



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

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

*Publication date:*  
2017

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*

Valverde Pérez, B. (Author), Wágner, D. S. (Author), Steidl, M. (Author), Villez, K. (Author), & Plósz, B. G. (Author). (2017). UV-Vis spectrophotometry for Wastewater Resource Recovery with Algae Photobioreactors. Sound/Visual production (digital), Department of Environmental Engineering, Technical University of Denmark (DTU).

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

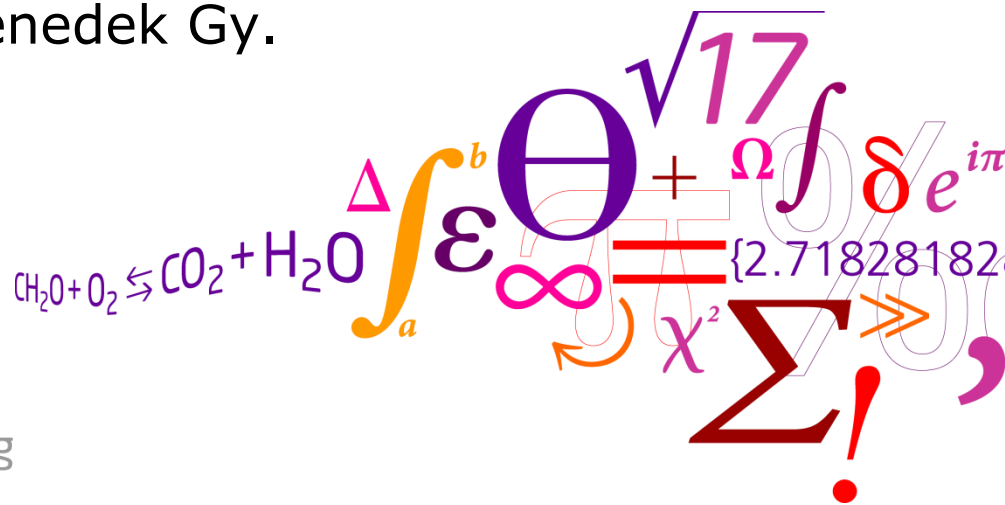
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

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

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

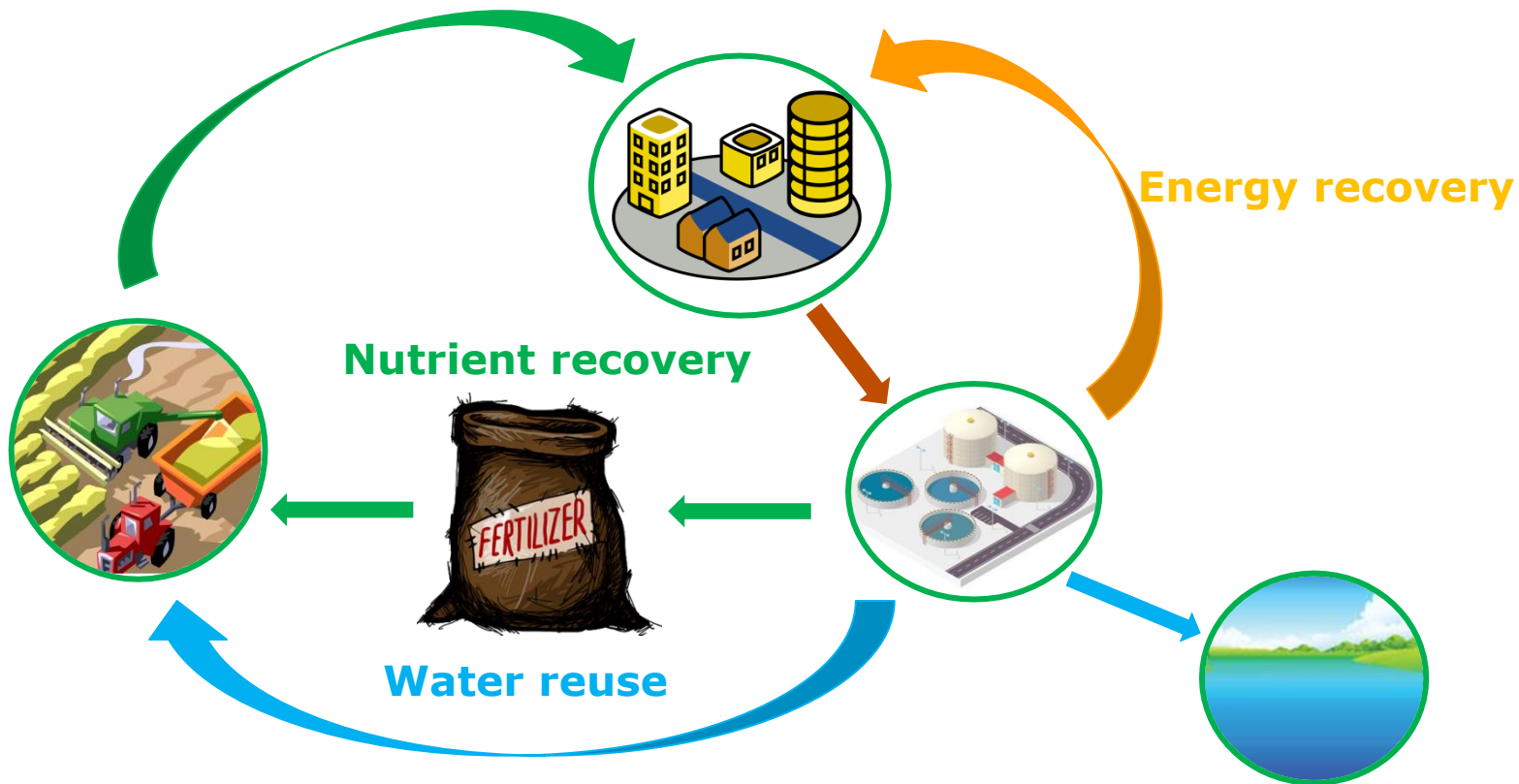
DTU Environment  
Department of Environmental Engineering

---



# Paradigm shift in wastewater treatment

- Circular scheme
- Paradigm shift: wastewater → “used water”



# Microalgae for used water recovery

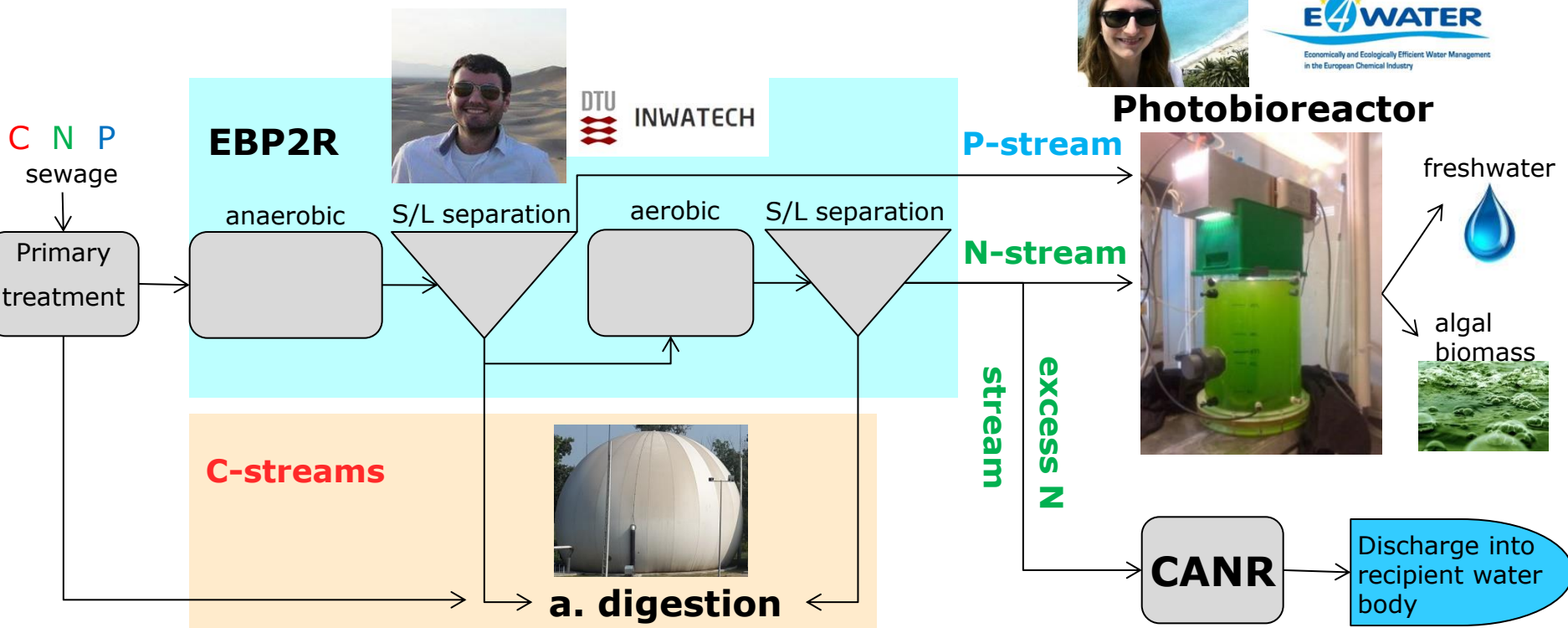
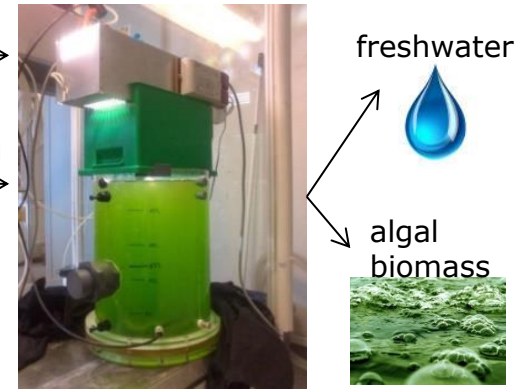
- Most resource recovery schemes are based on chemical processes, e.g. struvite precipitation
- Cultivation of microalgae on used water resources
  - Nutrients recycling through bio-fertilizer production
  - Biofuel production
  - Decoupling food and biofuel production



# TRENS – Biochemical Resource Recovery



## Photobioreactor

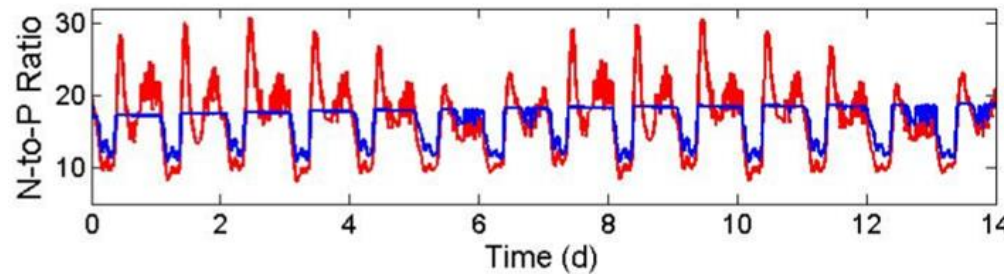


### End use:

- ✓ Fertigation
- ✓ Biogas production



# Experimental set up and operation

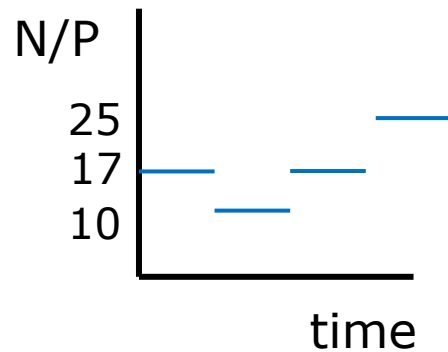
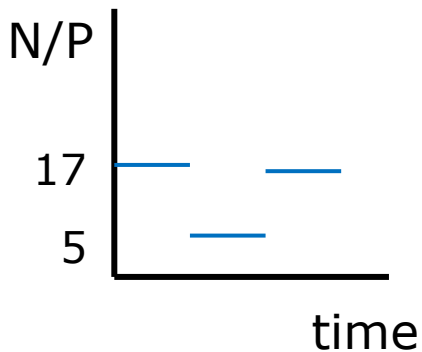


Valverde-Pérez et al., 2016

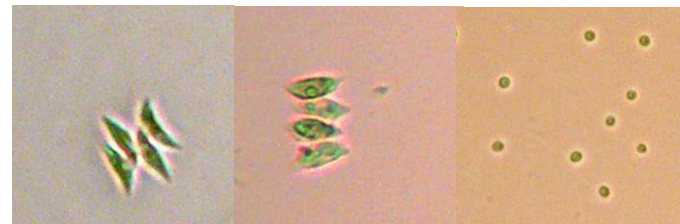
- The effect of the variation of N-to-P ratio is tested – fed with treated municipal wastewater
- Mixed consortium and mono-culture
- Open system

