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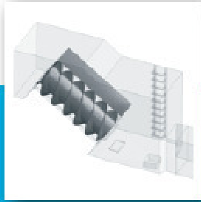

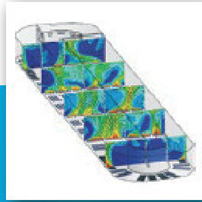

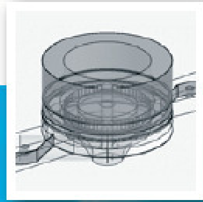

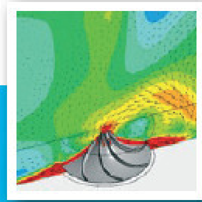

Computational Fluid Dynamics and Optimization

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

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.

Reasons for hydrograv

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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

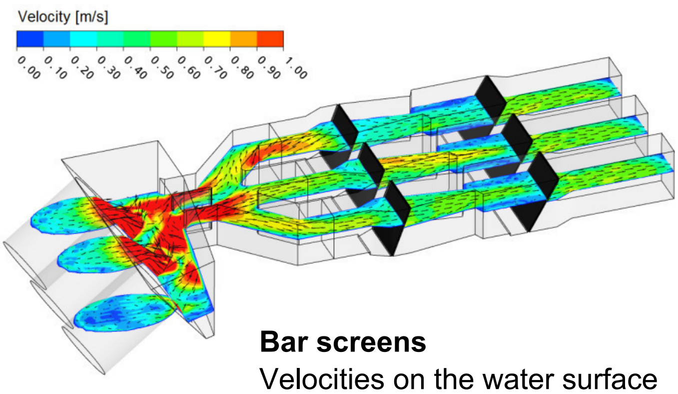
We deliver:
- proof of functionality
- facility dimensioning
- verification of safety reserves
- performance limits
- avoidance of weak points and bottlenecks
- development and validation of emergency strategies
- effects of changes in requirements and accidents
- process logic/control criteria

Primary Treatment

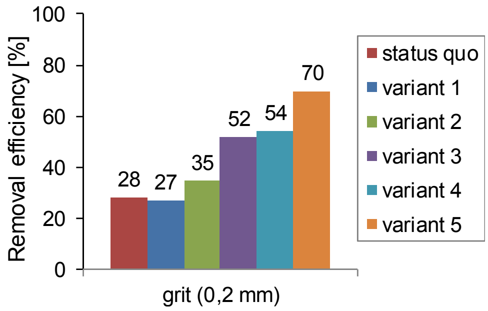
Maximization of the removal efficiency

Your benefits

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



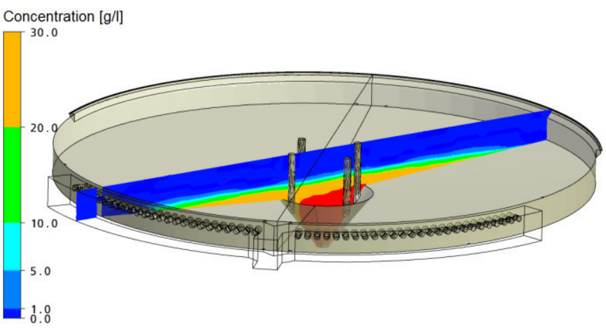
Bar screens
Velocities on the water surface



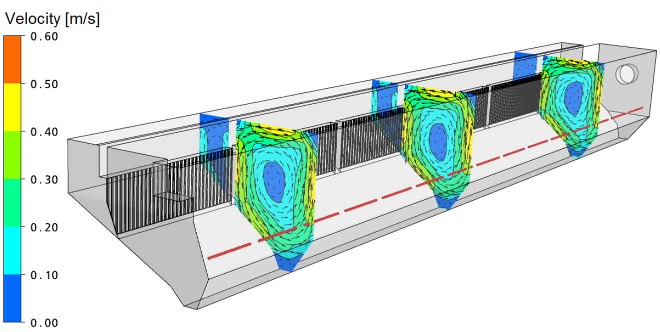
Grit chamber
Increased removal of grit particles

Methods

- Three-dimensional, multiphase 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 vertical planes

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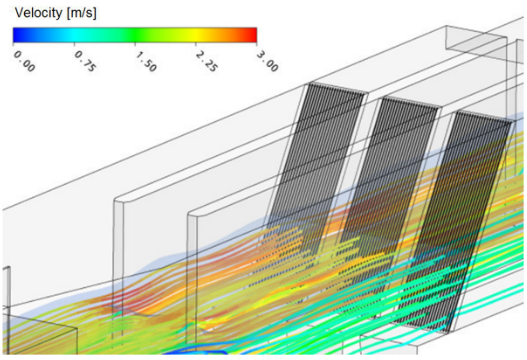
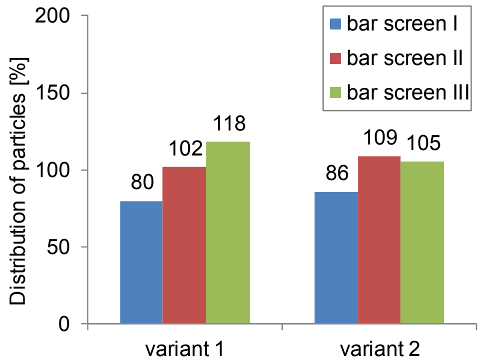
Primary Treatment

Maximization of the removal efficiency



Bar screens
realistic modellng by calibration



Deterministic analysis
Distribution of particles at bar screens

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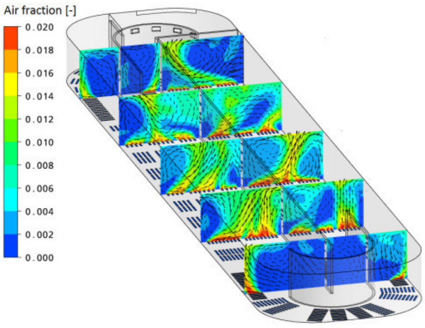
Activated Sludge Tanks

