Project and master thesis topics in water and wastewater engineering 2020/21

NTNU

Preface

The water and wastewater engineering group is introducing a new procedure for the publication and distribution of project and master thesis topics this spring semester. The new procedure aims at a **balanced** master student distribution among scientific staff in a **transparent** way and bridging the demand in ongoing research projects and student interests.

A balanced distribution of students will increase the room for **adequate supervision** and support and increases the **spectrum of topics** covered by master thesis work. Even though there may be strong demand for specific topics, it should be noted that there is a need for diverse education, and that a master thesis is not a comprehensive specialisation, but a short term project work where students are supposed to learn how to tackle a specific research question within limited amount of time. Many topics are related to each other and more focus on shared topics may be a way to facilitate.

One main priority of master student projects is the support of **ongoing activity and PhD students**. Another priority is the establishment and maintenance of **links to the water industry** (external topics).

Table of Contents

The new distribution procedure

1. Topic collection

Each professor suggests 3 to 4 topics, each Prof. II suggests 1 to 2. Submission deadline is the right **after Easter, 14th** of April. A template will be provided for Word and PowerPoint. The Wordfiles contain more details about the project, and will be compiled in one document and share with the students. The PowerPoint slide contains a short version, that will be show at the meeting with the students.
All submitted topics should be in a matured stage, including supervisors, partners, financing (travel of the student, lab work…) etc. The proposals should highlight the possibility for consecutive project and master topics, maybe already defining them in detail.

2. Internal review

After submission, topics will be reviewed internally. As many topics as we have students will be selected, maybe 10% more. Possibilities for coalescence and collaboration will be identified, projects with high relevance og needs prioritized etc.
As many topics as we have students will be made available, maybe 10% more, during the spring semester on a given platform, using a fixed template. **Deadline: End of April**

3. Publication

The topics will be compiled and made available for the students via the internal website and by email. There will be a meeting with the students where the PowerPoints will be presented, and the new procedure will be introduced. The topics will be published right after the internal review is completed.

4. Additional topics

Students will have the possibility to deliver independent project proposals until the end of **2nd week of August** 2020. These proposals will need to be mature, well defined and need to have the support of a local supervisor at NTNU. Potential lab cost, travel costs etc. need to be covered. The template will be provided on the webpage.

5. Application phase

After the topics are published, students apply for their favourite topics. The topics will be divided into three groups and students will pick two topics from each group. Each group will contain topics from two permanent employees and one or two Prof. II. The six topics selected can be ranked freely. All this will be done via an online form that will be available on the master topic page.
All students are encouraged to write half a page motivation letter (A4), their they explain and justify their ranking and motivation for the selected topics. This is optional.
Deadline for the application is the end of the **3rd week of August**.

6. Internal review and topic assignment

The ranking and the motivation letters will be evaluated. Topics will be distributed based on that evaluation. In case of many applicants for certain topics and the delivery of several strong motivation letters, distribution will be done by drawing lots.

7. Publication of results

Results will be published right after the review is finished, latest by the **end of August**.

1. Topic collection	• Professor delivers 3 to 4 topics, Proff. II 1 to 2 • Fixed template (word + ppt) • Deadline: **14th April**
2. Internal review	• Prioritation and selection of published topics • Pojects in need? • Feedback on topics, possibility for collaboration or coalescence
3. Publication	• Meeting with students • Published online • Deadline: **End of April**
4. Additon of own topics	• Possibility to propose independed topics • Deadline: **End of 2nd week of August**
5. Application phase	• Students pick 2 topics from each group, rank them freely and and write motivation letter of max 1/2 A4 page where they argue about their motivation, ranking • **3rd week August**
6. Internal review	• Evaluation of independent topics, ranking and motivation letters • Draft for final distribution
7. Publication of decisions	• Publication of final topic distribution • **End of August**

Topic overview

Master projects in Group 1

Number	Title	Supervisor(s)	Partner(s)
1.1	Modelling water transport in swales and hydrologic modelling of surrounding catchment at Rv3	Tone Muthanna, Knut Alfredsen	Klima 2050, Hydraulic Engineering Group
1.2	Treatment of road water from Rv3	Tone Muthanna, Tor Håkonsen, Carlos Monrabal-Martinez	Klima 2050, Multiconsult
1.3	Modelling a full-scale combined infiltration and detention solution	Tone Muthanna, Edvard Sivertsen	Klima 2050, SINTEF
1.4	Precipitation of heavy metals: Particle removal and sludge management	Thomas Meyn, Kyrre Halvorsen	Trondheim Municipality
1.5	Handling of wash water from road tunnels	Thomas Meyn, Nina Jørgensen, Mathilde Francis	Statens Vegvesen, Vianova
1.6	Adsorption and membrane filtration of tunnel wash water	Thomas, Tor, PhD, Nina	SVV, Vianova
1.7	Renewable alternative to polymer in water treatment and alternative applications in advanced treatment of run-off water using biopolymers	Tor Håkonsen, Thomas Meyn	Haugesund municipality, Multiconsult, Teta Vannrensing AS
1.8	Ultrafiltration for water treatment using new coagulants	Tor Håkonsen, Thomas Meyn	Pentair, NOKA AS, Teta Vannrensing AS, Multiconsult

Master projects in Group 2

Number	Title	Supervisor(s)	Partner(s)
2.1	*Legionella* Control in Building Water Systems using Flushing 'Best Practices'	Cynthia Hallé, Michael Waak, Charuka Meegoda	
2.2	Hydraulic Residence Time and Water Quality in Drinking Water Distribution Networks	Cynthia Hallé, Michael Waak, Charuka Meegoda	
2.3	Quantitative Microbial Risk Assessment (QMRA) of Norwegian Drinking Water Systems	Cynthia Hallé, Michael Waak, Marius Møller Rokstad	
2.4	Wastewater treatment in AS-EBPR	Stein W. Østerhus Blanca M. Gonzales Silva	
2.5	Wastewater treatment in cMBBR-EBPR	Stein W. Østerhus Blanca M. Gonzales Silva	
2.6	Wastewater treatment: EBPR and microbial community	Stein W. Østerhus/ Blanca M. Gonzales Silva/ Ingrid Bakke	Department of Biotechnology
2.7	Statistical analyses to detect patterns and sources of heavy metals in sewer sludge	F. Tscheikner-Gratl, M. M. Rokstad, S. Sægrov, T. Meyn	Trondheim Municipality
2.8	New filtermedia and filterdesign	Tor, Stein, Thomas	Dryden Aqua ltd, Saint Grobain, Multiconsult

Master projects in Group 3

Number	Title	Supervisor(s)	Partner(s)
3.1	Utilizing artificial intelligence methods for inflow and infiltration (I&I) problems in wastewater networks	Franz Tscheikner-Gratl, Marit Aase, Jon Røstum	Bergen Municipality, Powel Environment
3.2	Reduction of water leakages by smart water technologies	Christos Makropolous, Franz Tscheikner-Gratl, Marius Møller Rokstad, Sveinung Sægrov, Kyrre Halvorsen, Stian Bruaset	Trondheim commune, SINTEF
3.3	Water Level Detection Through Image Analysis	Franz Tscheikner-Gratl / Robert Meier / Christos Makropolous	
3.4	Measurement data quality control using examples Risvollan and pump station Trolla		
3.5	Digitalization of urban water services in Vestfold	Sveinung Sægrov, Franz Tscheikner-Gratl, Marius Møller Rokstad	
3.6	Water supply and sanitation in Africa	Sveinung Sægrov	
3.7	ASSET MANAGEMENT OF NATURE-BASED SOLUTIONS: WHAT INFORMATION TO COLLECT AND HOW FOR MAINTENANCE MANAGEMENT	Rita Ugarelli / Edvard Sivertsen / Gema Raspati	SINTEF
3.8	Sustainable approaches to long-term asset management	Rita Ugarelli / Stian Bruaset / Håkon Reksten	SINTEF; Norconsult

Detailed project descriptions: Group 1

Project Title	Modelling water transport in swales and hydrologic modelling of surrounding catchment at Rv3
Type	Project and Master thesis
Supervisors / Contacts	Knut Alfredsen / Tone Muthanna
Location	Trondheim / Rv3 Løten – Elverum

Project background

The SFI Centre Klima 2050 (www.klima2050.no) studies climate adaption within the build environment, including stormwater management. Klima 2050 has a strong focus on innovation and demonstration of novel solutions through pilot projects in close collaboration with the public and private partners within the centre.

