

UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

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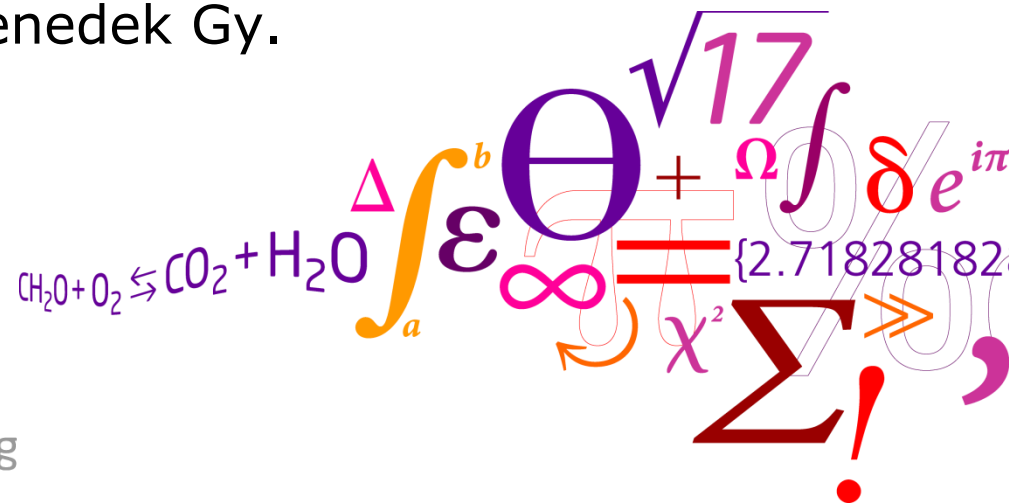
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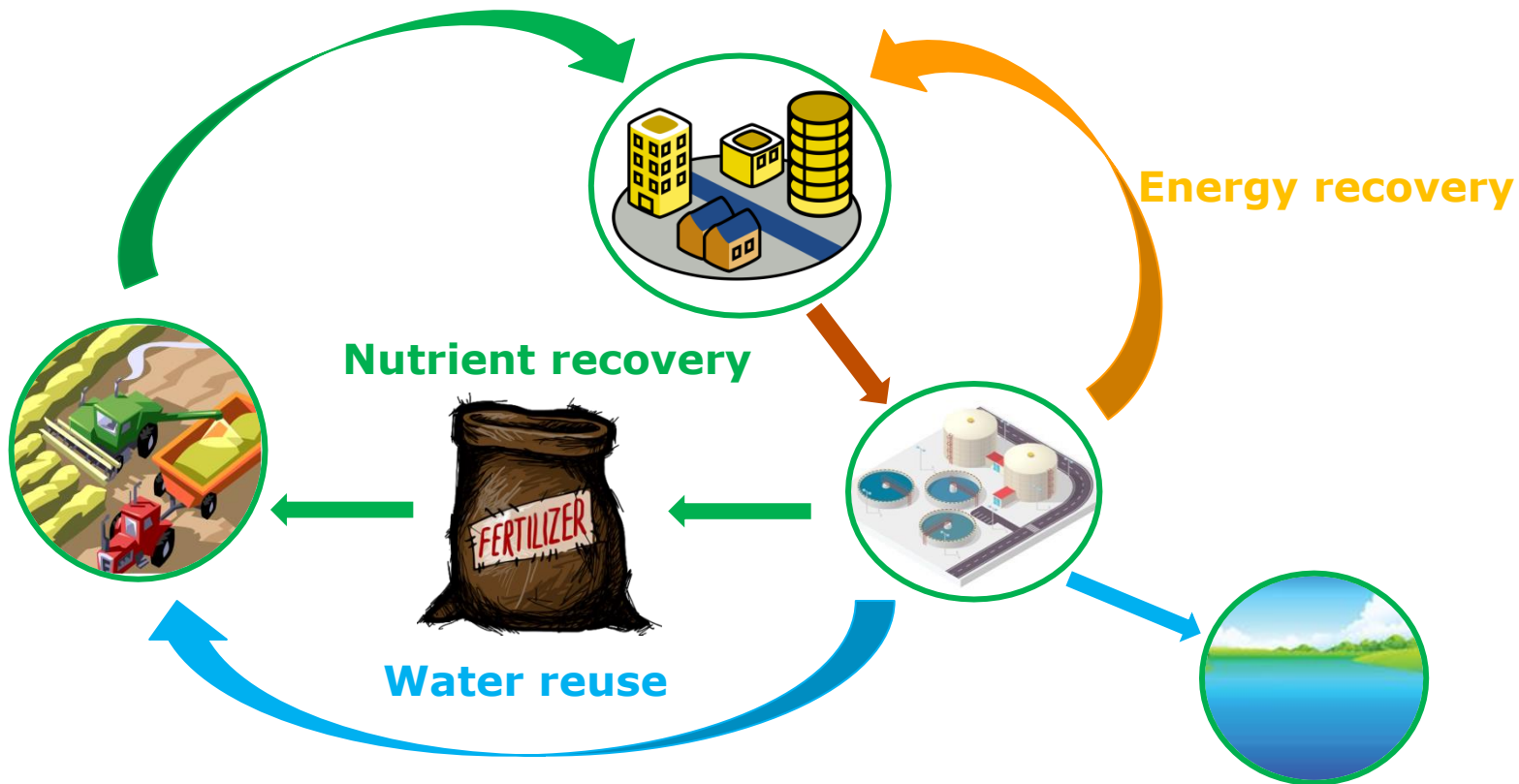
UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors

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



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

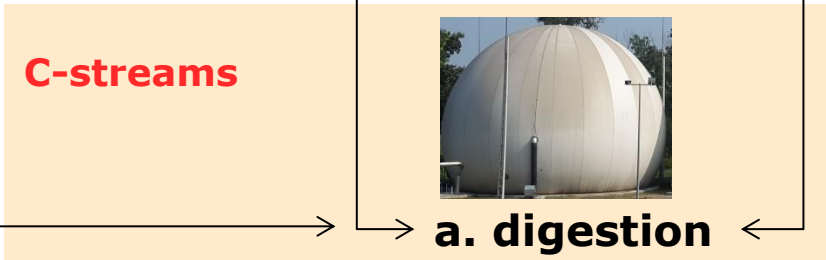
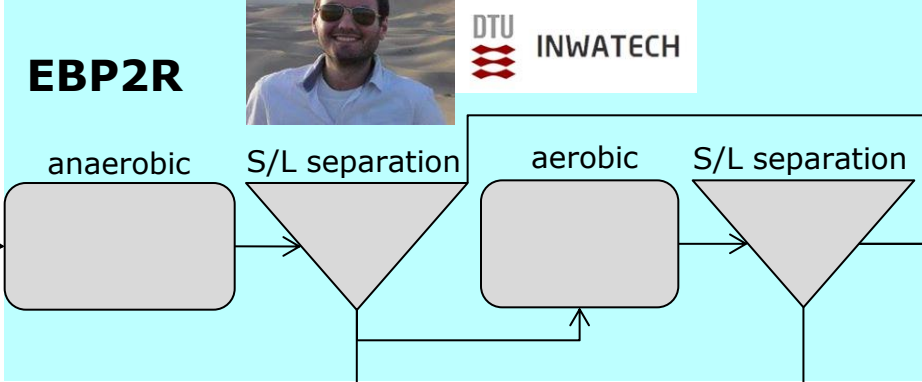


TRENS – Biochemical Resource Recovery



C N P
sewage

Primary
treatment



P-stream

N-stream

stream
excess N

Photobioreactor



freshwater



algal
biomass



CANR

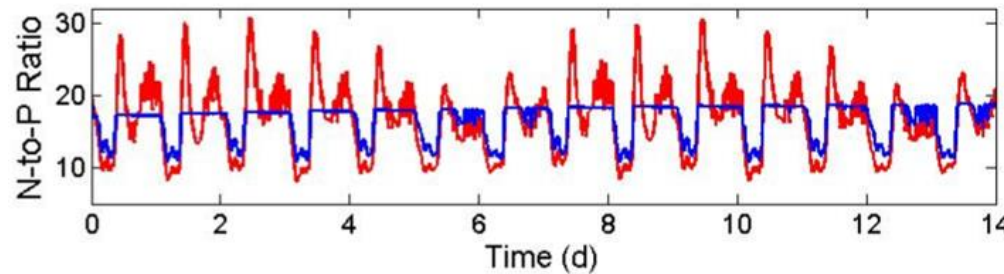
Discharge into
recipient water
body

End use:

- ✓ Fertigation
- ✓ Biogas production



Experimental set up and operation

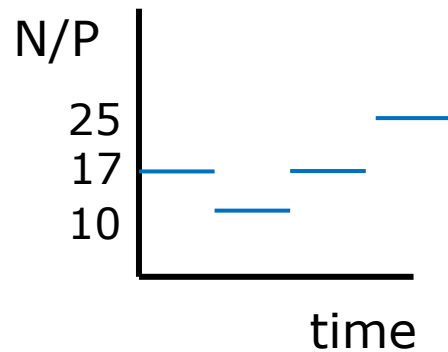
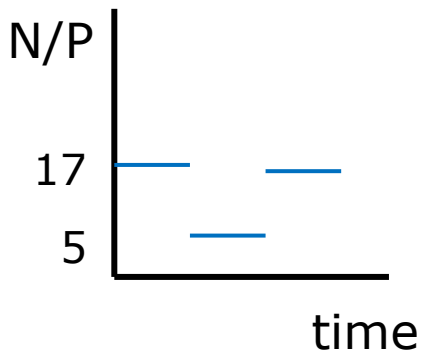


Valverde-Pérez et al., 2016

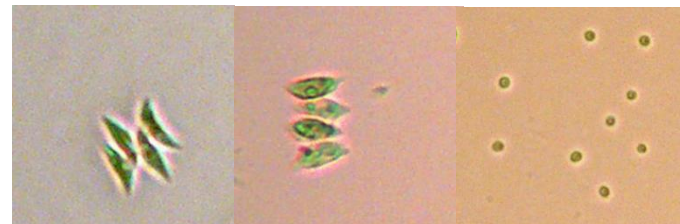
- The effect of the variation of N-to-P ratio is tested – fed with treated municipal wastewater
- Mixed consortium and mono-culture
- Open system

