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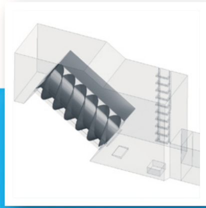
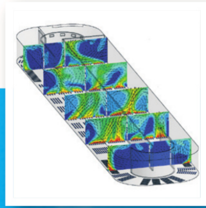
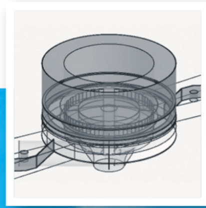
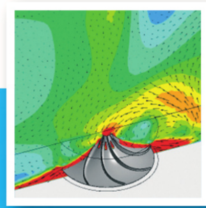








Computational Fluid Dynamics and Optimization

Measurement, Simulation, Evaluation, Solution

Ten good reasons for hydrograv

1. Interdisciplinary team
2. Advanced know-how in simulation
3. Profound expertise in measurements
4. In-house developments
5. Open to external impulses
6. Validated simulation results
7. Advanced analyses
8. Internationality
9. Knowledge transfer with leading university institutes
10. Training

Good reasons for hydrograv

Interdisciplinary team
For CFD simulations in urban water management it is important to combine the knowledge of flow engineers with the know-how of municipal water management engineers and other experts. Therefore, experts from many disciplines work at hydrograv, such as hydrologists, mathematicians, civil engineers or mechanical engineers.

Advanced know-how in simulation
Our simulations are based on more than 35 years of experience in the field of CFD simulations in wastewater technology. Our roots lie in the CFD team of the Institute for Hydromechanics of Karlsruhe Institute of Technology (KIT) that was a pioneer of wastewater relevant simulations. Its first paper about the modeling and simulation of clarifiers was already published in 1981. Since then we have continued developing and improving CFD models.

Profound expertise in measurements
For more than three decades, we have been testing and, if necessary, improving our model approaches based on measured data. This includes external data and our own measurements in the laboratory, in nature and of course in sewage treatment plants and gives us the practical experience we need to perform and interpret simulations practice oriented.

In-house developments
After decades of development work, the quality of our simulations is very high and acknowledged by our customers. But there is no time to rest. Our approaches are still subject to our own critical examination and further development. In the meantime, hydrograv has developed a number of innovative model approaches, for example the modelling of sludge rheology, reaction kinetics in ozone reactors or the oxygen transfer in aeration tanks (k_La, SOTE, SSOTR), e.g. according to the German design guideline DWA-M 209.

Open to external impulses
Quite a few of our models were developed to meet customer requests with particular hydraulic problems. Our mission is that these developments always have to meet scientific requirements. Do you have maybe a particular hydraulic question?

Validated simulation results
hydrograv is convinced that regular measurement is necessary for responsible handling of simulations. Therefore we offer you measurements and simulations from a single source. Before simulating your system we recommend to carry out measurements in your facility. Without measurements we can make use of a huge data base of previous measurements from which reliable calibrated model approaches have been arisen. Basically, with measured data, we critically assess how accurately the simulation reflects the flow patterns or settling processes in each particular case. This provides confidence, deepens process understanding and motivates model improvements.

Advanced analyses
With our data mining tools we process and analyze large amounts of data of a plant. We apply statistical methods systematically and goal-oriented to solve technical problems. For this reason, every flow simulation involves a variety of deterministic analyses. These analyses together with visualizations of flow processes improve the understanding of the actual causes and lead to efficient and targeted solutions. These analyses reveal, for example separation rates in percent, potential deposition areas, residence time curves, variant-dependent oxygen transfer rates (k_La, SOTE, SSOTR) or hydraulic pressures and torques.

Good reasons for hydrograv

Internationality

Time and again we have cooperated with institutions in several European and non-European countries, e.g. in United Kingdom, Spain and Netherlands. We also work successfully for customers from all over the world.

Knowledge transfer with leading university institutes

We have close contacts to different scientific institutes, such as the Institute of Urban and Industrial Water Management at the Technische Universität Dresden. These contacts provide valuable support and opportunities for our projects.

Training

Our employees are continuously trained to sustain our high quality standard. Additionally, our employees train other professionals.

We deliver verified, comprehensible, comparable and interpreted results:

- hydrograv delivers reviewed and verified simulations. Therefore we regularly perform measurements to validate our simulation results and ensure that our simulation models are applied within valid system constraints.
- Sensitivity analyses are carried out regularly to archive a better understanding of system behavior, to interpret the simulation results in a targeted manner and to verify the plausibility of the simulations.
- Operating data of several years will be extensively analyzed and evaluated statistically. These statistical analyses are the basis for the simulations which are agreed with the customer.
- hydrograv delivers extensive and comprehensible analyses and technically targeted interpretations of the results, for example as comparable key indicators.

Why a computer-based simulation?

- Cost saving in construction and operation due to early identification of weak points, often with possible performance increases of 20 % and more
- complex tasks cannot be solved with analytical methods in most cases
- extensive variation of building geometries are possible easily and quickly
- simple and fast analyses of variants including dynamic processes
- cost-efficient testing ground
- verification of special solutions which do not correspond to the state of the art or are outside the validity of design guidelines

We deliver:

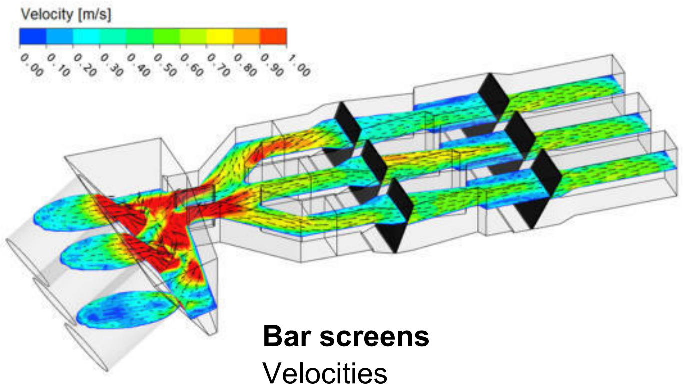
- proof of functionality
- facility dimensioning
- verification of safety reserves
- performance limits
- avoidance of weak points and bottlenecks
- development and validation of emergency strategies
- effects of changes in requirements and accidents
- process logic/control criteria

Primary Treatment

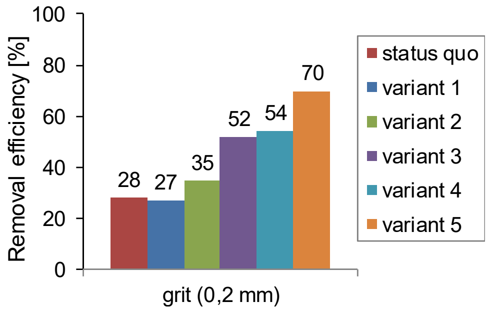
Maximization of the removal efficiency

Your benefits

- Optimization of hydraulic and material distribution
- Maximization of grit removal efficiency
- Minimization of energy usage for aeration in grit chambers
- Comparison of variants, e.g. types of bar screens
- Verification of hydraulic losses



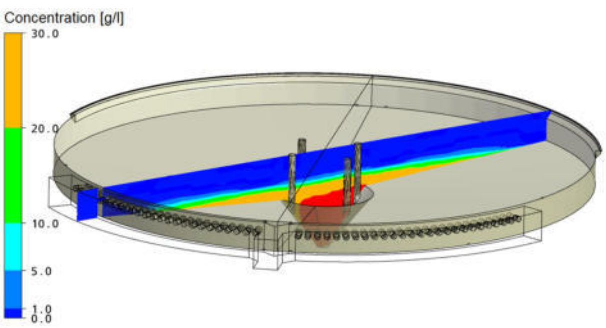
Bar screens
Velocities



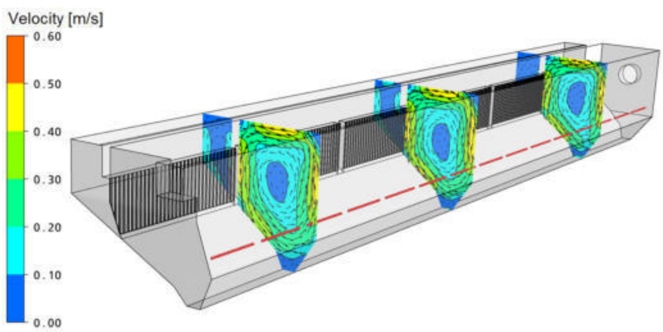
Grit chamber
Improved removal of grit particles

Methods

- Three-dimensional, multiphase flow simulation
- For each treatment step specific modeling approaches:
  - Free surface in channels
  - Aeration in grit chambers
  - Simulation of different wastewater substances: grit and organic particles, grease, primary sludge



