Aalto University
School of Engineering

Physical & chemical treatment processes of water and waste

WAT - E2120

Anna Mikola TkT D Sc (Tech)

Lecture outline

Course team introduction

Participants' introduction

Course's learning outcomes

Content and assessment of the course

- Lectures & exercises
- Laboratory work
- Excursion

! 2 groups for the lab intro and 4 groups for the group work + group work lab day ! → In MyCourses

Introduction discussion: What kind of compounds do we need to remove and why?

Lecturer
Anna Mikola

- **M.Sc. From HUT Water lab 1999**
- **Exchange year in France at ENCR 1994-1995**
- **D. Sc. (Tech.) Spring 2013 Dissertation: The effect of flow equalizationa and prefermentation on BNR**

- **Working experience:**
  - 3 years at Nopon Oy
  - Researcher at HUT/Aalto
  - 18 years with a consultant (Kiuru&Rautiainen Oy, Ramboll Finland)
  - Post-doctoral researcher at Aalto 2013-2018
  - Lived 5 years in Berlin, 4 children
  - Visiting researcher in INSA Toulouse in 2017

The course team

Course assistant: Shanna Myers

Lab project responsible: Juho Kaljunen

Lab staff: Aino Peltola, Heikki Särkkä and Marina Sushko

Lecturers from the lab:

Irina Levchuk

Riku Vahala

Riina Liikanen

Roza Yazdani

Guest lecturers from Kemira, LUT and VTT

Participants' introduction

1 minute each containing e.g.

- **Background?**
- **Experience with water and wastewater treatment**
- **Expectations for this course?**

Learning outcomes

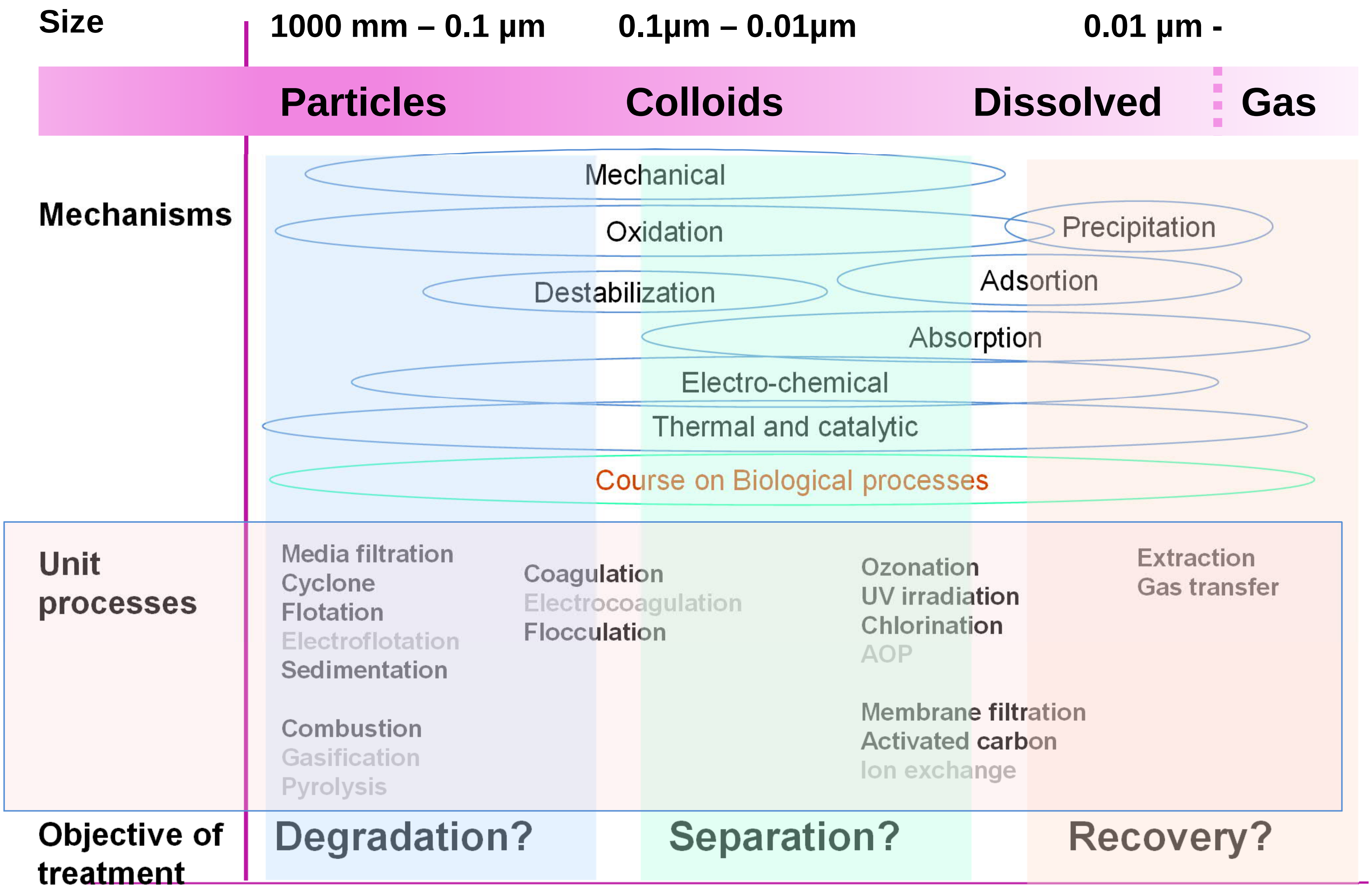
Knowledge Skill Identity

Upon completion, the student should be able to:

1) **Describe the most important physical and chemical water, wastewater, sludge, solid waste and waste gas treatment processes**
2) **Explain the theoretical background of relevant physical and chemical treatment units**
3) **Choose favorable treatment methods for specific water, waste and gases**
4) **Design and dimension the most common physical and chemical unit processes**
5) **Do simple chemical analyses in the analytical water laboratory and write a report**
6) **Have a mind-set for understanding the inter-linkages between water, energy and other resources [identity]**