Mixed consortium

Mono-culture

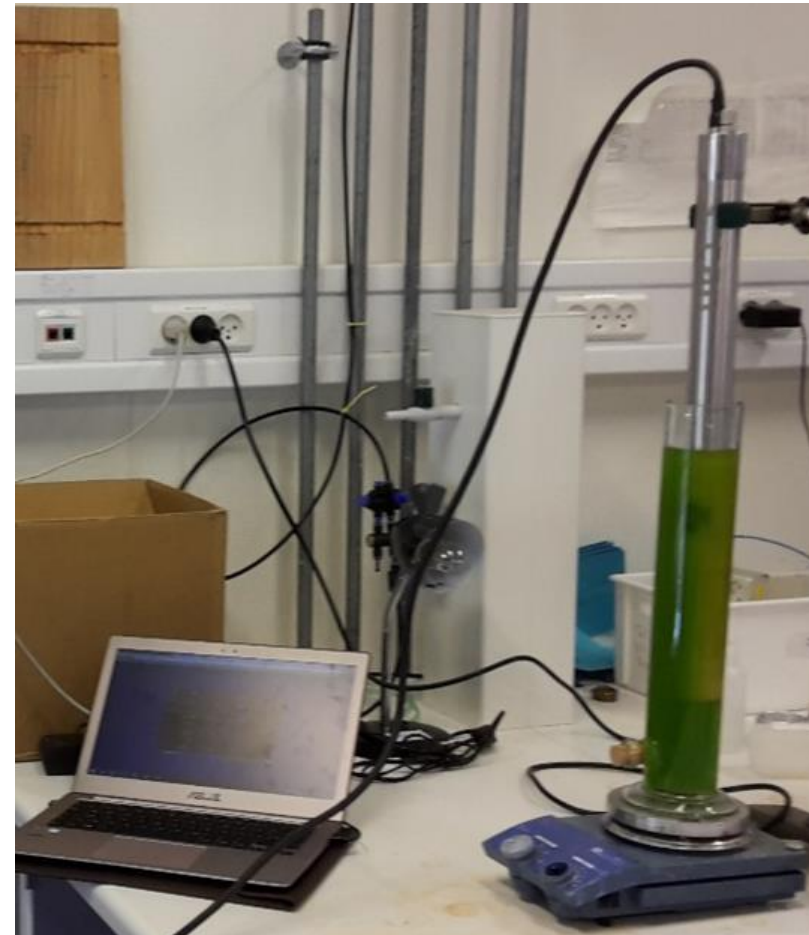


Wágner et al., 2017



Analytical procedure

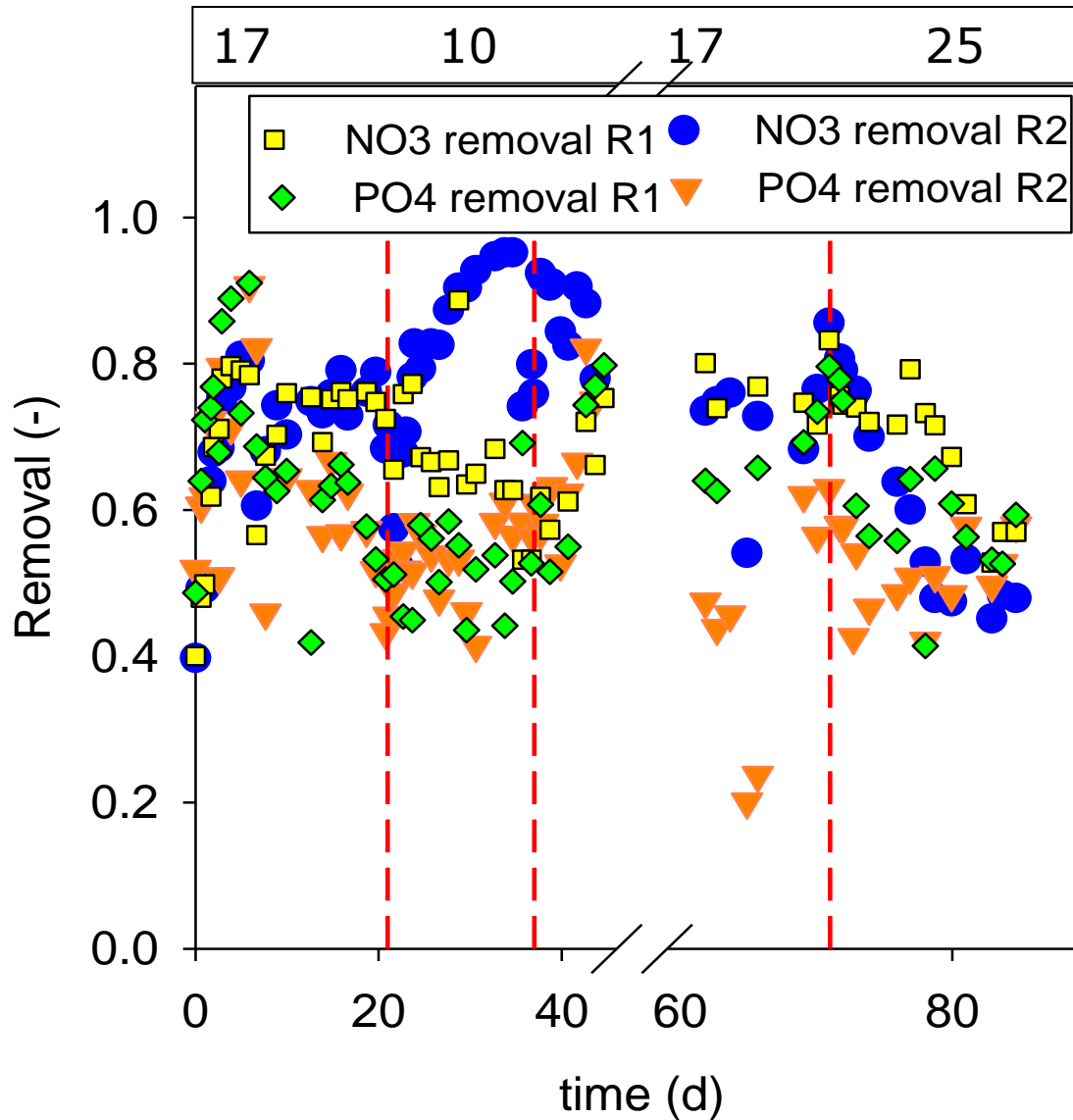
- Total suspended solids
- Nitrate
- Pigments: chlorophyll, lutein, β -carotene and violaxanthin
- Nitrite
- Phosphate
- Stored nutrients
- Microbial diversity
 - Based on morphology of the different species
 - Using microscopy



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

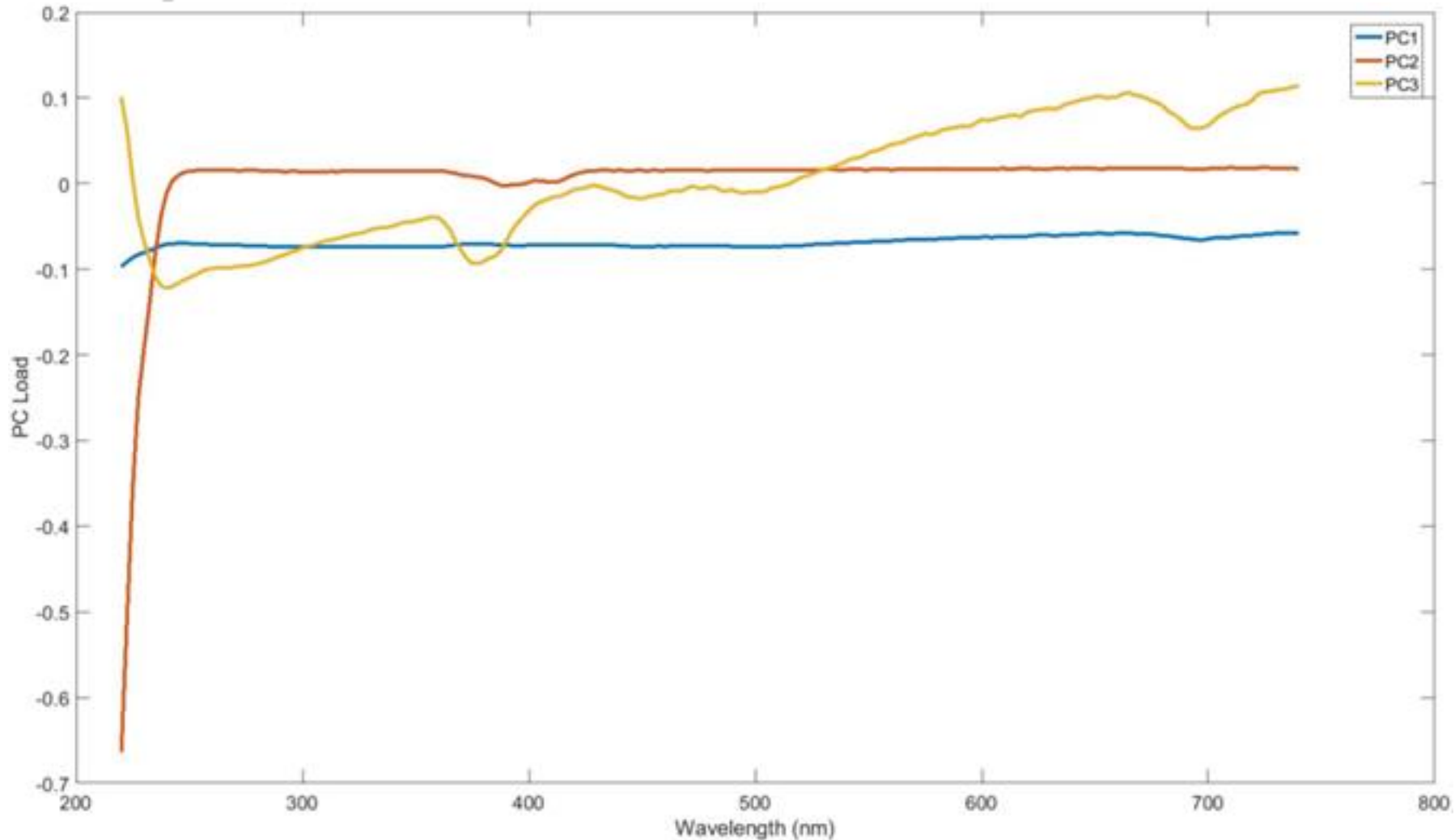
Chlorella sp. – process performance



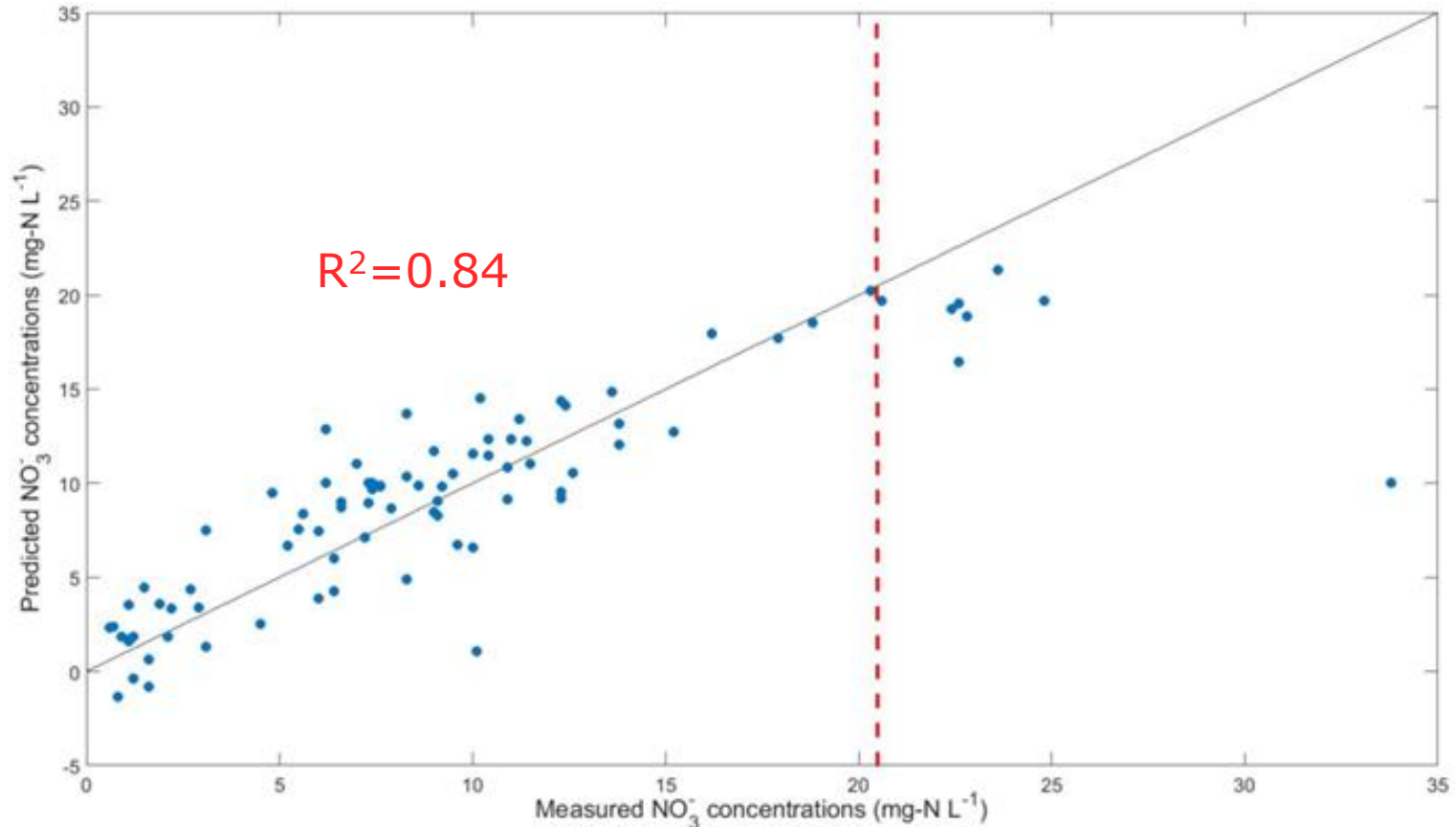
R1 – control

R2 – test

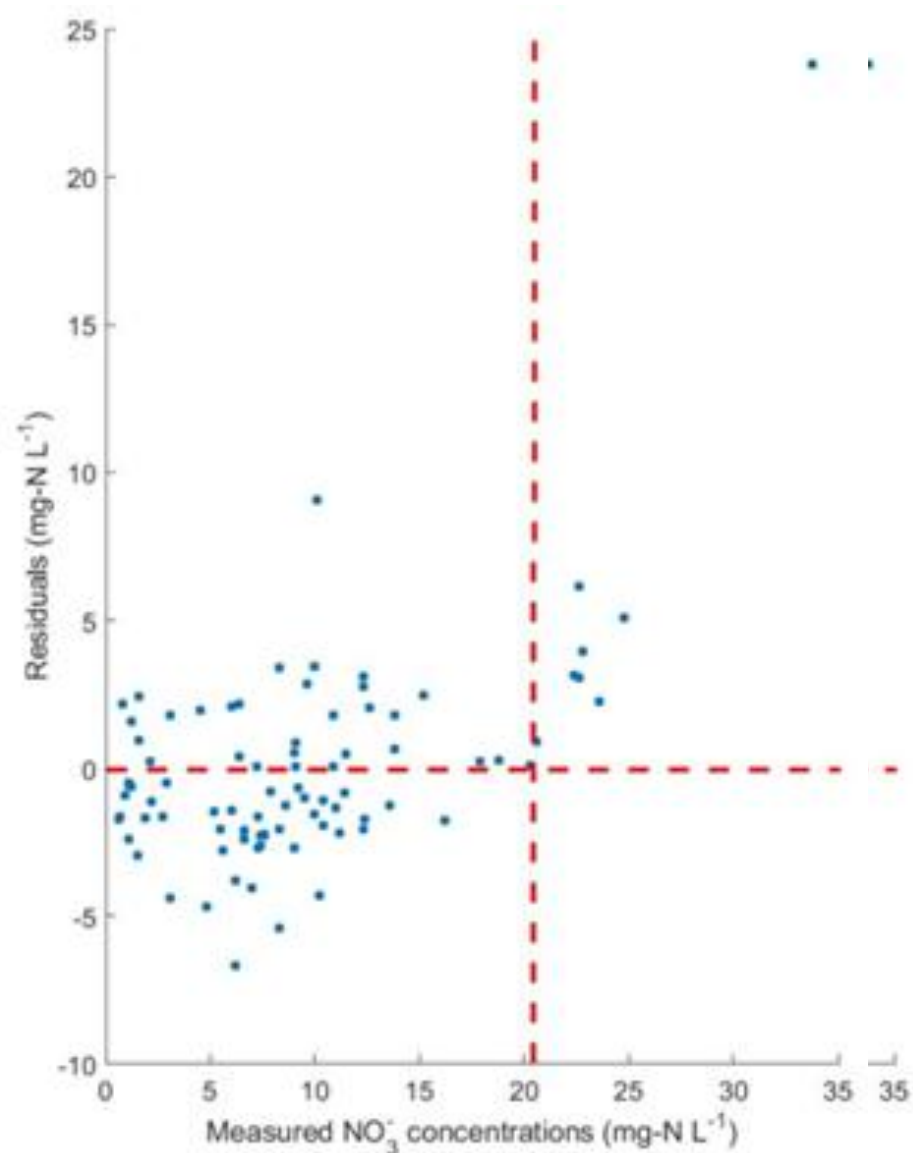
Chlorella sp. – principal component analysis



