

Suppression of nitrite-oxidizing bacteria in intermittently aerated biofilms: a model-based explanation

Ma, Yunjie; Domingo-Felez, Carlos; Plósz, Benedek G.; Smets, Barth F.

Publication date:
2016

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

[Link back to DTU Orbit](#)

Citation (APA):

Ma, Y., Domingo Felez, C., Plósz, B. G., & Smets, B. F. (2016). Suppression of nitrite-oxidizing bacteria in intermittently aerated biofilms: a model-based explanation. Poster session presented at MEWE and biofilms IWA specialist conference, Copenhagen, Denmark.

DTU Library

Technical Information Center of Denmark

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.

Suppression of nitrite-oxidizing bacteria in intermittently aerated biofilms: a model-based explanation

Y. Ma*, C. Domingo-Félez, B. G. Plósz, B.F. Smets

Department of Environmental Engineering, Technical University of Denmark, Kongens Lyngby, Denmark.

Introduction & Aims

- Short-cut ammonium (NH_4^+) removal via nitrite (NO_2^-) is energy- and cost- efficient. The challenge is to suppress nitrite-oxidizing bacteria (NOB).
- Despite successful NOB suppression versus ammonium-oxidizing bacteria (AOB) in activated sludge based on differential growth kinetics, maintaining long-term nitrification in biofilms can be challenging¹.
- Pellicer-Nàcher² observed that fully nitrification membrane-aerated biofilm reactors accumulated NO_2^- immediately after switching from continuous to intermittent aeration.
- The purpose of this study was to develop and calibrate an improved biofilm model incorporating pH calculation, systematically evaluate potential causes for NOB suppression associated with intermittent aeration.

Model development & Model calibration

The multi-species nitrifying biofilm model is a one-dimensional model based on Terada³, incorporating explicit pH calculation.