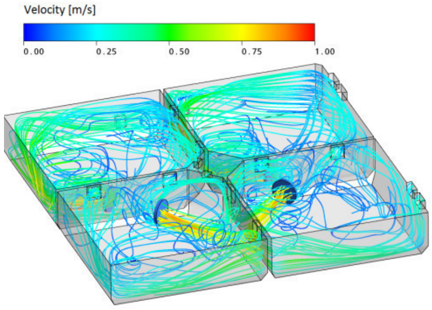
Enhanced biodegradation

Your benefits

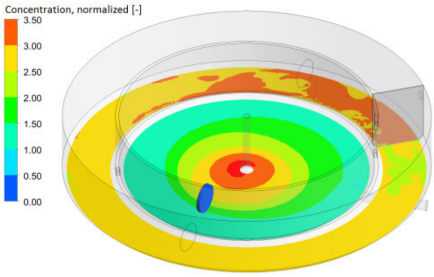
- Optimal process conditions
- Cost reduction due to energy and investment saving
- Optimization of position, performance and number of agitators
- Avoiding depositions
- Increased oxygen transfer



Optimization of aerator arrangement



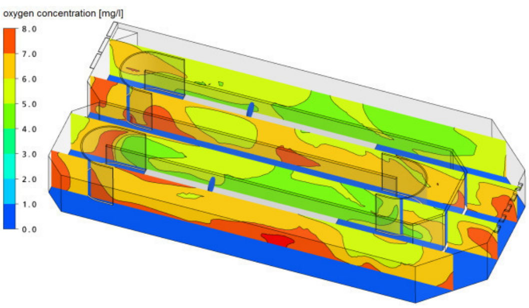
Optimization of agitators



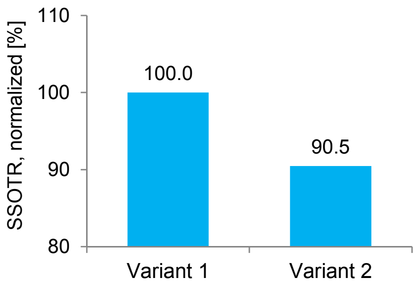
Analysis of depositions

Virtual oxygen transfer experiments

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



SSOTR +23 %
Simulation of oxygen transfer



SSOTR - comparison of variants

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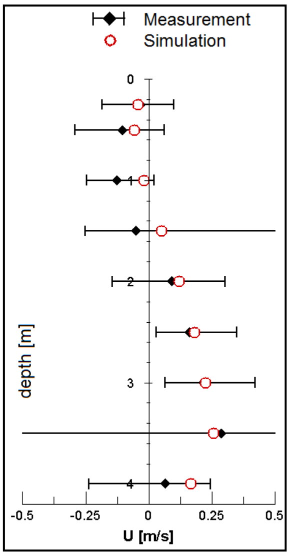
Activated Sludge Tanks

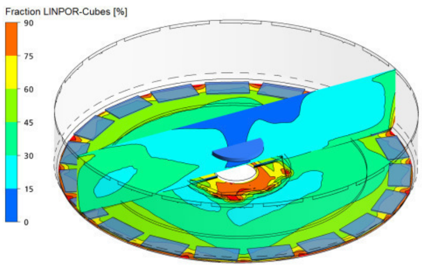
Enhanced biodegradation

Methods

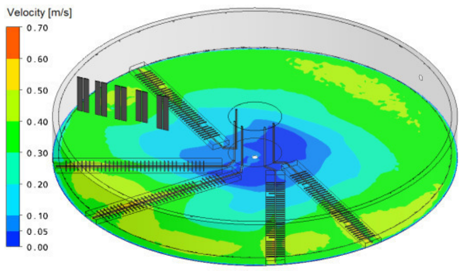
- Three-dimensional, multiphase simulation incl. aeration
- Modeling activated sludge or floating biofilm carriers
- Agitators as impuls source or real geometries
- Virtual oxygen transfer experiments
- Velocity measurement for validation of modeling approaches



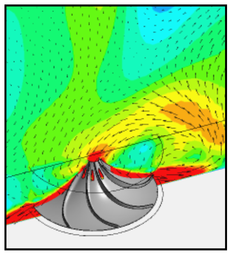
Comparison
Measurement - Simulation



Simulation
of biofilm carriers



Rotating
agitators for
mixing



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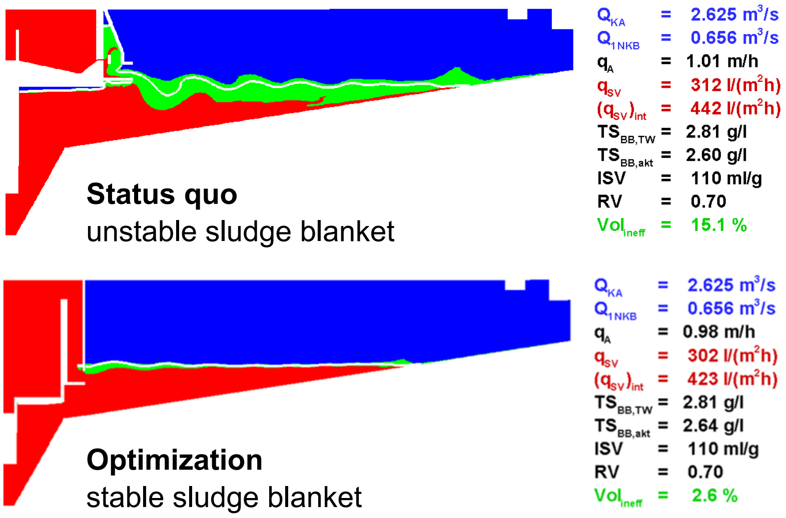
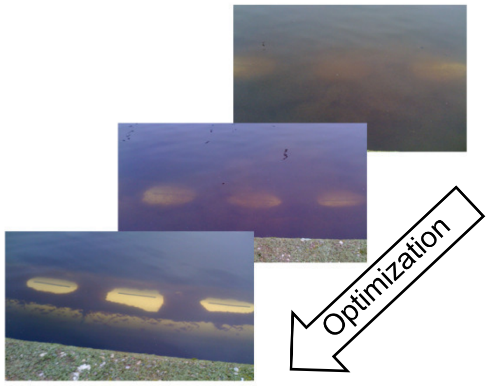
Secondary Clarifiers

Highest effluent quality

Your benefits

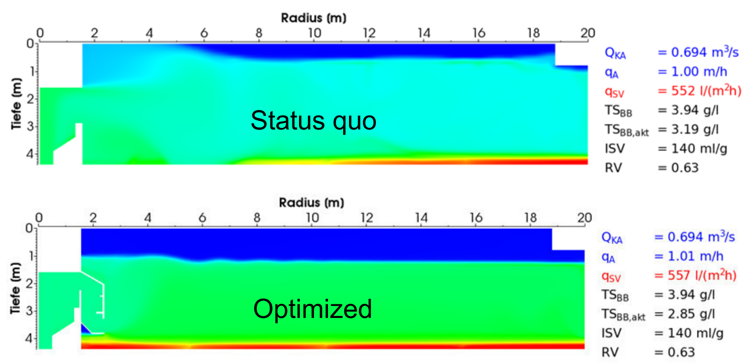
- Maximum safety in terms of sludge overflow and flock discharge
- Optimization of operating strategies, e.g. optimal return sludge flow
- Variant comparison already in the planning phase
- Proof of performance limits even beyond design guidelines
- Determination of the flocculation potential



