Project and master thesis topics in water and wastewater engineering 2022/23

NTNU

Contents

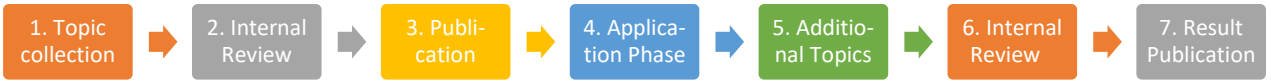
Introduction

The water and wastewater engineering group has introduced a procedure for the publication and distribution of project and master thesis topics 2 years ago. 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. One main priority of master student projects is the support of **ongoing activity and PhD students**.

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.

The procure was adapted based on last years' experience. The main adjustment is the significantly shortened amount of time between the submission of desired topics by the students and the final distribution of topics. The process will be finished at the beggining of June.

The distribution procedure



1. Topic collection

Each professor suggests a maximum of 3 to 4 topics and each Prof. II suggests 1 to 2 topics. Submission deadline is the right **after Easter**. 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. Possibilities for coalescence and collaboration will be identified and projects with high relevance will be prioritized.

3. Publication

The topics will be compiled and made available for the students via the internal website and by email, no later than **21. April**. There will be a digital meeting with the students on **2. May at 13:00**, where the projects will be presented.

4. Application phase

After the topics are published, students apply for their favourite topics. The topics are divided into two groups and students will need to pick three topics from each group. The six topics selected must be ranked (1:favorite to 6: least favorite), and the ranking will be submitted via an online form that will be available on the master topic page.

In addition, you are encouraged to write half a page letter (A4) to explain your motivation and justify the ranking of the selected topics. This letter of motivation is optional. Deadline for the application of the ranking and the motivation letter is on **25. May**.

5. Additional topics

Students will have the possibility to deliver independent project proposals, i.e. with external partners, until the end of the application phase **25. May.** These proposals will need to be as mature and well defined as possible. A template for the proposals will be provided on the webpage.

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, on **13. June**.

Topic overview

Master projects in Group 1

Number	Title	Supervisor(s)	Partner(s)
1.1	Development of a smart sensoring strategy for identifying illicit connections in urban drainage systems	Franz Tscheikner-Gratl Francois Clemens-Meyer Marius Møller Rokstad	
1.2	Quantifying Infiltration and inflow (I/I) in sewage systems	Franz Tscheikner-Gratl Marius Møller Rokstad Bardia Roghani	Horten
1.3	Machine learning-based deterioration modelling of water distribution or sewer pipe network	Franz Tscheikner-Gratl Marius Møller Rokstad Shamsuddin Daulat	
1.4	Calibrating discharge measurements at Risvollan	Franz Tscheikner-Gratl Francois Clemens-Meyer Thomas Meyn	
1.5	Water supply in developing countries	Sveinung Sægrov Marius Møller Rokstad	IUG
1.6	Nature-based solution retrofit in an urban catchment	Tone Muthanna	

Master projects in Group 2

Number	Title	Supervisor(s)	Partner(s)
2.1	Decision support for selection of future treatment technology for tunnel wash water	Thomas Meyn Franz Tscheikner-Gratl Kamal Azrague	SINTEF
2.2	Impact of detergents on the mobility of heavy metals and micropollutants in road tunnel wash water	Thomas Meyn Subhash S Rathnaweera	Aquateam COWI
2.3	Quantitative Microbial Risk Assessment (QMRA) of Norwegian Drinking Water Systems and Water Reuse Systems (Wider Uptake)	Cynthia Hallé Kamal Arzague Rizza Ardiyanti	SINTEF Wider Uptake
2.4	Understanding the Enhanced Biological Phosphorus Removal (EBPR) process	Stein W. Østerhus Blanca M. Gonzales Silva	Wider Uptake
2.5	Optimization of the Enhanced Biological Phosphorus Removal (EBPR) process for typical Norwegian conditions	Stein W. Østerhus Blanca M. Gonzales Silva	Wider Uptake

Detailed project descriptions: Group 1

Project Title	Development of a smart sensoring strategy for identifying illicit connections in urban drainage systems
Type	Project / Master thesis
Supervisors/ Contacts	Franz Tscheikner-Gratl (NTNU), Francois Clemens-Meyer (NTNU/Deltares), Marius Møller Rokstad (NTNU)
Location	Trondheim/Delft