- A physical gas diffusion link between compartments

$$A \cdot k_{M,i} \left(\frac{1}{H_i} C_{i,air} - C_{i,base} \right)$$

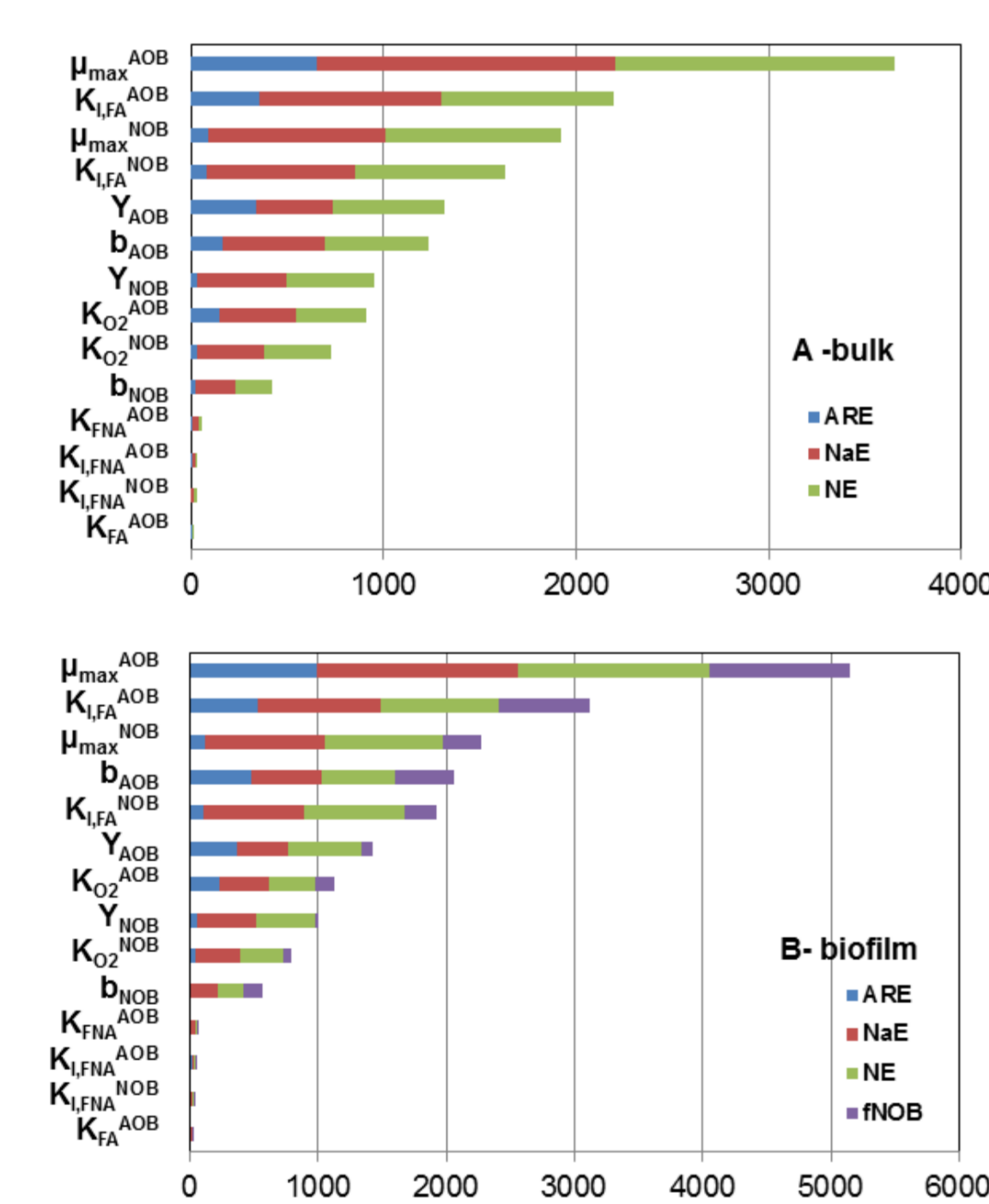
- Biological process, e.g. AOB

$$\mu_{AOB,f(pH)} \cdot X \cdot \frac{S_{O_2}}{K_{O_2} + S_{O_2}} \cdot \frac{S_{FA}}{K_{FA}^{AOB} + S_{FA} + S_{FA} \cdot S_{FA} / K_{I,FA}^{AOB}} \cdot \frac{K_{I,FNA}^{AOB}}{K_{I,FNA}^{AOB} + S_{FNA}}$$

