

Performance monitoring of a biological deoxygenation process to treat ballast waters

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The biological deoxygenation as a BWT

- Bioreactive process using a non-fermenting yeast
- Developed by MD Technologies, Quebec, Canada
- Hypoxic conditions (< 0.5 mg/L) within a few hours, without alcohol production
- No persistent toxic chemicals at the time of discharge

“Treated waters must meet environmental criteria at the time and point of discharge”

Study objective

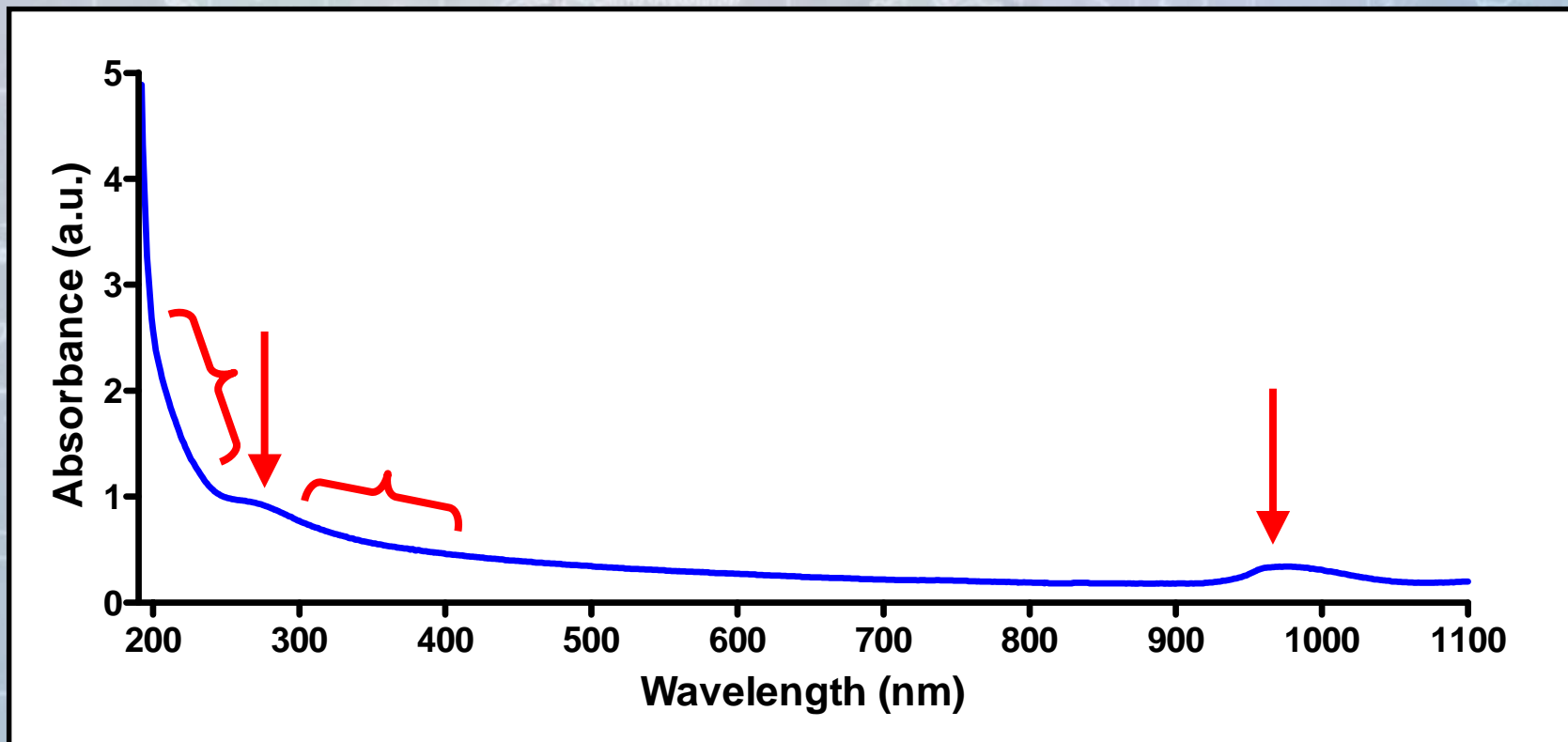
Since classical analytical methods for water quality monitoring are:

- Time consuming;
- Difficult to perform on board ship

Develop and validate a rapid and integrated method for *in situ* monitoring of the biological deoxygenation treatment

UV (Visible-NIR) spectrophotometry

- Direct measurement, without any transformation of the sample
- Small volume needed (~ 3 mL)
- Rapid analytical time (< 1 min)
- Spectral acquisition from 190 to 1100 nm
- Allows single and multi-wavelength analysis