Project background

Urban drainage systems are being built to collect and transport wastewater and excess stormwater out of urban areas to avoid, respectively, the spread of waterborne diseases and the occurrence of urban flooding. In the early systems the two 'types' of water (wastewater and storm water were collected in on single system (the combined sewer system, this however has some disadvantages like the fact that a large amount of 'clean' stormwater' is transported to the wastewater treatment lant to undergo purification. Apart from the costs involved, it also reduces the efficiency of the treatment process and as such contributes to a deterioration of the aquatic environment. Over the past ~50 years the construction of separated systems has started, that implies that two collection and transport systems are being constructed (a wastewater and a stormwater system). In theory this would solve all issues related to the combined system (no spills of raw wastewater into open water courses, an increased efficiency of the wastewater treatment lant. However, due to small mishaps that occur in practice, in the course of time more and more so-called 'wrong connections' evolve, this can imply that a toilet, a bathtub, a shower is connected to the stormwater system, or that some surface generating run-off during storm events discharges into the wastewater system. There are cases known in which > 5% of the connections were wrong, resulting in massive pollution of o[ern waterbodies and a substantial loss of efficiency of the wastewater treatment plant.

Aim of the project

There exist many methods to detect wrong connections, in general, the easiest to identify are run-off generating surfaces connected to the wastewater systems by the application of classical methods like smoke testing, of by applications of acoustic methods. However, identifying wastewater discharges into a stormwater system is less straight forward, there are several methods that can provide and almost 100% certainty on finding and locating such discharges (e.g., Distribute Temperature sensing, using the optical properties a glass-fibre cable that has to be inserted in the sewer system, another manner is to take samples of the water on a regular basis and thy to find out where the observed dilution comes from). However, when applied on a large scale such methods are expensive. An alternative is to develop a strategy in which using low-cost sensors to narrow down the search areas to reduce the cost of e.g., DTS or sampling. One of the cheapest sensors available that produces a large amount of information is a camera, using advances postprocessing methods (e.g., particle Image Velocimetry) on the footage can reveal increased water flow during storm events, in such a manner after observing a period of dry weather and storm flow conditions the camera can tell whether wrong connections are likely to be resent in a certain area. Bear in mind that normally only u to 5% of the connections is wrong, so it expected that many areas can be ruled out, to reduce the search area for detailed investigations

Specific work description

The proposed project will encompass:

- Some (simple) hydraulic modelling to find 'strategic' locations
- Development of a monitoring strategy
- Working with low-cost camera's (camera calibration, get acquainted with IV)
- Investigating some metrological aspects (like uncertainty repeatability and the risk on false negatives and false positives in the 'camera' phase when compared to the DTS sampling stage.
- Data validation and data analysis
- Some fieldwork (depending on the time frame and the willingness of a student to come over to the Netherlands)

Candidates are expected to have some 'feeling' for hydraulics, knowledge of Python/MATLAB programming (but preferably Python), and a working knowledge of statistics.

Project Title	Quantifying Infiltration and inflow (I/I) in sewage systems
Type	Project and Master thesis
Supervisors/ Contacts	Franz Tscheikner-Gratl (NTNU), Marius Møller Rokstad (NTNU), Bardia Roghani (NTNU)
Location	NTNU in collaboration with Horten

Project background

Infiltration and inflow (I/I) of groundwater or wrongly connected stormwater into the sewer system is a significant challenge for many municipalities, including Horten. This leads to increased cost for transport and treatment of wastewater. Localization and removal of I/I water is therefore a priority in Horten municipalities' plan for upgrading drainage network. 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.

Aim of the project

Present methods for locating and quantifying I/I in sewage systems, and discuss opportunities and limitations of the methods.

The candidate will on the work and the cooperation with the Horten municipality achieve a deep insight of an emerging challenge (I/I water), establish a good overview of relevant data sources, have practical experience with analytical tools and will gain a good platform of understanding 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 Horten Municipality can be used including flow and water level data from SCADA systems, similar data from IoT sensors, 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. Identification and localisation of zones with high I/I and risk assessment of those zones.