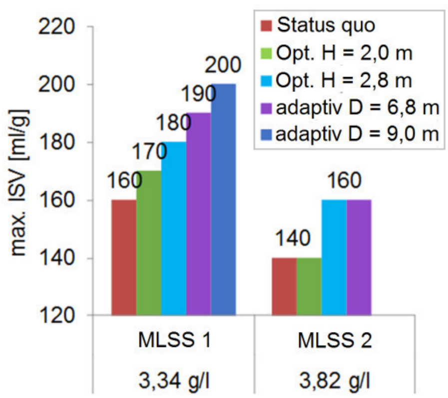


Methods

- 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



Increased capacity by optimization



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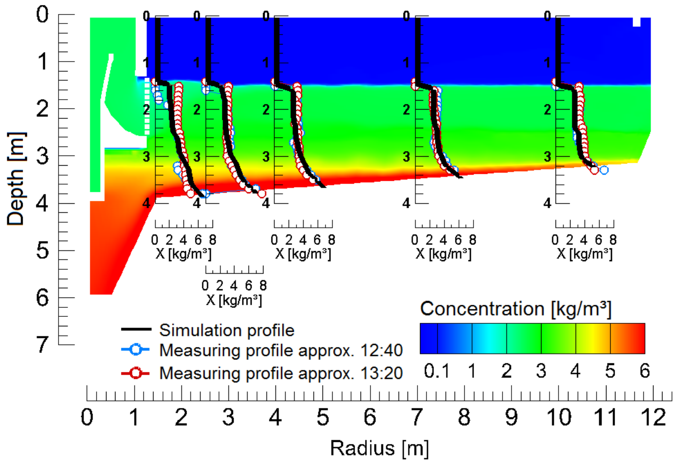
Secondary Clarifiers

Highest effluent quality

Measurement

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



Calibration using measurement of sludge concentration

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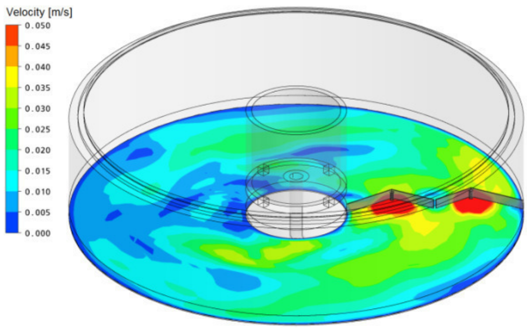
Q_{KA} = 0,152 m^3/s
Q_{Faktor} = 65 %
Q_{NKB1} = 0,099 m^3/s
$q_{SV,A131}$ = 525 $l/(m^2h)$
q_A = 0,80 m/h
TS_{BB} = 3,54 g/l
ISV = 186 ml/g
RV = 0,68



Simulation of a rotating suction scraper systems

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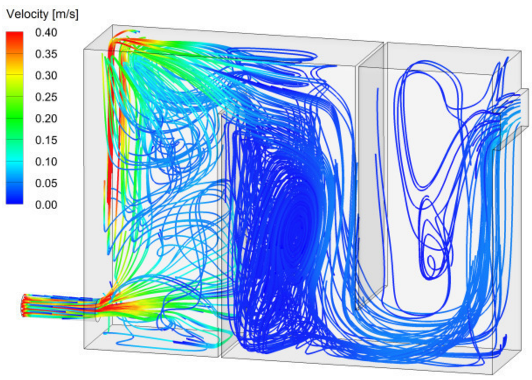
Fourth Treatment Stage

Increased degradation of micropollutants

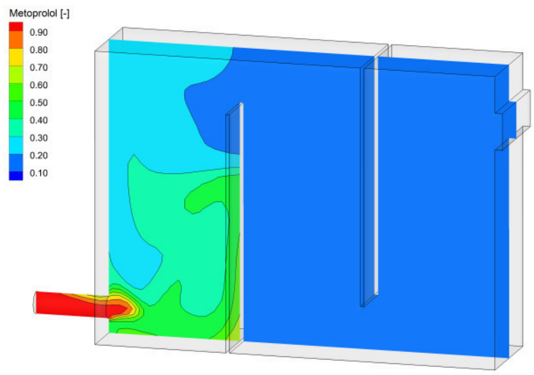
Ozone Reactor

Your benefits

- Proof of degradation rates of micropollutants
- Optimized hydraulics for efficient degradation
- Cost savings through less required volume
- Proof of concentrations in off-gas and effluent flow



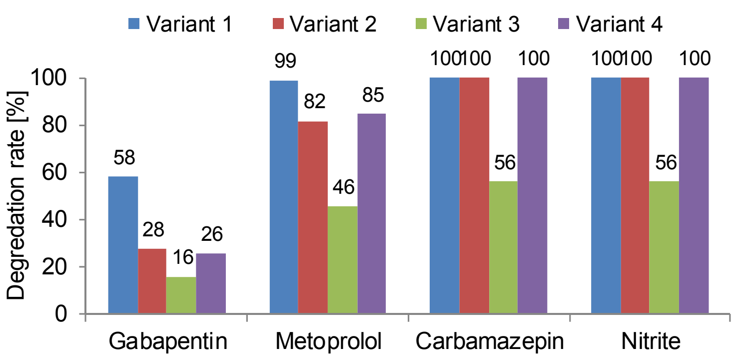
Streamlines



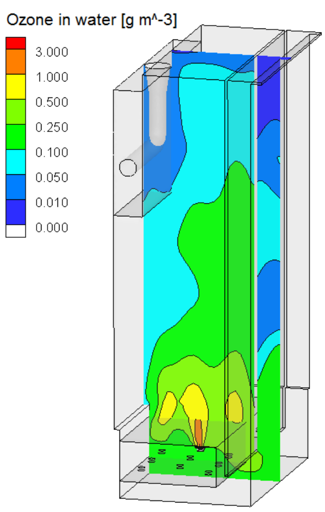
Concentration of the micropollutant metoprolol