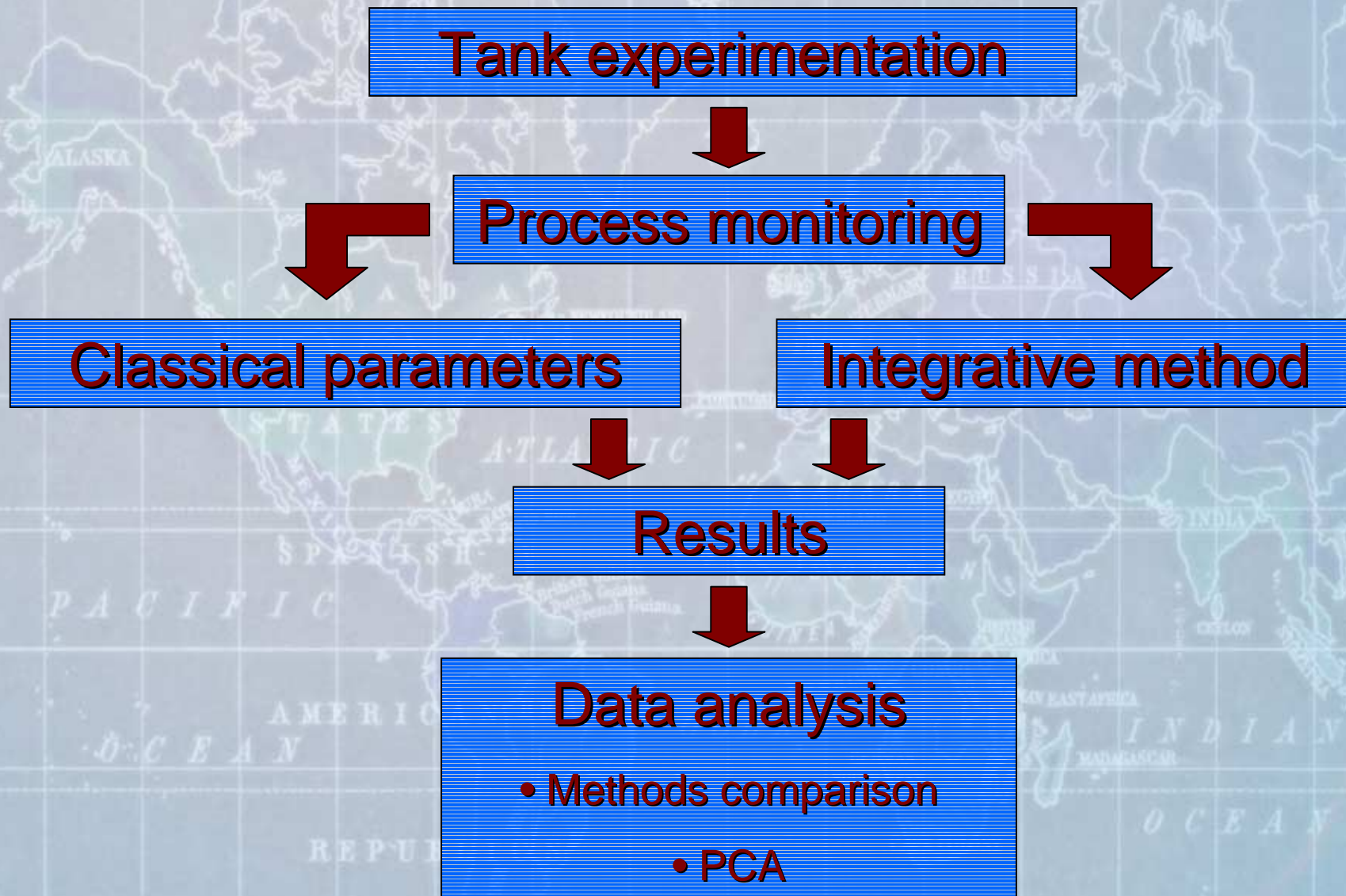
Hypothesis

Given that:

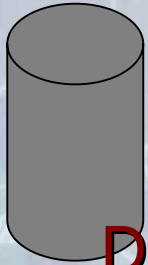
- Spectrophotometry is used to directly monitor rapid changes in the water quality (Thomas, 2001)
- The bioreactive process modifies the water quality over time

Rapid and quantitative assessment of the bioreactive process can be done *in situ* by using spectrophotometry

Experimental approach



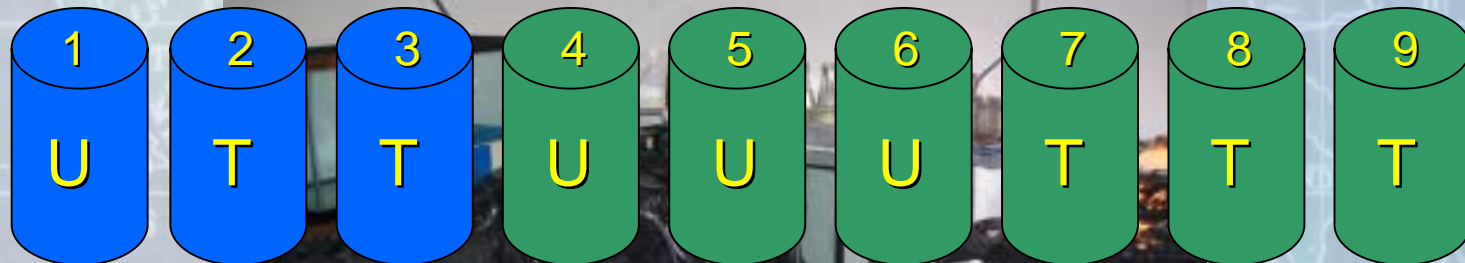
Tank experimentation: setup



9 polyethylene tanks (150 L)