Skanska, Multiconsult and Statens Vegvesen have established a pilot project in connection with the new Rv3 Løten – Elverum project.

Aim of the project

Set up a complete model of the water transport from the road into the swales, transport in/along the swales and the interaction with the surrounding catchment in order to predicting floods in the small catchment.

Specific work description

The work will include the following main tasks:

1. Make a system description of installed stormwater measure (swales)
2. Make a runoff model of the area around the wales estimating the water entering the swales
3. Make a hydrologic model of the surrounding catchments using the recently developed DDD model
4. Combine the models in 2 and 3

Project Title	Treatment of road water from Rv3
Type	Project and Master thesis
Supervisors / Contacts	Tone Muthanna / Tor Håkonsen / Carlos Monrabal-Martinez
Location	Trondheim / Rv3 Løten – Elverum

Project background

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Skanska, Multiconsult and Statens Vegvesen have established a pilot project in connection with the new Rv3 Løten – Elverum project. The road water will several places be treated using swales and sand filtration.

Aim of the project

The objective of the thesis is to make system description of all installed solutions, , make water quality monitoring plan (short-term and long-term), start monitoring the road run-off and water quality in receiving waters, make the first assessment of treatment efficiencies, and finally, possibly set up a model for pollution transport.

Specific work description

The work will include the following main tasks:

1. Make system description of installed solutions and identify critical discharge points
2. Make water quality monitoring plan, both short-term and long-term
3. Start monitoring of water quality and characterise the runoff from the road and the effluent/receiving waters and start developing mass balances and models on contaminants removal

The system will be evaluated looking upon the efficiency in removing particles and other contaminants, mostly heavy metals and PAHs. Samples will be collected manually or by an auto-sampler at the inlet and outlet of the systems. The water sample will be analysed for a selection of parameters like pH, conductivity, turbidity, TSS, TOC/DOC, heavy metals, PAH, according to Standard Methods and depending on adequate extra financial support is available for the most expensive analysis. Metal concentrations in water samples will be analysed using ICP-MS or other relevant methods. PAH will be analysed by commercial laboratories, if relevant. Furthermore, particle size distribution will be also performed.

Project Title	Modelling a full-scale combined infiltration and detention solution
Type	Project and Master thesis
Supervisors / Contacts	Tone Muthanna / Edvard Sivertsen
Location	Trondheim

Project background

The SFI Centre Klima 2050 (www.klima2050.no) studies climate adaption within the build environment, including stormwater management. Klima 2050 has a strong focus on innovation and demonstration of novel solutions through pilot projects in close collaboration with the public and private partners within the centre.

Trondheim kommune has installed a full-scale combined infiltration and detention solution at Trondheim town square (Torvet i Trondheim). To monitor and assess the performance of the instalment, a pilot project within Klima 2050 has been established with Trondheim kommune and Multiconsult as partners.

Aim of the project

Multipurpose use systems for stormwater management are growing in popularity across the world. The functionality over time for such systems is of interest to municipalities and consultants; information may be useful input in decision-making and planning of future projects. Certain infiltration-based solutions can potentially reduce detention-volume requirements, which is beneficial in monetary terms and in restoring pre-development hydrological conditions.

Specific work description

This study aims to answer the following research questions:

1. To what extent can infiltration systems reduce detention-volume requirements?
2. Create a model to model the performance of the system and verify the model with the observed data.

Collaboration partners: Klima 2050 and Trondheim Kommune
Work place: IBM

Project Title	Precipitation of heavy metals: Particle removal and sludge management
Type	Project and Master thesis
Supervisors / Contacts	Thomas Meyn / Kyrre Halvorsen (Trondheim Municipality)
Location	VA-Labs / Field site Ilsvika (Ila)

Project background

Acid runoff from pyrite mines is a well-known and serious environmental problem. Acid runoff is generated when sulfide minerals come into contact with water and air, and generally contains high concentration of heavy metals that get dissolved due to the low pH. Killingdal mine's mineral processing plant was active from 1953 until 1986 in the Ilsvika area in Trondheim. During operation and in the years after, the plant was a source of pollution to the harbour basin. The whole area surrounding the processing plant was therefore renovated in 2011. Despite this, acidic water with high concentrations of metals is still leaking to the sea, through an underground tunnel. Like too many sulfide mines, the main problem at Killingdal is that iron, copper and zinc are detected in very high concentrations, accounting for 99.8% of the total metal emissions from the tunnel. Cadmium, arsenic and nickel have also been detected in significant concentrations and removal of these contaminants is important.

(Right) Aerial view of the Killingdal area: Before cleanup, during cleanup - the warehouse and unloading shafts are open and after finishing the project - new walkway and bike path follow the old railway tracks. (Left) Location of the Killngdal area in Trondheim.

Aim of the project

The municipality is in the process of finding a future treatment solution for the water leaching into the fjord. A typical solution comprises increase of pH to a value of 10, which minimizes the solubility and the metals do precipitate and can be subsequently removed by particle removal strategies. This project aims at providing information about the particle removal efficiency in dependence on process selection and operating conditions, as well as investigating the corresponding sludge properties and management strategies.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding treatment of acid mine drainage, particle separation and sludge management. Jar tests will be introduced as standard method for evaluation of pH adjustment and polymer dosage with subsequent sedimentation / flotation treatment on the water quality and the sludge properties, and the obtained results will be evaluated.

During the master project, the student will continue with jar testing and optimising the treatment conditions. In addition, the student will work independently on the filed site at Ilsvika, there the municipality of Trondheim has built a full-scale treatment pilot. Operational conditions at the plant will be optimized, resulting in better particle removal and sludge handling properties.

Example of jar test after pH adjustment and dosage of polymer

Pilot plant at the field site in Ilsvika

Project Title	Handling of wash water from road tunnels
Type	Project and Master thesis
Supervisors / Contacts	Thomas Meyn + PhD student Nina Jørgensen (Statens Vegvesen) Mathilde Francis (ViaNova Plan og Trafikk)
Location	Vassbygget Trondheim

Project background

Norway has more than 1000 road tunnels. In order to have safe traffic conditions and enhance lifespan of the tunnels, they are frequently cleaned and washed. Wash water does contain a cocktail of pollutants consisting of e.g. heavy metals, different PAHs, soap, microplastic (e.g tire wear), road salt etc. The concentrations of the pollutants substantially exceeding that of normal road runoff and has caused acute toxicity of e.g. amphibians in nature-based treatment ponds. Many of the tunnels do not have a treatment for the wash water, and it is discharged directly to the closest recipient (creeks, rivers, fjords). Newer tunnels are built with a sedimentation basin, that is removing particulate pollutants. However, little is known about the efficiency of such basins. The use of detergent complicates things; they do improve cleaning efficiency but remobilize many pollutants and reduce the effect of sedimentation. This project is related to ongoing collaboration with Statens Vegvesen, looking at future storm water treatment solutions.

Aim of the project

In order to develop future treatment solution, more information about pollutants present are needed, and how they evolve over time in the sedimentation basin. Real wash water will be sampled, and the sedimentation process will be simulated in the lab. Subsequent analysis will focus on measurement of heavy metal concentration, particles, degradation of detergent and remobilisation potential.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding tunnel wash water quality and treatment. Basic methods of water quality analysis will be introduced, and sample analysis carried out in the lab (pH, turbidity, particle analysis, organic carbon, sample preparation for advanced analysis such as heavy metals etc.), and results will be evaluated.

During the master project, the student will take part in sampling campaigns in road tunnels in the Oslo area. The water will be transported to Trondheim, there a sedimentation pilot will be used for treatment and analysis. The student will be responsible for operating that pilot. Sampling and analysis will be done like in the project work.