Primary clarifier
Maximization of primary sludge



Aerated grit chamber
Velocities on cross-stream planes

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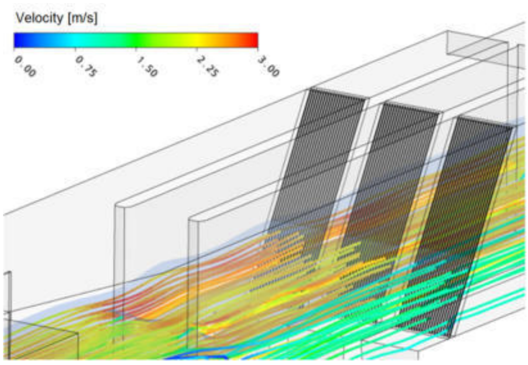
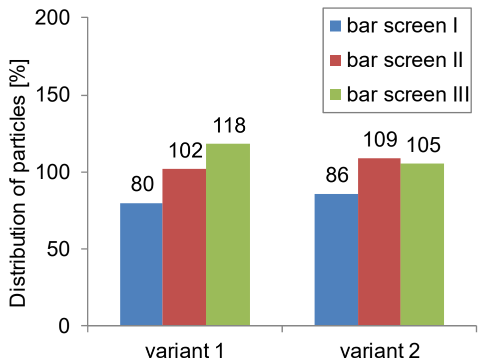
Primary Treatment

Maximization of the removal efficiency



Bar screens
Realistic modeling by calibration



Deterministic analysis
Distribution of particles at bar screens

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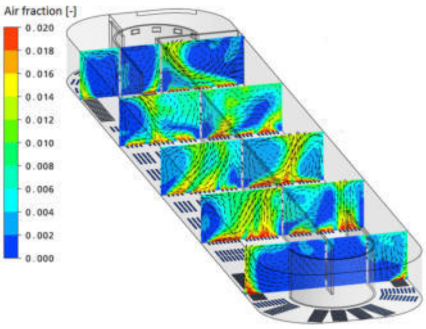
Activated Sludge Tanks

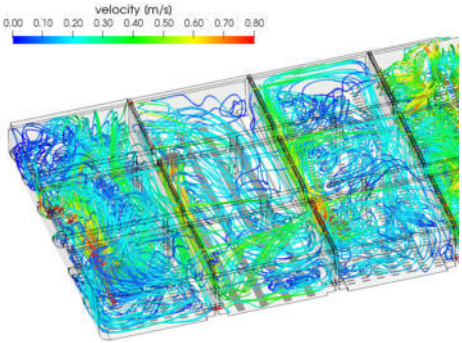
Enhanced biodegradation

Your benefits

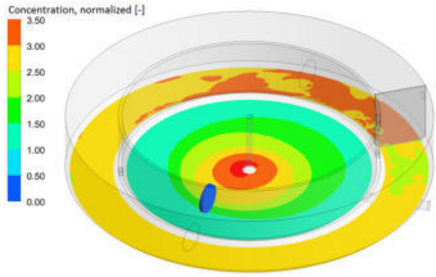
- Optimal operational conditions
- Cost reduction due to savings in energy and investment
- Optimization of position, performance and the number of agitators
- Prevention of depositions
- Increased oxygen transfer



Optimization of aerators arrangement



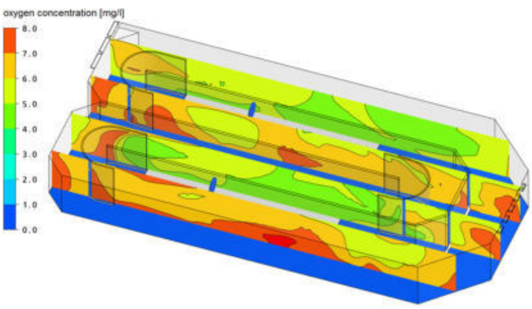
Optimization of agitators



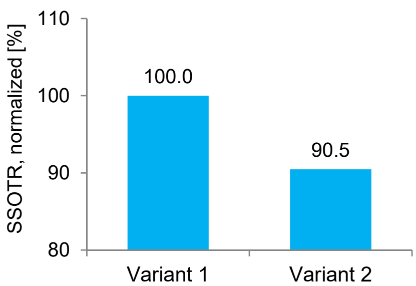
Analysis of depositions

Virtual oxygen transfer experiments

- Optimization of aerator arrangement by virtual oxygen transfer experiment
- Realistic determination of SSOTR, SOTE and $k_L a$



SSOTR +23 %
Simulation of oxygen transfer



SSOTR - comparison of variants

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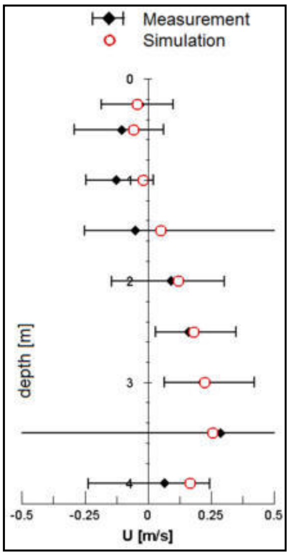
Activated Sludge Tanks

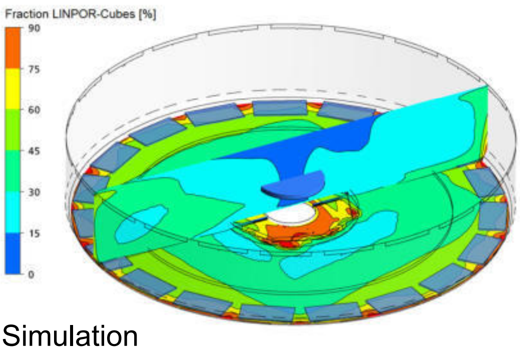
Enhanced biodegradation

Methods

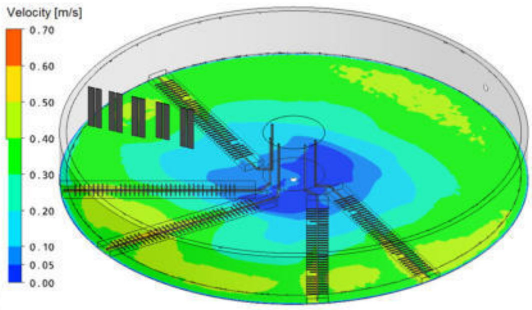
- Three-dimensional, multiphase flow simulation incl. aeration
- Modeling activated sludge or floating biofilm carriers
- Agitators as impulse source or real geometries
- Virtual oxygen transfer experiments
- Velocity measurement for the validation of modeling approaches



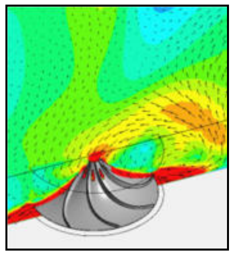
Comparison
Measurement - Simulation



Simulation
of biofilm carriers



Rotating
agitators used
for mixing



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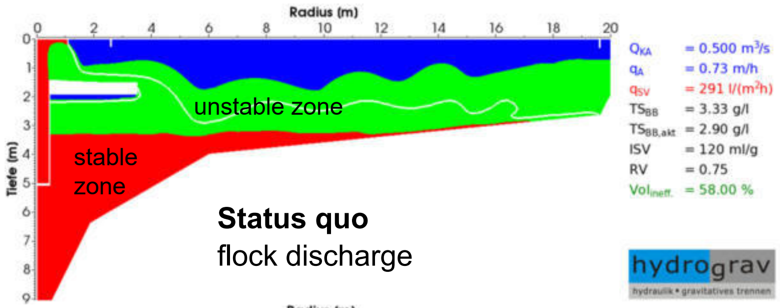
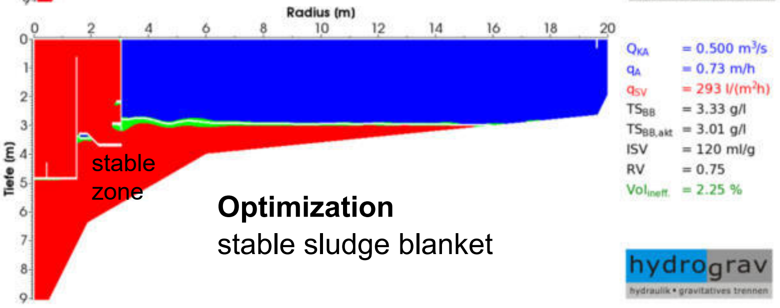
Secondary Clarifiers

