



Aerobic granular sludge:

**Assessing a novel approach to
pharmaceutical removal from wastewater**

Kylie Bodle

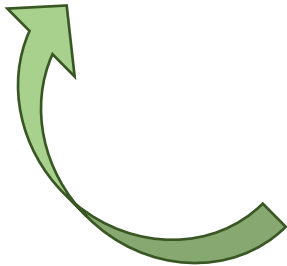
PhD Candidate

Montana AWRA 2023

Human health and clean water



Wastewater treatment

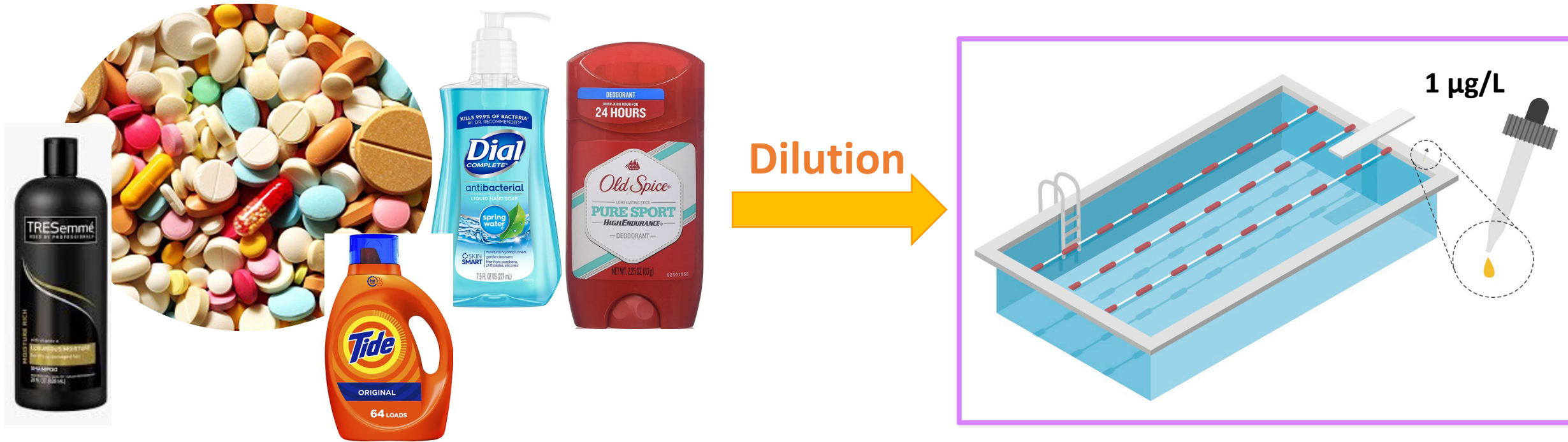


Drinking water treatment



Threats to clean water:

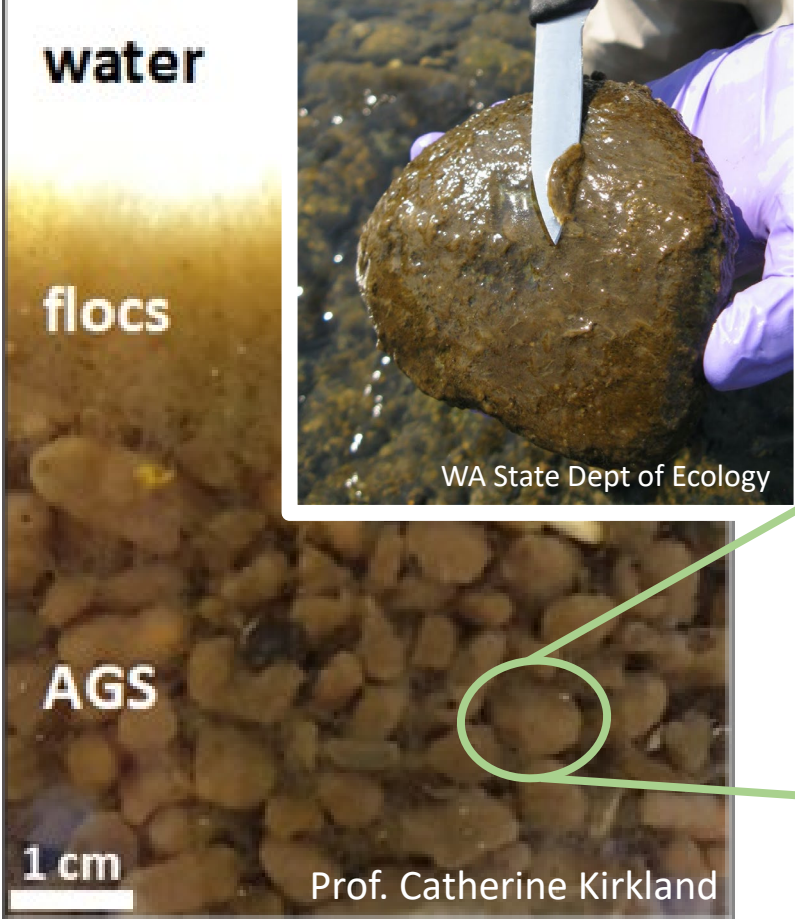
Contaminants of emerging concern (CECs)



Wastewater treatment plants are **not designed** to treat these compounds

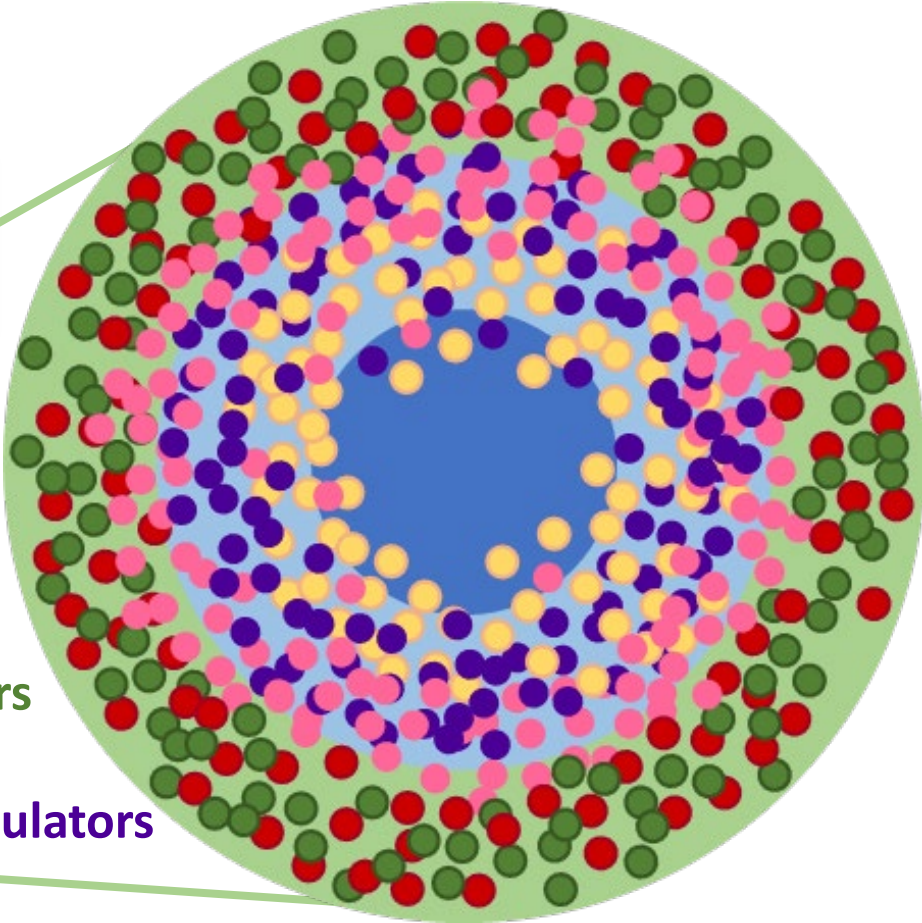
A potential solution:

Aerobic granular sludge (AGS)



Aerobic
Anoxic
Anaerobic

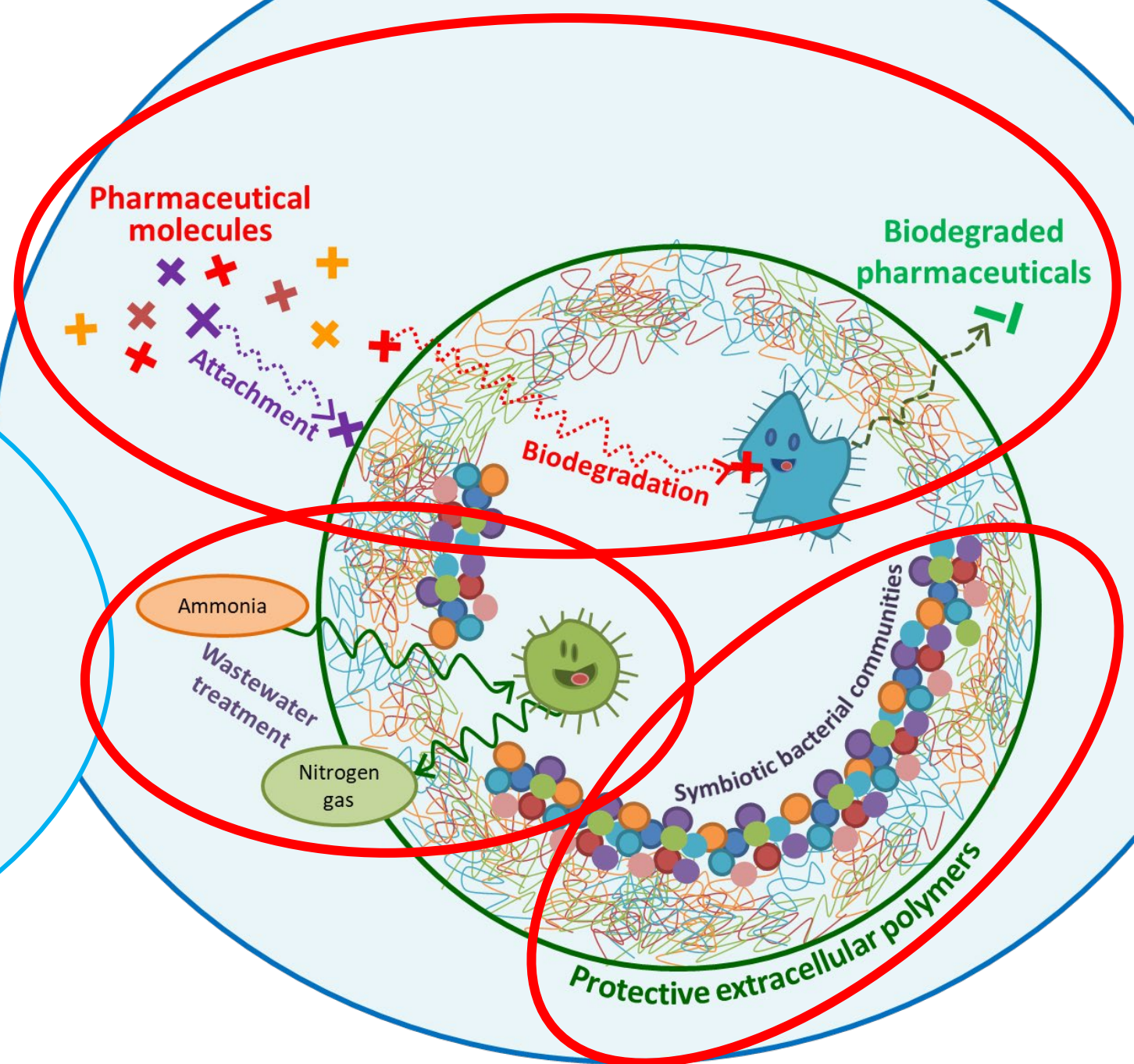
Ammonia oxidizers
Nitrite oxidizers
Phosphate accumulators
Denitrifiers
Others



