Aalto University
School of Engineering

Biological treatment processes of water and waste

WAT - E2180

Anna Mikola Professor of Practice D Sc (Tech)

Lecture outline

Course team introduction

Participants' introduction

Course's learning outcomes

Content of the course

- **Lectures & exercises**
- **Laboratory work**
- **Excursion**

Introduction discussion: What kind of biological processes do you already know?

! 4 groups for the group work → In MyCourses

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
  - Professor of Practice since 2018

The course team

Course's microbiology content and lab reactors: Dr. Antonina Kruglova

Course assistant: Maija Sihvonen

Lab staff: Aino Peltola, Heikki Särkkä and Marina Sushko

Lecturers from the lab:

Irina Levchuk

Antonina Kruglova

Guest lecturers from Griffin Refineries and Tampere University

Participants' introduction

1 minute each containing e.g.

- **Background?**
- **Experience with biological processes**
- **Expectations for this course?**

Learning outcomes

Upon completion, the student should be able to:

Knowledge

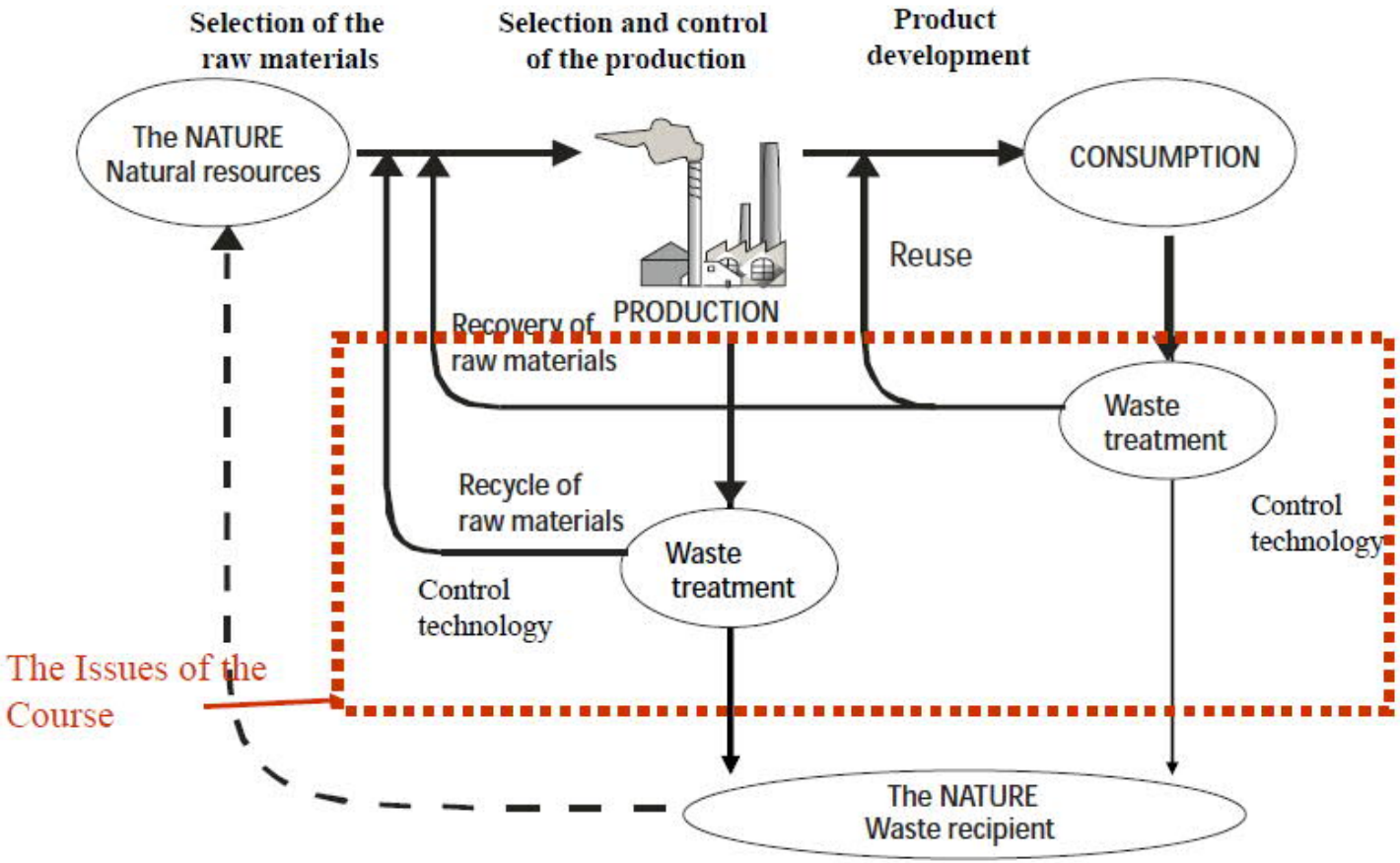
1) **Describe the most important biological water, wastewater, sludge, waste and gas treatment processes**
2) **Explain biochemical, microbiological and ecological phenomena in biological treatment processes**

Skill

3) **Form simple mass balances of biological unit processes**
4) **Identify the critical factors affecting the efficiency of biological treatment processes and describe their control systems**