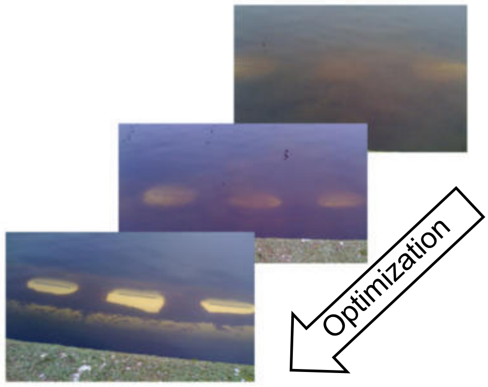
Highest effluent quality

Your benefits

- Maximum safety in terms of sludge overflow and flock discharge
- Optimization of operating strategies, e.g. optimal return sludge flow
- Variant comparison already in the planning phase
- Proof of performance limits even beyond design guidelines
- Determination of the flocculation potential

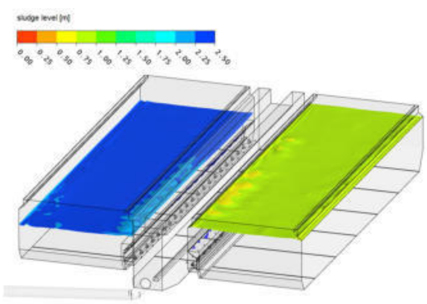




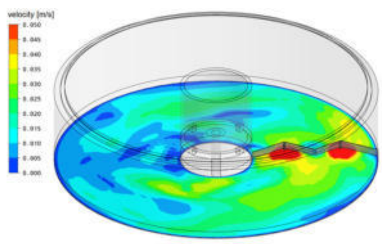


Methods

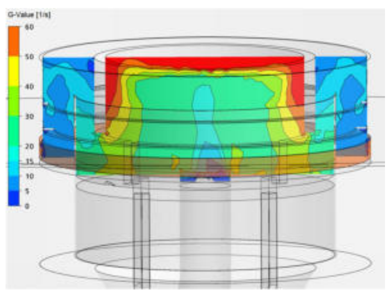
- Two- and three-dimensional simulations
- Realistic modeling of the settling and flow characteristics of activated sludge
- Consideration of sludge displacement into the clarifiers
- Realistic modeling of scraper systems



Rectangular Tank:
Sludge Level



Circular Tank:
Velocities above the Floor



G-Value Determination

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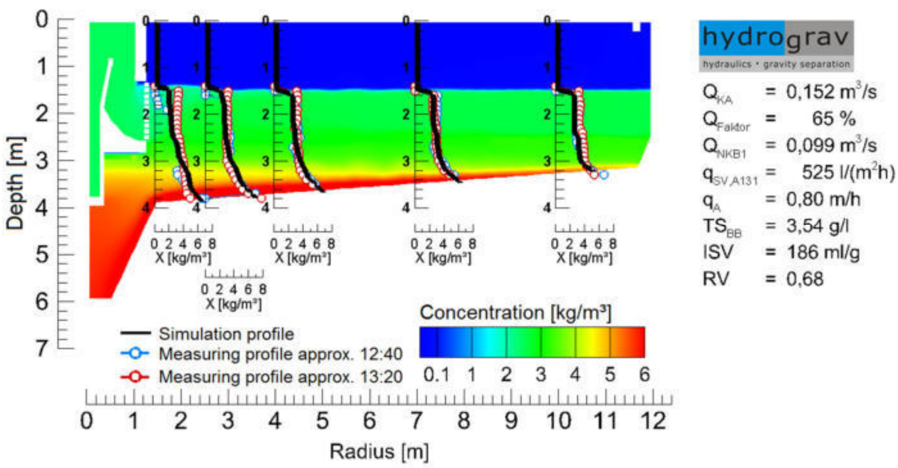
Secondary Clarifiers

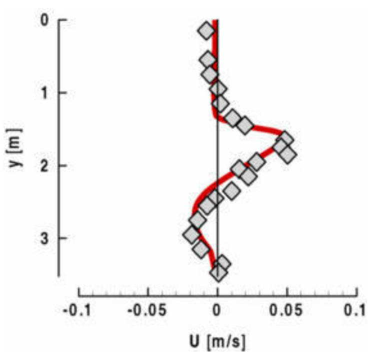
Highest effluent quality

Measurement

- Calibration of modeling approaches by measurement of
    - sludge concentration,
    - settling velocities and
    - flow velocities.



Calibration using measurement of sludge concentration



Velocity measurement

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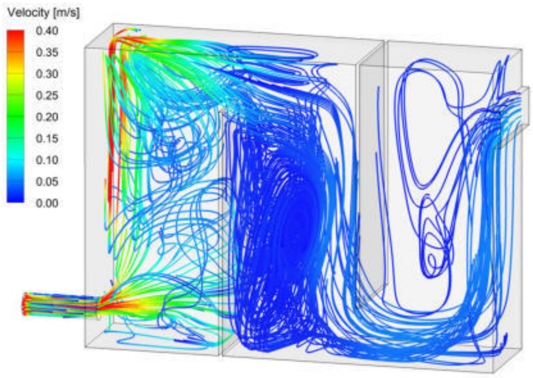
Fourth Treatment Stage

Increased degradation of micropollutants

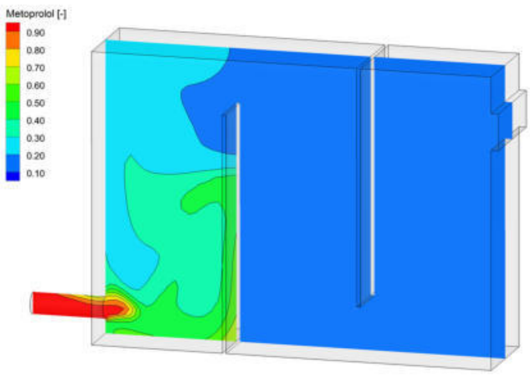
Ozone Reactor

Your benefits

- Calculation of micropollutants degradation rates
- Optimized hydraulics for efficient degradation
- Cost savings due to reduction of required treatment volume
- Detection of micropollutant concentration in off-gas and effluent flow



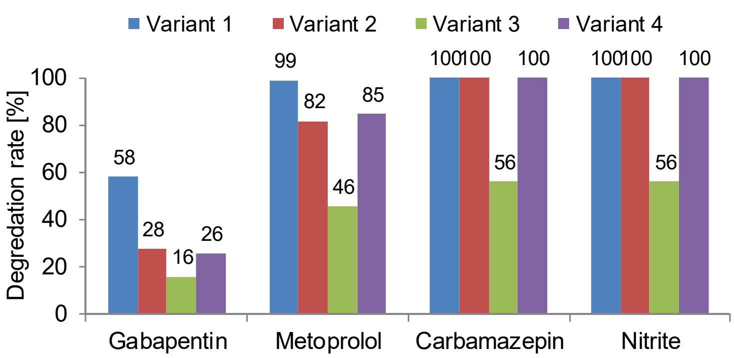
Streamlines



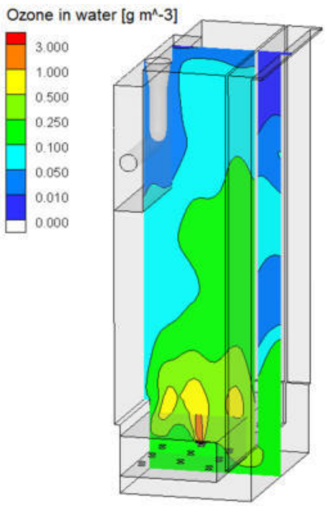
Concentration of the micropollutant Metoprolol

Methods

- Three-dimensional, multiphase flow simulations
- Mass transfer between ozone-oxygen mixture and water
- Decay of ozone
- Reaction with micropollutants and other substances in water, e.g. Metoprolol and DOC



Analysis of degradation rates for micropollutant and nitrite



Ozone distribution in the reactor

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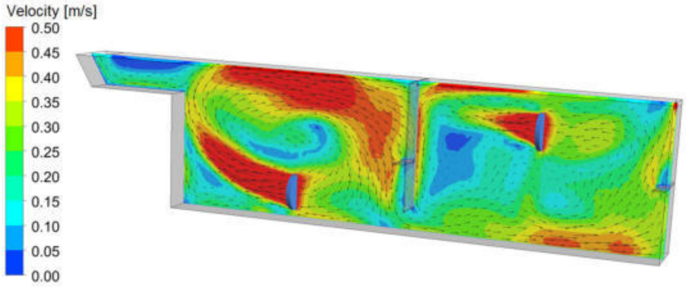
Fourth Treatment Stage

Increased degradation of micropollutants

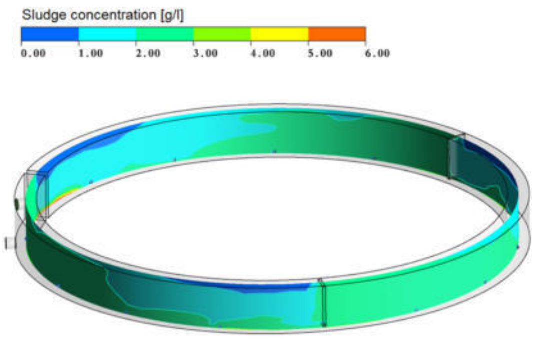
Activated carbon reactor

Your benefits

- Optimal mixing in the reaction tank
- Maximum separation in the sedimentation tank



