UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

Valverde Pérez, Borja; Wágner, Dorottya Sarolta; Steidl, Michael ; Villez, Kris; Plósz, Benedek G.

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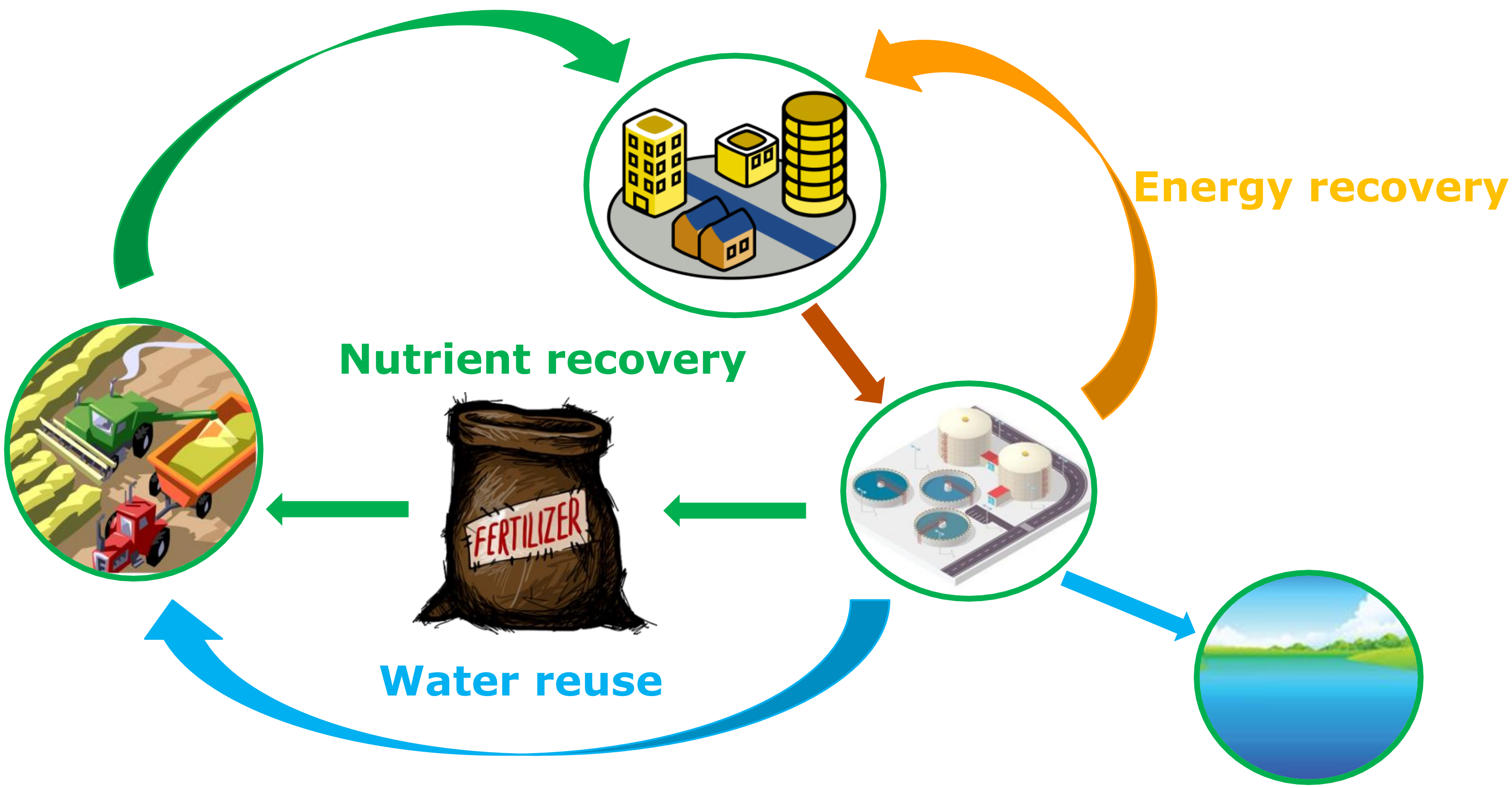
UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

Borja Valverde-Pérez, Dorottya S. Wágner, Michael Steidl, Kris Villez, Benedek Gy. Plósz

DTU Environment
Department of Environmental Engineering

Paradigm shift in wastewater treatment

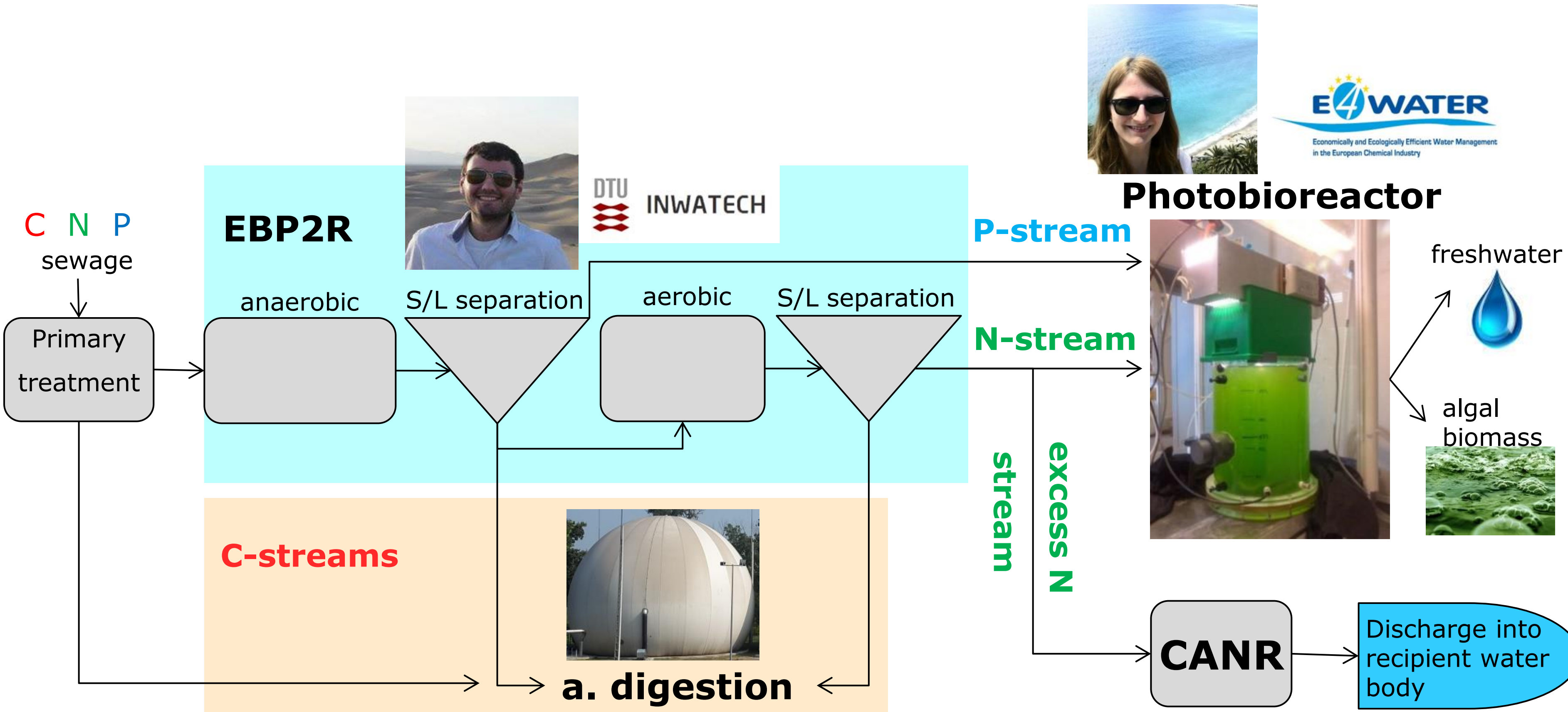
- Circular scheme
- Paradigm shift: wastewater ⟶ "used water"



Microalgae for used water recovery

- 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

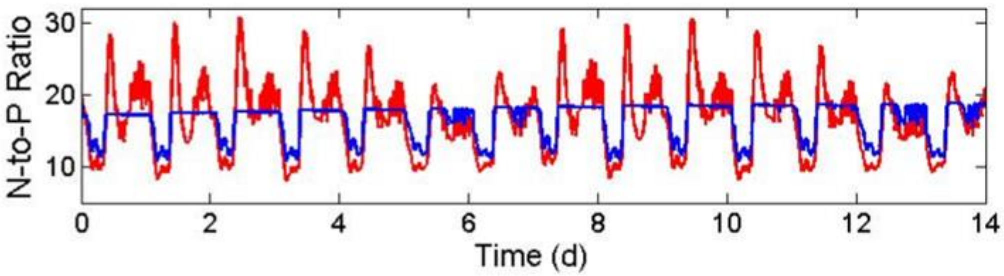

TRENS – Biochemical Resource Recovery



End use:

- ✓ Fertigation
- ✓ Biogas production

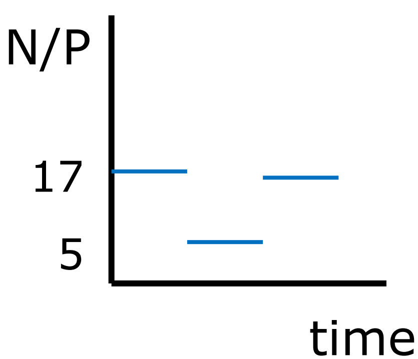
Experimental set up and operation



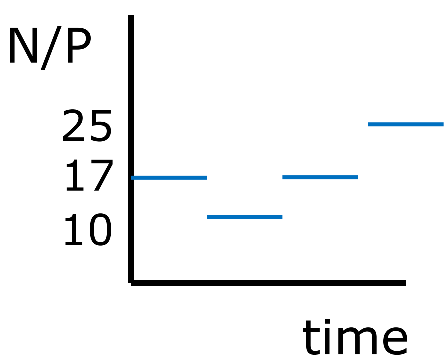
Valverde-Pérez et al., 2016

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

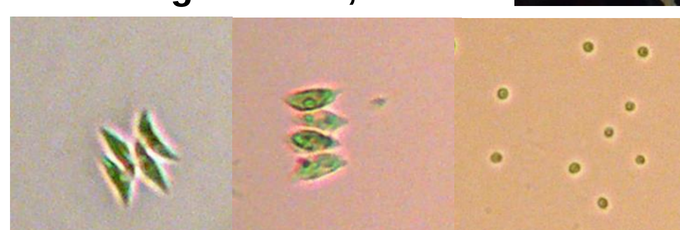
Mixed consortium



Mono-culture

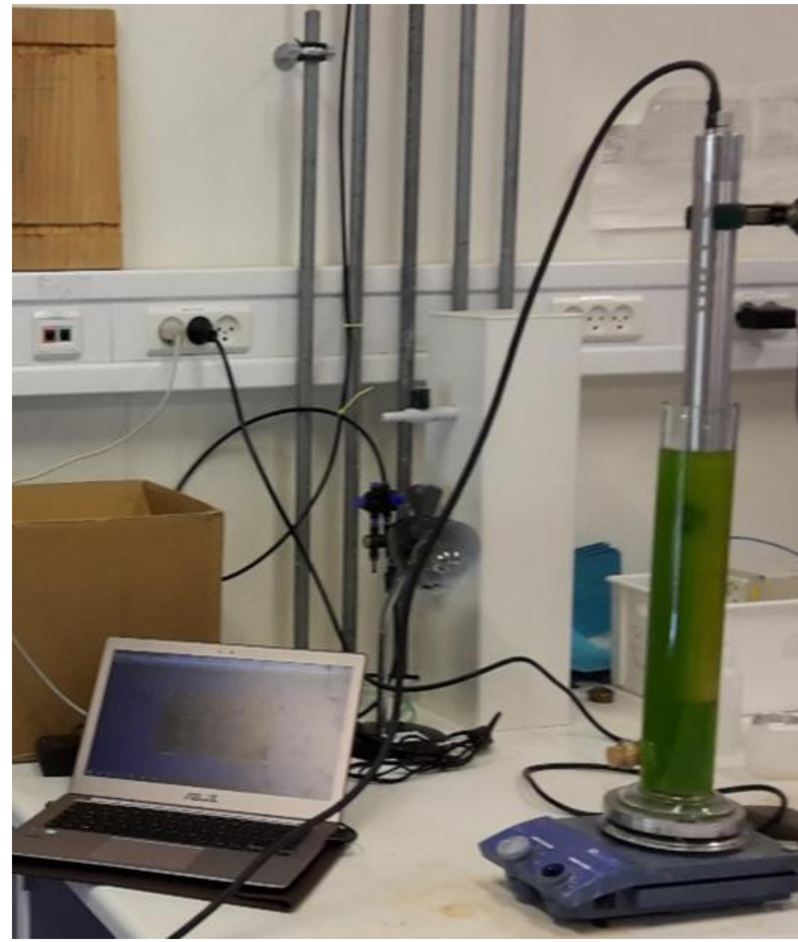


Wágner et al., 2017



Analytical procedure

- Total suspended solids
- Nitrate
- Pigments: chlorophyll, lutein, β-carotene and violaxanthin
- Nitrite
- Phosphate
- Stored nutrients
- Microbial diversity
  - Based on morphology of the different species
  - Using microscopy

