BioCo master thesis topics 2024-2025

Research in the 'Biosystems Control (BioCo)' group aims at sustainable process design and control, applied to biological wastewater treatment and other bioconversion processes. 'Sustainability' is interpreted as meeting the required product or effluent quality while minimizing the use of energy and resources, aiming at reuse and recovery, through compact installations, in an economically viable and socially acceptable way. We do process engineering via physical-based models (mass balances) combined with measurement campaigns at full scale and lab-scale experiments.

For 2024-2025, we offer the following master thesis topics:

* Sustainable recirculating aquaculture systems integrating shrimp with seaweed : monitoring and mass balance analysis
  Eveline.Volcke@UGent.be
* CO2 to mitigate carbon impact in industrial wastewater treatment plants
  Eveline.Volcke@UGent.be
* Potential of pure oxygen supply for efficient industrial wastewater treatment
  Eveline.Volcke@UGent.be
* Aerobic granular sludge pilot/lab-scale modelling: simulation with both perspectives of process performance and biokinetics insights
  Eveline.Volcke@UGent.be
* Sustainable biomethane production from landfills through the injection of hydrogen from surplus electricity generation
  Eveline.Volcke@UGent.be, Jo.DeVrieze@UGent.be
* … (feel free to propose your own topic matching our research scope)

The following master thesis research topics will be carried out in **collaboration with Prof. Di WU (UGent Global Campus) and Prof. Eveline Volcke (Home campus)**. The master student is welcome to carry out a research stay at GUGC, the duration of which will be determined in mutual agreement. **Scholarships** are available for both the **travel costs and the accommodation** at GUGC.

This Joint Master thesis research in Global Campus Saline Environmental technoLogy InNovAtion (SELINA) research group and Home Campus Biological system Control (BioCo) research group aims at sustainable process design and control, applied to biological wastewater treatment and resource recovery technology. We do environmental life-science experimental research and process engineering via modeling and machine learning.

* Exploiting sulfur for innovative nitrogen removal from wastewater
  Bohan.Yu@UGent.be

More information on these topics is provided below. Do not hesitate to contact us if you are (potentially) interested

Sustainable recirculating aquaculture systems integrating shrimp with seaweed: monitoring and mass balance analysis

Summary

Recirculating aquaculture systems (RAS) are applied to grow commercially important aquatic organisms such as shrimp and fish in a controlled environment. The RAS reuses most of the water within the system and is considered a sustainable way of doing aquaculture. The advantages of using a RAS entail a low water use, efficient land and energy use, easy harvesting and disease control. To preserve the quality of the water which is reused within the system, RAS also requires a water treatment unit e.g. a trickling filter, moving bed bioreactor (MBBR) etc.

A RAS infrastructure consisting of integrated shrimp and seaweed culture within the R&D facility of ZILT will be utilized for this study.

This master thesis will focus on tackling some of the challenges regarding measurements within this full-scale RAS. More specifically, the high salinity of the water makes it difficult to use sensors to accurately measure e.g. the low ammonia concentration in the water. This ammonia can be toxic for the shrimp at low concentrations, thus tracking these concentrations is crucial for a successful culture. In this thesis, we will investigate whether mass balances and correlations between components in the water can provide accurate estimates of concentrations. The development and automation of alternative cheap sensors can be investigated as well. These challenges will be addressed through experimental work, modelling and simulation, and/or the analysis of data from lab/pilot/full-scale setups. Depending on the background and interest of the student, the focus can be put on one or another methodology.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be) (Home Campus)
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Key words: RAS, aquaculture, modelling, mass balances, sensors, wastewater treatment

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie

- Campus Kortrijk: industr. wetenschappen - Circulaire bioprocestechnologie
- Campus Coupure: Bio-ir - Milieutechnologie
- Campus Coupure: Bio-ir - Chemie en bioprocestechnologie
- Could also be taken by incoming exchange students.