Different media to be treated

Environmental challenges to be solved


Size
1000 mm – 0.1 µm
0.1µm – 0.01µm
0.01 µm -
Particles
Colloids
Dissolved
Gas
Mechanisms
Mechanical
Oxidation
Precipitation
Destabilization
Adsortion
Absorption
Electro-chemical
Thermal and catalytic
Course on Biological processes
Unit processes
Media filtration
Cyclone
Flotation
Electroflotation
Sedimentation
Combustion
Gasification
Pyrolysis
Coagulation
Electrocoagulation
Flocculation
Ozonation
UV irradiation
Chlorination
AOP
Membrane filtration
Activated carbon
Ion exchange
Extraction
Gas transfer
Objective of treatment
Degradation?
Separation?
Recovery?

Course content

- Lectures
- "Einstein" exercises

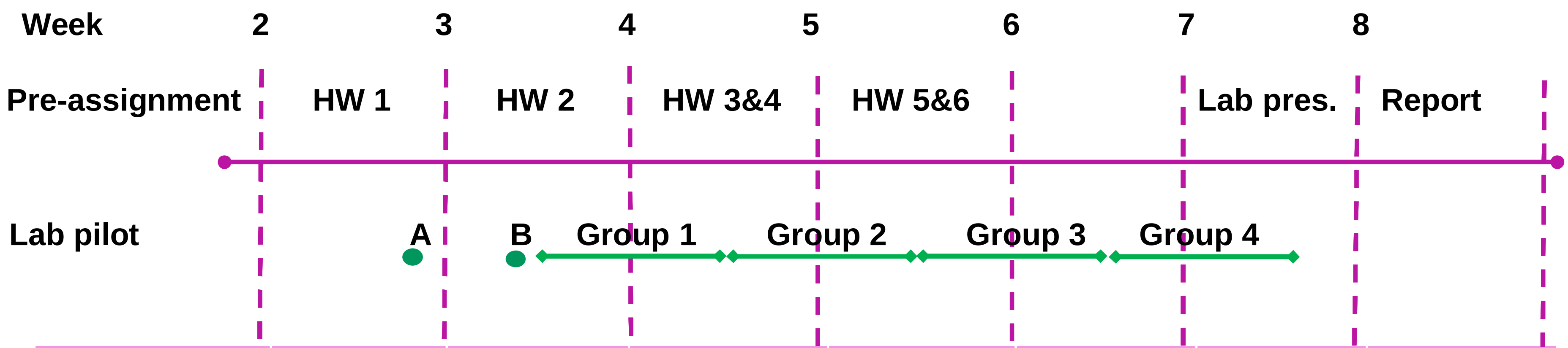
Practical knowledge

- Lectures
- "Worker" exercises
- Excursion

Hands-on knowledge

- Laboratory pilot operation
- Lab project work

Timeline for the course



Lectures	**Intro *(1)**	***(2) ***	*** ***	*** ***	*** ***	**Excu ***	
Exercise DLs			HW 1	HW 2&3	HW 4	HW 5&6	
Exams			Exam 1			Exam 2&3	Extra 1,2,3
Lab project	Lab intro group A	Lab intro group B Group 1	Group 2	Group 3	Group 4		
Presentation				Support session		All groups	
Written report		Lab intro report		Support session		1st draft + feedback	Final report

Course content – lectures, exercises and exams

- **Lectures and exercises**
  - Lecture sessions: 3.5 hours Wednesday afternoon at 13:00 and Friday morning at 8:30
  - Each session will be divided into several interactive lectures, demo exercises and group discussions
  - For many sessions some reading material will be given before
  - Lecture 2: basic theories
  - Lectures 3 – 6 & 9: most relevant processes
  - Lectures 7 - 8: emerging processes
  - Homework exercises from most of the sessions (6 sessions, totally 21 exercises)
  - The content will be divided into theoretical and practical parts  &  symbols
- **Three mid-term exams**
  - 40 – 50 min on two Mondays (at 16:30) and the last one in the beginning of the last lecture
  - One extra during the last week