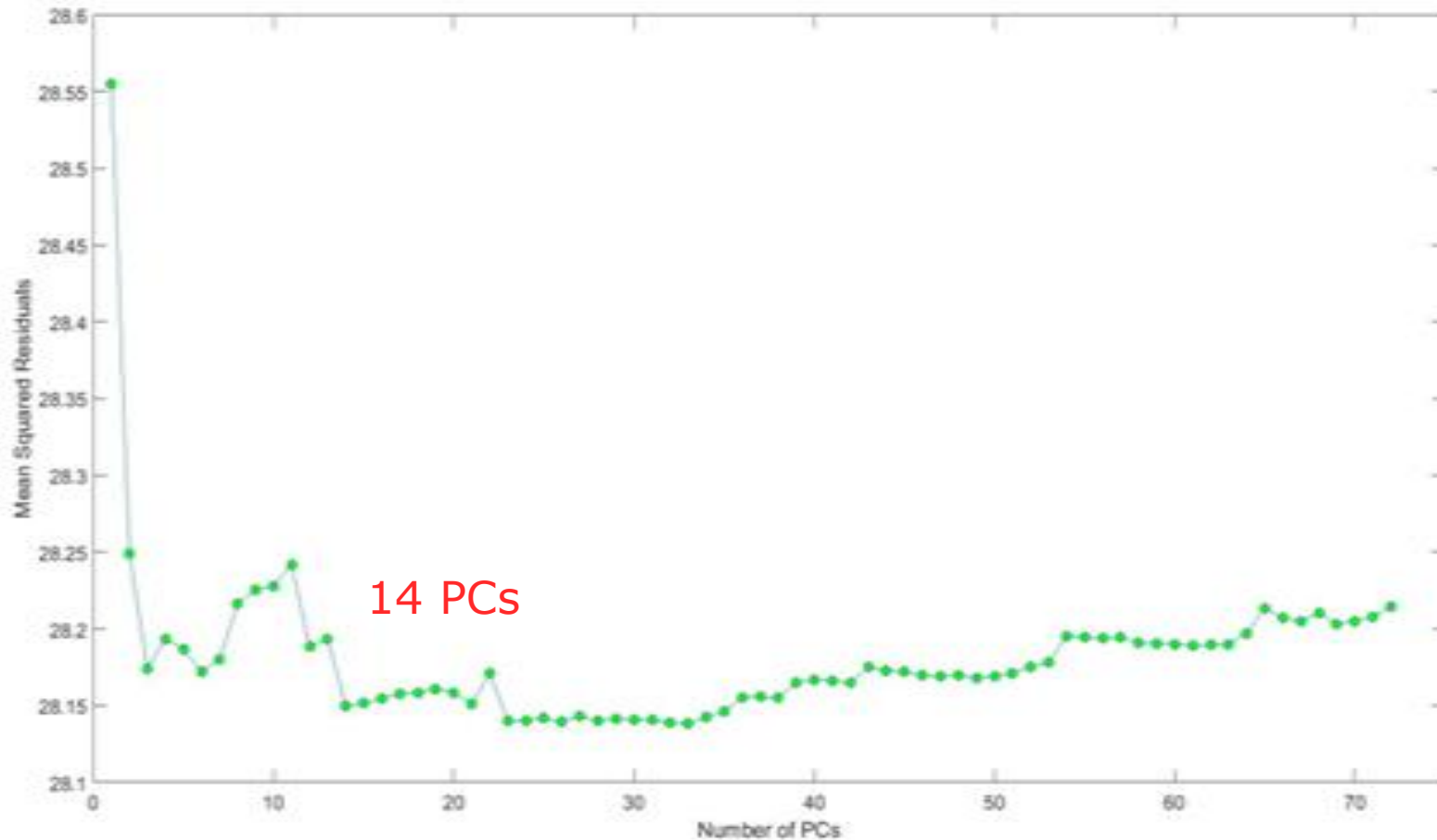
Chlorella sp. – principal component regression NO_3^- 3 PCs



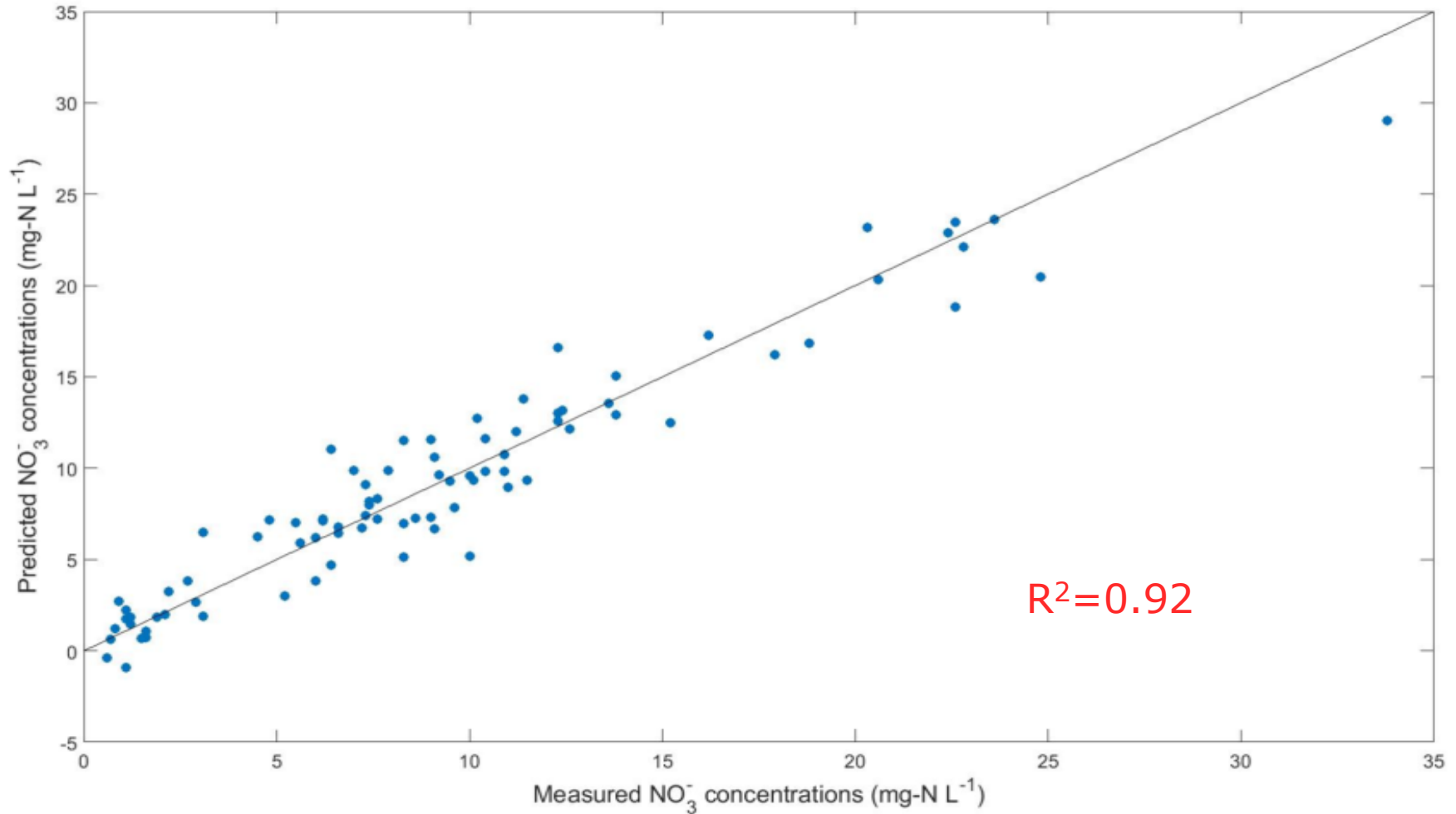
Chlorella sp. – principal component regression NO_3^- 3 PCs



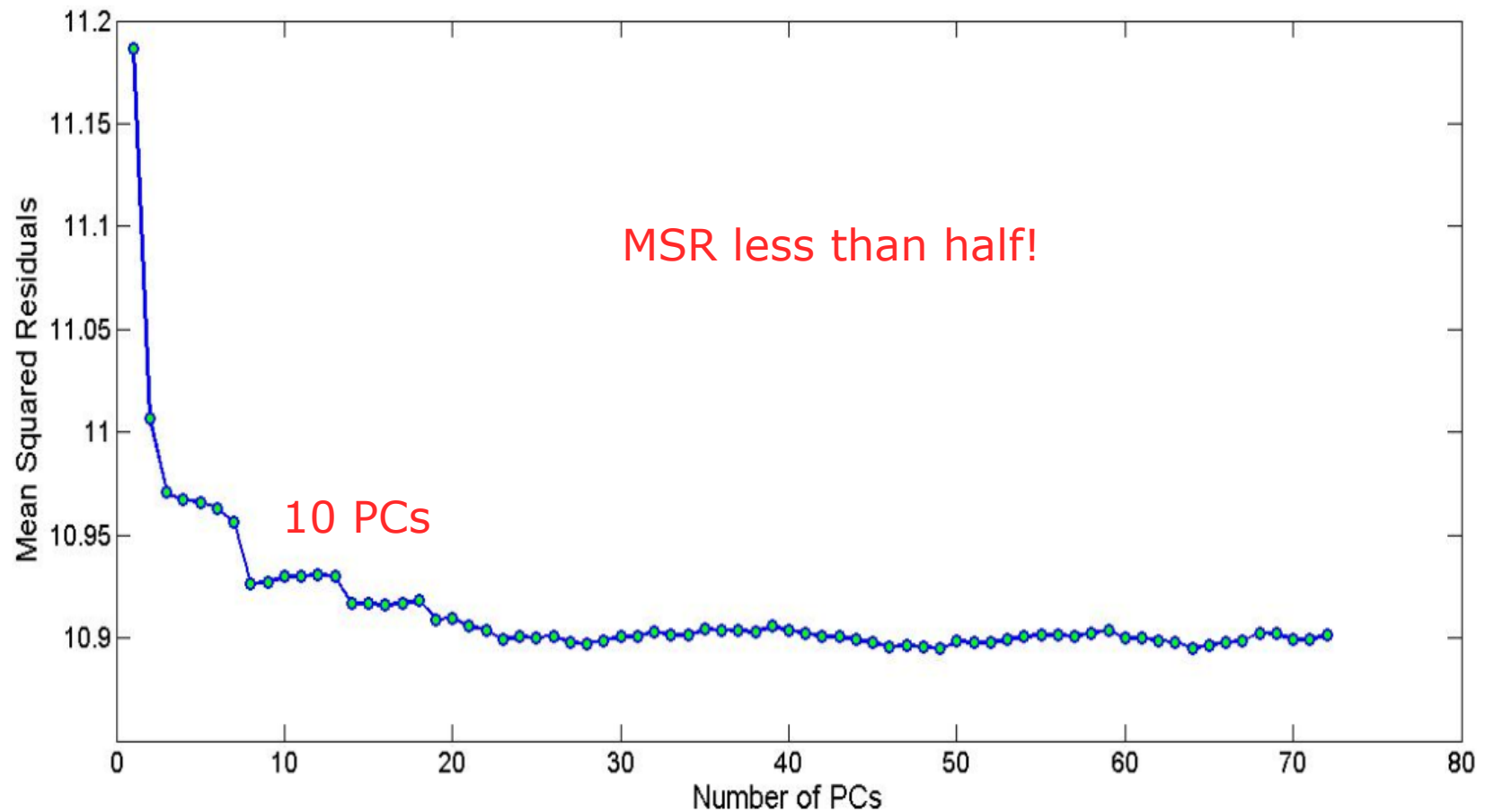
Chlorella sp. – leave one out cross validation NO_3