Project Title	Machine learning-based deterioration modelling of water distribution or sewer pipe network
Type	Bachelor / Project / Master thesis
Supervisors/ Contacts	Franz Tscheikner-Gratl (NTNU), Marius Møller Rokstad (NTNU), Shamsuddin Daulat (NTNU)
Location	Trondheim

Project background

The deterioration of pipes in urban water distribution systems presents a major challenge to water utilities throughout the world. Pipe deterioration can lead to pipe breaks and leaks, which may result in a reduction in the water-carrying capacity of pipes and lead to substantial repair costs. Physical modeling of individual pipes can provide strong inferences about pipe condition if sufficient data about the pipes are available, but, because pipes are buried, it is prohibitively difficult to gather the information needed for physical models of every pipe in a given water distribution system. Other models are based on statistics and machine learning. Machine learning (ML) techniques are recently developed and have already shown promising results in many different fields including water/wastewater pipe deterioration modelling. Studies show that ML techniques are even superior to statistical methods in many cases. Yet ML techniques are still in their infancy age period and new concepts/techniques are popping up here and there each year. Recently, some new techniques in the field of medicine have been developed to predict the survival probability of humans. One of these techniques is called Random Survival Forest which was developed in 2008. Due to some similarities in the survival of humans and pipes, this technique was used to predict the survival probability of water distribution pipes and the results showed superior performance than the other ML techniques. However, this technique still has some limitations. After 2008, some few other techniques are also developed but only tested in predicting survival probability of humans in field of medicine.

Aim of the project

Aim of this project is to explore these techniques and choose one or two best technique which are suitable for water/sewer pipe deterioration modelling and apply it.

Specific work description

During the project, the student will get familiar with deterioration modelling of pipes, pre-processing of data and machine learning techniques. The student will be provided the necessary data and the necessary guidance throughout the project. The student is expected to have some skills in one of the programming languages. Data will be provided. The student might need to “clean” the data and prepare for modelling.

Project Title	Calibrating discharge measurements at Risvollan
Type	Project and Master thesis
Supervisors/ Contacts	Franz Tscheikner-Gratl (NTNU), Francois Clemens-Meyer (NTNU/Deltares), Thomas Meyn (NTNU)
Location	NTNU

Project background

Several types of data can be recorded to better understand and manage urban drainage and stormwater management systems. However, discharge is probably the most common one, especially to operate facilities and evaluate pollutants loads. At the same time discharge is a quantity that cannot be directly measured, urging engineers to retreat to indirect measurements involving readings from multiple sensors and/or a certain amount of postprocessing applying implicit assumptions. Therefore, calibrating those measurements is of the utmost importance, as is to identify the relative contribution to the overall measuring uncertainty of all components of the measuring system. Several sensors and methods are available to estimate or measure flows and validate recorded discharges data. Such measurements are conducted in many urban drainage systems in the world. They may look easy and well established, but they are often prone to error and biases that are not always obvious. Even when applying methods described in standards, one needs to be aware of the limitations posed by the conditions in field measurements on the applicability.

Aim of the project

Test different measuring systems (i.e., sensor + postprocessing applied) and methods for discharge monitoring at the Risvollan measurement station applying strict metrological demands, in order to supply technicians working in practise with a guide on decide which method is best for their specific needs depending on the field conditions encountered.

Specific work description

The goal of this work is therefore:

1. Assess the existing literature and describe the state of the art, best practice.
2. Look at the existing measurement devices (Isotope measurements, doppler flow meters…) and test them for their performance in lab conditions.
3. Develop a calibration procedure for the existing measurement site at Risvollan
4. Carry out the calibration of the discharge measurements and evaluate the existing set-ups performance
5. Develop a method (i.e., practical guide for practitioners) to choose the ‘best’ method given practical demands and limitations set by the field conditions.

Project Title	Water supply in developing countries
Type	Project and Master thesis
Supervisors/ Contacts	Sveinung Sægrov, Marius Møller Rokstad
Location	NTNU / Tanzania

Water supply in developing countries

Inspired by the local organization 4CCP (4 Corners Cultural Program) and the outcome of several NTNU master students' work, a water supply well was built in 2021 for the local village Dang'aida in Haydom district of Tanzania. This on-site water supply replaces a walking distance of 13 km to nearest water source in drought periods.

It is assumed that the Dang'aida well contains enough water that a wider district can be supplied. Therefore, a project including pipelines, pumping stations and water tanks are under preparation. The first step in this project is likely to link the water supply to the primary school of Dang'aida. The project will be carried out with 4CCP as local host and will contain:

- Control of capacity of Dang'aida water well, volume and water quality
- Design and dimension the linked water supply to two sub-villages (ca 10 km away from source) and a primary school (1,3 km from source)
- Observation of water management, including maintenance, safety measures, economy (water supply payment), benefit for society when it comes to hygiene, local industries, agriculture etc.