Placed in darkness at 15°C during 10 days
Dechlorinated water River water

Gently mixed with submersible garden pumps



Same density of yeast in each treated tank

Process monitoring

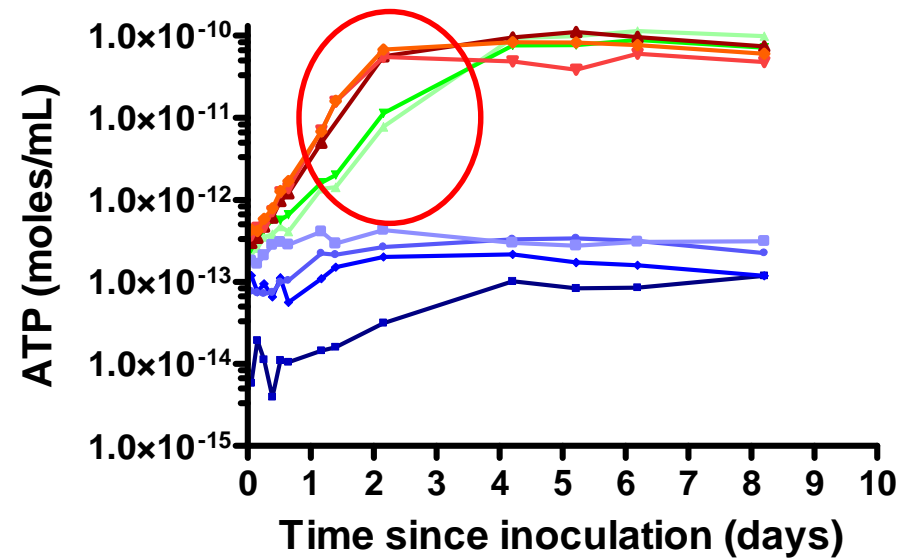
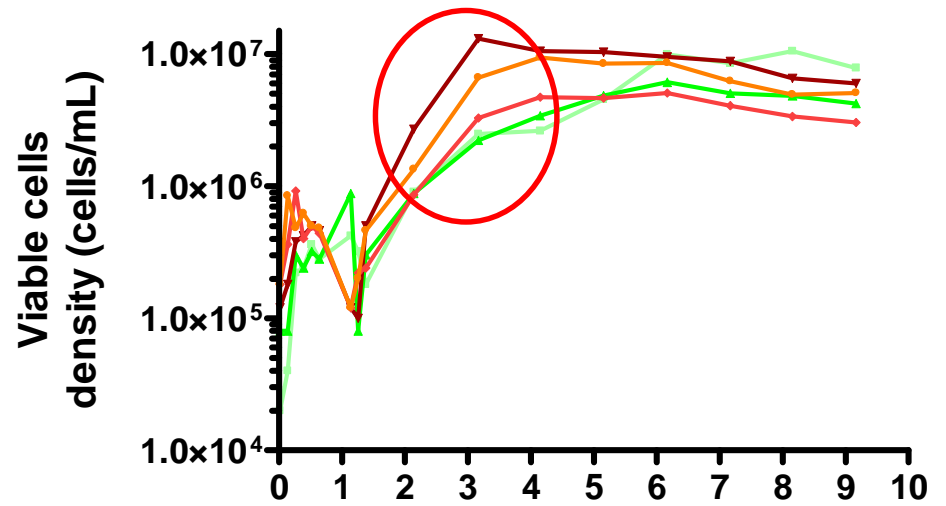
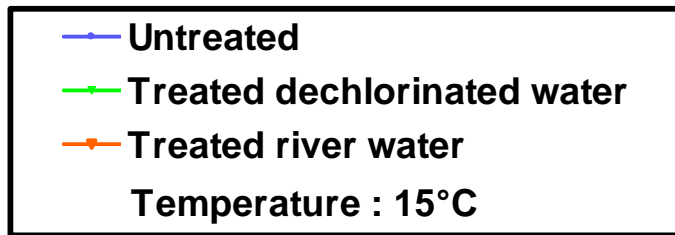
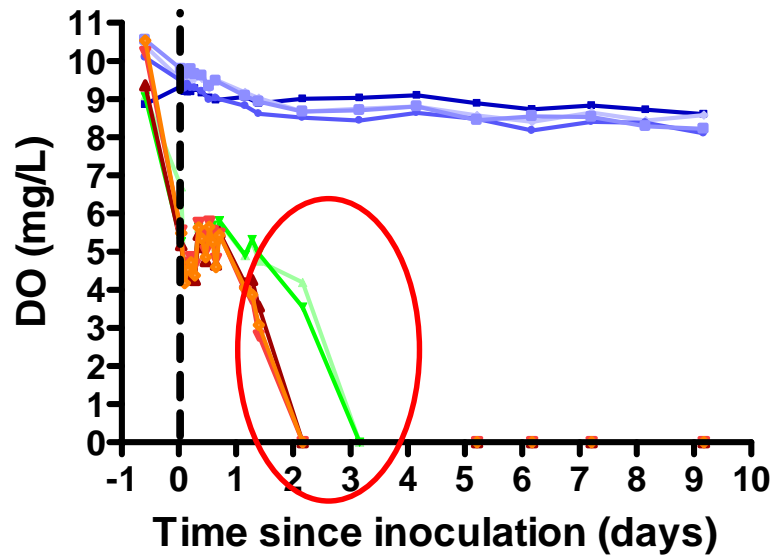
Parameters	Techniques
Dissolved oxygen	Winkler titration technique
DOC and NH_4^+	Automated chemical analysis
pH, conductivity, temperature	<i>In situ</i> sensor probes
Yeast cell density and viability	Microscopic cell count
	ATP extraction
	Flow cytometry
Integrative spectral response	UV (Visible-NIR) spectrophotometry

UV spectrophotometry in this study

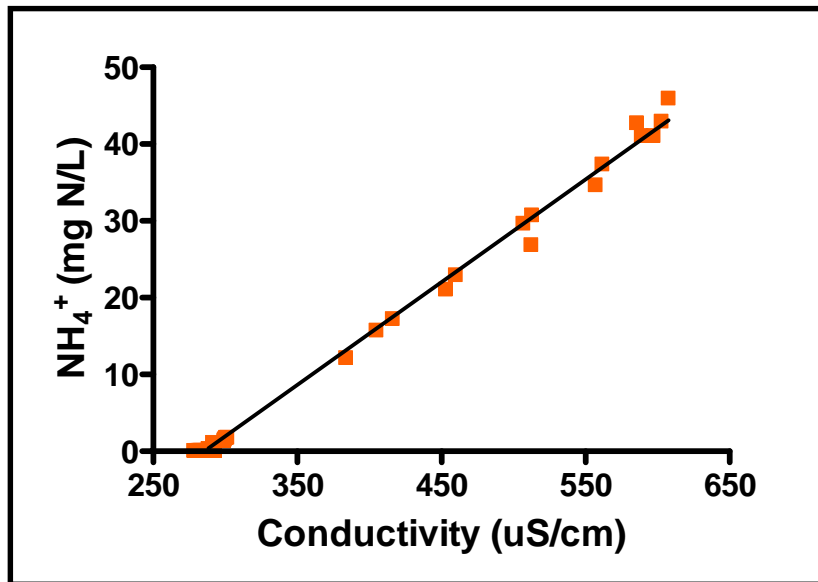
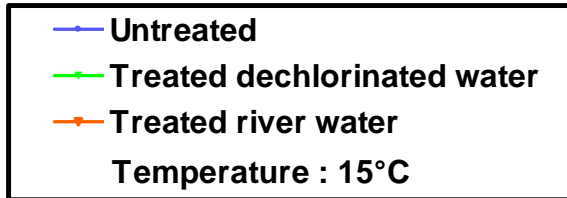
- **Exploitation range from 190 to 320 nm (UV band)**
- **Single and multi-wavelength analysis**