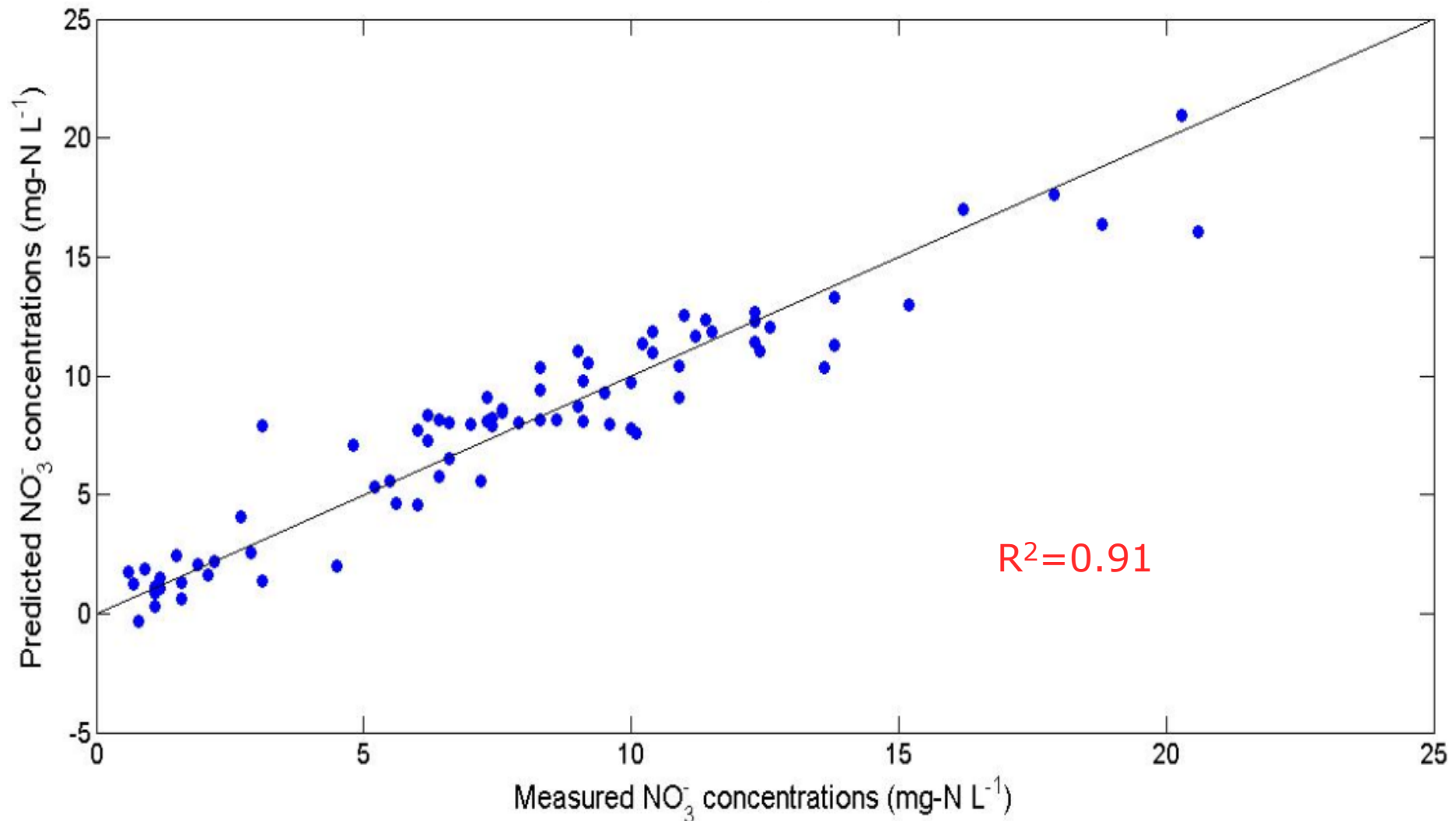
Chlorella sp. – principal component regression NO_3^- 14 PCs



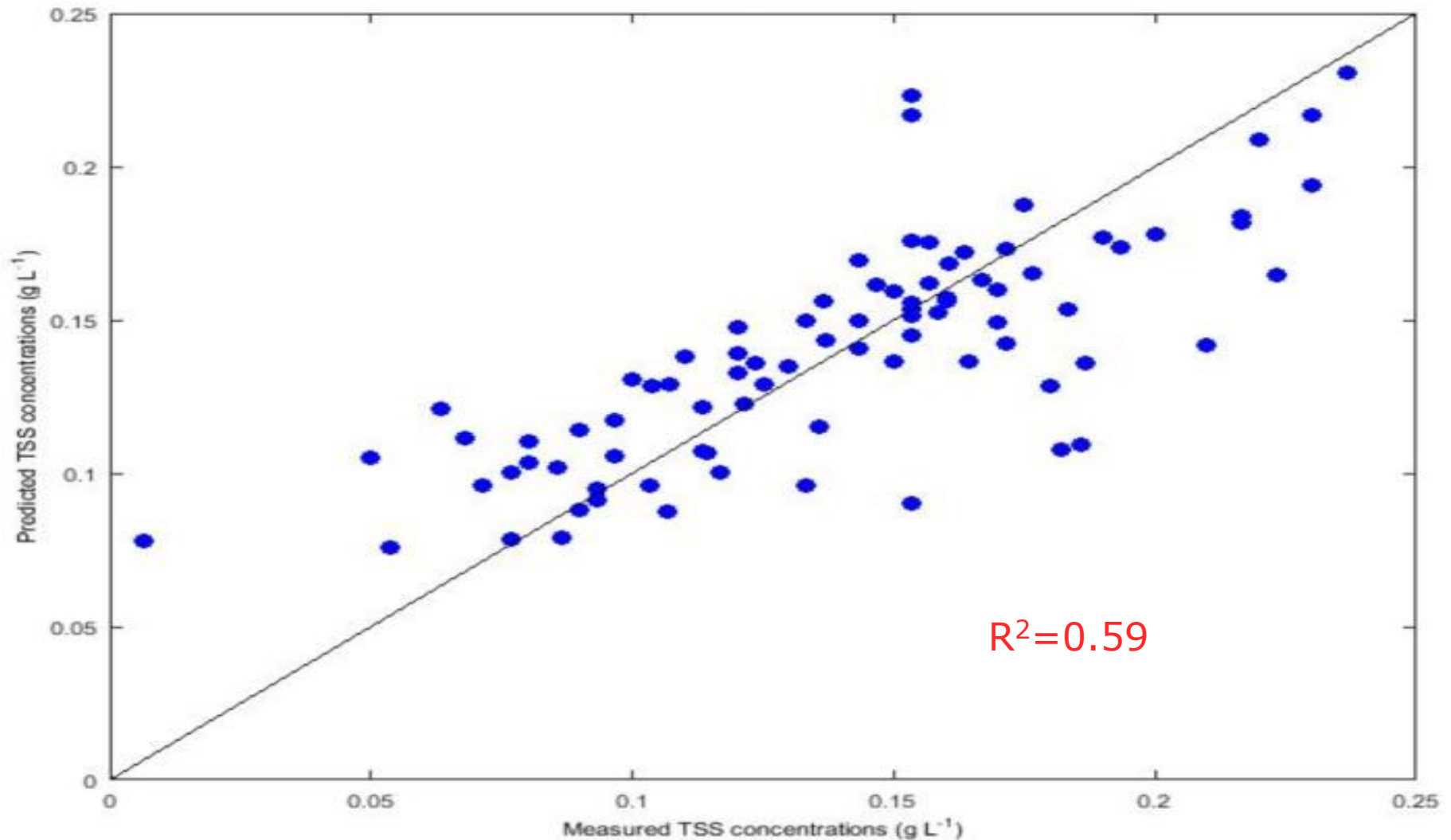
Chlorella sp. – leave one out cross validation NO_3 without saturation



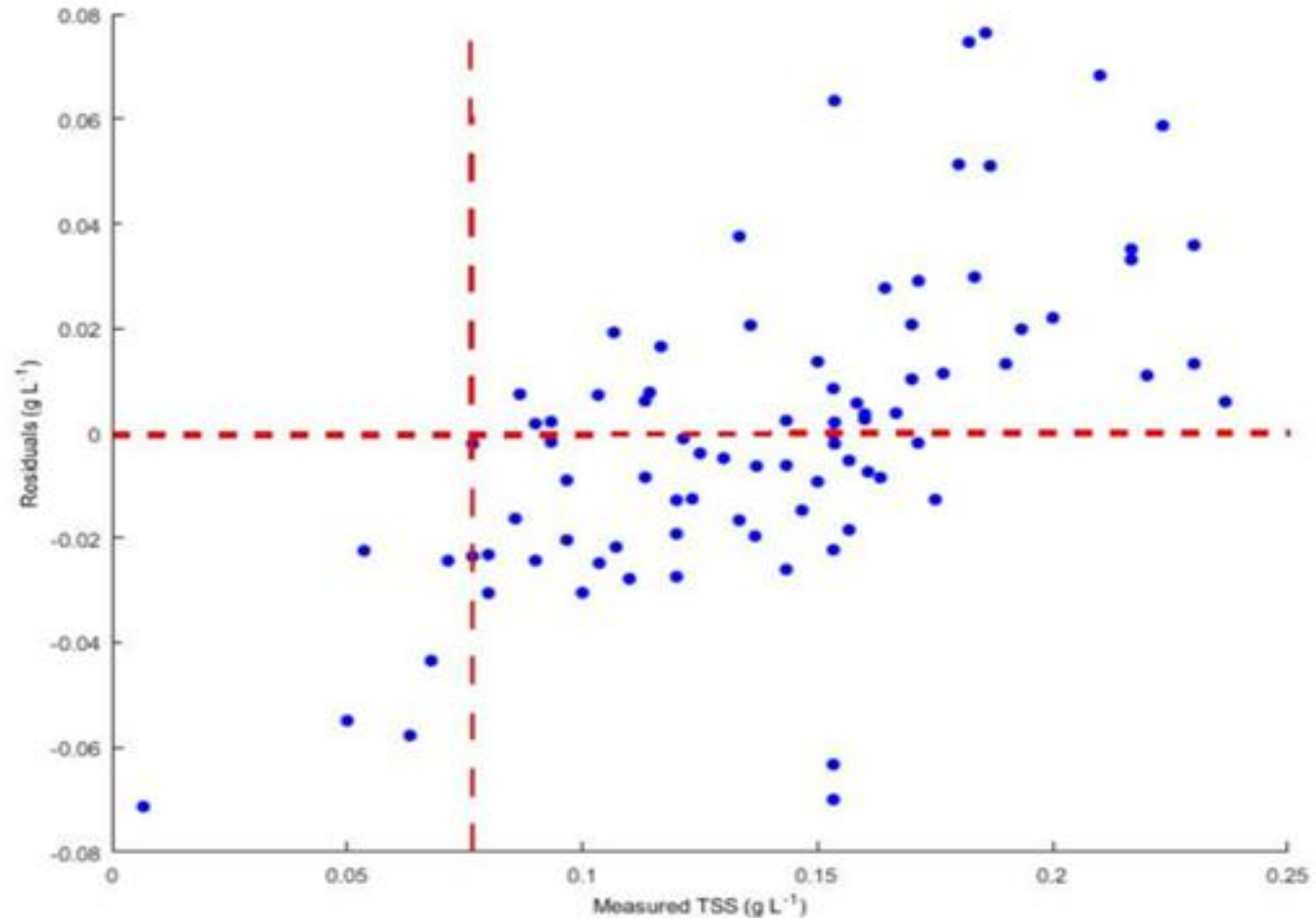
Chlorella sp. – principal component regression NO_3^- 10 PCs without saturation



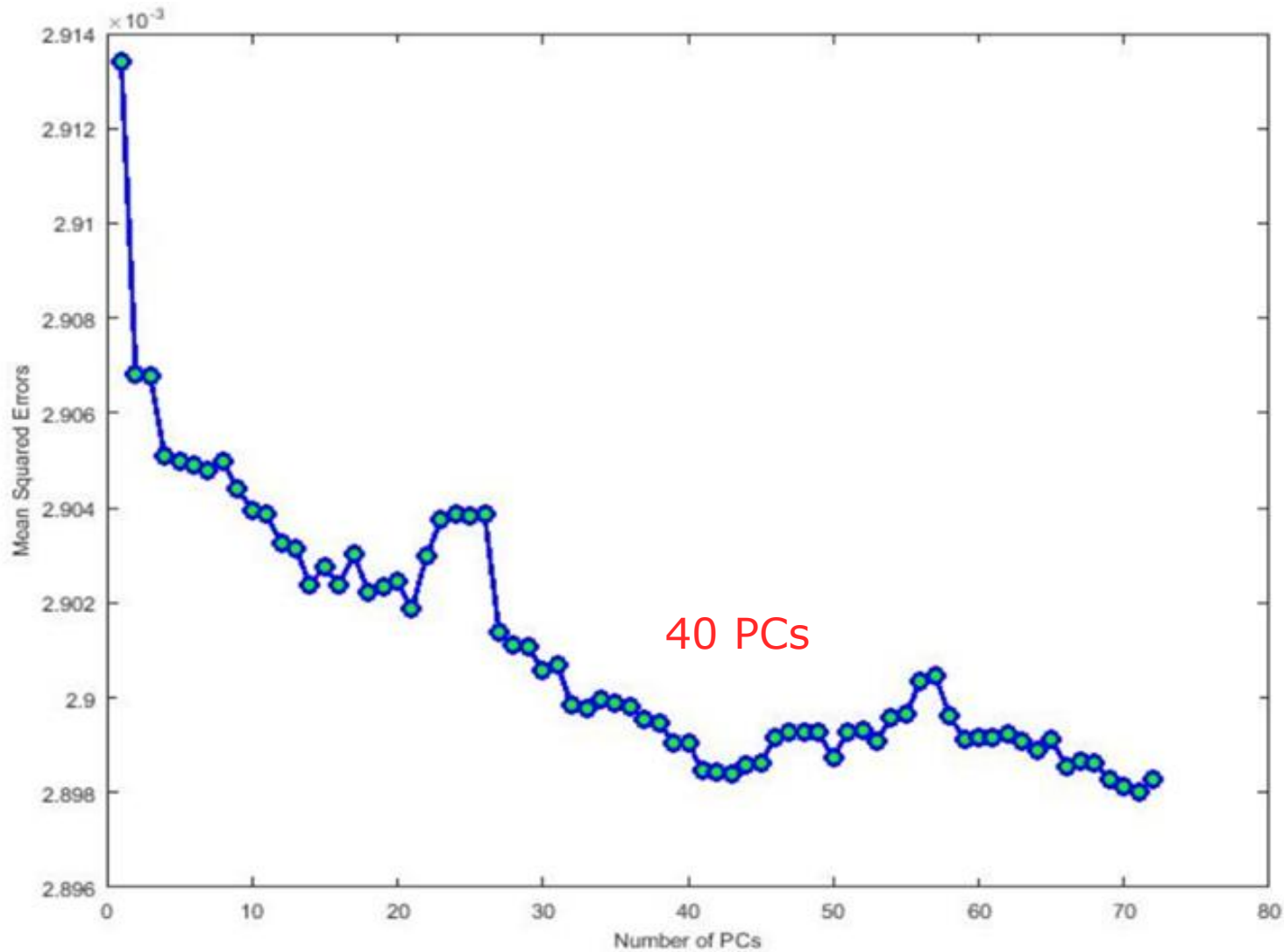
Chlorella sp. – principal component regression TSS 3 PCs



