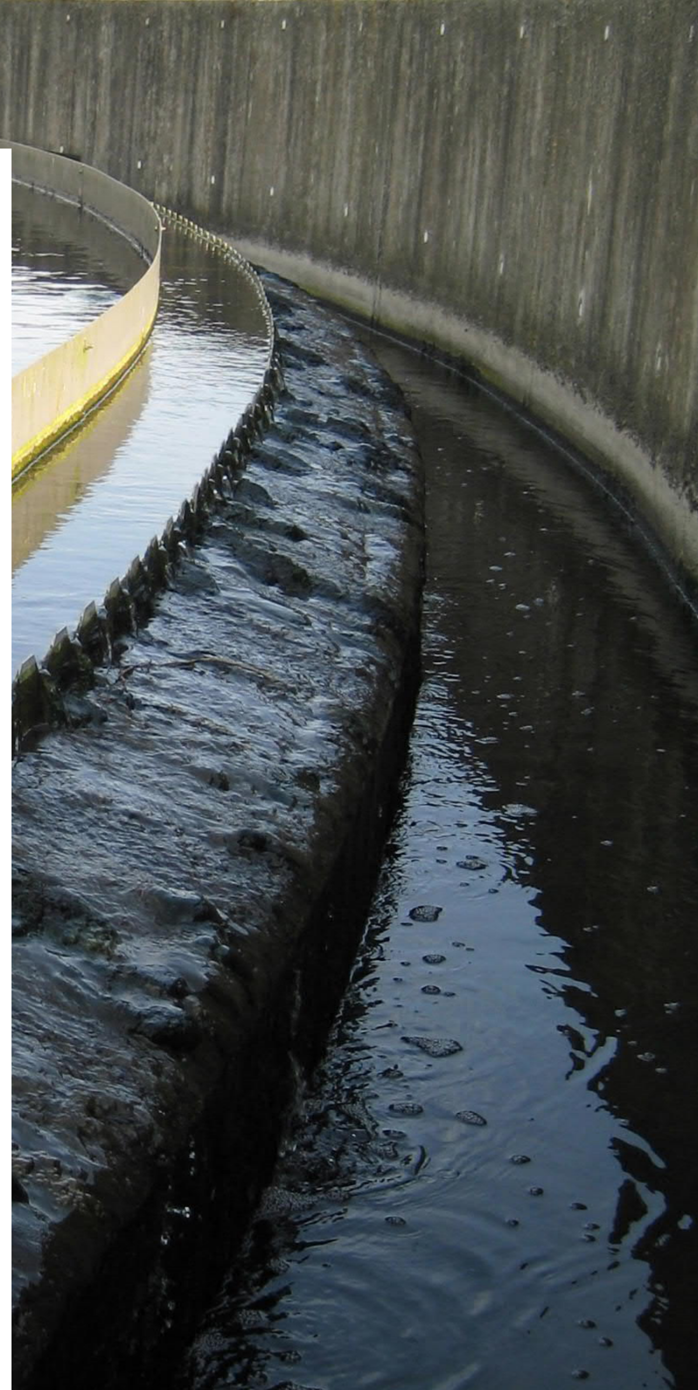
Modelling/Control Project Work Descriptions



Submit to MyCourses one report file of the project work in pdf-format. Also attach corresponding Sumo files for the project work. Name your files:

PDF-file “Project topic_*Name_Surname”*
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General information and background on the project theme.

21.4.2021

WAT-E2130
Modelling and Control of Water and wastewater treatment processes

Aalto University
School of Engineering

Theme 1: Oxygen concentration

	Providing oxygen to the wastewater treatment process consumes 50 – 80 % of the energy required for the treatment. Having the optimal concentration of oxygen in the process is crucial for the biological process and for minimizing costs.
Modelling	Oxygen is vital for certain microbes to break down pollutants in the wastewater. The aim of this task is to create a model which will analyze the effects on removal performance and on energy demand when the oxygen concentration in the bioreactor is varied.
Control	The aim of the controller task is to implement a controller that will automatically adjust the oxygen concentration in the system to meet the desired oxygen set point. For this task, the controller to be implemented will be based on the ammonium concentration.

Theme 2: Primary clarifier by-pass

	Primary clarifiers remove organic matter to lower the load to the biological step. Some of this organic matter might be useful for the denitrification step in the biological process, at least sometimes. This is why sometimes primary clarifiers are by-passed.
Modelling	Primary clarifiers are sometimes by-passed during treatment processes in order to provide more carbon source for denitrification. The aim of this task is to create a model which will analyze the effects on removal performance and on energy demand when the primary clarifier is by-passed with varying percentages.
Control	A controller should be implemented in the model which will adjust the primary by-pass flow in the system based on the nitrate concentrations in order to maintain a desired set-point.