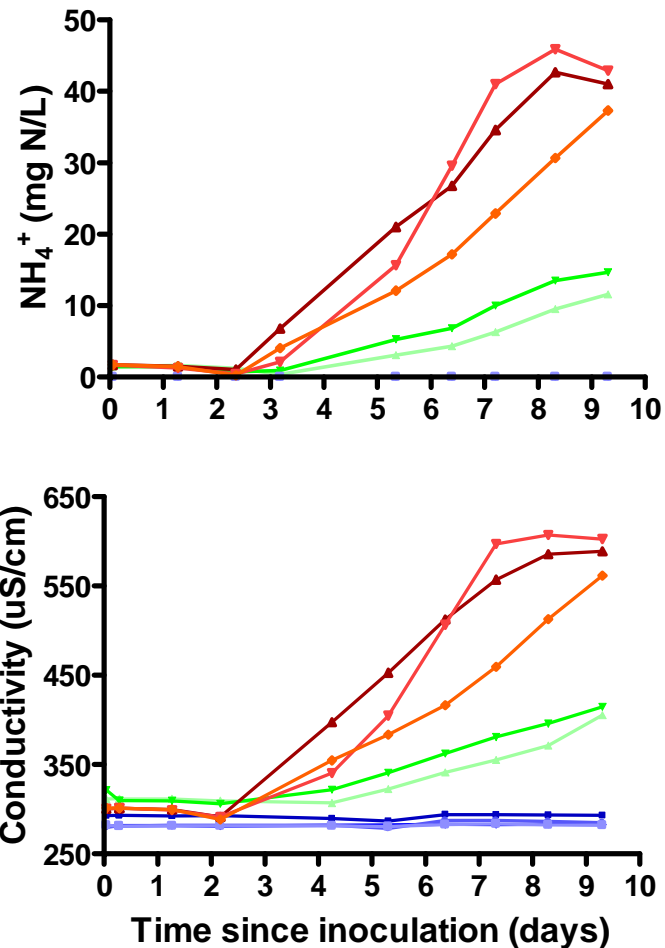
Results: classical parameters



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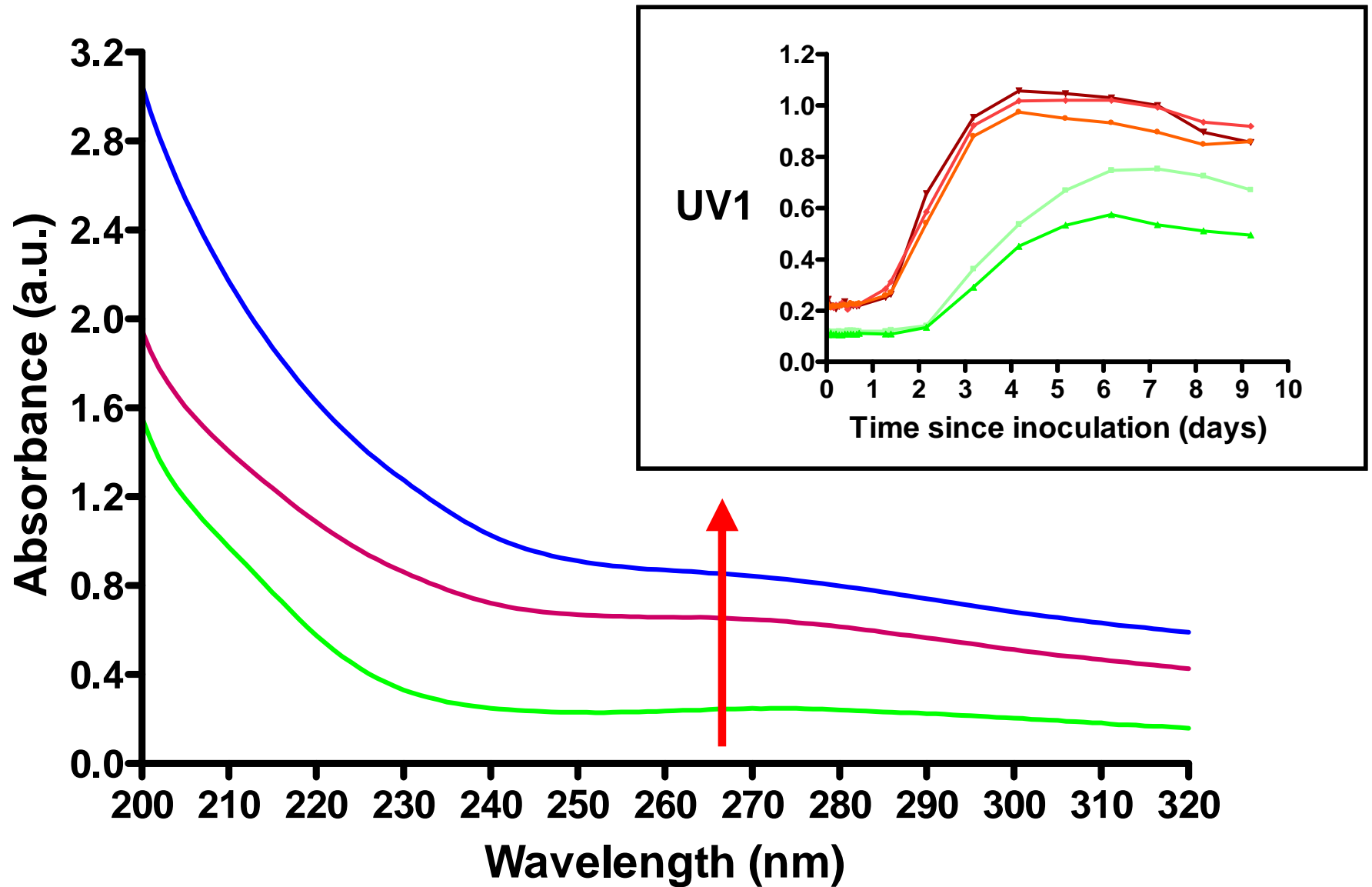