Mixed consortium

Mono-culture



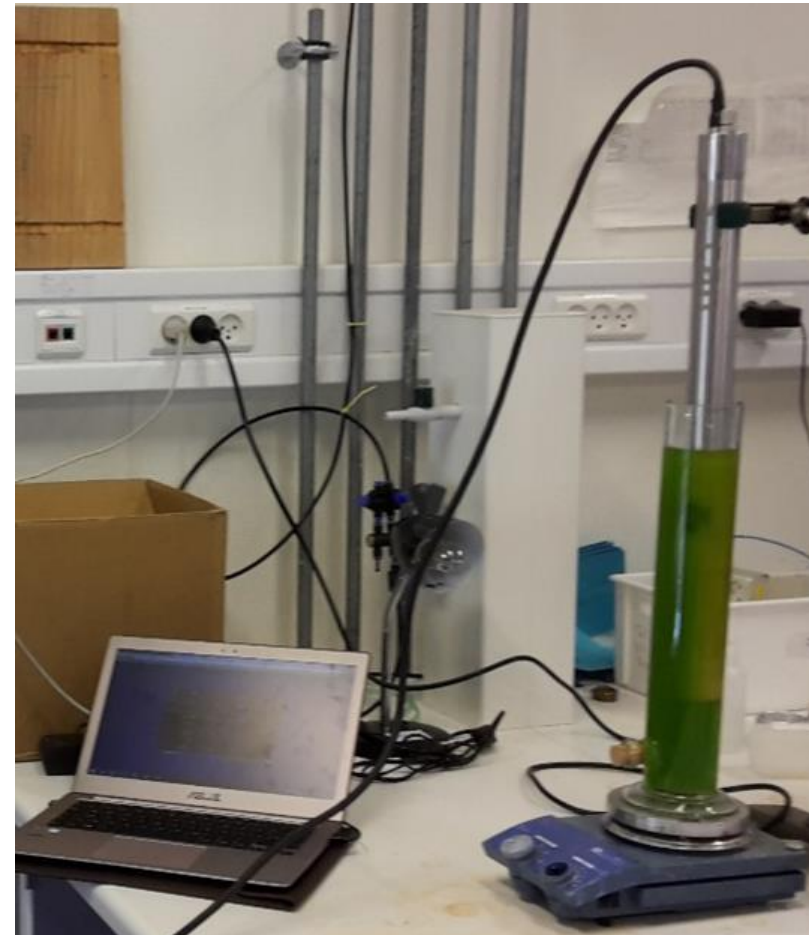
Wágner et al., 2017





# Analytical procedure

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

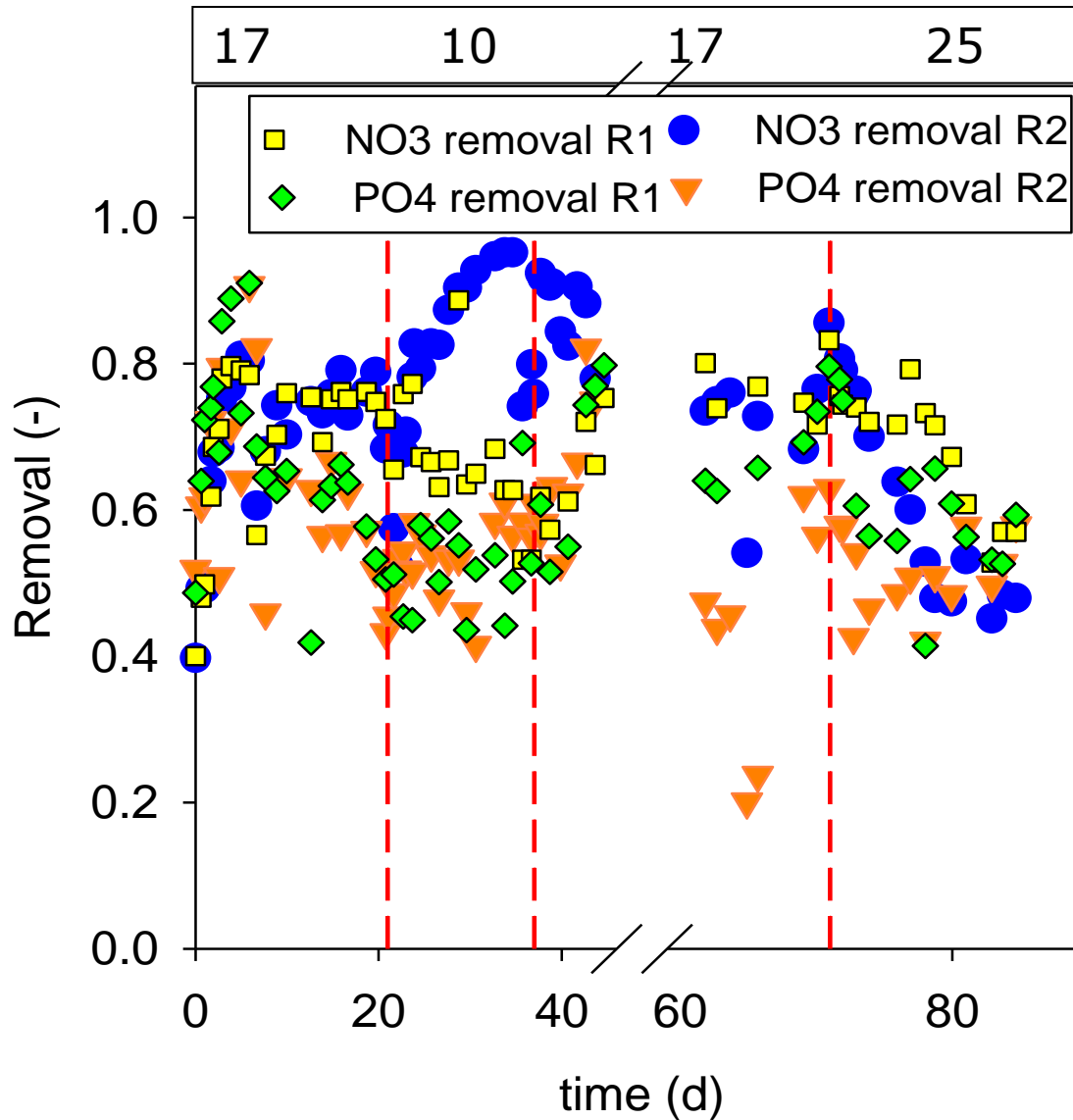


# Predictive model

- 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

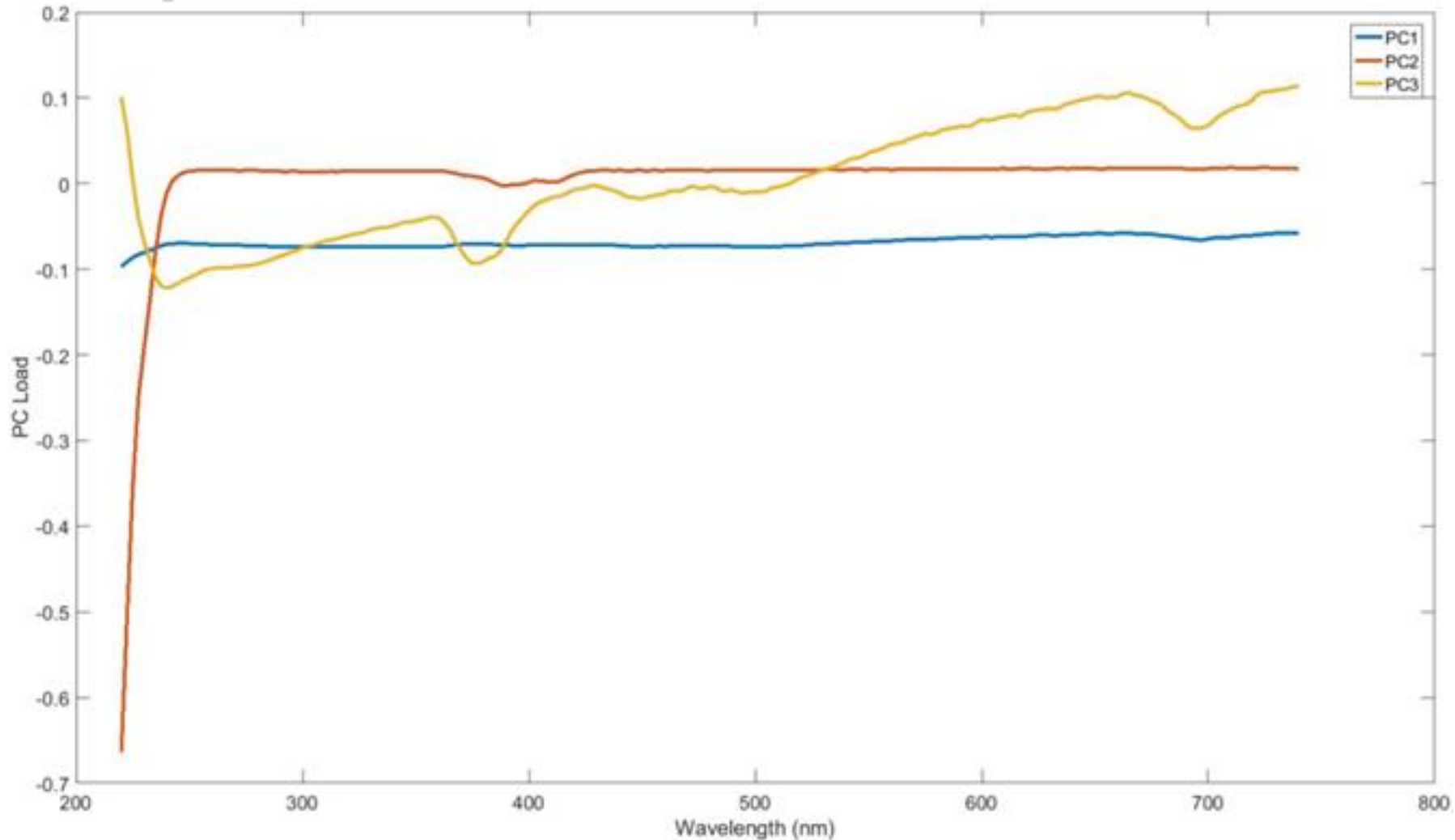


# *Chlorella sp.* – process performance

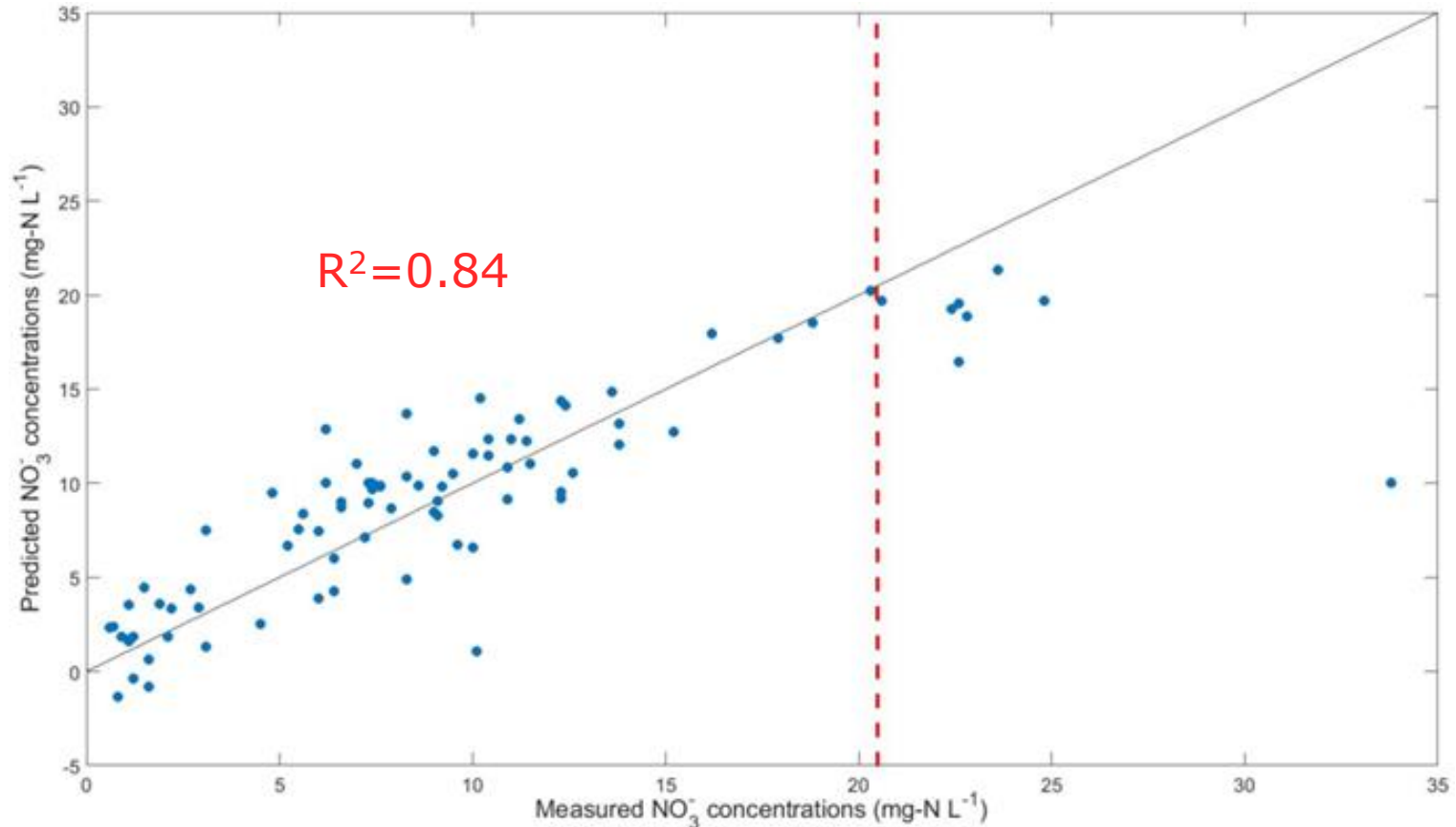