→ objective to learn the theory and design principles of the processes

Support sessions for homework exercises

With Shanna in the Water lab computer room

- **Tuesday afternoon between 13:00 and 15:00?**
- **Other suitable slots?**

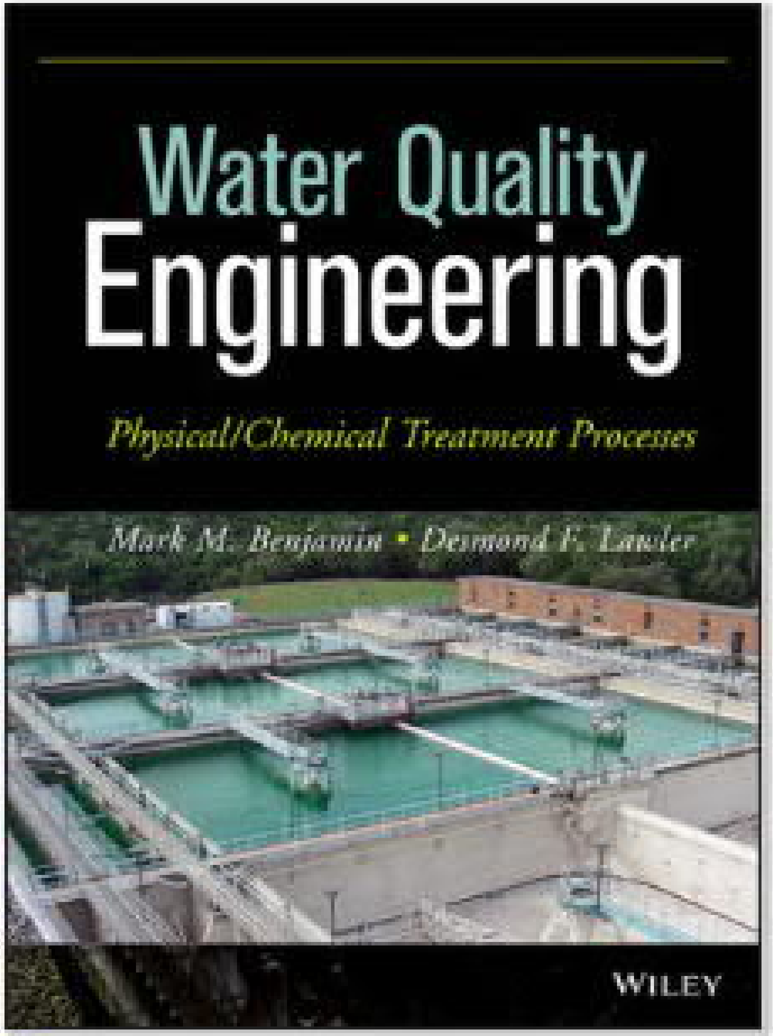
Course book

Water Quality Engineering: Physical / Chemical Treatment Processes

Mark M. Benjamin, Desmond F. Lawler

ISBN: 978-1-118-16965-0

Available as eBook



Read an Excerpt

Course content – lab project

- **Laboratory work**
  - Produce drinking water during 4 weeks in the lab reactor
  - Weeks 1-2: Introduction to basic process and analyses (Groups A&B) → short report
  - Weeks 2-5: Four groups of students (1,2,3 and 4) will operate the reactor and study different alternative treatments
  - Week 6: Presentations
  - Week 7: Written report

- **Laboratory work**
  - Excursion to Vanhakaupunki water purification plant on Wednesday 13.2.
  - Same process steps as in the small lab reactor
  - → Objective to understand the theories and design principles in practice, to learn about the process monitoring and to explain, present and report practical laboratory work.

EXCURSION

To Vanhakaupunki water purification plant

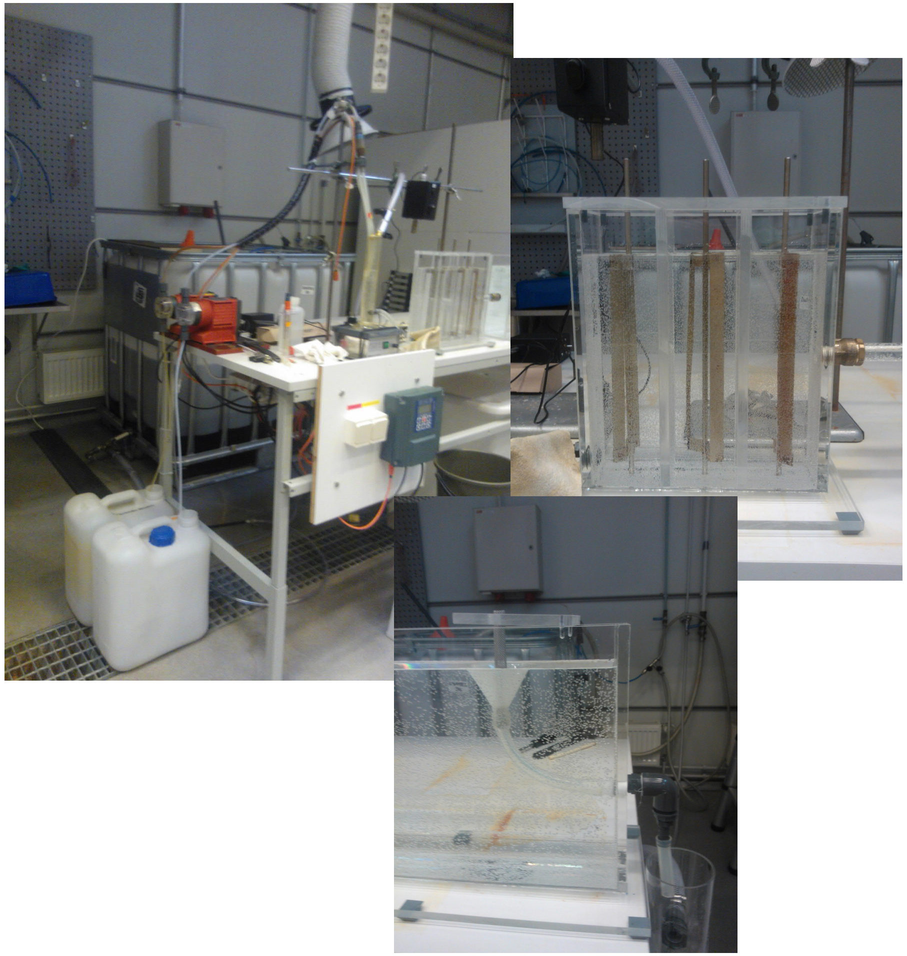
WEDNESDAY 13.2. during the course teaching session

