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 2019-2020, we offer the following master thesis topics:

* The future of wastewater treatment - novel technologies in smart schemes
  Kimberly.Solon@ugent.be
* What bubbles can tell about water – control of wastewater treatment basins using off-gas analyses
  Janis.Baeten@UGent.be
* Optimal design and control of aerobic granular sludge reactors for sustainable wastewater treatment
  Laurence.Strubbe@UGent.be
* Reduction of greenhouse gas emissions from innovative wastewater treatment processes
  Xinyu.Wan@UGent.be
* Nitrogen removal from sewage: a challenge for developing countries?
  Thiago.BressaniRibeiro@UGent.be
* Sulfate-reducing bacteria in anaerobic wastewater treatment: gift or threat?
  Annelies.VandenHove@UGent.be
* Energy from manure as a climate measure on pig farms?
  Tine.Vergote@UGent.be

(feel free to propose your own topic matching our research scope)

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

The future of wastewater treatment – novel technologies in smart schemes

Summary

The increasing interest on resource recovery coincides with the development of new technologies for wastewater treatment. Conventional wastewater treatment plant configurations are being revisited in order to come up with innovative process schemes which incorporates these new technologies. The design of innovative wastewater treatment process schemes is a hot topic and a promising research area which helps to achieve compact installations with significant reduction of operational costs, more efficient pollutants removal, and increase in energy and nutrient recovery. Through mathematical modelling and simulation, this thesis aims to perform a plant-wide evaluation of innovative wastewater treatment process schemes and objectively compare them with that of a conventional wastewater treatment plant configuration.

This master thesis topic is part of a EU-funded project based on research excellence, in close collaboration with industry.

Relevant to: Bio-engineer Environmental Technology, Bio-engineer Chemistry and Bioprocess Technology

Tutor: dr. Kimberly Solon (kimberly.solon@ugent.be)

Promotor: prof. dr. ir. Eveline Volcke

Keywords: wastewater treatment, modelling, plant-wide simulation, innovative process schemes, CAPTURE

No obligatory initial competences.
Subject assigned to 1 or 2 students.

What bubbles can tell about water control of wastewater treatment basins using off-gas analyses

Summary

An active biological wastewater treatment basin consists of wastewater, purifying bacteria and air bubbles. The bubbles are pumped into the basin to provide the purifying bacteria with enough oxygen to eat the wastes out of the water. At the top of the basin, the bubbles pop, releasing a gas that contains less oxygen and more carbon dioxide than the air that was originally pumped into the system, since the purifying bacteria have consumed oxygen and produced carbon dioxide while eating the waste. In this way the composition of the gas coming out of the bubbles at the surface tells something about what is happening inside the water.
Would it be possible to know when the waste water is clean enough for discharge if only the oxygen and/or carbon dioxide concentration are measured in the off-gas? Could a wastewater treatment plant be operated automatically (without human intervention) despite of a changing influent composition and flow rate based on solely the off-gas composition? How would this compare to existing control loops based on liquid-phase measurements? Would off-gas hold more potential for batch-fed reactors compared to continuously fed ones? These are questions that will be answered in this thesis using a mathematical model of a biological wastewater treatment reactor.

By choosing this thesis, you will learn to combine existing process insight (in the form of models) to design operational strategies for environmental constructions that do not yet exist.

Relevant for: Bio-engineer Environmental Technology, Bio-engineer Agriculture, Bio-engineer Chemistry and Bioprocess Technology, Bio-engineer Land and Water Management

Tutor: ir. Janis Baeten & ir. Laurence Strubbe

Promotor: prof. dr. ir. Eveline Volcke

Keywords: biological wastewater treatment, off-gas, batch reactor, modelling, simulation, control, CAPTURE

Innovative wastewater treatment with granular sludge reactors

Summary

The Flemish wastewater treatment sector faces a major challenge. In the near future, the capacity of the current wastewater treatment plants will increase by 30%. This is due to population growth and stricter effluent quality targets. Aerobic granular sludge offers a possible solution. In this innovative process, bacteria grow in granules which settle better than the flocs in conventional systems. This means that settling tanks can handle a larger quantity of sludge, which increases the capacity of the existing installation. If the aerobic granular sludge can be implemented in the existing installations, large investment costs can be avoided and energy consumption can be saved. In addition, the expropriation of adjacent areas is prevented.