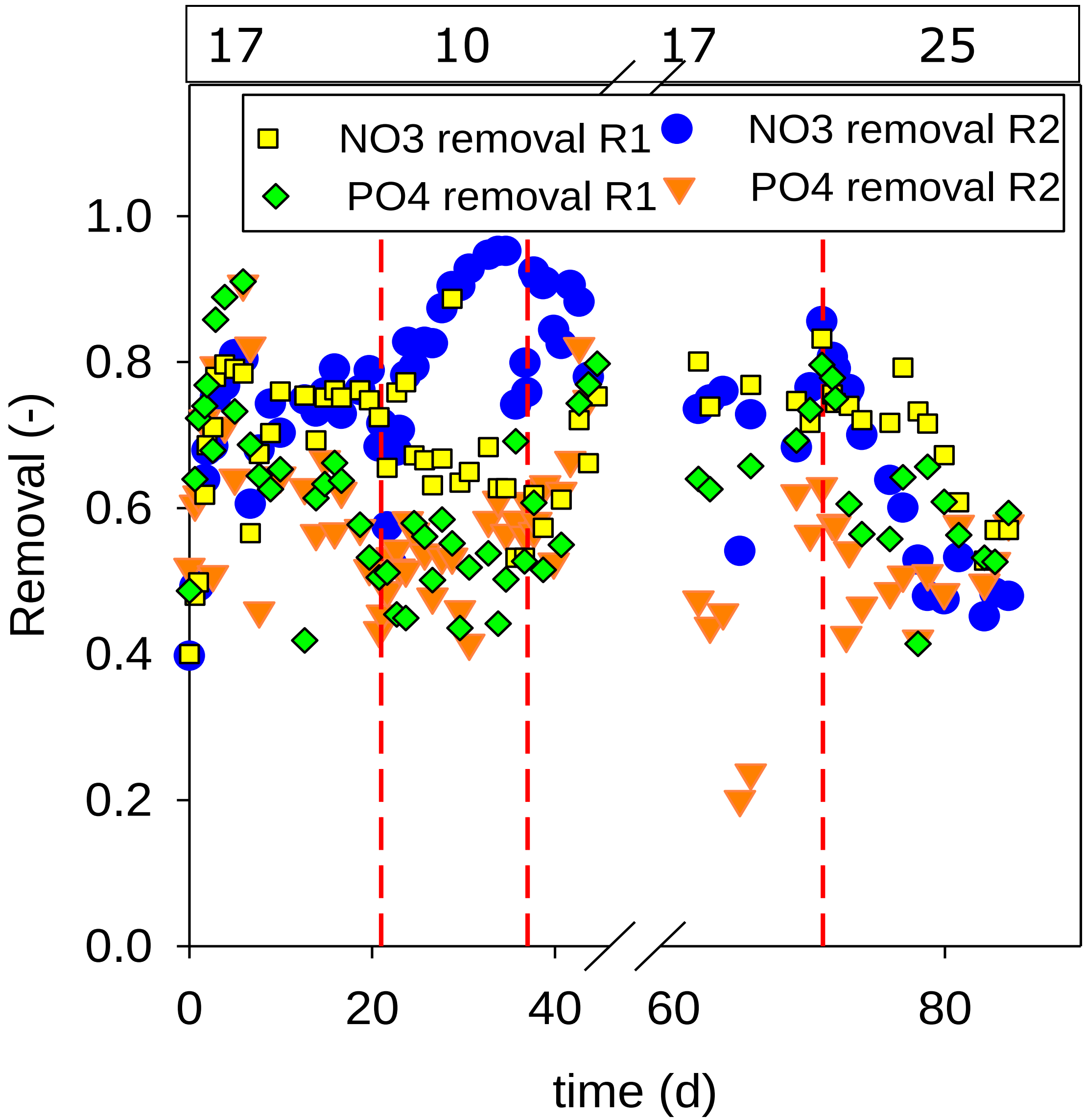


Predictive model

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

Masic et al., 2015, Water Res.

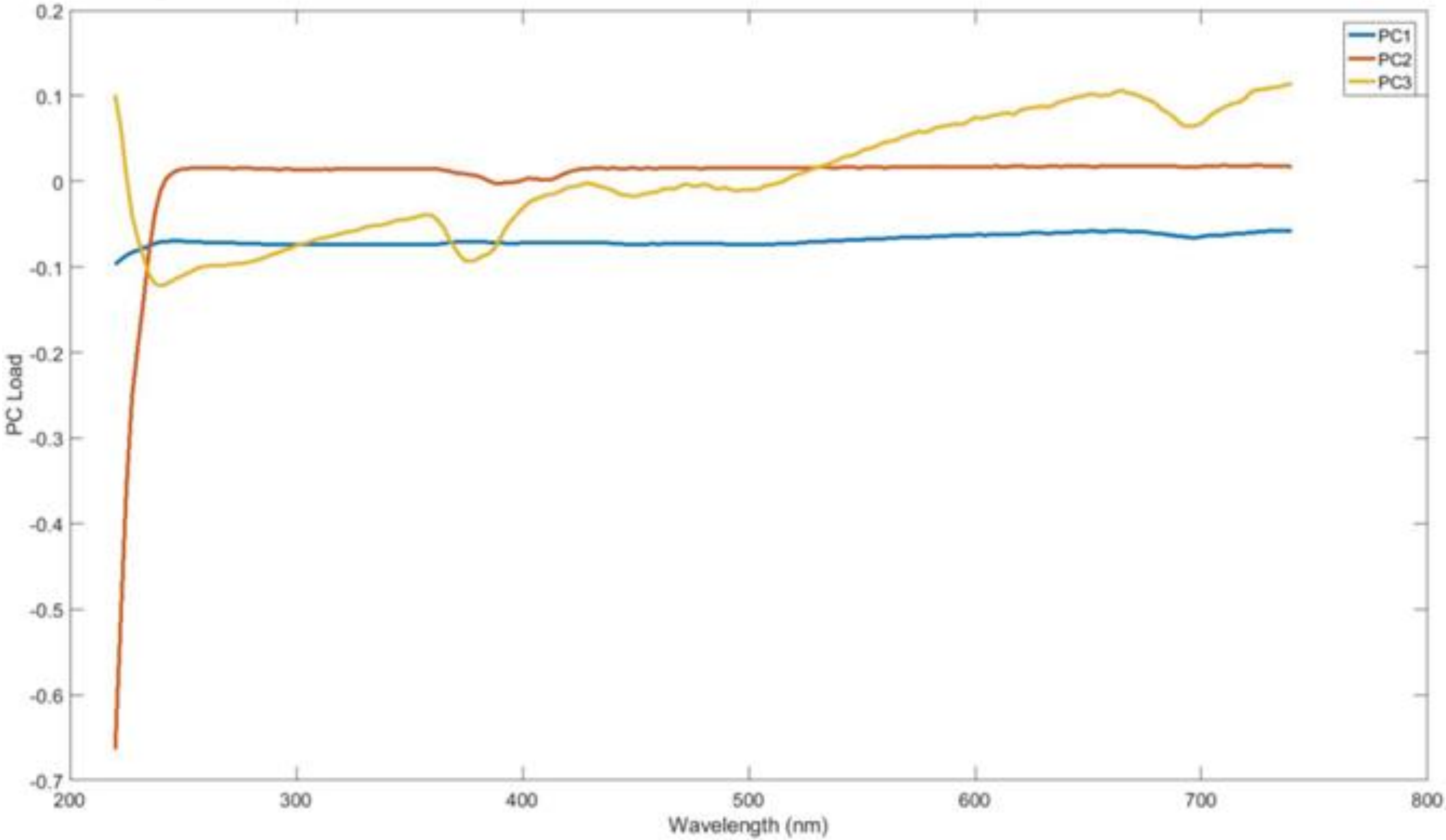
Chlorella sp. – process performance



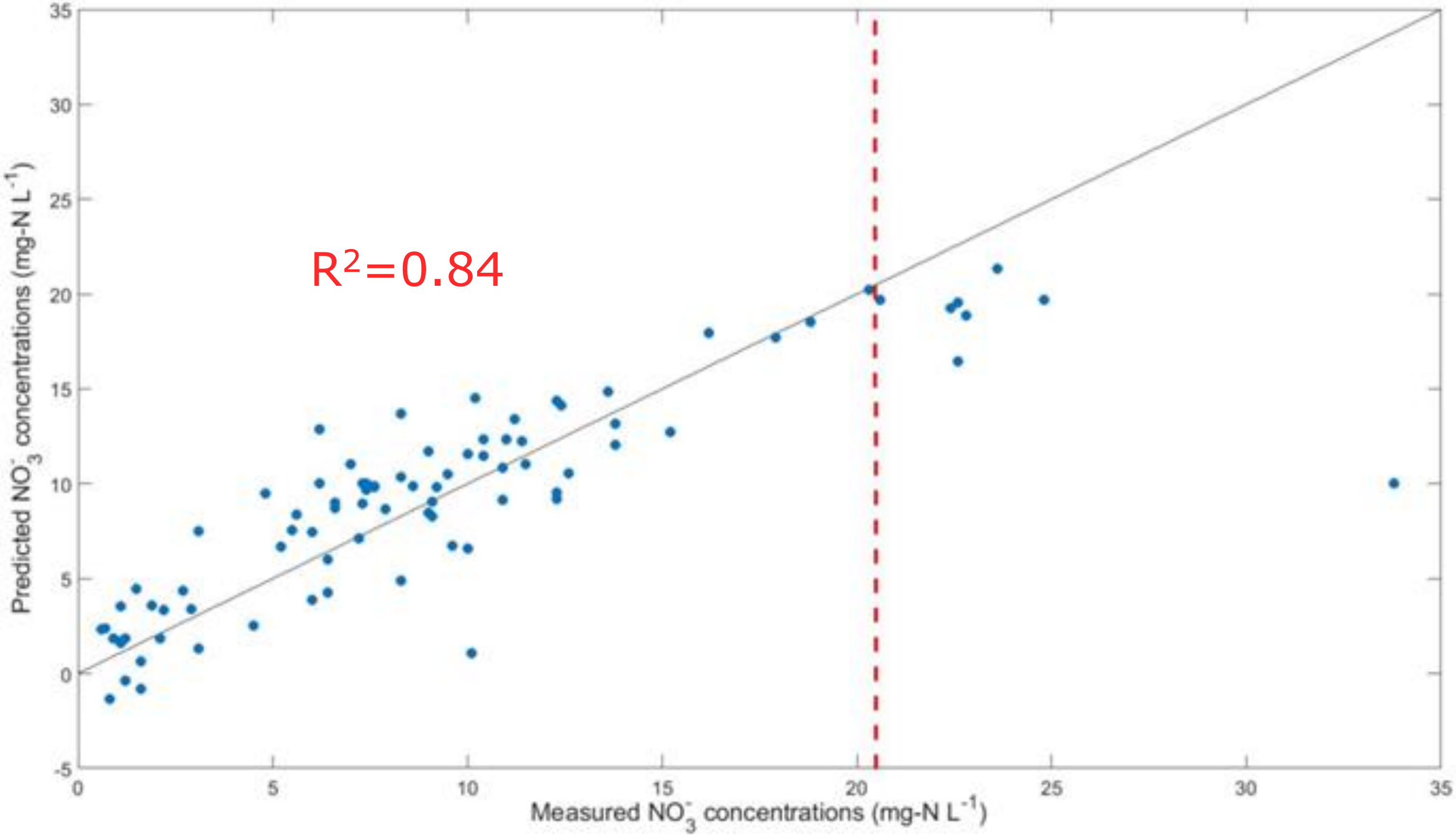
R1 – control

R2 – test

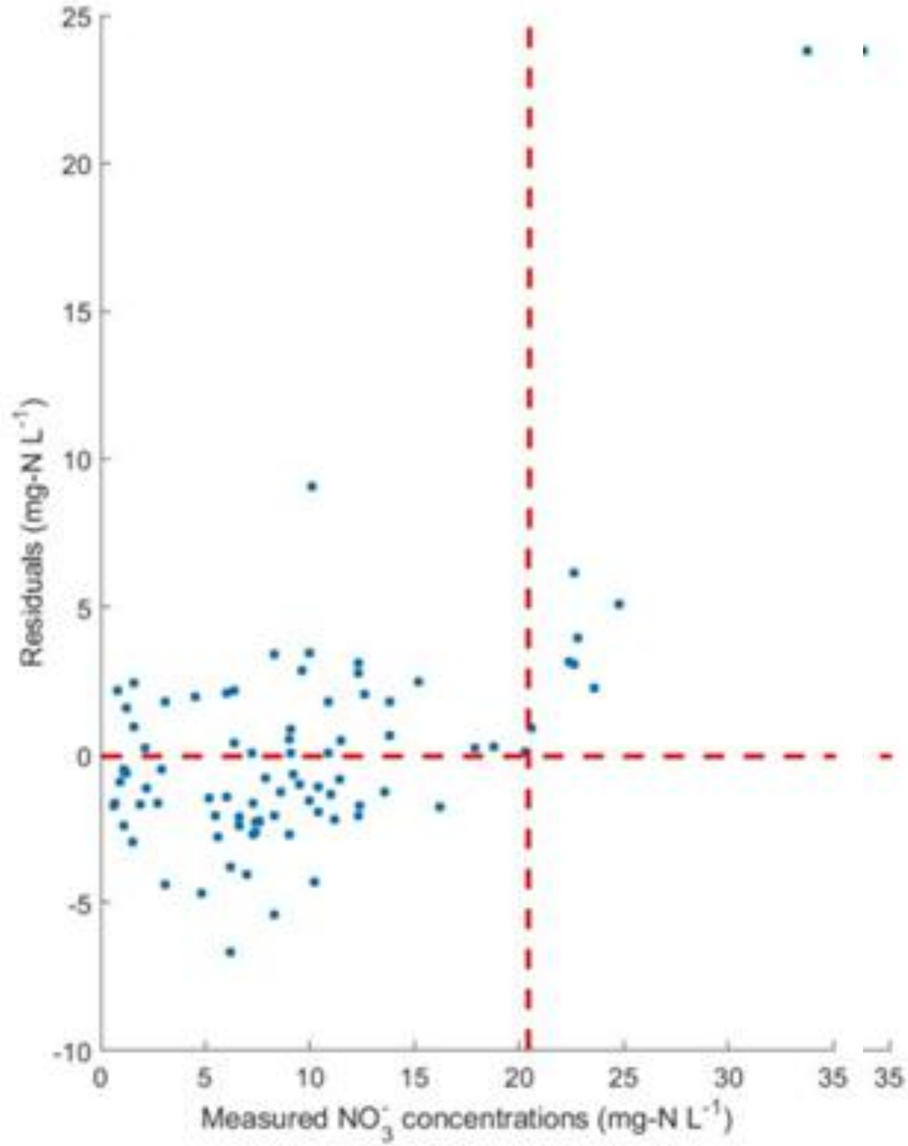
Chlorella sp. – principal component analysis