Some assignments during the visit

Using public transportation

COMPULSORY

Lab work introduction



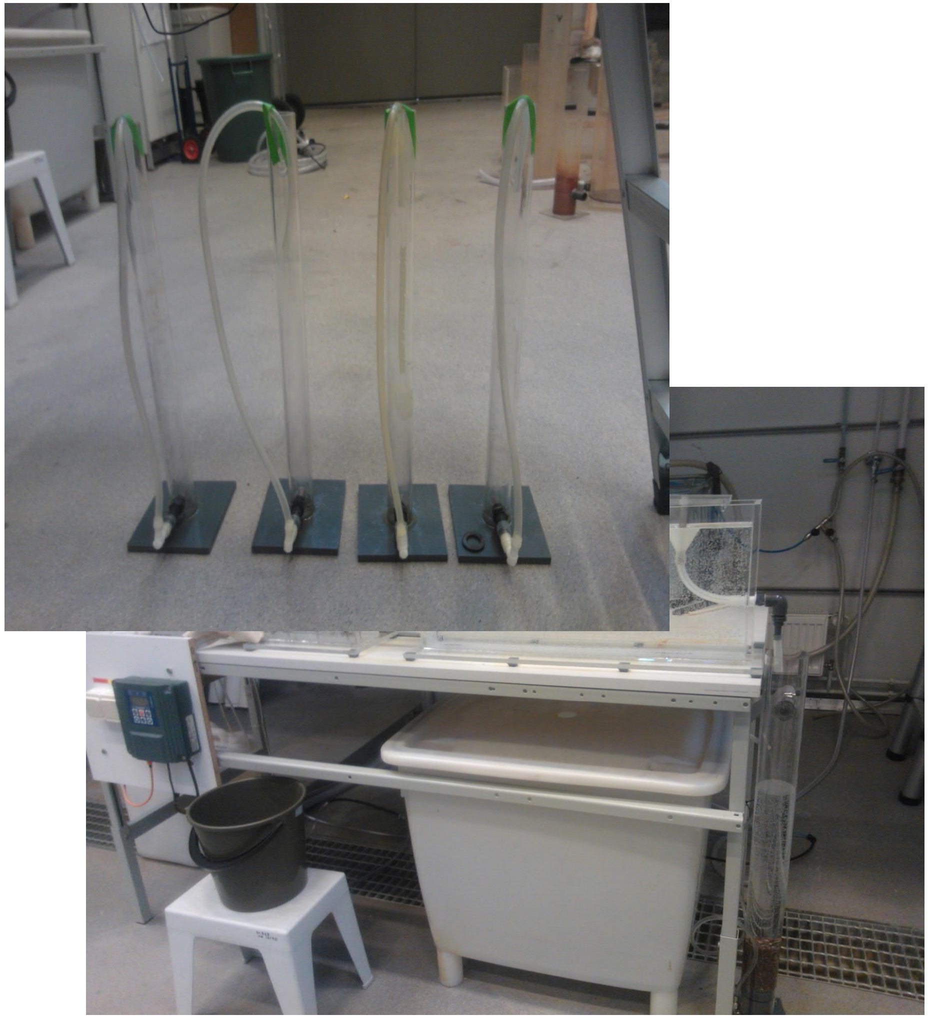
- Objective: Produce high quality water in the lab reactor
- During 4 weeks

Raw water: Diluted pond water

Continuous flow reactor:

- Chemical precipitation + settling + Sand/dual media filtration
- Week 1-2: Jar tests to determine the dosing of coagulant and acid to control pH
- Start-up of the reactor week 2

Lab work introduction



Four alternative treatment methods:
1 Flotation
2 Activated carbon
3 UV and chlorination
4 Nanofiltration

Each group will run batch tests
Each group will test a new analytical method

Presentations – Group work Friday 15.2. at 9:30

- approximately 20 min
- Followed by questions and discussion
- Idea is to explain your part so that the other students learn from it!!
- it should contain

1) an overview of the pilot process performance during the groups week

2) the process adjustments made and their effect

3) What did you do?

- lab pilot used
- test procedure scheme
- analysis carried out

4) Explanation of the results obtained by the process

5) General information about the process studied by the group

Written report / Group work

- **Simulates scientific report**
- **Introduction**
- **Literature background – should be relevant to the results presented in the report e.g. NOM removal using nanofiltration**
- **Methods – a detailed decription of your work, don't copy standards!!**
- **Results of the whole period, detailed results from your week**
- **Discussion = your own evaluation of the results + comparison with literature**

Contribution of the members of the group

Introduction

Literature (depending on results)

Methods

- Lab reactor description
- Post-treatment description
- Analytical methods

Results of the lab reactor and process optimization

Results of the post treatment

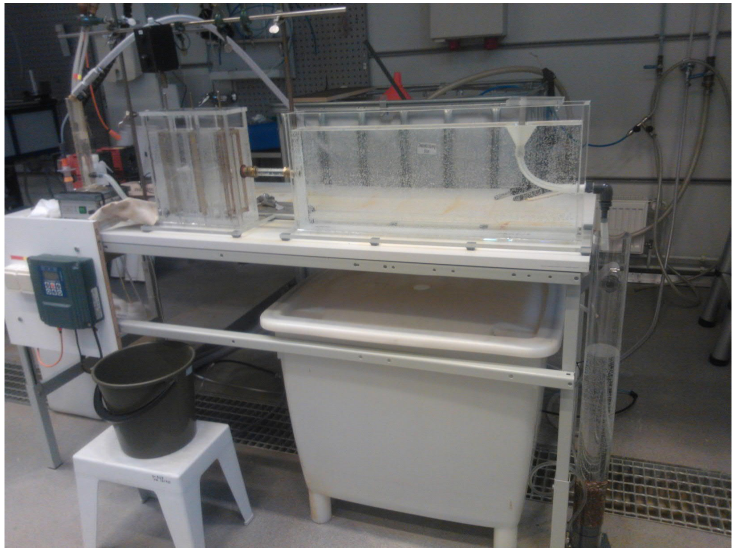
Discussion of the treatment performance

Conclusions and suggestions for the treatment to be used

Forming the groups for the lab work

Some boundary conditions:

- **Responsibility over the reactor during one week**



Forming 2 groups (A&B) for the introduction tasks in the lab

- **Friday 11.1. morning or**
- **Wednesday 16.1. afternoon**

- **4 groups (1,2,3 and 4) for each week of the pilot operation (from Wednesday to Wednesday), suggested time Monday afternoon**
- **Each group decides the monitoring (about 1 hour) schedule and informs the lab (Aino)**