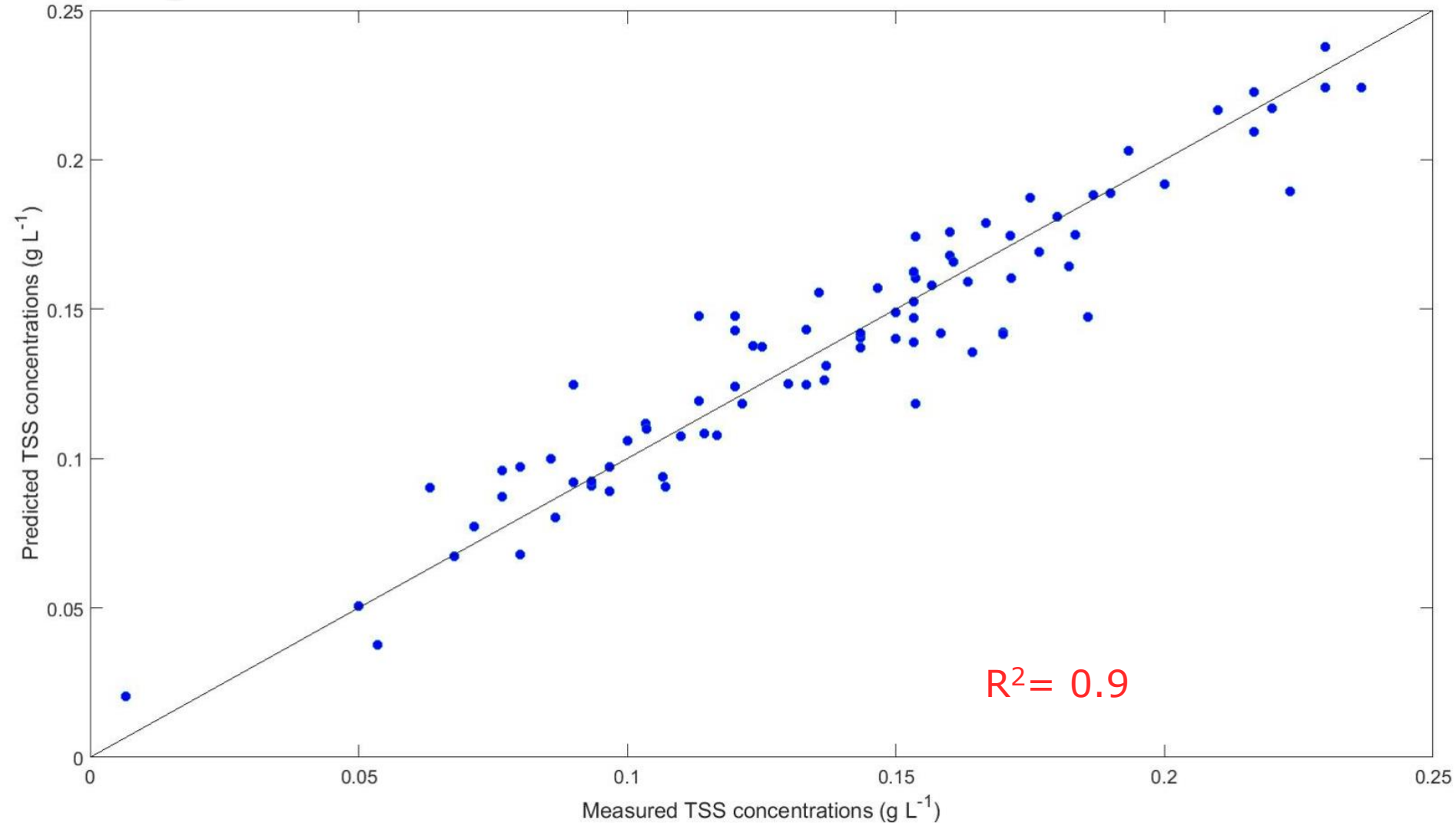
Chlorella sp. – principal component regression TSS 3 PCs



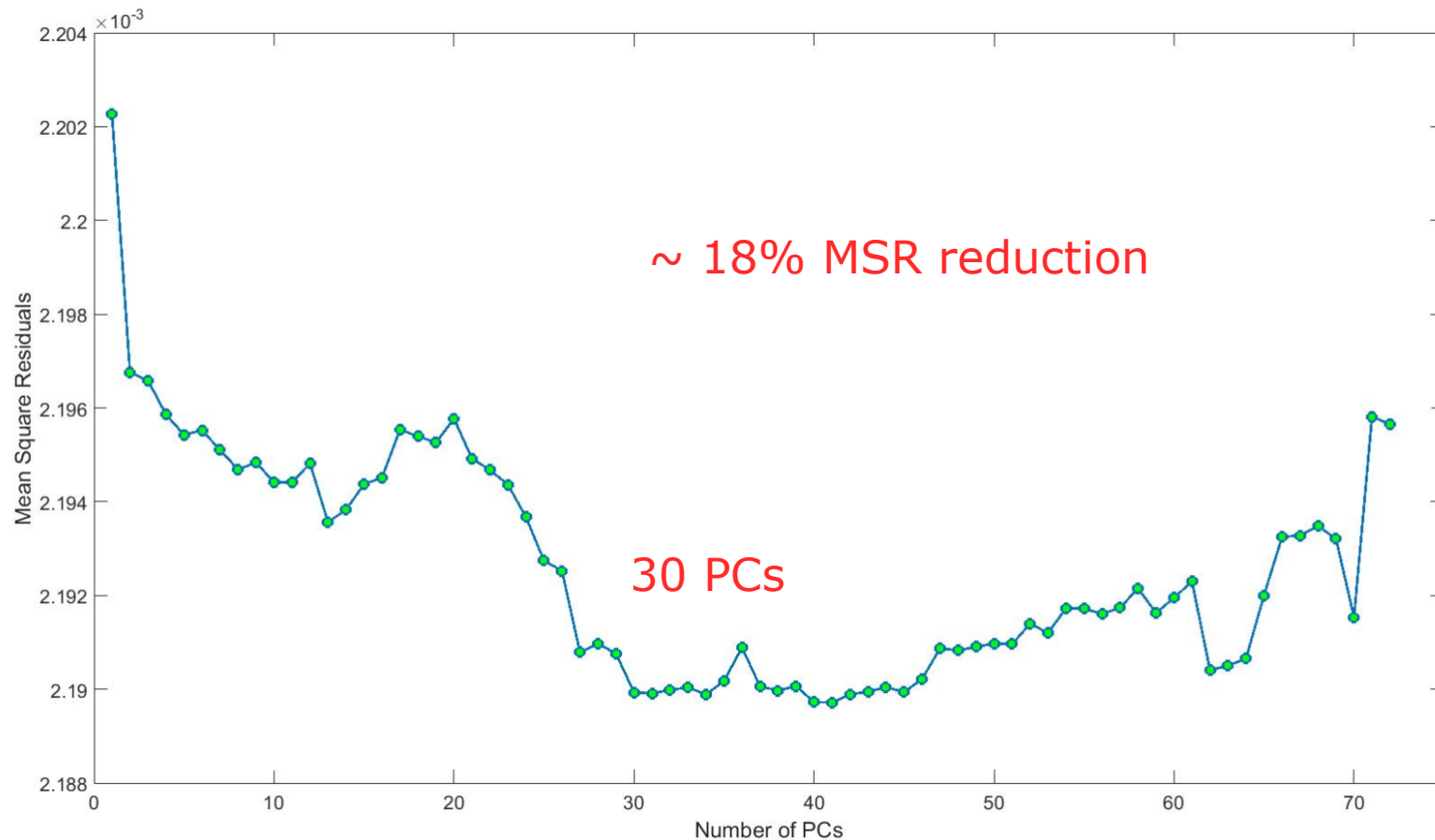
Chlorella sp. – leave one out cross validation TSS



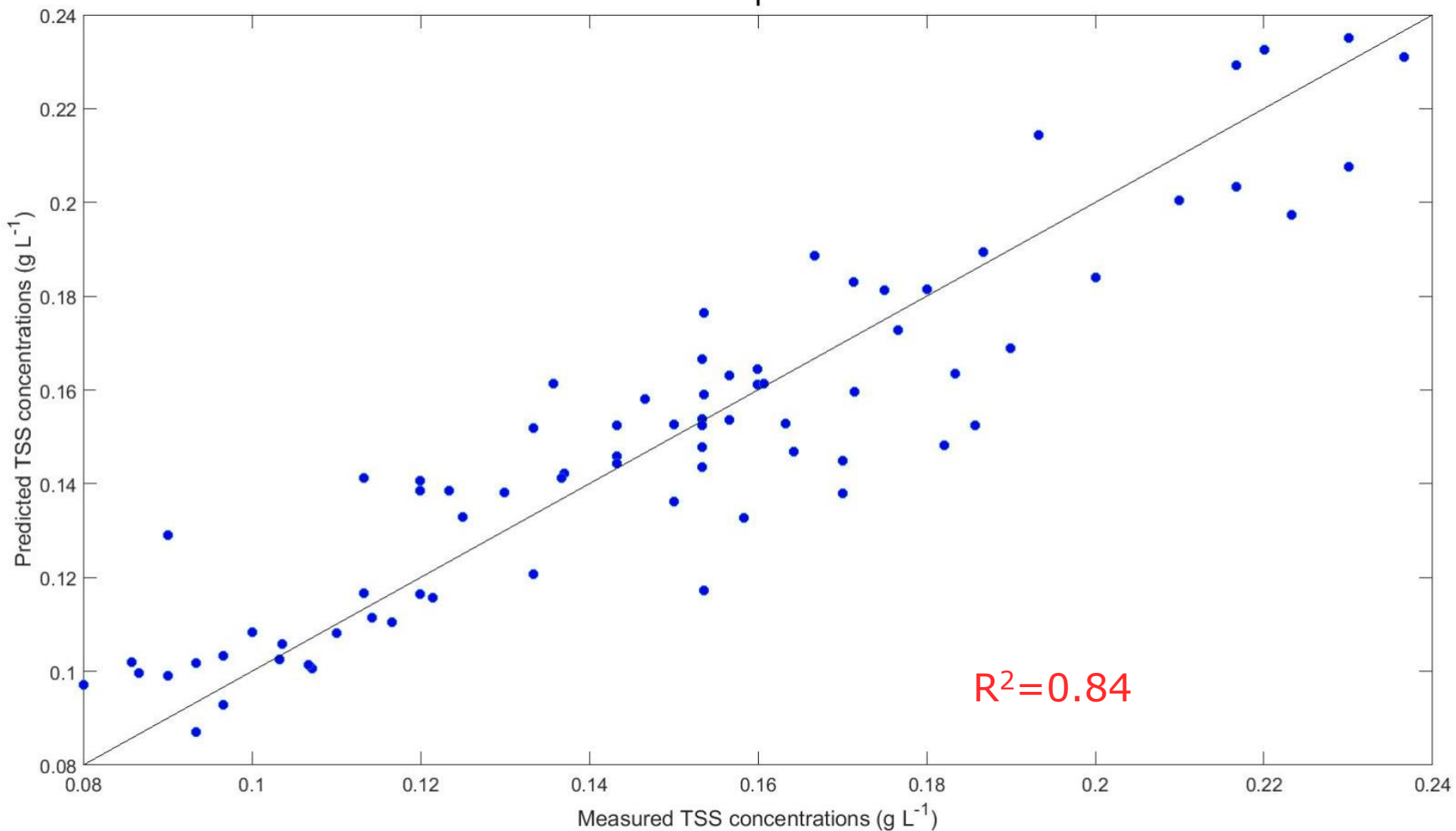
Chlorella sp. – principal component regression TSS 40 PCs