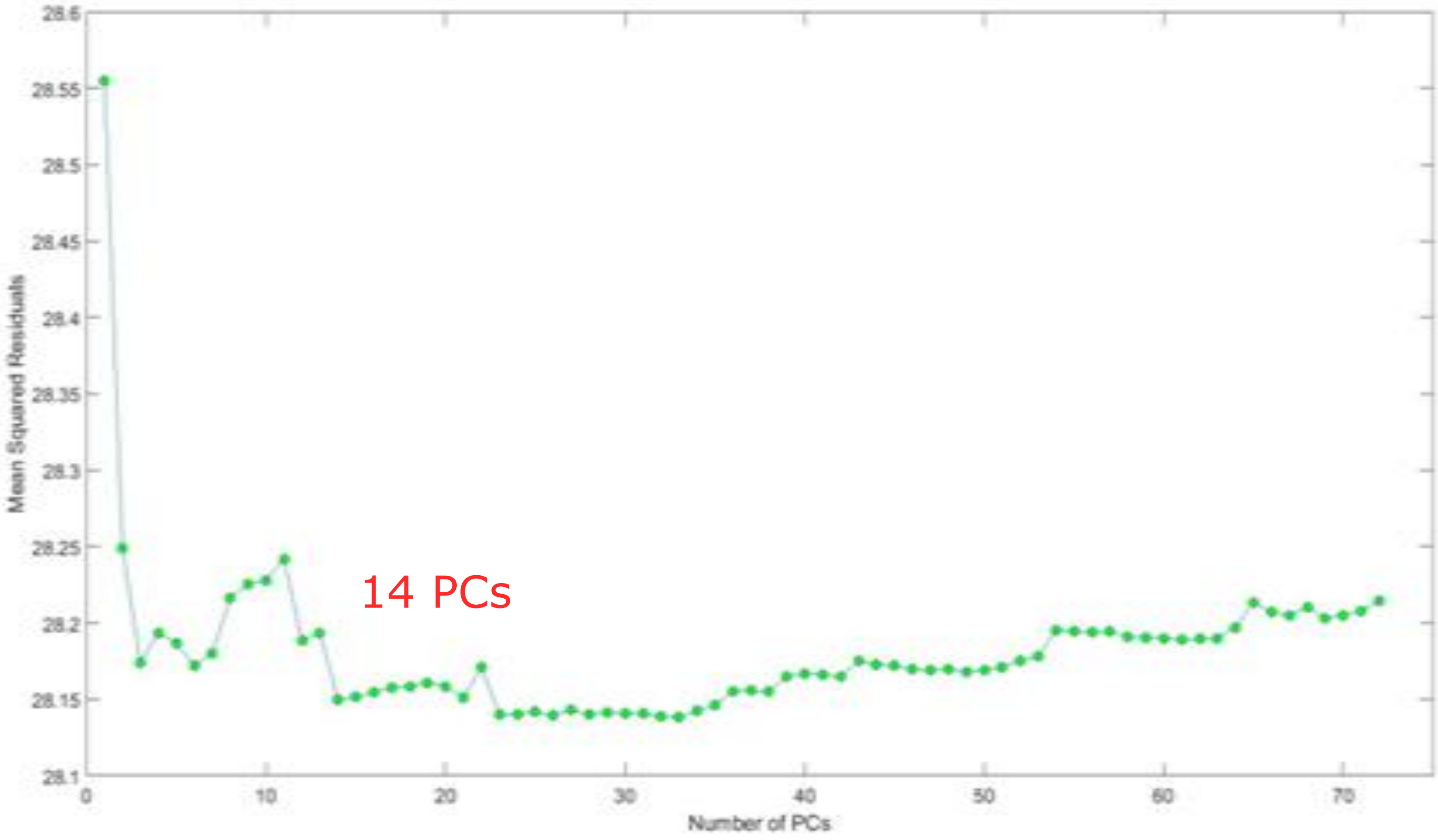
Chlorella sp. – principal component regression NO_3 3 PCs



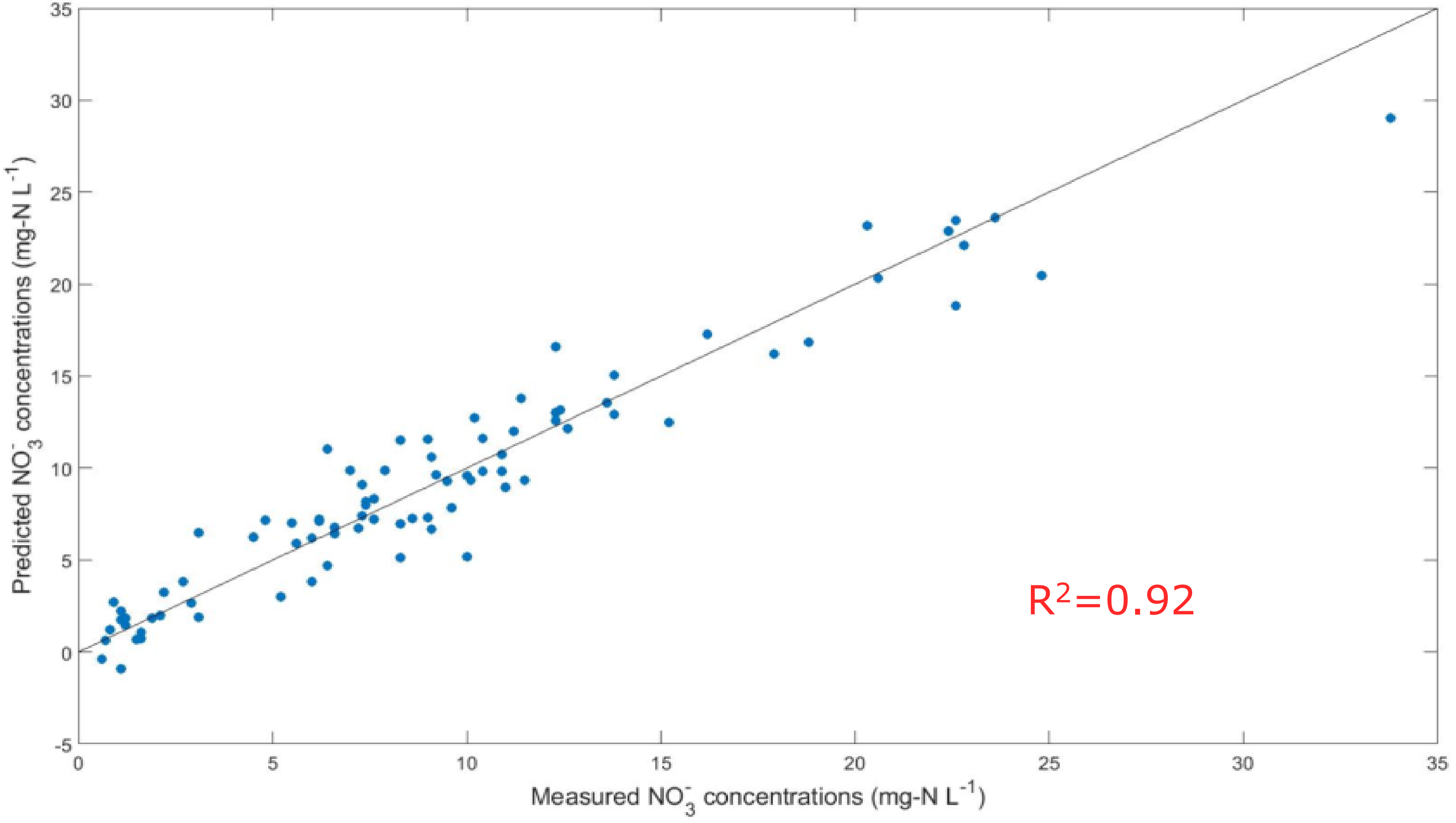
Chlorella sp. – principal component regression NO_3 3 PCs



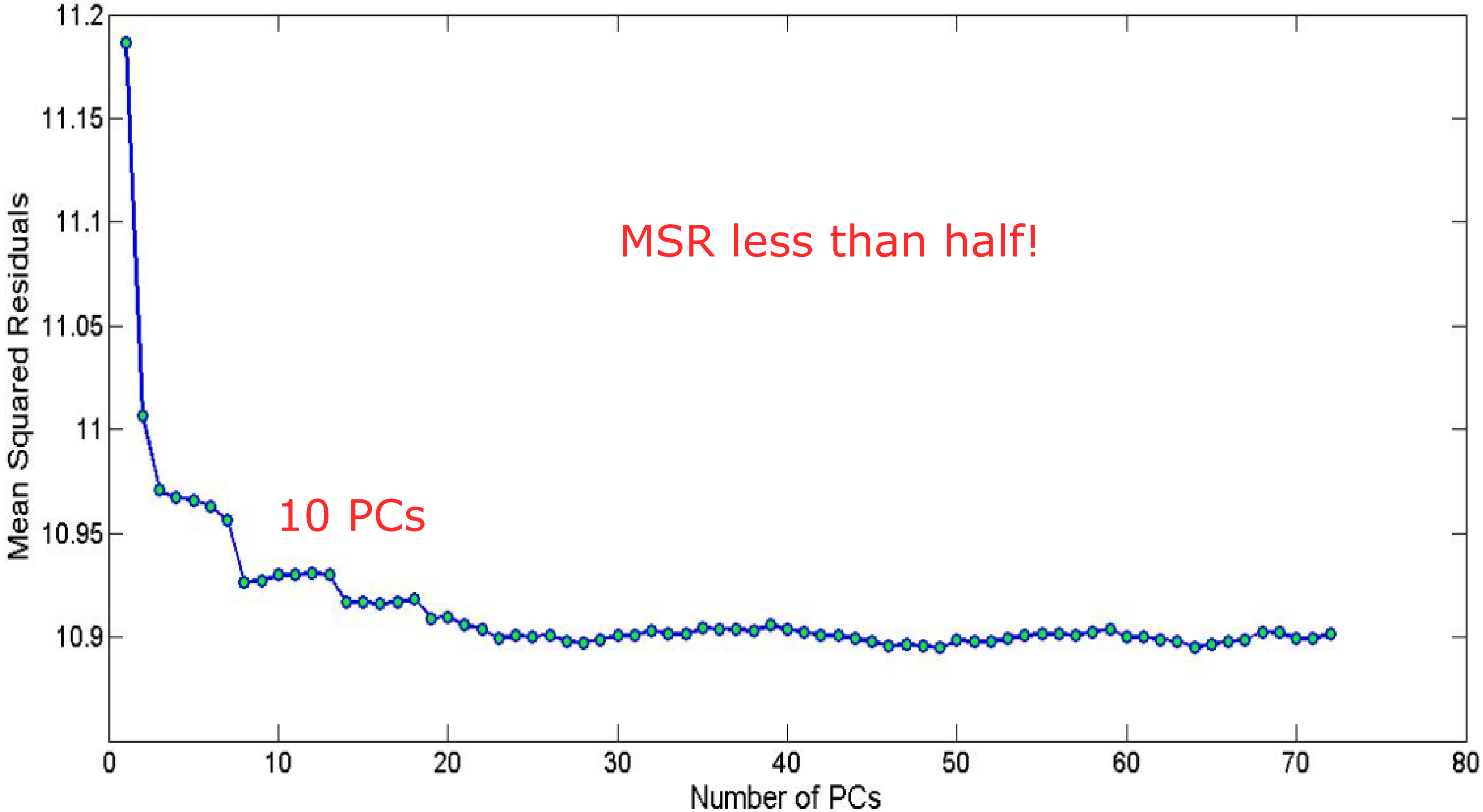
Chlorella sp. – leave one out cross validation NO_3