Workload

Learning activity	Workload calculation (hours)	Remarks
Lectures	31,5	9 x 3,5 hours
Exercises	12	Support sessions (not obligatory)
Home assignments	12	2 hours per homework assignment
Reading materials	30	5-10 pages for each session (6 sessions)
Group work (Lab project work)	31	9 hour in the lab, 2 hours in presentations, 20 h for preparing, reporting and preparing the presentation
Midterm exam (3x)	15	4h preparation for each mid-term exam + 1h writing the exam
In total	131,5	

Changes from last year to reduce the workload:

- Exams 4 → 3
- Lectures 10 → 9
- Exercises 30 → 21
- Chemistry pre-assignment
- Better instructions and clear separation between theoretical and practical assignments

Communication

- MyCourses -page
  - Lecture material available mostly before the lecture
  - Instructions for homework assignments
  - Submission of home assignments & grades
  - Information and submissions for the lab project
- Communicating
  - *Whole course*: MyCourses & email
  - anna.mikola@aalto.fi, juho.kaljunen@aalto.fi, shanna.myers@aalto.fi
  - *Within the groups:* please organize the communication within the group already in the beginning!

Course grading

- **40 % mid-term exams - 3 exams 20 points each**
- **30 % lab project (presentation and written report)**
  - 1/3 from the presentation, 2/3 from the written report
  - Grading scale 1 – 5
  - Based on assessment of Juho and Anna
  - The same grade for the whole group unless the group communicates differences in contribution
- **30 % homework exercises + activity during the course**
  - 6 exercises, 81 points total
  - Bonus possibility up to 0.5 grade when attending the lectures

Grading thresholds:

1-40% of total points **2**-52% **3**-64% **4**-76% **5**-88%

Important to do after the introduction lecture

Register to group A or B in MyCourses

Register to one of the groups 1-4 in MyCourses

Share contact information with your group members (1-4)

Start planning your monitoring week shedule (1 student – 1 hour every day + 4 hour project with the whole group, suggested time Monday afternoon)