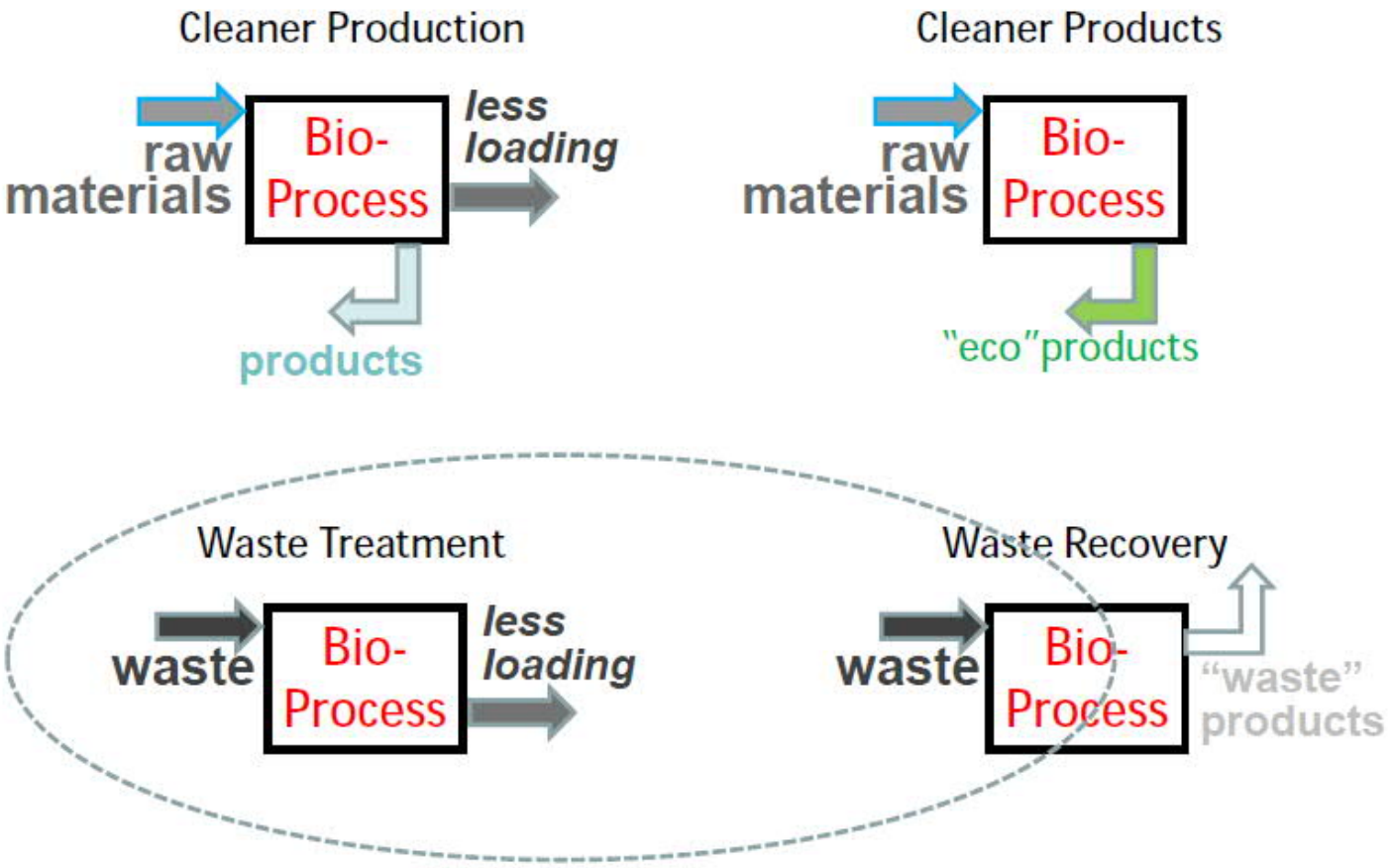
The focus will be on wastewater treatment but same principles and phenomena are applicable everywhere!!