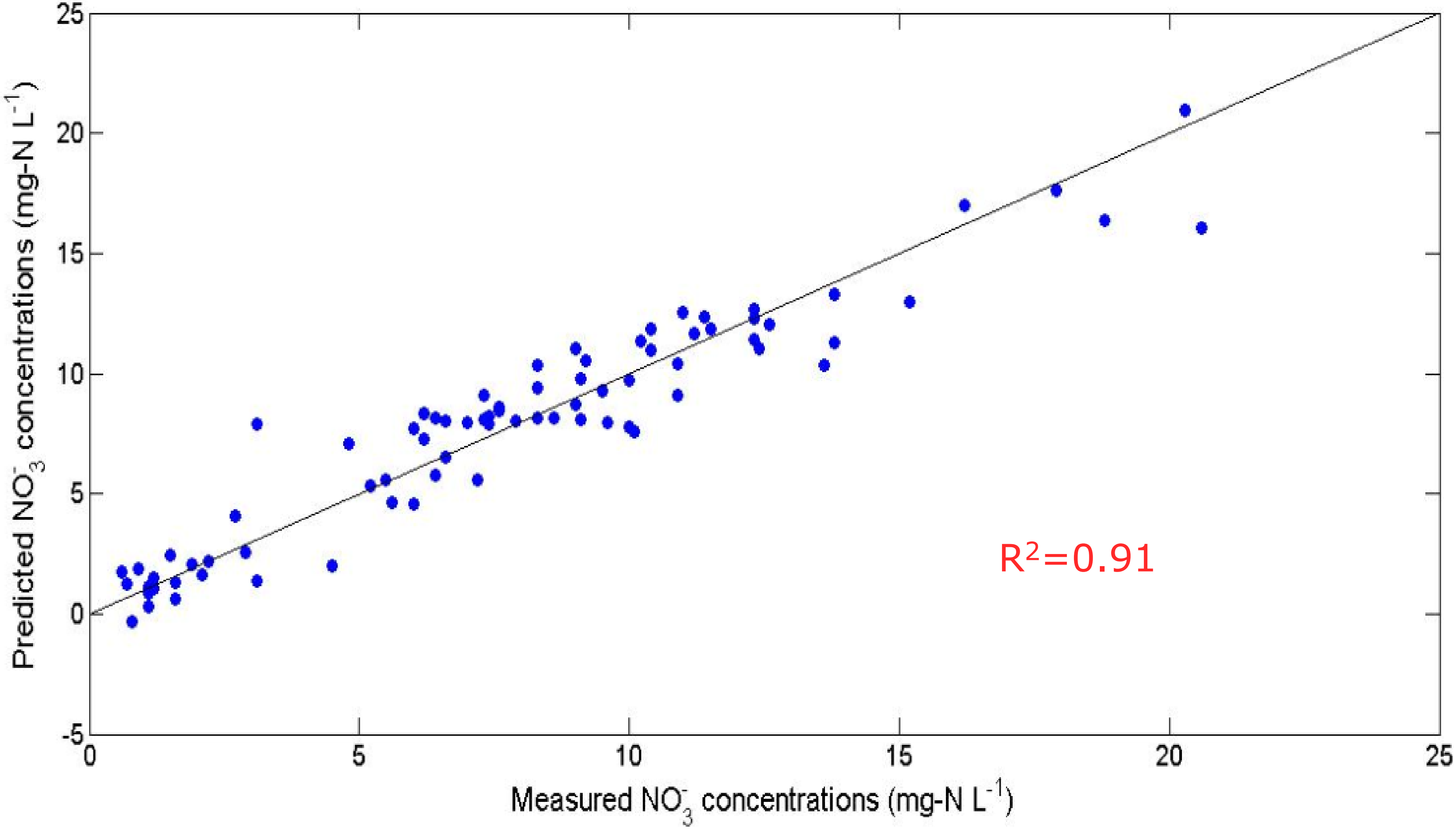
Chlorella sp. – principal component regression NO_3 14 PCs



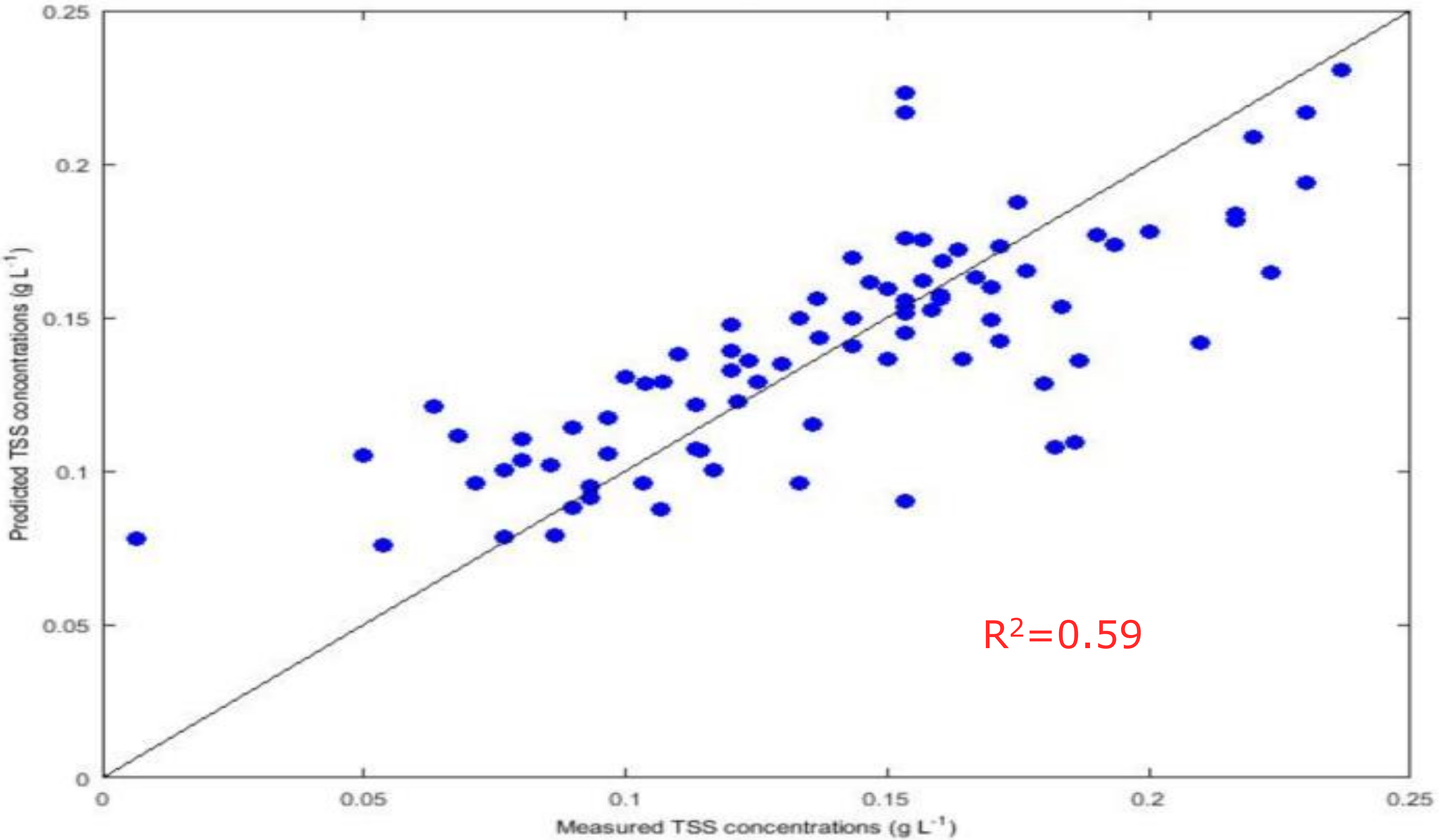
Chlorella sp. – leave one out cross validation NO_3 without saturation



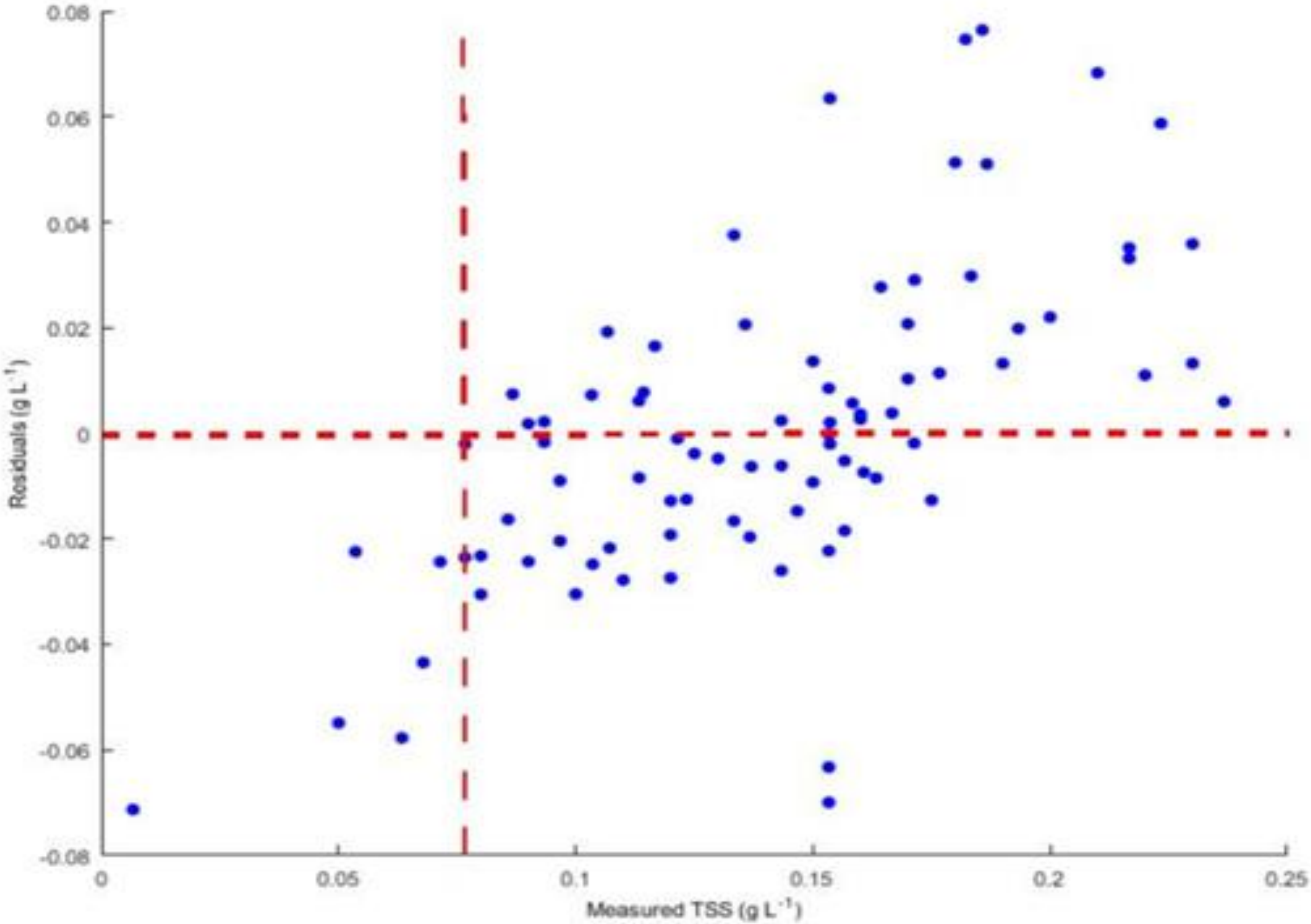
Chlorella sp. – principal component regression NO_3 10 PCs without saturation



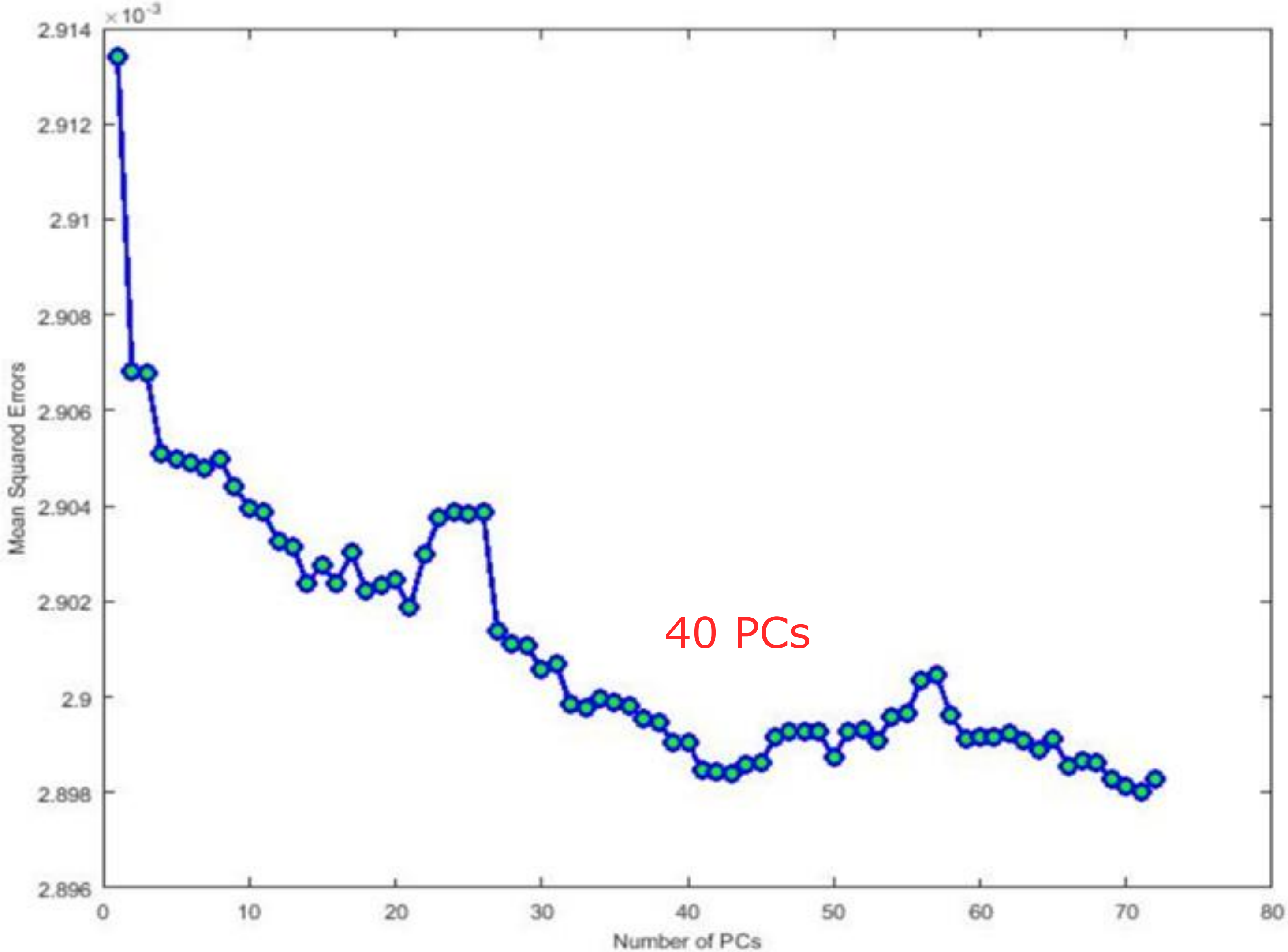
Chlorella sp. – principal component regression TSS 3 PCs