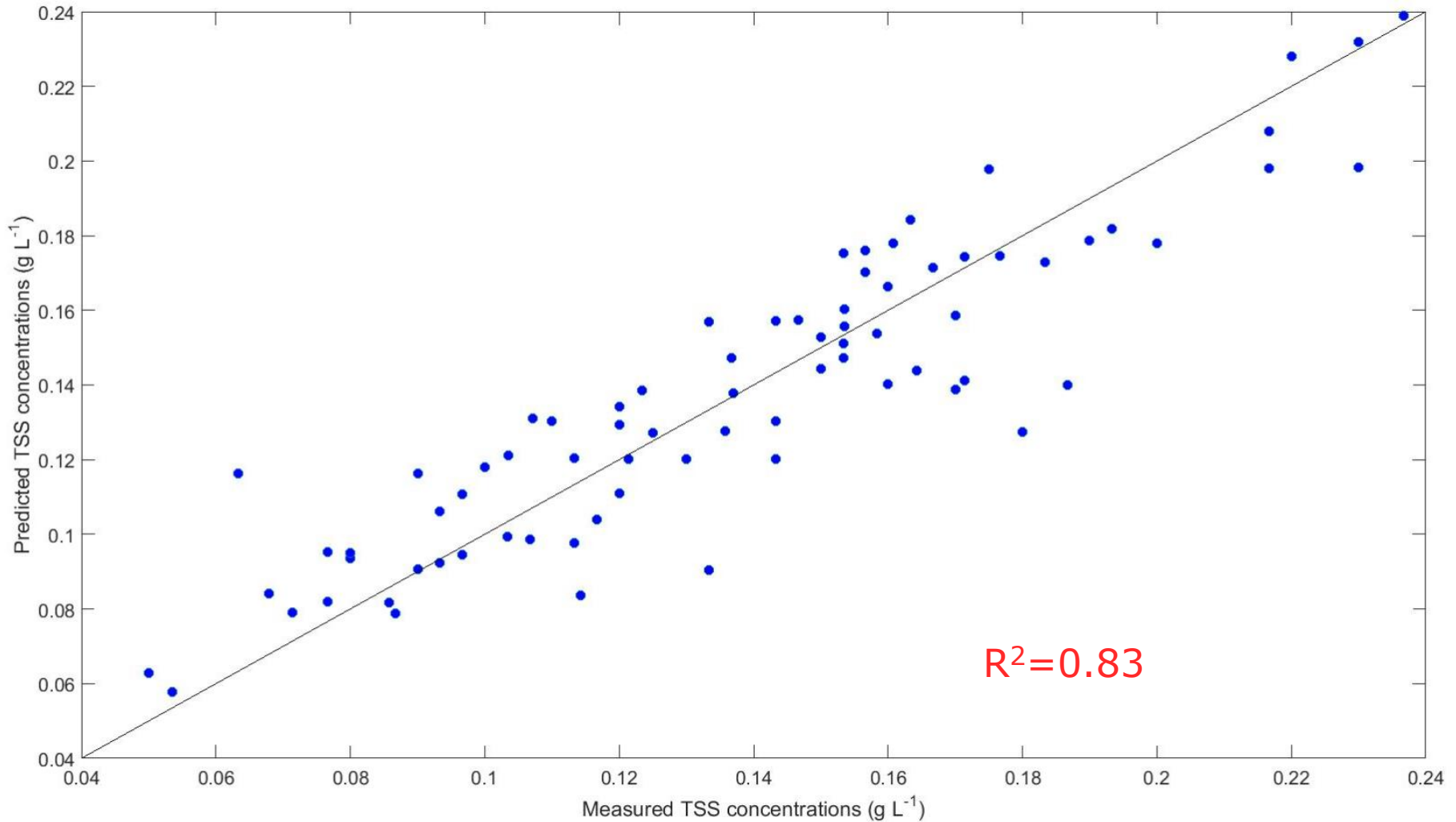
Chlorella sp. – leave one out cross validation TSS above detection limit



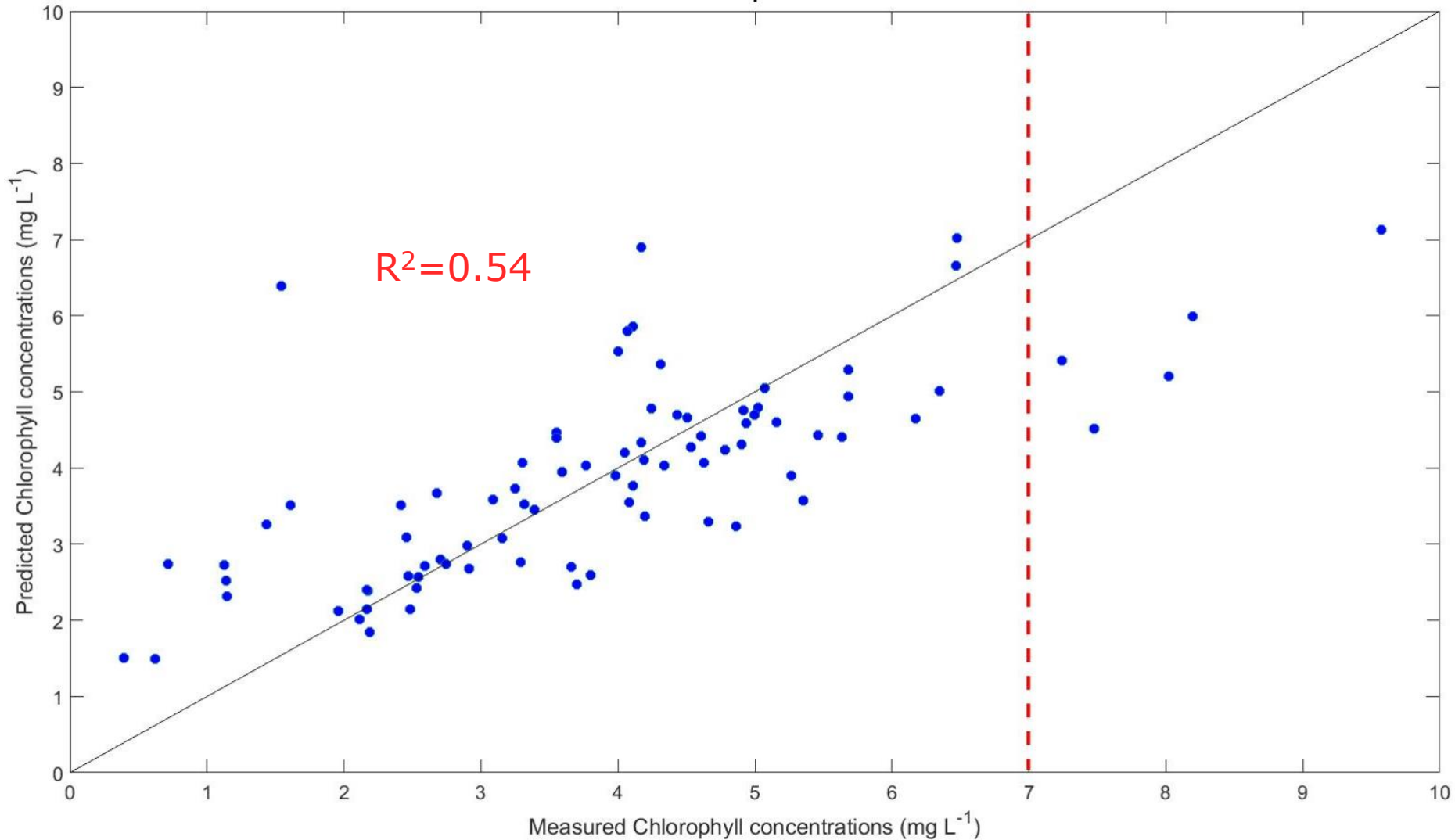
Chlorella sp. – principal component regression TSS 30 PCs above detection limit



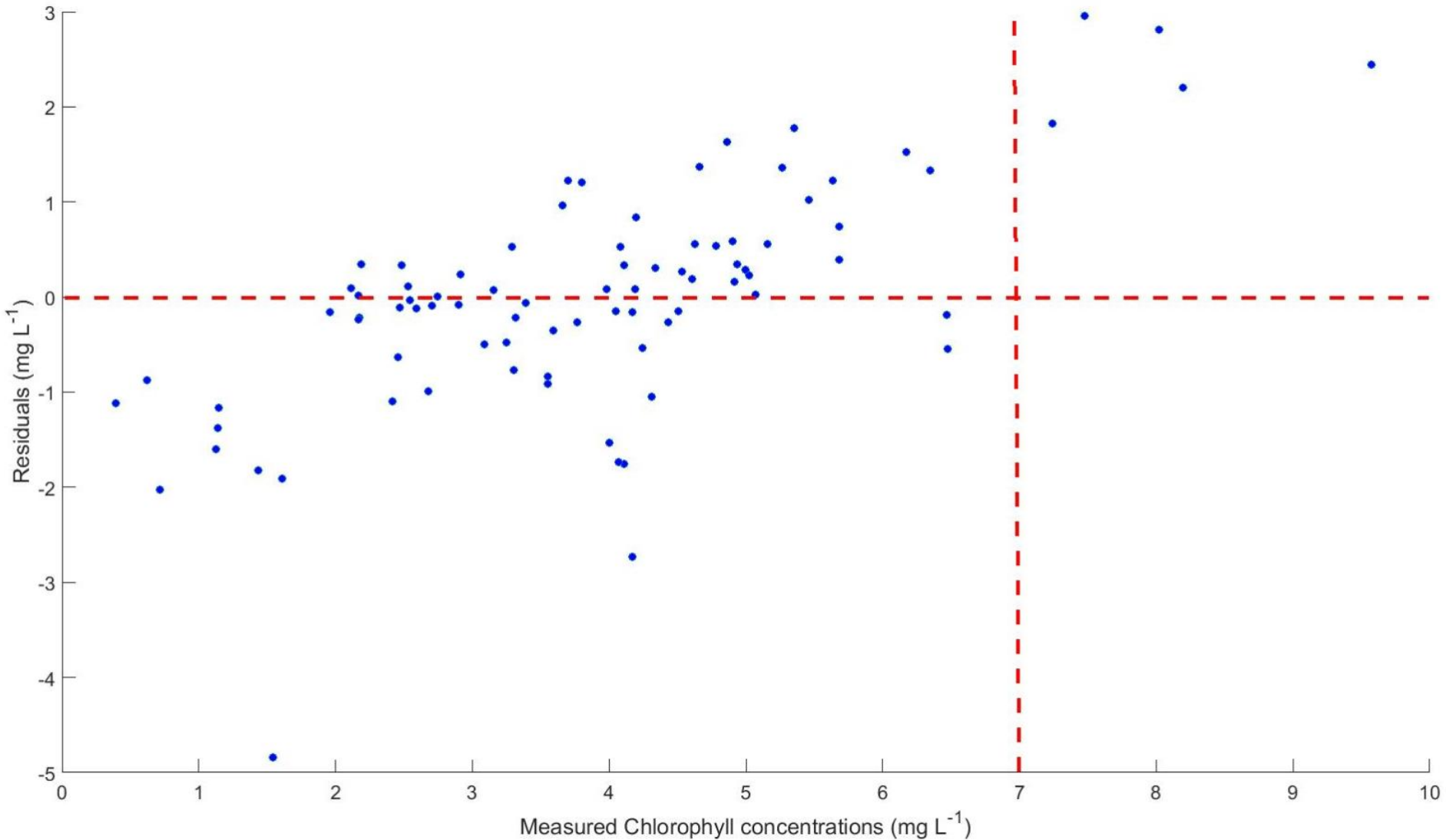
Chlorella sp. – principal component regression TSS 10 PCs outliers removed



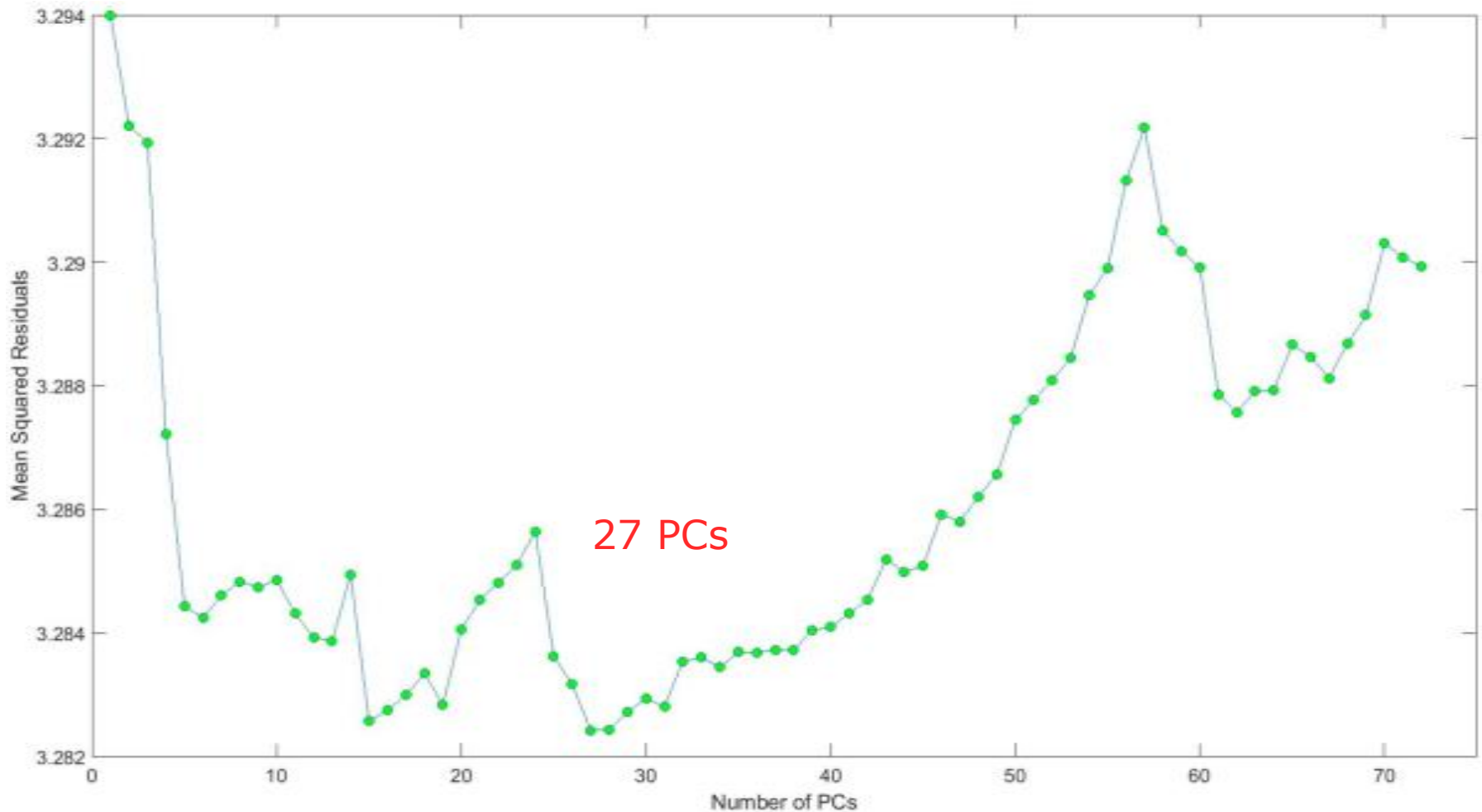
Chlorella sp. – principal component regression Chlorophyll 3 PCs