The project will be connected to two ongoing projects conducted by Norwegian Church Aid (NCA)

- Development of a tool and guideline for measuring affordability of water, sanitation and hygiene products.
- Guideline for water quality testing / monitoring- NCA has developed a guideline, but more can be done.

Supervisors:
NTNU: Sveinung Sægrov and Marius Møller Rokstad
4CCP: Eliminata Awet and Ahadi Mollel
NCA: Manfred Arlt + more

We will apply for a status as a project within Engineers Without Borders

Dang'aida water supply

Project Title	Nature-based solution retrofit in an urban catchment
Type	Project and Master thesis
Supervisors/ Contacts	Tone Muthanna
Location	Trondheim

Project background

The StopUP project (EU financed) includes a study of potential for retrofitting combined sewer systems with NBS solutions as step-1 solutions with overflow to the combined sewers. The Lademoen city district has been selected as a focus district in 2022/2023 by the municipality. This includes investment for upgrades to the infrastructure, community development programs, social meeting points and net- work building in the community. The district has combined sewers which are old. Over the next four years, the municipality plans to renew parts of the old system, yet only little space is available on the surface for nature-based solutions (NBS) which are commonly installed as separate units. This case will investigate a bioretention systems, directly installed online on the sewer intercepting the first runoff, and at exceedance of design capacity send the bypass flow onto the combined sewer systems.

Aim of the project

This solution will be explored with modelling and through a pilot study. The pilot has three main activities: (1) The modelling will explore temporal and spatial resolutions for an optimal approach on computational effort and accuracy of analysis. (2) The bioretention system will be assessed for runoff reduction and frequency and duration of CSOs spills, combined with water quality improvement performance. (3) WQ measurements with online IoT based sensors for conductivity, turbidity combined with TSS, metals and prioritized emerging pollutants will be used to correlate flow and rainfall using machine learning techniques and input into a mass balance-based model focusing on the sources and pathways for the water quality parameters of interest.

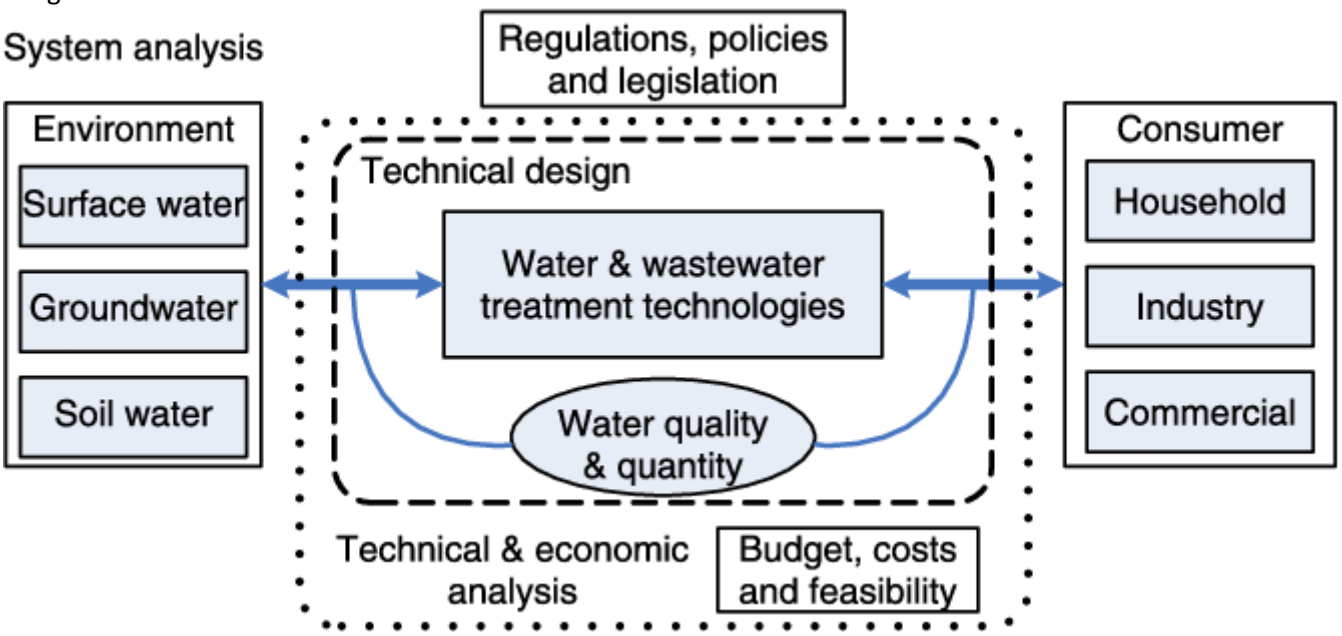
Modelling will be carried out to investigate the potential for using online nature-based solutions (NBS) to reduce volume and duration for combined sewer overflows. An evaluation of the impact on water quality in the receiving waters will be made through assessment of the frequency and duration of spills of the CSOs. The performance of the online bioretention systems will be evaluated from an operational and maintenance view.