Material flows of the human economy



18.2.2018 Timo Laukkanen

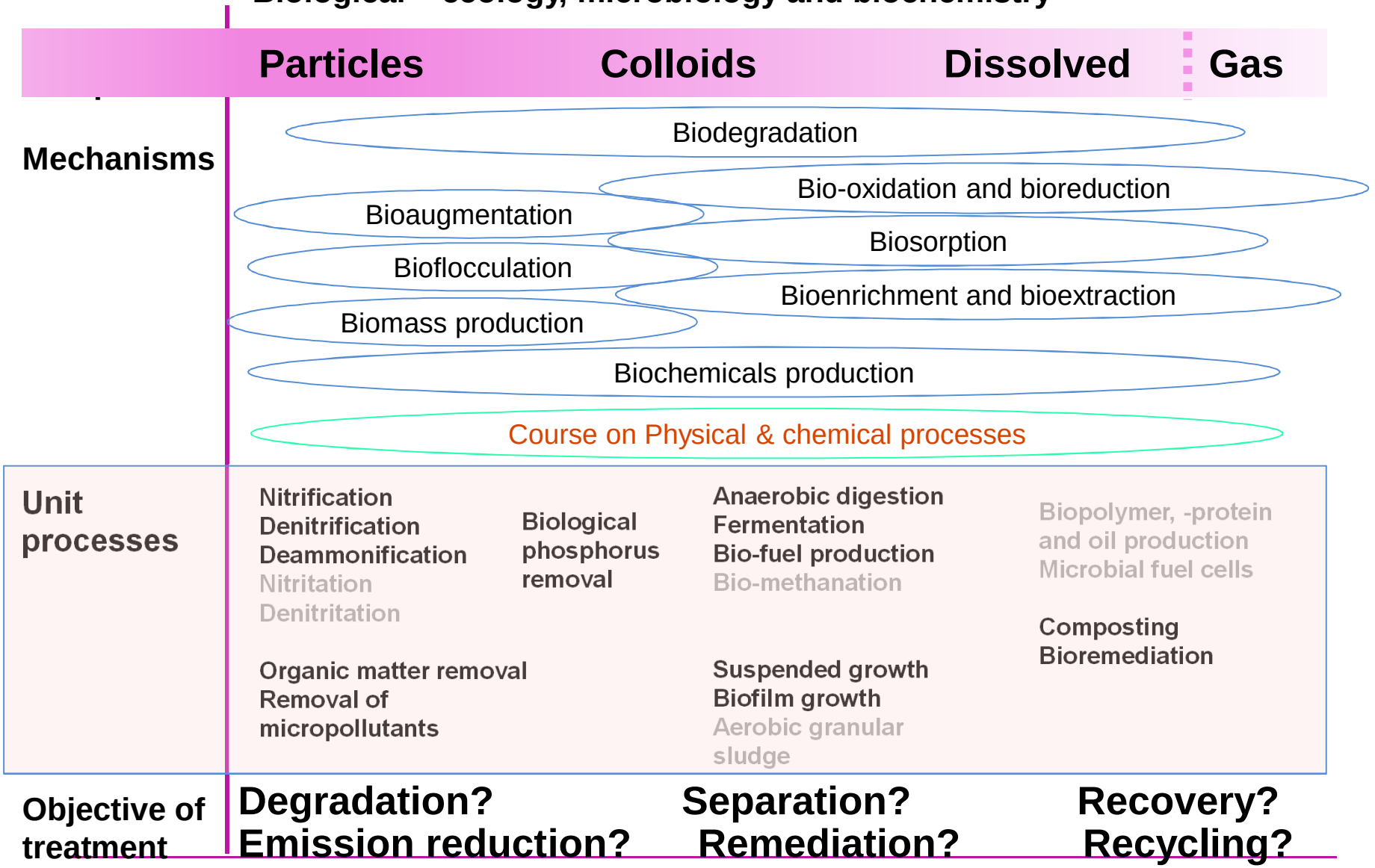
Environmental Sound Bioprocesses



18.2.2018 Timo Laukkanen

Environmental challenges to be solved

Biological = ecology, microbiology and biochemistry



Course content

Theoretical knowledge

- Lectures
- “Einstein” exercises
- Lab project

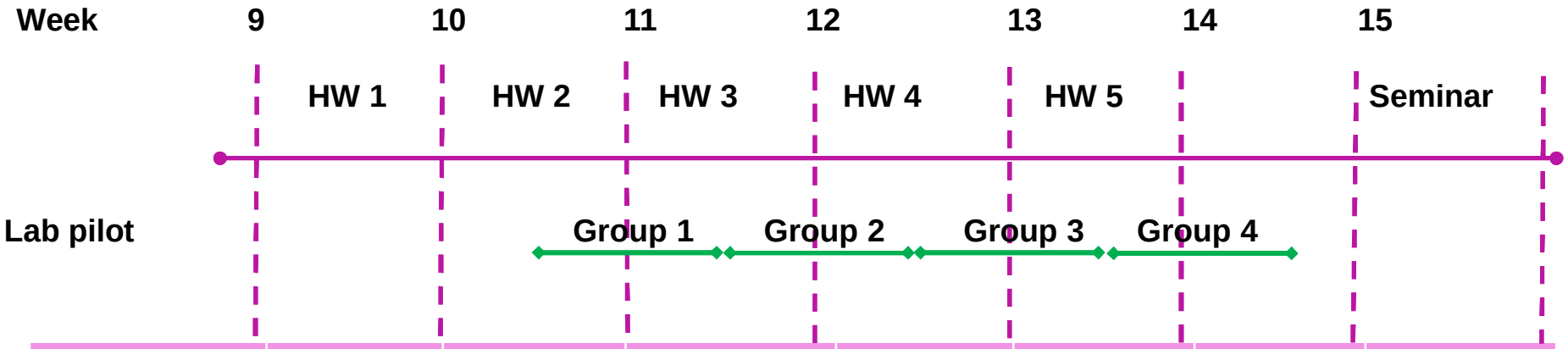
Practical knowledge

- Lectures
- “Worker” exercises

Hands-on knowledge

- Laboratory pilot operation
- Lab project
- Excursion

Timeline for the course



Lectures	**Intro** *	*	*	* *	* **Excu**	* *	
Exercise DLs			HW 1	HW 2	HW 3	HW 4	HW 5
Exams			Exam 1	Exam 2		Exam 3	Extra 1,2,3
Lab project		Monitoring lab Group 1	Microbiology lab Group 2	Group 3	Group 4		
Presentation						Support session	Final presentations
Written report		Monitoring notebook					