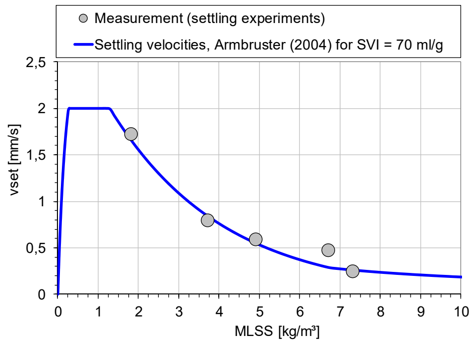
Velocity distribution



Distribution of concentration

Methods

- Three-dimensional, multiphase flow simulations
- Modeling of activated carbon particles
- Experimental determination of settling velocities



Comparison experiment vs. model

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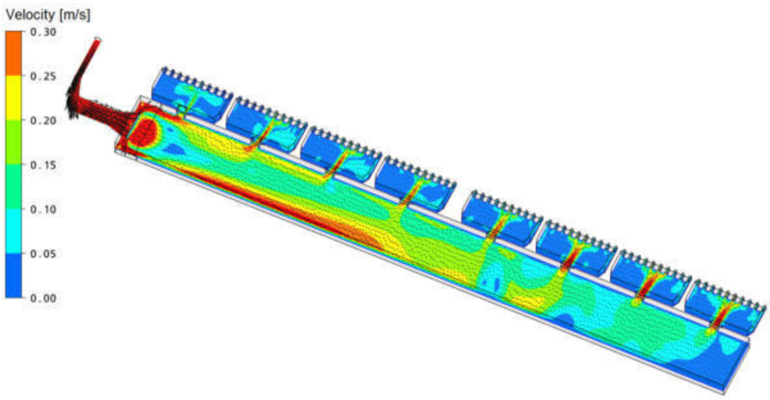
INNOVATIVE THROUGH RESEARCH

Distribution Structures

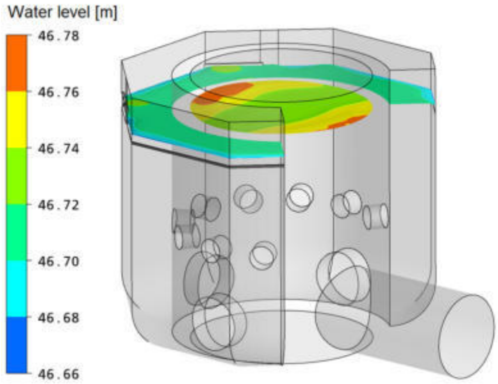
Optimal hydraulic and material distribution

Your benefits

- Optimization of hydraulic and material distribution
- Prevention of depositions
- Analysis of water levels and hydraulic losses



Optimization of the hydraulic distribution

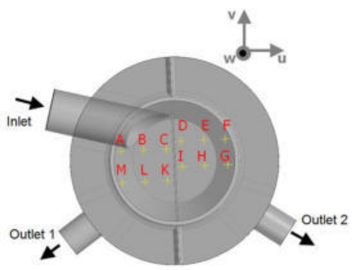


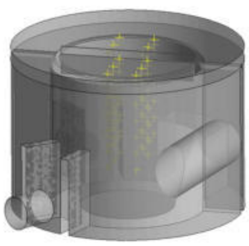
Analysis of hydraulic losses

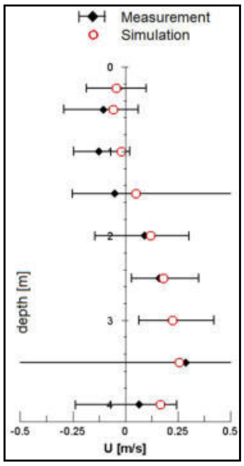
Methods

- Three-dimensional, multiphase flow simulations
- Free surface flow simulation
- Modeling of particle or activated sludge
- Verification of modeling approaches with velocity measurement

Velocity measurement







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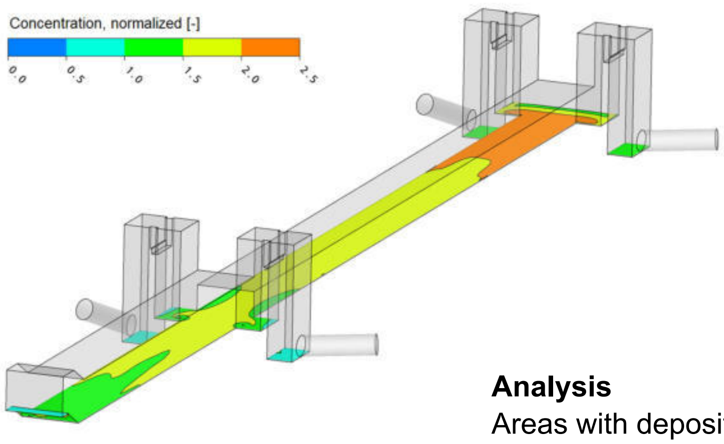
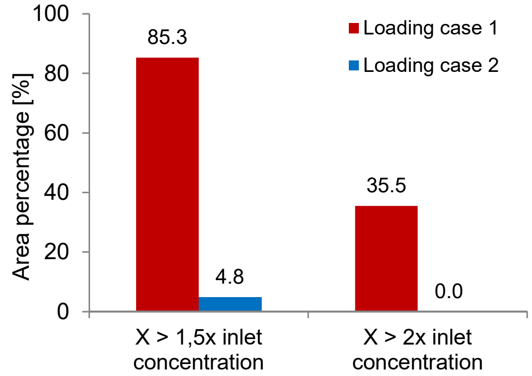
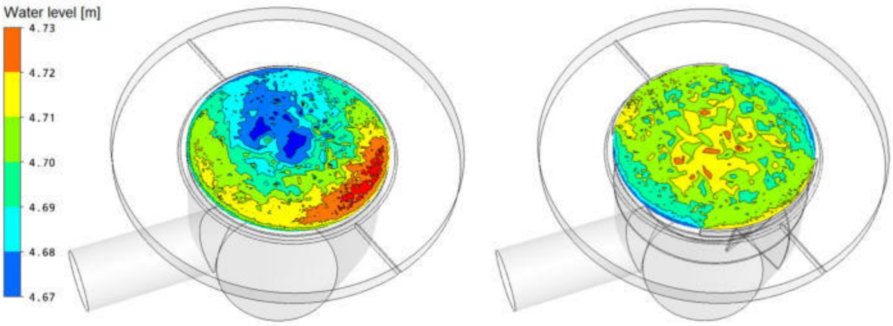
Distribution Structures

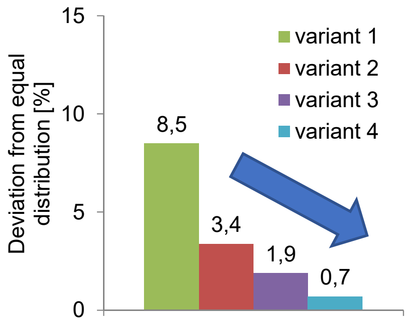
Optimal hydraulic and material distribution





Analysis
Areas with deposition





Optimization
of the hydraulic distribution

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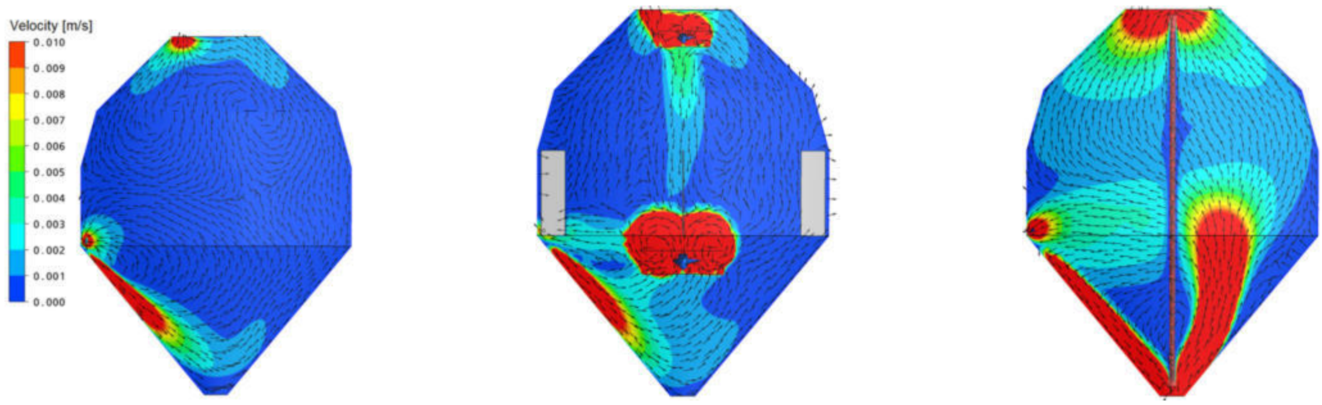
Anaerobic Digesters