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 micropolutant and nitrite



Ozone distribution in the reactor

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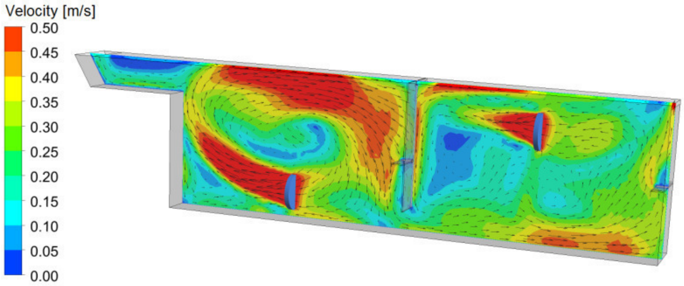
Fourth Treatment Stage

Increased degradation of micropollutants

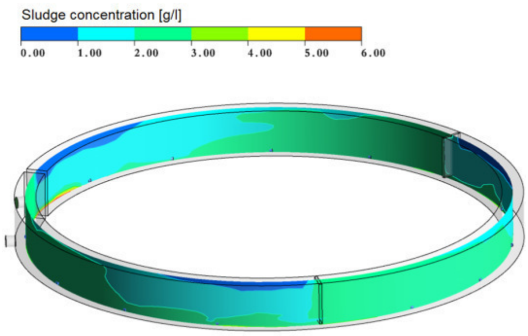
Activated carbon reactor

Your benefits

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



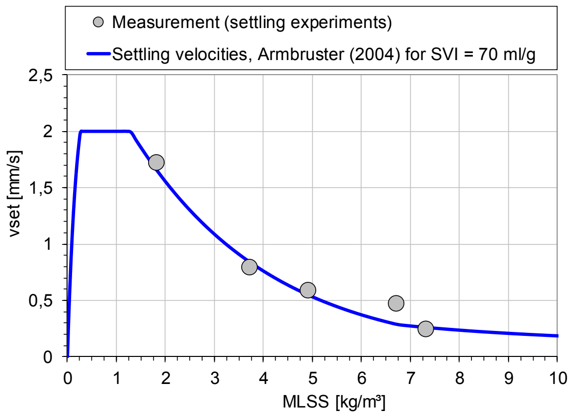
Velocity distribution



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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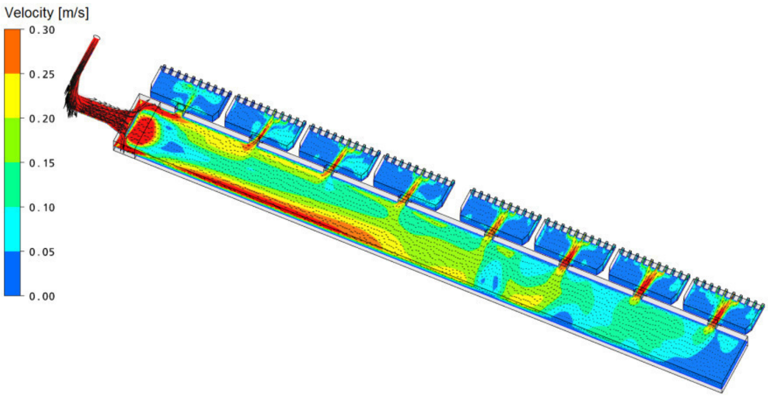
Distribution Structures

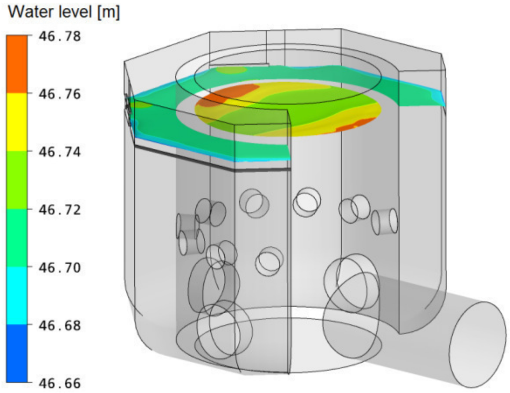
Optimal hydraulic and material distribution

Your benefits

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



Optimization of the hydraulic distribution

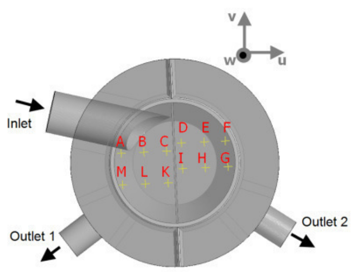


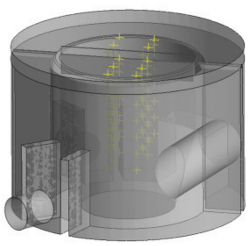
Analysis of hydraulic losses

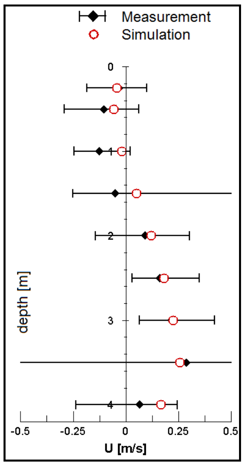
Methods

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

Velocity measurement







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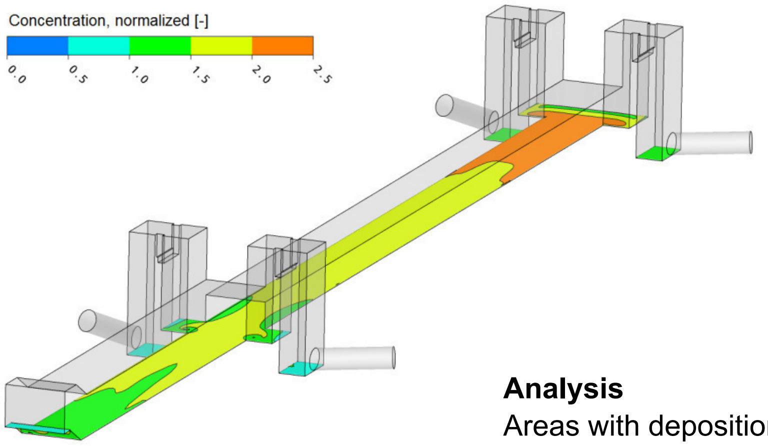
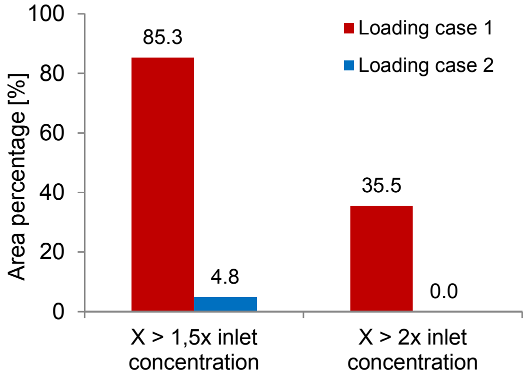
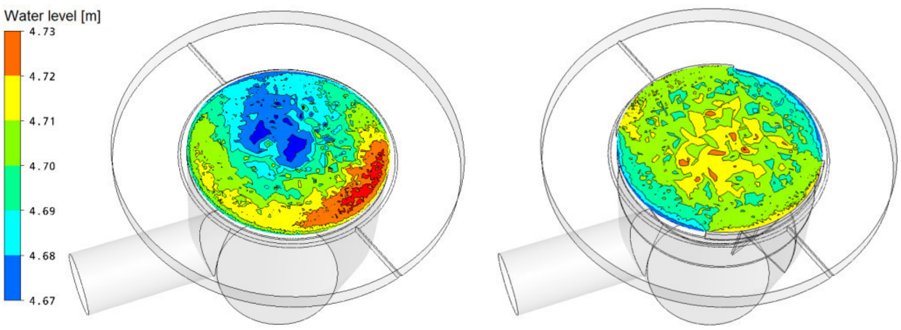
Distribution Structures

