

# Water and Environmental Engineering Research Group

Anna Mikola Postdoc researcher

# School of Engineering

#### Science to Engineering

Staff 800 Professors 60 Students 3 300 Annually 300 MSc and 30 DSc (Tech.

Departments

#### Other units

Applied Mechanics Civil and Environmental Engineering Civil and Structural Engineering Energy Technology Engineering Design and Production Real Estate, Planning and Geoinformatics Aalto University Digital Design Laboratory | Design Factory | Center for Energy Technology



RUB 26.8.2015

## Department of Civil and Environmental Engineering

Research Focus of the Department of Civil and Environmental Engineering is in ecoefficient society and sustainable use of natural resources:

- Global water issues
- Sustainable material cycles
- Arctic geo-engineering and mineral resources
- Ecoefficient and intelligent transport



## Department of Civil and Environmental Engineering

#### We are the one of the research groups of the Department

- Geoengineering (4 professors, ~30 persons)
- Transportation Engineering (2 professors, ~10 persons)
- Water and Environmental Engineering (5 professors, ~60 persons)





## Water and Environmental Engineering

The research group is segmented to two strategic focuses, Global Water Issues and Sustainable Material Cycles, which are dealt with in five teams:

- Water resources management, Prof. Harri Koivusalo
- Water and wastewater engineering, Prof. Riku Vahala
- Water and development, Prof. Olli Varis, Assistant prof. Matti Kummu
- Environmental Engineering, Prof. Jaana Sorvari



# Water and Wastewater Engineering

#### Main themes:

- Drinking water production ٠
- Water supply and sewer ۲ systems

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- Wastewater treatment
- Modeling and control of water treatment processes



# 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. Submitted to Nordic Drinking Water Conference





# Water and Wastewater Engineering - Water Supply and Sewer Systems

The objective is to allow renovation of pipes at the right time at the right location, to reduce leakage and to better operate and control the 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
- Maintenance strategies for sewer networks (EfeSus)

Laakso T., Vahala R. 2014. Risk analysis framework for planning sewer renovations, inspections and preventive maintenance. Urban Water Journal: Special Issue on "Sewer Asset Management"



# Water and Wastewater Engineering

#### - Wastewater Treatment

#### **Research projects:**

- Optimization of process conditions for enhancement of removal of pharmaceuticals in low temperatures
- Screening of wastewater toxicity based on Effect-Directed Analysis (EDA)
- Occurrence of microplastics in wastewater, the removal in the wastewater treatment plants and effects in the receiving water body
- Nitrous oxide emissions from the wastewater treatment processes and their minimization

Antonina Kruglova, Pia Ahlgren, Nasti Korhonen, Pirjo Rantanen, Anna Mikola, Riku Vahala Biodegradation of ibuprofen, diclofenac and carbamazepine in nitrifying activated sludge under 12 °C temperature conditions; Science of the Total Environment 499 (2014)



# Water and Wastewater Engineering - Modeling and control of processes

The research targets for the development of tools that support the operation of the municipal WWTPs.

#### **Research projects:**

- AdvanceD data management and InformAtics for the optimuM operatiON anD control of wastewater treatment plants (DIAMOND)
- Data derived modelling of biological wastewater treatment processes using statistical multivariate methods





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# Research on N<sub>2</sub>O emissions



## **Background on N<sub>2</sub>O emissions**

- Strongest green house gas emitted from the wastewater treatment plant – 298 times CO<sub>2</sub>
- Catalytic role in the destruction of ozone layer
- Produced during biological nitrogen removal processes



## Pathways of N<sub>2</sub>O emissions



Wunderlin, 2012



# Study set-ups and methodology

- In-situ full-scale measurements
- Measurements from anoxic and aerobic zones, secondary clarifiers, denitrifying filters...
- Mobile gas analyzer Gasmet DX-4000 used with capture hood
- Close cooperation with Helsinki Region Environmental Services HSY





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### **In-situ measurements**







# Examples of our finding: Emissions from aeration basins and secondary clarifiers



Concentration in the gas emissions at the same level in aerated zones and in secondary clarifiers!



# Examples of our findings: Longitudinal profile of N<sub>2</sub>O emissions in clarifiers



# Examples of our findings: Diurnal variation of emissions



# From single process units to overall plant monitoring



Apparatus	Name
1	Gasmet computer
2	Keyboard and
	mouse
3	Sampling unit
4	Oxygen analyzer
5	Gasmet gas analyzer
6	Cabinet cooling unit
7	Display
8	Drawer
9	Cabinet





## Viikinmäki WWTP in Helsinki





## Viikinmäki WWTP in Helsinki





## N<sub>2</sub>O research and objectives at Viikinmäki WWTP

- Comprehensive inventory of N2O emissions from a advanced WWTP
- Scale and dynamics in different process units
- Optimization of process with a view on N<sub>2</sub>O
- Implementation of N<sub>2</sub>O in the plant wide process model



Kosonen, 2013



# Challenges in N<sub>2</sub>O research

- Multiple and complex pathways for production, utilisation and emission
- Very few full-scale measurement campaigns covering the whole process
- Full understanding of mechanisms and phenomena not yet accomplished
- Several different separate models proposed



Ni et al. 2013