R1 – control  
R2 – test

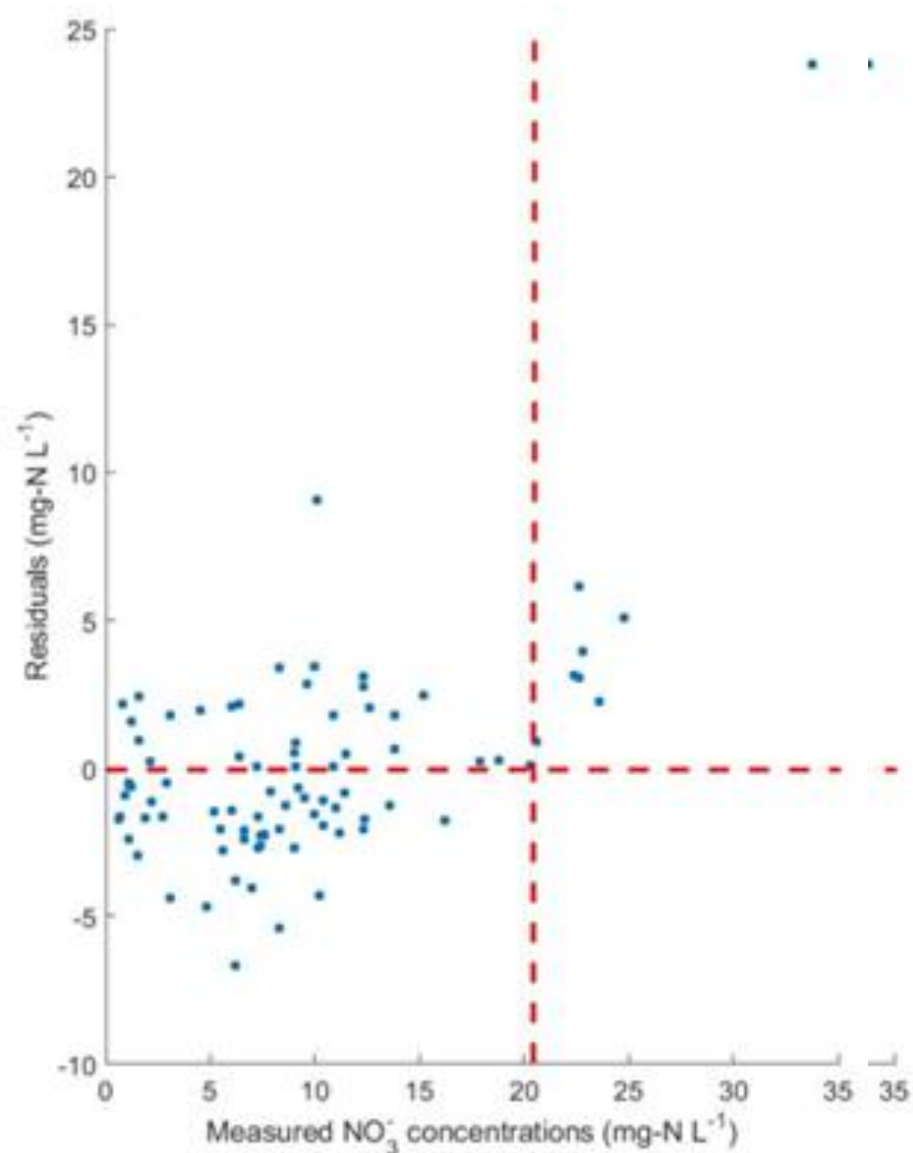
# *Chlorella sp.* – principal component analysis



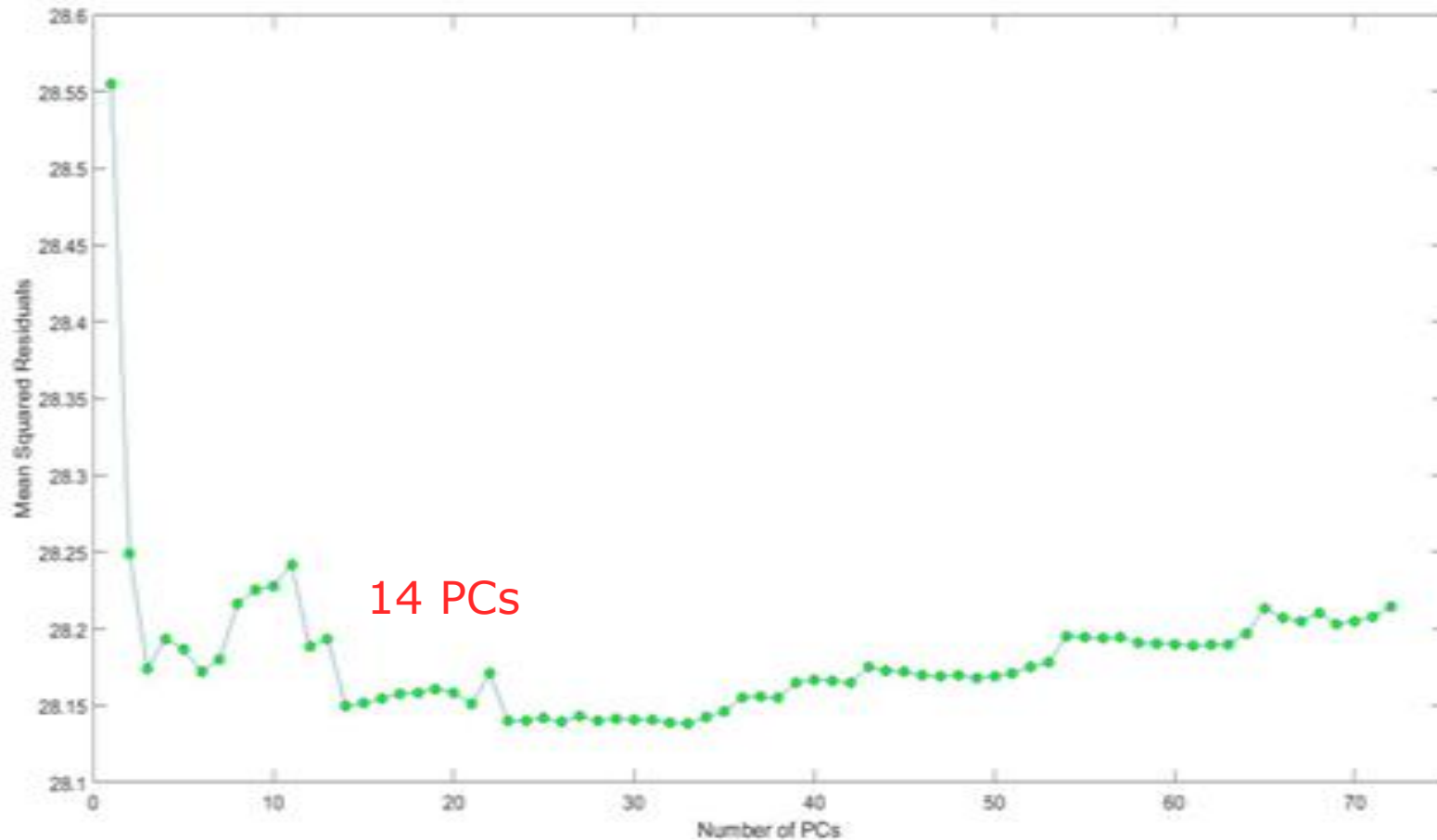
# *Chlorella sp.* – principal component regression $\text{NO}_3^-$ 3 PCs



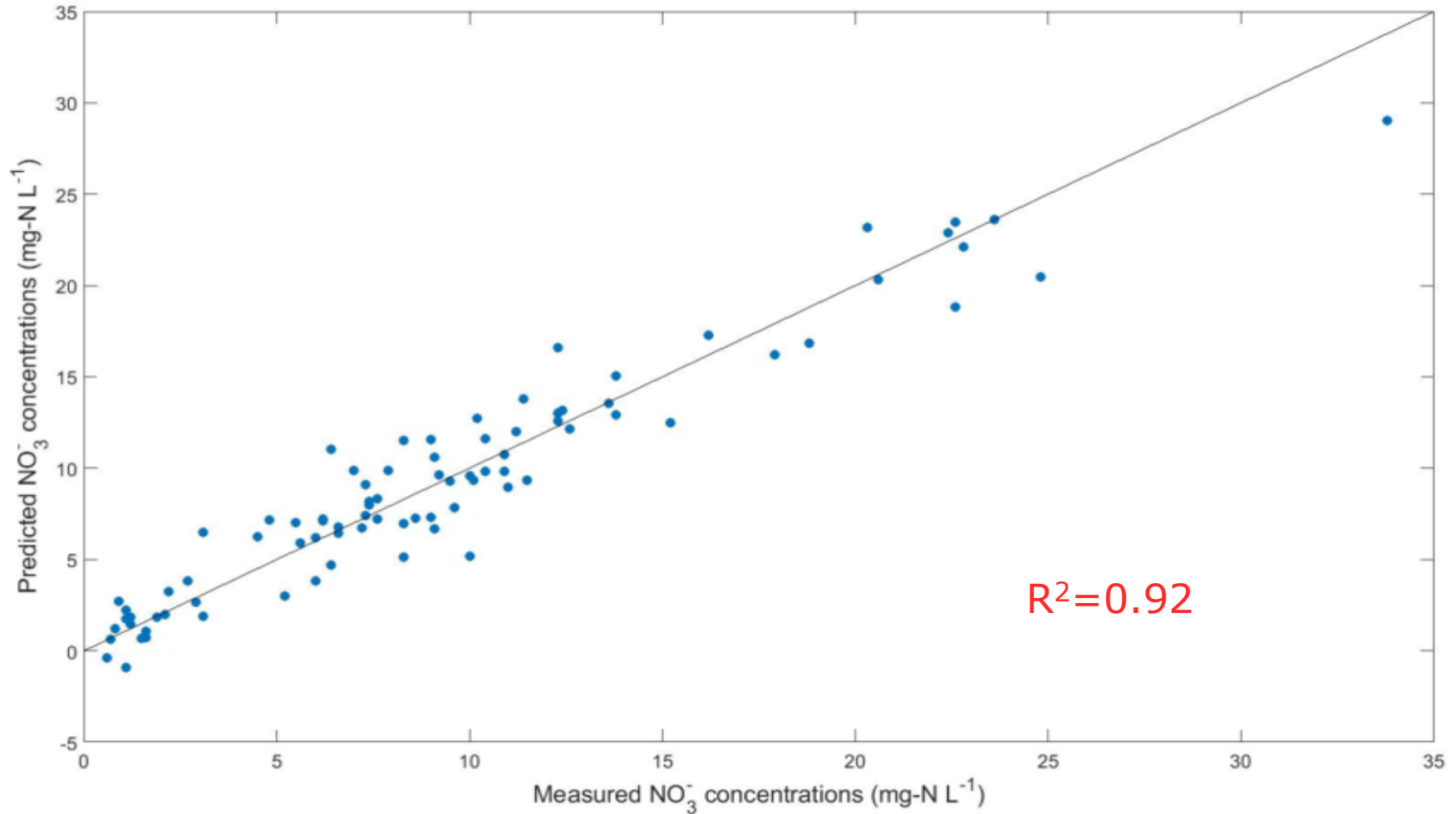
# *Chlorella sp.* – principal component regression $\text{NO}_3^-$ 3 PCs