Research questions

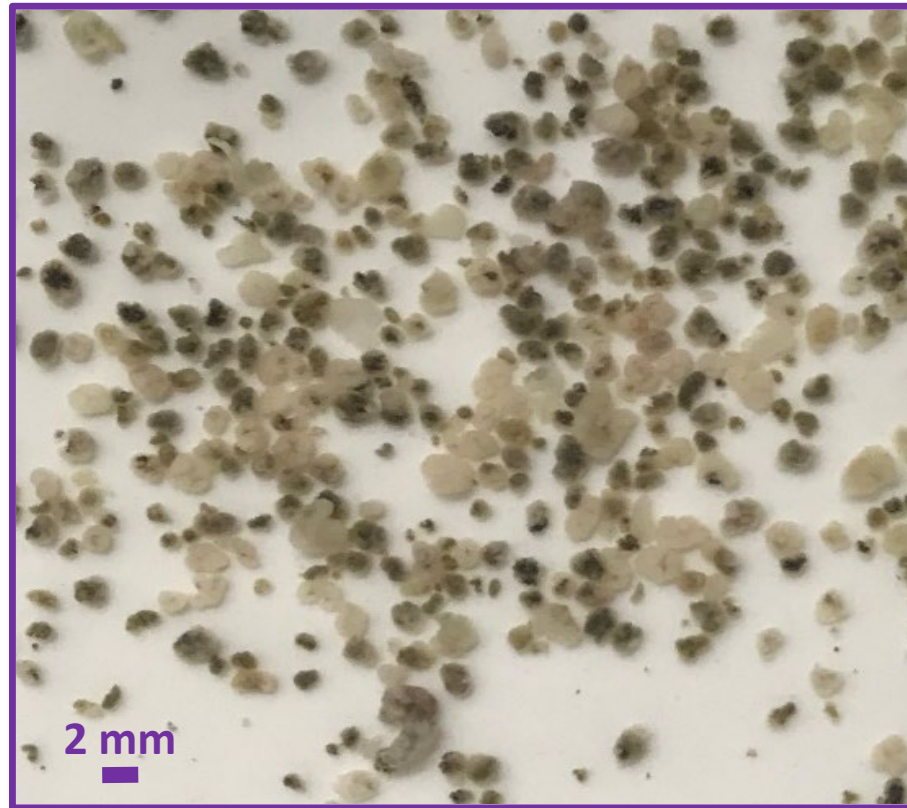
If we use AGS to treat pharmaceutical-contaminated WW...

1. Are pharmaceuticals removed?
2. How is wastewater treatment affected?
3. How are granules affected?



How representative are lab-based results?

Lab-grown granules \neq “real” granules



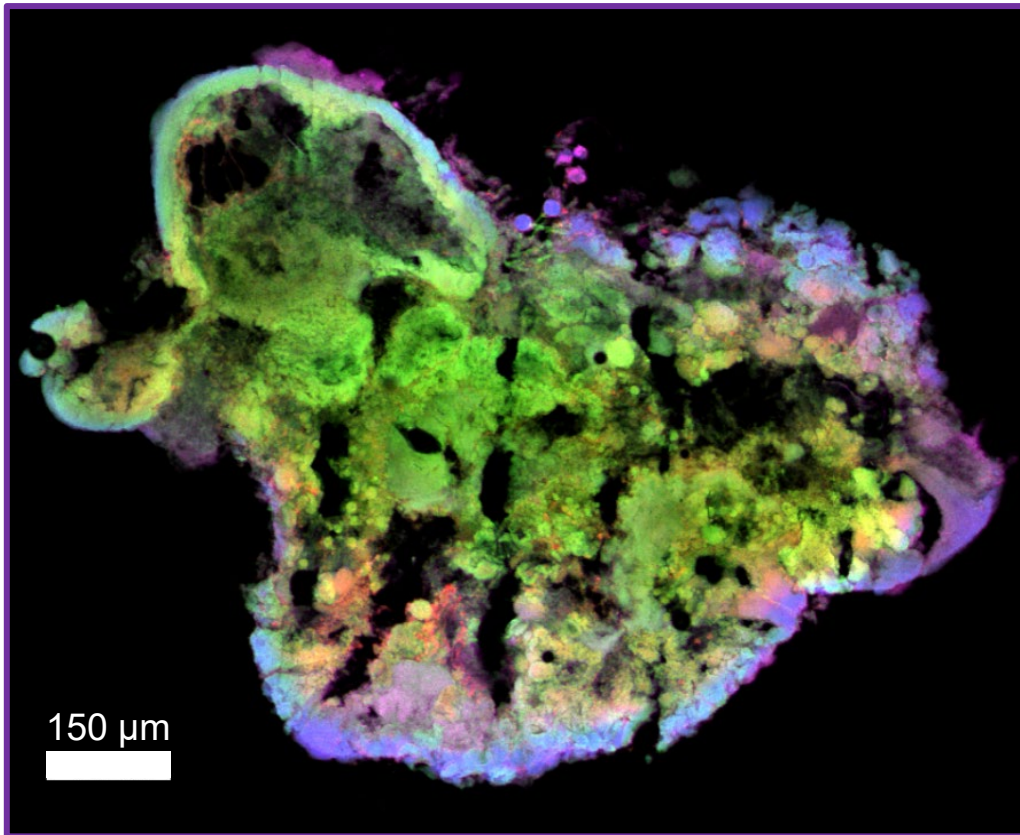
Lab



“Real”

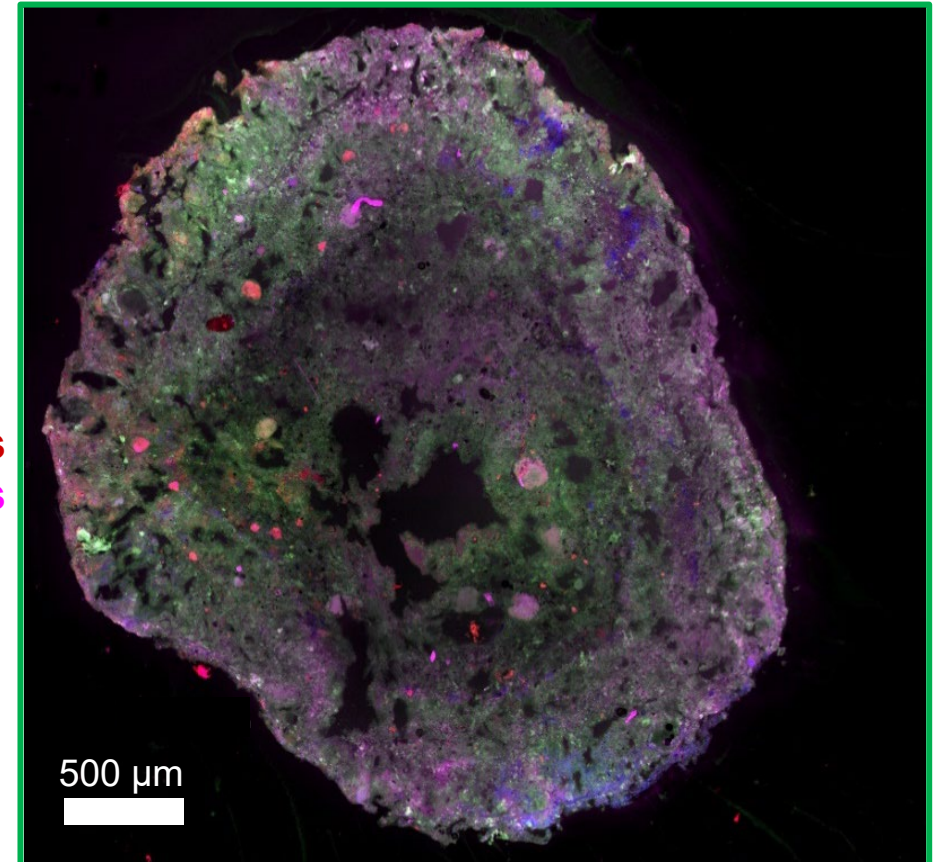
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Lab