- Chemical process: pH calculation



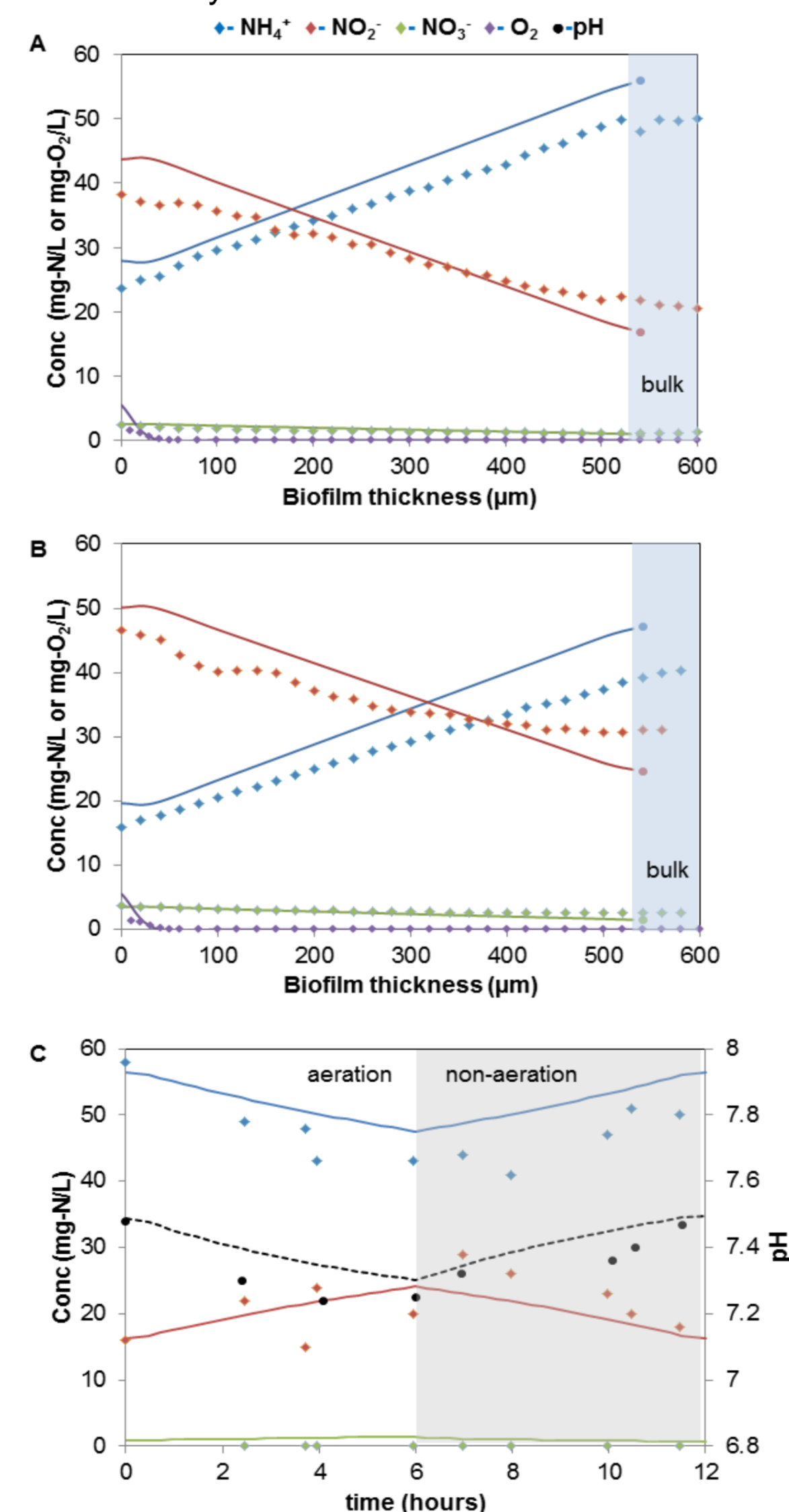
Sensitivity ranking of kinetic parameters with default ASMN values



- μ_{max} - the most determinant kinetic parameter in N conversion simulation.
