure developments in the two participating municipalities is currently underway. Developed visualisation approaches for detailed representation of outcomes or chronological map views are currently being refined based on the stakeholder survey, and a use-case analysis performed. The next big milestone will be the completion of the model concept in mid-2015.

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Project period: 05/2013 – 04/2016

TWIST++

Paths of transition for water infrastructure systems

Adapting to new challenges in urban and rural areas

BACKGROUND

The necessity to adapt urban and rural water infrastructure systems in the face of the grad challenges is obvious. At the end of the transition pathway stand sustainable infrastructures with a high degree of flexibility and more efficient water, energy and resource use. In consequence, the collaborative research project TWIST++ is concerned with the development of new and sustainable concepts of urban water infrastructure systems, together with the relevant technical components; the development of a planning support and data maintenance system as well as the design of a serious game (simulation game), which also includes an evaluation tool to assess the sustainability of water infrastructure systems. The planning tools support renewal and conversion planning to make the transition from today's infrastructure concepts towards innovative and more sustainable integrated ones. As an additional tool, the serious game offers an opportunity to get to learn about and understand such new infrastructure system concepts intuitively. Using these tools, sustainable concepts will be developed and assessed specifically for three model areas. Additionally, drivers for and obstacles to the implementation of these innovative concepts, will be identified based on the analysis of the institutional context and the transferability of the concepts to other sites will be evaluated and assessed.

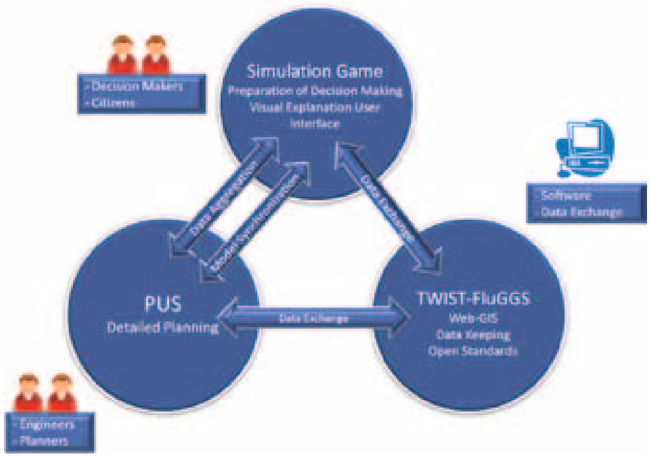

Figure 1: Interaction of the different software products in TWIST++. Graphics: Own representation

Figure 2: Target system of the evaluation process for multi-criteria evaluation. Graphics: Own representation

INTERIM RESULTS

Figure 3 shows several components of a future water supply and wastewater disposal infrastructure. These include upgradeable vacuum sewer systems of the right size for households or catchment areas; fit-for-purpose treatment of different types of raw water using membrane technology; domestic greywater treatment with heat recovery; anaerobic blackwater treatment and nutrient recovery from blackwater and urine and from suitable commercial and industrial wastewater, including appropriate pre- and post-treatment technologies; and solutions for alternative provision of water for fire-fighting and the hydraulic adjustment of drinking water networks in the event of substantially lower drinking water demand. All the necessary technical developments are currently in the laboratory or semi-technical test phase.

The most important software products, whose interactions are shown in Figure 1, are the central data maintenance platform TWIST-FluGGS, the planning support system (PUS) and the simulation game. The data collected for each of the three model areas were integrated into TWIST-FluGGS. A first version of PUS was made available and the technical integration of the two basic software packages and the possibility of data exchange with the TWIST-FluGGS platform were validated. Additionally, innovative technical elements (e.g. greywater filter, parameterisable network) were incorporated. An initial version of the simulation game has also been developed. It offers users to gather experience with innovative concepts and technologies for water infrastructure systems in concrete case studies. Evaluation of the game has commenced.

The three TWIST++ model areas were Lünen in North Rhine-Westphalia (urban area with trade and industry, a population of 87,000, steady drop in population and falling demand for drinking water); Wohlsborn-Rohrbach in Thuringia (two villages in a rural area with district sewerage mostly in need of rehabilitation, population 500 and 200 respectively) and the former colliery

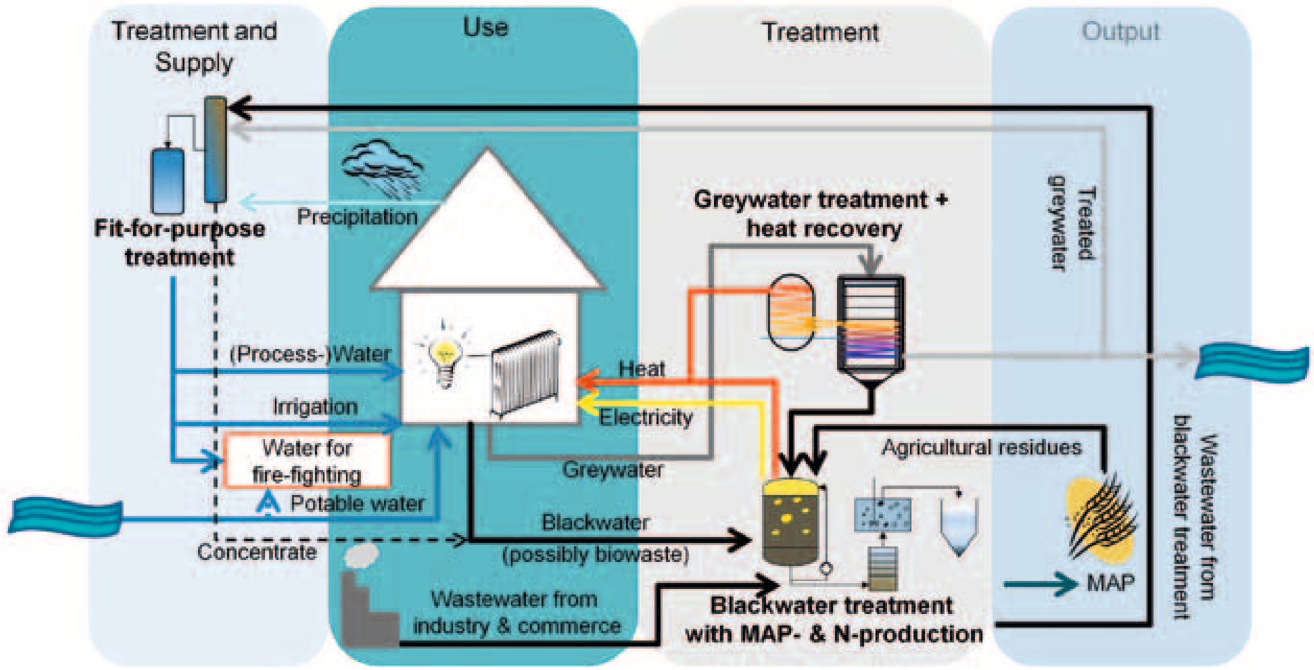

Figure 3: Interaction of water supply, greywater treatment/recycling, blackwater treatment, nutrient recovery, fit-for-purpose processing and industrial/commercial wastewater treatment in an optimised and integrated overall concept for water supply and waste water management. Graphics: Own representation

Lippe-Westerholt in North Rhine-Westphalia (land development and conversion area of 32 ha). The very different areas were examined for baseline and boundary conditions plus possible future developments. Different water infrastructure concepts and possible transition pathways were developed for each model area, based on its specific baseline situation. These are currently being debated and discussed with local decision-makers and will be further elaborated and adapted depending on the results of technical R&D work.

In order to assess and evaluate the infrastructure concepts developed for the three model areas a multi-criteria method is developed which takes into account the specific aspects of the long technical life time of water infrastructure systems in the sustainability assessment of these systems.