$$R^2 = 0.996$$

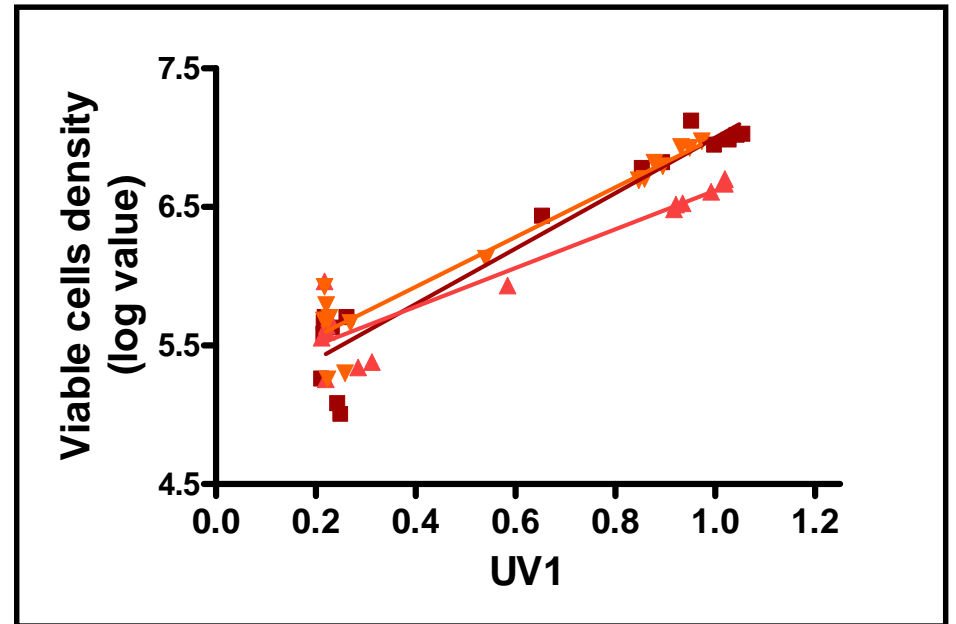
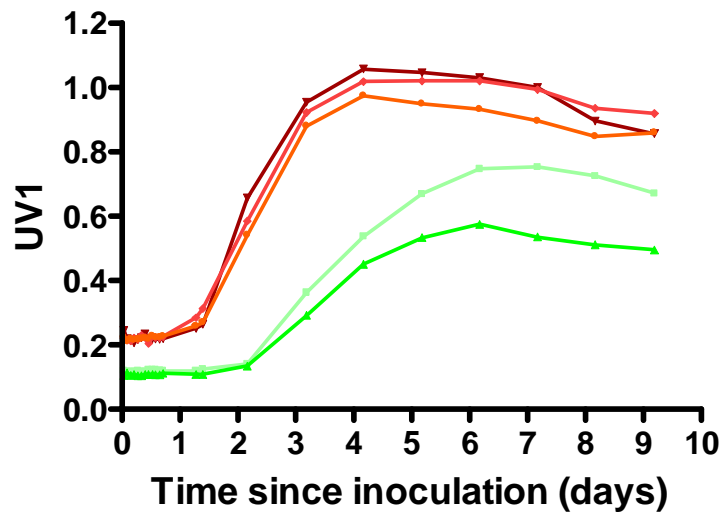
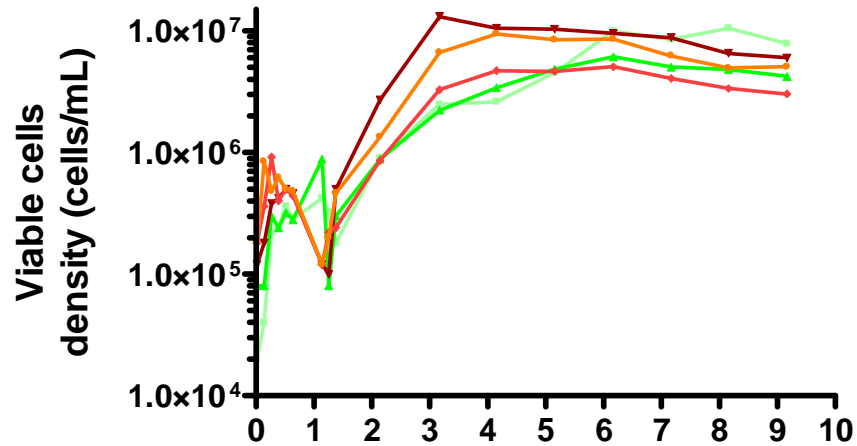