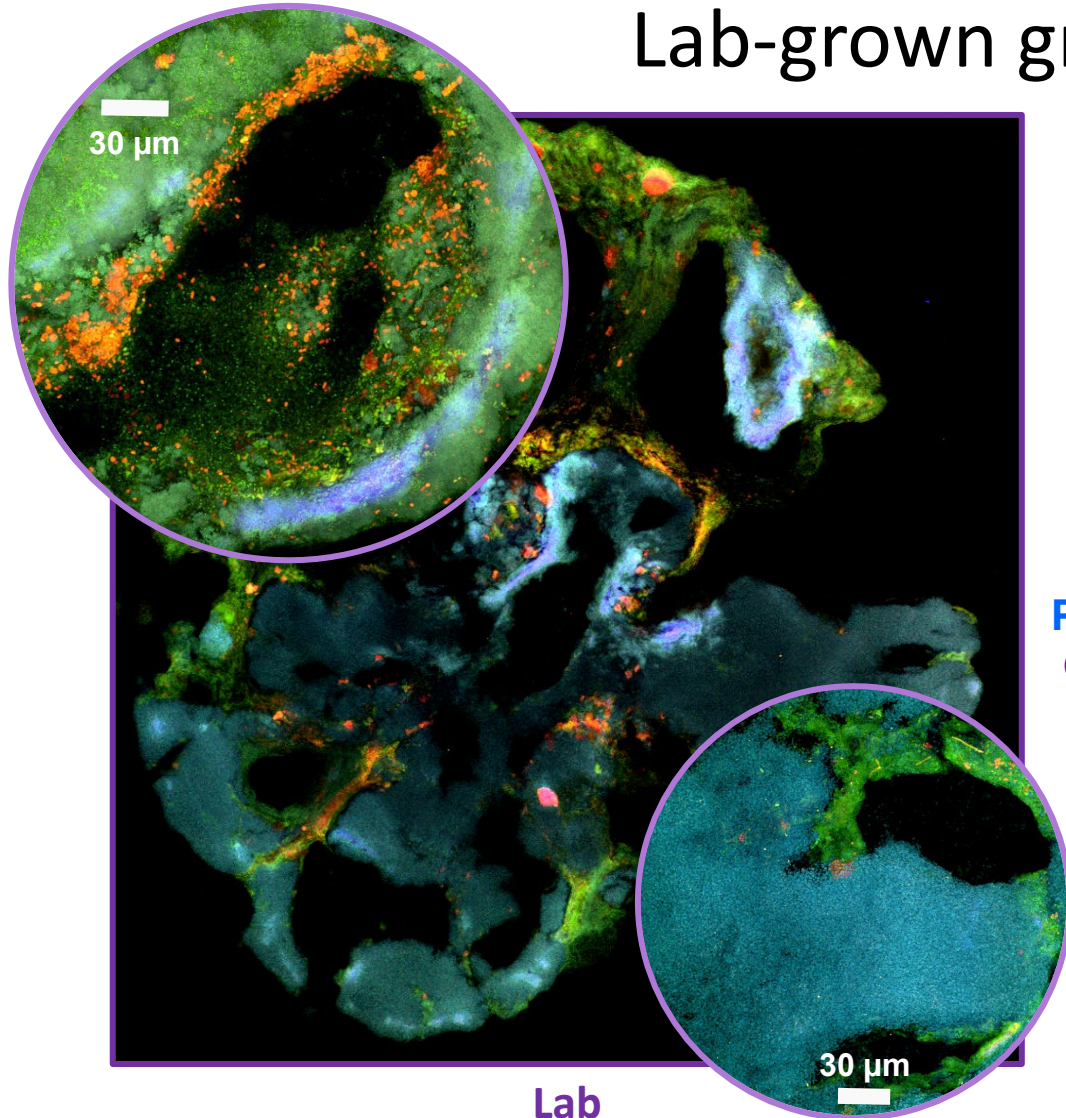
Proteins
Lipids
 α -polysaccharides
 β -polysaccharides



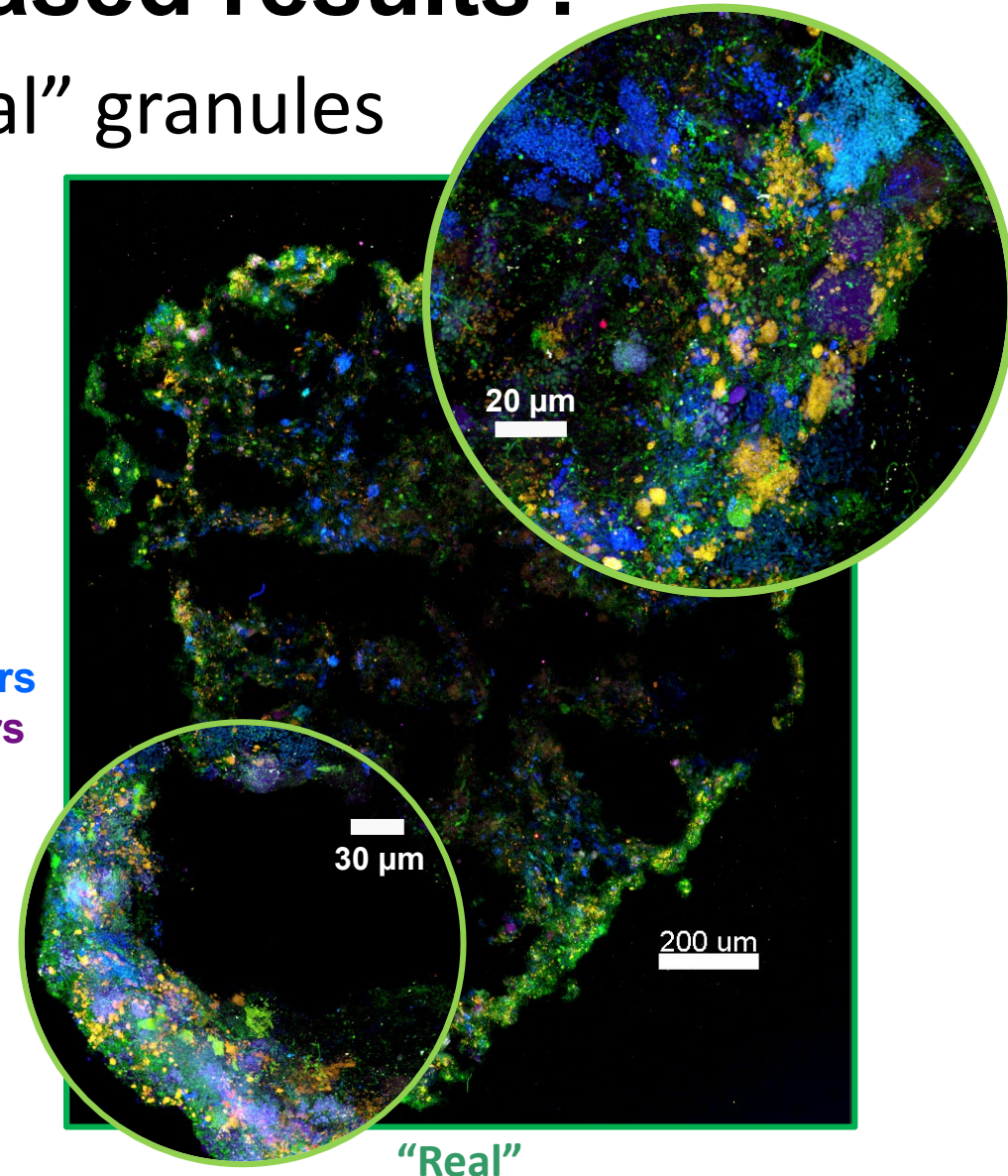
“Real”

How representative are lab-based results?

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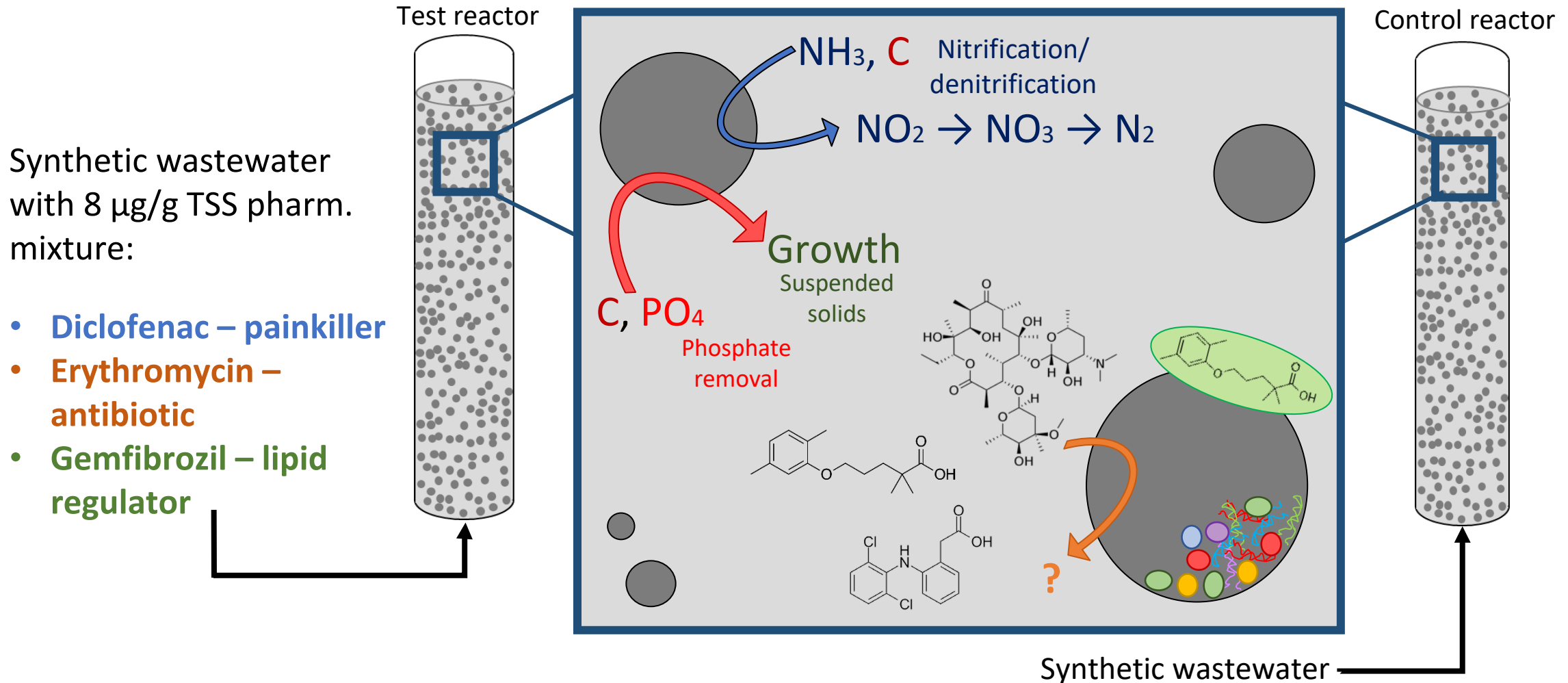