The assessment method's target system consists of five major groups of objectives (Figure 2). Based on the "List of Criteria for the Evaluation of Sanitary Systems" from the DWA-A 272 worksheet, specific evaluation at total of 22 criteria was formulated. The criteria were tested for independence, indifference, congruency, and relevance and finally, appropriate indicators representing these criteria were defined

OUTLOOK

According to the planned schedule, apart from continuing the research on the various TWIST++ components (development of single technologies and software, evaluation methodology and conceptual work), the information from the different work packages was shared and exchanged and the results were pooled. This is done in concrete terms based on the example of the three model regions.

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Project period: 06/2013–05/2016

EDIT

Development and implementation of a concentration and detection system for the inline monitoring of water-borne pathogens in raw and drinking water

BACKGROUND

The provision of hygienically safe drinking water by public supply companies is an important achievement of developed societies. However, there is a need for reliable, stationary or mobile, rapid detection and warning systems for microbiological water contamination. The current standard method for monitoring drinking water hygiene, which is based on the cultivation of indicator bacteria on selective nutrient media in the laboratory, is poorly suited for rapid warning in the event of a microbiological contamination (by bacteria, viruses or parasites). Moreover, it does not allow for a continuous monitoring which is needed to assess dynamic contamination processes in pipe networks.

At this point EDIT comes in: The project aims at the development and practical evaluation of a hygiene online monitoring system (HOLM). This system combines different concentration steps with the multiplex amplification and detection of DNA/RNA of selected water-borne pathogens and indicator organisms (see Table 1). The goal is a complete and largely automated analytical system that meets the requirements of water providers.

Table 1: List of pathogens to be detected by the EDIT project

Bacteria	Viruses	Phages
- *Escherichia coli*	- Norovirus GGI-II	- MS2
- *Enterococcus faecalis*	- Adenovirus 40,41,52	- PhiX174
- *Pseudomonas aeruginosa*	- Enteroviruses	
- *Campylobacter jejuni*		
- *Klebsiella pneumoniae and Klebsiella oxytoca*		

INTERIM RESULTS

The HOLM system, being developed by the EDIT project, is composed of several subsystems. Following the sampling, large volumes of water are concentrated in three steps and further processed before the actual detection takes place and results can be delivered.

The first stage is cross-flow ultrafiltration (CUF), by which volumes are reduced from several hundred or even thousand litres to approximately 20 litres. The second stage of concentration varies depending on the turbidity of the sample. For raw water, monolithic affinity filtration (MAF) is used to eliminate most of the turbidity and concentrate the 20-litre sample down to 20 millilitres. For drinking water, which has practically no turbidity, the existing Munich Microorganism Concentrator (MMC3) is used. It combines ultrafiltration with monolithic affinity filtration and achieves final volumes of approximately 1 ml. An automated lab-on-a-chip system (see Figures 3 and 4) forms the third concentration stage. Pathogens are extracted from the liquid by means of free-flow electrophoresis and concentrated at a hydrogel front to the point where the volume can be reduced to approximately 10 µl. Extraction and purification of the nucleic acids is then realized on the same microchip. Subsequently, the extracts are transferred to the automated microarray analysis platform (MCR3), where RNA/DNA extracts are identified after amplification. Since only living organisms represent a risk of infection, alive/dead differentiation is also implemented.

Figure 1: Starting up the continuous cross-flow ultrafiltration.
Photo: Daniel Karthe

Information about the sample, sampling and the HOLM's operating parameters is registered via a specially developed smartphone and tablet-compatible app. These data do not only allow for a comprehensive documentation but also make it easier to troubleshoot in the event of faulty operation or defects.

Figure 2: Model plant for continuous cross-flow ultrafiltration at the waterworks in Friedrichshagen, Berlin. Photo: Daniel Karthe

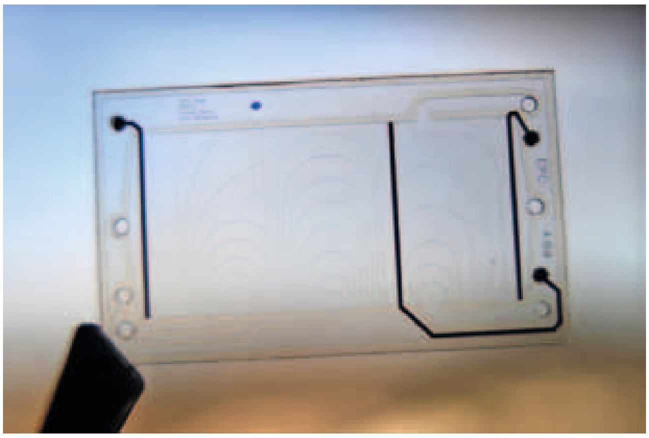

Figure 3: Implemented microchip in the lab-on-a-chip system. Photo: Gregory Dame

The CUF module, the first concentration system for raw and drinking water, was constructed during the first part of the project and then set up and tested at the Friedrichshagen waterworks in Berlin in the summer of 2014 (see Figures 1 and 2). This meant that the requirements of a typical end user could still be incorporated into the final device during the remaining project period. A first trial of all other subsystems was carried out during function tests in the laboratory.

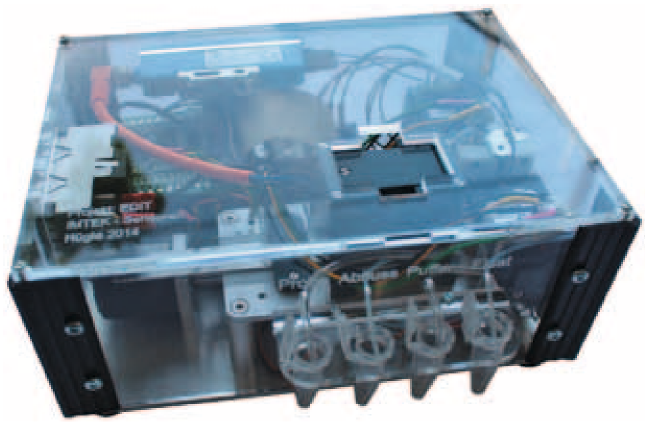

Figure 4: Automated lab-on-a-chip system. Photo: Matthias Hügle

OUTLOOK

So far, the EDIT consortium has been developing and testing the modular HOLM components. The ultimate goal is to automate the workflow as far as possible through interfaces between the subsystems. A prerequisite for this is extensive function testing. Moreover, some adjustments of the system components may be necessary. Finally, function tests are to be carried out on the complete system under 'field' conditions. For this purpose, controlled trials on a special test stretch of Berlin's municipal water supply company are planned, as well as an experimental routine use by the water provider.

Perspectively, there is a significant market for HOLM systems both in Germany and abroad. Environmental and socio-demographic changes and the increasing incidence of highly resistant pathogens may all pose new challenges to water hygiene. For this reason, the system development is accompanied by supplementary research into the effects of climate change and demographic trends on water hygiene in Germany, ensuring a more effective assessment of influences and/or threats. To this end, brief reports will be compiled in the course of the project.

Ultimately, the EDIT project aims at enabling water providers to implement suitable measures to safeguard drinking water hygiene promptly and continue to deliver drinking water of the highest quality to consumers.

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Project period: 06/2013–05/2016

NAWAK

Development of sustainable adaptation strategies for water management under conditions of climatic and demographic change

BACKGROUND

The objective of the research project NAWAK is to examine the effects of climatic and demographic changes on water management in selected regions. Its focus is on future implications for water availability and water demand. Based on this research, it aims to develop possible adaptation strategies for the water management sector and its infrastructure.

Pilot region Sandelermöns: Progressive intrusion of seawater into the groundwater body of the Sandelermöns waterworks, operated by the water board Oldenburgisch-Ostfriesischer Wasserverband (OOWV), is in part the result of climate change and could be combated by reducing abstraction rate, moving the operating plant or artificially recharging groundwater.