Results: spectral response

Treated river water



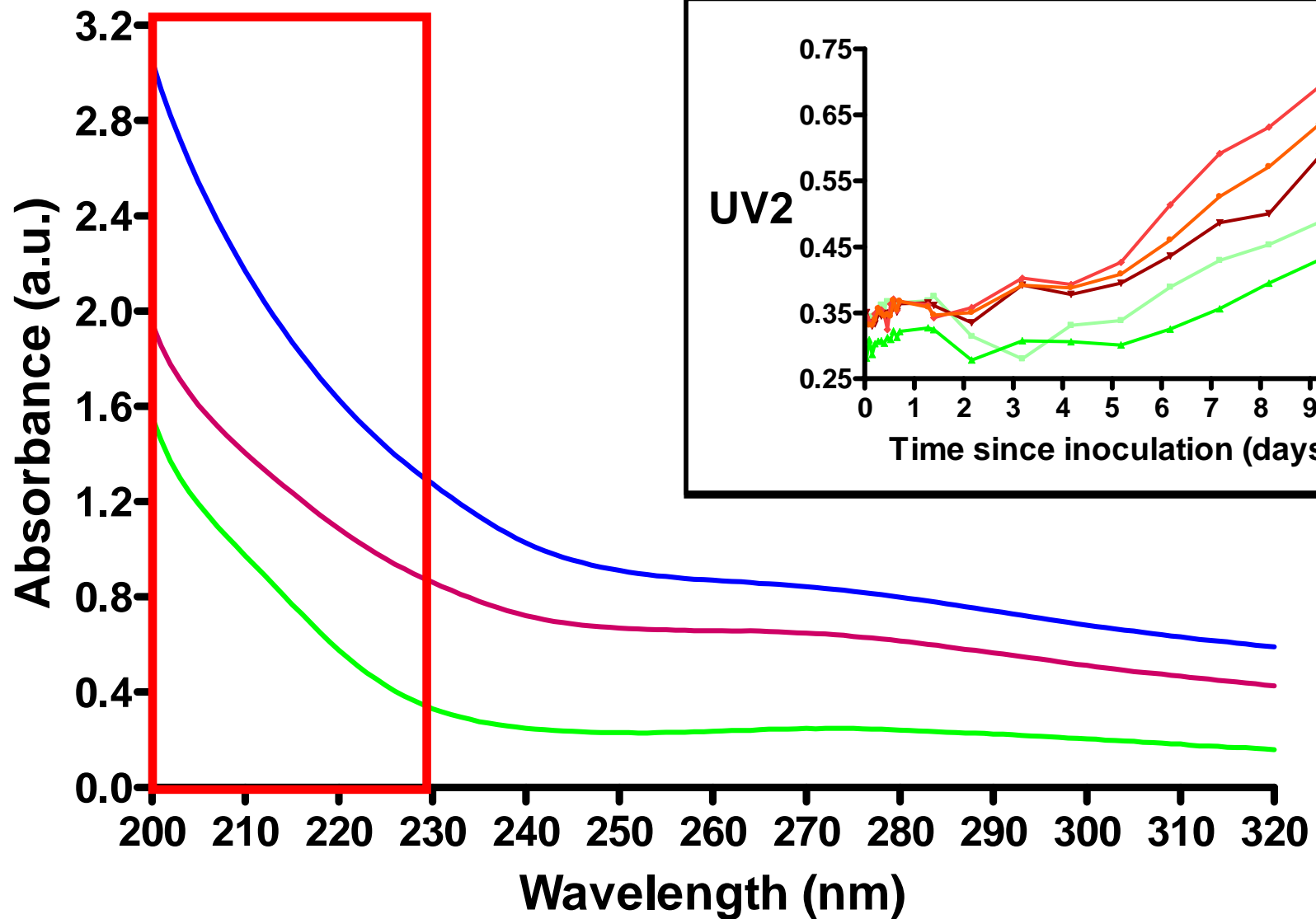
Results



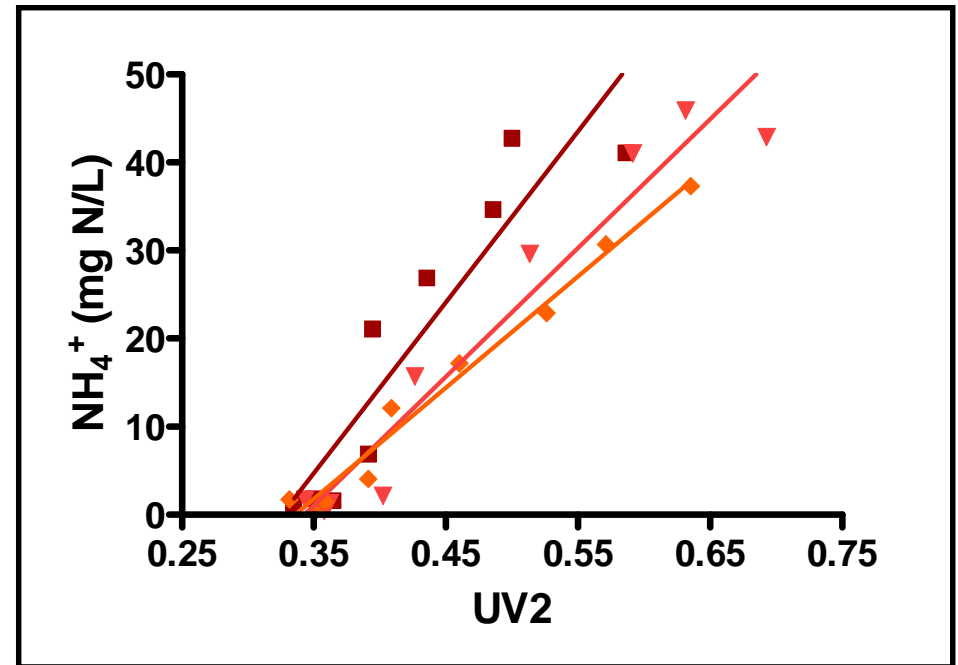
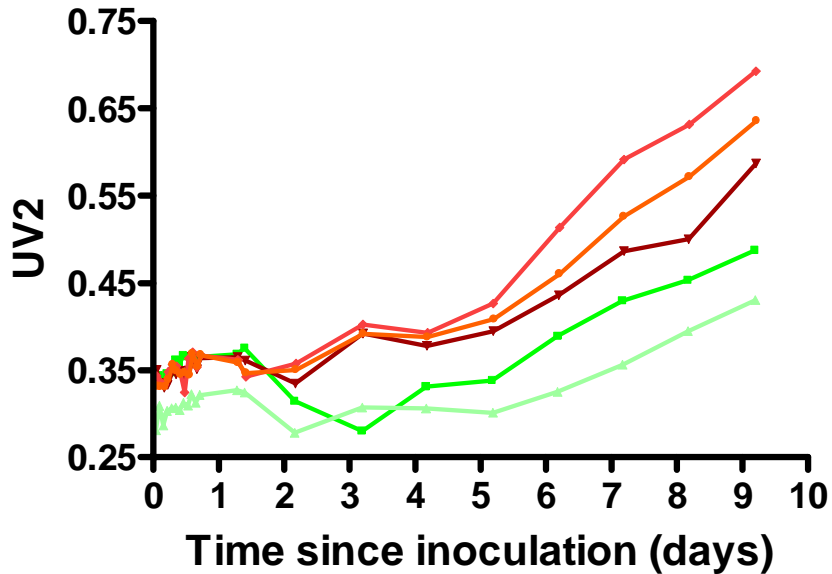
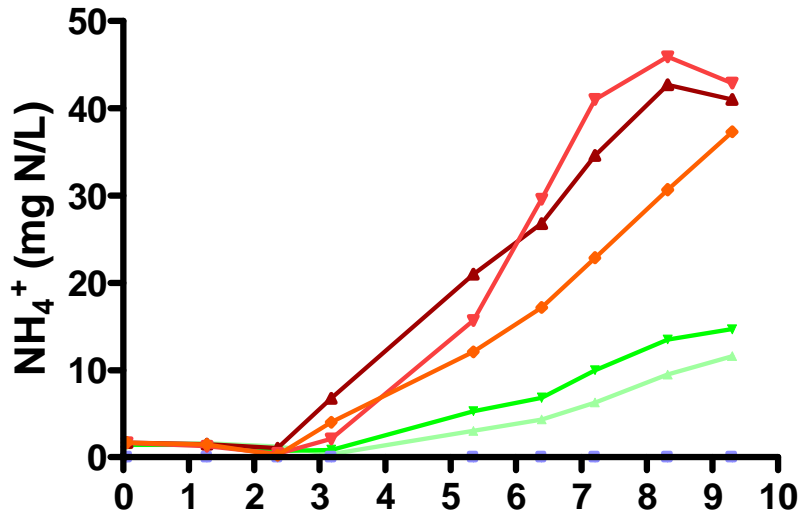
R^2 from 0.89 to 0.93