Optimal mixing

Your benefits

- Verification and optimization of mixing
- Comparison of various mixing systems like pumps, screw pumps, agitators or gas injection
- Increased forecast accuracy by measurements of the sludge rheology

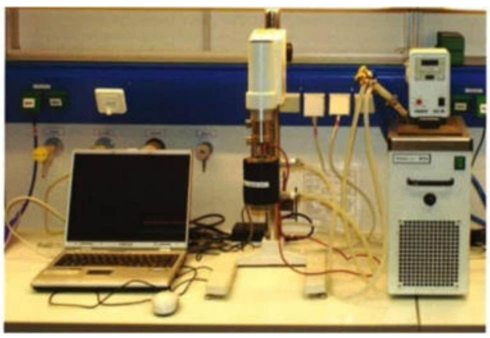


External mixing by pumps Central agitators Central screw pump

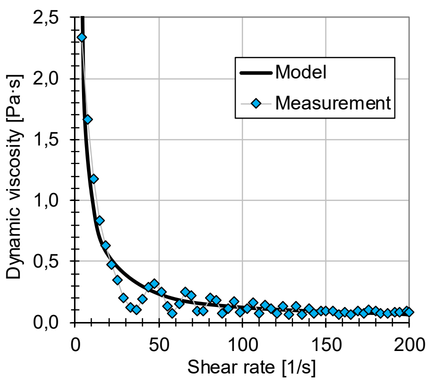
Comparison of various mixing systems

Methods

- Three-dimensional, multiphase flow simulations
- Implementation of gas formation
- Use of rheological models
- Measurement of sludge viscosity



Measurement of sludge viscosity



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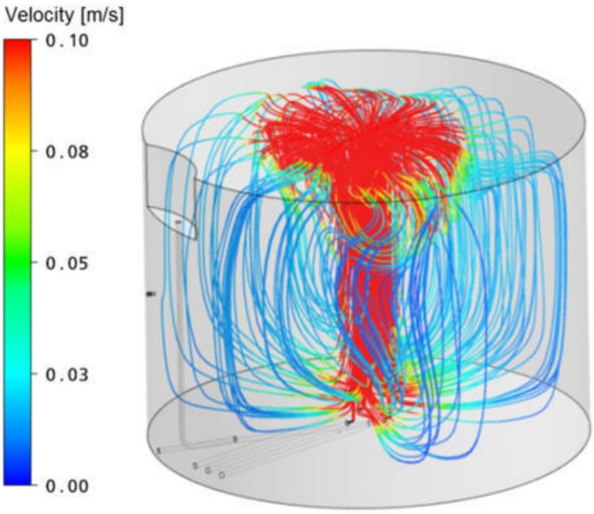
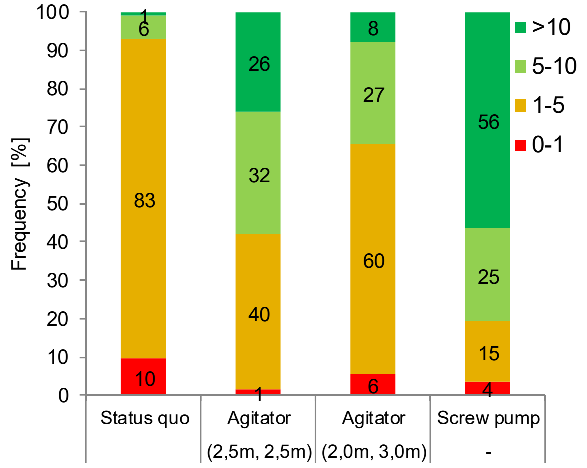
Anaerobic Digesters

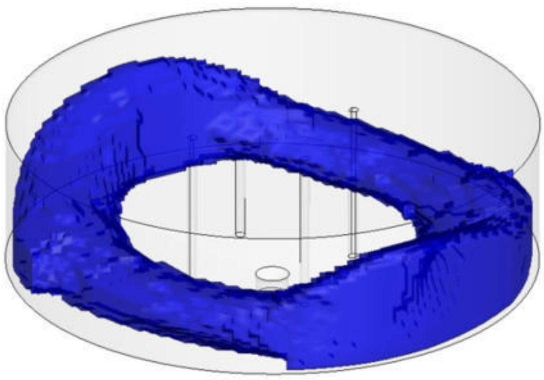
Optimal mixing



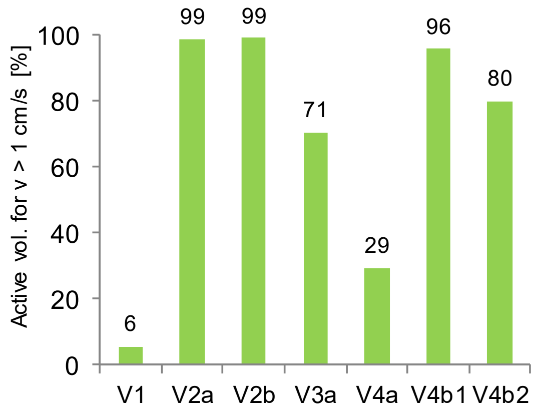
Anaerobic digester with gas injection



Analysis of the mixing rate



Areas with active volume



Analysis of the active volume

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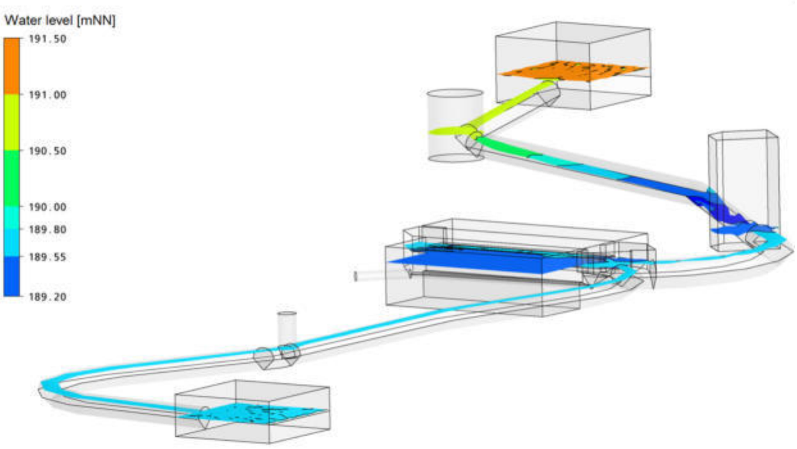
2022/2023 INNOVATIVE THROUGH RESEARCH

Sewer Systems and Stormwater Basins

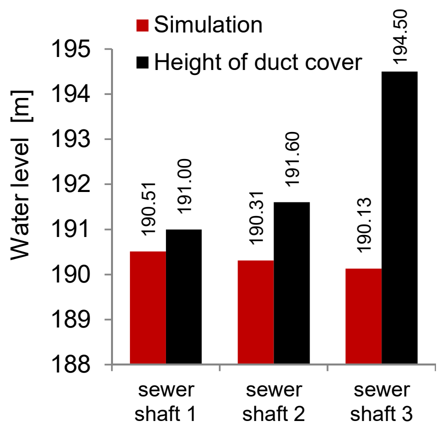
Optimal hydraulic and material distribution

Your benefits

- Proof and optimization of stormwater tanks, separation structures and sewer systems
- Hydraulic distribution
- Determination of the separation rate, e.g. according to DWA-A-102 (AFS63)



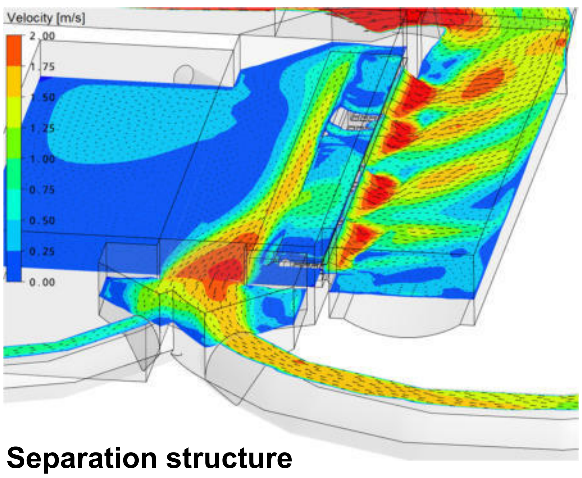
Separation structure with sewers and sewer shafts
Water level