All bacteria
Nitrifiers
Phosphate accumulators
Glycogen accumulators

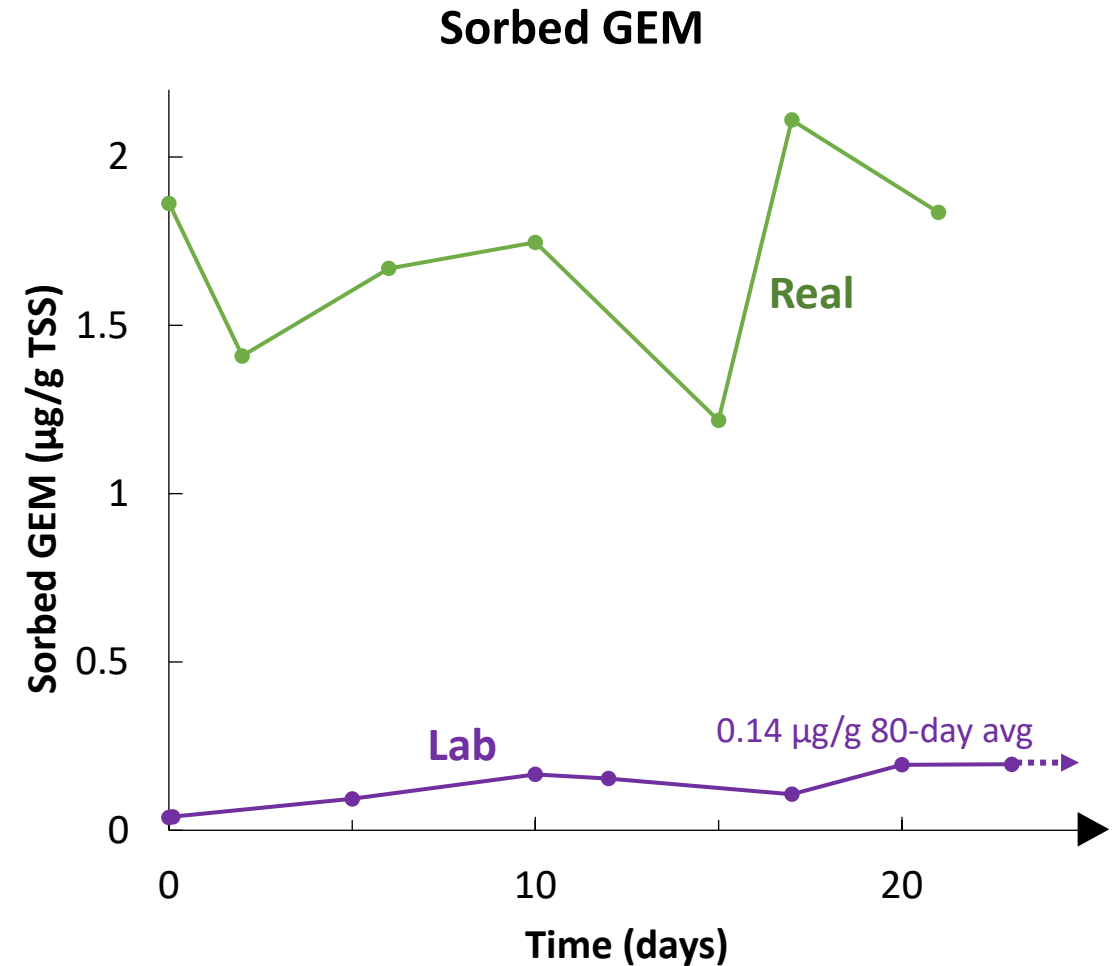
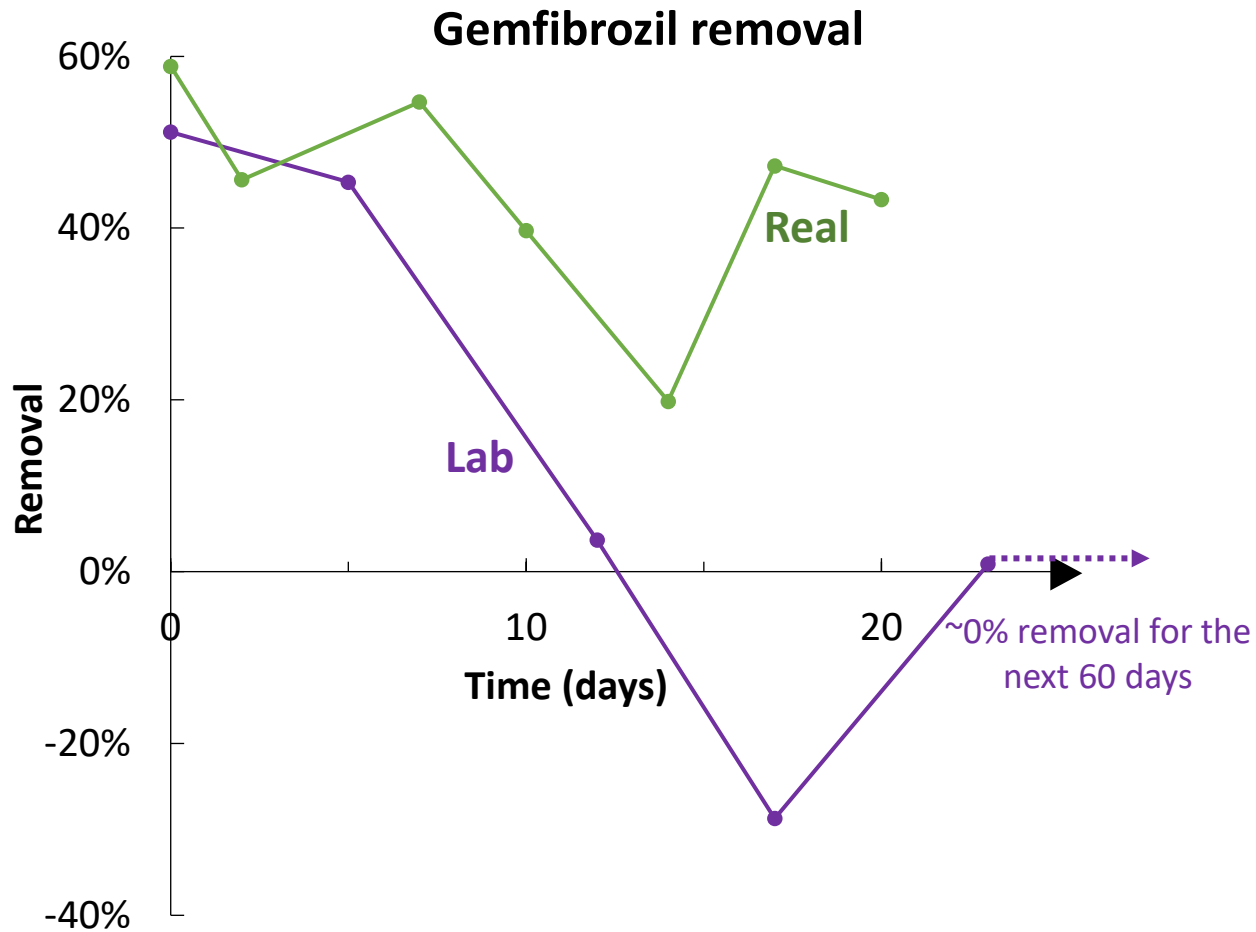