Pilot region Heidewasser: This pilot region includes the area supplied by the company Heidewasser GmbH in Saxony-Anhalt. The region as a whole is already being affected by demographic change. The shrinking population and the resulting reduction in drinking water withdrawals mean that the water provider faces the task of developing new models of infrastructure and concepts for provision in the long term.

Pilot region Elbe-Weser Triangle: In the Elbe-Weser triangle there are plans to deepen the Elbe River. Working with the providers Stader Land (TWV Stader Land) and Land Hadeln (WVV Land Hadeln) as examples, the effects of this work on the groundwater body will be examined.

In future, the water industry will face challenges characterised by highly complex structures and dynamics with widely differing timescales. Transdisciplinary approaches must deliver potential solutions that meet the requirements of service providers.

INTERIM RESULTS

The results compiled from the NAWAK project work are currently being collected to provide a set of planning instruments.
This will provide an analytical framework to

» describe the probable effects as scenarios,

» process and visualise the results, methods of analysis and simulation used and disciplinary inputs (modelling, evaluation of historical data, economic analyses, scenarios, expert interviews, outcomes from participatory processes, etc.) and

» collate them in an evaluation in order to

» derive options for adaptation strategies and new infrastructure strategies (Figure 1).

The purpose of the planning instruments is to coordinate sectoral developments, taking into account the system characteristics of hydrological conditions and the anthropogenic profiles of utilisation and specifications:

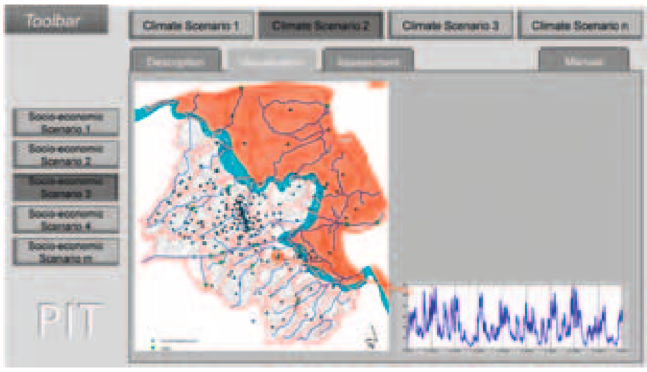

Figure 1: User interface of the prototype planning instruments (under development). Example: Representation of the border between fresh and salt water in the Sandelermöns pilot region.
Graphics: TU Braunschweig

Water availability

The available water supply is identified in the scale range appropriate to the planning and two-way coupling of the dependence of uses on hydrological conditions and the change in these conditions due to water use. The prognosis of medium and long-term changes in the position of the salt-water line on regional scales, in particular, is pioneering modelling technology (Figure 2).

Water demand

When estimating regional water requirements, it is no longer possible to take the conventional route of assuming specific per

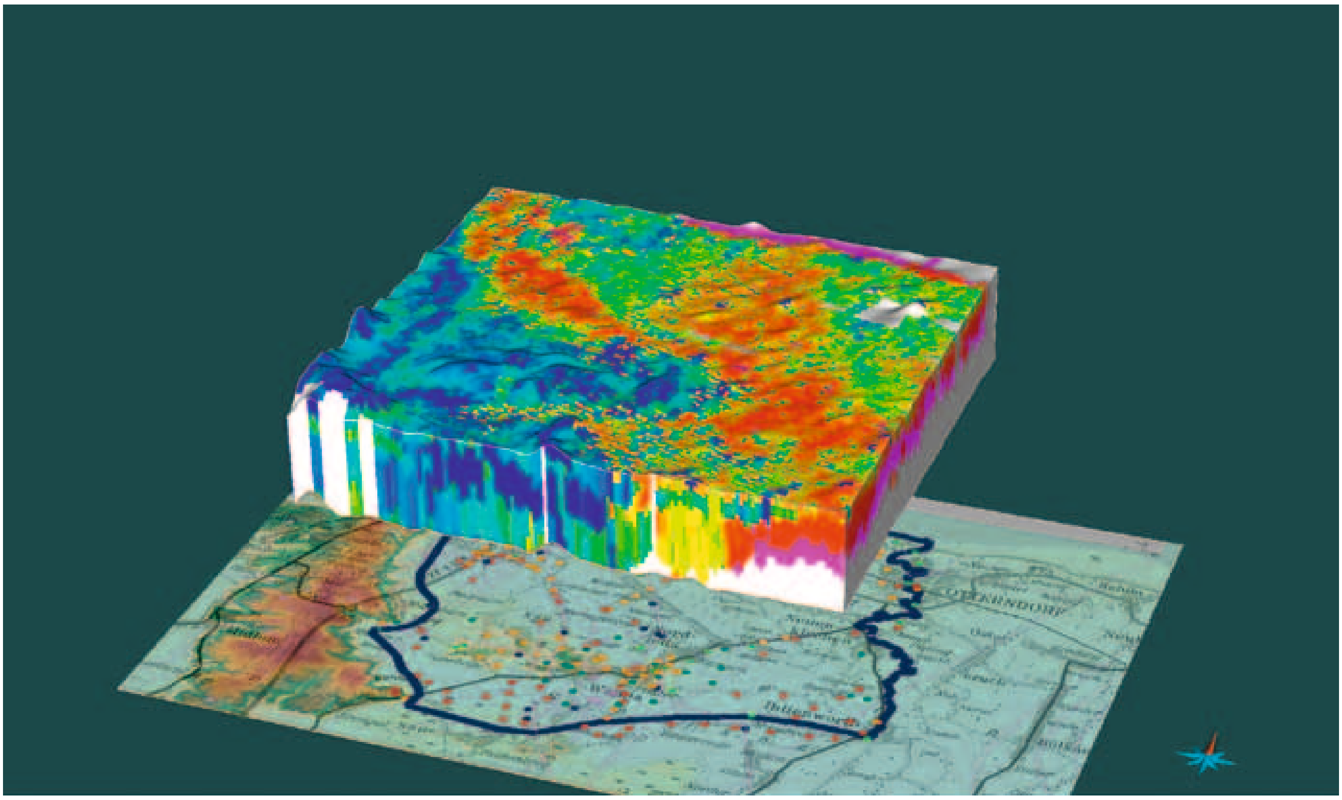

Figure 2: Determination of salt-water intrusion into the groundwater by geophysical examinations in the Elbe-Weser Triangle model region to identify starting and boundary conditions. Graphics: Leibniz Institute for Applied Geophysics

capita water consumption and predicting trends in population numbers. Instead, water requirements are calculated from scenarios relating to the socio-economic development of the region obtained through a participatory process. In this context, general growth trends for the regional economy, demographic trends, sector-specific trends, competition for use between public water providers, industry and agriculture, and the water required to safeguard ecosystem services all have a role to play.

The planning instruments are currently under development. At the same time, various components of models relating to surface-water hydrology, density-driven groundwater flow, calculation of retention times in the pipe network and concepts for sectoral development of regions examined are being implemented.

OUTLOOK

In the second half of the project, problems specific to particular regions and appropriate strategies for action will be depicted and evaluated based on the results derived from simulations of selected scenarios. In a further step, the set of planning instruments will be converted into a marketable tool.

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Project period: 07/2013 – 06/2016

KURAS

Concepts for urban rainwater management, drainage and sewage systems

BACKGROUND

Urban spaces need drainage and rainwater management concepts that guarantee safe disposal while also contributing to the solution of environmental problems closely linked to urban hydrology. The development of strategies to adapt the relevant urban infrastructure to cope with the consequences of climate change and other future changes is already well underway. However, investigations that examine in greater depth the effectiveness and optimisation of concrete measures and their adjustment to institutional requirements are needed before the strategies can be implemented and put into operation. These measures affect drainage planning as well as building, open space and environmental planning and the creation of incentive systems.

The KURAS project examines, describes and characterises the effects of measures and actions aimed at adapting the urban wastewater and stormwater system. These investigations are extensive and cross-scale, with the aim of developing and demonstrating concepts for sustainable management of wastewater and rainwater.