Detailed project descriptions: Group 2

Project Title	Decision support for selection of future treatment technology for tunnel wash water
Type	Bachelor / Project / Master thesis
Supervisors/ Contacts	Thomas Meyn & Franz Tscheikner-Gratl (NTNU) / Kamal Azrague (SINTEF)
Location	Trondheim

Project background

Norway has around 1150 road tunnels with a total length of approximately 800 km. In urban areas, where space is limited, and traffic load is high, road tunnels are often a preferred solution. For example, in the Oslo and Akershus region, there are 55 tunnels with a total length of 37 km. To maintain traffic safety and increase lifespans of the tunnels, tunnels are normally cleaned 1 to 12 times per year, using high pressure water jets and soap. Approximately 60-100 L water, mixed with 0.5-1% soap is used to clean one meter of tunnel. 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. While various projects evaluate possible treatment future solutions, a strategic framework for the selection of the "best technology" is missing right now. The problem at hand is complex and driven by multiple criteria, such as treatment efficiency, costs, maintenance needs, lifetime, environmental impact, policies, and legislation etc.



Approaches to water treatment problem analysis and their respective scopes (Hamouda et al. 2009)

This project is related to two ongoing research projects, collaborating with Statens Vegvesen, Nye Veier AS, Aquateam COWI and Aalborg University.

Aim of the project

The aim of the project is to develop a decision support system that allows the Norwegian Road Authorities and other relevant parties to assess and compare different treatment solutions for tunnel wash water, in dependence on their economic, social and environmental impact and other relevant criteria. The decision support system will be applied to the case study of Bjørnegårdtunellen in Sandvika, which is related to the politically controversial upgrade of the E18 highway between Sandvika and Oslo.

Specific work description

Project work autumn 2022

- Literature study on state of the art regarding tunnel wash water quality and treatment and decision support systems
- Identify relevant criteria for the decision support system, including approaches for how to quantify them.
- Evaluate various methods for decision support systems, including weight and utility elicitation
- Optional: Follow the course TEP4223 – Livssyklusanalyse, to get familiar with the Live Cycle Assessment methodology.

Master project spring 2023

- Finalize the decision support system and apply it by using the results and information collected in the ongoing project
- Evaluation of efficiency and environmental impact for the different treatment options
- Scenario and robustness analysis, what happens if the surrounding conditions change
- Ranking

The ideal candidate for this project

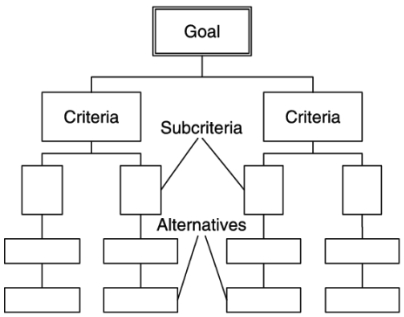
- This project is perfectly suited for students that would like to combine the topics water and roads
- Interest in data evaluation / modelling / programming
- Bonus: Previous experience with decision support, life cycle assessment and environmental impact analysis, i.e. from course TEP4223 – Livssyklusanalyse, which could be also followed in the autumn

What's in it for you?