In this thesis, you will learn to gain insight into the advantages and disadvantages of the current and new process with the help of a mathematical model. With this mathematical model new operational strategies can be devised to optimize the aerobic granular sludge process.

Research in the BioCo (prof. E. Volcke) group aims at sustainable process design and control, applied to biological wastewater treatment and other bioconversion processes. 'Sustainability' is interpreted as achieving the desired product or effluent quality while minimizing the use of energy and resources, aiming at reuse and recovery, in 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.

Relevant for: Bio-engineer Environmental Technology, Bio-engineer Chemistry and Bioprocess Technology

Tutor: ir. Laurence Strubbe (laurence.strubbe@ugent.be)

Promotors: prof. dr. ir. Eveline Volcke & ir. Janis Baeten

Keywords: biological wastewater treatment, modelling, simulation, control, CAPTURE

Reduction of greenhouse gas emissions from innovative wastewater treatment processes

Summary

Partial nitritation-anammox is an innovative nitrogen removal process for wastewater treatment. This technology comprises the partial oxidation of ammonia to nitrite and subsequent conversion of ammonium and nitrite to nitrogen gas (anammox reaction). Compared to conventional nitrogen removal systems, it consumes up to 63% less aeration energy, does not require an external carbon source for denitrification, produces less waste sludge and emits less CO_2. More than 100 full-scale partial nitritation-anammox installations are currently in operation worldwide to treat various types of wastewaters. However, the potential emissions of N_2O, a greenhouse gas which is 300 times stronger than CO_2, need to be minimized.
This master thesis project will study the effect of the operation conditions (DO, influent organics etc.) on the N_2O emissions in the one-stage partial nitritation-anammox reactor, combining experimental work with modelling and simulation. A lab-scale partial nitritation-anammox reactor with granular sludge will be operated at different conditions and monitored in terms of effluent quality and N_2O off-gas concentrations. The measured data will be applied to verify previously obtained simulation results, in particular concerning potential operation conditions resulting in both a high nitrogen removal efficiency and low N_2O emissions. Through this study, the master student will gain insight in the mechanisms of nitrogen removal and N_2O formation during biological wastewater treatment. He or she will gain experience in operating an automated lab-scale granular sludge reactor and conduct simulation studies with dedicated software.

Relevant to: Bio-engineer Environmental Technology, Bio-engineer Chemistry and Bioprocess Technology

Tutor: MSc. Xinyu Wan (Xinyu.Wan@UGent.be)

Promotor: prof. dr. ir. Eveline Volcke

Key words: biological wastewater treatment, N removal, greenhouse gas emissions, modelling, simulation, wastewater treatment, aerobic granular sludge, process optimization, CAPTURE

Nitrogen removal from sewage: a challenge for developing countries?

Summary

Anaerobic-based sewage treatment plants are widely implemented in developing countries. As such, Brazil has the largest number of Upflow Anaerobic Sludge Blanket (UASB) reactors worldwide for sewage treatment. Nevertheless, as UASB reactors only removes part of the influent organic carbon, a post-treatment step is required to remove the residual carbon and nitrogen. Given financial constraints in developing countries, simple operating and maintaining post-treatment systems should be adopted. Sponge-bed trickling filters are an effective option, however the operational strategies for simultaneous removal of carbon and nitrogen remains unclear.

In this thesis, you will investigate a set of operating conditions through modelling and simulation studies. The goal is to elucidate which is the most suitable operating condition for carbon and nitrogen removal in sponge-bed trickling filters post-UASB reactors, taking into account the treatment of real sewage in Brazil. Part of this master thesis could be conducted at the Federal University of Minas Gerais (UFMG) in Brazil, including the operation of experimental pilot-scale reactors. We are open to discuss this possibility with motivated students.