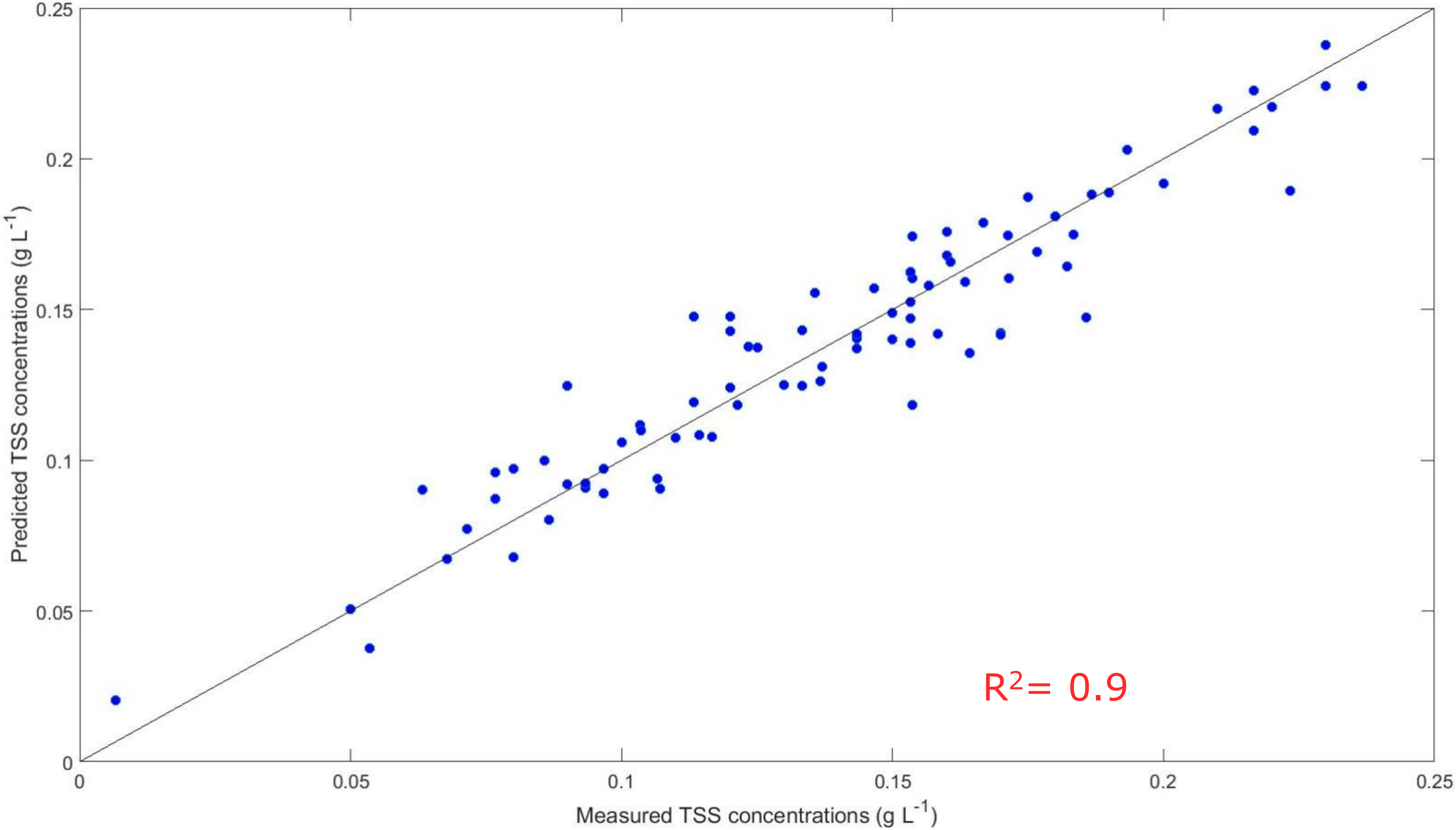
Chlorella sp. – principal component regression TSS 3 PCs



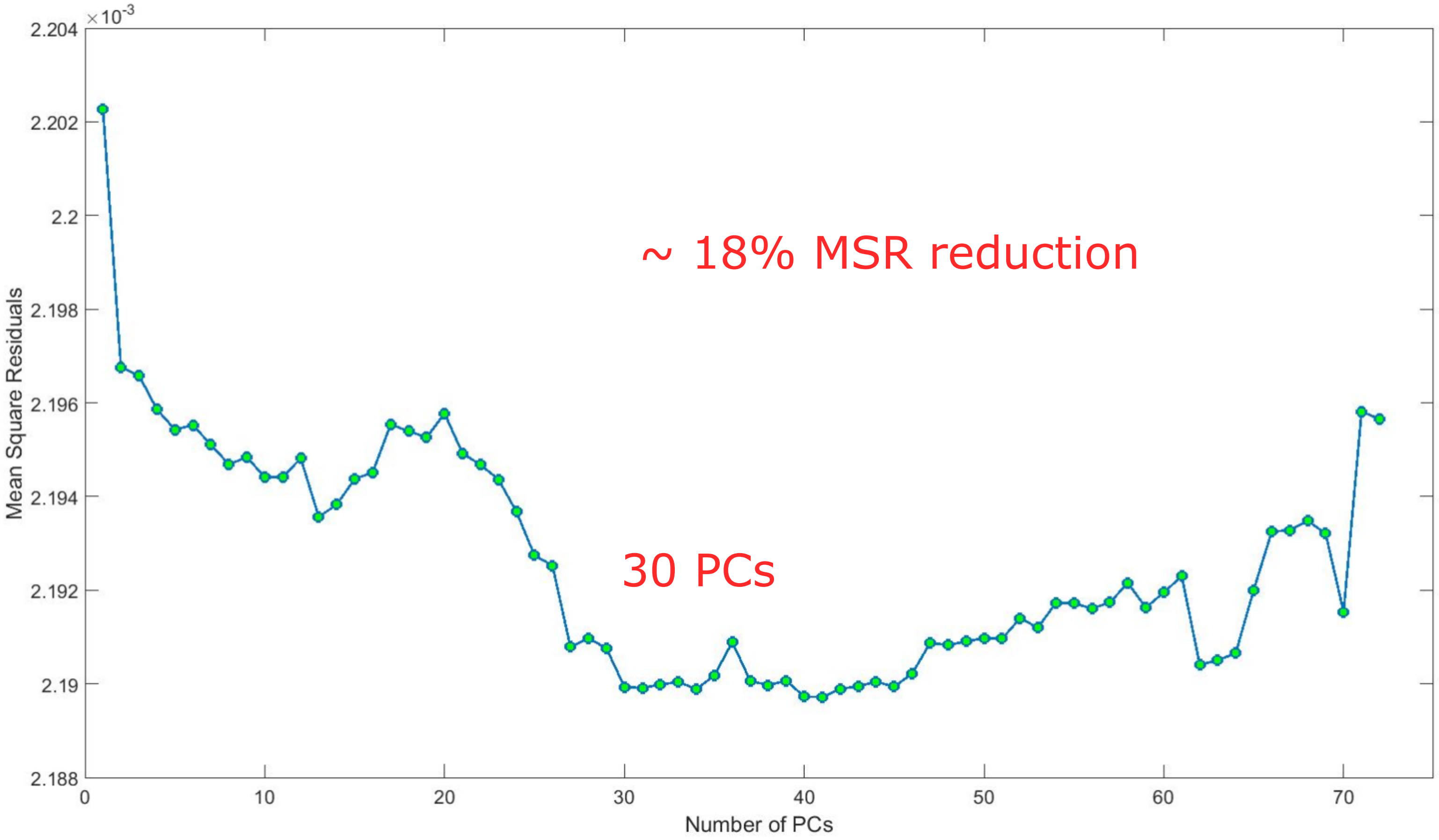
Chlorella sp. – leave one out cross validation TSS



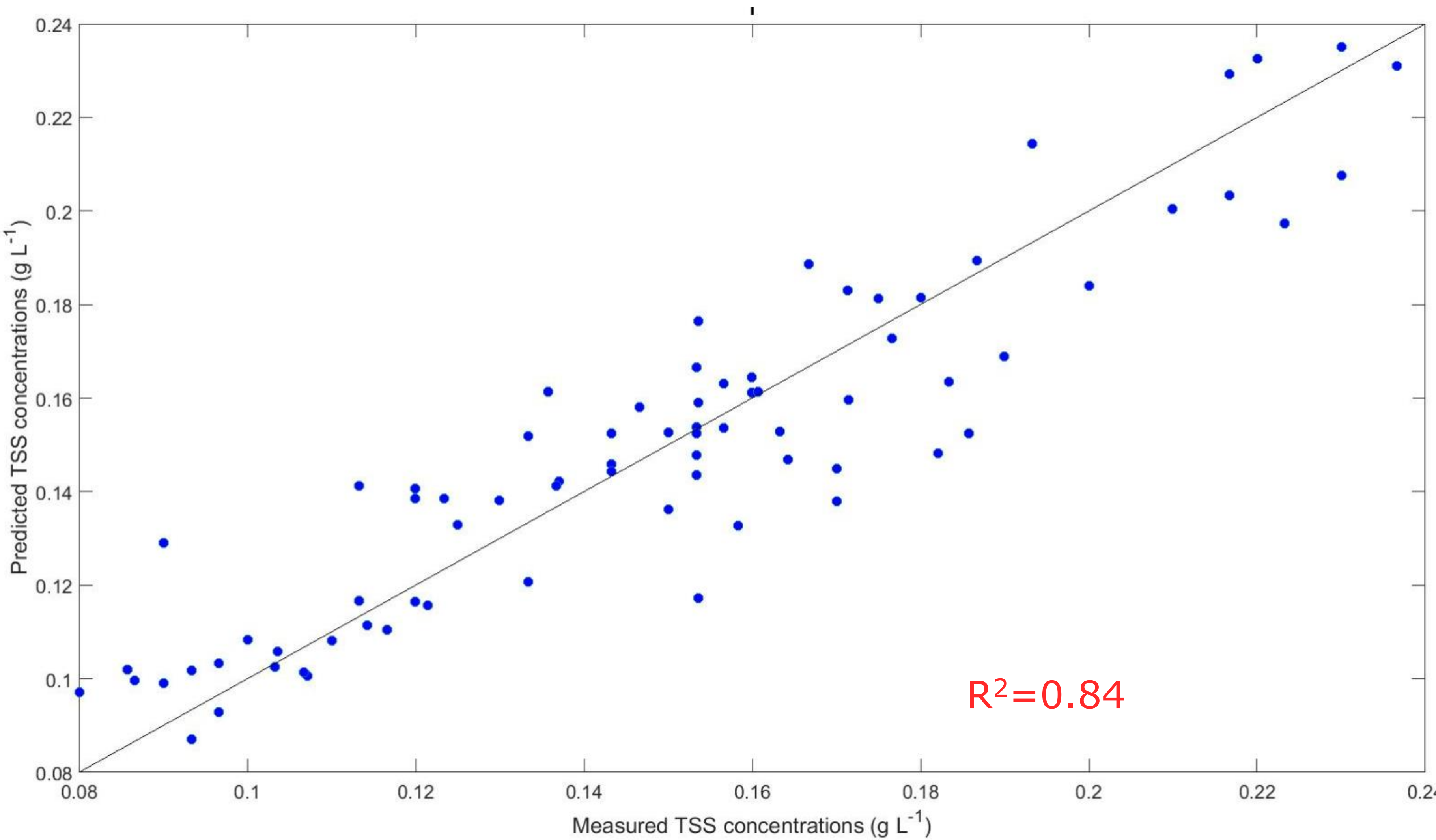
Chlorella sp. – principal component regression TSS 40 PCs