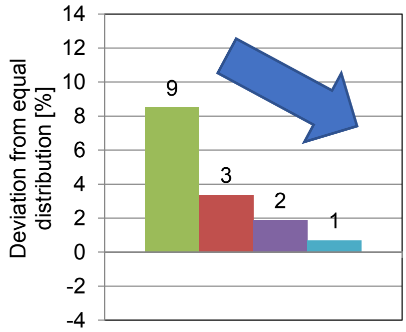
Optimal hydraulic and material distribution





Analysis
Areas with deposition





Optimization
of the hydraulic distribution

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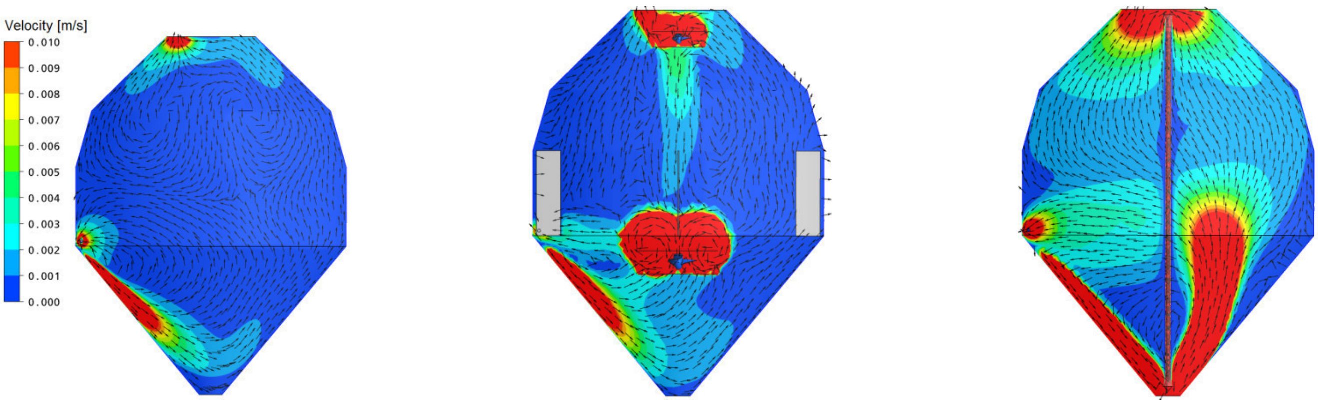
Anaerobic Digesters

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

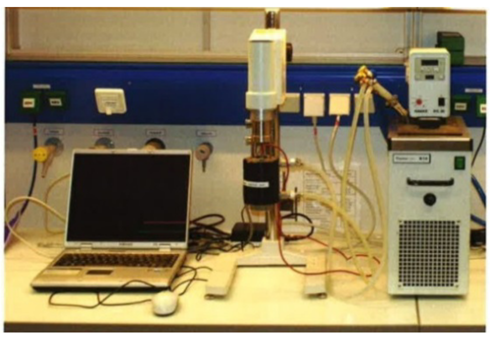


External mixing by pumps   Central agitators   Central screw pump

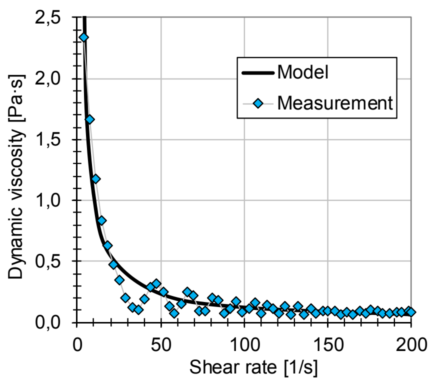
Comparison of various mixing systems

Methods

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



Measurement of sludge viscosity



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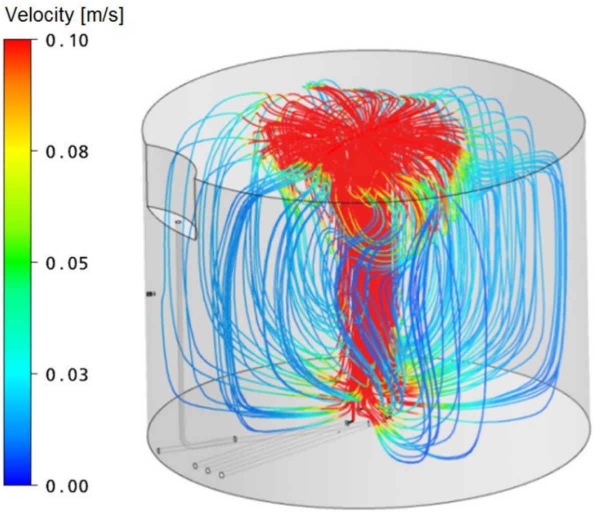
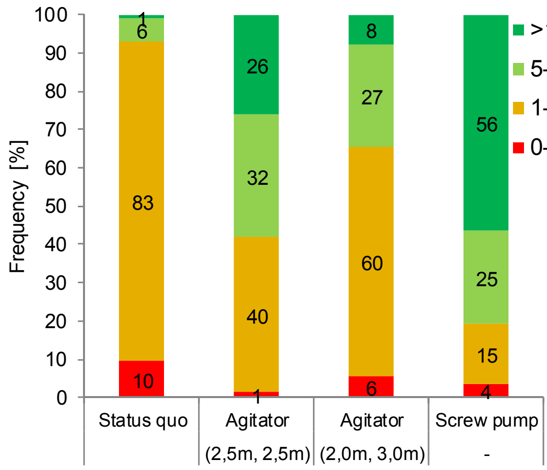
Anaerobic Digesters