- In-situ microprofiling data is more informative than bulk measurements.

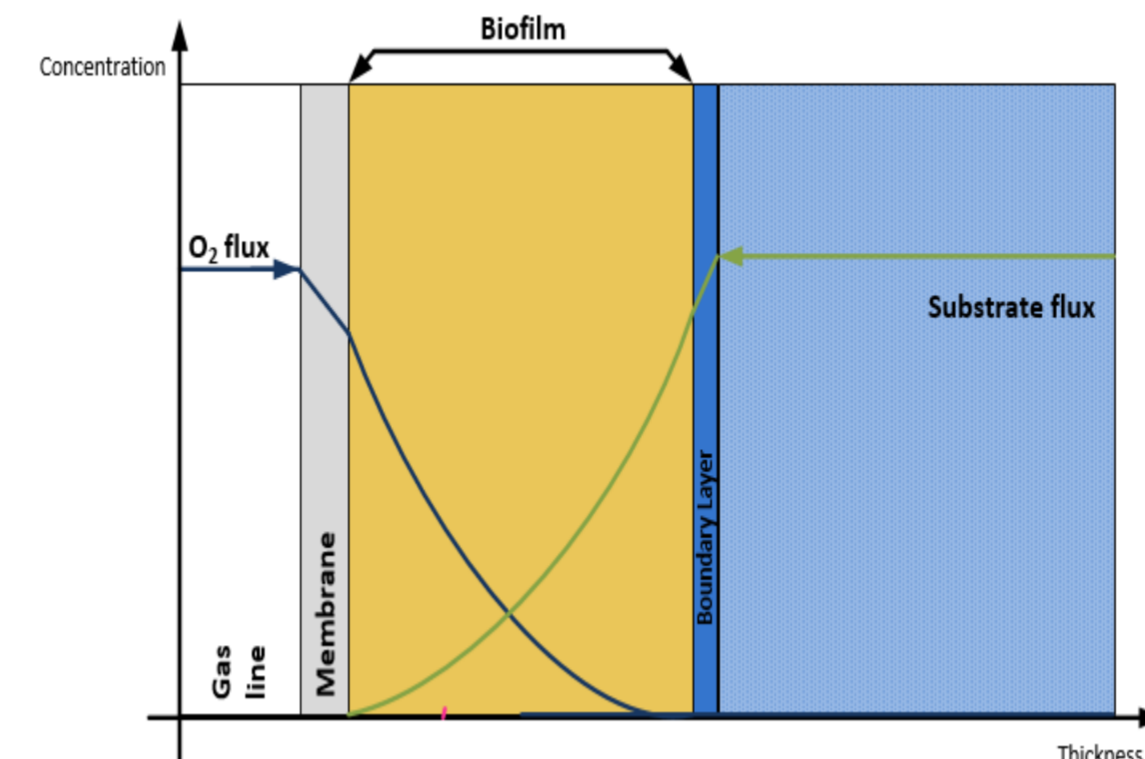
Experimental (symbols) and predicted (lines) concentrations