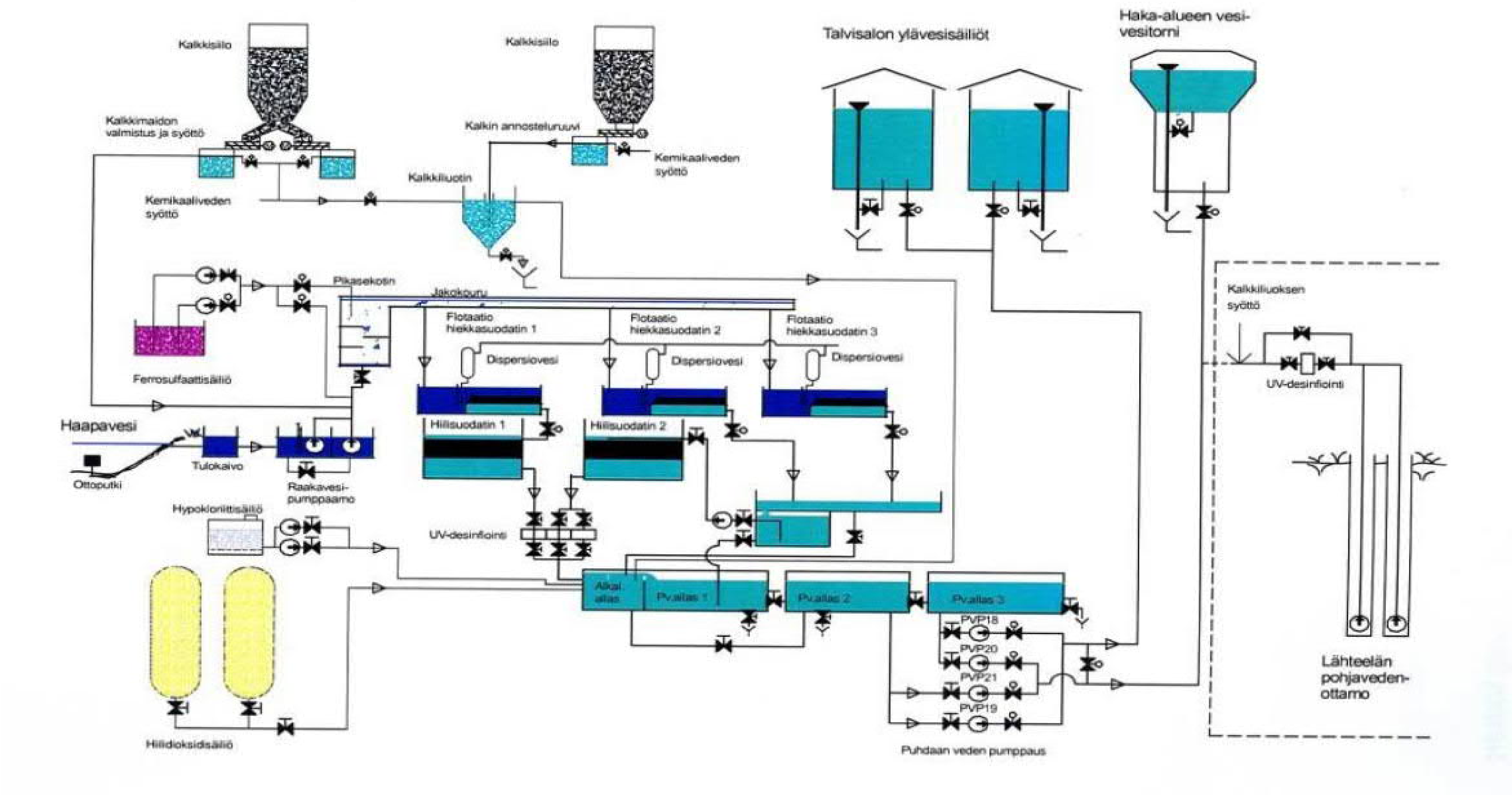
Submit the schedule in MyCourses

Pollutants in water, soil and gas emissions

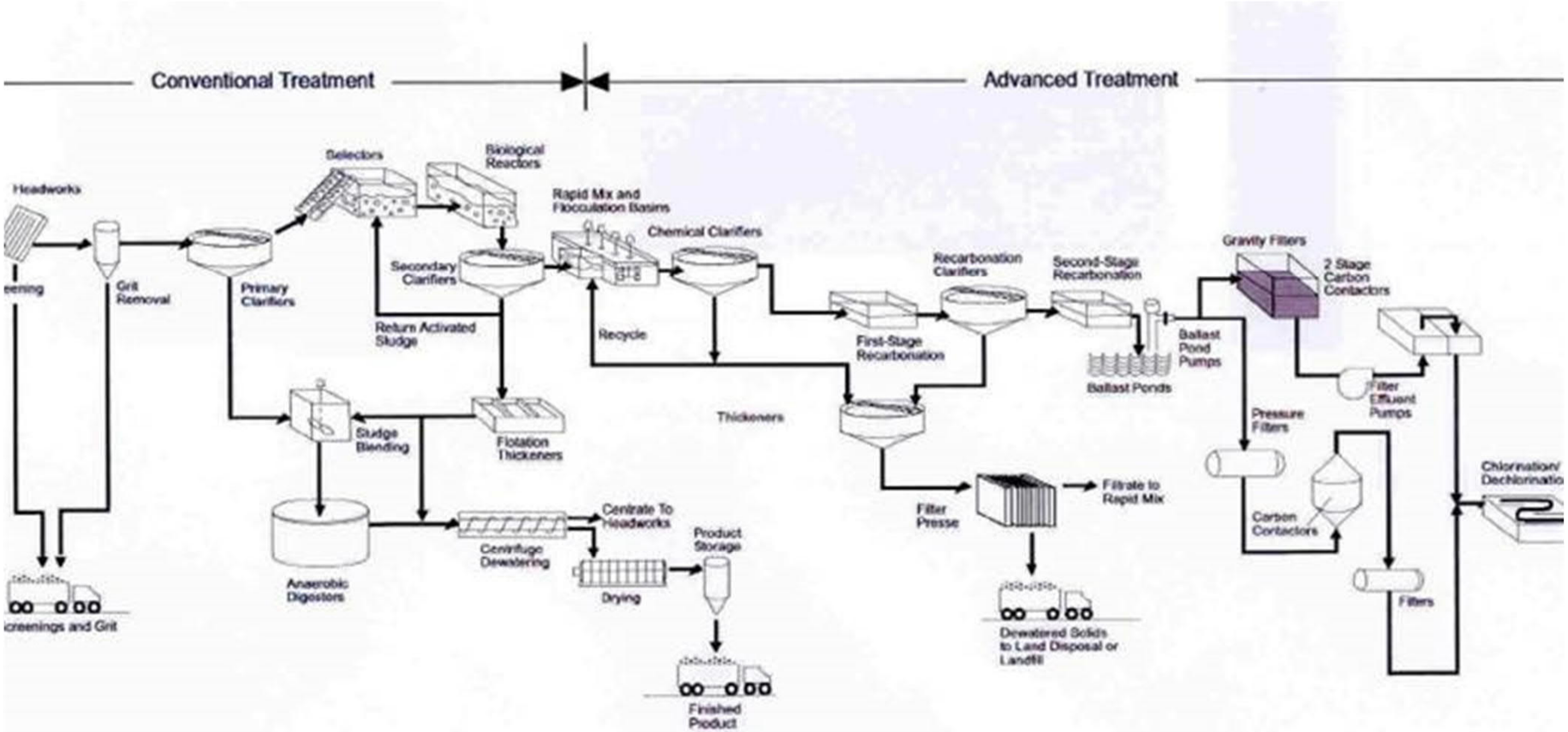
Aalto University
School of Engineering

Some examples of treatment processes

Vääräsaari purification plant, Savonlinna, Finland



UOSA WWTP Virginia USA



What kind of compounds do we need to remove?

Discussion in groups

Examples of on-going research

Water and Wastewater Engineering
- Drinking Water Production

Research is focused on developing environmentally friendly and energy efficient treatment processes to produce safe drinking water.

Research projects:

- Membrane technologies
- Low-cost adsorbents

Laurell P., Poutanen H., Vuorilehto V-P, Tuutijärvi T.; Hesampour M., Kettunen V., Vahala R. (2014). Retrofitting membrane processes for enhanced NOM removal in a drinking water treatment plant. Nordic Drinking Water Conference

Water and Wastewater Engineering

- Water Supply and Sewer Systems

In drinking water quality the focus is in the role of natural organic matter in the water quality changes in the distribution system, which is closely related to our research in drinking water treatment.

Research projects:

- The influence of organic matter on nitrification in the drinking water distribution system

Enhanced treatment of micropollutants from wastewater

- Optimization of process conditions for enhancement of removal of pharmaceuticals in low temperatures (Doctoral student Antonina Kruglova)

Contents lists available at ScienceDirect

ELSEVIER

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

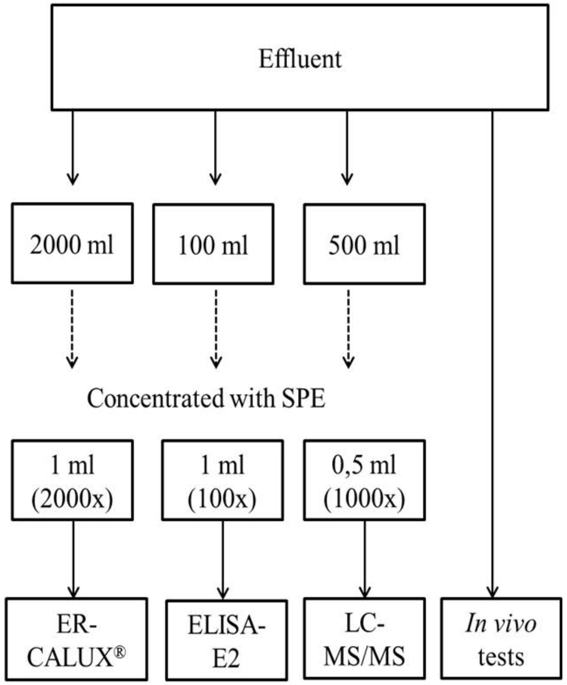
Biodegradation of ibuprofen, diclofenac and carbamazepine in nitrifying activated sludge under 12 °C temperature conditions