Relevant for: Bio-engineer Environmental Technology, Bio-engineer Chemistry and Bioprocess Technology

Tutor: ir. Thiago Bressani Ribeiro (Thiago.BressaniRibeiro@UGent.be)

Promotors: prof. dr. ir. Eveline Volcke & prof. dr. Carlos Chernicharo (UFMG, Brazil)

Keywords: wastewater treatment, biological nitrogen removal, biofilm reactors, modelling, simulation

The UFMG research group (prof. Chernicharo) is part of the highest scored post-graduation programs in Brazil.
See: http://www.smarh.eng.ufmg.br/historicoi.php

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

Summary

Upflow Anaerobic Sludge Blanket (UASB) reactors are widely applied for anaerobic wastewater treatment. In this technology, organic matter is converted into biogas under anaerobic conditions. For this conversion of organic matter, different groups of microorganisms are active, including methanogens. Under anaerobic conditions however, sulfate-reducing bacteria (SRB) can also utilize the organic carbon, while reducing sulfate into sulfide. While sulfide production is mostly undesired because it is odorous, toxic and corrosive, this thesis investigates if there can also be beneficial applications of SRB.

In this thesis, you will investigate a set of operating conditions through simulation studies. The goal is to elucidate at which operating conditions sulfate reduction or methane production prevails during treatment of municipal wastewater containing sulfate.

Relevant to: Bio-engineer Environmental Technology, Bio-engineer Chemistry and Bioprocess Technology

Tutor: ir. Annelies Van den Hove (annelies.vandenhove@ugent.be)

Promotors: prof. dr. ir. Eveline Volcke & dr. Kimberly Solon

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

Energy from manure as a climate measure on pig farms?

Summary

Currently, Flanders counts more cattle and pigs than inhabitants. Most of the manure produced by this livestock can be used as a fertilizer for crop production. However, fertilizers can and will in general only be applied on the field from mid-February until the end of August, like stated in the Flemish Manure Decree. Long-term manure storage will thus be common in Flanders. Anaerobic conditions during long-term manure storage result in unwanted methane formation and emissions to the atmosphere. Appropriate manure management systems will have to be found to avoid a future emission increase related to the growing global population and their increasing demand for livestock. By developing **a fit-for-purpose model**, we have been investigating the methane emission reduction and renewable energy production potential through **farm-scale anaerobic digestion of dairy manure**. Results illustrated that controlled anaerobic digestion in a reactor seems a promising climate protection measure on dairy farms.

But what does this entail for pig farms? Can they also profit from this technology although the feedstock contains more nitrogen, which will probably increase the risk for ammonia inhibition during digestion? This master thesis project aims to **investigate the emission reduction and renewable energy production potential of pig manure digestion through modelling and simulation**. The fit-for-purpose model for dairy manure or the well-known Anaerobic Digestion Model No. 1 will be adapted/extended for that purpose. Input data will be gathered from literature and practice. Based on the obtained results, suggestions may be formulated to constructors and policy makers regarding optimization and acknowledgement of this technology as a climate protection measure, respectively. The acquired insights will be used as input for the Vlaio-LA project Pocket Power, which aims to increase the potential of farm-scale anaerobic digestion in Flanders.

Relevant to: Bio-engineer Environmental Technology, Bio-engineer Agriculture, Bio-engineer Chemistry and Bioprocess Technology, Industrial engineer Biochemistry

Tutor: ir. Tine Vergote (tine.vergote@ugent.be)

Promotors: prof. dr. ir. Eveline Volcke & dr. Kimberly Solon

Keywords: Farm-scale anaerobic digestion, Pig manure, Modelling and simulation, Emission reduction potential, Process optimization

No obligatory initial competences – subject assigned to 1 or 2 student