Sampling from a sedimentation basin at Bjørnegårdtunnelen (Sandvika)

Fresh tunnel wash water in the sedimentation columns in our lab

Project Title	Adsorption and membrane filtration of tunnel wash water
Type	Project and Master thesis
Supervisors / Contacts	Thomas Meyn + PhD student Nina Jørgensen (Statens Vegvesen) Mathilde Francis (ViaNova Plan og Trafikk)
Location	Vassbygget Trondheim

Project background

Norway has more than 1000 road tunnels. In order to have safe traffic conditions and enhance lifespan of the tunnels, they are frequently cleaned and washed. Wash water does contain a cocktail of pollutants consisting of e.g. heavy metals, different PAHs, soap, microplastic (e.g tire wear), road salt etc. The concentrations of the pollutants substantially exceeding that of normal road runoff and has caused acute toxicity of e.g. amphibians in nature-based treatment ponds. Many of the tunnels do not have a treatment for the wash water, and it is discharged directly to the closest recipient (creeks, rivers, fjords). Newer tunnels are built with a sedimentation basin, that is removing particulate pollutants. However, little is known about the efficiency of such basins. The use of detergent complicates things; they do improve cleaning efficiency but remobilize many pollutants and reduce the effect of sedimentation. This project is related to ongoing collaboration with Statens Vegvesen, looking at future storm water treatment solutions.

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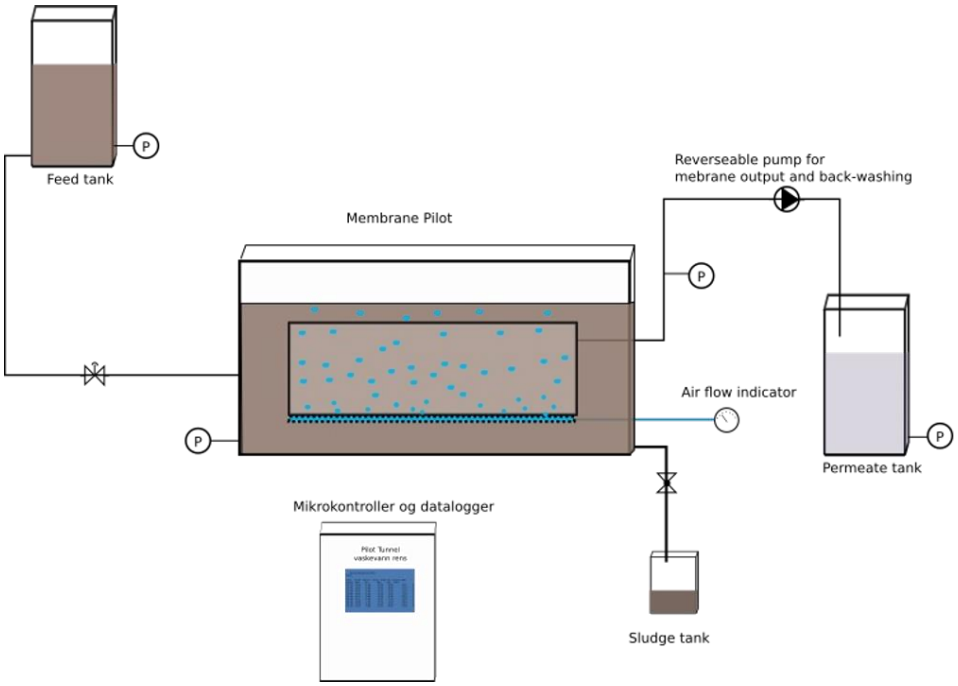
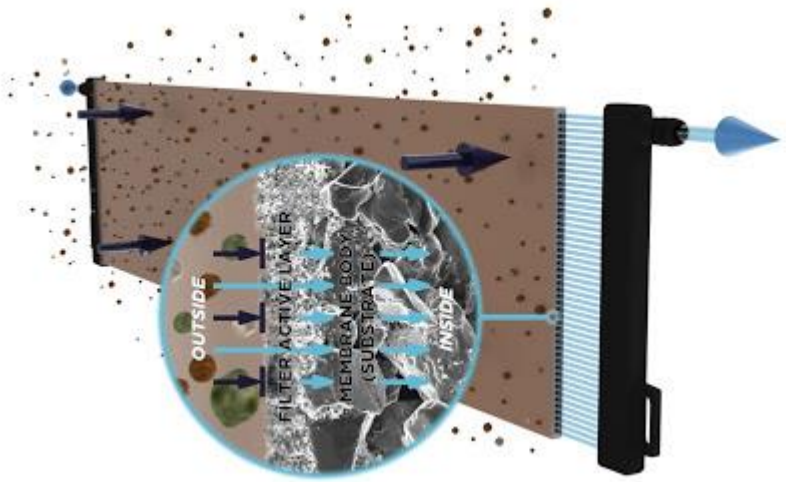


Scematic of the membrane filtration pilot



Scematic of a ceramic membrane sheet

Project Title	Renewable alternative to polymer in water treatment and alternative applications in advanced treatment of run-off water using biopolymers
Type	Project and Master thesis
Supervisors / Contacts	Tor Håkonsen, Thomas Meyn
Location	

Project Title	Ultrafiltration for water treatment using new coagulants
Type	Project and Master thesis
Supervisors / Contacts	Tor Håkonsen, Thomas Meyn
Location	Vassbygget Trondheim

Detailed project descriptions: Group 2

Project Title	*Legionella* Control in Building Water Systems using Flushing 'Best Practices'
Type	Project and Master thesis
Supervisors / Contacts	Cynthia Hallé, Michael Waak, Charuka Meegoda
Location	NTNU Vassbygget, Trondheim

Project background

Drinking water is not sterile and may contain diverse microorganisms, including some that may cause disease. Opportunistic pathogens, such as *Legionella* bacteria, may cause severe or even deadly pneumonia, like Legionnaires' disease. Infection may occur after exposure to contaminated aerosols, such as by inhalation while showering.

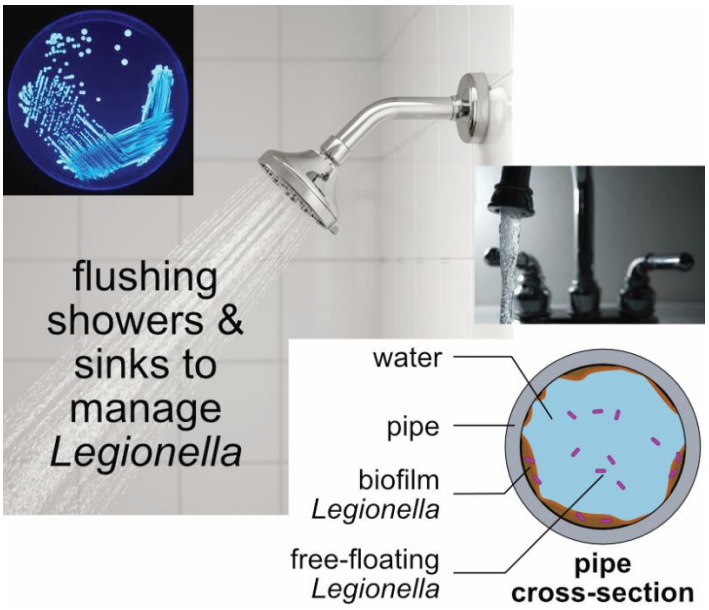
Legionella are commonly found in Norwegian drinking water at low concentrations. Building water systems—the pipes that bring hot and cold water to sinks, toilets, faucets, etc.—can be near-ideal environments for the proliferation of *Legionella*. This is especially true in large buildings, like hospitals and sports centers, because long, unused lengths of pipes may stagnate, favoring *Legionella* growth. Regular flushing of building water systems—running the water for extended periods—may effectively remove *Legionella* and prevent favorable conditions for growth. It is unclear, however, which flushing practices are best for *Legionella* control.

Aim of the project

To help develop international flushing guidelines ("best practices") for the Water Research Foundation (USA), a team of researchers from NTNU, the University of Minnesota, the Norwegian Institute of Public Health, and the City of Trondheim will combine pilot-scale flushing trials with real-world experiments in municipal buildings around Trondheim. *Legionella* concentrations will be monitored and related to various experimental variables, such as flushing duration, frequency, intensity (flow rate), water temperature, pipe material, and pipe diameter. Best practices will be developed based on the experimental results.