INTERIM RESULTS

Measures for rainwater and wastewater management were catalogued and defined in the form of profiles to be used in the project (e.g. mode of operation, legal requirements, specifications, examples of implementation, etc.). The effects of the measures on the environment (e.g. water or biodiversity), residents (e.g. quality of open spaces, urban climate, odour nuisance or flooding risk) and the economy (e.g. costs or safety of operations) are currently being evaluated on the basis of existing data and new surveys. The results are being collected in a joint database (currently > 1,000 entries; see Figure 1), which will be made generally available upon completion of the project.

This knowledge should then be applied in the planning of exemplary rainwater and wastewater management strategies in different model areas in Berlin. The model areas selected are representative of urban localities, making it possible to apply research outcomes to other towns and cities.

Based on several criteria (e.g. current problems and drainage system), the Berlin district of Wilmersdorf (31 km^2, population ~260,000, ~40,000 m^3 dry weather flow) was selected for the research focus Wastewater System (see Figure 2). The district sewerage system includes both separated and combined sewers, so that measures can be tested in both sewer systems.

For the research focus Rainwater Management, two urban districts with an area of approximately 1 km^2 each were defined, one with combined sewers and one with separated sewers. In order to achieve a direct synergy between the two research foci, rainwater and wastewater, one rainwater model area is situated within the wastewater model area.

The effectiveness of the measures and combinations of measures investigated is being examined and represented via several different platforms. These include both experimental investigations as well as hydraulic models in the simulation program Infoworks. The simulations are based on climate projections of the IPCC for the year 2050. In addition, prognoses by the Berlin Senate regarding population trends in the catchment area and different water consumption scenarios for the planning interval to 2050 are used. These are being employed to create a basic scenario as well as development scenarios for overload and underload in the hydraulic model. In the simulation, it is thus possible to represent the effectiveness of measures and combinations of measures in the form of change from the basic scenario.

The measures and actions proposed and examined for the model areas are to be based on the evaluation and modelling

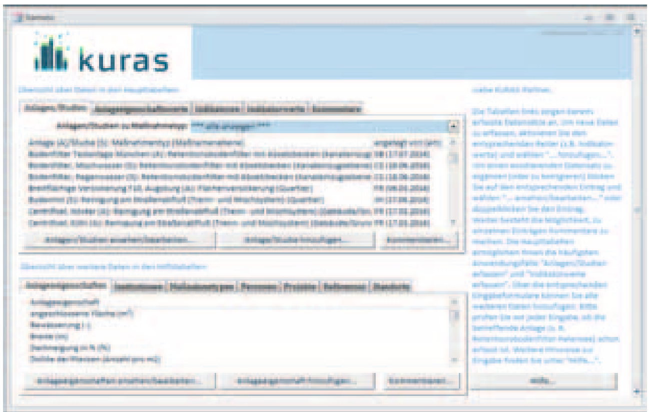

Figure 1: Input mask of the server-based project database to record partners' evaluation of the measures.
Graphics: Kompetenzzentrum Wasser Berlin

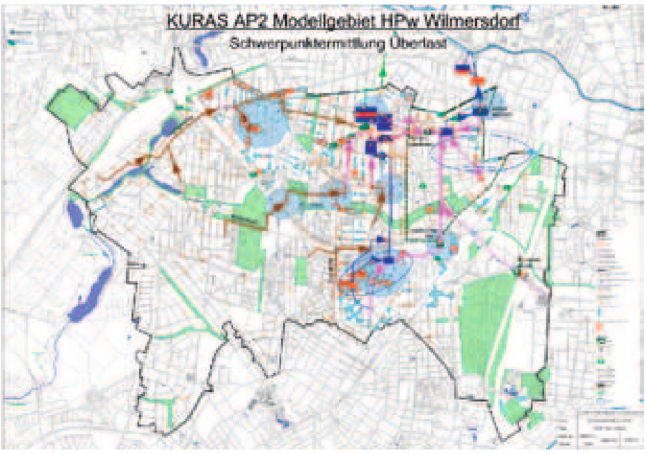

Figure 2: Model area Wilmersdorf for the research focus Wastewater, showing the detected overload priority areas.
Graphics: Berliner Wasserbetriebe

Figure 3: The KURAS Model. The model of the urban wastewater infrastructure can be used to explain various elements of the project.
Photo: TU Berlin

approaches developed in the project. Additionally, the participation of important stakeholders is also intended. The cooperation of the city of Berlin, the Berlin water utility (Berliner Wasserbetriebe), the district administrations responsible for the model areas and other important stakeholders have already been enlisted. A network linking experts and stakeholders in Berlin, Germany and abroad is an important aspect of the work. Accordingly, KURAS has been presented at an exhibition organised by the City of Berlin, at events such as the Berlin Water Workshop and the DWA Inspektions- und Sanierungstagen [DWA Inspection and Rehabilitation Days], as well as at several national and international conferences (see Figure 3).

OUTLOOK

The evaluation of the measures will be continued throughout the project. Also, the measurement programmes and studies started in the course of the project (e.g. programmes to measure deposits in the sewers or the effects of greening buildings and studies recording resource consumption or economic directions of action) will be interpreted and evaluated.

A first stakeholder workshop is planned for spring 2015 to establish the objectives in the model areas. Combinations of measures will be developed from the objectives and scientific insights, and will be evaluated for all effects using the models that have been set up.

At the end of the project, recommendations are to be developed from the evaluation, again with the participation of key stakeholders. These recommendations will comprise software tools and decision aids that have been developed and enhanced during the project. Proposals for the certification of buildings and quarters in regard to water will also be included, which should facilitate the concrete implementation of the outcomes by planners and architects. Additionally, superordinate planning instruments are to be developed for urban wastewater and rainwater management.

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Project period: 06/2013 – 05/2016

SAMUWA

The city – a hydrological system in change

Steps towards an adaptive management of the urban water balance

BACKGROUND

The urban water infrastructure is subject to changing framework conditions. These changes are the result of general trends in population, economic development and climate change, and of developments – such as the integration of rivers into local recreation spaces and the management of residential areas threatened by flooding – which are specific to certain cities. Urban drainage, in particular, faces great challenges as a result. The collaborative research project SAMUWA questions the previously static approaches to the planning and operation of drainage systems and shows how with smart, integrative system solutions and management concepts, dynamic and adaptable management of the complete urban hydrological system can be achieved (see Figure 1).

Figure 1: SAMUWA – Steps towards an adaptive management of the urban water balance. Photo montage: Stuttgart University, ILPÖ

INTERIM RESULTS

SAMUWA is strategically organised into four foci. In the first of these, "Ask the Future", the Chair of Urban Development & Urban Scape at the University of Wuppertal (BUW) started by selecting pilot areas in Gelsenkirchen, Münster, Reutlingen and Wuppertal and examining them from the point of view of urban development. This research led to the creation of scenarios for urban and infrastructure development that take into account trends in society, the economy, land-use, infrastructure and user behaviour. The Institute for Modelling Hydraulic and Environmental Systems at the University of Stuttgart is continuing development of the stochastic precipitation generator NiedSim with the aim of generating spatially and time-based chronologically correlated synthetic precipitation time series. These will take account of climate developments. The first results have been conveyed to the collaborative partners.