# *Chlorella sp.* – leave one out cross validation $\text{NO}_3$

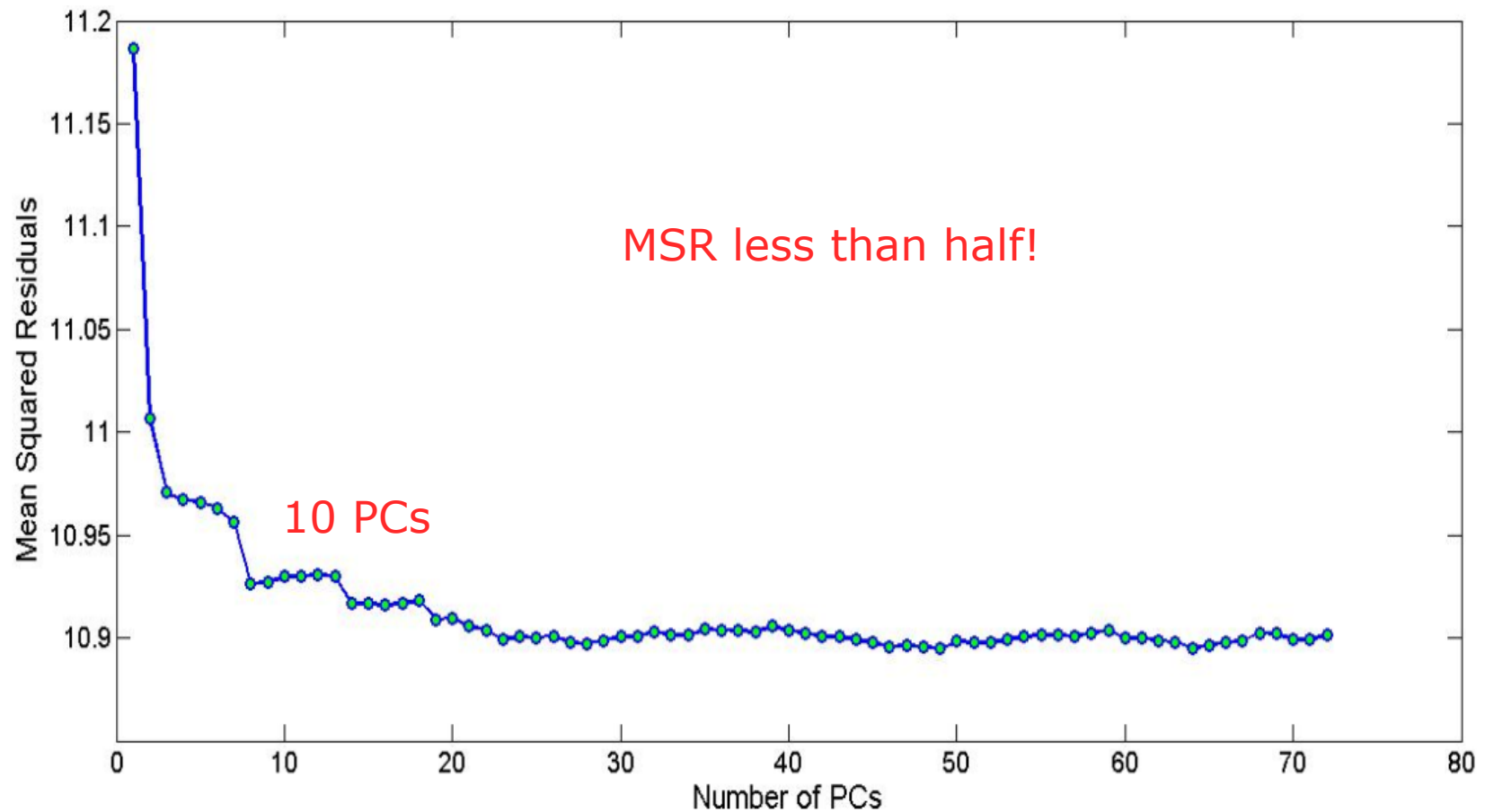


# *Chlorella sp.* – principal component regression $\text{NO}_3^-$ 14 PCs

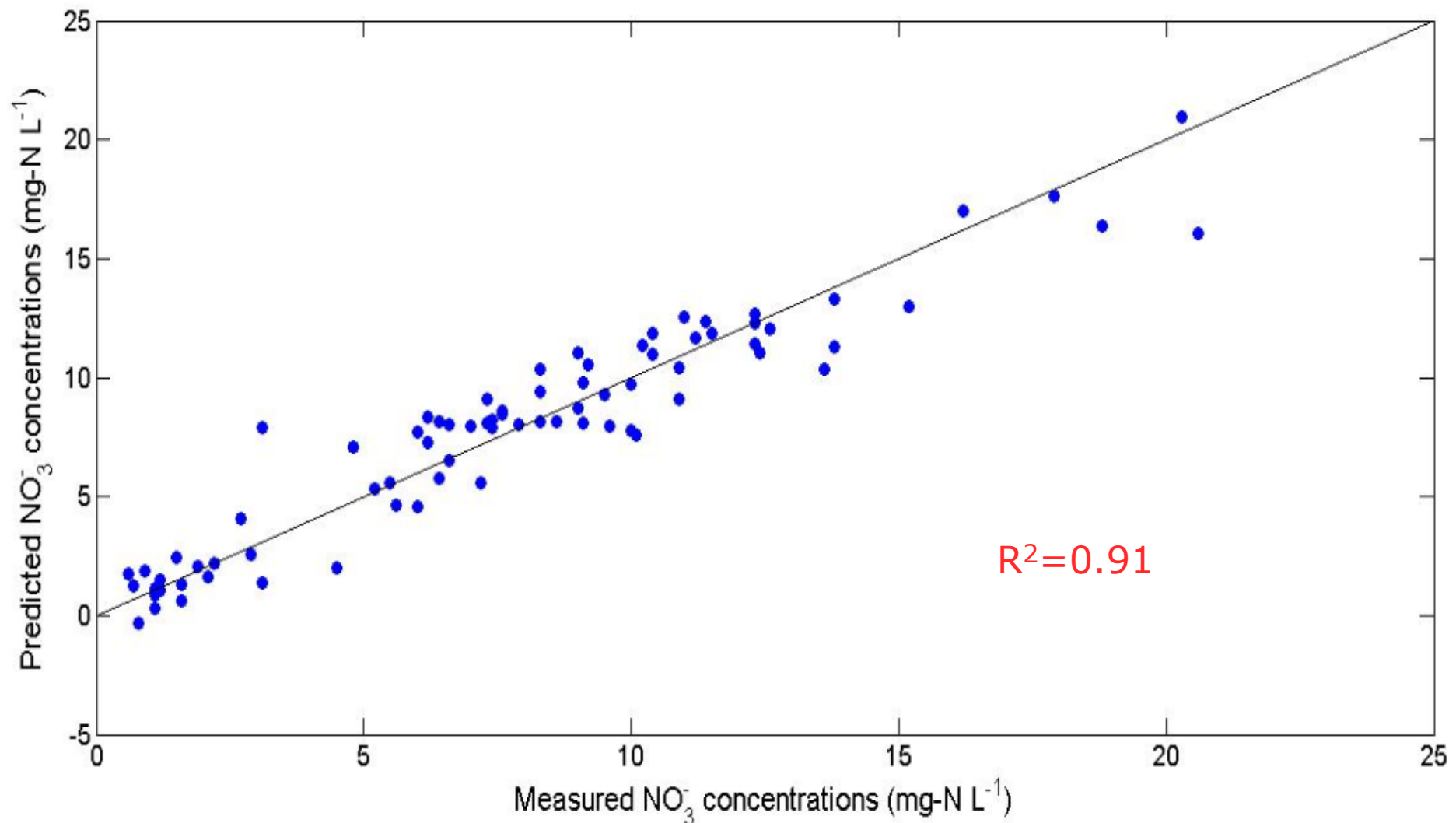




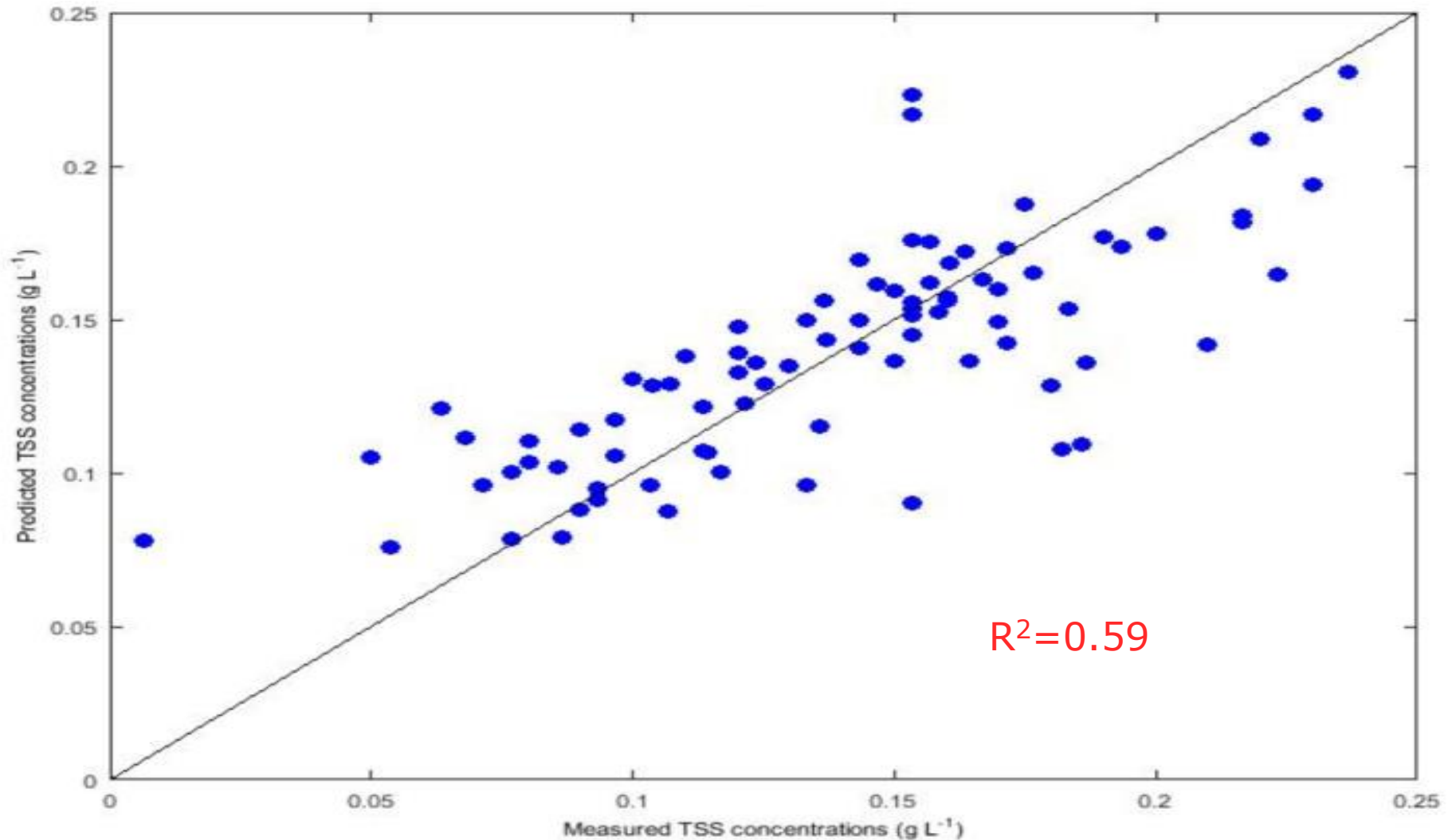
# *Chlorella sp.* – leave one out cross validation $\text{NO}_3$ without saturation



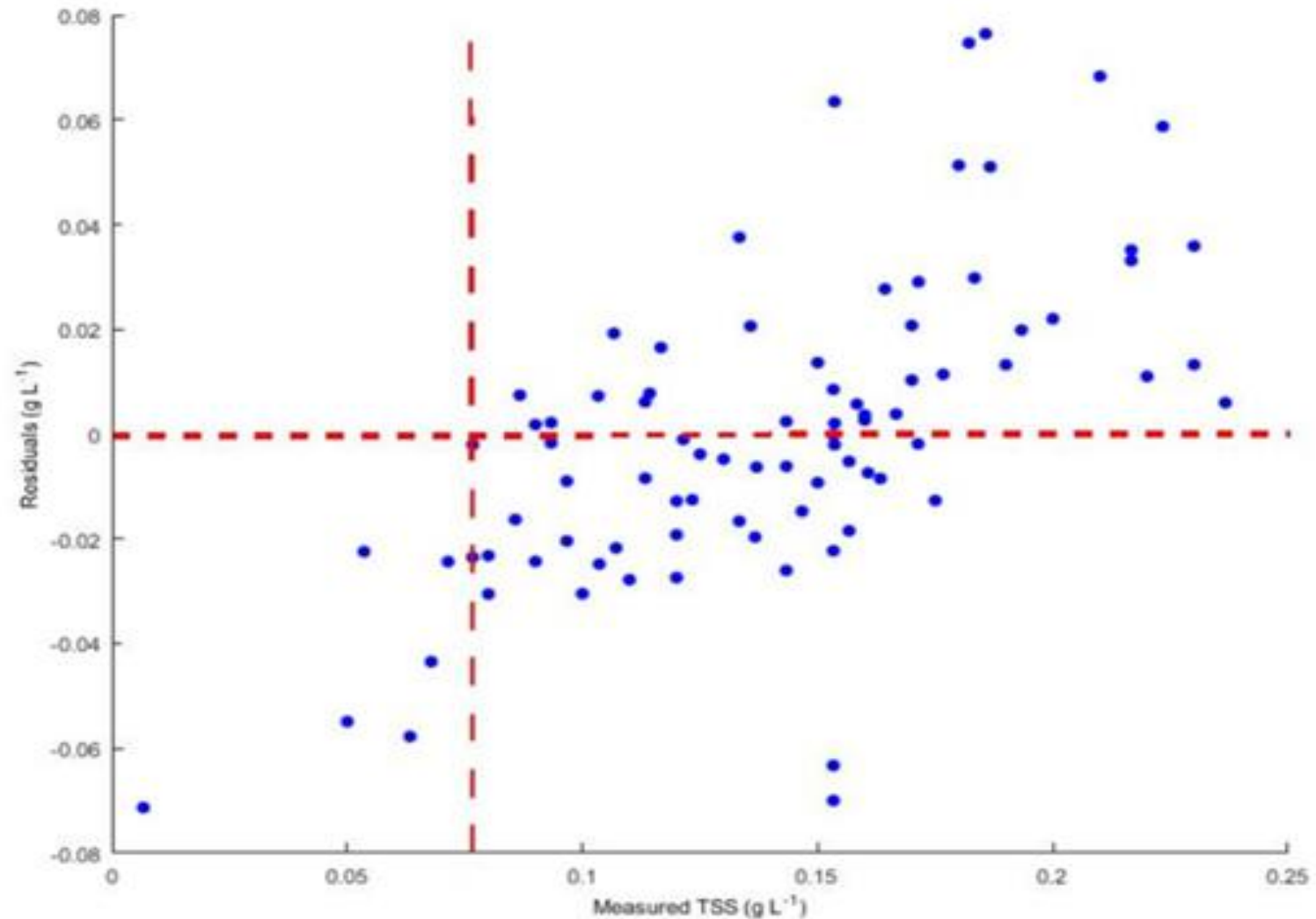
# *Chlorella sp.* – principal component regression $\text{NO}_3^-$ 10 PCs without saturation