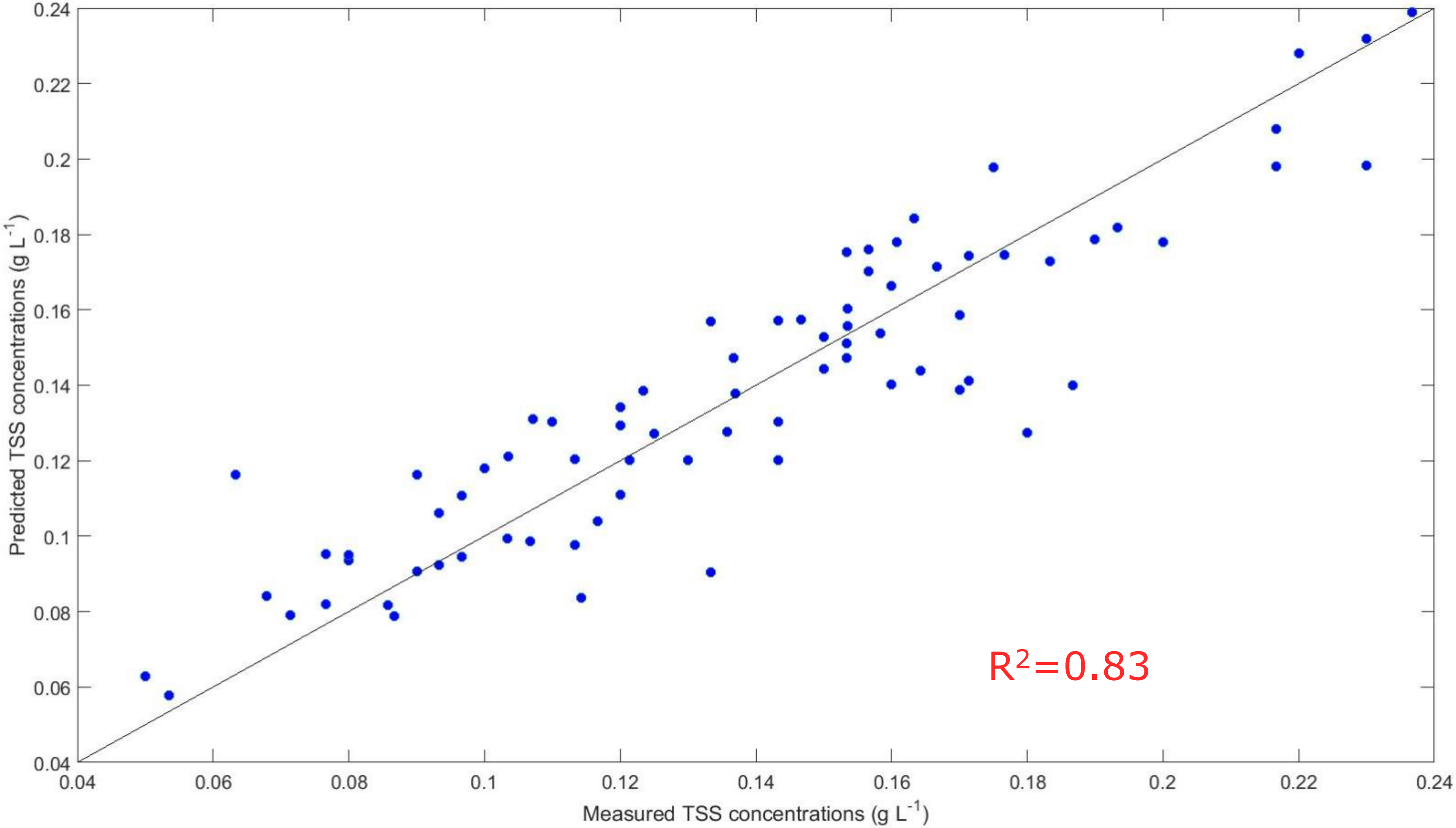
Chlorella sp. – leave one out cross validation TSS above detection limit



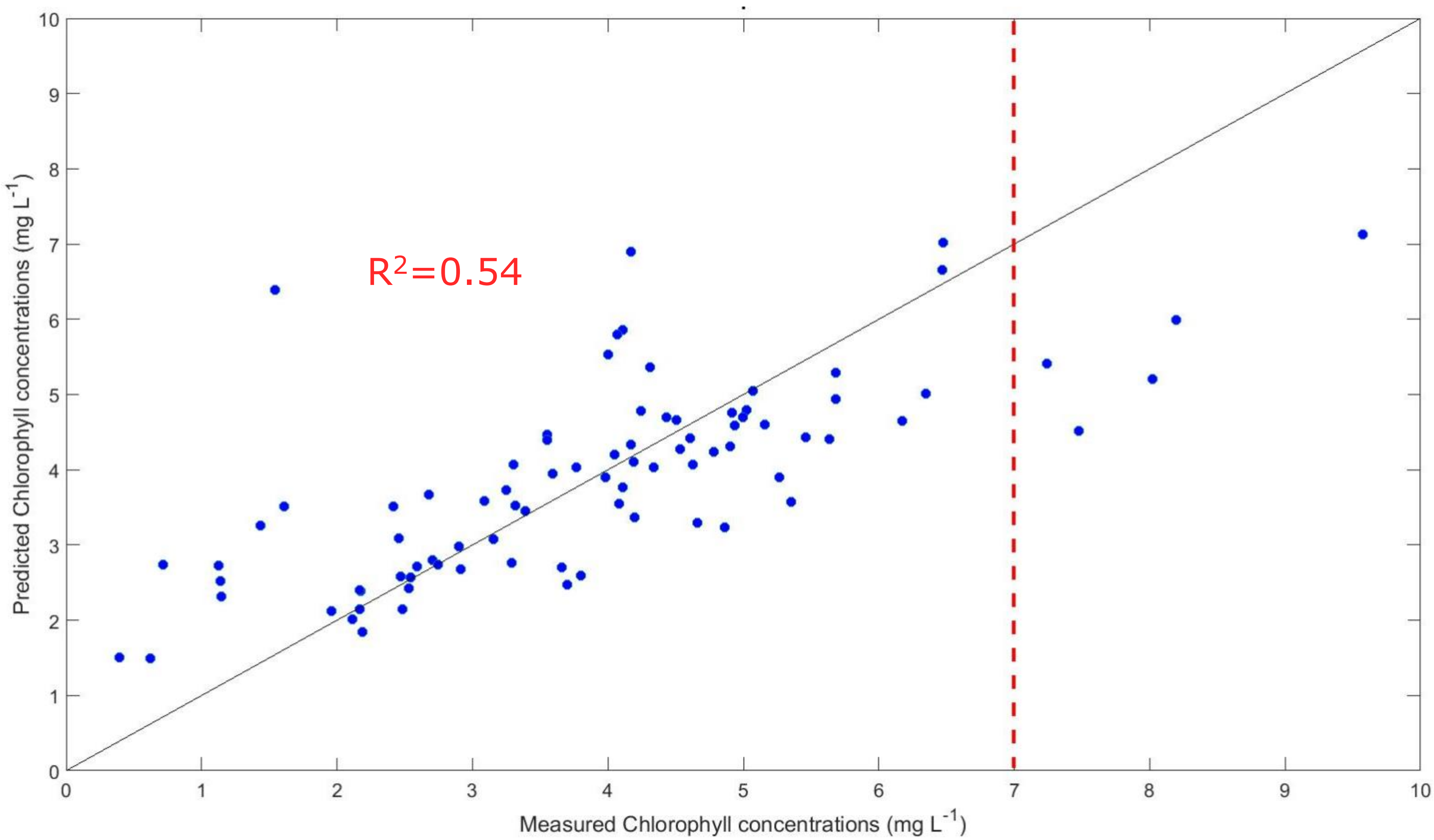
Chlorella sp. – principal component regression TSS 30 PCs above detection limit



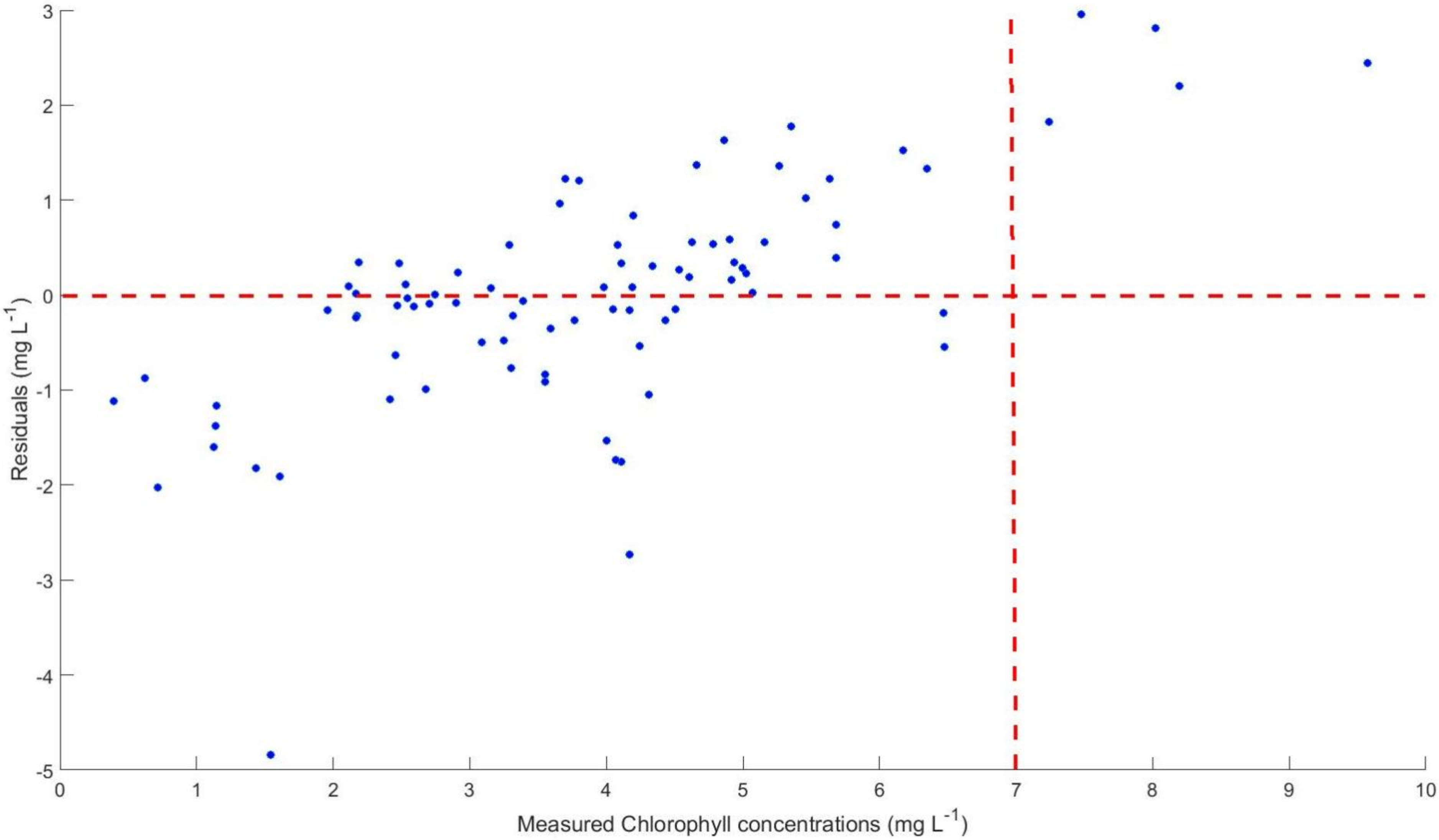
Chlorella sp. – principal component regression TSS 10 PCs outliers removed



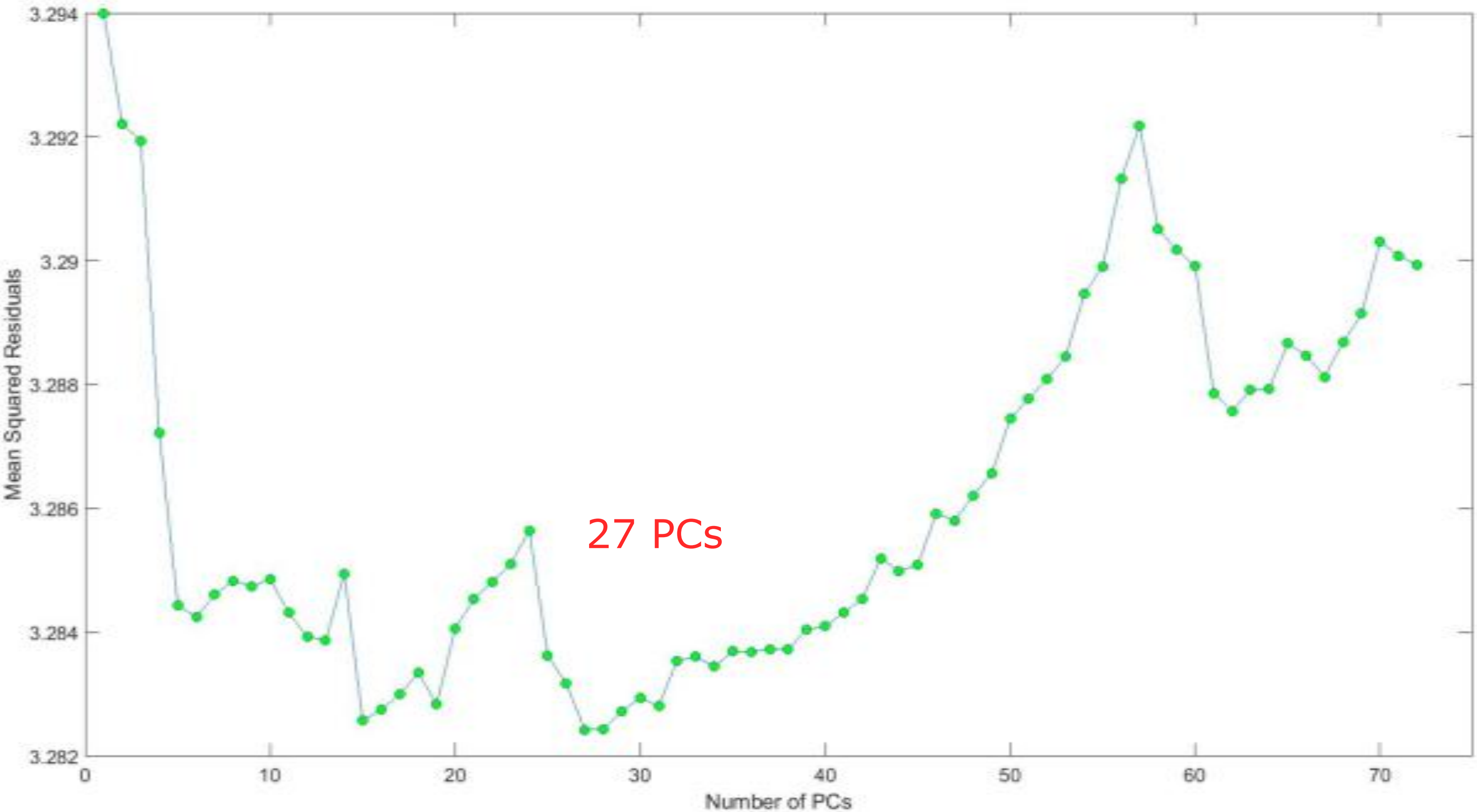
Chlorella sp. – principal component regression Chlorophyll 3 PCs