Specific work description

The student will help design and carry out experiments designed to determine the best practices for flushing. A literature review will help the student develop competency in relevant areas, like drinking water, public health, and infrastructure management. The student will be trained in both fundamental and advanced laboratory skills, focusing on pilot-scale experiments in the laboratories at Vassbygget. The student will therefore be partially responsible for operating and maintaining the pilot system. The student will also participate in sampling campaigns around Trondheim. Using experimental results and the literature review, the thesis will assess best practices for flushing building water systems to control or prevent *Legionella*.


flushing showers & sinks to manage *Legionella*
water
pipe
biofilm *Legionella*
free-floating *Legionella*
pipe cross-section

Project Title	Hydraulic Residence Time and Water Quality in Drinking Water Distribution Networks
Type	Project and Master thesis
Supervisors / Contacts	Cynthia Hallé, Michael Waak, Marius Møller Rokstad
Location	NTNU Vassbygget, Trondheim

Project background

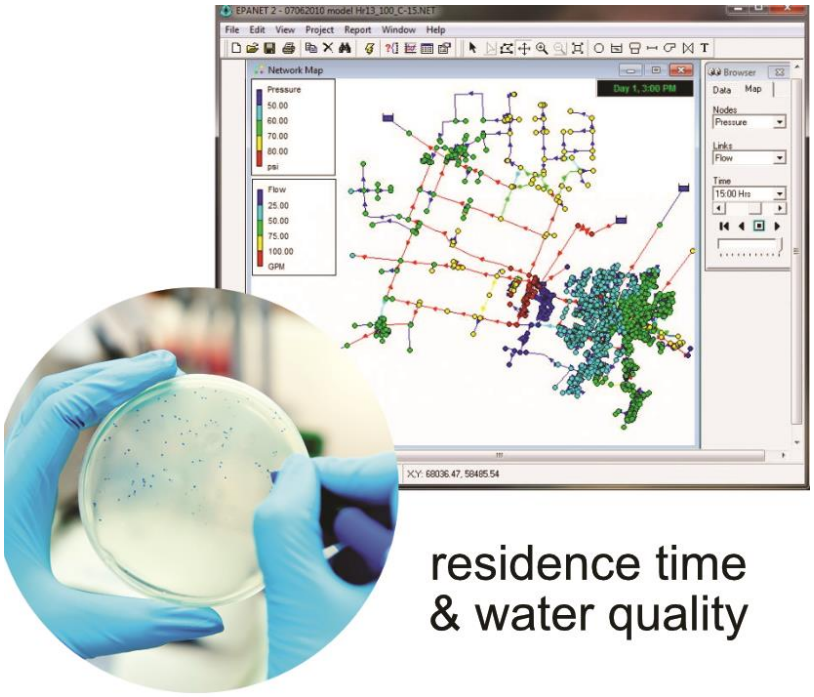
Despite treatment, drinking water may contain diverse microorganisms. After leaving the treatment plant, drinking water may spend hours, days, or even weeks in the municipal distribution network—traversing large storage basins and kilometers of water transmission mains. In contrast to many countries, Norwegian drinking water typically does not contain chlorine-based disinfectants during distribution, which may allow microbes to grow during distribution. Microbes may cause human disease but may also contribute to pipe corrosion as well as poor aesthetic qualities, like undesirable color, taste or odor. Additionally, hydraulic residence models of the distribution network are difficult to develop and calibrate. As a consequence, many municipalities in Norway have little knowledge about residence time ("water age") in their distribution networks.

Aim of the project

The goal of the project is twofold: First, there must be continued development of a hydraulic model for the Trondheim drinking water distribution network using EPANET (derived from MIKE URBAN). An accurate model is key to estimating water age and identifying problematic regions in the city's water network. Second, water age may influence multiple water quality parameters, but these parameters have not yet been measured or compared to water age in Trondheim. These parameters include indicators of microbiological activity as well as chemical parameters like organic carbon (total, dissolved, assimilable), temperature, dissolved oxygen, turbidity, and pH.

Specific work description

During the project, the student will become familiar with hydraulic modelling and water quality. The student will obtain valuable hands-on skills collecting samples, performing chemical tests, and analyzing data. The student will work in a collaborative, cross-discipline research team but will also be expected to take ownership of this specific topic through self-initiative, leadership and self-guided learning. A literature review will help the student develop competency in areas of drinking water, hydraulic modelling, public health, and infrastructure management. Most activities will take place at NTNU Vassbygget and around Trondheim. The thesis is expected to help Norwegian water utilities learn more about water quality—specifically as it relates to water age—and will also serve as a basis for future research activities at NTNU.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& water quality

Project Title	Quantitative Microbial Risk Assessment (QMRA) of Norwegian Drinking Water Systems
Type	Project and Master thesis
Supervisors / Contacts	Cynthia Hallé, Michael Waak, Charuka Meegoda
Location	NTNU Vassbygget, Trondheim

Project background

Drinking water is not sterile and may contain diverse microorganisms. Opportunistic waterborne pathogens like *Legionella pneumophila* are commonly present in water and can cause a severe and often fatal pneumonia (Legionnaires' disease) when inhaled. *Legionella* proliferate in stagnant water within building cold and hot water systems and may be transmitted to humans through aerosols generated while showering, for example.

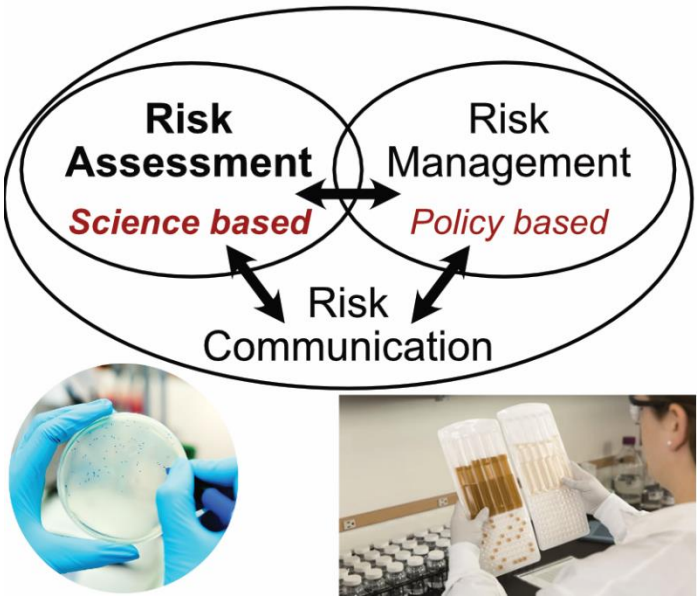
Previous research has indicated that *Legionella* are commonly present in Norwegian drinking water at low concentrations. There remains uncertainty, however, regarding the actual risk to water users. An important tool for quantifying this risk is quantitative microbial risk assessment (QMRA). QMRA utilizes mathematical models to convert various environmental factors into data, such that it becomes possible to compare the risks among different exposure scenarios. Identification of the most problematic scenarios is critical for developing effective mitigation strategies.

Aim of the project

The primary goal of the project is to develop a QMRA using existing datasets. Specifically, we wish to develop a QMRA for Norwegian drinking water systems so we can more effectively communicate environmental data (like *Legionella* concentrations in drinking water) to the relevant authorities (Norwegian municipalities, regulatory agencies like the Norwegian Institute of Public Health, and the scientific community at large). Part of the QMRA may be expansion of current datasets through ongoing environmental monitoring around Trondheim. This project will integrate with other projects, meaning there is a high potential for collaboration, teamwork, and research synthesis.

Specific work description

Using software tools like R or Matlab, the student will work on developing models/simulations to quantify microbial risk. Additionally, the student will perform a literature review to develop competency in various topics, such as QMRA, *Legionella*, drinking water, and public health/epidemiology. The student will work in a collaborative, cross-discipline research team but will also be expected to take ownership of this specific topic through self-initiative and self-guided learning. Through these collaborations, the student will have opportunities to either participate or directly lead environmental monitoring campaigns, such as testing for *Legionella* in drinking water around Trondheim and in the water supplies, Jonsvatnet and Benna. Other water quality parameters may also be tested, such as pH, temperature, and organic carbon. Thus, the student should expect some hands-on experience and training in the laboratories at Vassbygget as well as in the field. Overall, the thesis is expected to help the Norwegian water sector learn more about microbial risk in Norway and will also serve as a basis for future research activities at NTNU.