Experimental setup

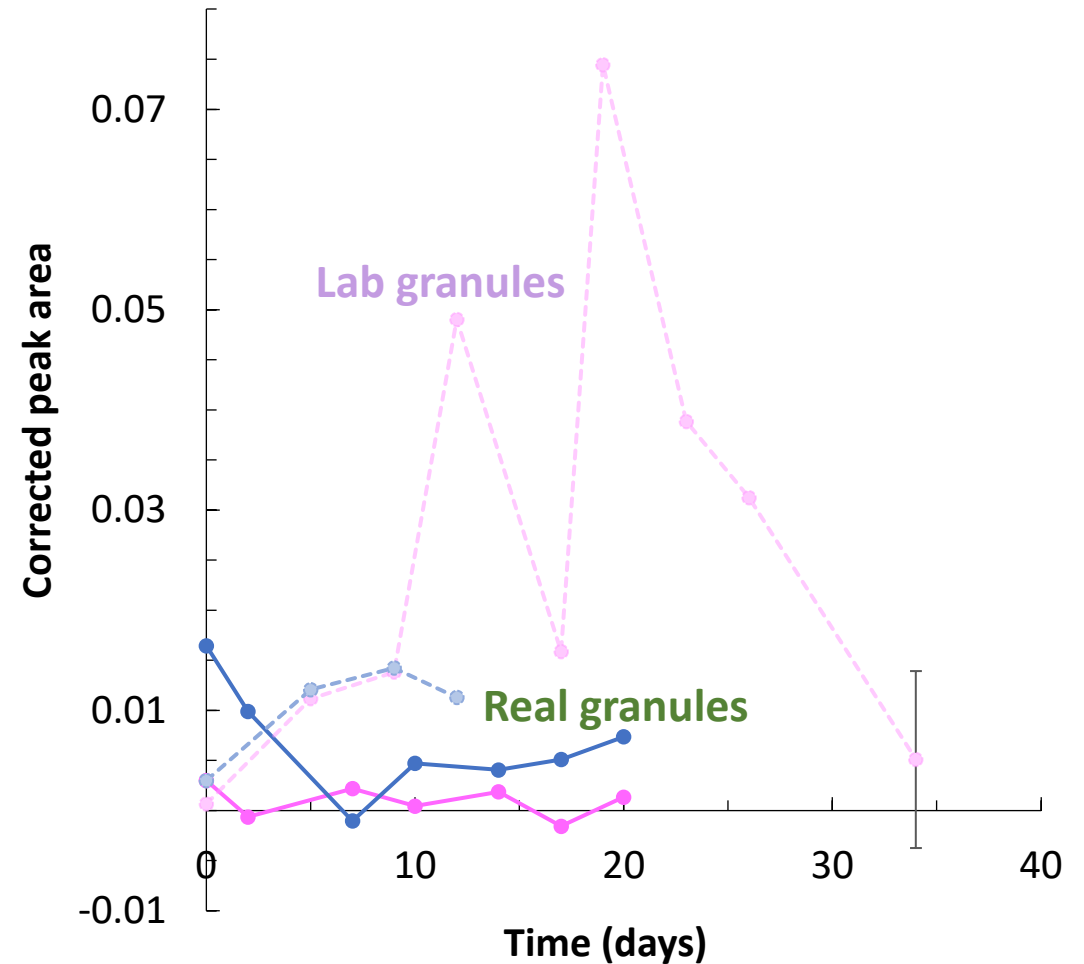
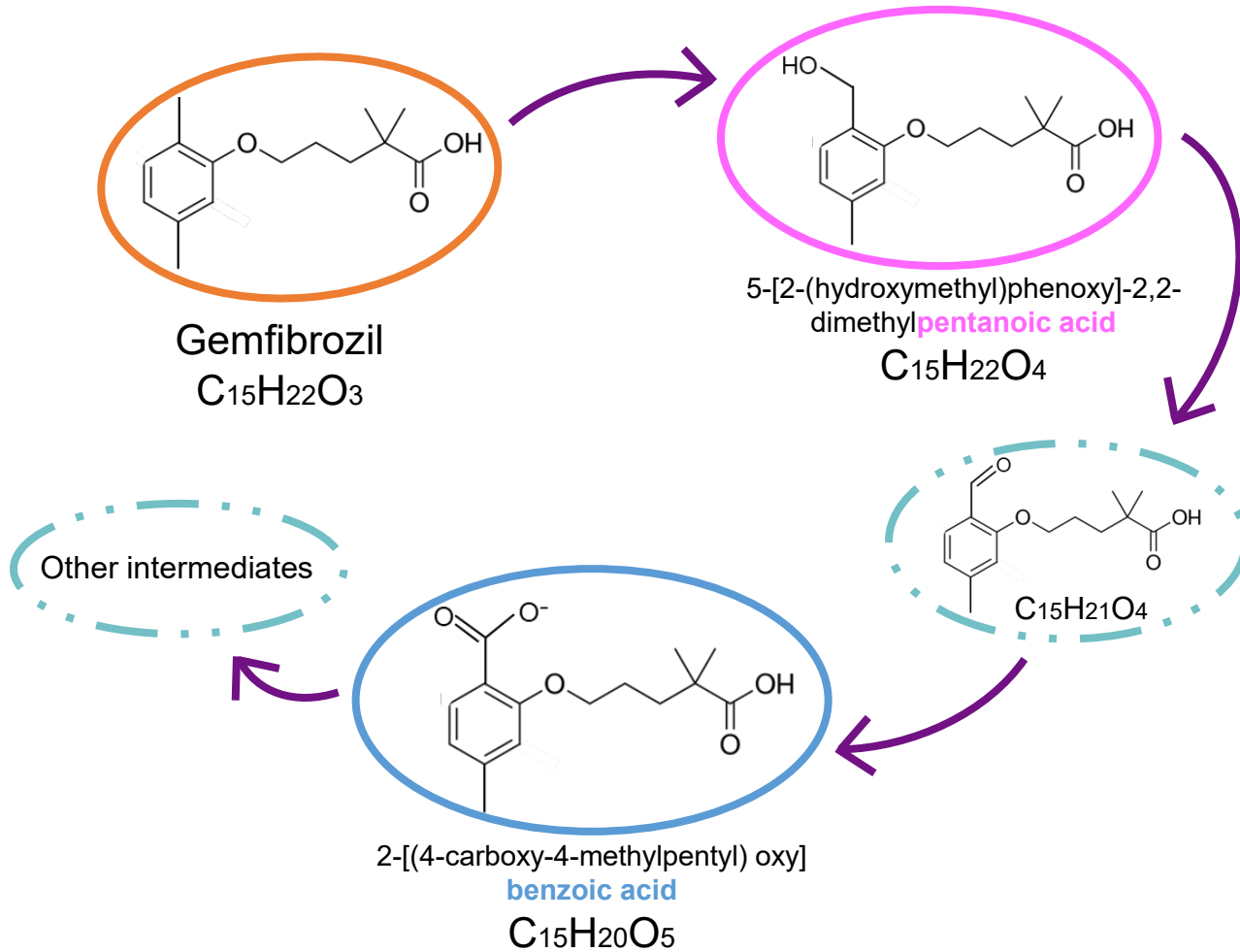
80-day duration



Gemfibrozil fate – Lab vs. Real granules



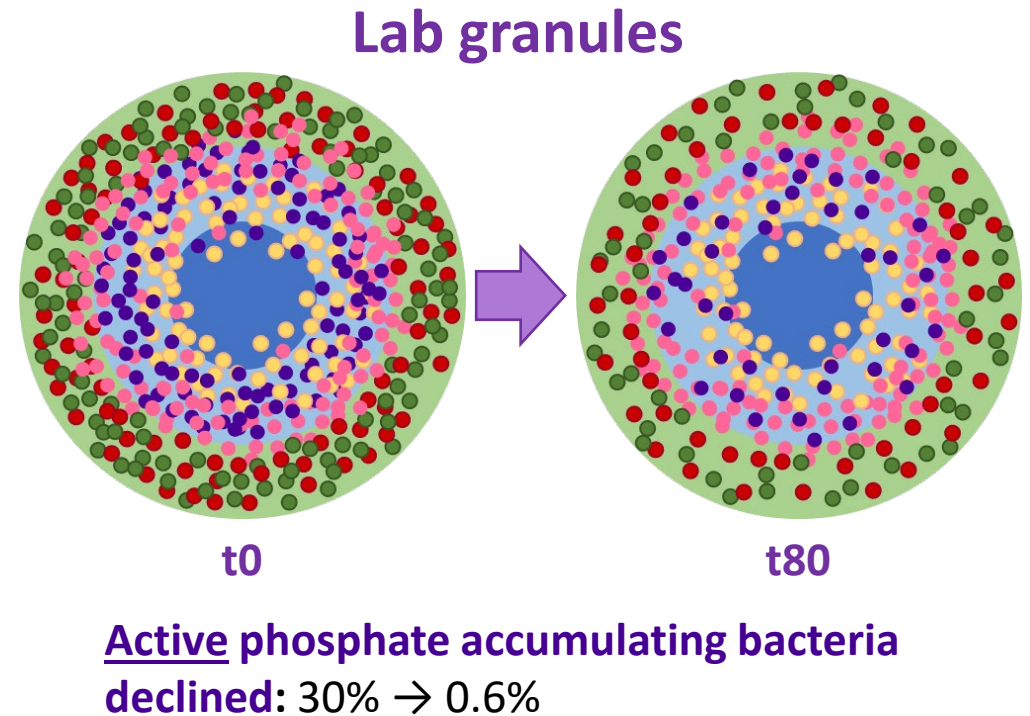
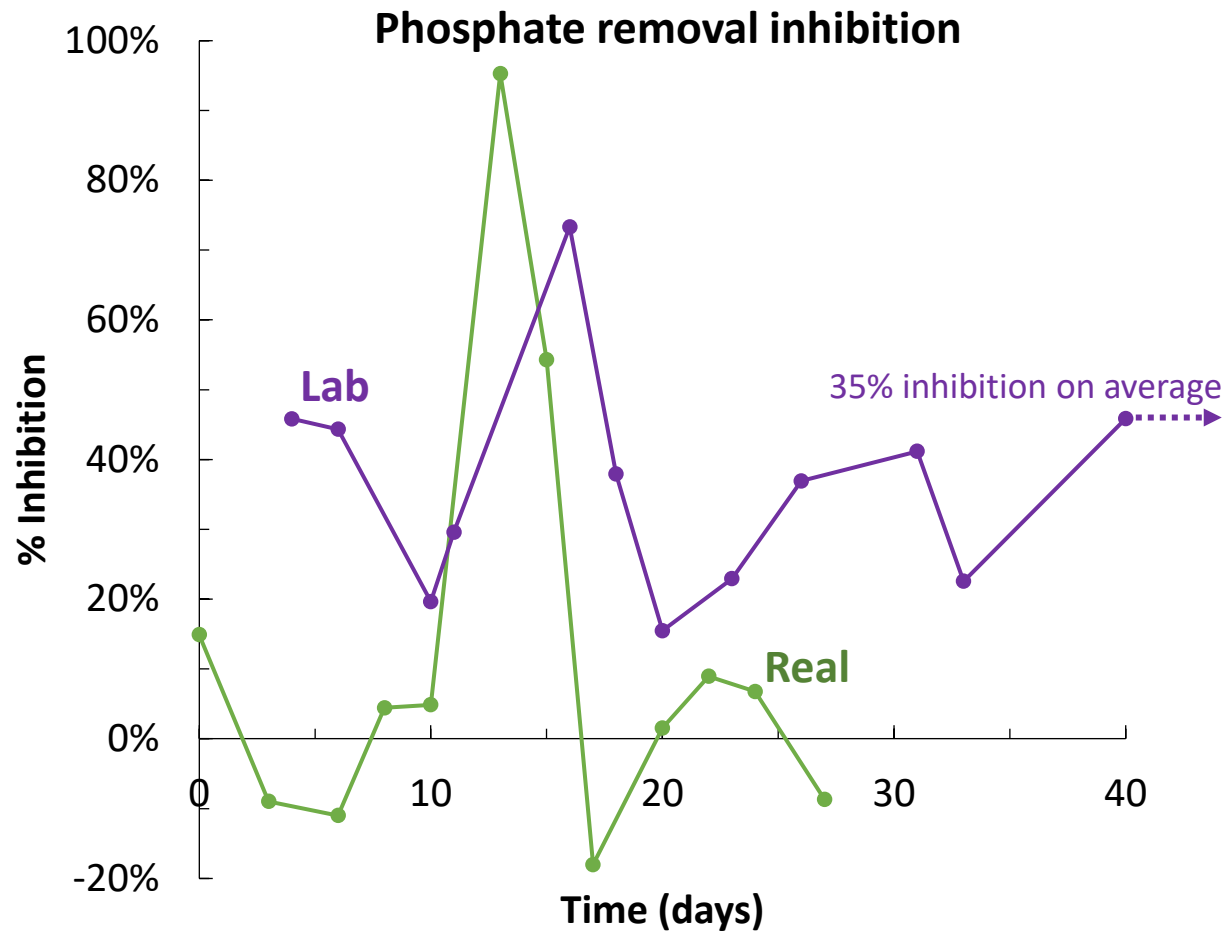
Lab granules produce more degradation products



Pathway proposed in Kjeldal, H., et al., *Genomic, Proteomic, and Metabolite Characterization of Gemfibrozil-Degrading Organism Bacillus sp. GeD10*. Environmental Science & Technology, 2016. **50**(2): p. 744-755.