CO_2 to mitigate carbon impact in industrial wastewater treatment plants

Summary

Industrial wastewater treatment plants need to spend large amounts of resources every day to adjust the wastewater characteristics and ensure a good performance of the biological systems. For instance, pH adjustment is usually done through the addition of chemicals such as sulfuric acid or sodium hydroxide to the wastewater. However, the use of chemicals for pH adjustment, and the associated large costs, could be reduced by increasing the buffering capacity or alkalinity from the wastewater. CO_2 has a natural capacity to retain alkalinity of the wastewater, and thus holds the potential to reduce chemicals use for pH control. In addition, it can be considered a nature-based solution, and thus more sustainable than adding strong acids.

In this thesis, you will study how CO_2 supply impacts the buffering capacity of the wastewater, and the associated savings in chemical dosage for pH adjustment. For this purpose, a model will be developed to represent an industrial case study. Scenario analysis will be performed to evaluate the impact of replacing the current solution by CO_2 supply for pH adjustment in a full-scale industrial wastewater treatment plant. Additionally, and depending on the interest of the student, there is also a possibility of performing pilot-scale experiments.

This master thesis research is conducted in close collaboration with Air Liquide as an industrial partner (https://be.airliquide.com/nl).

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Keywords: Industrial wastewater treatment, modelling, scenario analysis, CO_2, CAPTURE

Relevant for: Campus Coupure: Bio-ir - Chemie en bioprocestechnologie, Campus Coupure: Bio-ir – Milieutechnologie, Campus Coupure: Msc in Environmental Science and Technology – Resource Recovery

Potential of pure oxygen supply for efficient industrial wastewater treatment

Summary

Aeration is the most critical aspect in aerobic biological wastewater treatment. It is key to ensure a good reactor performance and it is one of the most energy-consuming processes. During aeration, air is supplied to the reactor to provide the purifying bacteria with enough oxygen to remove the pollutants present in the wastewater. However, the oxygen transfer efficiency is usually low, meaning that most of the oxygen in the supplied air leaves the reactor without being effectively used. This strategy is usually enough to treat municipal wastewater, but limits the treatment of industrial wastewaters, since they present higher pollutant concentrations. One option to improve the efficiency of aeration for the treatment of industrial wastewater is the use of pure oxygen. Potential benefits are a better buffering capacity of the wastewater due to the produced CO_2 in solution and a better pH control. In addition, the overall stripping potential of volatile compounds and dissolved gasses is also reduced to a great extent.

The aim of this master thesis is to investigate the potential of pure oxygen supply for the aerobic biological treatment of industrial wastewater, as well as to quantify its benefits on the overall plant performance and operational costs. The research will consist of modelling and simulation work applied to an industrial wastewater treatment plant in which the operators can choose between pure oxygen and air aeration depending on the requirements. The overall benefits throughout the water chain will be evaluated from water treatment to water reuse in the specific industrial case study.

This master thesis research is conducted in close collaboration with Air Liquide as an industrial partner (https://be.airliquide.com/nl).

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Keywords: industrial wastewater treatment, pure oxygen, modelling, CAPTURE

Relevant for: Campus Coupure: Bio-ir - Chemie en bioprocestechnologie, Campus Coupure: Bio-ir – Milieutechnologie, Campus Coupure: Msc in Environmental Science and Technology – Resource Recovery

Unravelling the anaerobic sulfate reduction ammonium oxidation (SRAO) phenomenon for nitrogen removal from wastewater

Summary

Biological nitrogen removal from wastewater is crucial for both human health and the environment. The conventional technology, i.e., nitrification/denitrification-based process, is facing challenges, such as high costs associated to energy consumption, chemicals addition, and excessive sludge production. To solve this problem, autotrophic anaerobic ammonium oxidation(anammox) has been found and proved to be a promising way in future wastewater treatment plants.