In the second focus, "Enhancing facilities", the partners InfraConsult, Stadtentwässerung [urban drainage] Reutlingen and Stuttgart University in the Reutlingen pilot area, and Dr. Pecher AG and the public utility company Wuppertaler Stadtwerke (WSW) in the Wuppertal pilot area are working on the further development of technical interventions to control discharge in the drainage system. Interventions to control discharge offer an opportunity to use existing drainage systems more efficiently with regard to separate and combined stormwater treatment, and to adapt their operation to changed framework conditions without alterations or re-construction. Stadtentwässerung Reutlingen was able to start operating the prototype of integrated sewer drainage control in a combined system in June 2014 (see Figure 2). The pilot project for a pollution-dependent discharge control system is being further developed in Wuppertal. Under this system, the regulated runoff from a stream can be directed into the Wupper River in dry weather and either to the wastewater treatment plant or to the Wupper River in rainy weather, depending on the degree of pollution from surface discharge. The collaborative partner ifak is developing a simulator and a methodology for simulation-supported determination of the control potential for a sewer network control that takes account of the interaction between sewer network and wastewater treatment plant. The partner aquaplan is continuing development of a data management system that will assist with the management and inspection of large volumes of data.

The third focus, "Designing the Future", extends the approaches to sewer network planning previously applied in urban drainage by including the local water balance, possibilities for open space planning and infiltration water and groundwater management.

The Münster University of Applied Sciences has developed the water balance model WABILA for simplified determination of the local water balance in urban areas. Its aim is to integrate persistent changes in the water balance into the planning process for new building and urban redevelopment areas as operable parameters, while including major land types and uses as well as measures for decentralised and semi-centralised stormwater

Figure 2: Installation of a measuring station for quality testing at a stormwater overflow basin. Photo: Stuttgart University, ISWA

management. The results are currently under intense discussion among experts.

In the field of stormwater management and flood prevention, Stuttgart University's Institute of Landscape Planning and Ecology, together with its partners, BUW, Münster University, Dr. Pecher AG, EGLV and WSW, is linking strategies for the organisation of urban open space development with water management planning and simulation tools. Initially, it is combining flood prevention measures with current urban development processes in a pilot study in Wuppertal, and designing concepts for integrating water into urban development (see Figure 3). The outcome will be a guide that describes methods and concepts of open space use and structuring for stormwater management and flood prevention.

The fourth focus, which is currently being jointly prepared in a partnership between BUW, Münster University and the municipality of Münster, is entitled "Overcoming barriers". It will analyse the present organisation of planning processes and their institutional framework conditions in order to identify barriers and demonstrate possibilities of adaptation for integrated and participatory planning in the areas of urban drainage, urban development, open space planning, environment and traffic. The result will be a guideline – Governance – that is addressed to municipalities and stakeholders in the field of planning. Even now, it is already clear that addressing these interdisciplinary questions about urban water balance will be crucial to the future establishment of smart, multifunctional infrastructure systems.

OUTLOOK

The latest information is available on the website www.samuwa.de/index.en.html, which also gives contact details for the project partners. During the second half of the project period, project work will continue, and results will be published, presented and discussed at various advisory boards and workshops with external experts and the target group – municipalities and their drainage enterprises.

Guidelines will be drawn up and software developed based on the project outcomes. Further, residents and members of the general public with an interest in the work of the project will be involved and SAMUWA will participate in knowledge transfer activities of the supporting project INISnet.

Figure 3: Linking water management measures with integrated strategies for urban and open space planning.
Graphics: Stuttgart University, ILPÖ

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Project period: 07/2013 – 06/2016

SYNOPSE

Synthetic precipitation time series for the optimal planning and operation of urban drainage systems

BACKGROUND

For the planning and optimisation of urban drainage systems using mathematical simulation models, long, continuous precipitation series with high temporal resolution are needed. Since observed time series are not available for the whole of Germany, planning concepts are often based on unreliable or unsuitable data and are therefore frequently uneconomical and not sustainable. One good alternative is the use of synthetic precipitation series. The objective of the SYNOPSE project is to examine and further develop, test and compare precipitation models for the generation of synthetic precipitation data with regard to various urban hydraulic applications (see Figure 3). Based on the pilot areas of Hamburg, Braunschweig and Freiburg and the federal states of Baden-Württemberg and Lower Saxony, a nationally applicable data generation method is to be developed.

Figure 1: Heavy rain can overload sewer networks and lead to flooding.
Photo: Lothar Fuchs, itwh

INTERIM RESULTS

The project is examining three different precipitation models (see Figure 2) that generate rain series with a temporal resolution of five minutes for their suitability in relation to urban drainage. In the first phase of the project, the parametric stochastic precipitation model from Hannover University was enhanced and adapted for urban hydrology. This was performed by analysing and estimating parameters from observed time series for Lower Saxony. Stuttgart University's non-parametric stochastic

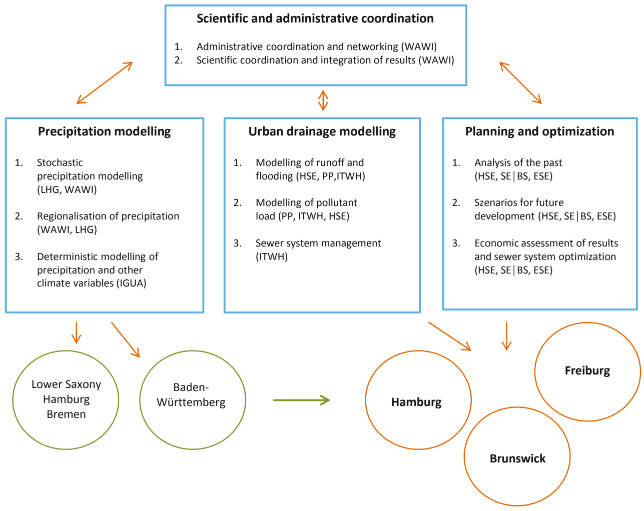

Figure 2: Overview of the different project areas and responsibilities in the collaborative project SYNOPSE.
Graphics: Sophia Rohde, HAMBURG WASSER

precipitation model, which is based on the NIEDSIM approach, generates time series with high temporal resolution for Baden-Württemberg. Augsburg University is pursuing an approach that generates spatially consistent precipitation fields with a spatial resolution of 1 km by 1 km by downscaling from a regional climate model. The synthetic data are also being generated for Lower Saxony first here.

All three models were first conditioned to the current climate. The synthetic time series generated have to be tested in various ways for plausibility. This includes comparison of several precipitation characteristics and statistical parameters for synthetic and observed time series. Moreover, the synthetic precipitations are also used to load the sewer network models built by the utility and industry partners for the three test areas. Here the objective is to check whether the synthetic precipitations accurately reflect the behaviour of the sewer networks with respect to surcharge and flooding frequencies and volumes and also with respect to pollutant load calculation. Observation-based reference rainfall time series of the project partners serve as comparisons.