Theme 3: Storm flow by-pass

	During storm events, there is a higher flow rate of influent to the activated sludge process which causes the overflow rate in the secondary clarifiers to increase. When the overflow rate is higher than the settling velocity rate, this results in more solids flowing over the weir. This causes solid washout from the bioreactors and decreases the treatment performance. To prevent this activated sludge process can be by-passed.
Modelling	The purpose of this task is to model a system which represents the plant during storm periods with and without a by-pass. Long and short-term effects of the storm event on the effluent quality should be analyzed.
Control	Once the model has been created, the next task is to set a controller for the by-pass or another manipulated variable based on the effluent quality results.

Theme 4: Intermittent nutrient rich influent

	Reject water from digested activated sludge or industrial wastewater can contain high level of nutrients which cause the concentration of influent water in the plant to increase when introduced into the system. This could affect the effluent quality after treatment.
Modelling	The purpose of this task is to create a model of the plant which includes a separate influent flow with concentrated wastewater. The goal is to analyze the effects of intermittent nutrient load on the effluent quality.
Control	After the model is created, the next step is to implement a controller which modifies the process based on the influent or effluent quality measurement.

Theme 5: Internal nitrate recycle

	Nitrogen removal in treatment plants can be difficult for plants with high nutrient loads. Some/most plants implement an internal recycle of nitrates after the nitrification step to further enhance the denitrification process. This however results in an increase in operational costs as well.
Modelling	In this task, a realistic model of the plant with an internal nitrate recycle rate should be created and the effects of the nitrate recycle on the effluent quality and the operational costs should be analyzed.
Control	For this task, a controller should be implemented which controls the effluent quality at an optimal level while simultaneously minimizing the operational costs.

Theme 6: Effect of pre-precipitation

	Some plants implement chemical dosing (instead of biological removal) to precipitate phosphorous which is subsequently removed. Plants usually try to use these coagulants in a cost-effective manner.
Modelling	The purpose of this task is to model the system of the wastewater treatment plant including the chemical dosing component and analyze the effects of pre-precipitation on the system's performance (phosphorous removal and cost).
Control	The purpose of the control task is to control the dosing of the coagulant based on the influent flow rate and to maximize resource efficiency.

Theme 7: Separate pretreatment for nitrogen-rich influent stream

	Reject waters or industrial wastewaters can cause disturbance for the nitrogen removal process. Sometimes it is beneficial to implement a separate pre-treatment unit. In this case reject water/industrial water is warm and has high ammonium content.
Modelling	The aim of this modelling work is to implement a pretreatment using alternatively nitrification reactor, nitritation reactor or deammonification reactor. The performance of the plant is evaluated using the model.
Control	In this task a controller is implemented for the dissolved oxygen concentration in the pretreatment based on the pretreatment effluent ammonium concentration.

Theme 8: By-pass flow treatment in Disc filters

	Within the capacity of the plant, a by-pass is not needed. However, when the influent load exceeds the capacity of the plant's treatment system, changes in the quality parameters can be seen (e.g. increase of TSS, phosphates) This theme involves setting up a by-pass for the biological process with a disc filter system right after the primary clarifier with the outlet going directly to the effluent.
Modelling	The aim of the modelling task is to analyze the removal performance of the system when the by-pass disc filter system is introduced.
Control	The aim of this task is to set up a controller which manipulates the dosage of the metal coagulant based on the phosphate concentration of the effluent.

Theme 9: Post-denitrification treatment

…	With denitrification, plants usually implement pre-denitrification with internal nitrate recycling, but depending on the COD fractions in the influent, this might allow only up to 60% of nitrogen removal. Post-denitrification with an addition carbon source is one possibility to increase the nitrogen removal. This theme deals with the post-denitrification method.
Modelling	The aim of the modelling task is to set up the model of the treatment plant which includes the post-denitrification components and analyze the system's performance.
Control	The aim of the control task is to set up a controller which manipulates the dosage of the carbon source (methanol) based on the chosen control variable of the project.

Theme 10: Biological phosphorous removal

…	Biological phosphorus removal is an alternative to removal using chemical precipitation. This biological process is based on microbe's ability to store phosphorus inside their cells and it requires alternating anaerobic and aerobic conditions.
Modelling	The aim of the task is to set up the model of the plant including the bioreactors needed for the removal of phosphorous without compromising the nitrogen removal. The system performance should then be analyzed.
Control	A controller should then be implemented which manipulates the sludge flow from the secondary clarifier based on the phosphate concentration in the system.