Results: spectral response

Treated river water

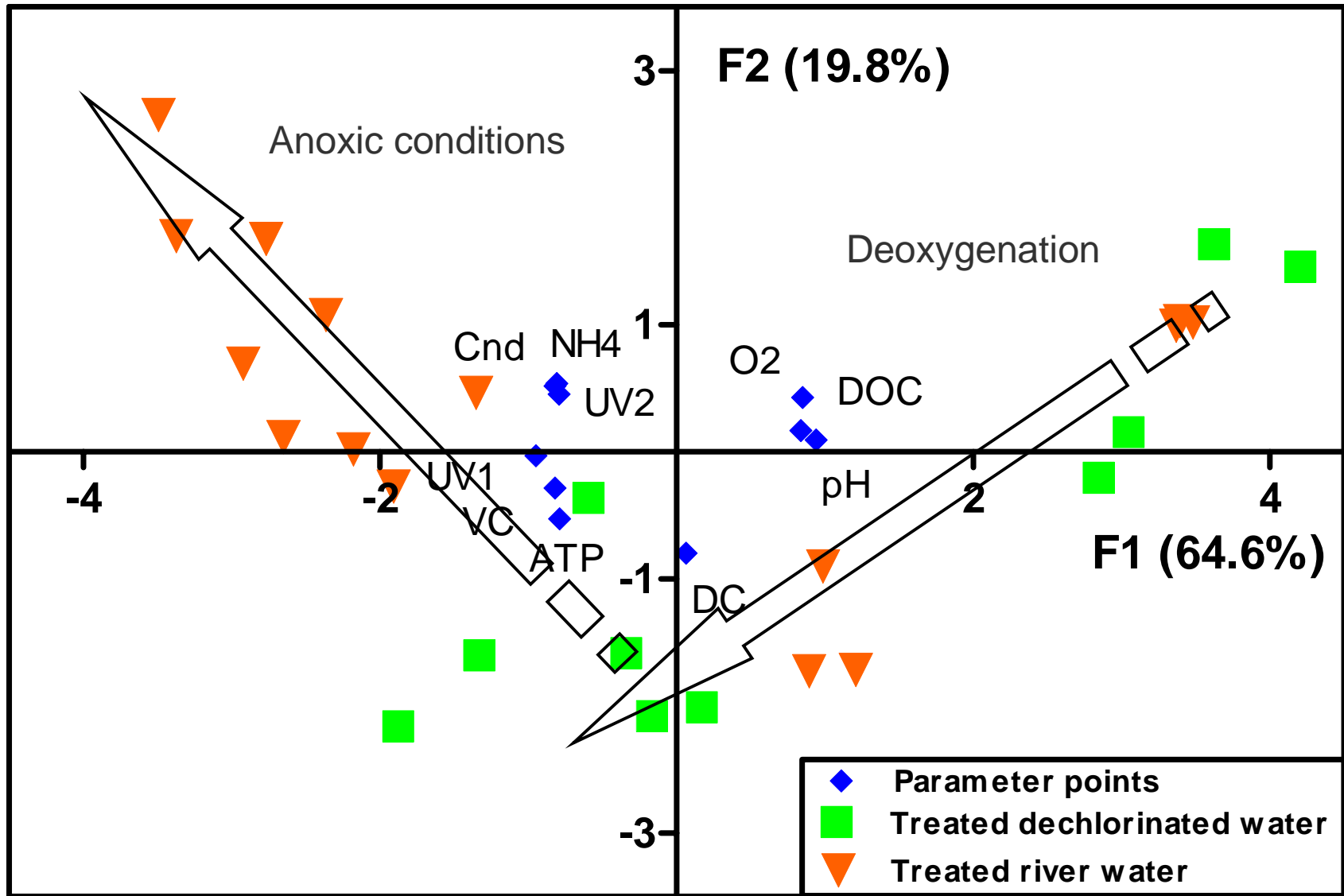


Results



R^2 from 0.85 to 0.98

Results: PCA



Discussion

- **First demonstration that spectrophotometry can be used for real-time tracking of the behaviour of a yeast bioreactor**
- **The UV spectrum (200-320 nm) provides information on both water quality parameters and biological material (yeast) during the biological treatment**
- **Viable cells density is strongly correlated ($r^2 > 0.89$) with the absorbance at 266 nm (UV1), which corresponds to DNA absorbance**
- **The second derivative (UV2), depicting the change in the slope of the UV-spectrum, is strongly correlated ($r^2 > 0.85$) with ammonia, currently used in water quality assessment**