Course content – lectures, exercises and exams

- **Lectures and exercises**
  - Lecture sessions: 3.5 hours Tuesday afternoon at 13:00 and Thursday 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 2-3: Basic process principles
  - Lectures 4 – 5: Microbiology
  - Lectures 6 - 8: Process design and applications
  - Homework exercises from most of the sessions (5 sessions, totally 20 exercises)
  - The content will be divided into theoretical and practical parts

 &  symbols

- **Three mid-term exams**
  - 40 – 50 min on two Thursdays (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

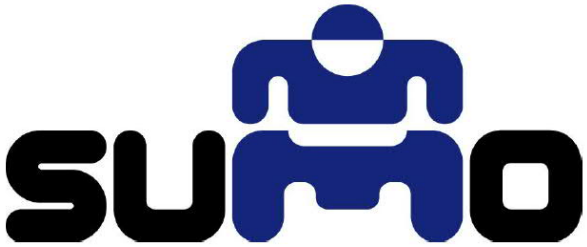
Software used during the course Support sessions for homework exercises

With Maija in the Water lab computer room

- **Wednesdays starting at 10:00**
- **Other suitable slots?**

SUMO

- Available in our computer room + TUAS 1621 + MaariE



Course books

Biological wastewater treatment

Author(s) / Editor(s) Henze, Mogens; Loosdrecht, Mark C. M. van; Ekama, George A.; Brdjanovic, Damir

Publisher IWA Publishing

Copyright Date 2008

ISBN 978-1-84339-188-3

Electronic ISBN 978-1-68015-582-2

Environmental biotechnology

Author(s) / Editor(s) Bhattacharyya, Bimal C.; Banerjee, Rintu

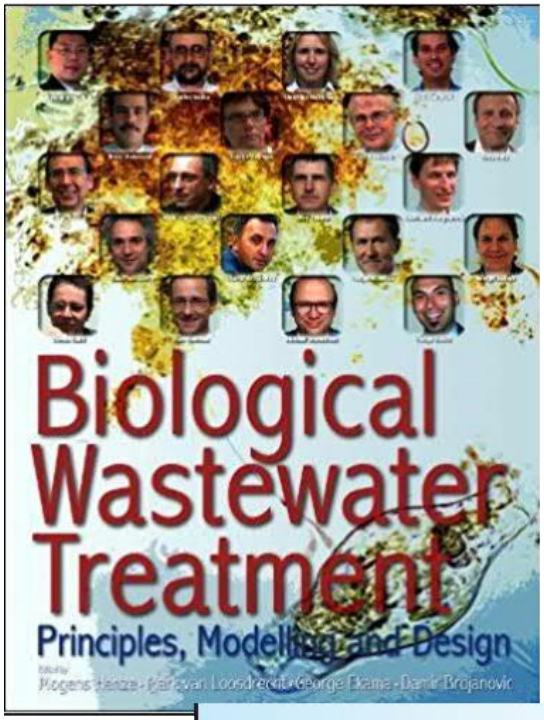
Publisher Oxford University Press

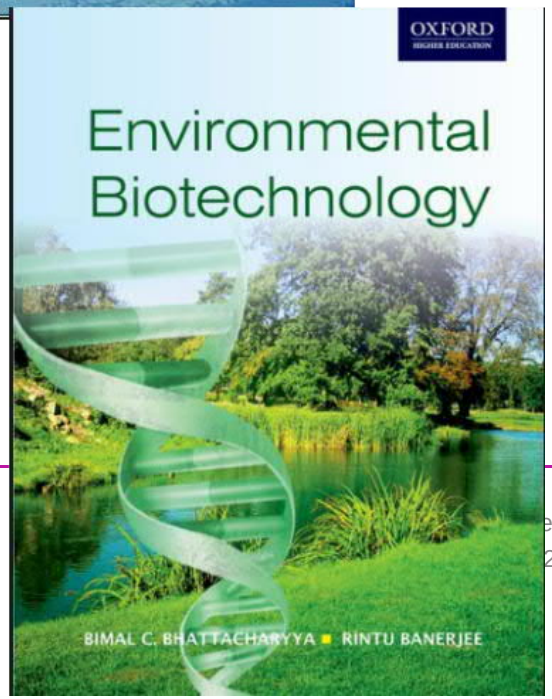
Copyright Date 2007

ISBN 978-0-19-568782-8

Electronic ISBN 978-1-61344-143-5

Both available as eBook





Course content – lab project

- **Laboratory work**
  - Task: to operate and monitor two lab reactors during four weeks in different conditions
  - Weeks 1-2: Introduction to basic monitoring and microbiology→ monitoring notebook
  - Weeks 2-5: Four groups of students will operate the reactor in different conditions (oxygen, temperature, total N removal, bioP)
  - Week 6: Scientific papers
  - Week 7: Presentation and/or poster

- **Excursion**
  - Excursion to Viikinmäki wastewater treatment plant on Thursday 28.3.
  - WWTPcaching at the plant
  - → Objective to understand the theories and design principles in practice, to learn about the process monitoring and to assess, present, plan and report practical boratory work.