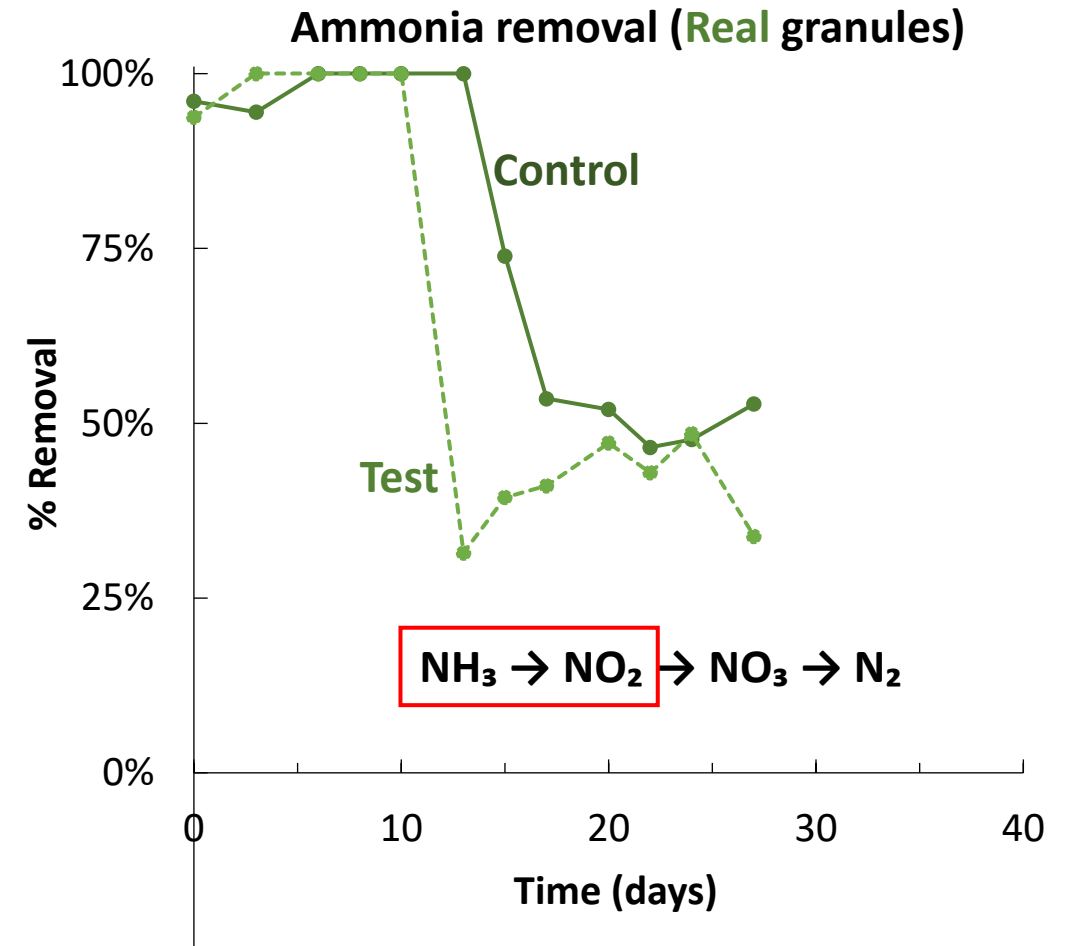
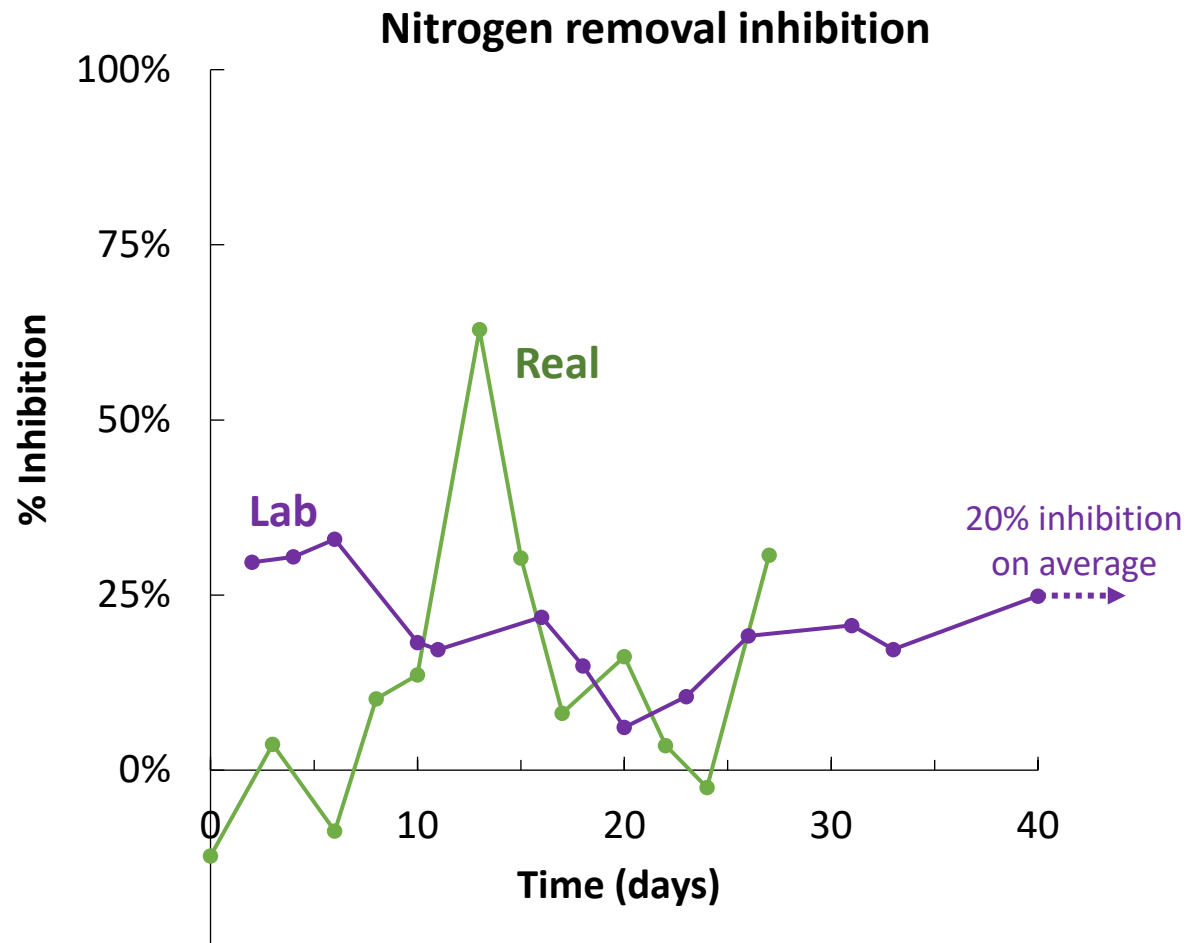
Lab granule data published in Bodle, K.B., et al., *Treatment performance and microbial community structure in an aerobic granular sludge sequencing batch reactor amended with diclofenac, erythromycin, and gemfibrozil*. Frontiers in Microbiomes, 2023. **2**.

Phosphate removal is more inhibited in lab granules



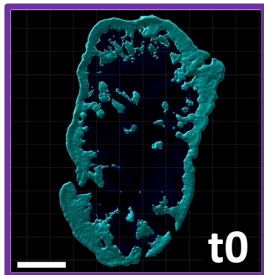
Lab granule data published in Bodle, K.B., et al., *Treatment performance and microbial community structure in an aerobic granular sludge sequencing batch reactor amended with diclofenac, erythromycin, and gemfibrozil*. *Frontiers in Microbiomes*, 2023. 2.

