

#### UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

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# UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

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## Paradigm shift in wastewater treatment



Orcular scheme
Paradigm shift: wastewater→"used water"



### Microalgae for used water recovery

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- Most resource recovery schemes are based on chemical processes, e.g. struvite precipitation
- Cultivation of microalgae on used water resources
  - Nutrients recycling through bio-fertilizer production
  - Biofuel production
  - Decoupling food and biofuel production





End use: Fertigation
Biogas production

DTo conversion Department of Environmental Engineering





# **Experimental set up and operation**



- The effect of the variation of N-to-P ratio is tested fed with treated municipal wastewater
- Mixed consortium and mono-culture
- Open system





5

### **Analytical procedure**



Total suspended solids

Nitrate

- Pigments: chlorophyll, lutein, βcarotene and violaxanthin
- Nitrite
- Phosphate
- Stored nutrients
- Microbial diversity
  - Based on morphology of the different species
  - Using microscopy





### **Predictive model**



- Spectra mean-centered
- Principal component analysis
- Principal component regression  $\rightarrow$  based on the most informative PCs
- Leave one out cross validation to find optimal model
- Revision of detection limits and signal saturation

### Chlorella sp. – process performance





# *Chlorella sp.* – principal component analysis



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### **Chlorella sp.** – principal component regression NO<sub>3</sub> 3 PCs



### Chlorella sp. – principal component regression NO<sub>3</sub> 3 PCs

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# **Chlorella sp.** – leave one out cross validation NO<sub>3</sub>



# **Chlorella sp.** – principal component regression NO<sub>3</sub> 14 PCs



# *Chlorella sp.* – leave one out cross validation NO<sub>3</sub> without saturation



### **Chlorella sp.** – principal component regression NO<sub>3</sub> 10 PCs without saturation



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### **Chlorella sp.** – principal component regression TSS 3 PCs



ΠΤΗ

### **Chlorella sp. – principal component** regression TSS 3 PCs



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# **Chlorella sp.** – leave one out cross validation TSS



# **Chlorella sp.** – principal component regression TSS 40 PCs



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### **Chlorella sp. – leave one out cross** validation TSS above detection limit



### Chlorella sp. – principal component regression TSS 30 PCs above detection limit



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### **Chlorella sp. – principal component** regression TSS 10 PCs outliers removed



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### **Chlorella sp.** – principal component regression Chlorophyll 3 PCs



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### Chlorella sp. – principal component regression Chlorophyll 3 PCs



Measured Chlorophyll concentrations (mg L<sup>-1</sup>)

# *Chlorella sp.* – leave one out cross validation Chlorophyll



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### **Chlorella sp.** – principal component regression Chlorophyll 27 PCs



# Chlorella sp. – leave one out cross validation Chlorophyll without saturation



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#### **Chlorella sp.** – principal component regression Chlorophyll 24 PCs without saturation



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### Variation in microbial diversity

- Contamination by diatoms when N-to-P is lowered to 5
- Washout of diatoms when N-to-P is set back to 17
- Change in abundance of Chlorella and Scenedesmus sp.
- Hypothesis to test:
  - Do changes on shape and size affect the prediction capacity by UV-Vis sensors?









### **Mixed culture – process performance**







### Mixed culture – principal component analysis

ΠΤΙΙ



### Mixed culture – principal component regression TSS 1 PC



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# **Concluding Remarks**

#### Monoculture

- More complex models required to predict data "out of range"
- Successful predictive models were built for nitrate, suspended solids and chlorophyll

#### Mixed culture

 Very simple model succesfully predicted the TSS despite contamination in the reactor.





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