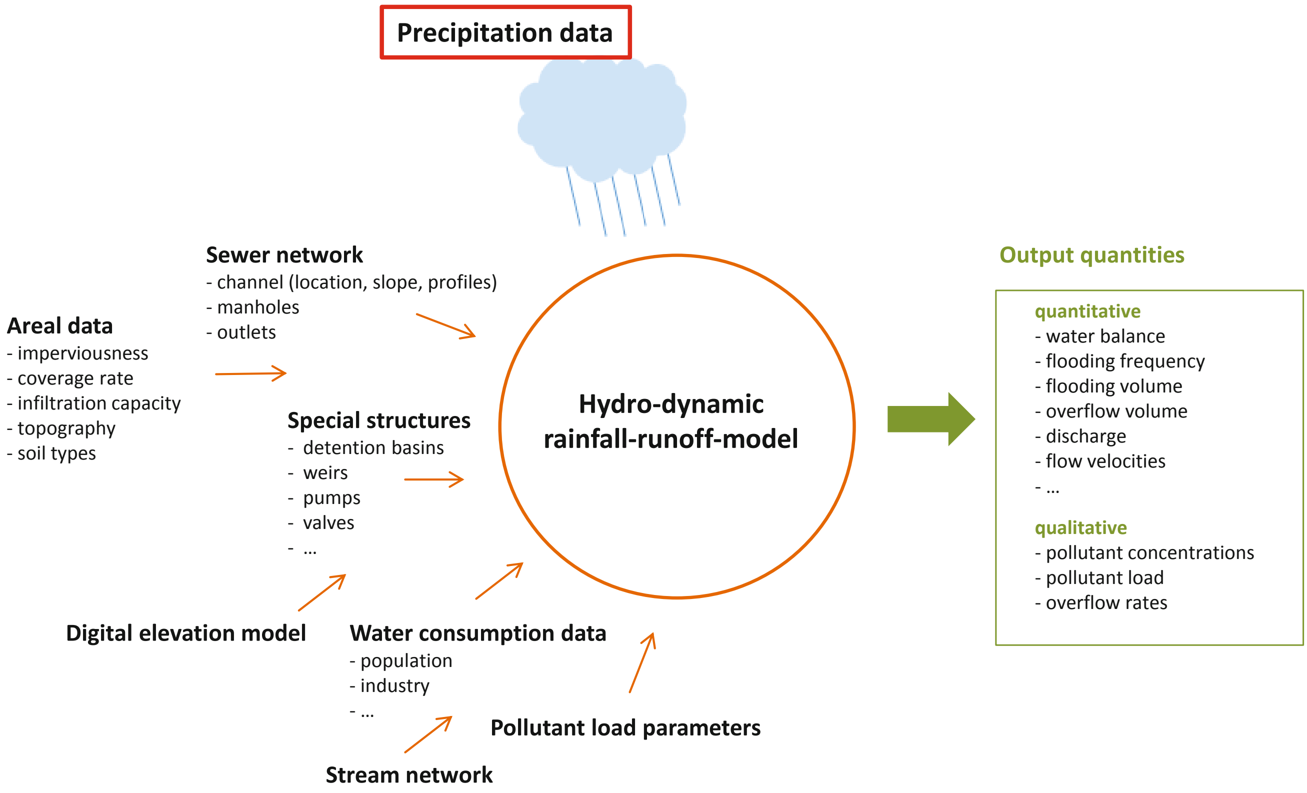

Figure 3: Schematic representation of principles and influencing factors for hydrological/hydraulic rainfall-runoff models and resulting output quantities. The precipitation load is key. Graphics: Sophia Rohde, HAMBURG WASSER

Using an iterative process, the detailed analyses and comparisons led to a continually improving adaptation of all three precipitation models to the conditions actually observed and the requirements of urban drainage.

OUTLOOK

In contrast to the Augsburg approach, the other two models are not automatically able to generate spatially consistent precipitation time series. Whilst the spatial consistency is generated by a resampling approach in the parametric model, copulas are to be used for the non-parametric model. Furthermore, all three models are being adapted for the other regions, i.e. the Hannover and Augsburg University models will be adapted for Baden-Württemberg and the Stuttgart University model for Lower Saxony. Hence each of the three precipitation models will be applied in all three urban test areas, facilitating a comprehensive comparison and evaluation of the three different methods in respect of their suitability for urban hydrological investigations. Moreover, it is not only the current climate that is being studied.

Based on an average climate prognosis, the three precipitation models will be adapted for expected future conditions and used to generate synthetic time series for a possible future climate. This will give industry partners the option to test their sewer networks for sustainability – an important economic consideration with facilities like these that have a life expectancy of many decades. The project results are to be used in the medium term to draw up practical recommendations for the use of synthetic precipitation time series in urban drainage planning. It is also intended that the results will be made available to the public via a web-based application.

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Project period: 05/2013 – 04/2016

nidA200

Innovative wastewater treatment

Sustainable, innovative and decentralised wastewater treatment system, including co-treatment of organic waste based on alternative sanitary concepts

BACKGROUND

Although more than 95 % of the population of Germany is connected to the central wastewater treatment system, there remains a need, especially in rural areas, for decentralised wastewater treatment systems. In order to make such solutions sustainable, however, the disadvantages of present systems – like the relatively large areas they take up, their considerable technical complexity and in some cases inadequate levels of purification – must be overcome.

The nidA200 project is solving this problem by developing a sustainable concept for decentralised wastewater treatment. The introduction of alternative sanitary systems, co-treatment of urban organic waste and use of algal mass cultures can lead to very comprehensive wastewater treatment with high energy efficiency and maximum nutrient recovery, especially of phosphate. Realisation at scale is planned for peripheral populated areas and for specific properties (hotels, residential homes, hospitals).

Figure 1: *Scenedesmus quadricauda* (left), *Oedogonium* or *Ulothrix* (filamentous algae, right). Photos: Peter Roggentin

INTERIM RESULTS

Algae with rapid rates of sedimentation and growth are required for large-scale implementation of the nidA200 concept. These algae were bred by selection processes that included daily removal of the supernatant after short sedimentation phases and the intermittent addition of new (synthetic) greywater analogue. Figure 1 shows a section of the selected biomass consisting primarily of *Oedogonium* or *Ulothrix* (filamentous algae) and *Scenedesmus quadricauda.*

Figure 2: Piping system for algae cultivation – experimental plant. Photo: LimnoSun

Relevant factors for large-scale implementation (growth rates, nutrient uptake, optimum DM, etc.) could be defined using the selected algal cultures. The incremental growth rates are highest in summer, as is to be expected. It is, however, remarkable that even in the month with the lowest yield, December, the average yield was still about 25 % of that in June, the month with the highest yield to date. This means that year-round operation is possible. On the strength of these promising results, a second experimental algae plant was installed in October 2014, this time as a piping system (see Figure 2).

In order to quantify the elimination of pathogens by the algae, reliable methods of determining colony counts from wastewater and runoff were established for the model organisms *Enterobacteriaceae, E. coli, Listeria* and *Salmonella*. The elimination rates of algal cultures using synthetic greywater or raw wastewater were as high as 99.996 % for *Enterobacteriaceae* and as high as 99.95 % for *E. coli.*

The quantification of the relative norovirus count presents a special challenge, because the virus can only be detected using mo-

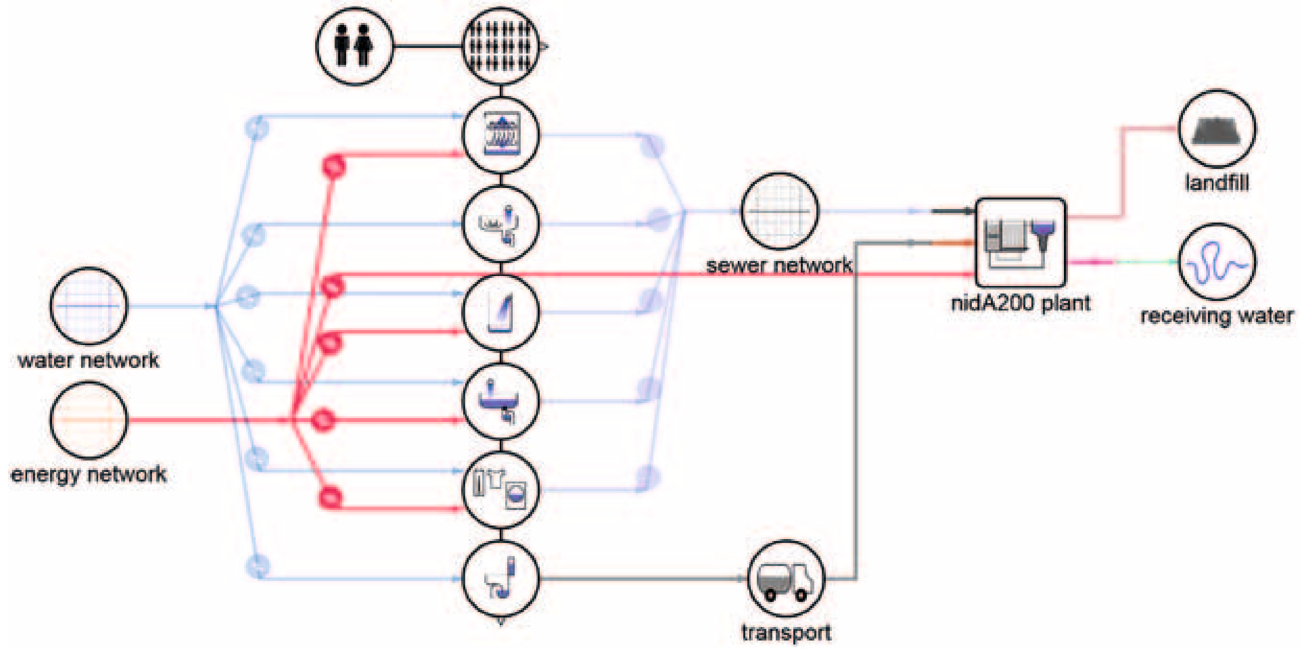

Figure 3: Initial design of a nidA200 model plant. Graphics: ifak

lecular-biological methods (polymerase chain reaction). It cannot be detected by culture. One method, in which the virus particles were bound to a charged sterile filter and the virus nucleic acid was released directly from the filter, showed positive results.