In the recent years, a new anammox-like phenomenon has been found, which is sulfate reduction ammonium oxidation (SRAO), also termed as sulfammox. It relies on the activity of microorganisms that are capable of oxidizing ammonium while reducing sulfate. This innovative and cost-effective process holds advantages when ammonium and sulfate co-exist in the wastewater. Also, it has potential of elemental sulfur recovery from wastewater.

However, the mechanisms behind SRAO are still not well-understood, including the reaction stoichiometry and the functional microorganisms responsible for it. This has brought a new challenge to the current biological nitrogen and sulfur cycles.

This master thesis will gain insights into the kinetics and influencing parameters of the SRAO process through mathematical modelling and simulation. Depending on the student's interest, experimental work and data analysis at GUGC-Korea could be performed as well.

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Key words: Biological wastewater treatment, sulfammox, SRAO, CAPTURE

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie

Could also be taken by incoming exchange students.

Aerobic granular sludge pilot/lab-scale modelling: simulation with both perspectives of process performance and biokinetics insights

Summary

Thanks to the recent sharp development of computer and data sciences, process modelling starts to step into the full-scale WWTP sites, rather than being limited in the academic world as in the past.

As an novel technology within the wastewater treatment field, Aerobic Granular Sludge (AGS) has caught great attention as the next generation of biological treatment. Yet, the bio-kinetic insight of the aerobic granules is unclear because of the complexity of the microbial-consortia, as well the operational knowledge is limited due to in-sufficient full-scale installation in the field.

The combination of AGS technology in a process modelling approach could provide insight of the links between the operational process performance and the microbial bio-kinetics:

- To investigate/evaluate a lab/pilot-scale AGS (Waterleau site) process performance;
- To build a process modelling based on the lab/pilot-scale AGS;
- To calibrate the AGS model according to the lab/pilot-scale performance data;
- To prospect the use of the AGS model for the future assist to the full-scale operation

This master thesis research is conducted in close collaboration with Waterleau as an industrial partner (https://www.waterleau.com/)

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Key words: Biological wastewater treatment, modelling, aerobic granular sludge, CAPTURE

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie

Could also be taken by incoming exchange students.

Sustainable biomethane production from landfills through the injection of hydrogen from surplus electricity generation

Summary

Landfills are, historically, still present around the globe. Although, in most cases, no more biodegradable waste streams are landfilled, older landfill sites still commonly contain such biodegradable organics, and by the activity of microorganisms, diffuse methane emissions are taking place at these sites. The prevent the release of this methane in the atmosphere, because it is a powerful greenhouse gas, these landfill sites are covered and methane is collected.

This opens the opportunity to use landfill sites as a bioreactor for the microbial production of renewable methane, by injecting hydrogen gas that can be generated during periods when there is a surplus in renewable electricity from wind and solar power. This biomethane, produced through microorganisms could serve as a renewable alternative to natural gas. In this thesis, we will investigate at which conditions the injection of hydrogen gas in such landfill sites would enable the production of renewable biomethane in landfill sites. A combination of lab-scale experiments and modelling will be applied to achieve an in-depth understanding of the (microbial) conversion and physical transport processes involved. Depending on the interest of the student, the focus can be put on experimental and/or mathematical modelling work.

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Key words:

Confidential: yes

Relevant for:

- Campus Kortrijk: industr. wetenschappen - Circulaire bioprocestechnologie
- Campus Coupure: Bio-ir - Chemie en bioprocestechnologie
- Campus Coupure: Msc in Environmental Science and Technology - Major 2.1 Environmental Assessment and Management of Chemicals
- Campus Coupure: Msc in Environmental Science and Technology - Major 2.2 Resource Recovery Technology
- Campus Coupure: Msc in Environmental Science and Technology - Major 2.3 Environmental Health and Technology for Developing Economies
- Campus Coupure: Msc in Environmental Science and Technology - Major 2.4 Urban Environmental Management
- Campus Coupure: Bio-ir - Milieutechnologie