(A) the first aeration hour (B) the last aeration hour (C) bulk profiles in a 12-hour cycle



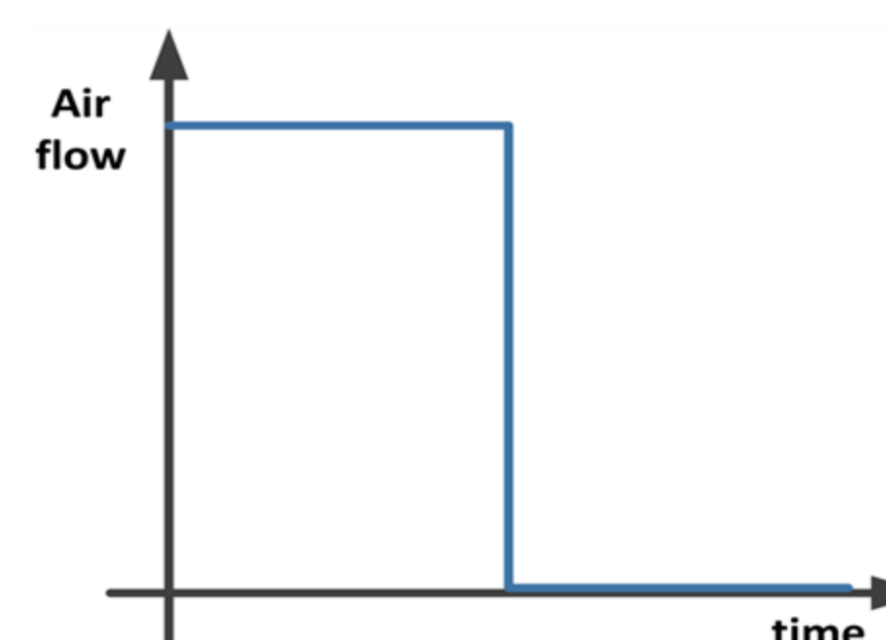
Counter diffusion biofilm system

NOB suppression challenges



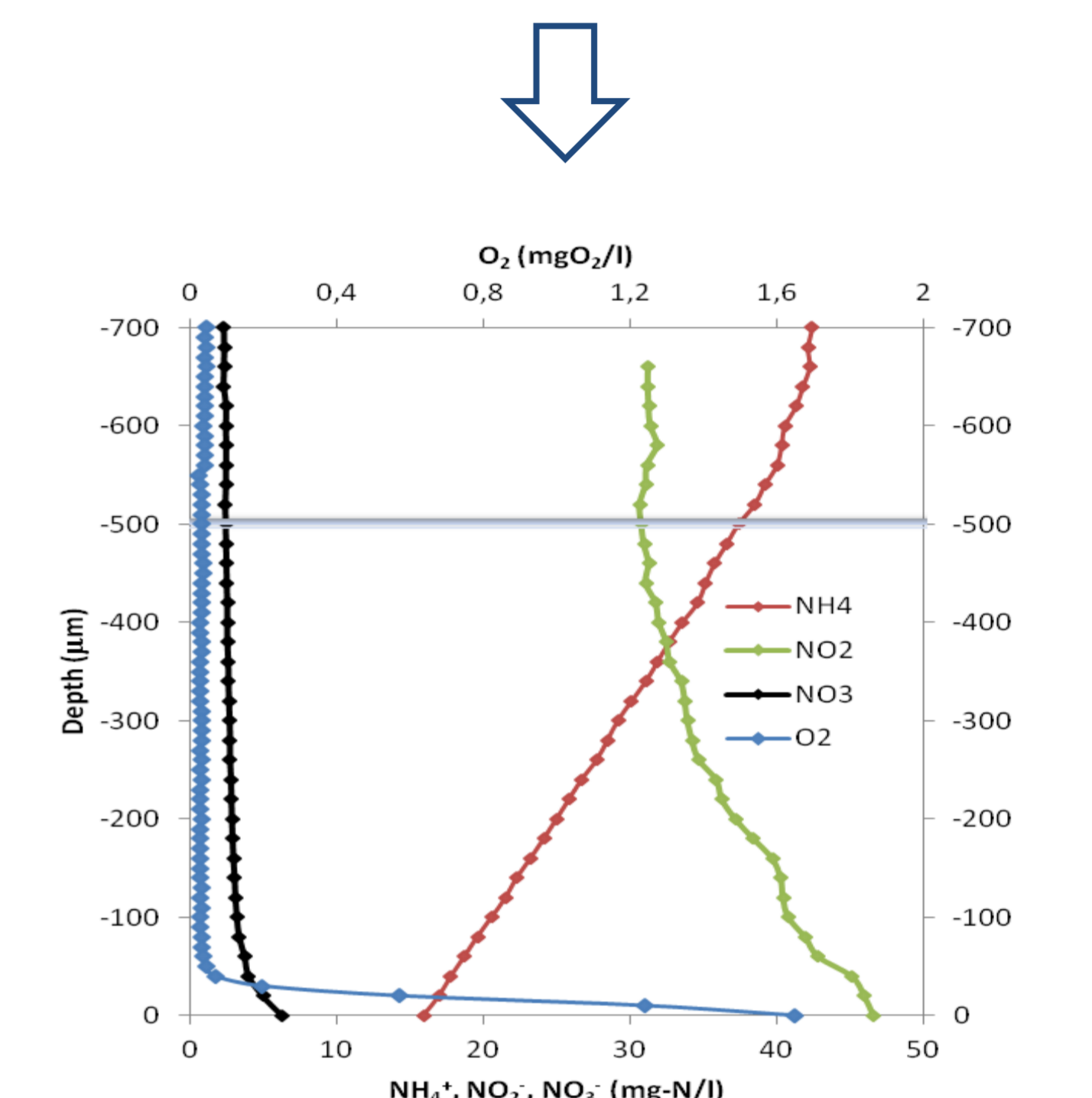