Lab project

Week 1
Orientation to lab project

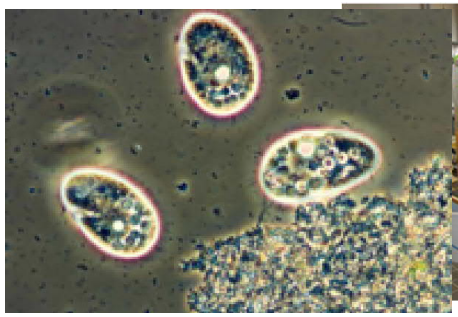
Week 2
Monitoring lab (4h)
Group 1 operates the reactors (2h/d)

Week 3
Mikrobiology lab (4h)
Group 2 operates the reactors (2h/d)

Week 4
Group 3 operates the reactors (2h/d)

Viikko 5
Group 4 operates the reactors (2h/d)

Viikko 6-7
Analysis of the results, poster and presentation



Content and objectives, linking to theory

Learning the basic monitoring,

Preparing own lab toolbox

Focusing on microbiology

Presenting the results, learning from each other, feedback

Students operating the reactors independently

Conditions: 1: DO 2: Anoxic 3: Anaerobic 4: Temperature

Aalto-yliopisto
Aalto-universitetet
Aalto University

EXCURSION

To Viikinmäki wastewater treatment plant

THURSDAY 28.3. during the course teaching session

Some assignments during the visit

Using public transportation

COMPULSORY

Pictures: HSY

Reactor operation and monitoring

- Reactors: Sequencing bacth reactor SBR and membrane bioreactor MBR
- Objective: Study two different suspended growth reactors with different sludge age during 4 weeks
- Monitoring process conditions, effluent water quality and sludge characteristics
- Week 1: Effect of oxygen
- Week 2: Implementation of anoxic sequence in the SBR
- Week 3: Implementation of anaerobic sequence in the SBR
- Week 4: Effect of temperature
- Influent water: synthetic wastewater

Written outcome – Individual work Monitoring toolbox DL 7.3.2019

- **Written based on the monitoring lab on Tuesday 5.3.**
- **Purpose:**
  - Work as a toolbox and check-list for you further work with the reactors

- Submitted to MyCourses and evaluated

1) Short work description of all the monitoring methods

- **On-line probes**
- **Sampling**
- **Analysis**

2) Purpose of the method

3) Special hints for avoiding problems (e.g. typical values, calibration needs, …)

Seminar and poster – Group work
Tuesday 4.4. at 13:00

- **Three roles in the groups:**
  - Presenters
  - Competitors
  - Planners
- **Three outcomes:**
  - Presentation of the lab study
  - Presentation of another study (from the literature)
  - Experimental plan and expected outcomes for your further study

- **Presentations: 10 min + 10 min + 10 min**
- **Discussion (10 – 15 min)**

Forming the groups for the lab work

Some boundary conditions:

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

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

Bonus points from the lecture presentation

- Lecture on April 2nd
- Several short presentations about various applications of biological processes
- If you are especially interested in something or have acquired special knowledge of a process, you can prepare a 20 min presentation for the lecture

Topics:

- Membrane bioreactors
- Microbial fuel cells
- Aerobic granular sludge
- Biological iron removal
- Biomethanation

Workload

Learning activity	Workload calculation (hours)	Remarks
Lectures + excu	35	10 x 3,5 hours
Exercises	10	Support sessions (not obligatory)
Home assignments	15	3 hours per homework assignment
Reading materials	10	5-10 pages for each session (5 sessions)
Lab project work	34	12 hour in the lab, 4 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
Independent reflection	15	
In total	134	

Our attempts to reduce the workload:

- Good instructions and clear separation between theoretical and practical assignments
- Clear links and supporting elements between different assignments
- Motivating and inspiring course content

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, Antonina.kruglona@aalto.fi, Maija.sihvonen@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 (monitoring toolbox, excursion assignment, presentation)**
  - 1/3 from the individual part, 2/3 from the group work
  - Grading scale 1 – 5
  - The same grade for the whole group unless the group communicates differences in contribution
- **30 % homework exercises**
  - 5 exercises, 75 points total
- **Bonus possibility up to 0.5 grade when attending the lectures**
- **NOTE!! Late submission – 1 week → 50% off, more → 100% off**

Grading thresholds:

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

Important to do after the introduction lecture

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 (2 students – 2-3 hours every day during your week)

Submit the schedule in MyCourses

Biological processes

What kind of biological processes in environmental engineering you already know?