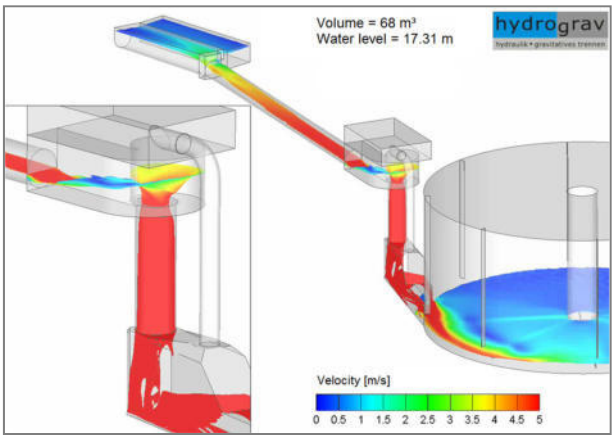
Deterministic analysis
Hydraulic losses

Methods

- Three-dimensional, multiphase flow simulation
- Free surface simulation
- Including particles



Separation structure
Optimization of hydraulic and material distribution



Transient processes
Verification of a stormwater tank with vortex drop shaft

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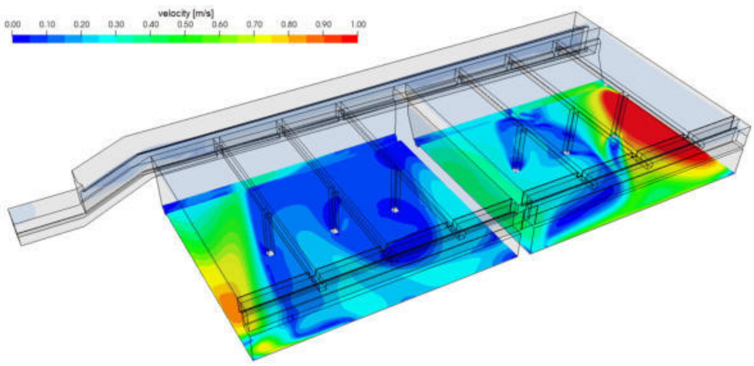
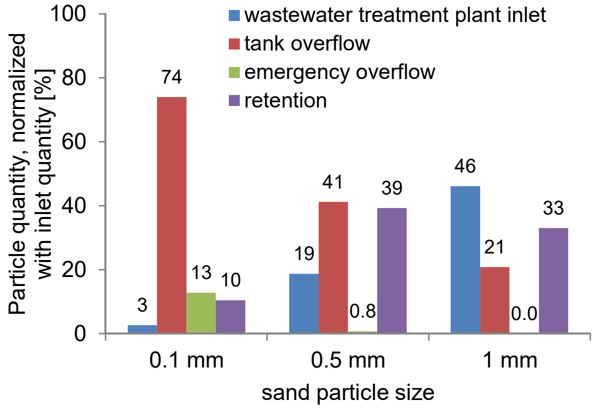
Sewer Systems and Stormwater Basins

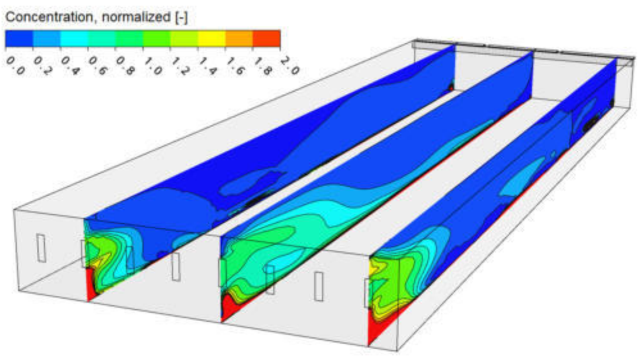
Optimal hydraulic and material distribution



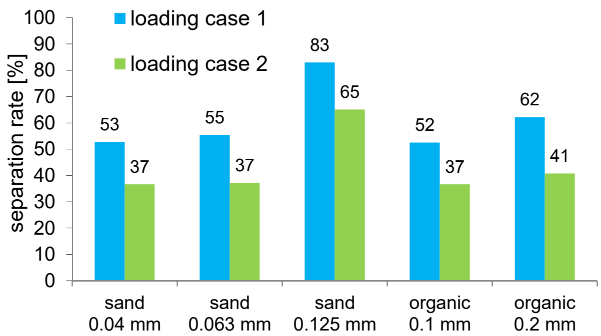
Stormwater tanks
Analysis of velocities near the bottom



Analysis of particle distribution



Stormwater tanks
Analysis of potential deposits and separation rate



Analysis of the separation rate

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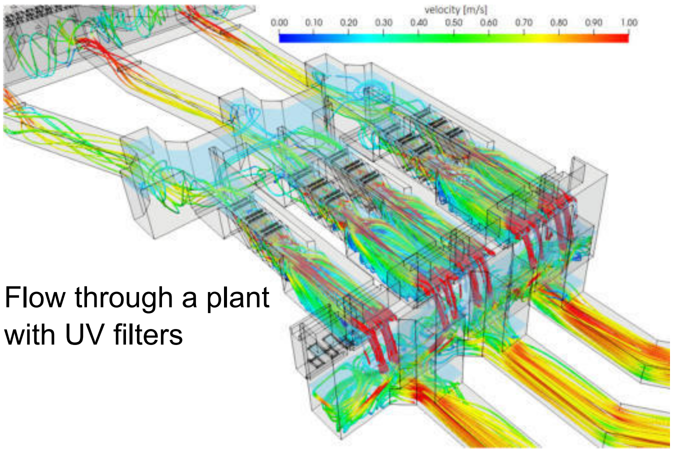
INNOVATIVE THROUGH RESEARCH

Drinking Water Supply

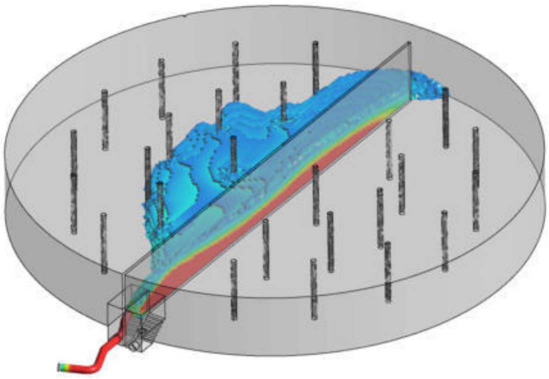
Enhanced water quality

Your benefits

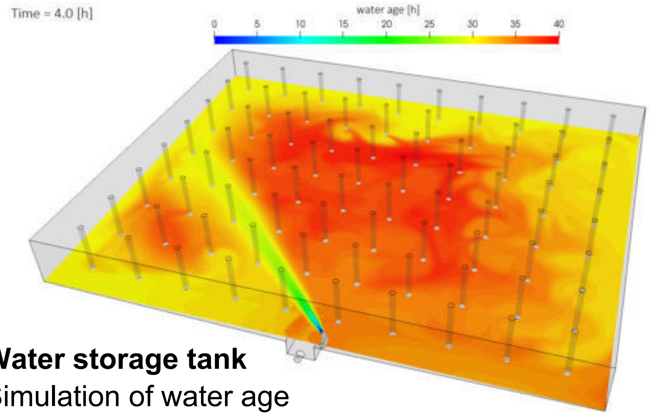
- Increased planning reliability
- Enhanced water quality
- Improved process knowledge



Flow through a plant with UV filters



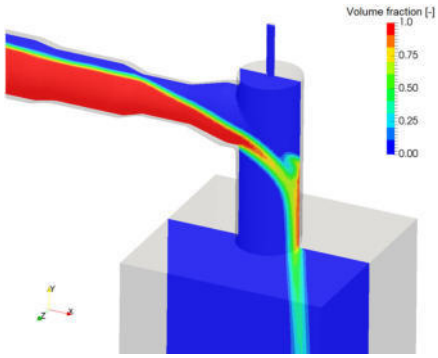
Water storage tank
Tracer distribution



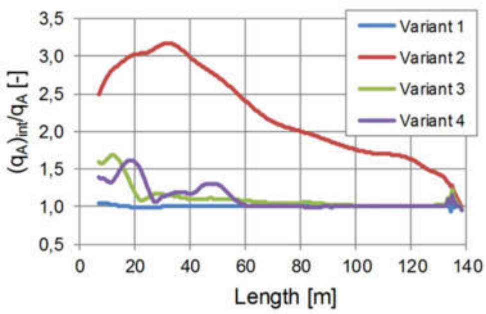
Water storage tank
Simulation of water age