- Get familiar with a pressing water management problem in Norway, and contribute to best solution section
- Project related to real life challenge
- Work in a small team with PhD and Post Doc
- SVV offers the possibility to apply for a student scholarship, corresponding to 15 000 NOK, which was granted to all students last year.
- (Co)-author and publish a scientific paper with your name on it

Literature

1. M. Hallberg; G. Renman; L. Byman; G. Svenstam; M. Norling (2014), Treatment of tunnel wash water and implications for its disposal, Water Sci Technol (2014) 69 (10): 2029–2035. https://doi.org/10.2166/wst.2014.113
2. M. A. Hamouda; W. B. Anderson; P. M. Huck (2009), Decision support systems in water and wastewater treatment process selection and design: a review, Water Sci Technol (2009) 60 (7): 1757–1770. https://doi.org/10.2166/wst.2009.538



Typical hierarchical structure implemented in an AHP optimization technique. Source Bick & Oron (2005)

Project Title	Impact of detergents on the mobility of heavy metals and micropollutants in road tunnel wash water
Type	Project & Master thesis
Supervisors/ Contacts	Thomas Meyn (NTNU) / Subhash S Rathnaweera (Aquateam COWI)
Location	Trondheim / Oslo

Project background

Norway has ~1150 road tunnels with a total length of ~800 km. In urban areas, where space is limited, and traffic load is high, road tunnels are often a preferred solution. For example, in the Oslo and Akershus region, there are 55 tunnels with a total length of 37 km. To maintain traffic safety and increase lifespans of the tunnels, tunnels are normally cleaned 1 to 12 times per year, using high pressure water jets and soap. Approximately 60-100 L water, mixed with 0.5-1% soap is used to clean one meter of tunnel. 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 for removal of particulate pollutants. However, little is known about the efficiency of such basins. Detergents improve the cleaning effectivity of the washing. However, they contribute to the mobilization and remobilization of e. g. heavy metals, which have been shown to complex with the detergents.

This project is related to two ongoing research collaboration with Statens Vegvesen, Aquateam COWI and Nye Veier AS and Aalborg University. The thesis is the continuation of several finished and ongoing master thesis. The student will work in a small research team together with the other students and a PhD and PostDoc.

Aim of the project

Detergents mobilize heavy metals and make removal of pollutants challenging when treating tunnel wash water. Though the natural degradation of soap is expected in sedimentation tanks, degradation of many soap types is slow and requires long residence time. Thus, the objective of this study is to understand the impact of detergents on the sedimentation rates of particles (including microplastics). As heavy metals may be complexed by the detergents, their adsorption to the particles is expected to be dependent on the detergent concentration and the type of detergent. Real wash water will be sampled and further studied in the lab.

Specific work description

During the **project work**, the student will get familiar with up-to-date knowledge regarding 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 size distribution and density, organic carbon, sample preparation for advanced analysis such as heavy metals etc.). Results will be evaluated including accuracy, precision, and confidence intervals.

During the **master project**, the student will take part in several sampling campaigns in road tunnels in the Trondheim and Oslo region. The water will be transported to the lab, there bench scale experiments will be performed, for example comparing aerobic vs. anaerobic conditions. Sampling and analysis will be done like in the project work. There may be the possibility that part of the experiments will be carried out in the Aquateam COWI laboratory.

The ideal candidate for this project

- This project is perfectly suited for students that would like to combine the topics water and roads
- Students that look for a practical project with hands-on experience
- Critical thinker
- Bonus: Experience, with work at roads and tunnels (maybe from summer job?), maybe trained in arbeidsvarsling via Statens Vegvesen or similar
- Bonus: driving license

What's in it for you?

- Hands on experience with a very relevant and sought-after topics
- Project related to real life challenge and ongoing projects
- SVV offers the possibility to apply for a student scholarship, corresponding to 15 000 NOK, which was granted to all students last year.

Washing of Grillstadtunellen (Trondheim), picture taken during sampling of wash water

Sampling from a sedimentation basin at Bjørnegårdtunnelen (Sandvika)

Fresh tunnel wash water in the sedimentation columns in our lab

Project Title	Quantitative Microbial Risk Assessment (QMRA) of Norwegian Drinking Water Systems and Water Reuse Systems (Wider Uptake)
Type	Project and Master thesis (2 students)
Supervisors/ Contacts	Cynthia Hallé, Kamal Arague, Rizza Ardiyanti
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.

Project Title	Understanding the Enhanced Biological Phosphorus Removal (EBPR) process
Type	Bachelor / Project / Master thesis
Supervisors / Contacts	Stein W. Østerhus (NTNU) / Blanca M. Gonzalez Silva (NTNU)
Location	Trondheim

Project background

Enhanced biological phosphorus removal (EBPR) process is an interesting alternative to chemical phosphorus precipitation. Successful operation of EBPR depends, among other factors, on the presence of high content of readily biodegradable chemical oxygen demand (rbCOD), such as volatile fatty acids (VFA), glucose, etc, in the influent wastewater. In Norway biological removal of phosphorus from wastewaters can be challenging because the wastewaters can be very diluted, caused by infiltration and inflow of stormwater after periods of rain and snowmelt, and because it has a low readily biodegradable organic carbon content (such as volatile fatty acids, VFA).