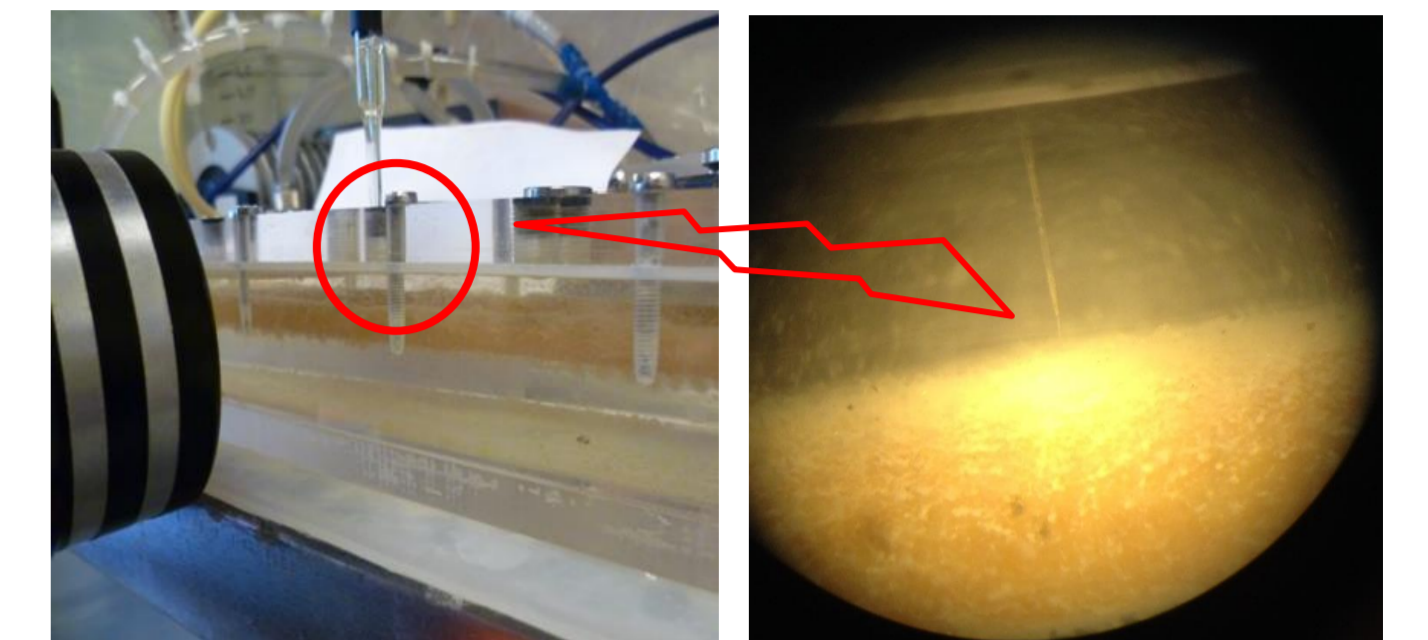
- Long solids retention times
- Strong spatial chemical gradients
- Multiple simultaneous chemical gradients
- Spatial protection of bacteria at the biofilm base