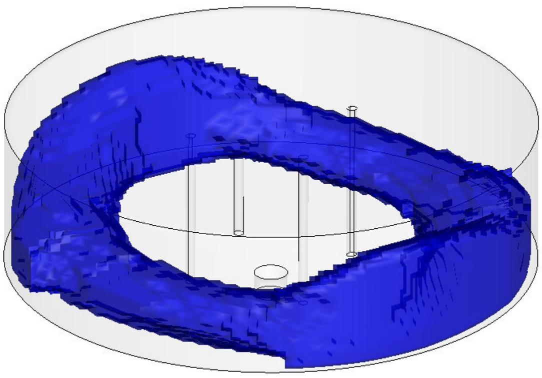
Optimal mixing



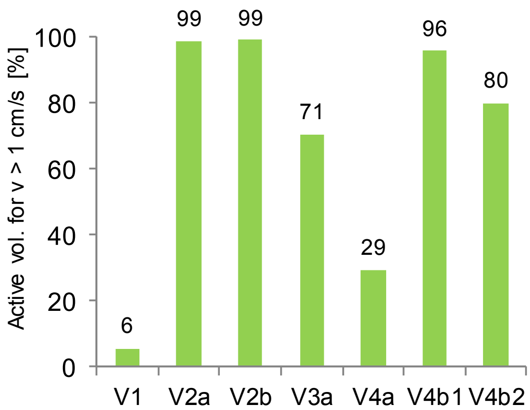
Anaerobic digester with gas injection



Analysis of the mixing rate



Areas with active volume



Analysis of the active volume

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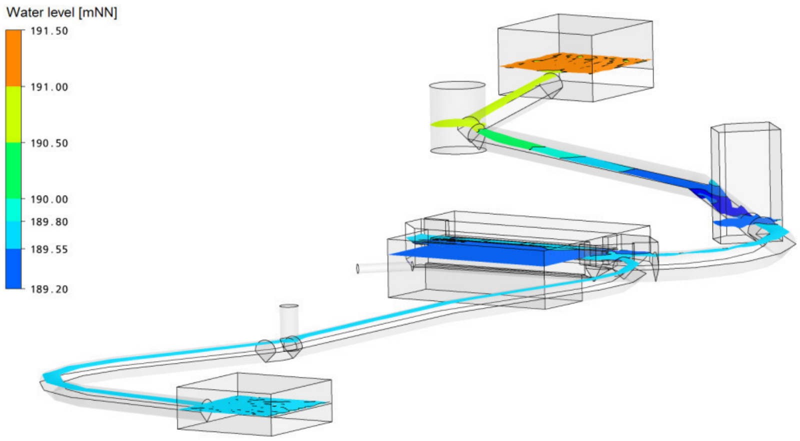
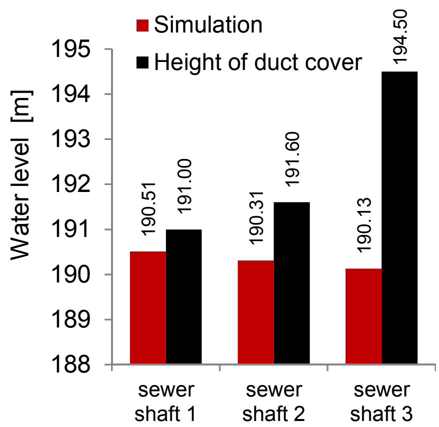
Sewer Systems and Stormwater Basins

Optimal hydraulic and material distribution

Your benefits

- Proof and optimization of stormwater tanks, separation structures and sewer systems
- Hydraulic distribution
- Prevention of depositions



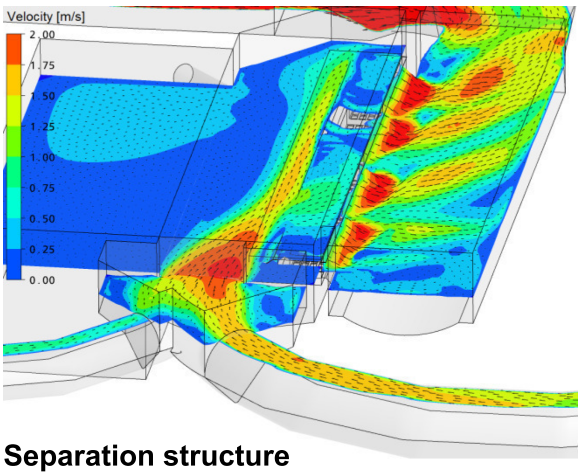


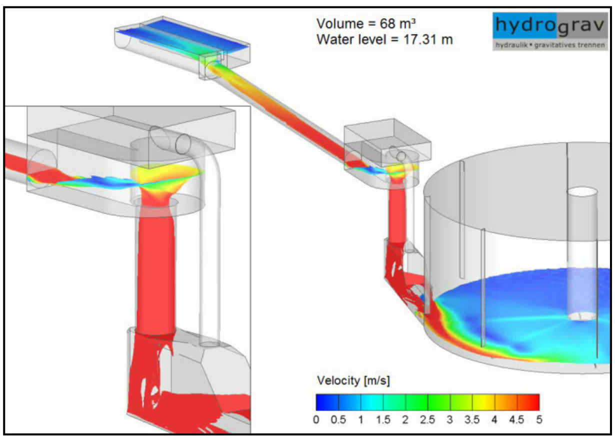
Separation structure with sewers and sewer shafts
Water level