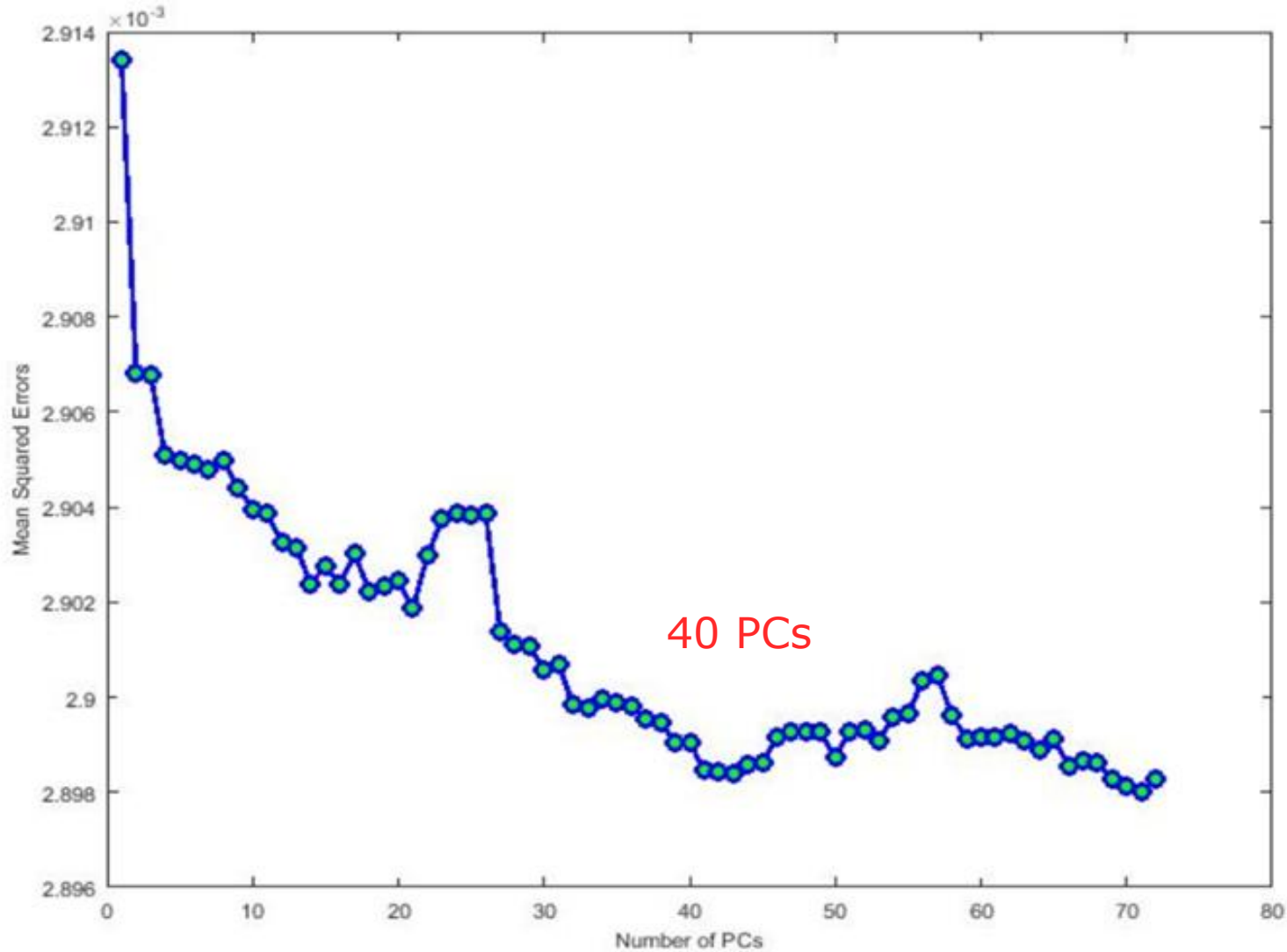
# *Chlorella sp.* – principal component regression TSS 3 PCs



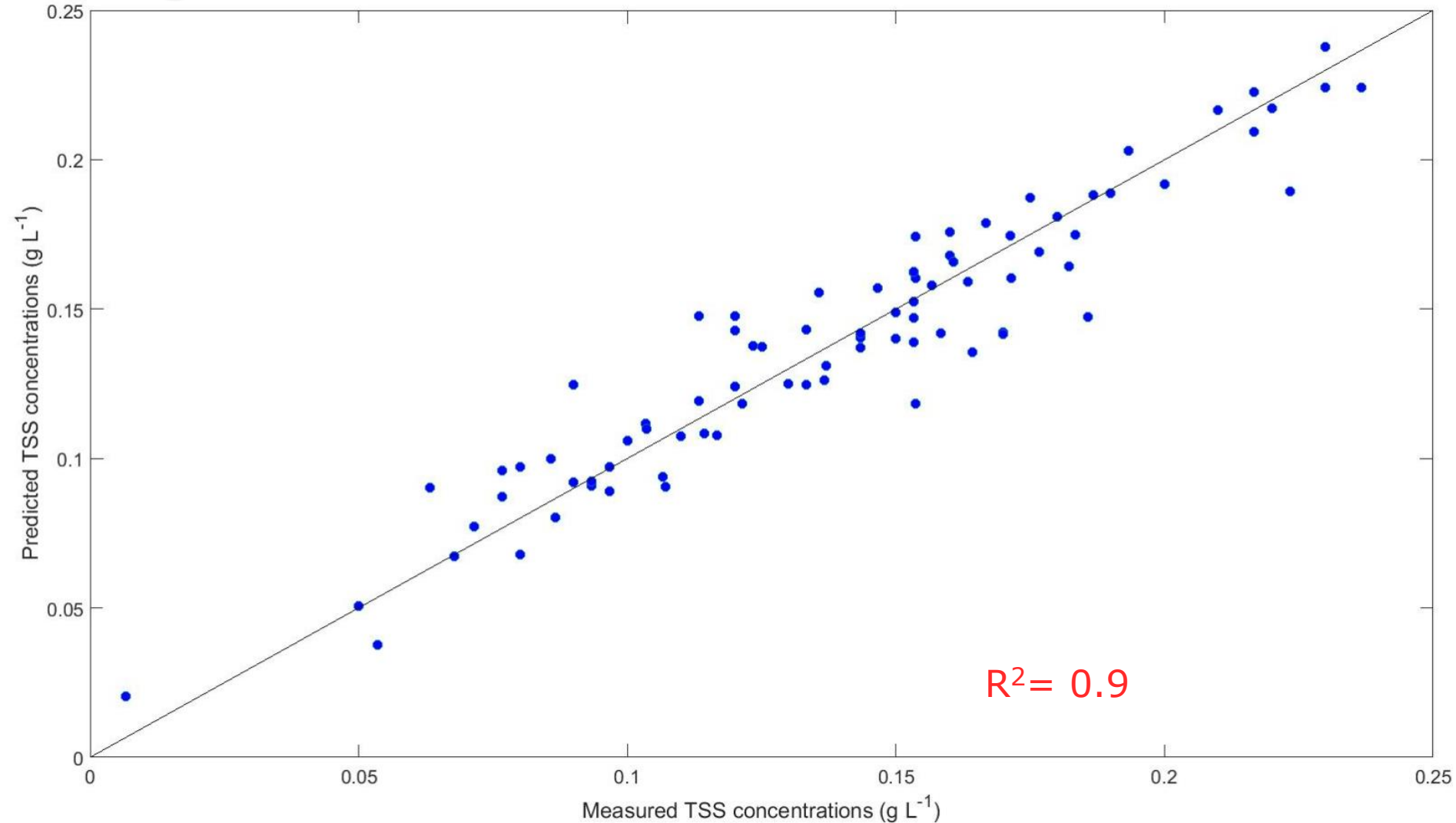
# *Chlorella sp.* – principal component regression TSS 3 PCs