Risk
Assessment
Science based
Risk
Management
Policy based
Risk
Communication

Project Title	Wastewater treatment in AS-EBPR
Type	Project and Master thesis
Supervisors / Contacts	Stein W. Østerhus Blanca M. Gonzales Silva
Location	Vassbygget Trondheim

Project background

Wastewater treatment applying enhanced biological phosphorus removal (EBPR) has got increased attention recent years, especially as there has been an more focus on phosphorus (P) recovery from wastewater. Norway would typically have challenging conditions for the EBPR process due to low temperature, low concentration of volatile fatty acids (VFA) in the wastewater, and general diluted wastewaters. Despite these challenges, the interest for EBPR in Norway is growing, both for the EBPR in the traditional activated sludge (AS) configuration (AS-EBPR), and for the newly developed EBPR in a continuous moving bed biofilm reactor (cMBBR) configuration (cMBBR-EBPR).

Newer research and results from wastewater treatment plants have shown that the EBPR process also can work well under challenging Norwegian conditions, making the process very interesting when recovering of phosphorus is major concern. However, existing knowledge and experience with the EBPR process (both the AS-EBPR and the cMBBR-EBPR configurations) under the challenging Norwegian conditions are limited, and there is a need to improve this knowledge.

Aim of the project

This project will focus on the AS-EBPR configuration. The overall aim of this project is to improve the process understanding of the AS-EBPR configuration, and to optimize the process. It is further important to obtain experience with the process under typically challenging Norwegian conditions in order to establish good design criteria and improved operational recommendations. The results will be compared to the performance of the cMBBR-EBPR configuration.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding the EBPR process in general and the difference between the traditional AS-EBPR and the cMBBR-EBPR configuration. Some specific tasks for the comparison of the AS-EBPR and the cMBBR-EBPR configuration could include:

- Investigate the effect of wastewater composition on the biological process occurring.
- Investigate how the kinetics of nutrients removal are affected by loads, quality parameters, design parameters, operational variables, etc.
- Optimize the pilot plant with respect to P- and N-removal, reaction kinetics, etc

The work on the AS-EBPR configuration will be performed at IVAR IKS, Stavanger. A cMBBR-EBPR pilot plant in th wastewater lab in Trondheim, will be made available for the student.

Project Title	Wastewater treatment in cMBBR-EBPR
Type	Project and Master thesis
Supervisors / Contacts	Stein W. Østerhus Blanca M. Gonzales Silva
Location	Vassbygget Trondheim

Project background

Wastewater treatment applying enhanced biological phosphorus removal (EBPR) has got increased attention recent years, especially as there has been an more focus on phosphorus (P) recovery from wastewater. Norway would typically have challenging conditions for the EBPR process due to low temperature, low concentration of volatile fatty acids (VFA) in the wastewater, and general diluted wastewaters. Despite these challenges, the interest for EBPR in Norway is growing, both for the EBPR in the traditional activated sludge (AS) configuration (AS-EBPR), and for the newly developed EBPR in a continuous moving bed biofilm reactor (cMBBR) configuration (cMBBR-EBPR).

Newer research and results from wastewater treatment plants have shown that the EBPR process also can work well under challenging Norwegian conditions, making the process very interesting when recovering of phosphorus is major concern. However, existing knowledge and experience with the EBPR process (both the AS-EBPR and the cMBBR-EBPR configurations) under the challenging Norwegian conditions are limited, and there is a need to improve this knowledge.

Aim of the project

This project will focus on the cMBBR-EBPR configuration. The overall aim of this project is to improve the process understanding of the cMBBR-EBPR configuration, and to optimize the process. It is further important to obtain experience with the process under typically challenging Norwegian conditions in order to establish good design criteria and improved operational recommendations.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding the EBPR process in general and the cMBBR-EBPR process in particular. Some specific tasks could include:

- Investigate the effect of wastewater composition on the biological process occurring.
- Investigate how the kinetics of nutrients removal are affected by loads, quality parameters, design parameters, operational variables, etc.
- Optimize the pilot plant with respect to P- and N-removal, reaction kinetics, etc

A cMBBR-EBPR pilot plant will be made available for the student.

Project Title	Wastewater treatment: EBPR and microbial community
Type	Project and Master thesis
Supervisors / Contacts	Stein W. Østerhus/ Blanca M. Gonzales Silva/ Ingrid Bakke
Location	Vassbygget Trondheim

Project background

Wastewater treatment applying enhanced biological phosphorus removal (EBPR) has got increased attention recent years, especially as there has been an more focus on phosphorus (P) recovery from wastewater. Norway would typically have challenging conditions for the EBPR process due to low temperature, low concentration of volatile fatty acids (VFA) in the wastewater, and general diluted wastewaters. Despite these challenges, the interest for EBPR in Norway is growing, both for the EBPR in the traditional activated sludge (AS) configuration (AS-EBPR), and for the newly developed EBPR in a continuous moving bed biofilm reactor (cMBBR) configuration (cMBBR-EBPR).

Newer research and results from wastewater treatment plants have shown that the EBPR process also can work well under challenging Norwegian conditions, making the process very interesting when recovering of phosphorus is major concern. However, existing knowledge and experience with the EBPR process (both the AS-EBPR and the cMBBR-EBPR configurations) under the challenging Norwegian conditions are limited, and there is a need to improve this knowledge.

Aim of the project

This project will focus on the comparison of the AS-EBPR and the cMBBR-EBPR configuration. The overall aim of this project is to improve the process understanding of both the EBPR configurations by analyzing the microbial community and link the results to process performance.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding the EBPR process in general and the difference between the traditional AS-EBPR and the cMBBR-EBPR configuration. The student will carry out microbial community analyses and link the results with process performance. The analysis will be Illumina sequencing characterization of the 16S rRNA amplicons and statistical analysis. The student should obtain a comprehensive insight into the key PAOs and determine their relative abundance.

The samples will be taken from EBPR plants in Norway run at different conditions, including, including a cMBBR-EBPR pilot plant in the wastewater lab in Trondheim.

Project Title	Statistical analyses to detect patterns and sources of heavy metals in sewer sludge
Type	Project and Master thesis
Supervisors / Contacts	F. Tscheikner-Gratl, M. M. Rokstad, S. Sægrov, T. Meyn
Location	Vassbygget Trondheim

Project background

Sewage sludge produced at wastewater treatment plants can be used as a **fertilizer** in agriculture, provided that the sludge meets the **regulatory quality requirements**. However, the **heavy metal concentrations** may often be too high to allow agricultural end-use of sewage sludge and is therefore often monitored carefully in sewage sludge.

Aim of the project

In order to improve the applicability of sludge as fertilizer it is desirable to **analyze and identify the sources of the heavy metals** in the sewer water and sludge. If one can identify the sources of heavy metal, one can possibly implement measures to **reduce the influence of some of the heavy metal contributors**, and thereby better control the sewage sludge quality. The composition of heavy metals and its dependency on other factors such as season, precipitation etc. may be indicative of the heavy metal origin, and knowledge of the origin may be used to direct measures to reduce the heavy metal source influence on the sewer. For instance, a certain combination of compound concentrations and time-signature may be indicative of household wastewater, whereas other combinations and time-patterns may be point towards contribution from ingress of certain soil types (e.g. clay), or first-flush wash-off from roads and urban traffic.