Conclusion

Spectrophotometry can be used for direct monitoring of the ballast water biological treatment on board ship

- **Rapid and easy to operate**
- **No transformation or preservation of samples**
- **Small volume is required**
- **No analytical delay**
- **Integrated or multifactorial response from a single analysis**
- **Low analytical cost**

Next steps

Further tests to verify the effect of water types (different water origins, saltwater, etc)

Definition of other spectral parameters to identify other components of the water sample

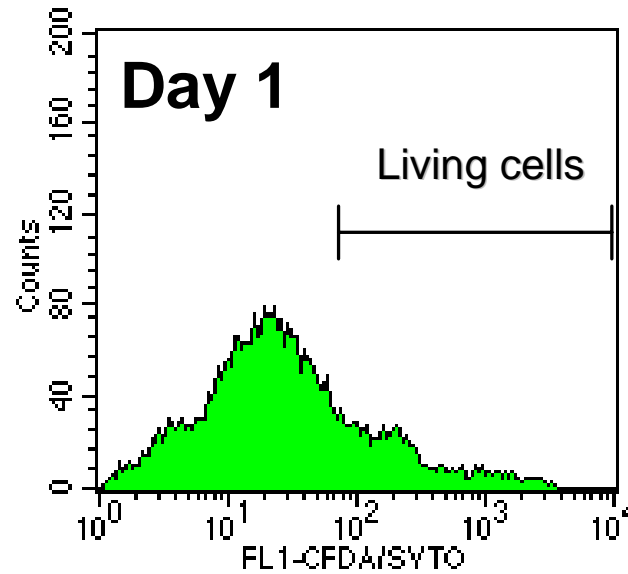
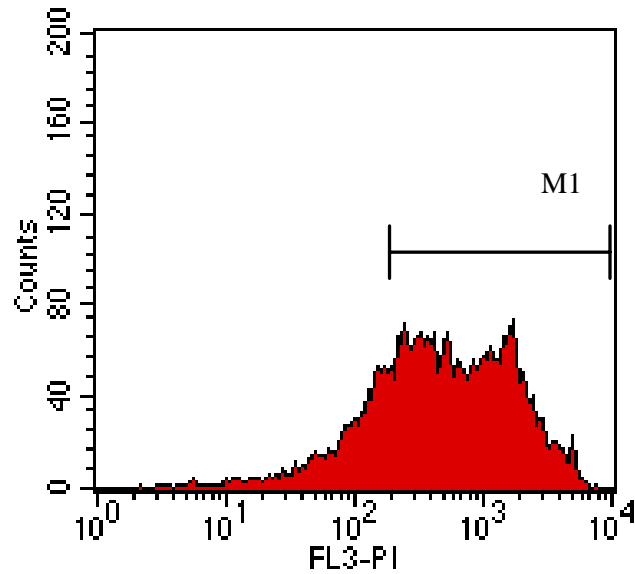
Technique could be adapted to other water quality monitoring (i.e. sewage waters or other ballast water chemical treatments)

Questions?

THANK YOU!

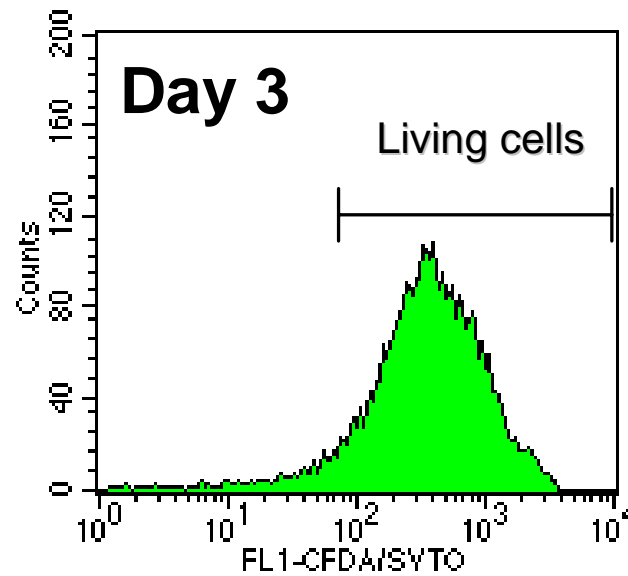
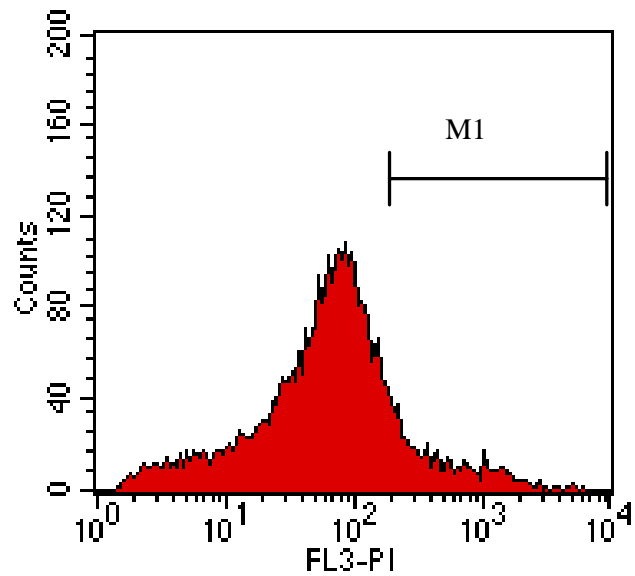


Results: flow cytometry



Vitality

18%



94%

Results: treated vs untreated