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

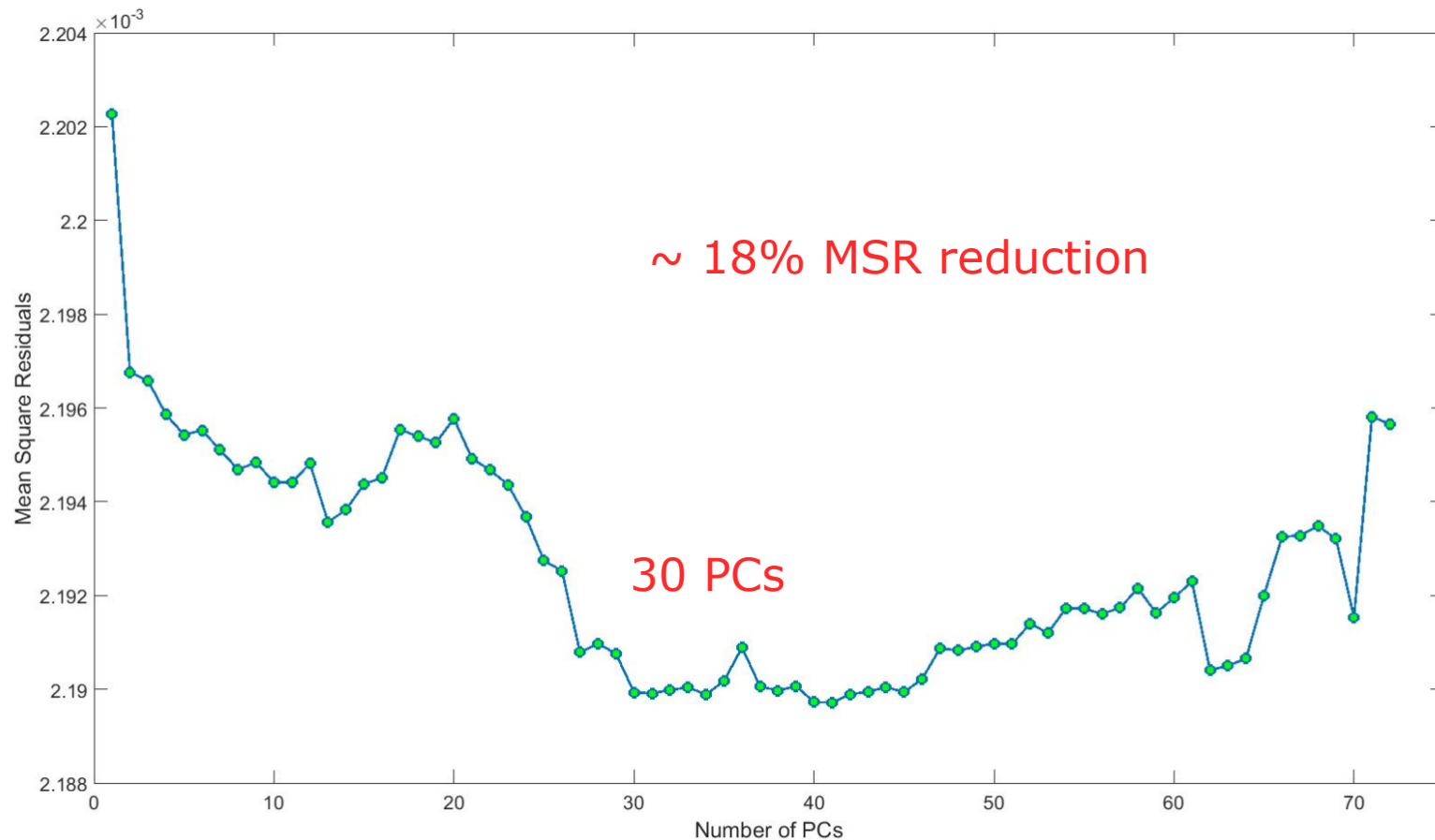


# *Chlorella sp.* – principal component regression TSS 40 PCs

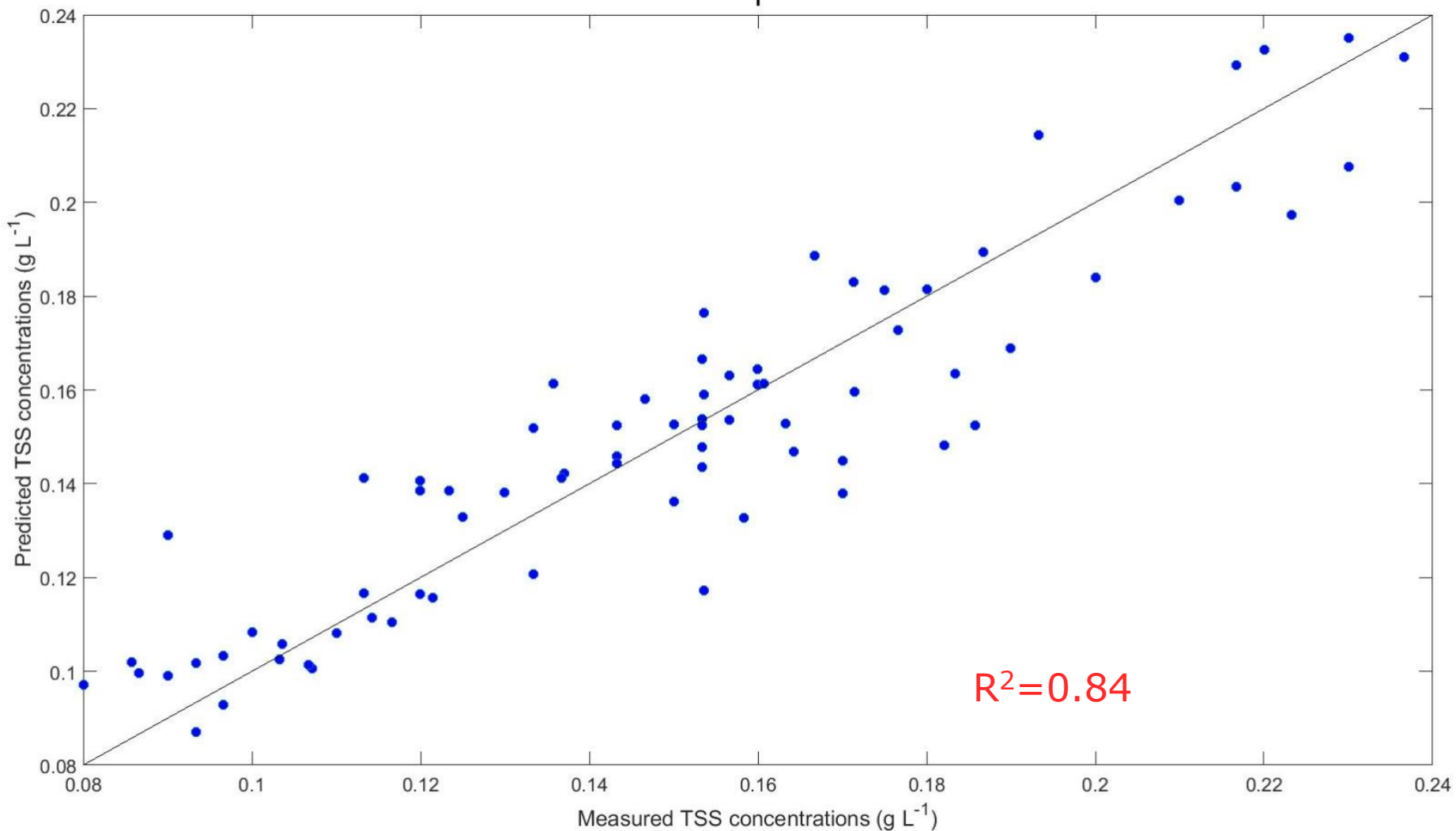




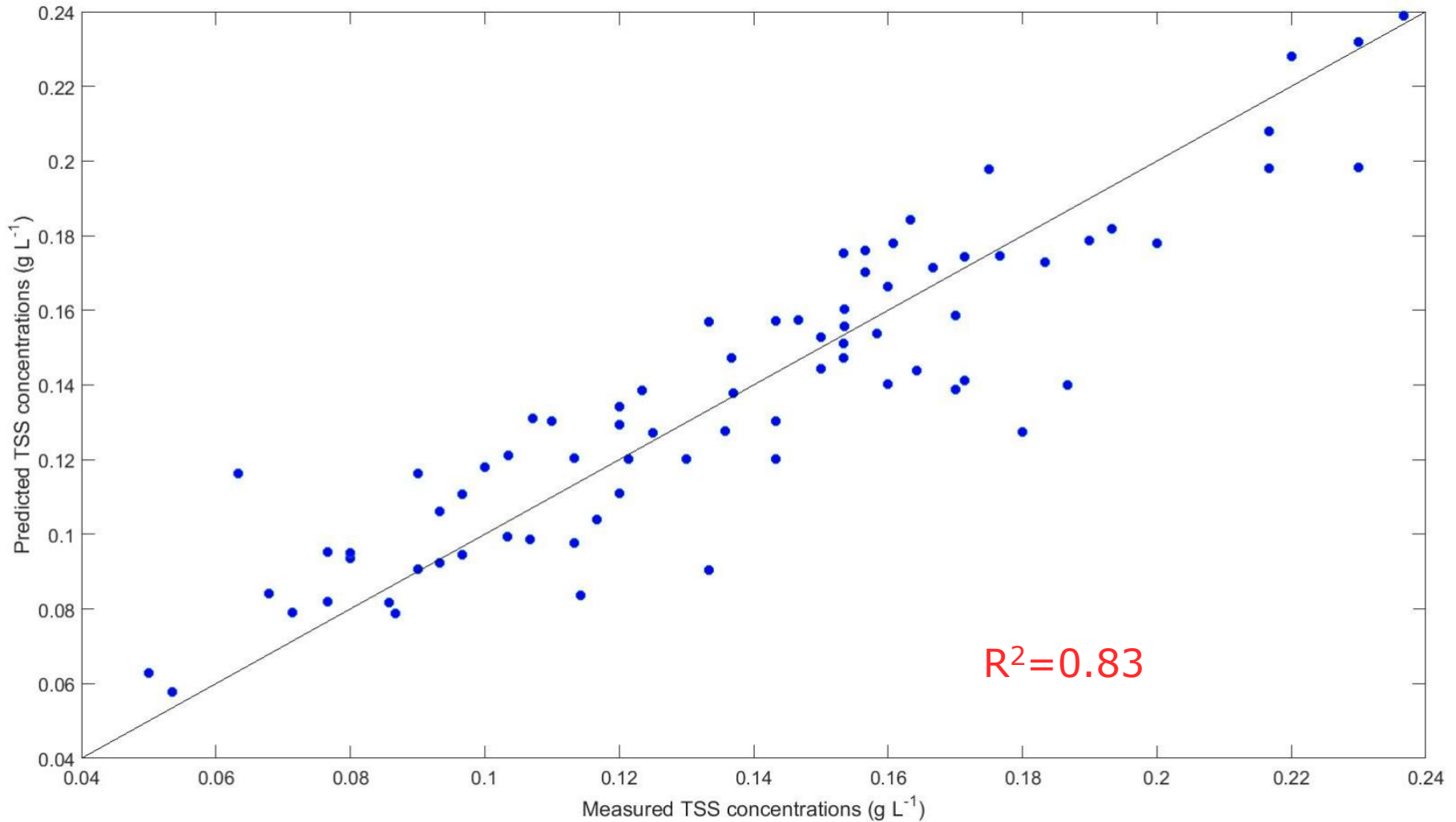
# *Chlorella sp.* – leave one out cross validation TSS above detection limit



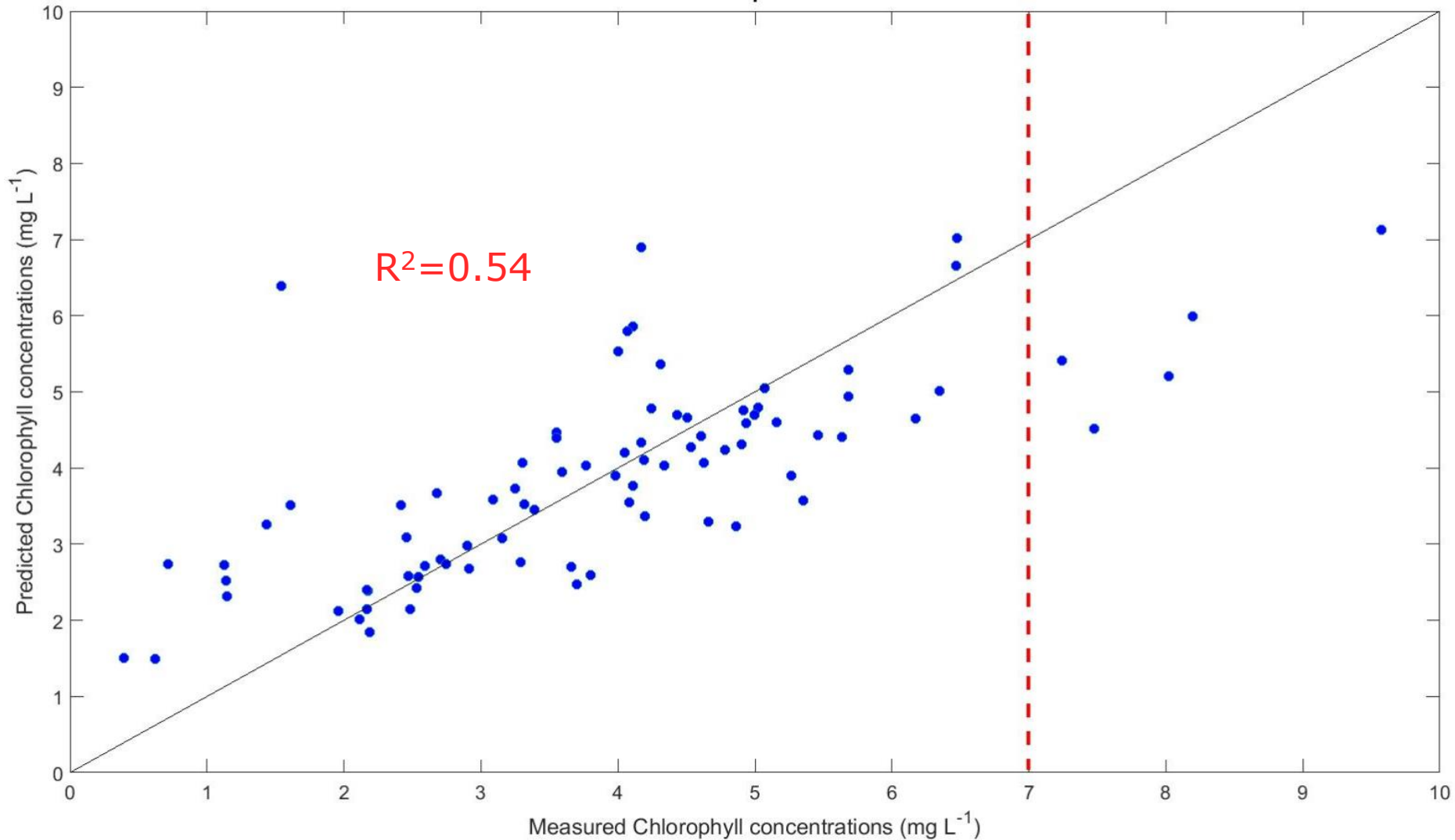
# *Chlorella sp.* – principal component regression TSS 30 PCs above detection limit