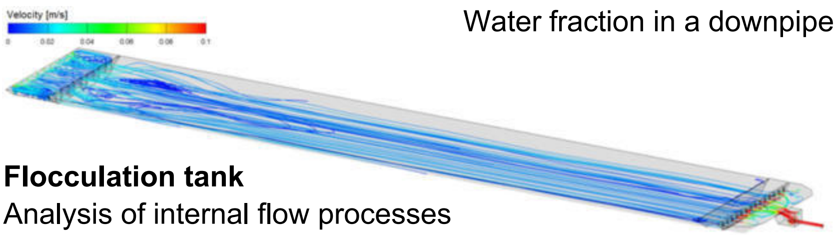
Applications

- Water storage tanks
- Valves
- Flocculation tanks



Valve in a waterworks
Water fraction in a downpipe





Flocculation tank
Analysis of internal flow processes

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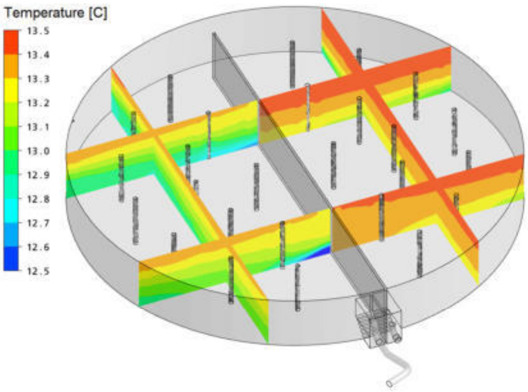
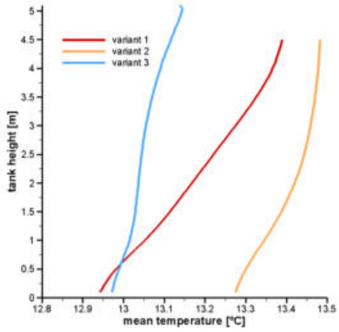
Drinking Water Supply

Enhanced water quality

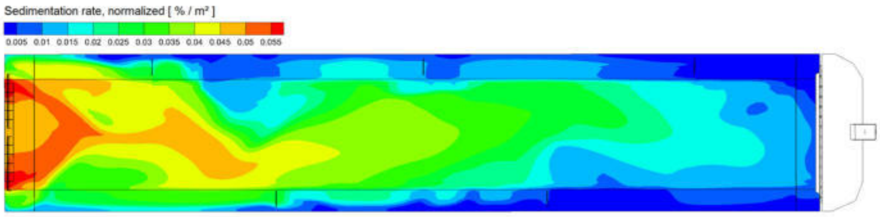
Methods

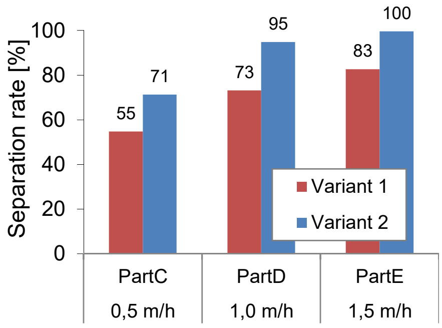
- Three-dimensional simulations
- Tracer analysis to compute residence time
- Determination of water age
- Consideration of temperature gradients
- Simulation of particles in flocculation tanks





Water storage tank
Distribution of temperature





Flocculation tank
Analysis of particle removal

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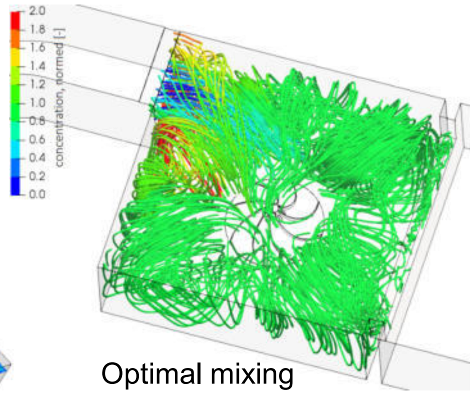
Flocculation Filtration

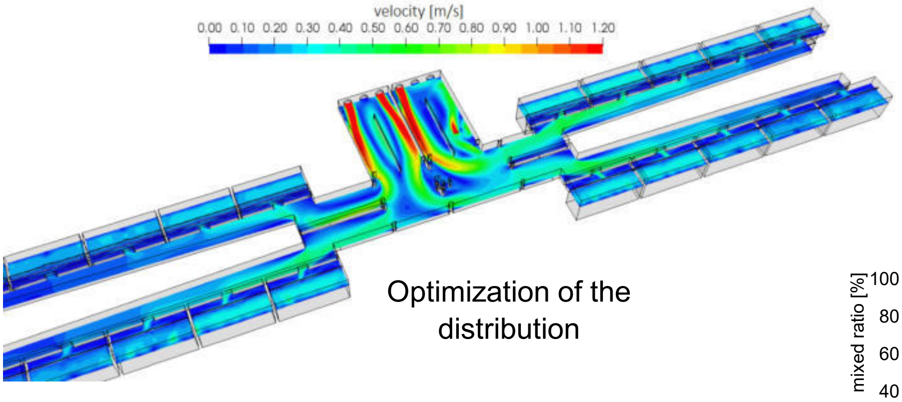
Optimal mixing, distribution and filter inflow

Your benefits

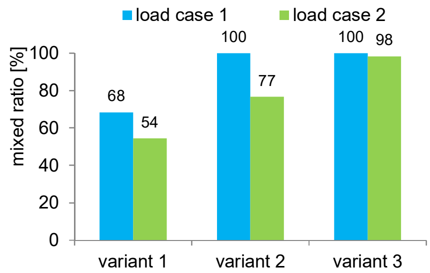
- Optimal mixing of activated carbon, precipitant and flocculants
- Optimization of the hydraulic and particle distribution to the filter chambers
- Prevention of depositions
- Calculation of the G-factor
- Optimal filter backwashing in the underdrain



Optimal mixing of precipitant



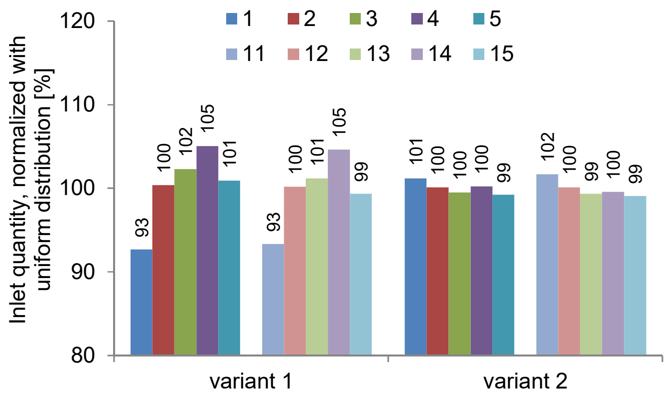
Optimization of the distribution



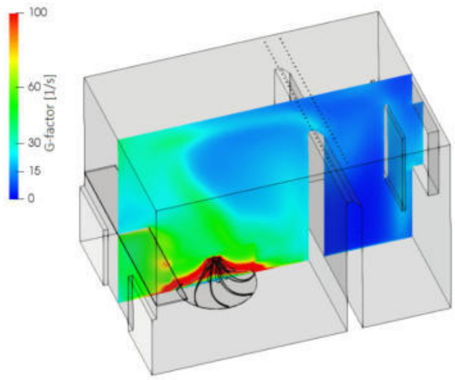
Mixing tank
Analysis of the precipitant mixing

Methods

- Three-dimensional, multiphase flow simulation
- With free water surface
- Incl. modeling of particles, activated carbon, precipitants and flocculants



Filter chambers
Analysis of the distribution to the filter chambers



Calculation of the G-factor

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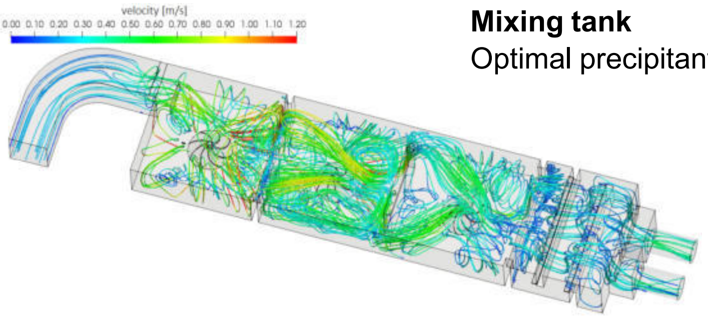
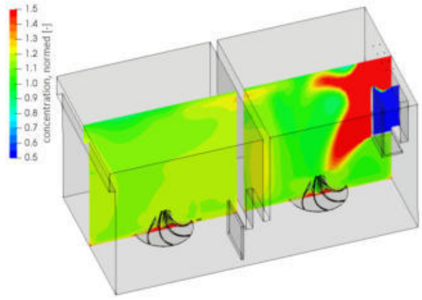
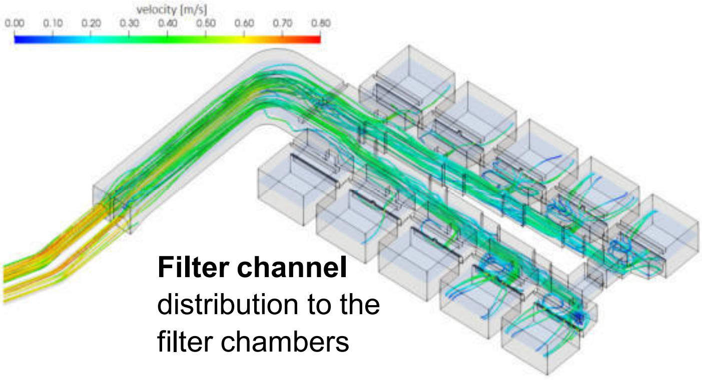
Flocculation Filtration