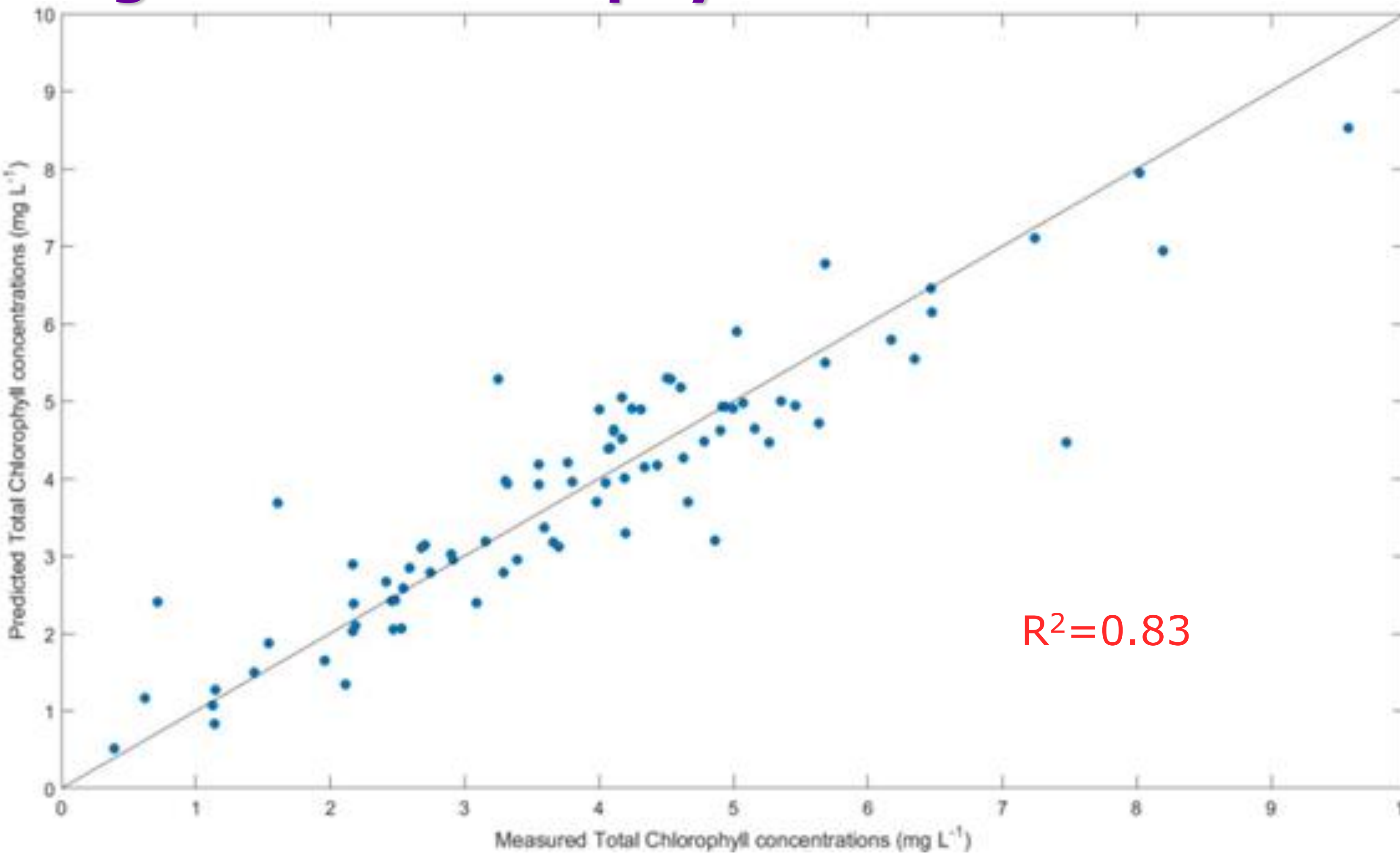
Chlorella sp. – principal component regression Chlorophyll 3 PCs



Chlorella sp. – leave one out cross validation Chlorophyll

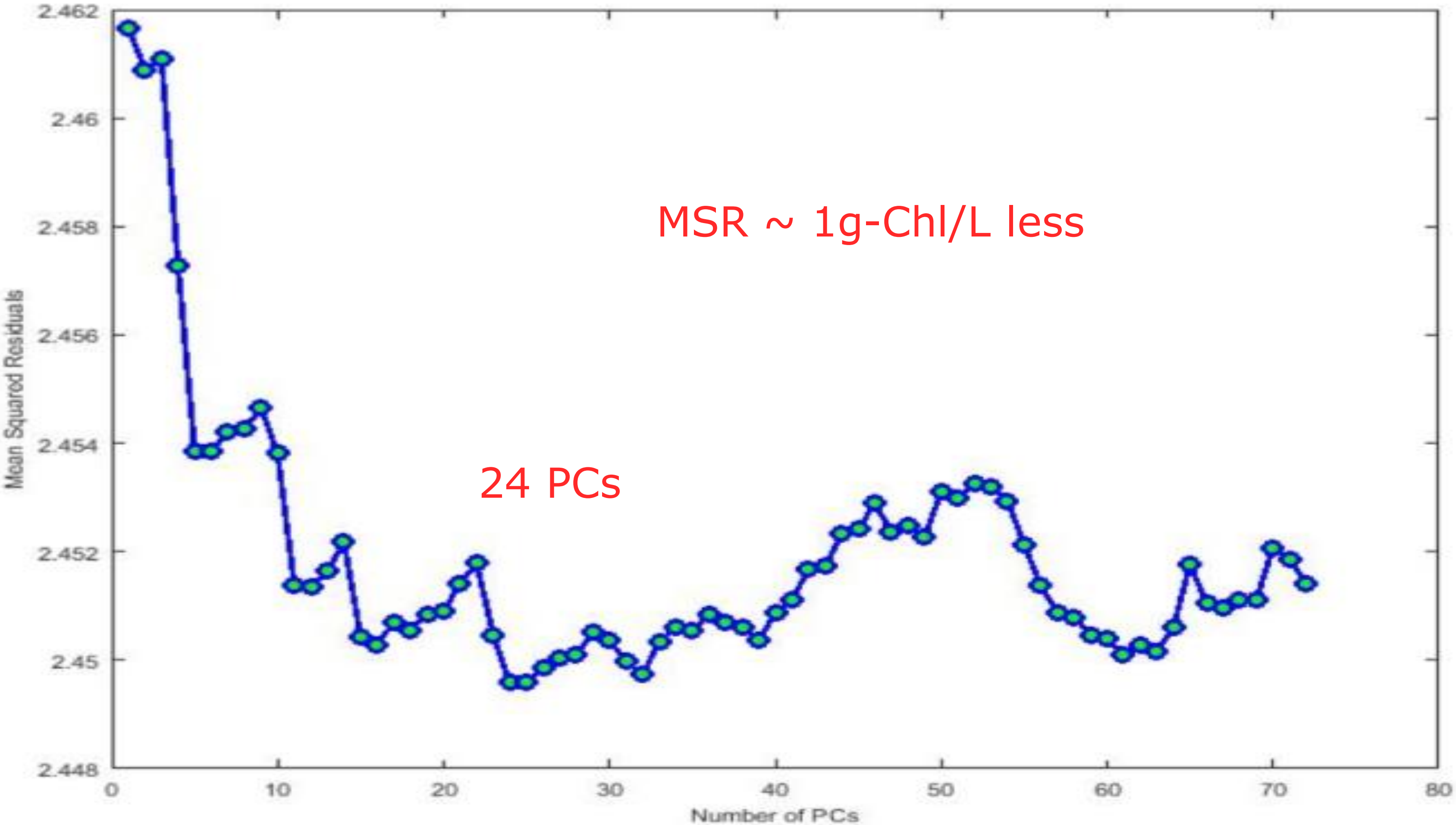


Chlorella sp. – principal component regression Chlorophyll 27 PCs

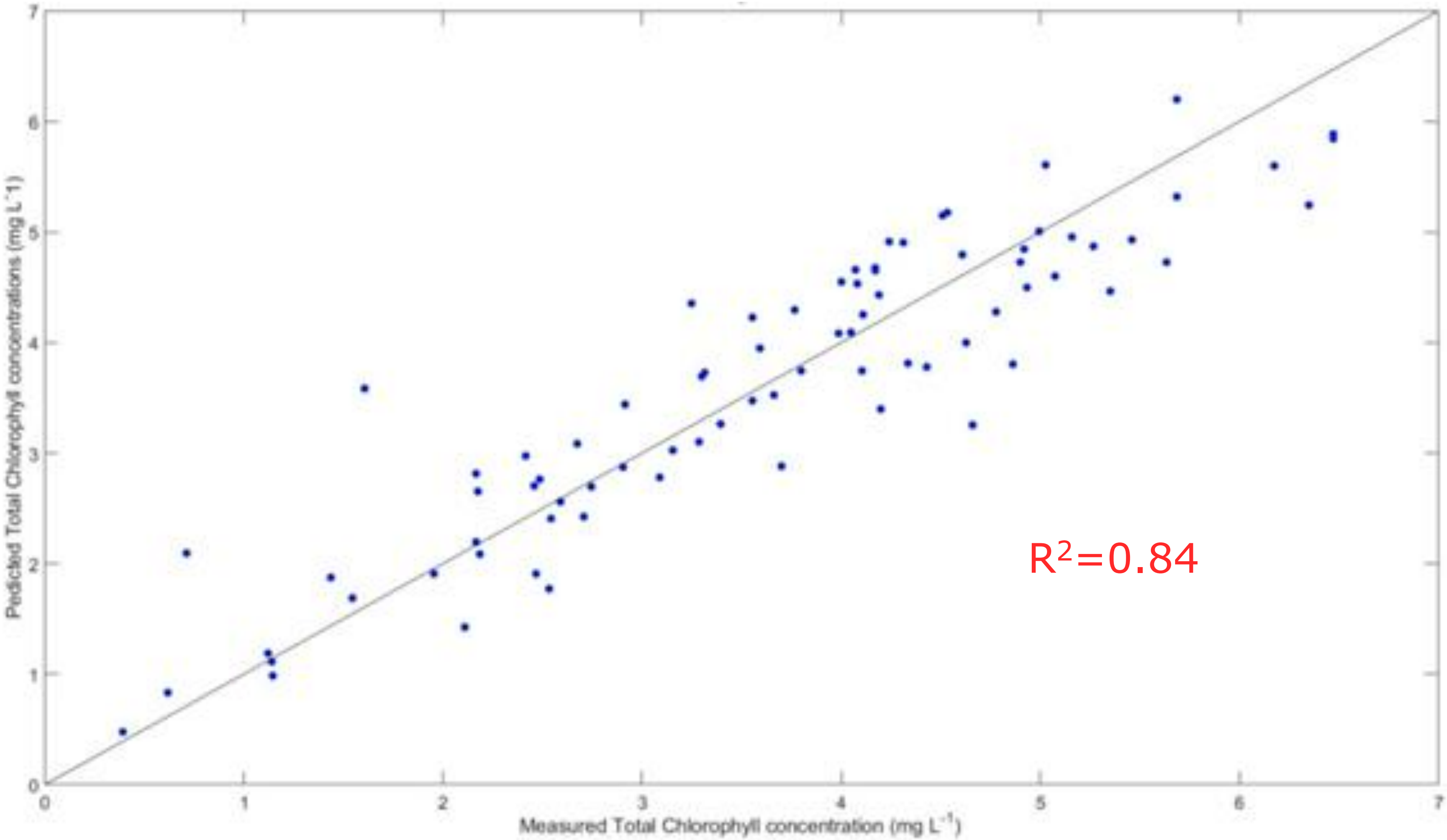


R^2=0.83

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



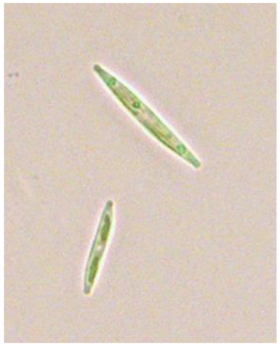
Chlorella sp. – principal component regression Chlorophyll 24 PCs without saturation