Ammonia oxidizing bacteria are sensitive to changing conditions



Conclusions + future work

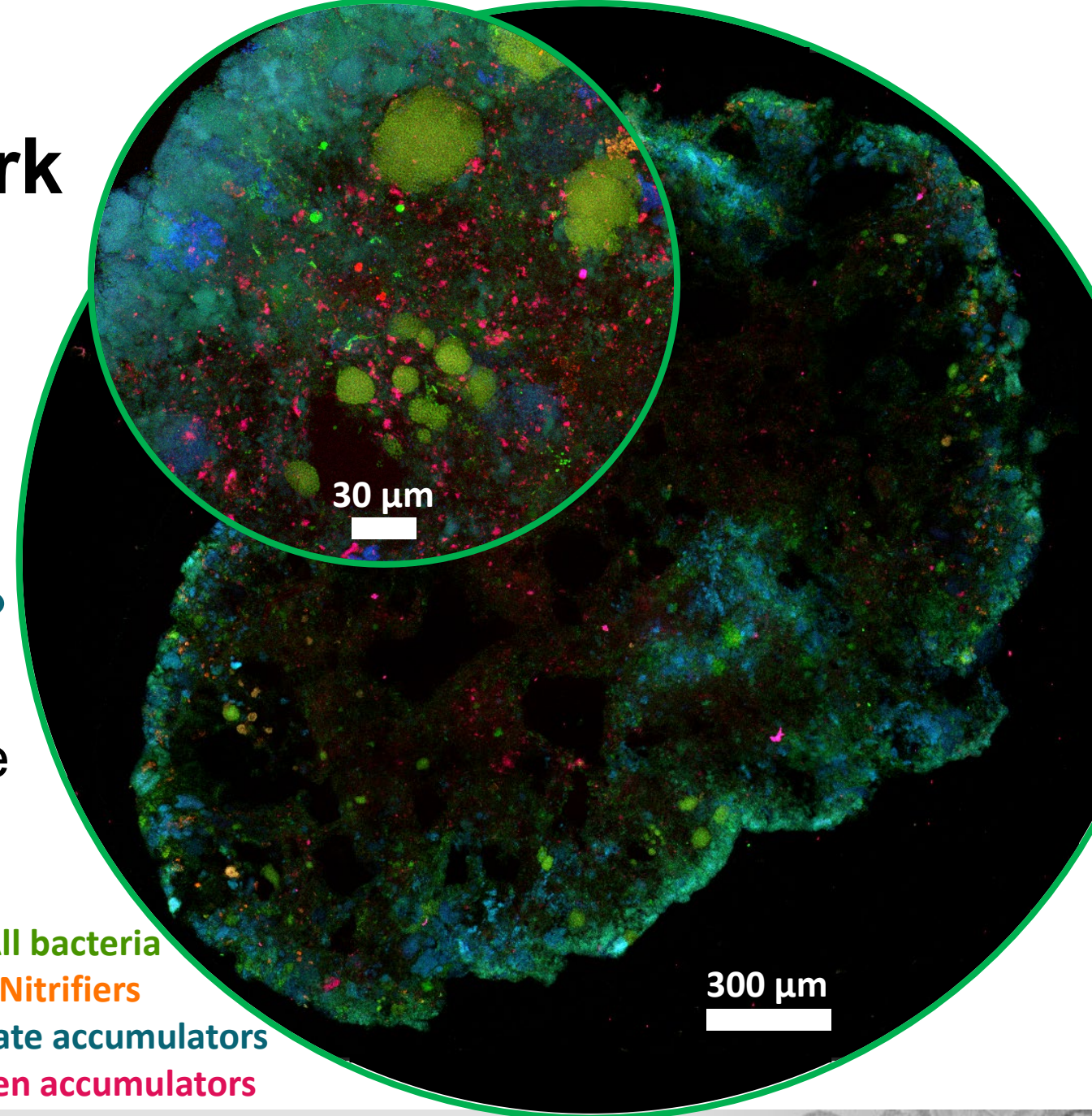
- GEM removal sustained up to 20 days
 - More sorption? Or more complete degradation?
- Less inhibited phosphate removal?
Nitrogen removal?
- Next analyses: Changes in granule structures and active populations



vs.

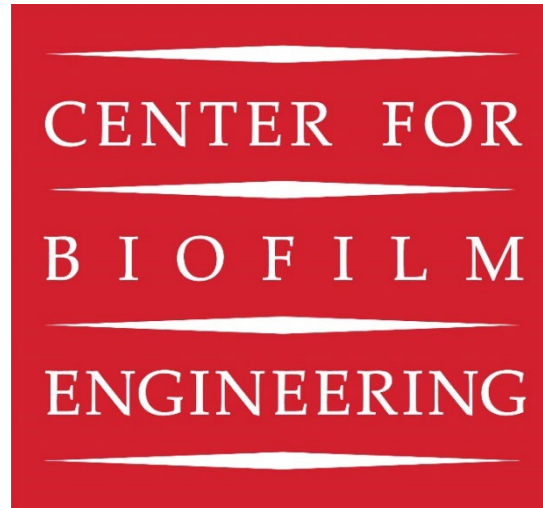


All bacteria
Nitrifiers
Phosphate accumulators
Glycogen accumulators





Thank you!



Special thanks to:

- Don Smith & the MSU Mass Spectrometry Facility
- Catherine Kirkland
- Kirkland lab group

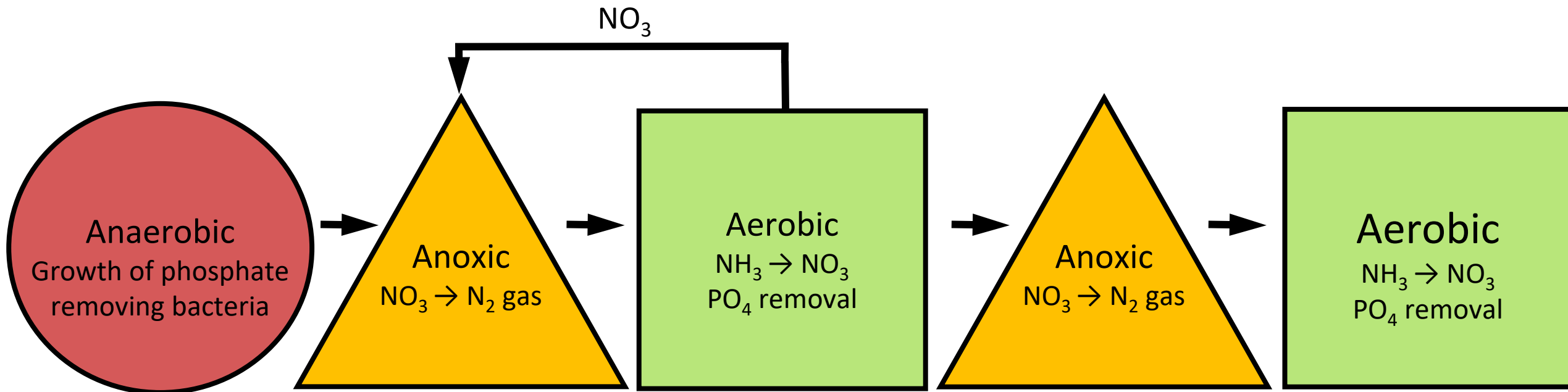


Contact me at
kyliebodle@montana.edu

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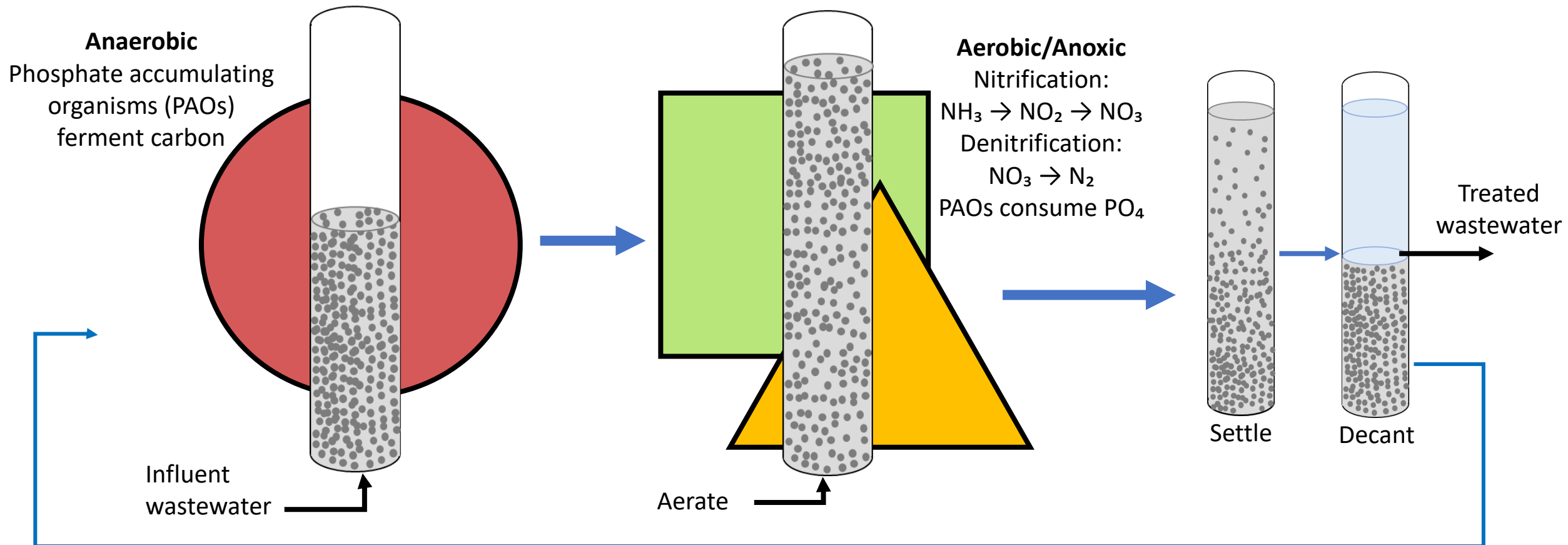
Supplemental slides