Optimal mixing, distribution and filter inflow



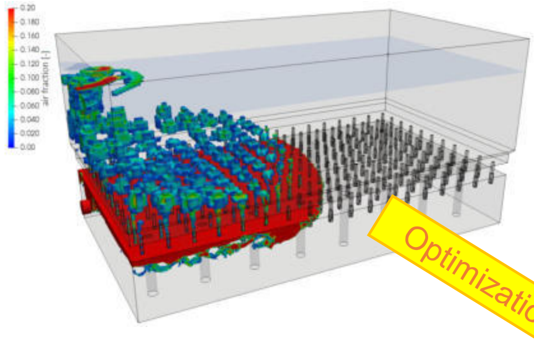
Mixing tank
Optimal precipitant mixing



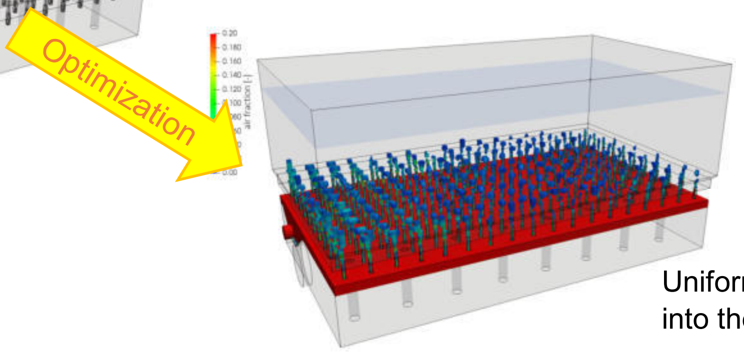


Filter channel
distribution to the filter chambers

Underdrain



Premature air introduction into the filter bed



Uniform air introduction into the filter bed

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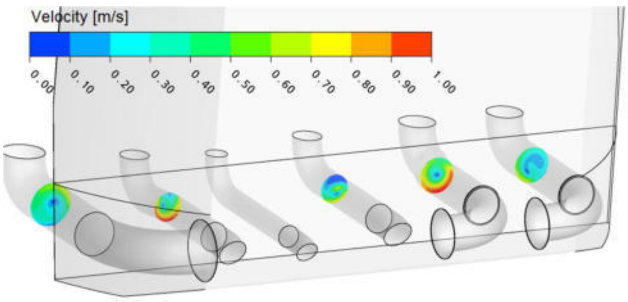
INNOVATIVE THROUGH RESEARCH

Pumping Stations and Agitators

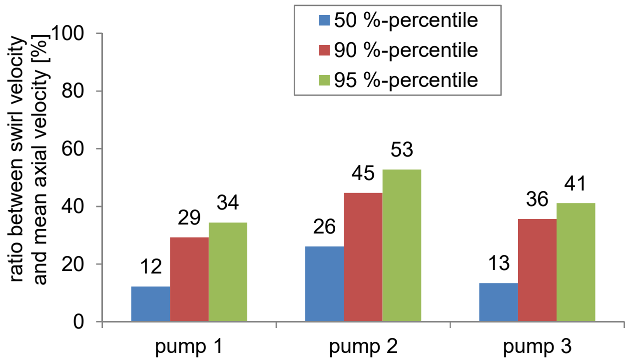
Optimal incident flow conditions

Your benefits

- Optimization of the incident flow
- Reduction of life cycle costs
- Evaluation with planning
- R&D-support, e.g for pump manufacturer
- Deterministic evaluation of hydraulic losses



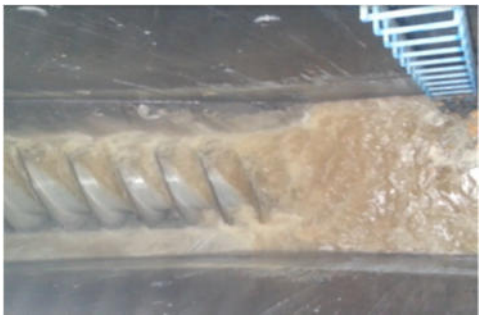
Pumping station
Analysis of incident flow velocity



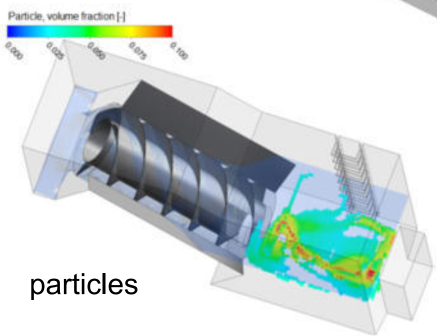
Deterministic analysis
Proof of swirl absence

Methods

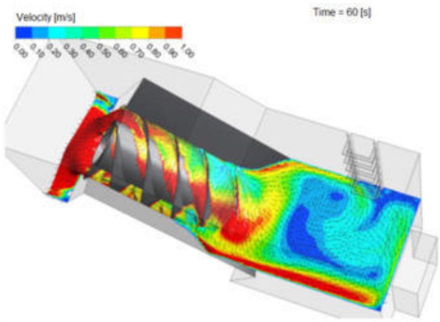
- Three-dimensional, multiphase flow simulations
- Free surface flow simulation
- Including particles, e.g. floating or settling particles



Screw pump
Simulation incl. floating sludge



particles



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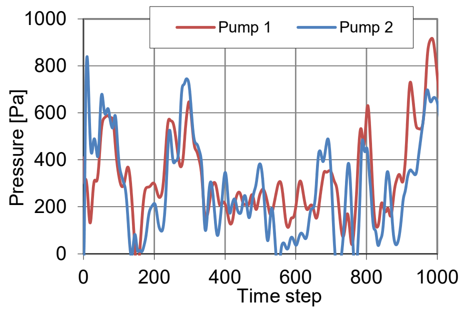
Pumping Stations and Agitators

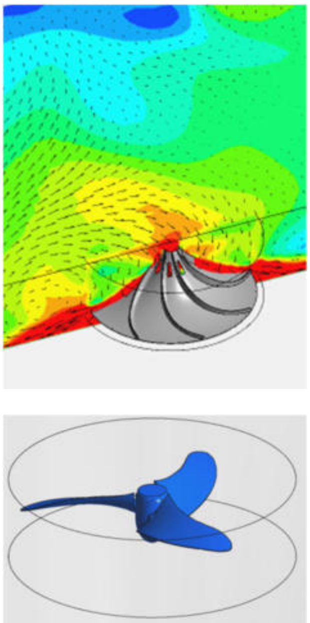
Optimal incident flow conditions

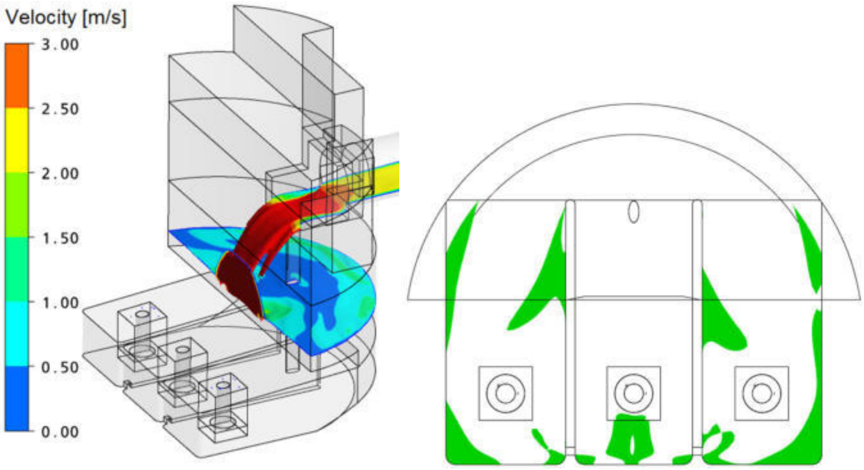
Analysis

- Pressure losses and fluctuations
- Proof of swirl, velocity distribution and vortices
- Areas with potential depositions



Pumping station
Analysis of pressure fluctuations





Agitators
Modeling of real geometries

Pumping station
Analysis of potential areas with depositions

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