Theme 11: Effect of pH on nitrification with and without a primary clarifier

	Nitrification is sensitive to pH. Sometimes influent wastewater has a pH that causes inhibition of nitrification. It has been argued that primary clarification offers good protection against this kind of risks. In this theme the effect of pH will be studied and also the influence of partly by-passed primary treatment.
Modelling	In this task pH of the influent will be changed and a nitrification inhibition will be demonstrated. Different by-pass percentages will be tested for the primary clarification.
Control	A controller will be implemented for the by-pass flow based on the pH measurement in the aeration tank.

Theme 12: Tertiary sand filter for P polishing

	In some cases very strict requirements for phosphorus removal (<0,1 mgP/l) are given to the wastewater treatment plants. In an existing plant a common solution is to implement a tertiary sand filter with chemical dosing.
Modelling	The aim of the modelling task is to analyze the removal performance of the system when the sand filter system is introduced. The performance of the plant during snow melt conditions could be modeled.
Control	The aim of this task is to set up a controller which manipulates the dosage of the metal coagulant based on the phosphate concentration of the effluent.

Theme 13: Effect of aerated volume on nitrogen removal

	Quite often so called swing zones are used in aeration basins. They are zones that have both aerators and mixers and they can be operated with and without aeration. These zones allow to increase the nitrifying volume, but when this is done the volume for denitrification will decrease accordingly.
Modelling	The aim of the modelling task is to analyze the effect of the use of swing zones. In Klaukkala zones 1 and 2 have mixers whereas 3, 4 and 5 are aerated. In the modelling task the purpose is to study a situation where zones 3 and 4 could be mixed or aerated.
Control	The aim of this task is to set up a controller which manipulates the aerated volume based on the ammonium concentration of the effluent.

Theme 14: Effect of sludge age

	Sludge age has a large impact on the process performance. Nitrification is the limiting reaction in the nutrient removal process and it is highly dependent on process temperature. In order to achieve efficient nitrogen removal all year around sludge age should be modified according to the temperature.
Modelling	The aim of the modelling task is to analyze the effect of sludge age in nitrogen removal. Short-term and long-term changes can be studied.
Control	The aim of this task is to set up a controller which manipulates the sludge age based on the temperature.

Theme 15: Modelling the sludge digestion

	In Klaukkala WWTP sludge is digested in order to produce biogas. This allows to recover a part of the energy content of the wastewater. Biogas is used to produce electricity and heat.
Modelling	The aim of the modelling task is to implement a digester model to the existing water process model. The dimensioning and the performance of the digester is studied.
Control	The aim of this task consists in the optimization of biogas production while keeping the process stable by manipulating the flow rate of the incoming sludge flow rate.

Theme 16: Effect of nitrifying bacteria seed on nitrification

	Nitrification is the limiting reaction in the nutrient removal process. Nitrification is highly dependent on the temperature and it suffers easily when the process temperature drops. Sometimes additional bacteria seed is proposed as a solution to help keep up nitrification. In practice this bacteria seed is dried nitrifying biomass that will become active when added to the process.
Modelling	The aim of the modelling task is to study the effect of a bacteria seed. An additional influent containing nitrifiers is added to the process.
Control	The aim of this task is to set up a controller which manipulates the bacteria seed based on the ammonium concentration of the effluent.

Theme 17: Effect of flow equalization

	Hourly and daily fluctuations in the influent flow rate are causing variations in the process and in the effluent quality. Some process improvements could be achieved by levelling out these flow fluctuations, but this would require more pumping and an investment to an equalization basin.
Modelling	The aim of the modelling task is to analyze the effect of the addition of flow equalization prior to the activated sludge process.
Control	The aim of the controller task is evaluate the benefit of control with and without flow equalization. For this task, the controller to be implemented will be dissolved oxygen control in aeration based on the ammonium concentration.

Theme 18: Effect of closing Kirkonkylä WWTP

	Our project work WWTP Klaukkala will soon go through major changes. The other WWTP in Nurmijärvi municipality, Kirkonkylä WWTP, will be closed and the wastewaters will be directed to Klaukkala WWTP. The treatment capacity in Klaukkala needs to be increased. Kirkonkylä WWTP treats wastewaters of about 7000 inhabitants. The daily average wastewater flow is 2100 m^3/d and the quality is typical for municipal wastewater from the households.
Modelling	The aim of the modelling task is to study the impact of this additional load on the process and evaluate alternatives to increase the treatment capacity. Different biological processes (e.g. MBR or MBBR) can be studied.
Control	The aim of this task is to set up a controller. In this theme the choice of controller is free.