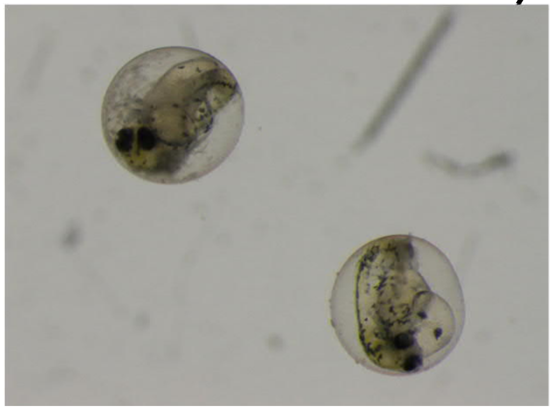
Antonina Kruglova *, Pia Ahlgren, Nasti Korhonen, Pirjo Rantanen, Anna Mikola, Riku Vahala

Department of Civil and Environmental Engineering, Aalto University, P.O. Box 15200, Aalto, FI-00076 Espoo, Finland

Smarter monitoring of micropollutants from wastewater

- Screening of wastewater toxicity based on Effect-Directed Analysis (EDA) (Doctoral student Pia Välitalo)





Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

ELSEVIER

Estrogenic activity in Finnish municipal wastewater effluents

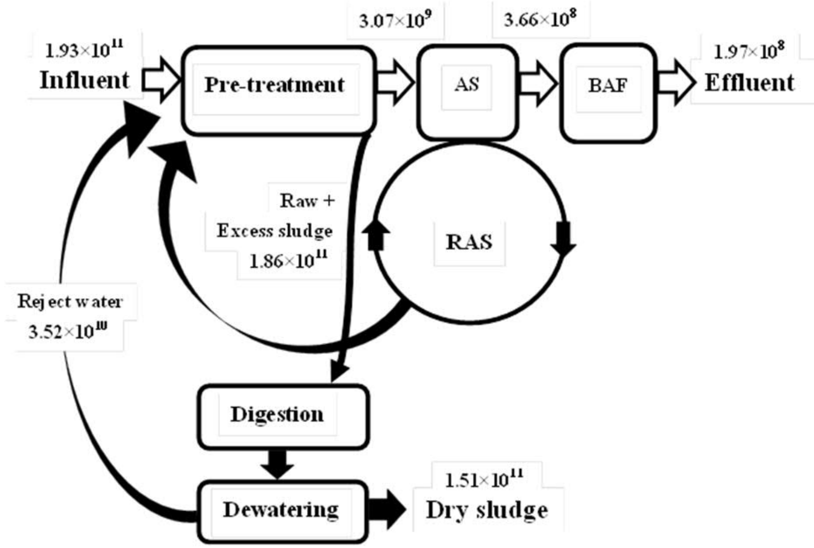
Pia Välitalo [a, b, *], Noora Perkola [a], Thomas-Benjamin Seiler [c], Markus Sillanpää [a], Jochen Kuckelkorn [c], Anna Mikola [b], Henner Hollert [c], Eija Schultz [a]

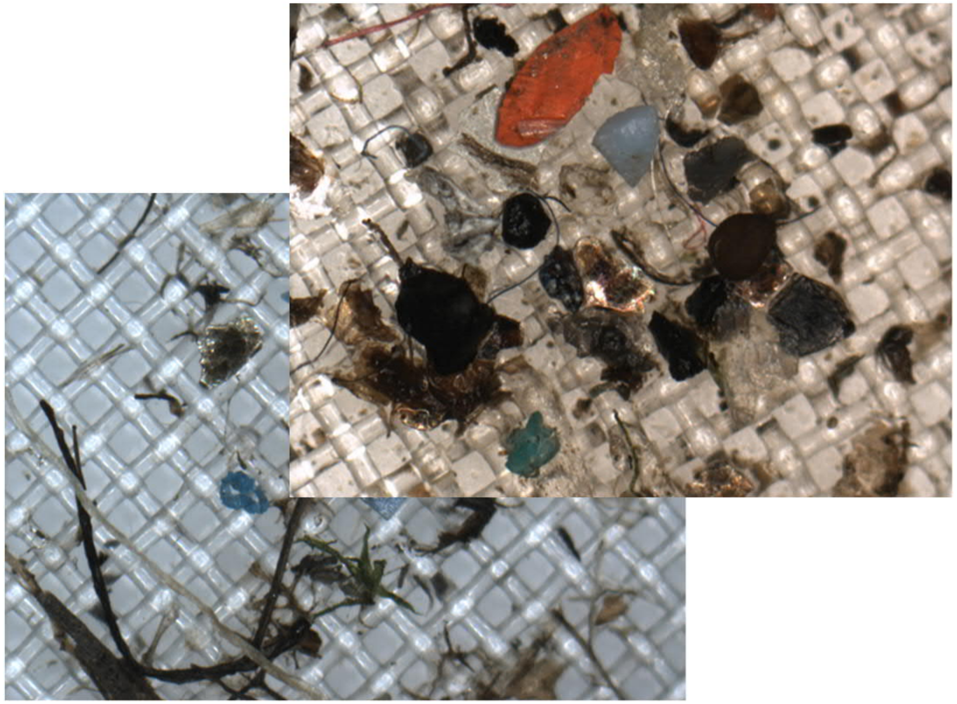
[a] Finnish Environment Institute, Laboratory Centre, Hakuninmaantie 6, 00430 Helsinki, Finland
[b] Aalto University, Department of Civil and Environmental Engineering, Tietotie 1E, 02150 Espoo, Finland
[c] RWTH Aachen University, Department of Ecosystem Analyses, Institute for Environmental Research, Worringerweg 1, 52074 Aachen, Germany