Discussion in groups

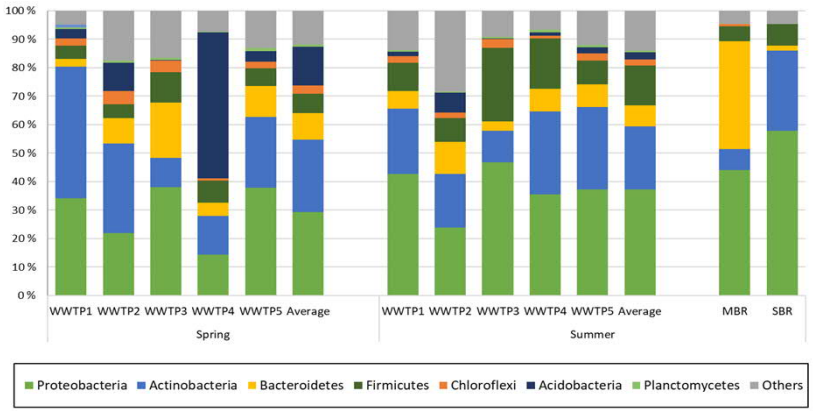
Examples of on-going research

Development of cold-climate treatment processes using microbial population information

I. Bacteria of low-temperature processes (Doctoral student Antonina Kruglova, PostDoc Alejandro Gongalez-Martinez, M.Sc. Jenni Kesulahti, M.Sc. student Khoi Le Minh)

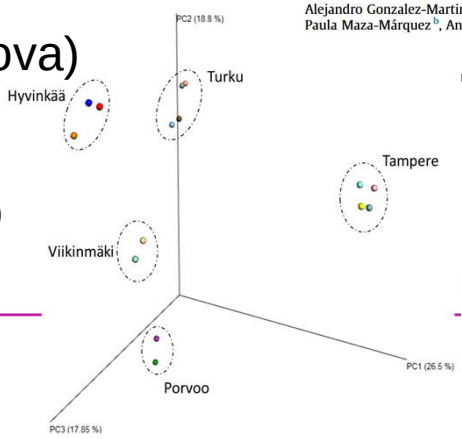
II. Comparison of conventional activated sludge with advanced activated sludge community (Doctoral student Antonina Kruglova)

III. Aerobic granular sludge in low temperatures (PostDoc Alejandro Gongalez-Martinez)



Start-up and operation of an aerobic granular sludge system under low working temperature inoculated with cold-adapted activated sludge from Finland

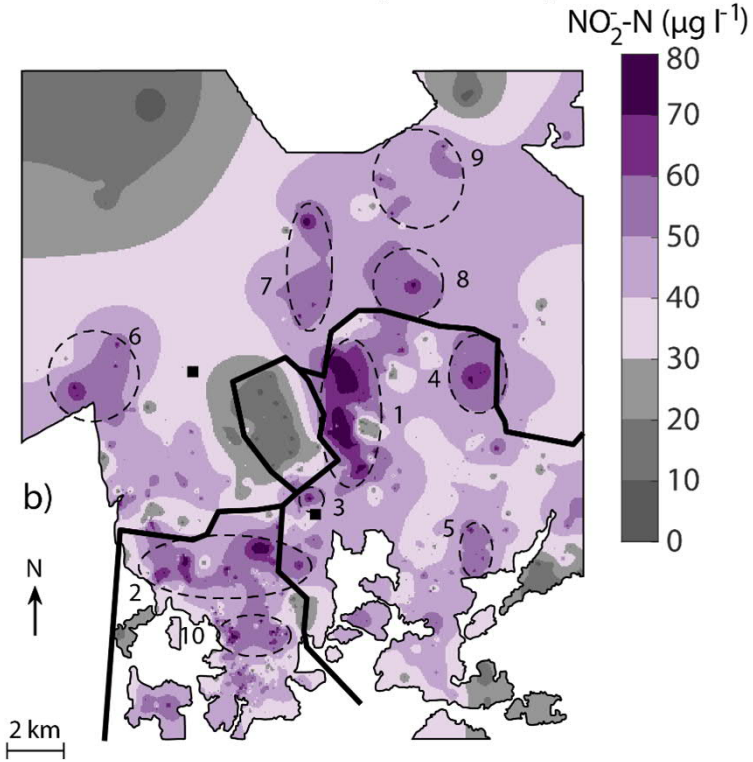
Alejandro Gonzalez-Martinez [a,*], Barbara Muñoz-Palazon [b], Alejandro Rodriguez-Sanchez [b], Paula Maza-Márquez [b], Anna Mikola [a], Jesus Gonzalez-Lopez [b], Riku Vahala [a]



Water Supply

In drinking water quality the focus is in the role of natural organic matter in the water quality changes in the distribution system.

- The influence of organic matter on nitrification in the drinking water distribution system (Lic. Tech. Pirjo Rantanen)



Scientific Research Publishing

Journal of Water Resource and Protection, 2017, 9, 1026-1042
http://www.scirp.org/journal/jwarp
ISSN Online: 1945-3108
ISSN Print: 1945-3094