Deterministic analysis
Hydraulic losses

Methods

- Three-dimensional, multiphase 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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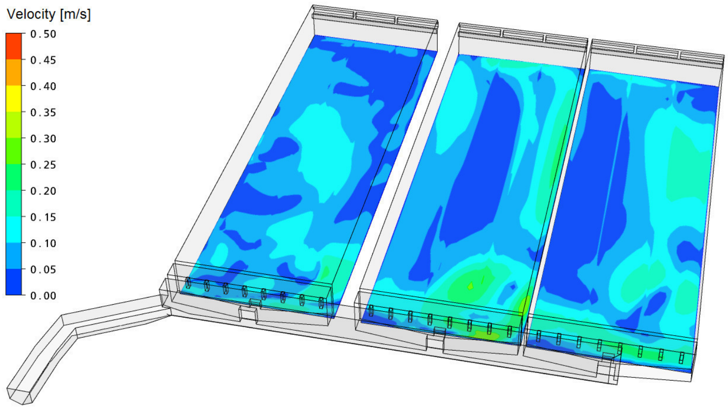
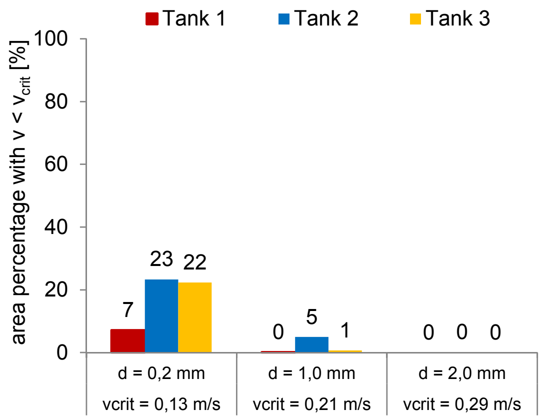
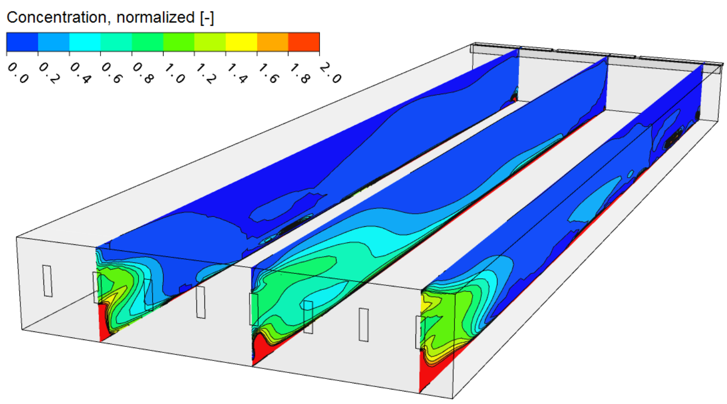
Sewer Systems and Stormwater Basins

Optimal hydraulic and material distribution





Analysis of velocities
Critical velocities near the bottom



Stormwater tanks
Analysis of potential deposits

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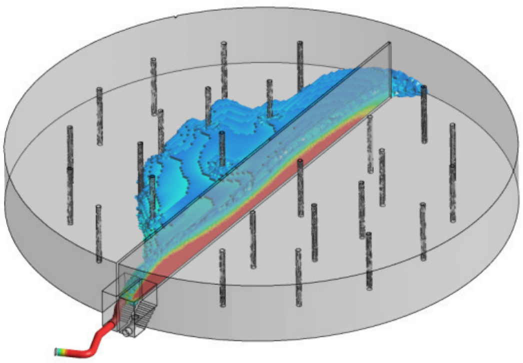
Drinking Water Supply

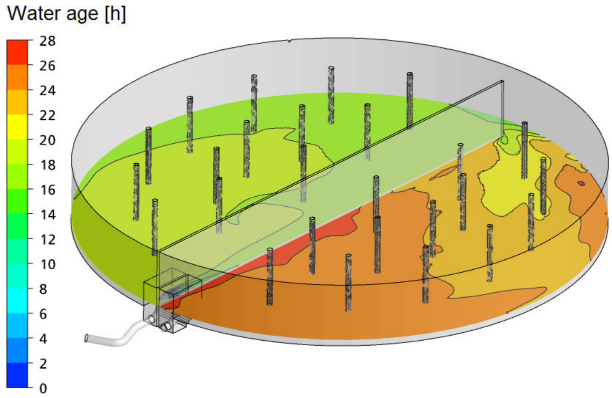
Increased water quality

Your benefits

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



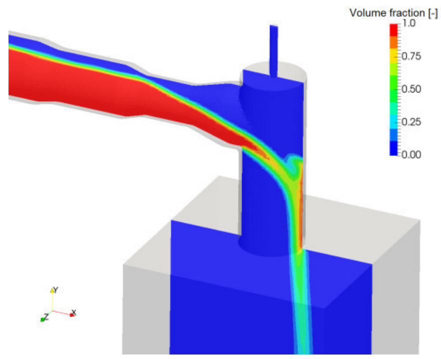
Water storage tank
Tracer distribution



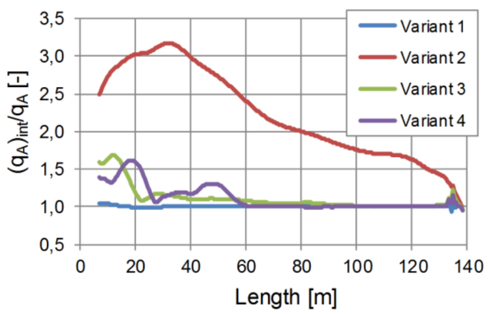
Water storage tank
Simulation of water age

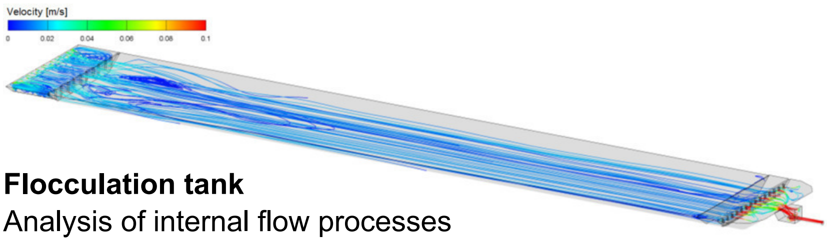
Applications

- 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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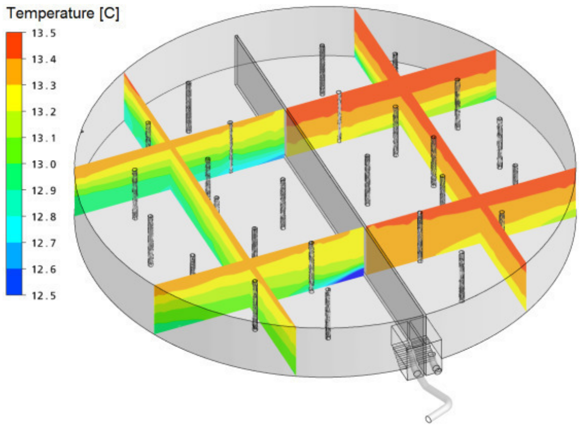
Drinking Water Supply