CrossMark

Occurrence and removal of microplastics in the existing wastewater treatment plants

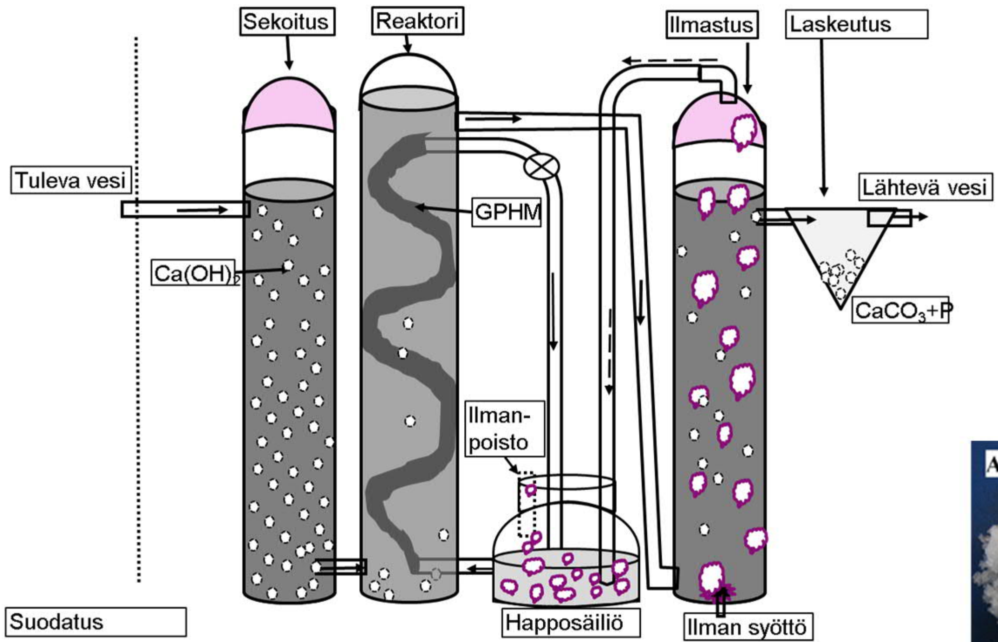
Development of sampling and analytical methods, removal in conventional and advanced processes (Doctoral student Julia Talvitie)





Nutrient recovery from wastewater

Nitrogen and phosphorus harvesting from different concentrated liquid waste streams (Post doc Surendra Pradhan)



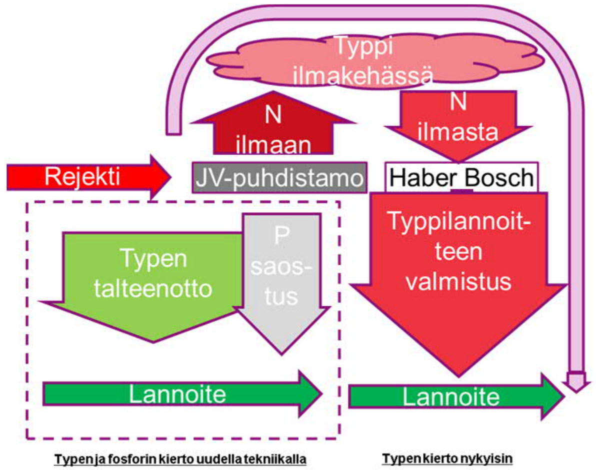
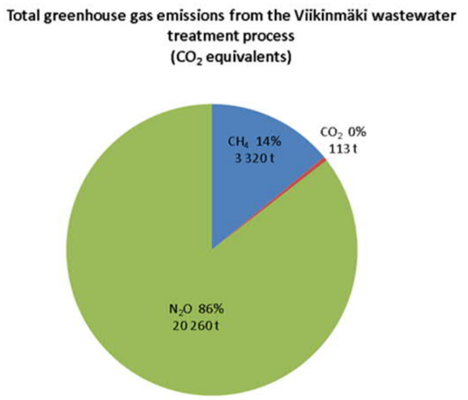
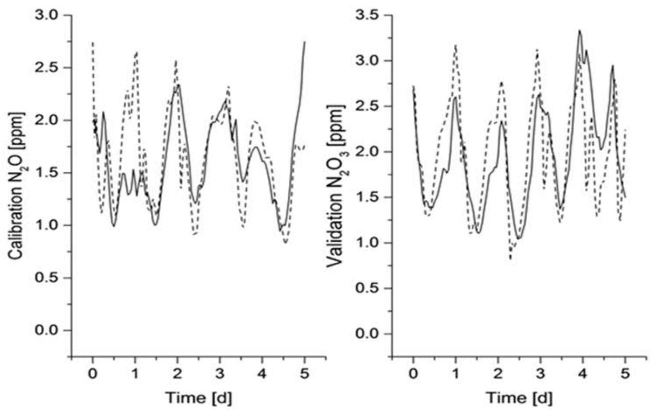


Figure 1. (A) $(NH_4)_2SO_4$ produced by NHT, (B) commercial $(NH_4)_2SO_4$

GHG emission studies from advanced nutrient removal processes

Comprehensive inventory of N_2O emissions from an advanced WWTP and implementation of N_2O in the plant wide process model





Environmental Science & Technology
Article
pubs.acs.org/est

Nitrous Oxide Production at a Fully Covered Wastewater-Treatment Plant: Results of a Long-Term Online Monitoring Campaign

Heta Kosonen,[†] Mari Heinonen,[*,‡] Anna Mikola,[†] Henri Haimi,[†] Michela Mulas,[†,∥] Francesco Corona,[‡,⊥] and Riku Vahala[†]