Specific work description

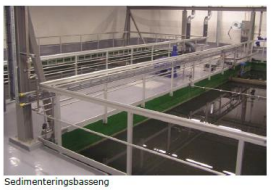
- Literature review on identification/ patterns of sewer heavy metals
- Statistical analyses to identify a model that represent the “normal” or baseline contribution of heavy metals from household wastewater, and identify irregular or “extra” contributions of heavy metals from extraneous sources
- Identify the relation between heavy metals at the wastewater treatment plant inlet, and the final concentration of heavy metals in the sludge

Benefits

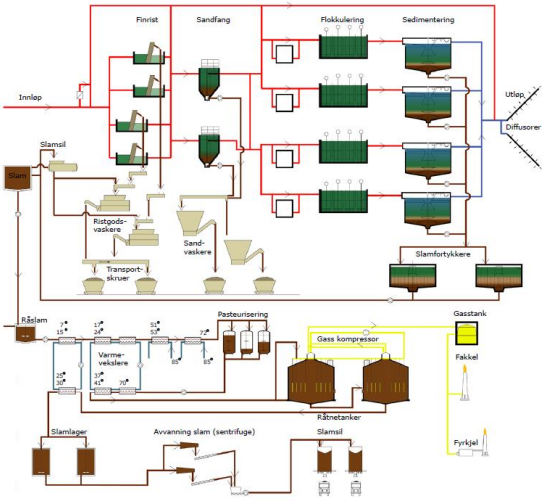
Circular economy and re-use of resources is a topic of increasing interest, and knowledge about how one can improve the applicability of sludge end-use is valuable for the industry.


Slambygg og administrasjonsbygg


Ristgodsvaskere


Sedimenteringsbasseng

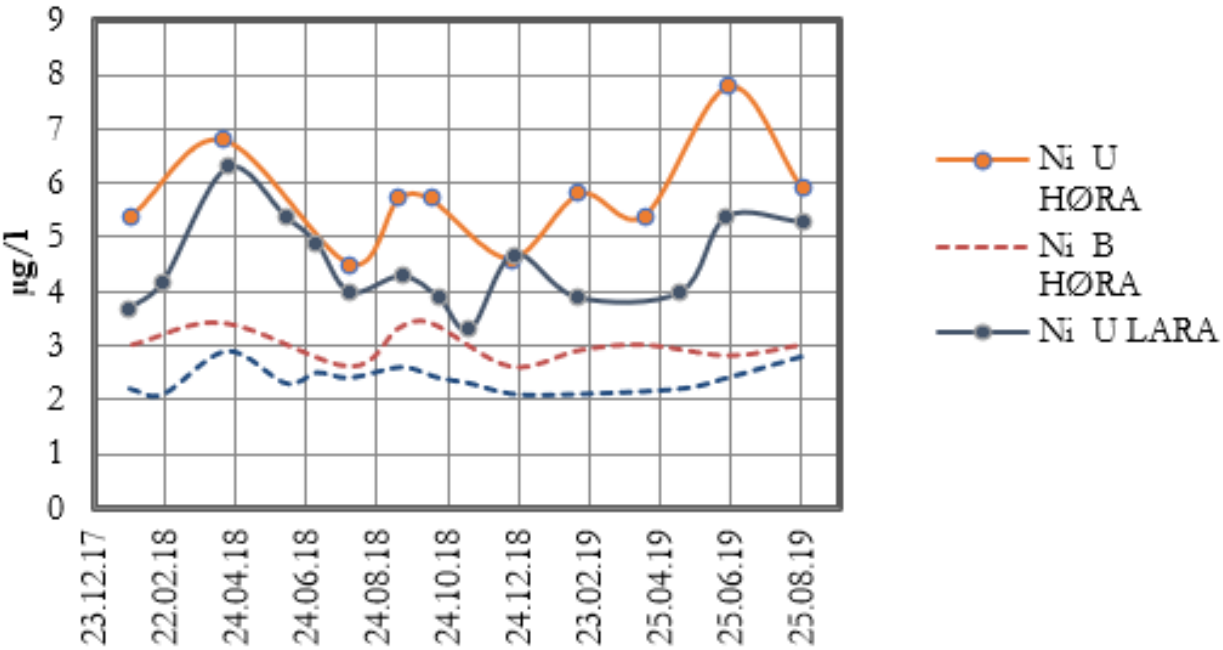
Flytskjema




Biogassanlegg


Gasskompressorer


Slamavvanning



Nickel in untreated and treated wastewater at LARA and HØRA

Project Title	New filtermedia and filterdesign
Type	Project and Master thesis
Supervisors / Contacts	Tor Håkonsen, Stein Østerhus
Location	Vassbygget Trondheim

Detailed project descriptions: Group 3

Project Title	Utilizing artificial intelligence methods for inflow and infiltration (I&I) problems in wastewater networks
Type	Project and Master thesis
Supervisors / Contacts	Franz Tscheikner-Gratl, Marit Aase (Bergen Municipality) and Jon Røstum (Powel Environment)
Location	Vassbygget Trondheim

Project background

Infiltration and inflow of non-sewer water to the wastewater network (I/I-water) represents a huge challenge in many countries. I&I water has a lot of negative effects such as increased CSO spills, increased costs for pumping, reduced treatment efficiency etc. Sources of I/I-water are rainfall, groundwater, and leakages from the water supply system. I/I-water finds its way into the wastewater network through damaged pipes, damaged manholes and fault connections, but can also enter intentionally, which is the case for rainwater in a combined sewer system. In Norway the Norwegian Water Association (Norsk Vann) has defined sustainability goals (SDG) regarding I/I- water. By 2020 the utilities should make a plan for dealing with I/I and by 2030 the amount of I/I should be reduced by 30% at the national level in order to become more sustainable.

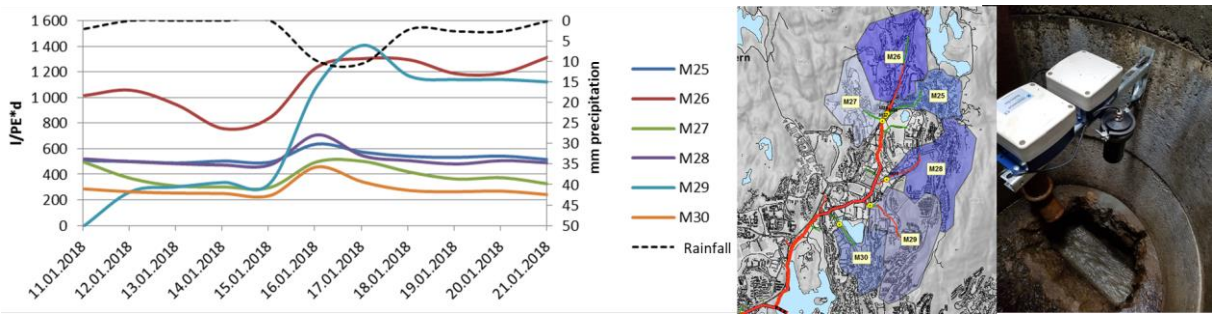
Aim of the project

The candidate will based on the work and the cooperation with the different partners achieve a deep insight of an emerging challenge (I/I water), establish a good overview of relevant data sources, have practical experience with advanced analytical tools and will gain a good platform of understanding of modern development of Industrial IT software where hopefully the candidates work can be implemented in the future.

Specific work description

The goal of this work is therefore:

1. Assess the the challenges of I&I form existing literature and describe the state of the art, best practice.
2. Evaluate relevant data sources usable for analysing the problem. For this data from Bergen Municipality can be used including flow and water level data from SCADA systems, similar data from IoT sensors (via API), rainfall data, tidal data (sea level data), water level data in nearby rivers and lakes etc.
3. Exploration of varying methods to assess the I/I. This ranges from statistical methods to advanced analytical methods (ML/AI).
4. Exploration of hydrodynamic model necessity. What can be done without it?
5. Automatic identification and localisation of zones with high I/I and risk assessment of those zones.


l/PE*d
mm precipitation
M25
M26
M27
M28
M29
M30
Rainfall
11.01.2018
12.01.2018
13.01.2018
14.01.2018
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16.01.2018
17.01.2018
18.01.2018
19.01.2018
20.01.2018
21.01.2018

Project Title	Reduction of water leakages by smart water technologies
Type	Project and Master thesis
Supervisors / Contacts	Christos Makropolous, Franz Tscheikner-Gratl, Marius Møller Rokstad, Sveinung Sægrov, Kyrre Halvorsen (Trondheim kommune), Stian Bruaset (SINTEF)
Location	Vassbygget Trondheim

Project background

Norwegian water supply systems suffer from significant water loss, in average 30%. Trondheim municipality is currently trying various measures to reduce the leakage level. This includes splitting leakage zones (DMA's), reduction of pressure, introduction of a finer network of acoustic meters for leakage sound, improvement of hydraulic network computer model and introduction of new algorithms that detect water losses. This work has a research character, and therefore a co-operation with NTNU has been established via a particular Municipality-University co-operation that also host a post-doc position in our department. This this master thesis is a part of a long-term collaboration between the two parties.