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

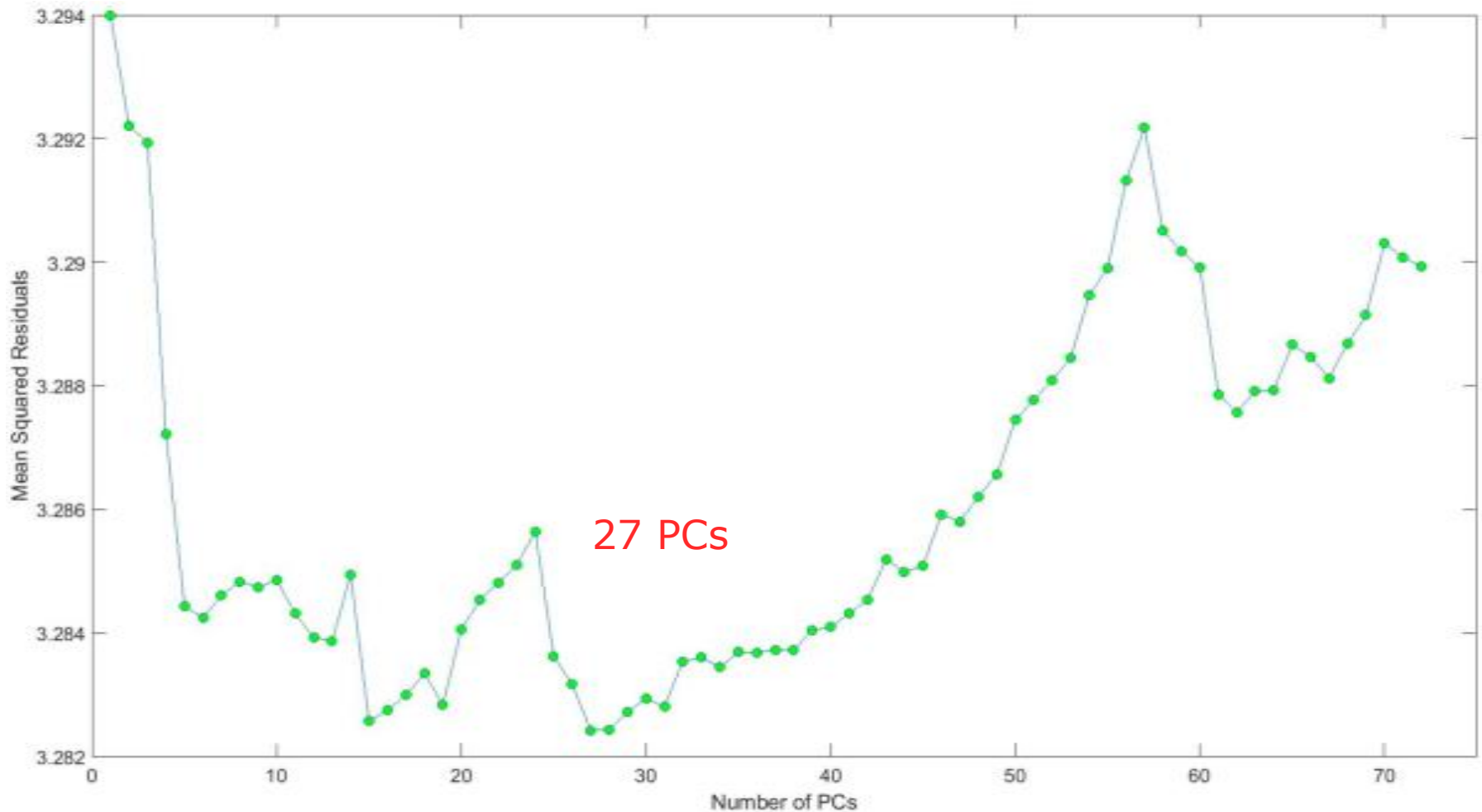


# *Chlorella sp.* – principal component regression Chlorophyll 3 PCs



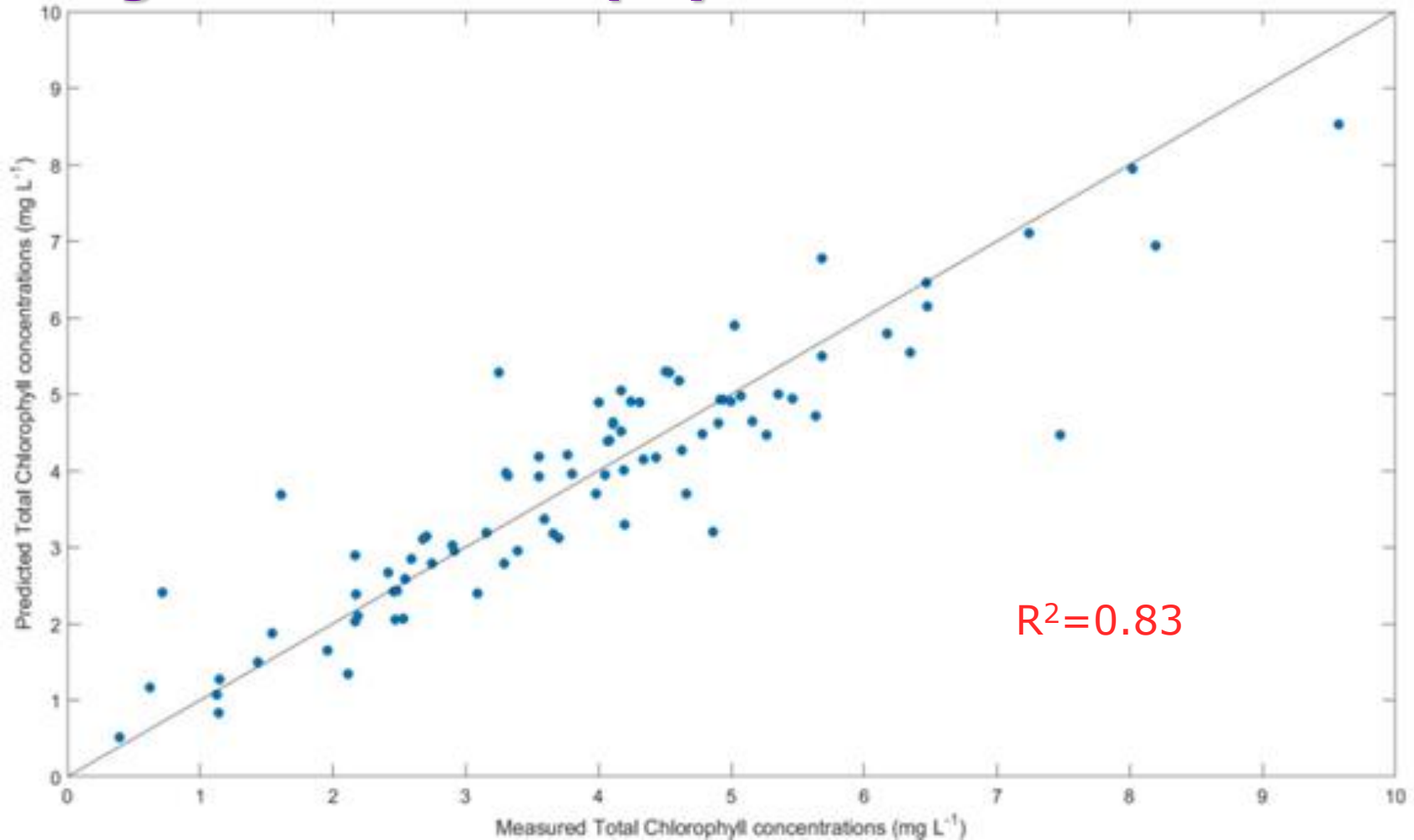


# *Chlorella sp.* – leave one out cross validation Chlorophyll

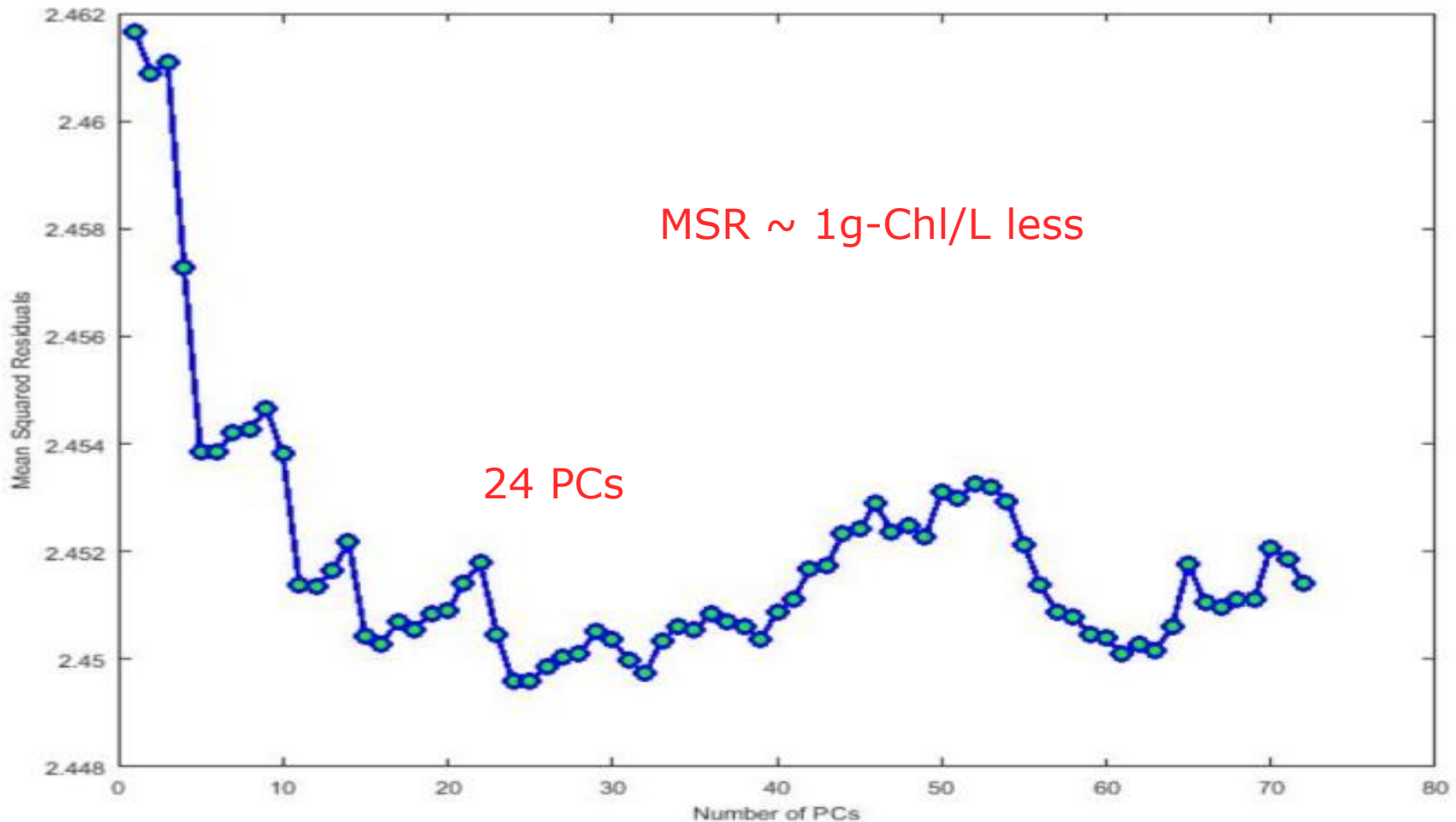




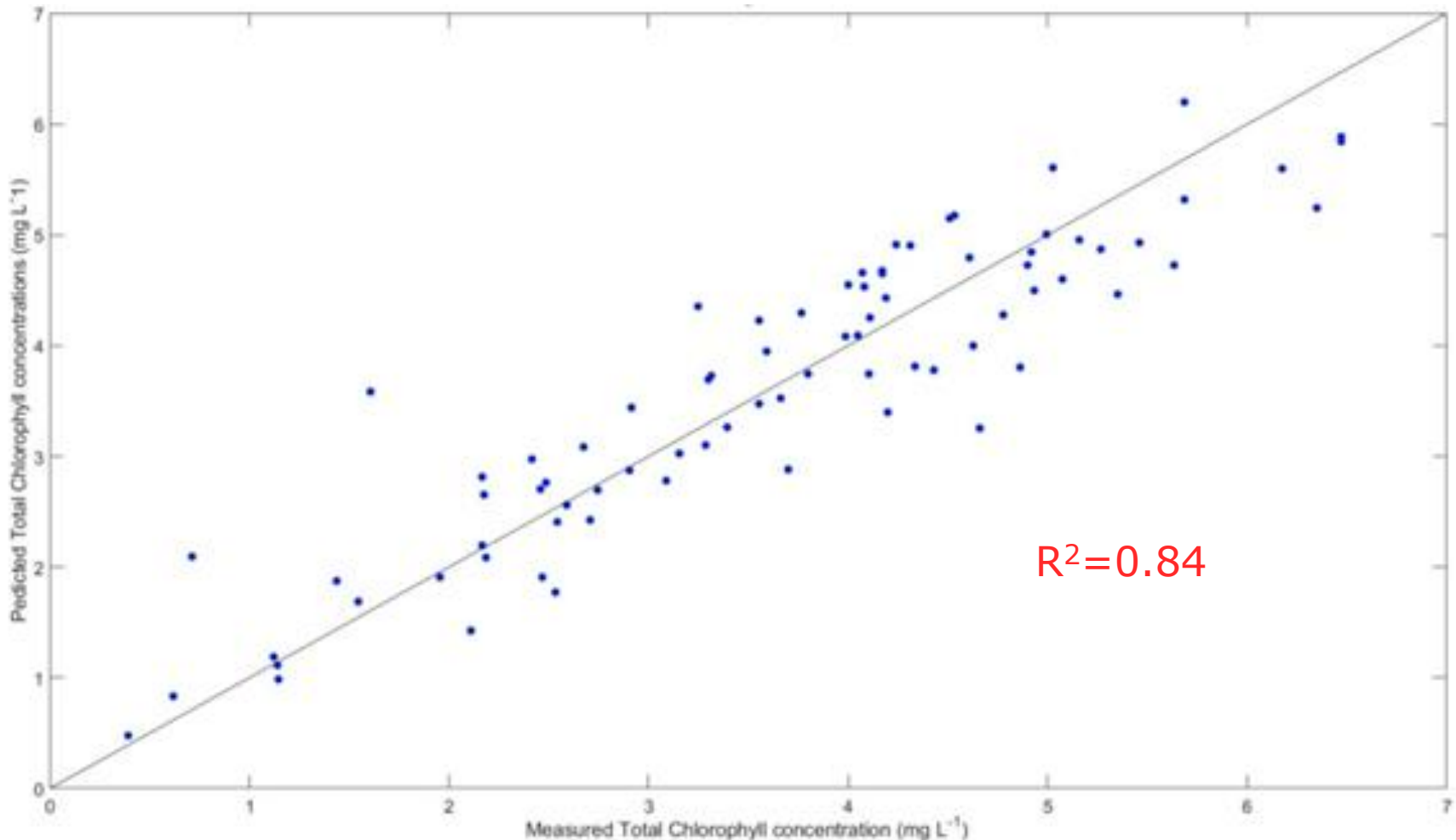
# *Chlorella sp.* – principal component regression Chlorophyll 27 PCs



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

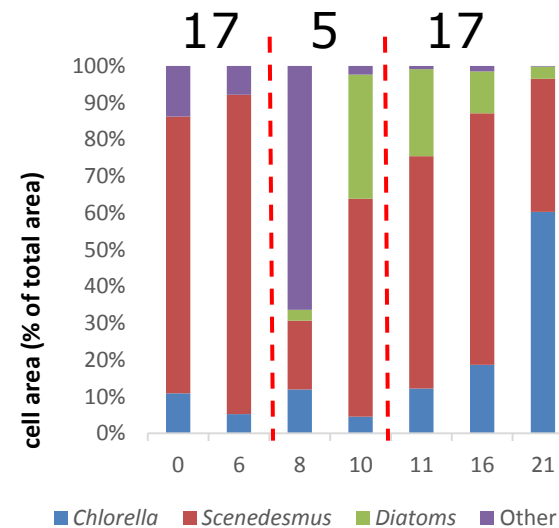
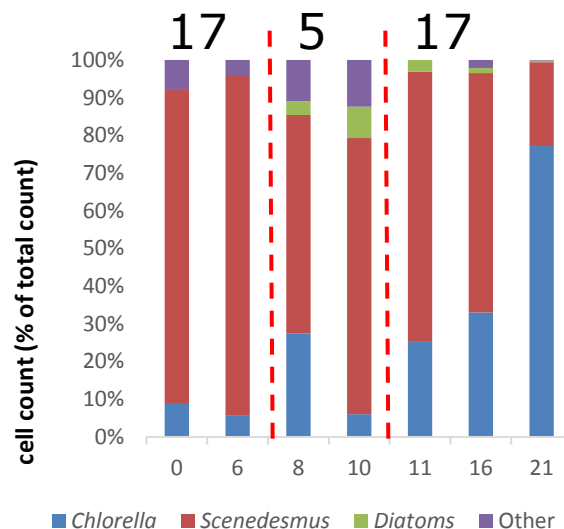