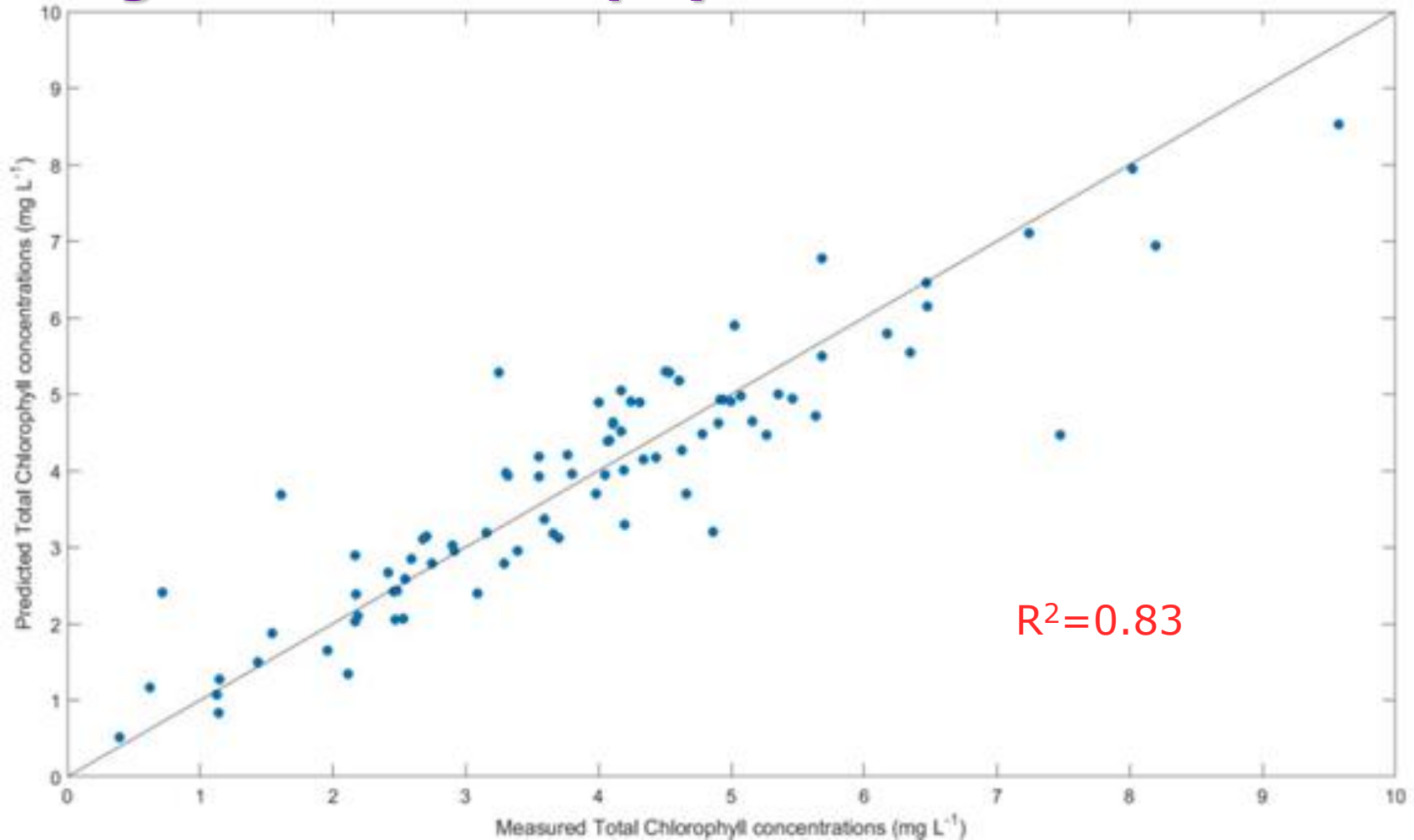
Chlorella sp. – principal component regression Chlorophyll 3 PCs



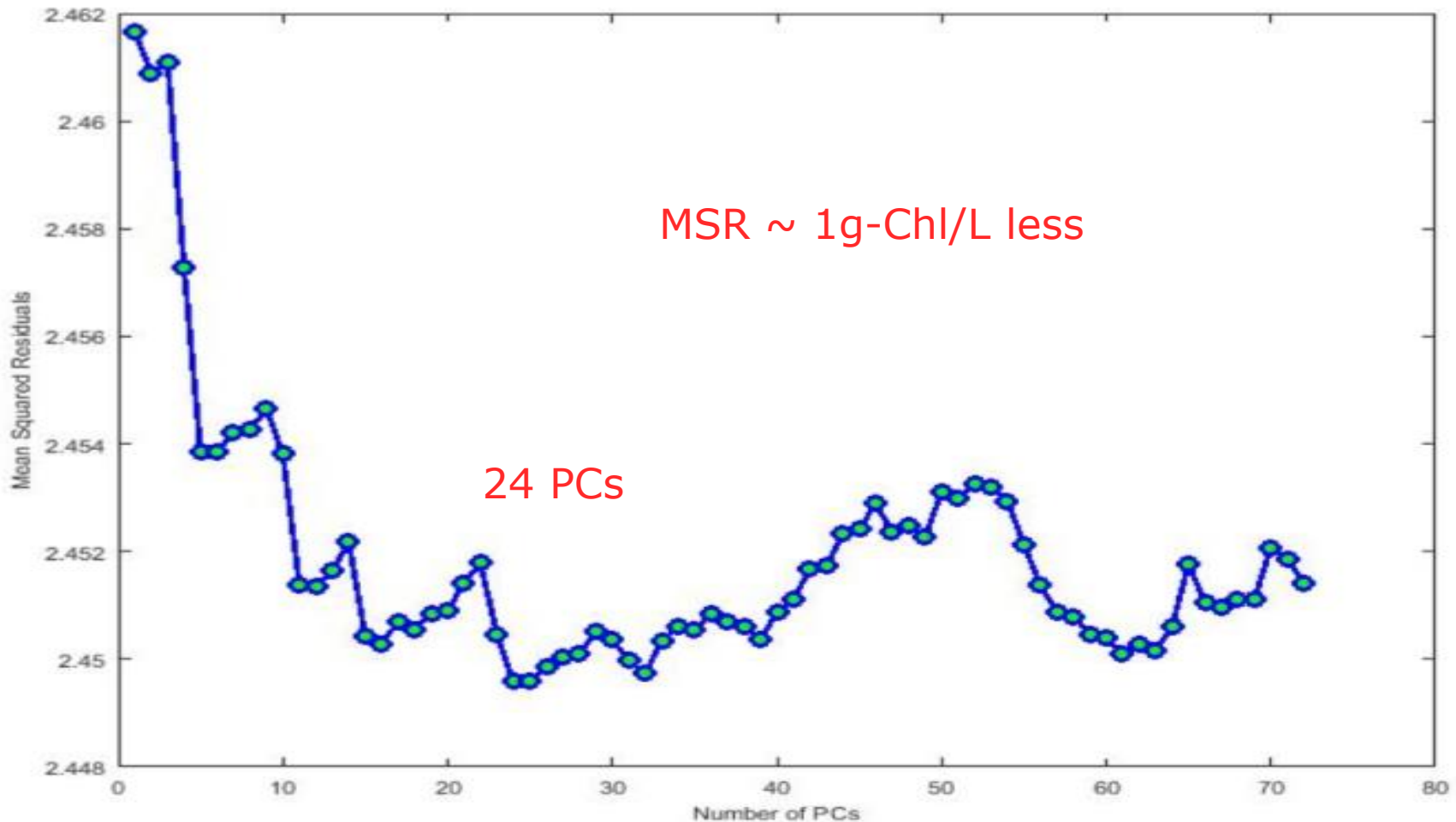
Chlorella sp. – leave one out cross validation Chlorophyll



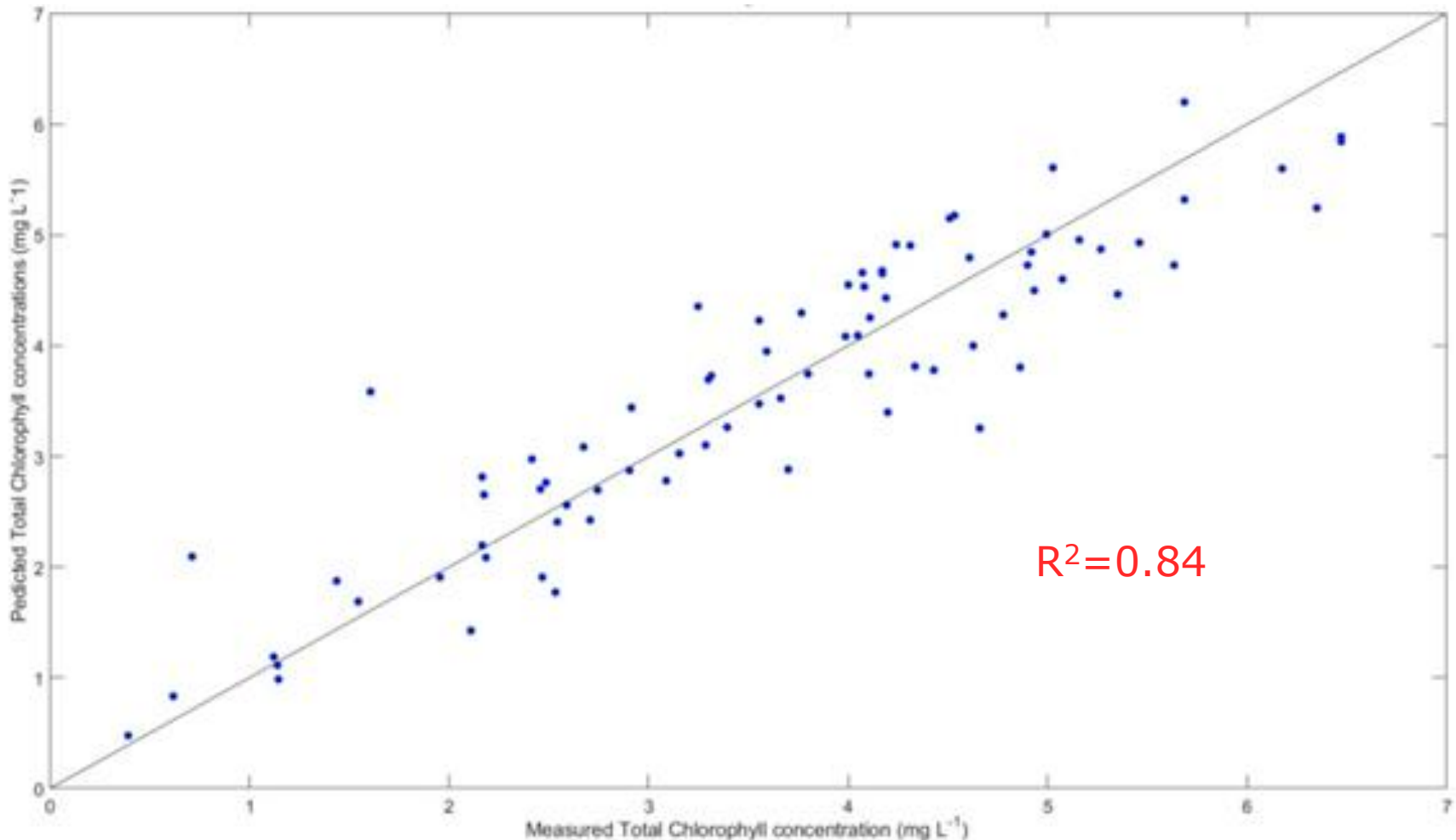
Chlorella sp. – principal component regression Chlorophyll 27 PCs



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

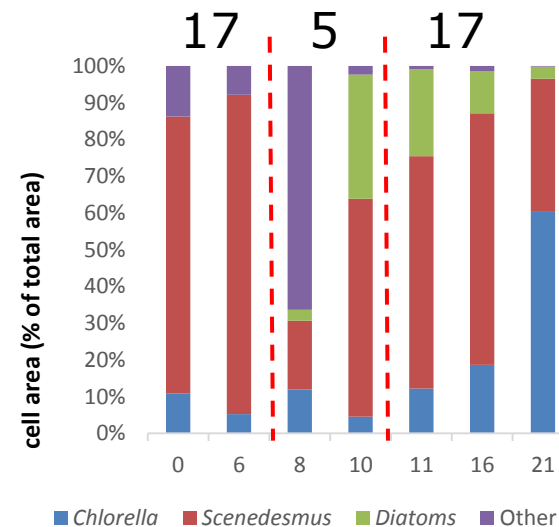
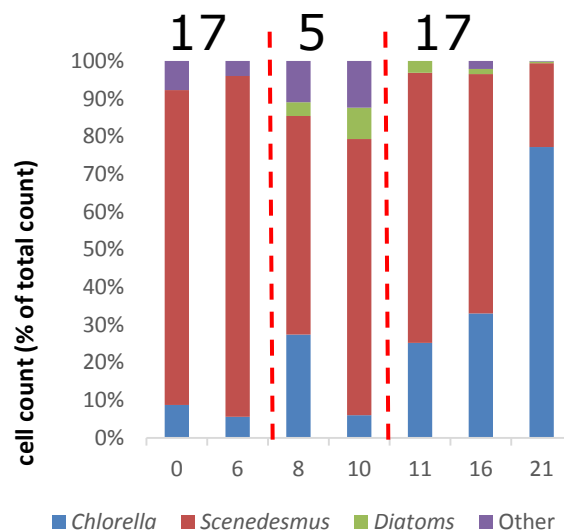