Intermittent aeration



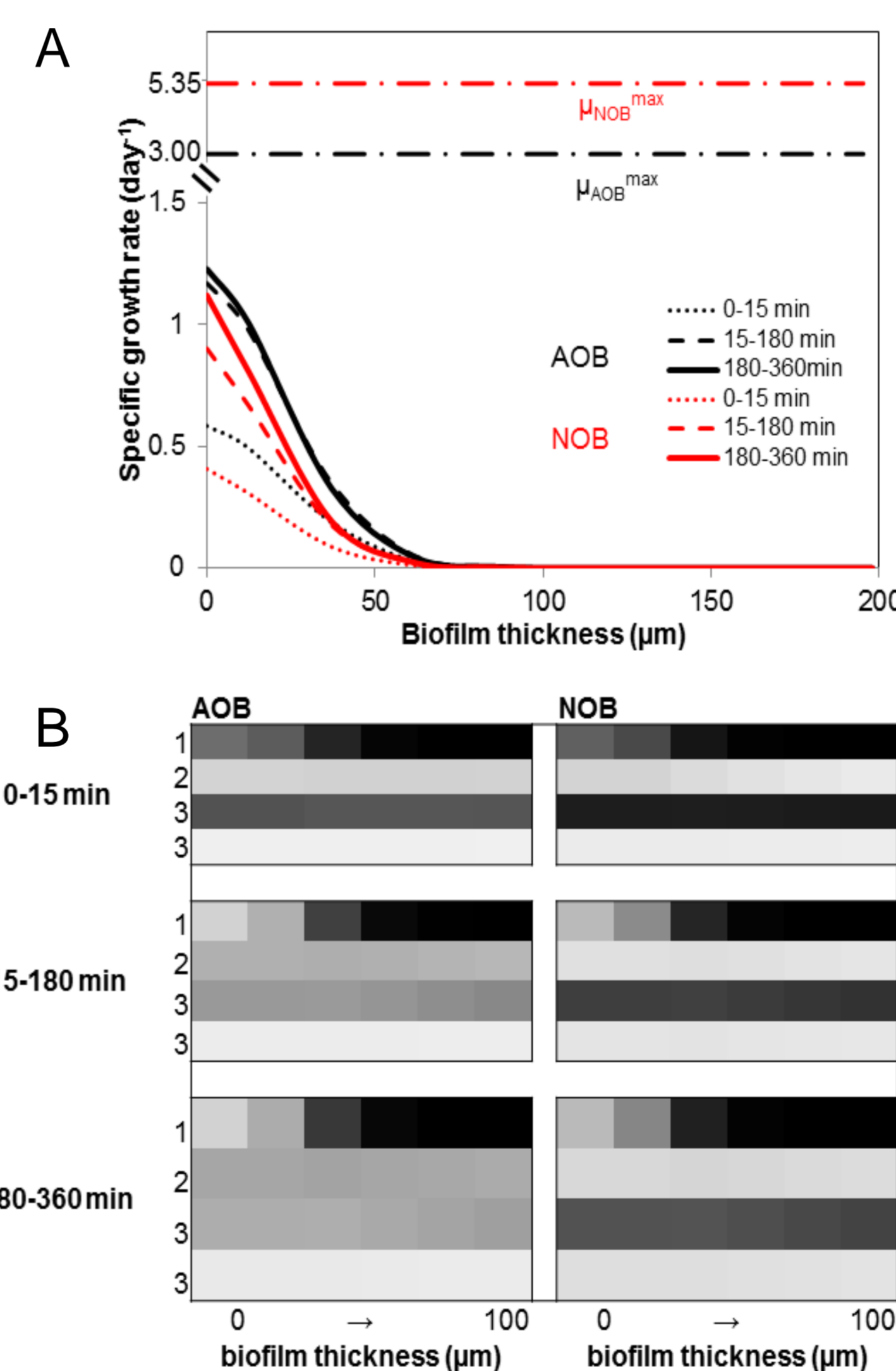
An intermittent aeration:
6-hour aeration period (100% air) + 6-hour non-aeration period (100% N_2)

Microsensor setup



Microprofiles measured within the biofilm in the aeration periods at steady state

NOB suppression exploration



- AOB preferentially utilize oxygen and outcompete NOB.
- FA inhibition caused by pH substrate-speciation is the crucial factor in suppressing NOB in intermittently aerated biofilms.
- Strong FA inhibition at the onset of aeration causes lag phase of NOB activity over AOB.

(A) Specific growth rate of AOB and NOB within the biofilm in a 6-hour aeration period at day 15 (B) individual effect on AOB and NOB within the 100 μm -aerated biofilm base (0- strong limitation/inhibition effect, 1- no limitation/inhibition effect)

Conclusions

- Intermittent aeration supports efficient nitrification in membrane aerated biofilm reactors.
- A pH-explicit 1-D multispecies nitrifying biofilm model reveals that NOB suppression- associated with intermittent aeration- is primarily governed by periodic FA inhibition, which is the consequence of transient pH upshifts. These pH upshifts caused by alkalinity increases during non-aeration are mainly due to carbon dioxide stripping to the membrane lumen.
- In counter diffusion biofilms pH effects appear more important than DO effects on NOB suppression.

References:

- 1 PMID: 15303723
- 2 DOI: 10.1021/es1013467
- 3 DOI: 10.1002/bit.21213
- 4 DOI: 10.1016/j.procbio.2007.09.010

yuma@env.dtu.dk



@Metlab_DTU



Research supported by:

