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 2022-2023, we offer the following master thesis topics:

* A future of wastewater treatment in Flanders with aerobic granular sludge?
  Laurence.Strubbe@UGent.be & Paula.CarreraFernandez@UGent.be

* Efficient and sustainable wastewater treatment with aerobic granular sludge
  Laurence.Strubbe@UGent.be & Paula.CarreraFernandez@UGent.be

* Inschatten van gasvormige emissies uit mestverwerkingsinstallaties (Estimating gaseous emissions from manure treatment)
  David.Ysebaert@UGent.be

* Sustainable recirculating aquaculture systems: monitoring and mass balance analysis
  David.Ysebaert@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.

* Sulfate-reducing bacteria in anaerobic wastewater treatment: gift or threat?
  Eveline.Volcke@UGent.be (Home campus) & di.wu@ghent.ac.kr (GUGC)

* Exploiting sulfur for innovative nitrogen removal from wastewater
  Eveline.Volcke@UGent.be (Home campus) & di.wu@ghent.ac.kr (GUGC)

* Efficient and sustainable wastewater treatment with aerobic granular sludge
  Paula.CarreraFernandez@UGent.be (Home campus)

* Phosphorus (vivianite) recovery from wastewater
  Eveline.Volcke@UGent.be (Home campus) & di.wu@ghent.ac.kr (GUGC)

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

A future of wastewater treatment in Flanders with aerobic granular sludge?

Summary

The Flemish wastewater treatment sector faces a major challenge. In the near future, the capacity of the current wastewater treatment plants needs to be increased by 30%. This is due to population growth and stricter effluent quality targets. Aerobic granular sludge offers a promising solution. In this innovative process, bacteria grow in granules which settle faster than the flocs in conventional systems. This means that a larger amount of biologically active sludge is retained inside the reactor, which increases the capacity of existing installations. Thus, the aerobic granular sludge process can treat the same volume of wastewater with less space and less aeration costs compared to conventional processes.

The aerobic granular sludge process has been successfully implemented at full-scale. The specific design maximizes the growth of granules and the efficiency of the process. However, the implementation of the aerobic granular sludge technology in existing installations remains largely unexplored. Still, with this alternative, one could potentially profit from the compactness and energy savings of the aerobic granular sludge technology without the need to re-build existing wastewater treatment plants or to expropriate adjacent land area to extend their capacity. Implementing granular sludge into existing wastewater treatment plants would be particularly promising in regions such as Flanders, which have a relatively young wastewater treatment infrastructure.

In this thesis, you will study how aerobic granular sludge could best be integrated in existing wastewater treatment plants to extend their capacity and/or realize energy and cost savings. For the evaluation and optimization of the different alternatives, you will perform model simulations.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be)
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Tutors: ir. Laurence Strubbe (Laurence.Strubbe@UGent.be)

Keywords: Biological wastewater treatment, modelling, simulation, design, control, activated sludge, aerobic granular sludge, CAPTURE

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

Efficient and sustainable wastewater treatment with aerobic granular sludge

Summary

The aerobic granular sludge technology is a true revolution in the field of wastewater treatment and also offers great potential for resource recovery. It has been widely applied for municipal wastewater treatment, but not yet so much for industrial wastewater treatment). One major knowledge gap is the removal of particulate (not soluble) compounds, which can contribute up to 50% of the total organic content present in the wastewater. This process has a big impact on the overall reactor performance, but it is still not well-understood (e.g., involved mechanisms, effect of operational parameters such as oxygen, pH, temperature).

The aim of this master thesis is to investigate the removal mechanisms and develop smart control strategies for the efficient removal of particulate compounds from wastewater with aerobic granular sludge. This research will mainly consist of experimental work, complemented with mathematical modelling and simulation.

In this thesis, you will gain hands on experience on the operation of lab-scale aerobic granular sludge reactors. Besides, you will collect and analyse data, and evaluate several scenarios through batch tests to study the biological processes and find the best operational conditions for the removal of particulate compounds.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be)
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Tutors: ir. Laurence Strubbe (Laurence.Strubbe@UGent.be)

Keywords: biological wastewater treatment, lab-scale experiments, modelling, particulate compounds, aerobic granular sludge, CAPTURE

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

Inschatten van gasvormige emissies uit mestverwerkingsinstallaties
Estimating gaseous emissions from manure treatment

Summary

In opdracht van de Vlaamse Milieumaatschappij (VMM, MilieuEmissie Inventaris Lucht) dient het bestaande Emissie Model Ammoniak Vlaanderen (EMAV2.1) te worden uitgebreid met CH4, N2O en NO. Deze taak wordt opgenomen door het Vlaams Instituut voor Landbouw- en Visserijonderzoek (ILVO). Het bestaande EMAV2.1 incorporeert het emissiestadium 'mestverwerking' wat resulteert in een inschatting van de NH3-emissie. Het is echter geweten dat de met EMAV2.1 berekende NH3-emissie in vele gevallen niet strookt met de realiteit en heel wat ruimte laat voor verbetering. Daarnaast wenst men het EMAV2.1-model uit te breiden met de broeikasgassen methaan (CH4) en lachgas (N2O), en met NO.
In deze masterproef zal je op basis van beschikbare data en informatie de meest toegepaste mestverwerkingsconfiguraties in kaart brengen. Voor deze configuraties zal je massabalansen opstellen en een inschatting maken van de emissies van NH3, CH4, en N2O. Je kan hierbij rekenen op de ondersteuning van experts van ILVO, VCM (Vlaams Centrum voor mestverwerking), en van je promotor. Jouw taak bestaat erin de bestaande informatie en complementaire expertise samen te brengen. Deze resultaten van dit masterproefwerk zullen rechtstreeks gevoed worden aan de werkgroep rond mestverwerking voor de EMAV-uitbreidingsstudie.

Dit is jouw kans om mee input te geven aan het beleid rond stikstof- en broeikasgasemissies in Vlaanderen!

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be)
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Key words: gasvormige emissies, ammoniak (NH3), methaan (CH4), lachgas (N2O), mestverwerking, mestbewerking

Relevant for: Campus Coupure: Bio-ir – Milieutechnologie, Campus Coupure: Bio-ir – Landbouwkunde

Sustainable recirculating aquaculture systems: 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 pilot setup with shrimp is installed in blok F of FBW Campus Coupure. It is part of a collaboration between the start-up company ZILT, which is specialized in biotechnical developments for RAS, and the 'Lab for Aquaculture & Artemia Reference Center'. During 2022, a larger RAS infrastructure will be constructed at the 'Otterburcht' site near the Ghelamco Arena within the R&D facility of ZILT. Collaboration with the work field will also be an important part of this thesis.
This master thesis will focus on tackling some of the challenges regarding measurements within this 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. This thesis will investigate whether mass balances and correlations between components in the water can provide accurate estimates of concentrations. Both modelling and data from lab/pilot scale setups will be used to address these challenges. The potential for automation of certain measurements can also be investigated.

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Key words: RAS, aquaculture, modelling, mass balances, sensors, wastewater treatment

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie
Could also be taken by incoming exchange students.

Sulfate-reducing bacteria in anaerobic wastewater treatment: gift or threat?

Summary

The presence of sulfur compounds in wastewater is often overlooked, or only considered to mitigate associated adverse effects. Indeed, the formation of sulfide under (local) anaerobic conditions may give rise to odour nuisance, corrosion problems and health risks. Still, the presence of sulfur compounds during anaerobic wastewater treatment can also be an asset, offering the potential for resource recovery.

This master thesis project aims to optimize the potential benefits and to reduce the negative impacts of sulfur during anaerobic treatment. Sulfur-based recovery technologies will be evaluated in order to provide suitable guidelines for application to various waste(water) streams.

In this thesis, you will collect and analyse data, and investigate several scenarios through simulation with available models in Matlab-Simulink and/or Python. In case the master student opts for a research stay in Korea, lab-scale experimental work can be carried out as well.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be) (Home campus)
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Tutor: To be confirmed

Keywords: biological wastewater treatment, anaerobic, modelling, simulation, sulfate-reducing bacteria, innovative process schemes, CAPTURE

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie
Could also be taken by incoming exchange students.

Exploiting sulfur for innovative nitrogen removal from wastewater

Summary

Biological nitrogen removal during municipal wastewater treatment is crucial for both human health and the environment. Conventional technologies consist of nitrification followed by denitrification on organic carbon, additional amounts of which may need to be dosed. In the meantime, many wastewater treatment installations cope with problems related to sulfide (e.g. odour, corrosion, toxicity).