# *Chlorella* sp. – principal component regression Chlorophyll 24 PCs without saturation

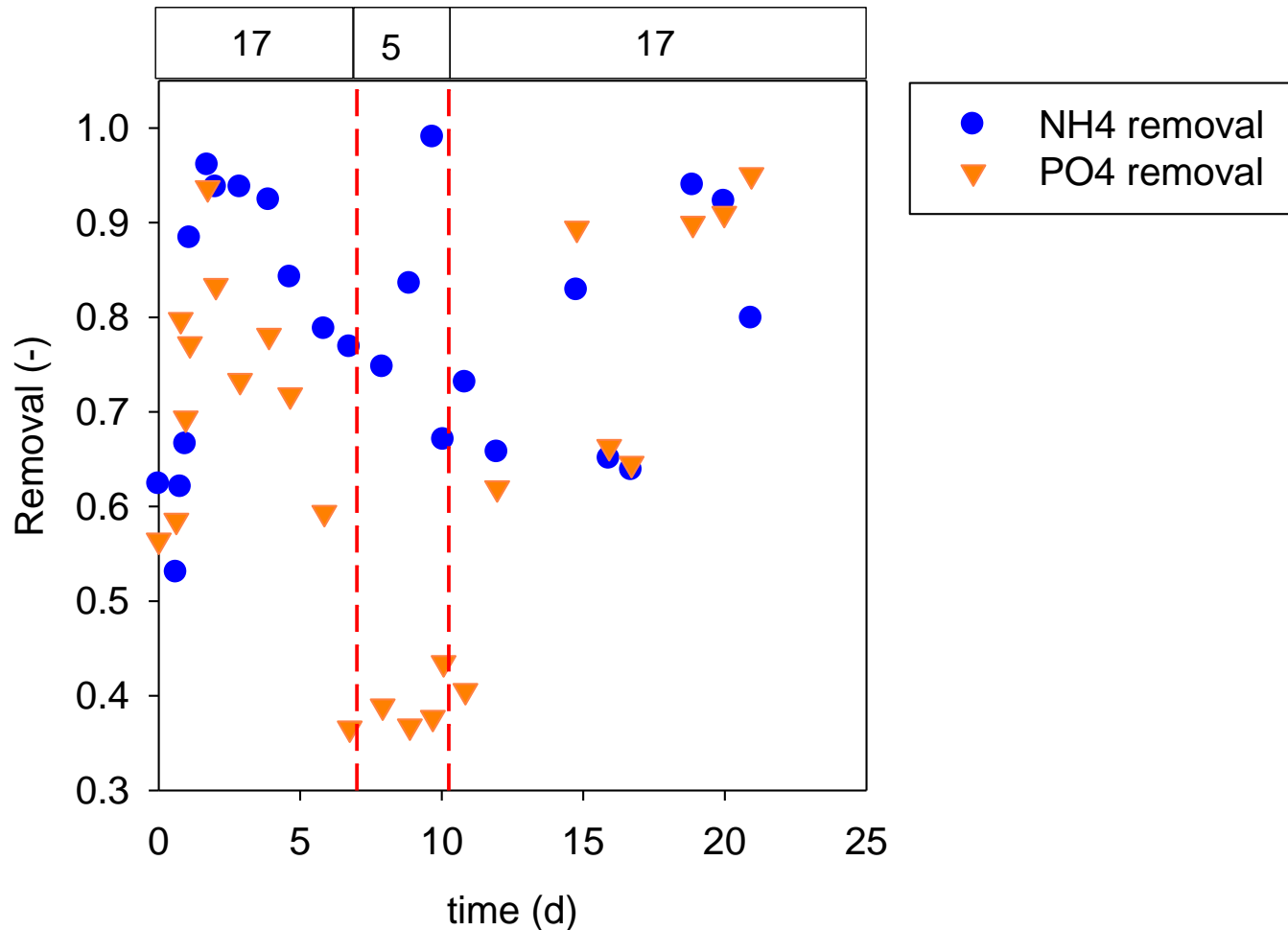


# Variation in microbial diversity

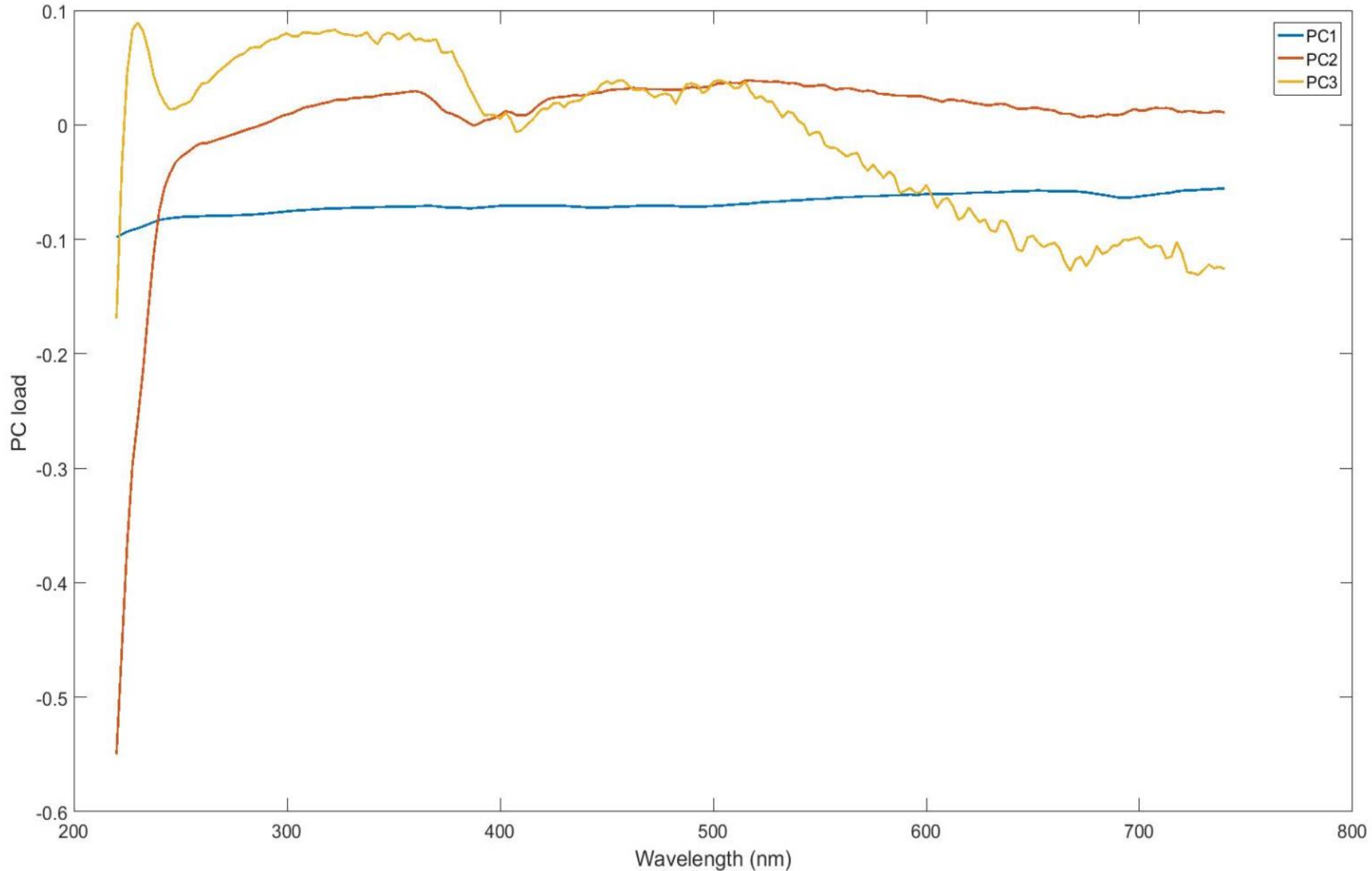
- Contamination by diatoms when N-to-P is lowered to 5
- Washout of diatoms when N-to-P is set back to 17
- Change in abundance of *Chlorella* and *Scenedesmus* sp.
- Hypothesis to test:
  - **Do changes on shape and size affect the prediction capacity by UV-Vis sensors?**



# Mixed culture – process performance

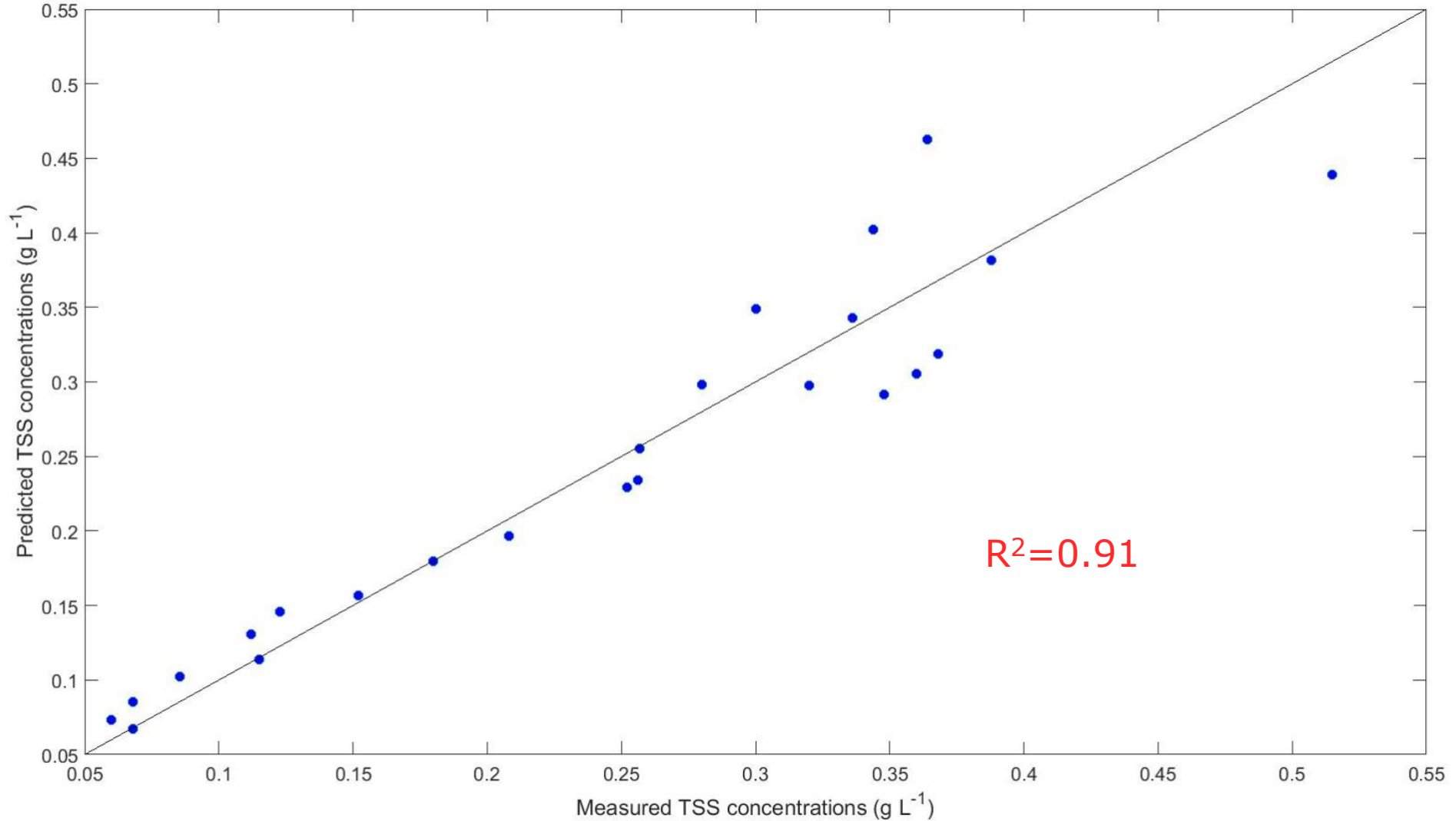


# Mixed culture – principal component analysis



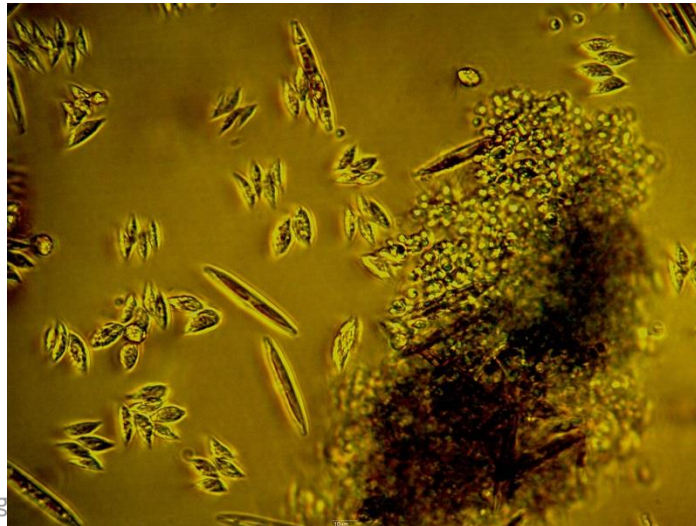


# Mixed culture – principal component regression TSS 1 PC



# 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



The research was partly financed by EU European Commission, (E4WATER Project) and the Integrated Water Technology (InWaTech) project (<http://www.inwatech.org>)