Aim of the project

The aim of this project is to improve the process understanding by investigating the effect of some design and operational parameters on the performance of the EBPR process using a lab scale set-up (Figure 1).

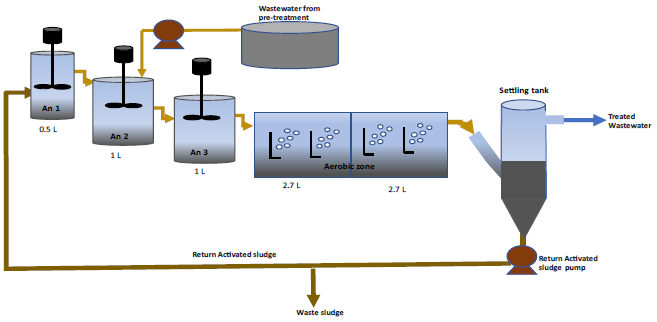


Figure 1. Lab scale Bio-P (EBPR) plant.

Specific work description

During the project work the student will get familiar with relevant literature and reports that describe the state of the art of activated sludge process for EBPR, and the lab work activities will involve investigations of different operational parameters, such as (using the lab scale Bio-P plant):

- Mixed liquor suspended solids (MLSS) in the reactors, in An1, and in the Return Activated Sludge (RAS).
- Waste activated sludge (WAS) flow rate
- Solids Retention Time (SRT)
- Hydraulic Residence time (HRT)

Final delivery:

Project report from the lab work activities, including theoretical background and methods.

Project Title	Optimization of the Enhanced Biological Phosphorus Removal (EBPR) process for typical Norwegian conditions
Type	Bachelor / Project / Master thesis
Supervisors / Contacts	Stein W. Østerhus (NTNU) / Blanca M. Gonzalez Silva (NTNU)
Location	Trondheim

Project background

Enhanced biological phosphorus removal (EBPR) process is an interesting alternative to chemical phosphorus precipitation. Successful operation of EBPR depends, among other factors, on the presence of high content of readily biodegradable chemical oxygen demand (rbCOD), such as volatile fatty acids (VFA), glucose, etc, in the influent wastewater. In Norway biological removal of phosphorus from wastewaters can be challenging because the wastewaters can be very diluted, caused by infiltration and inflow of stormwater after periods of rain and snowmelt, and because it has a low readily biodegradable organic carbon content (such as volatile fatty acids, VFA).

Aim of the project

The aim of this project is related to the optimization of a lab scale biological phosphorus removal (Bio-P or EBPR) plant (Figure 1), which is a semi replicate of the SNJ WWTP at IVAR, simulating the wastewater characteristics and operational conditions at SNJ-IVAR wastewater treatment plant, Stavanger.

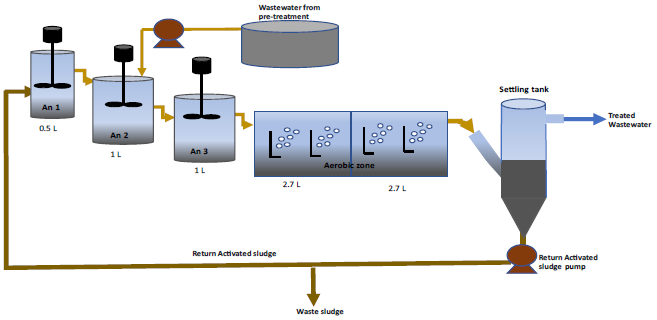


Figure 1. Lab scale Bio-P (EBPR) plant.

Specific work description

During the project work the student will get familiar with relevant literature and reports that describe the state of the art of activated sludge process for EBPR, and lab work activities will involve the following investigations:

- To investigate the potential of EBPR.
- Comparison of the sludge characteristics from Lab versus SNJ-IVAR WWTP.
- To investigate the potential of secondary P release.
- To investigate the quality of the sludge (mg P/mg TS ratio).

Final delivery:

Project report from the lab work activities, including theoretical background and methods.