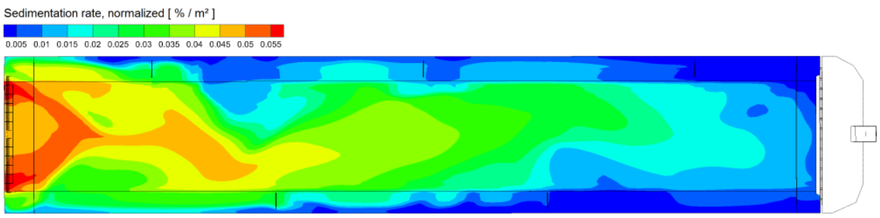
Increased water quality

Methods

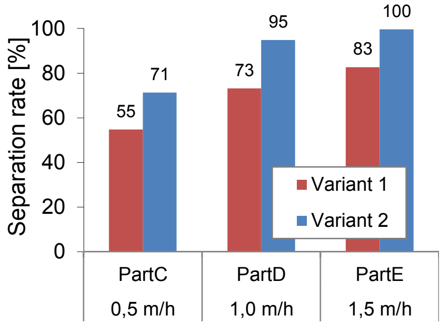
- Three-dimensional simulations
- Simulation of tracers to prove the residence time
- Determination of water age
- Consideration of temperature gradients
- Simulation of particles in flocculation tanks



Water storage tank
Distribution of temperature



Flocculation tank
Analysis of particle removal



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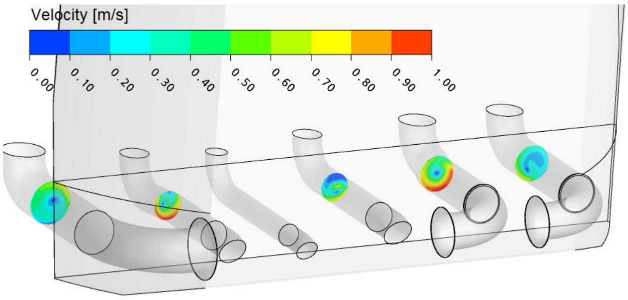
Pumping Stations and Agitators

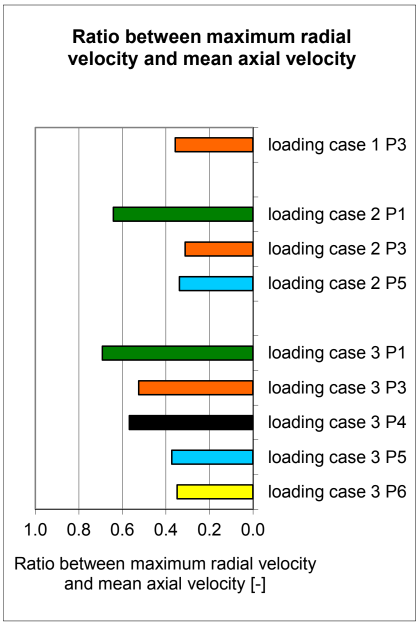
Optimal incident flow conditions

Your benefits

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



Pumping station
Analysis of incident flow velocity

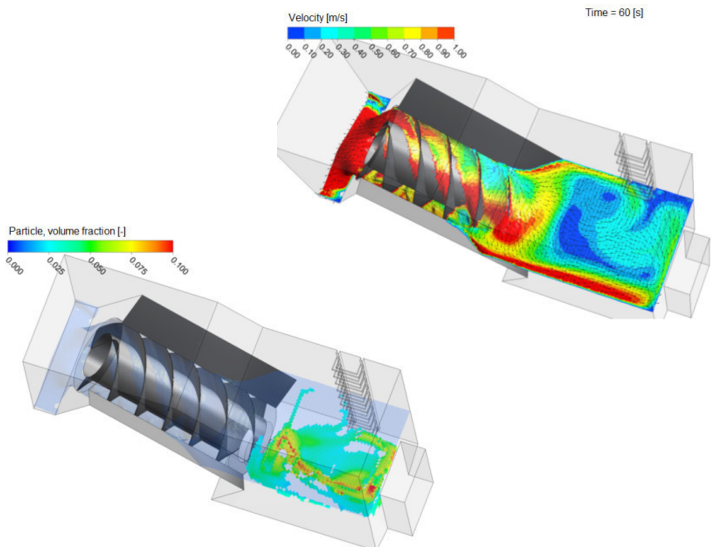


Deterministic analysis
Proof of swirl absence

Methods

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

Screw pump
Simulation incl. floating sludge



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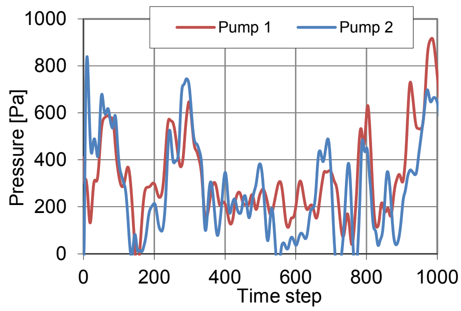
Pumping Stations and Agitators

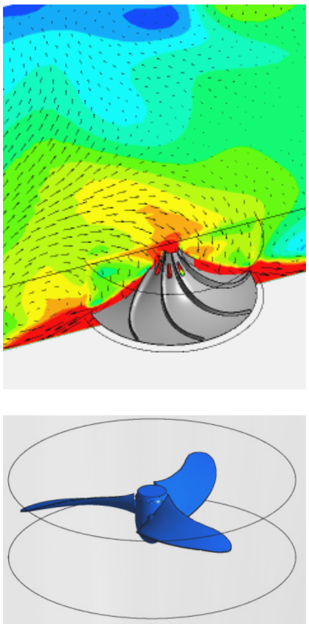
Optimal incident flow conditions

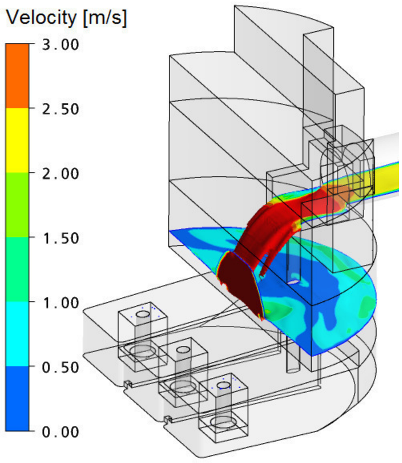
Analysis

- 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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