However, sulfide can be used beneficially via sulfur-based denitrification. It relies on the activity of autotrophic microorganisms that are capable of oxidizing sulfide or elemental sulfur while reducing nitrate and nitrite. This innovative and cost-effective process holds advantages over heterotrophic denitrification in terms of reduced sludge production and lower electron donor costs. A strategy that could even further optimize the process is shortcut nitrification to nitrite (25% lower aeration) coupled to shortcut denitrification of nitrite (40% less electron donor).

This master thesis will evaluate the performance of different sulfur-based denitrification process configurations, through mathematical modelling and simulation. Control strategies will be implemented for process optimization. Overall, this master thesis aims to provide a proof of concept for the proposed sulfur-based denitrification technology.

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Tutor: To be confirmed

Key words: biological wastewater treatment, modelling, simulation, sulfur cycle, CAPTURE

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

Could also be taken by incoming exchange students.

Efficient and sustainable wastewater treatment with aerobic granular sludge

Summary

The aerobic granular sludge technology is a true revolution in the field of wastewater treatment and also offers great potential for resource recovery. It has been widely applied for municipal wastewater treatment, but not yet so much for industrial wastewater treatment). One major knowledge gap is the removal of particulate (not soluble) compounds, which can contribute up to 50% of the total organic content present in the wastewater. This process has a big impact on the overall reactor performance, but it is still not well-understood (e.g., involved mechanisms, effect of operational parameters such as oxygen, pH, temperature).

The aim of this master thesis is to investigate the removal mechanisms and develop smart control strategies for the efficient removal of particulate compounds from wastewater with aerobic granular sludge. This research will mainly consist of experimental work, that can be complemented with mathematical modelling and simulation.

In this thesis, you will gain hands on experience on the operation of lab-scale aerobic granular sludge reactors. Besides, you will collect and analyze data, and evaluate several scenarios through batch tests to study the biological processes and find the best operational conditions for the removal of particulate compounds.

This Master thesis research will be carried out **in collaboration between Prof. Eveline Volcke (UGent home campus, BioCo research group) and Prof. Di WU (UGent Global Campus Korea – GUGC**; SELINA research on Saline Environmental technoLogy InNovAtion). We aim 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.

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**.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be) (Home campus)
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Tutor: dr. ir. Paula Carrera (Paula.CarreraFernandez@UGent.be)

Keywords: biological wastewater treatment, lab-scale experiments, modelling, particulate compounds, aerobic granular sludge, CAPTURE

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie
Could also be taken by incoming exchange students.

Phosphorus (vivianite) recovery from wastewater

Summary

Phosphorus (P) is a vital but scarce resource, which may be depleted in 50~100 years. Phosphorus recovery from wastewater could meet around 15-20% total world demand of P resource. In the past, the focus of P recovery from wastewater was on struvite (magnesium ammonium phosphate) precipitation, which could be applied as a fertilizer. However, the dependency of struvite precipitation on many process parameters along with the formation of impurities and low removal efficiency led the researchers to look for other alternative methods of recovering P. A recent, promising option in this respect is the precipitation of phosphorus as vivianite (Fe3(P04)2(8H20), which poses advantages in terms of cost effectiveness, operational flexibility, P removal efficiency of P and a wide spectrum of utilization, for example – a good alternative to commonly used chemical fertilizers, or raw material for fabricating Li-ion batteries.

The aim of this master thesis is to investigate the mechanisms of recovering vivianite from the wastewater treatment unites (activated sludge process and anaerobic digestion), and to develop new strategy to enhance vivianite formation and crystallization. This research will combine experimental work and data analysis (at GUGC-Korea), with mathematical modelling and simulation (in UGent home campus).

This Master thesis research will be carried out in **collaboration between Prof. Eveline Volcke (UGent home campus, BioCo research group) and Prof. Di WU (UGent Global Campus Korea – GUGC**; SELINA research on Saline Environmental technoLogy InNovAtion). We aim 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.

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**.

Promotors: prof. dr. ir. Eveline Volcke (Eveline.Volcke@UGent.be) (Home campus)
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Tutor: To be confirmed

Keywords: resource recovery, lab-scale experiments, modelling, anaerobic digestion, vivianite, CAPTURE

Relevant for: Bio-ir - Chemie en bioprocestechnologie, Bio-ir - Milieutechnologie
Could also be taken by incoming exchange students.