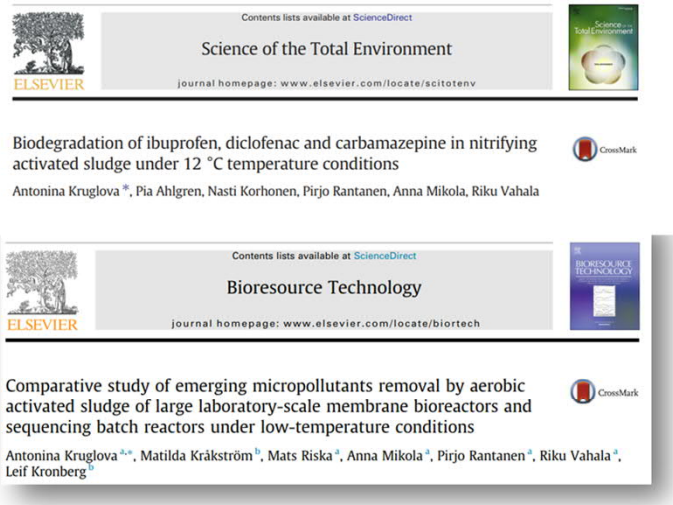
The Spatial Distribution of Nitrite Concentrations in a Large Drinking Water Distribution System in Finland

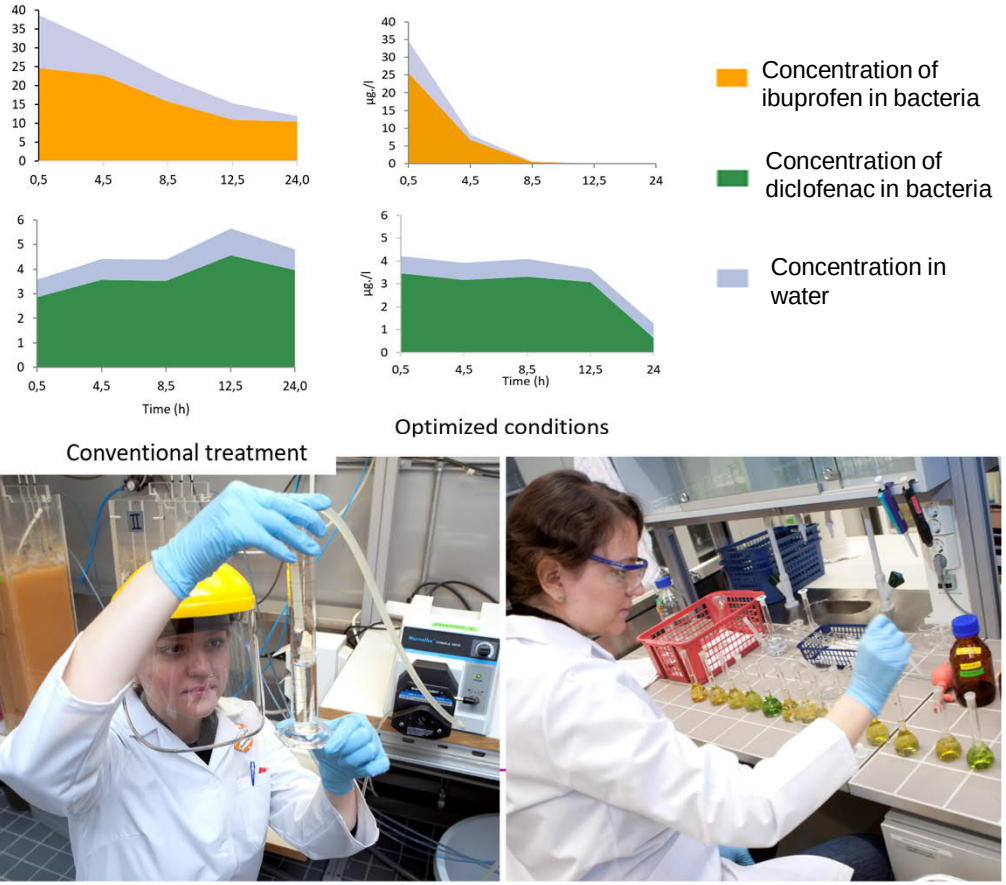
Pirjo-Liisa Rantanen[1*], Minna M. Keinänen-Toivola[2], Merja Ahonen[2], Ilkka Mellin[3], Duoying Zhang[4], Tuula Laakso[5], Riku Vahala[1]

[1]Department of Built Environment, School of Engineering, Aalto University, Espoo, Finland
[2]Faculty of Technology, Satakunta University of Applied Sciences, Rauma, Finland
[3]Department of Mathematics and Systems Analysis, School of Science, Aalto University, Espoo, Finland
[4]School of Civil Engineering, Heilongjiang University, Harbin, China
[5]Helsinki Regional Environmental Services Authority, Helsinki, Finland