Modelling and simulation as established tools for the design and optimisation of conventional wastewater technical plants can also be applied to decentralised concepts like nidA200. The separation of material streams, their separate, pollutant-load-specific treatment, the closing of cycles and recycling/recovery all play a central role. Decentralised concepts at the planning stage can be constructed virtually and tested for transparency and plausibility. The nidA200 concept works with a module library that can be used to model the production of diverse wastewater types (e.g. brown, grey and yellow water) (see Figure 3).

The legal issues concerning alternative decentralised wastewater collection and wastewater treatment concepts were examined to define all relevant framework conditions for the implementation of the concept. With the design capacities studied here, plant licences are necessary pursuant only to water legislation.

The collection and transfer of greywater can be regarded as unproblematic. Separate collection of yellow and brown water, particularly for the purpose of conserving water, is possible if state-of-the-art negative pressure or vacuum technology is applied. This also solves the problem of poor acceptance.

OUTLOOK

The pathogen elimination rates and the degradation of trace contaminants will be optimised by varying the operating conditions, as will algal growth and nitrogen and phosphate uptake. The second experimental plant means that considerably more comparative analyses may be performed. Furthermore, greater focus is placed on nutrient recovery.

The topic of simulation/modelling will cover the modelling of biological purification processes by biomass under aerobic and anaerobic conditions (including algal biomass), the modelling of new technologies and processes (like sludge washing), the modelling of investment and operating costs and the energetic and ecological evaluation of an overall concept.

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Project period: 05/2013 – 04/2016

NoNitriNox

Planning and operation of resource and energy-efficient wastewater treatment plants with simultaneous reduction of environmentally hazardous emissions

BACKGROUND

The operation of wastewater treatment plants for nutrient removal involves substantial costs and high resource consumption. The energy requirements (electricity) for wastewater treatment plants represent a significant item on the municipal energy bill. In consequence, many efforts have been made for several years now to minimise the energy demands of wastewater treatment plants. These include:

» Flexible process design and operation to maximise nitrogen elimination (denitrification) and
» Adapted control concepts intended to minimise the energy needed for aeration, including reducing O_2 set points, optimising O_2 profiles, ammonium-based aeration, and nitrate-based intermittent aeration.

These measures have demonstrated in practice that with good planning and set-up there is significant potential for improving energy efficiency of wastewater treatment facilities. However, the introduction of these methods also reveals downsides and risks. Apart from the potential maximisation of NH_4 emissions, the deterioration in sludge stabilisation and the potential deterioration in sedimentation behaviour and sludge dewaterability, there is a danger of increased emissions such as nitrite and nitrous oxide.

The project has two important objectives:

» The development of a planning tool for the design and optimisation of wastewater treatment plants to explicitly cover quantification and evaluation of nitrite, nitrous oxide and methane emissions, as well as compliance with typical requirements (nitrogen, phosphorus and carbon elimination) and the estimation of energy consumption and energy generation.
» The development of smart control concepts that reduce the risk of nitrite, nitrous oxide and methane emissions while fulfilling the conventional tasks of meeting process specifications and minimising energy consumption.

With these project outcomes, the costs of wastewater treatment for society as a whole can be holistically analysed and minimised. In addition to advanced wastewater treatment and the associated improvement in water quality, energy costs can be minimised without increasing environmental pollution from undesirable emissions.

Figure 1: Apparatus for laboratory ablation tests. Photo: B. Cybulski

INTERIM RESULTS

Activated sludge models that characterise important intermediate products like nitrite and N_2O, as well as nitrate and ammonium nitrogen, have been developed. The models were further developed and supplemented, based on existing model concepts, to obtain an extended activated sludge model (see Figure 2). The models developed continue to comply with the state-of-the-art activated sludge models (ASM1, ASM3) and the DWA dimensioning rules (A131).

Laboratory tests suitable for verifying the developed model concepts and determining the conditions for the occurrence of relevant intermediate products were performed. Suitable laboratory installations and measurement methods were developed and tested. The municipal wastewater plant operation company Stadtentwässerung Pforzheim (ESP) performed detailed laboratory tests with different carbon substrates, with the aim of expanding models to recognise nitrite production upon the addition of external carbon sources. Each substrate was examined for upstream and downstream denitrification. Figure 1 shows the experimental design. Stuttgart University's ISWA is performing more extensive tests. These include batch experiments to verify model hypotheses on the production of nitrite and nitrous oxide during denitrification and nitrification.

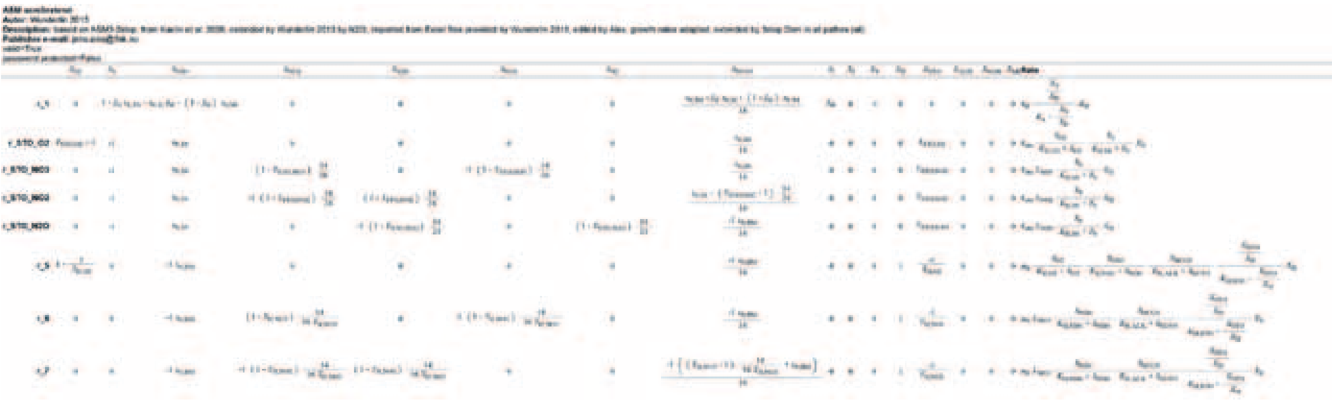

Figure 2: Section of the model matrix of a developed activated sludge model. Graphics: Jens Alex, ifak

Figure 3: Measuring cover in the Dusslingen nitrification basin. Photo: H. Miehle

Measurement facilities were prepared (see Figure 3) and simulation models of the two large-scale plants generated for verification of the activated sludge models at scale. The Steinlach-Wiesaz wastewater treatment association operates the treatment plant in Dusslingen, which has a design capacity of over 100,000 population equivalents. The wastewater treatment plant is operated with pre-denitrification and the association is interested in further improving energy efficiency. With this standard technology, the plant represents a good test case for many wastewater treatment plants of similar construction in Germany. It is possible to investigate whether the proposed control concepts avoid undesirable emissions of nitrous oxide and nitrite here.