Aim

Test new methods for reduction of water loss in Trondheim, and demonstrate their application in a wider context (other cities)

Work description

A number of potential actions are described. The project work will comprise a wide analysis of various opportunities, and also include the establisment of a modified network model. The master thesis will be a selection of measures for detailed testing by model, machine learning tools and field measurements

Description of status quo in Norway

- Use different metrics than % (ILI, NRW…) – possible to do a survey on different metrics for Norwegian municipalities
- Characteristics of leakages in Norway Distribution of big/small leakages, clusters, continuous/bursts, time until repair etc. – will be challenging to get sufficient data.
- Relation between leakage and pipe materials
- Calibration of PDA models in Norway
- The economics of water loss (water pricing; what is the right level of water loss; economic versus sustainable level of water loss; which strategies are economical?)

DMAs

- How big does a leak have to be to be detected under different DMA configurations? (Model study)

- DMA size? (Application of developed algorithm… e.g. Di Nardo et al.; Exeter guys; WDNetXL)
- DMA – leakage control versus reliability reduction? What about water age?
- How much looping is good looping? Is more loopedness always good? "Default" versus "conditional" looping – automatization. How do different designs affect hydraulic capacity, water age, stagnant water? Risk of valves not functioning? (Use work of Sitzenfrei)
- Pressure management
  - Active/dynamic pressure management. Risks? Risk of valves not functioning when required (fire flow)? Risk of damage from water hammer (pipe bursts, in-house equipment etc.)?
  - Energy recovery – pumps as turbines, pressure reduction valves

Real-time leakage/burst detection

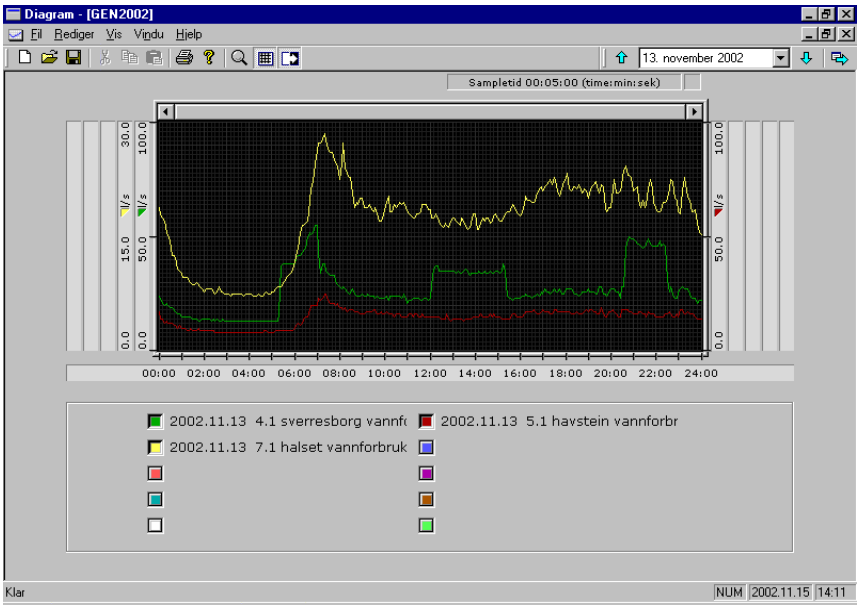
- Study on how to use SWMs for real-time leakage detection (study possibility of volumetric control or use pressure sensors)
- Lab work – study of different crack types, characteristics of different leaks (van Zyl… Fuchs-Hanusch etc.)

Leakage levels and health

- Risk analysis:
  - How would a burst/leakage in combination with other events (fire-fighting, bad repair, transient events etc.) affect the risk of pipe contamination?
  - Could be a master thesis to set up a methodology for this type of analysis
  - Event chains (fault tree analysis, event tree analysis)

"Trench hydraulics" – how does the hydraulics of a leakage behave in a typical multi-system closed trench in Norway? (E.g. trench in Trondheim, where the masses around the trench are denser than the in the trench itself).

Water consummtion by SCADA, basis for leakage identification



Project Title	Water Level Detection Through Image Analysis
Type	Project and Master thesis
Supervisors / Contacts	Franz Tscheikner-Gratl / Robert Meier / Christos Makropolous
Location	Vassbygget Trondheim

Project background

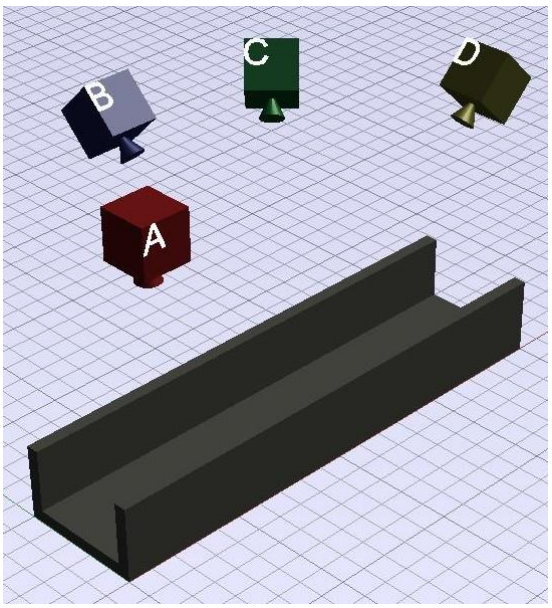
Traditional sensors to measure the water level in wastewater channels are often costly and if they are in direct contact with sewage, particularly dependent on thorough and regular maintenance. This project aims at developing an alternative way to measure water levels using image analysis on camera footage. As depicted in the sketch below, a camera directed at the flow captures the water in the open channel and uses a neural network to derive the water level from the image. In order to create a viable sensor option usable in practice, two specific aspects need to be clarified as part of this project. The first part is to compare different methods of foreground detection to make it possible for the algorithm to focus solely on the water flowing in the channel. The second part aims at comparing symmetric camera angles and their influence on the detection of the water level.

Student tasks

- Conduct laboratory tests to gather training data for the neural networks
- Compare the measurement accuracy when using different foreground detection techniques
- Compare the measurement accuracy when using symmetric camera angles

Learning Goals for Students

- Planning and conducting laboratory experiments
- Learn how to handle and process measurement data
- Gather hands-on experience using neural networks and apply them to a real-world problem



Schematic Overview of Cameras Directed at Channel

Project Title	Measurement data quality control using examples Risvollan and pump station Trolla
Type	Project and Master thesis
Supervisors / Contacts	
Location	Vassbygget Trondheim

Project Title	Digitalization of urban water services in Vestfold
Type	Project and Master thesis
Supervisors / Contacts	Sveinung Sægrov, Franz Tscheikner-Gratl, Marius Møller Rokstad
Location	Vassbygget Trondheim

Project background

The municipalities Horten andTønsberg, the disctict water supplier Vestfold Vann and Jarlsberg JICT together with local industial companies have lauched a project with the aim to promote digitalization of urban water services in Vestfold. The plan aims to develop a cost-efficient system for digitalization that comprises the entire value chain from sensor, gateway, signal transmission, data management platform (cloud) and integratian toward specific applications. The project incorporates both water and wastewater services.

The project includes a collaboration with an industrial interest for developing a new water meter based on vortex shedding technology.

NTNU is already involved in several activities to develop and promote appropriate digitalization of water and wastewater services, via our participation in EU projects, Ph D studies and master thesis.

Aim of the project

The project work aims to present and discuss opportunities and limitations when establishing a digital water and wastewater service. It will include an overview of information requirements that can be met by digital systems as well as presentations and discussions of sensors, transmissions, cloud solutions and applications.