Chlorella sp. – principal component regression Chlorophyll 24 PCs without saturation

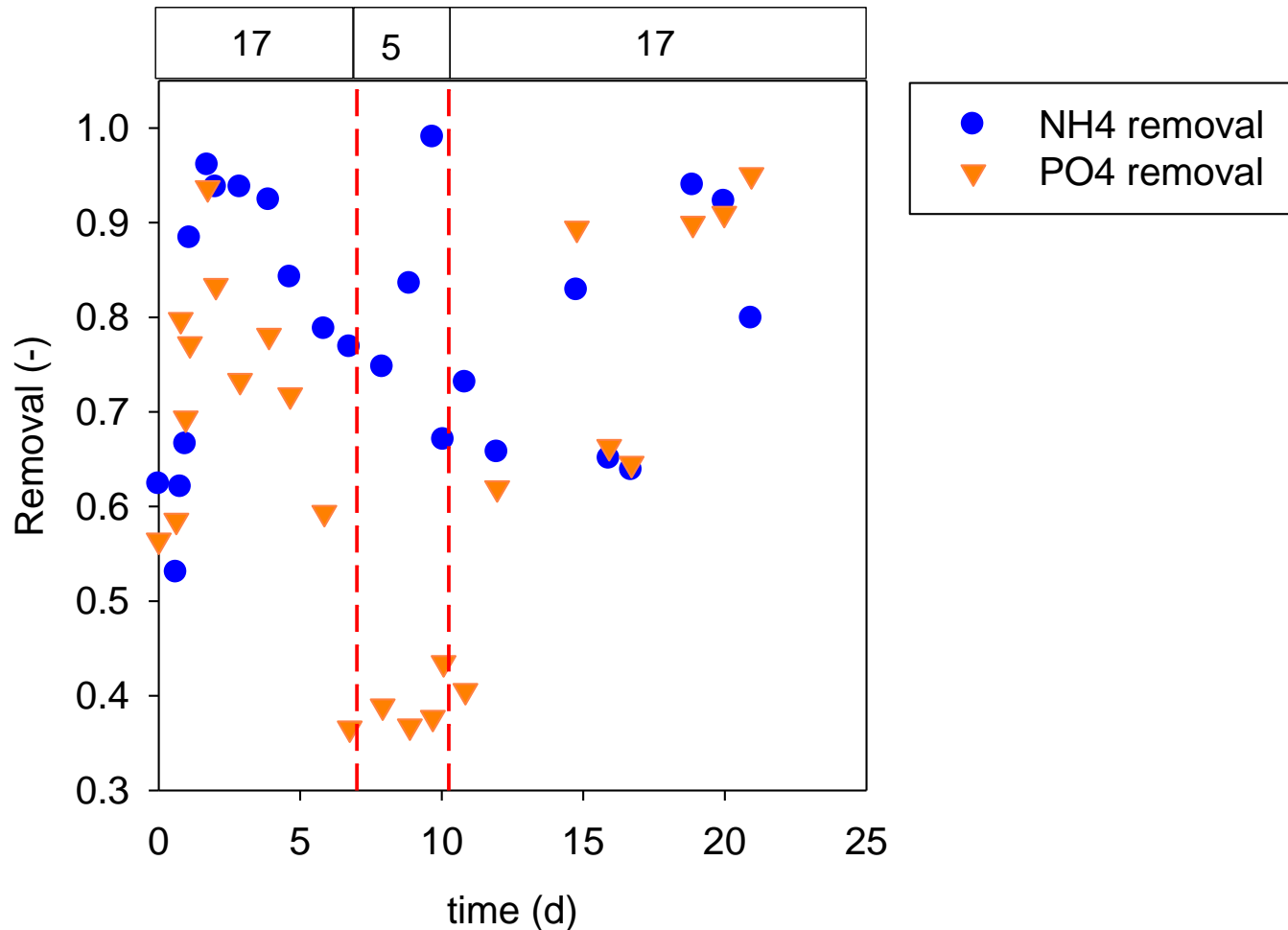


Variation in microbial diversity

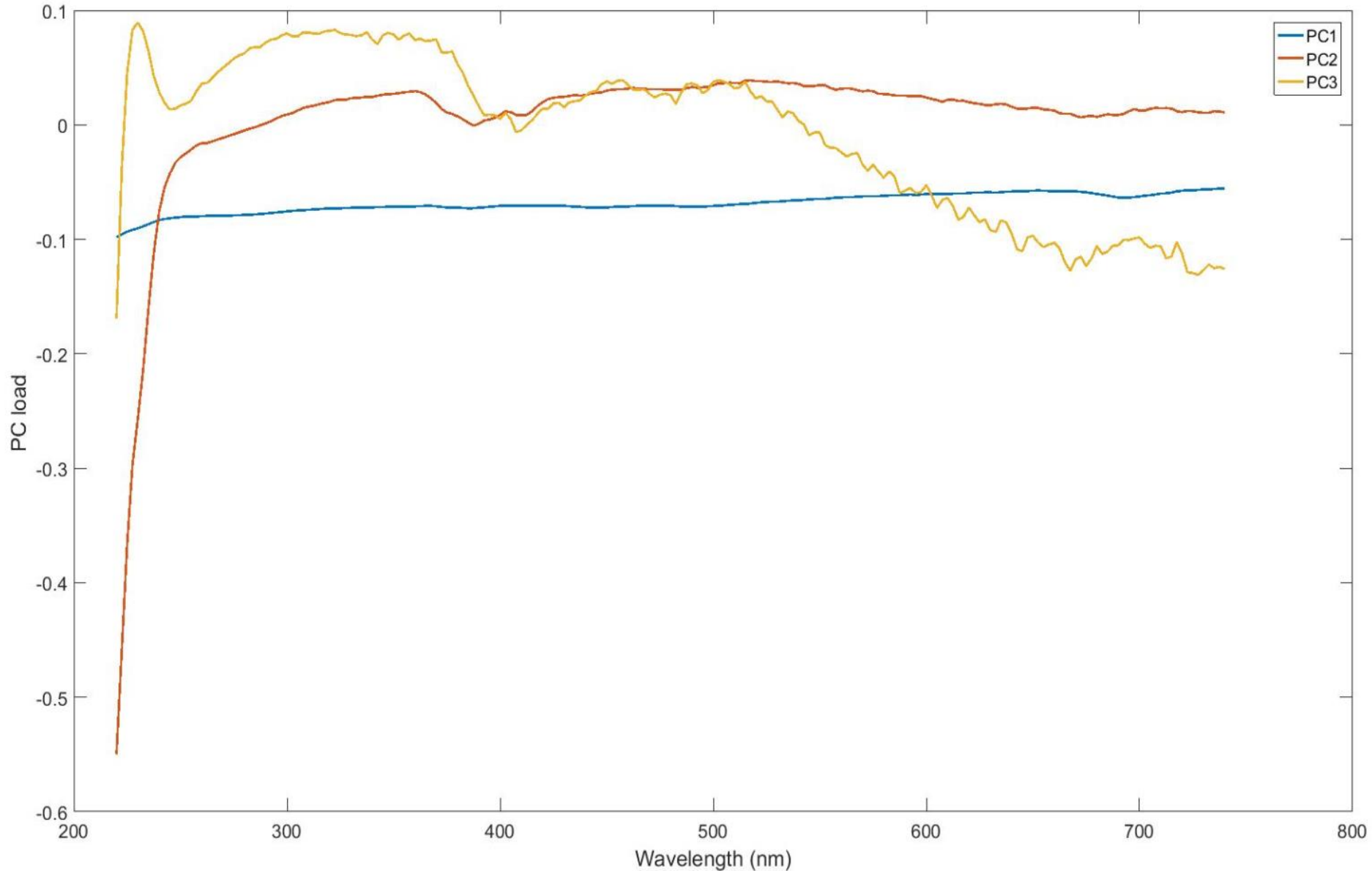
- Contamination by diatoms when N-to-P is lowered to 5
- Washout of diatoms when N-to-P is set back to 17
- Change in abundance of *Chlorella* and *Scenedesmus* sp.
- Hypothesis to test:
 - **Do changes on shape and size affect the prediction capacity by UV-Vis sensors?**



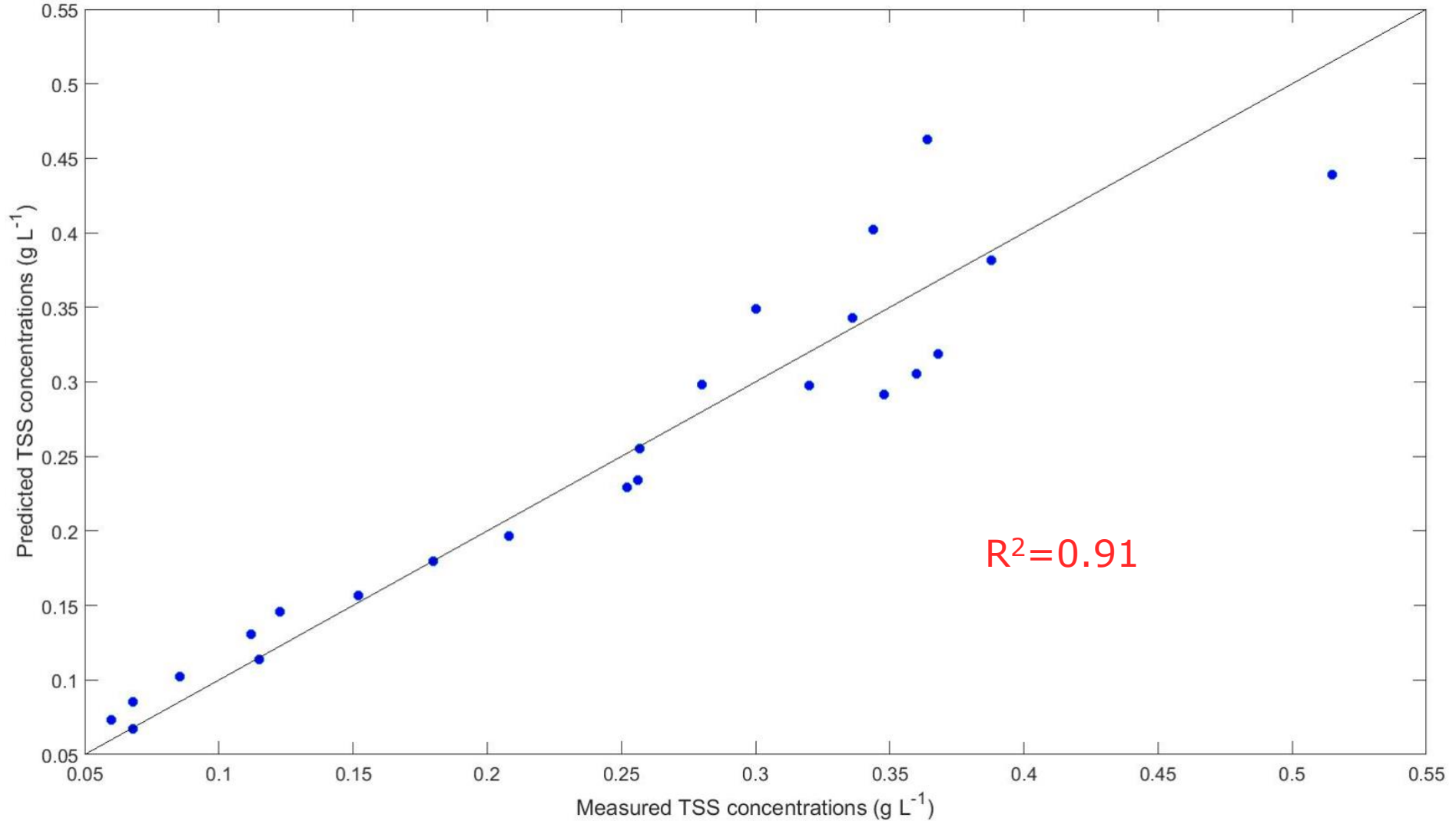
Mixed culture – process performance



Mixed culture – principal component analysis

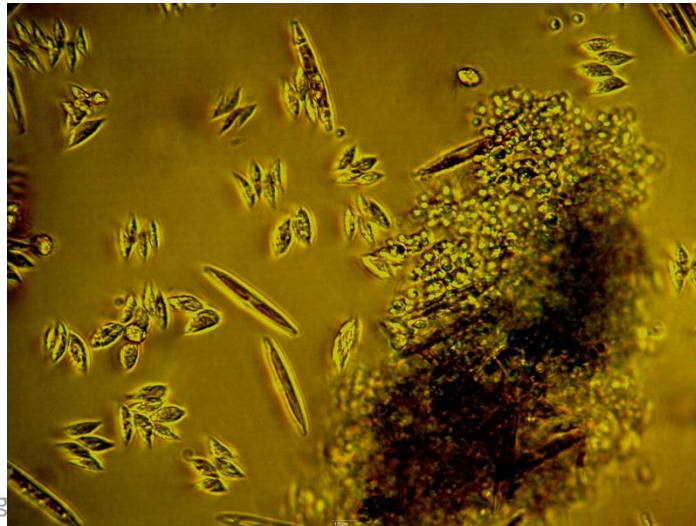


Mixed culture – principal component regression TSS 1 PC



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 successfully predicted the TSS despite contamination in the reactor.



Acknowledgements



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