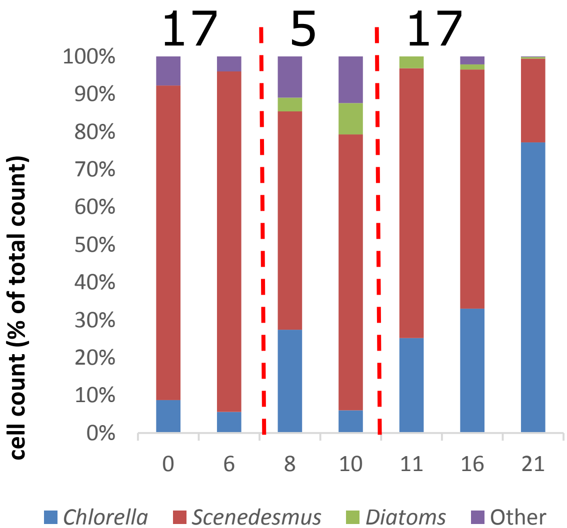


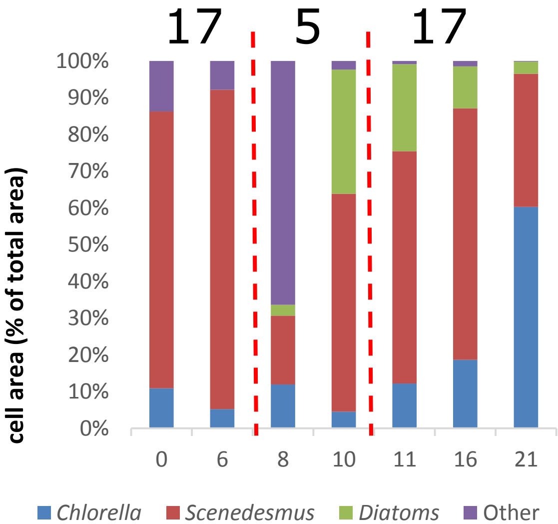
$R^2=0.84$

Variation in microbial diversity

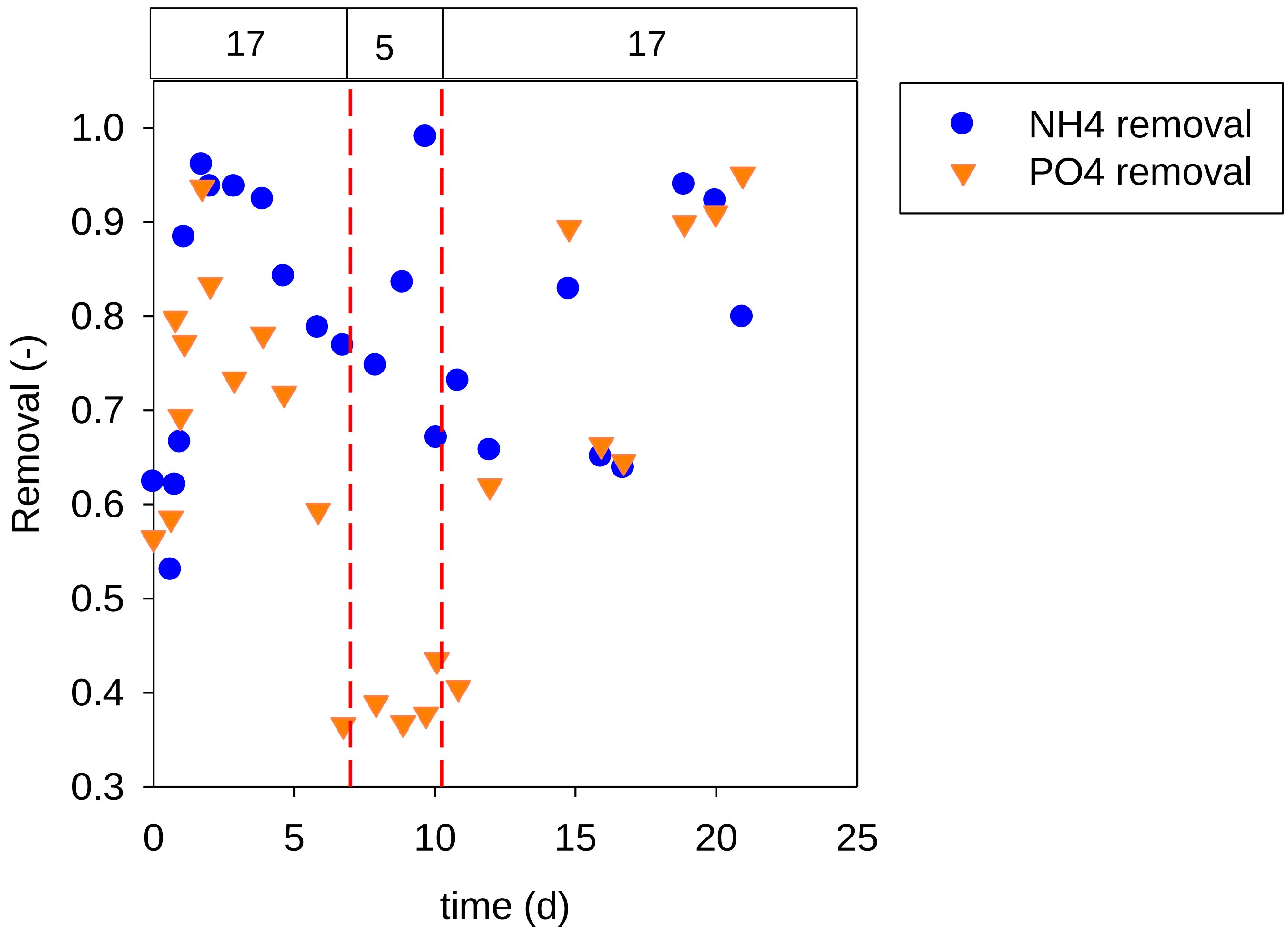
- Contamination by diatoms when N-to-P is lowered to 5
- Washout of diatoms when N-to-P is set back to 17
- Change in abundance of *Chlorella* and *Scenedesmus* sp.
- <u>Hypothesis to test:</u>
  - **Do changes on shape and size affect the prediction capacity by UV-Vis sensors?**



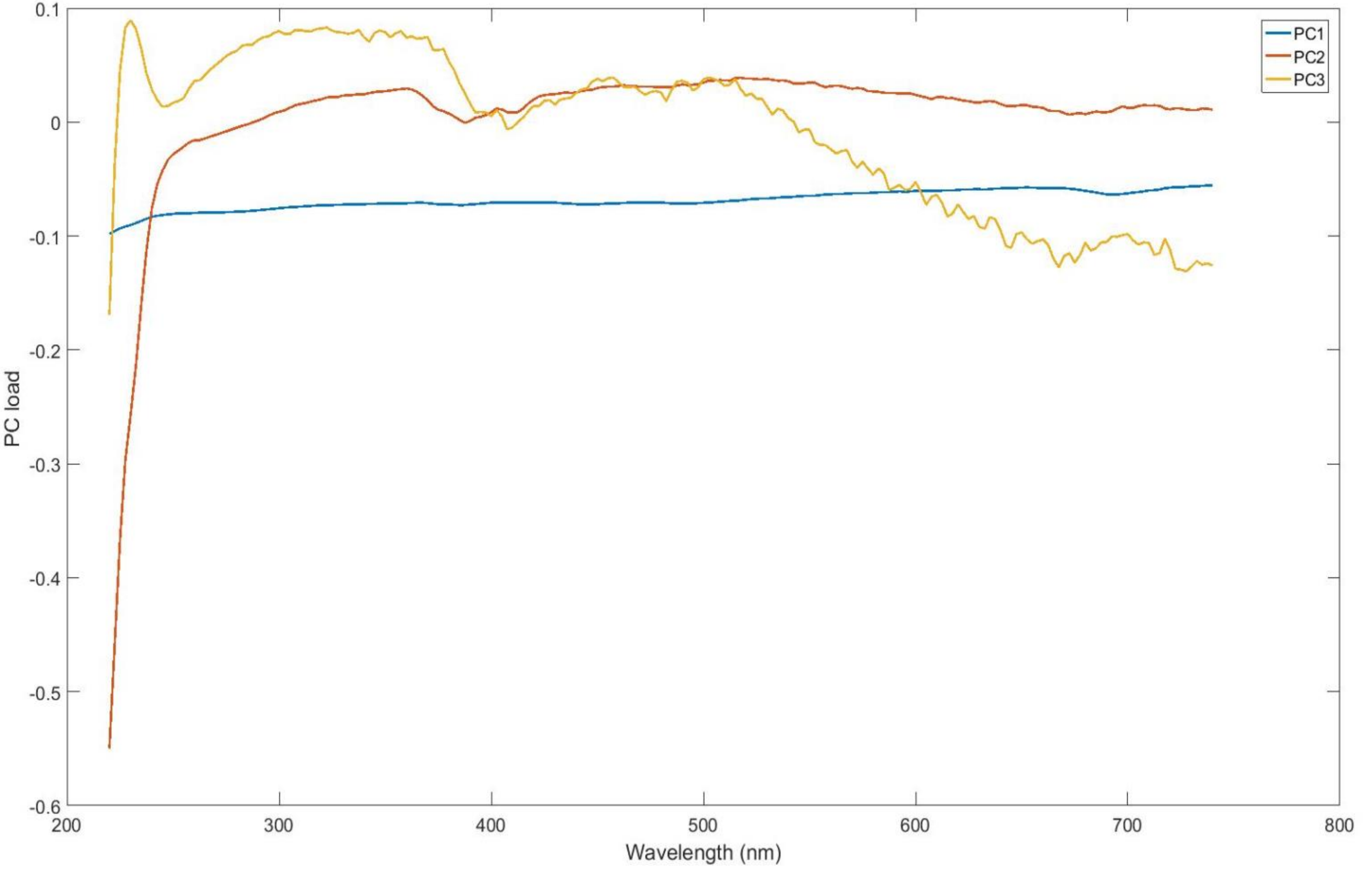




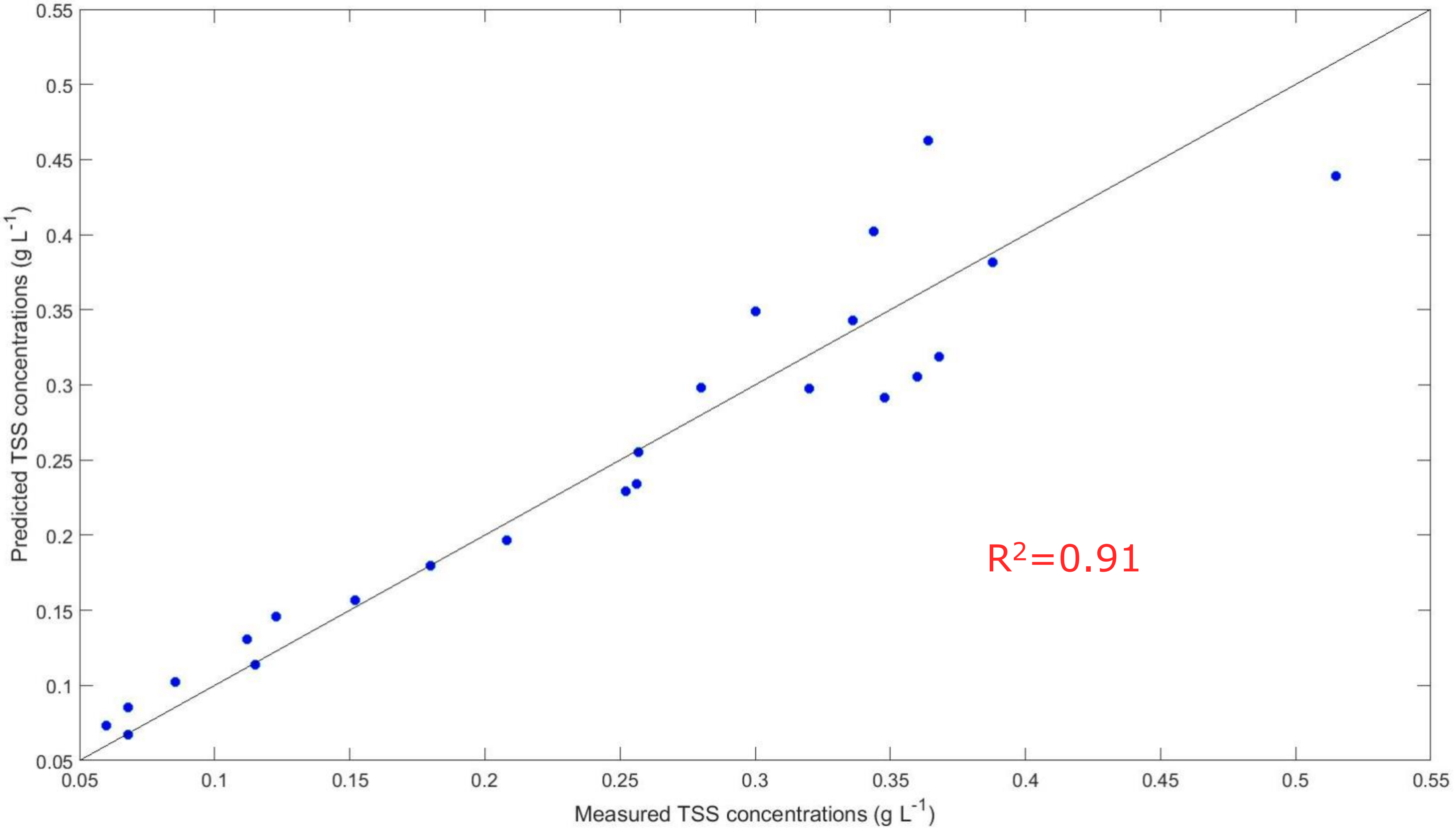
Mixed culture – process performance



Mixed culture – principal component analysis

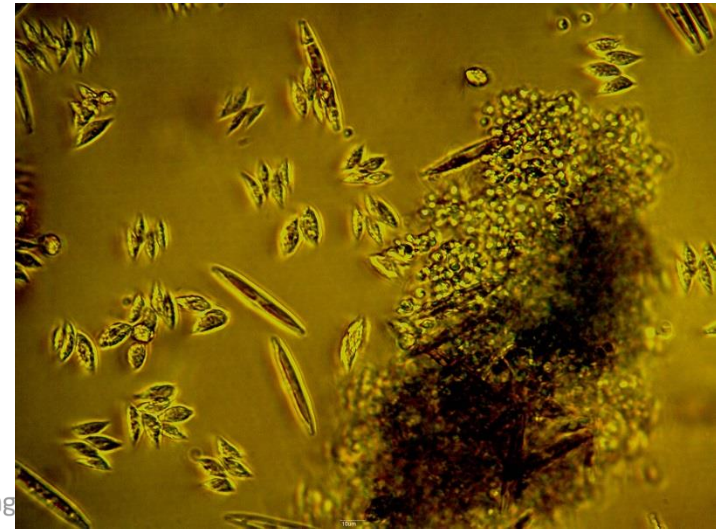


Mixed culture – principal component regression TSS 1 PC



Concluding Remarks

- <u>Monoculture</u>
  - More complex models required to predict data “out of range”
  - Successful predictive models were built for nitrate, suspended solids and chlorophyll
- <u>Mixed culture</u>
  - Very simple model succesfully predicted the TSS despite contamination in the reactor.



Acknowledgements

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