Specific work description

1. Meeting with partners of the Vestfold project to understand their requirements for digital support to water and wastewater services
2. Provide literature survey of international state of the art
3. Collection of information about sensors, such as water flow, pressure meters, temperature, turbidity from literature and ongoing projects in Norway and abroad. This include sensors for domestics (household), industry as well as urban water networks.
4. Particular study of new technology for water flow based on vortex shedding. Preparation of laboratory testing of method in our lab facility (ev to be conducted within master thesis)
5. Collection of information of transmission systems, limitations of signals from underground installations, cloud solutions
6. Discuss potential applications

Project Title	Water supply and sanitation in Africa
Type	Project and Master thesis
Supervisors / Contacts	Sveinung Sægrov
Location	Vassbygget Trondheim and Africa

Project background

The water and wastewater group at IBM is enganged in projects in with the aim to establish and improve water supply in remote areas of developing countries, currently in Africa. We have a broad approach to this, incorporating technology for water supply, in particular water yards based on groundwater wells, sustainable water consumption for domestic as well as small-scale agriculture. Currently we work in Tanzania, in a co-operation with Norwegian Church Aid (NCA) and Engineers Without Borders (EWB), as well as the local organisations 4CCP (4 Corner Cultural Program). It is also optional to work in other countries and with other partners, as projects are being established by our partners.

Sustainability of rural water supply is a challenge in low- and middle-income countries. It is likely that more than 1 billion people use local groudn water sources (Carter, et al. 2010). According to Baumann (2009) it is assumed that between 600,000 and 800,000 hand pumps have been installed in Sub-Saharan Africa (SAA) during the last 20 years. Sustainability of water supply schemes is a challenge in Sub-Saharan Africa (SAA). It has been estimated that 30% of all hand pumps (HP) in SSA are not working at any given time (Bauman, 2009). The Rural Water Supply Network (RWSN, 2009) calculated that across 21 countries in sub-Saharan Africa about 36% of hand pumps were not functional. Therefore, the trend is no to move to solar driven electrical pumps

Aim of the project

The ultimate aim is contribution to a sustainable water supply and sanitary situation in rural districts of Sub-Saharan Africa. The main focus will be laid on the performance of small-scale technology for water supply, with a focus on solar-power driven pumps.

Specific work description

During the project work, the student will get familiar with relevant literature and reports that describe the state of the art regarding water supply in rural districts of Sub-Sahara. During the master project, the student will take part in field work in cooperation with local organisations as well as NCA and EWB in analysing the performance of water schemes in selected villages. More details will come as we decide the specific site of the project.

Master thesis at Haydom, Tanzania (ongoing spring 2020, Maria Asklund and Trine Ånestad Røer)

Project Title	ASSET MANAGEMENT OF NATURE-BASED SOLUTIONS: WHAT INFORMATION TO COLLECT AND HOW FOR MAINTENANCE MANAGEMENT
Type	Project and Master thesis
Supervisors / Contacts	Rita Ugarelli (NTNU-SINTEF)/ Edvard Sivertsen (SINTEF) / Gema Raspati (SINTEF)
Location	Vassbygget Trondheim

Project background

The SFI Centre Klima 2050 (www.klima2050.no) studies climate adaption within the build environment, including stormwater management. Klima 2050 has a strong focus on innovation and demonstration of novel solutions through pilot projects in close collaboration with the public and private partners within the centre.

Cities are facing several types of challenges such as unsustainable urbanization, human health and inhabitants' well-being due to degradation of ecosystem (air, water and soil pollution), risks related to climate change and possible natural disaster. However, it is shown by various scientific publications that nature-based solutions (NBS) provide sustainable, cost-effective, multi-purpose and flexible alternatives for facing these challenges better than conventional methods.

NBS use the features and complex system processes of nature, such as its ability to store carbon and regulate water flow, in order to achieve desired outcomes, such as reduced disaster risk, improved human well-being and socially inclusive green growth. Maintaining and enhancing natural capital, therefore, is of crucial importance, as it forms the basis for implementing solutions. NBS are ideally energy, resource-efficient and resilient to change, but to be successful they must be adapted to local conditions and must undergo regular maintenance activities.

In addition, as decision-making in asset management of water-related infrastructure depends strongly on the available data on the assets' characteristics and operation and maintenance (O&M) activities, the need of a general data model, allowing asset managers to register useful and necessary information, is expressed also to manage NBS. A data model should be adaptable to each NBS type. Data should then registered and saved according to this data model and will be completed throughout the time.

In Klima 2050, several on-going pilot projects have been established with different kinds of Nature Based Solutions (NBS)-related measures installed, i.e. FV505, Rv3, Torvet I Trondheim, Høvringen, ZEB Lab.

Aim of the project

Building on the NBS-report published in KLIMA2050 (Klima 2050 Report No 18 - Documentation tool of nature-based solutions – a guideline, and the updated version in Report No 19 (in Norwegian)) and ongoing research lead by SINTEF on developing a data model for NBS management, the project should focus on performing a systematic description of each of the measures installed within KLIMA 2050 pilots, assess and develop the operation and maintenance needs and procedures based on the reliability assessment of

each solution, test and validate the use of the NBS framework for each of them.

Specific work description

During the project work, the student will get familiar with relevant National and International literature and reports that describe the state of the art regarding the classification of NBS solutions, their functional requirements and reports produced within KLIMA 2050 related to the specific solutions installed.
The objectives of this work will be as follows:

1. To identify the most important characteristics of the selected types of NBS which can have an impact on the maintenance activities necessary for their functionality. This should also include the study of combined effects, not only to NBS performance but also implications to operation and maintenance, i.e. in case where several types of NBS are installed in series/parallel in an area;
2. To suggest anticipated maintenance intervals considering tactical and strategic asset management definition;
3. Building on the ongoing research of SINTEF, to contribute to the general NBS data model defining all possible data for each studied NBS. This data model contains inventory and O&M data. The study should also suggest how the NBS data would be -ideally- quality assured/stored, updated and made available for stakeholders/interest group.
4. To study the impact of insufficient maintenance activities on the functioning efficiency of the studied types of NBS.

Project Title	Sustainable approaches to long-term asset management
Type	Project and Master thesis
Supervisors / Contacts	Rita Ugarelli (NTNU-SINTEF)/ Stian Bruaset (SINTEF)/ Håkon Reksten (NORCONSULT)
Location	Vassbygget Trondheim

Project background

Asset management and sustainable development must go hand in hand in order for utilities to be able to meet the future. Sustainability tools and approaches that facilitates sustainability should therefore be implemented in asset management tools which are widely used in water utilities. This will facilitate sustainable development in the Norwegian water sector.

A new project supported by the Norwegian Research Council will look into the creation of a Norwegian long-term model based on such survival functions. Long-term sustainable development will be important when developing the model. A work package is therefore dedicated to creating a sustainable approach to long-term rehabilitation planning of water networks. The process will be based on a past PhD, Master thesis at NTNU and past projects (e.g. DiVA https://diva-guiden.no/om).

Aim of the project

The aim of the project is to create the framework and a process (data + guideline) for how water utilities can analyse and implement the most robust and sustainable rehabilitation strategies for the renewal or urban water- and wastewater networks. The first part of the project will have to validate and solidify the scientific background.

Specific work description

During the project work, the student will take part in a large Norwegian research project which is funded by the Norwegian Research Council and where SINTEF is the project leader. The project is a collaboration between four large municipalities (Drammen, Oslo, Trondheim, Bergen,) SINTEF, NTNU, Norsk Vann, and two consultant agencies. The project work will consist of understanding and critically examining the scientific background of the project. This will result in a recommendation for how to build the framework and the process.

During the master project, the student will take part in the same project. The student will therefore have good opportunity to come in contact with a range of actors in the Norwegian water and wastewater market. The master project will consist of creating the framework and the process for choosing sustainable long-term strategies. The results will be an input to a new tool, so the student will have to work in close collaboration with SINTEF and other partners in the project. The results of the project will be something that the Norwegian water sector will actively use for many years to come.