The Pforzheim wastewater treatment plant, which treats wastewater for approximately 250,000 people, has a pre- and post-denitrification stage with an external carbon source. Here, a high nitrate load of the plant inflow from wastewater from separating facilities, versatile online measurement instrumentation and high laboratory qualification provide very good conditions for a simulation of sub-processes and the co-supervision of the test series for gas emissions from wastewater treatment.

The project has started to collect suitable control measures for the energy-efficient operation of large-scale sewage treatment plants and evaluate them using simulation techniques. The participating engineering firm Weber Ingenieure GmbH contributed some of the control measures. Suitable models were established for the aeration system – an important component with regard to energy consumption – and were tested in a simulation system that facilitated variant testing in this context, as well.

OUTLOOK

Currently, the project is conducting and evaluating laboratory testing to further verify the activated sludge models developed. Measurement campaigns have been conducted at the two large-scale plants for the same purpose, in order to try out the model under real conditions.

Based on the expected results, the expanded activated sludge model and the models of energy consumers can then be integrated into ifak e.V. Magdeburg's planning tool SIMBA#. This will enable the design and optimisation of sewage treatment plants that meet typical specifications (nitrogen, phosphorus and carbon elimination) with estimations of energy consumption and energy generation, and explicit quantification and evaluation of nitrite, nitrous oxide and methane emissions.

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Project period: 06/2013 – 05/2016

ROOF WATER-FARM

ROOF WATER FARM

Cross-sectoral use of water resources for building-integrated farming

BACKGROUND

Food is often grown far from consumers and transported over long distances. The collaborative project ROOF WATER-FARM examines new approaches to producing food in urban rooftop greenhouses and to providing these with sustainable supplies of treated water and nutrients from buildings. A concept is being developed and tested that uses single and combined processes for the hygienic use of rainwater, greywater and blackwater in conjunction with the cultivation of plants (hydroponics) and fish (aquaponics). The collaborative project is investigating the transferability and feasibility of the approach as a cross-sectoral infrastructure of urban food production and water management. It focuses on individual technologies, entire buildings and urban areas, and towns and cities as a whole. It simulates the effects on urban water management, the environment and the cyclical organisation of towns and cities. The project is also producing communications and training materials for specific target groups.

INTERIM RESULTS

The exemplary research concept is being implemented at a pilot facility in Berlin with public visibility. The existing integrated water concept of building complex Block 6 in Dessauer/Bernburger Straße in the Kreuzberg district of Berlin offers suitable structural conditions for this project, which has been developed in cooperation by the building's owner and the federal state of Berlin. Domestic wastewater from bathtubs, showers, washbasins and kitchens (greywater) is already being separately drained, processed to provide safe, hygienic process water and recycled for toilet flushing and watering the tenants' gardens. Rainwater is collected and evaporated in the original constructed wetland wastewater treatment facility.

ROOF WATER-FARM is continuing to develop this concept and is using the purified greywater as process water for the production of fish and plants in an on-site test greenhouse (see Figure 1). In addition, a safe, hygienic process for obtaining a fertilizer solution from blackwater (toilet wastewater) is being developed, tested and evaluated.

Technological development

» Pilot plant, industrial water processing (Nolde & Partners) and processing technology Water-Farm (TERRA URBANA): construction, operation and monitoring of industrial water processing system and greenhouse with fish and plant cultivation, performance of agreed screenings for hygienic quality of process water and quality of products (fish and plant)
» Pilot plant, blackwater processing (Fraunhofer UMSICHT), use of NPK liquid manure in the hydroponics testing area: identification of suitable procedures and process combinations for the treatment of blackwater, design and construction on a laboratory scale, coordination of test parameters for the hygienic supply of NPK liquid manure.

Initial analyses of the process water supplied show that the hygiene requirements for food cultivation (until now, the EU Directive for Bathing Water) have been exceeded by several orders of magnitude. The available results from trace substance and heavy metals analysis (process water, plants, fish) also show significantly low concentrations.

Upscaling, building typologies and urban transferability

» Urban Diffusion (TUB ISR, inter 3 GmbH): Selection and analysis of suitable pilot areas (TUB ISR), analysis of rooftop greenhouse potential in Berlin (see Figure 3), initial simulation of urban water management characteristics in the form of a GIS model (inter 3 GmbH), development of initial urban visualisations in the form of network plans, collages, narratives, representation as a diffusion scenario for the pilot area "suburb" (TUB ISR)

Figure 1: View of the ROOF WATER-FARM greenhouse on the occasion of the Strawberry Festival in June 2014. More than 250 visitors came to learn about the research project and the facilities. Photo: ROOF WATER-FARM

- Upscaling of buildings (TUB ISR): definition of transferable RWF building typologies according to uses, characterisation according to water and material streams and optional RWF variants (processing technologies), performance of initial residential building study, preparation of further application and prototype studies
- Innovation arena (inter 3 GmbH): preparatory work for implementation of multi-criteria innovation potential and risk analysis, internal workshop on multi-criteria analysis, initial analysis of the innovation arena

Communications, capacity building

- Launch of the online platform and start of the project's web campaign (see Figure 2) (TUB ISR)
- Regular guided tours, themed events and training events at the pilot plant premises (TUB ISR, all partners)
- Preparation of content of communications formats, adjustment to ways of addressing target groups, establishment of network (TUB ISR, all partners)
- Presentation of project at the exhibition "Ökologische Gebäudekonzepte" [Ecological Building Concepts] organised by the Senate Department for Urban Development and the Environment

Figure 2: Water, city, infrastructure, products, people – themes of the project's web campaign. Photo: ROOF WATER-FARM

OUTLOOK

- Testing and monitoring of process water quality and other product ranges plant + fish (TERRA URBANA, Nolde & Partner, Fraunhofer UMSICHT)
- Installation of the hydroponics test area in the water-farm greenhouse (TERRA URBANA, Nolde & Partner, Fraunhofer UMSICHT) and testing the safe, hygienic and productive use of NPK liquid manure
- Assessment of the procedures developed based on exemplary economic considerations and using ecological accounting (inter 3 GmbH, Nolde & Partner, Fraunhofer UMSICHT), derivation of optimisation potentials from an economic and ecological perspective

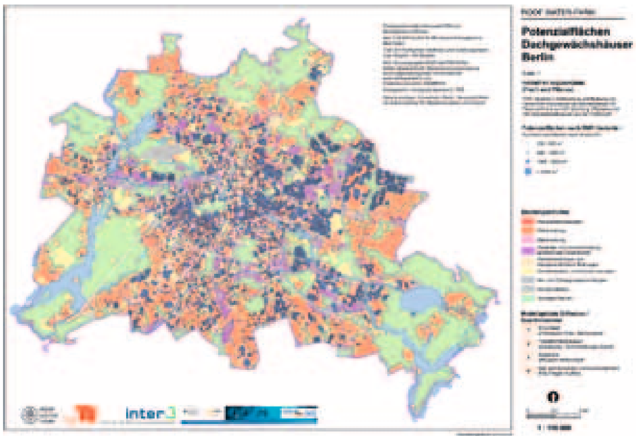

Figure 3: Visualisation of potential areas for rooftop greenhouses in Berlin. Section from the project's GIS working model. Database: Umweltatlas Berlin, Geoportal Berlin, Senate Department of Urban Development and the Environment. Graphics: ROOF WATER-FARM

- Exemplary representation of diffusion potential based on urban scenarios, interviews with stakeholders, prototypical building studies including operator models and recommendations for planning activities, evaluation of urban transferability (TUB ISR)
- Completion of multi-criteria analysis and analysis of the innovation arena for cross-sectoral infrastructure, derivation of stakeholder-specific recommendations for action (inter 3 GmbH)
- Publication of training and communications materials for various target groups in the fields of acceptance, education and specialist planning (TUB ISR, all partners).

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Project period: 07/2013 – 06/2016

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