Enhanced treatment of micropollutants from wastewater

Optimization of micropollutants biological removal at low temperatures





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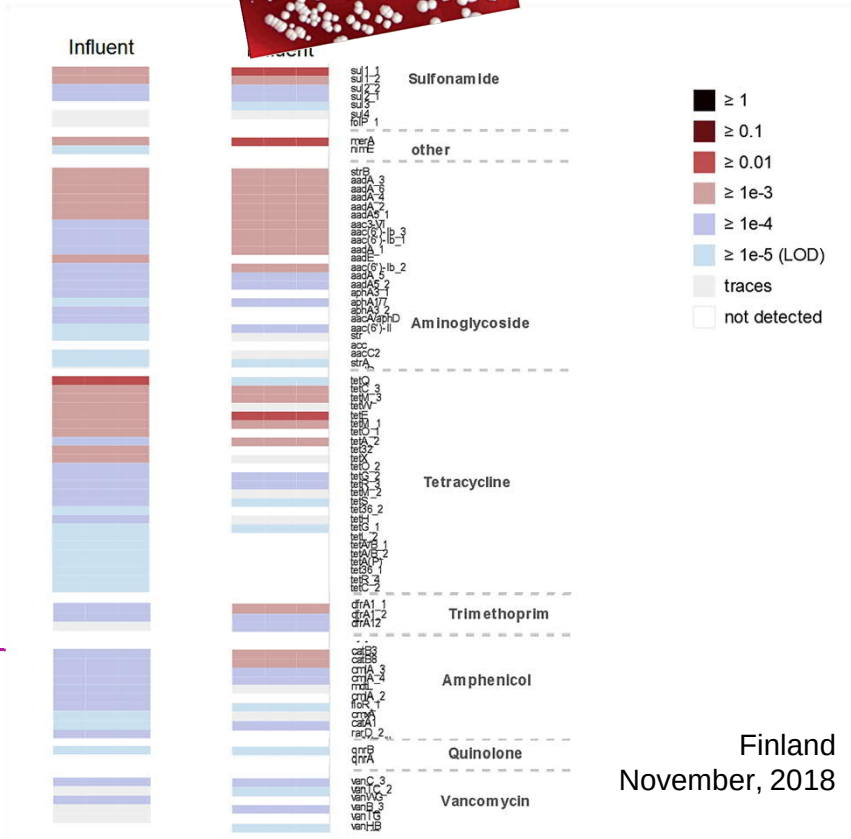
Antibiotics and antibiotics resistance bacteria in wastewater treatment

- Global antibiotics resistance crisis
- WWTPs are among the main sources of antibiotics resistance in the environmental
- Removal rates in wastewater treatment are highly dependent on process conditions and temperature

(*Kruglova et al., 2014, Kruglova et al., 2016*)

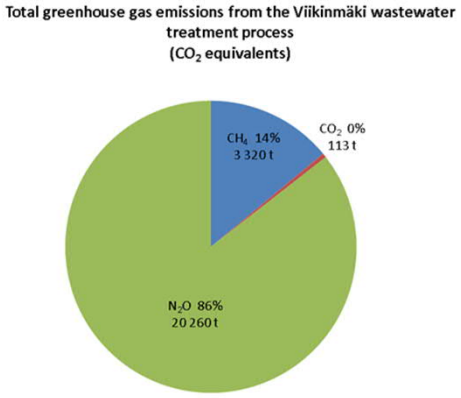


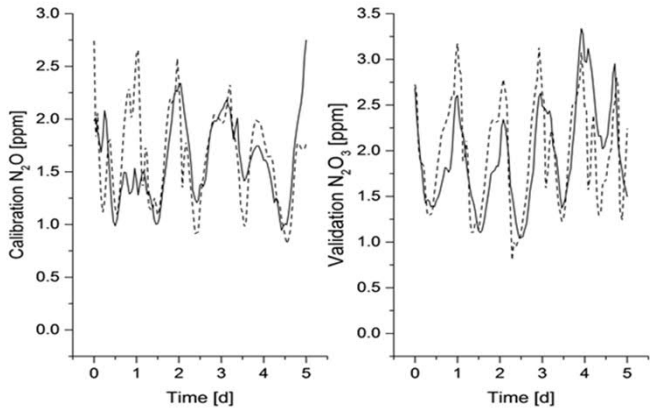
Aalto University
School of Engineering

Finland
November, 2018

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 (Collaboration with HSY)





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[†]

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

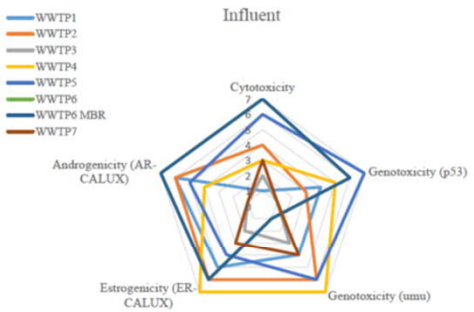
Water Research

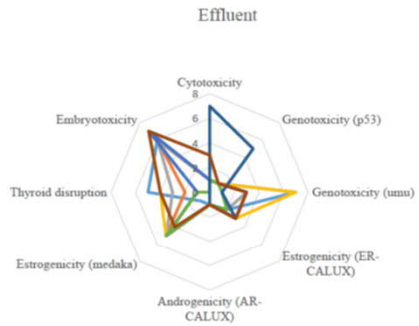
journal homepage: www.elsevier.com/locate/watres

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





Water Research 126 (2017) 153–163

Contents lists available at ScienceDirect

Water Research

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

Effect-based assessment of toxicity removal during wastewater treatment

Pia Välitalo [a, b, *], Riccardo Massei [c, d], Ilse Heiskanen [a], Peter Behnisch [e], Werner Brack [c, d], Andrew J. Tindall [f], David Du Pasquier [f], Eberhard Küster [c], Anna Mikola [b], Tobias Schulze [c], Markus Sillanpää [a]