Conventional wastewater treatment requires multiple reactors



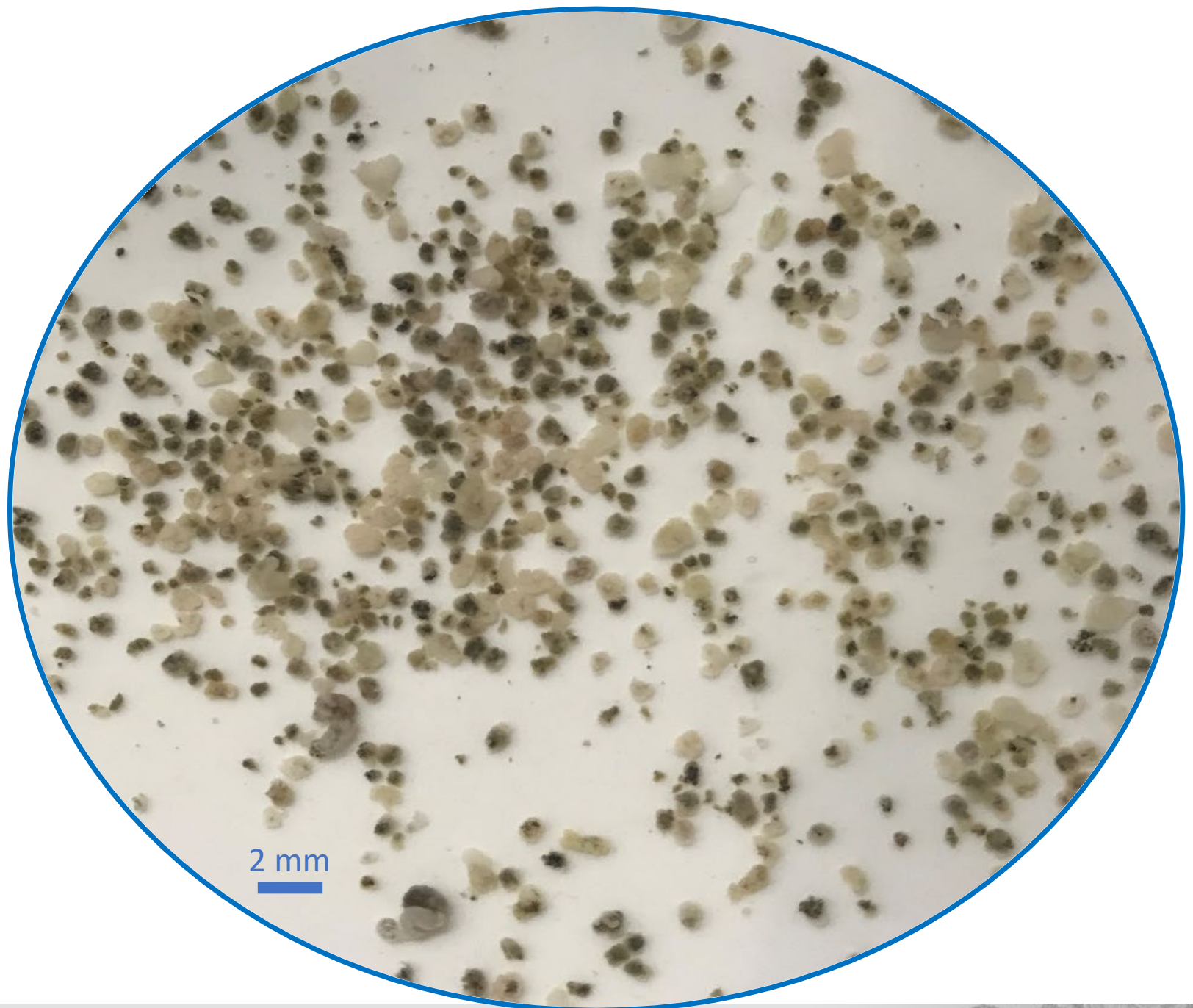
More efficient wastewater treatment is possible

...using Sequencing Batch Reactors (SBRs)

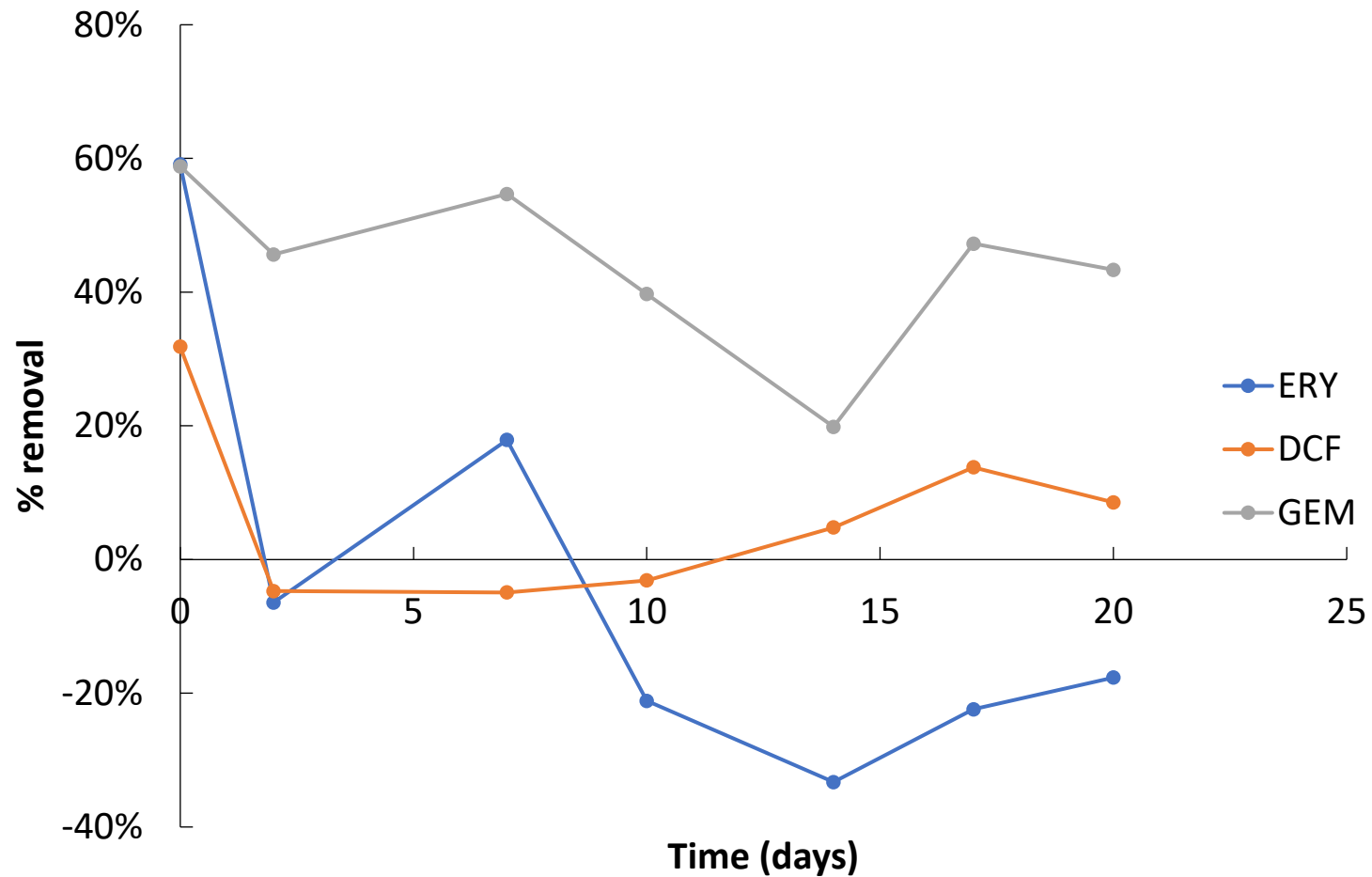


My research

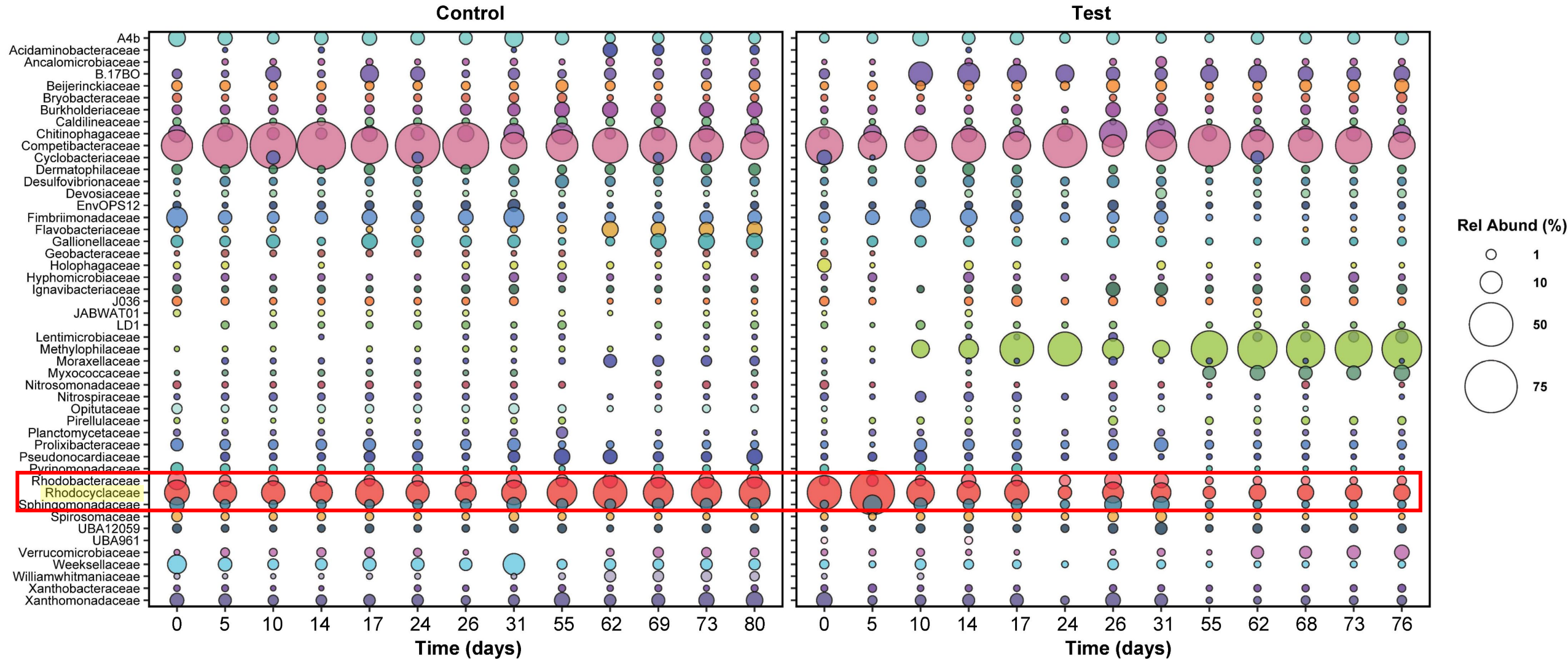
Can we use granular sludge
to treat wastewater AND
pharmaceuticals?



Pharmaceutical removal by real AGS

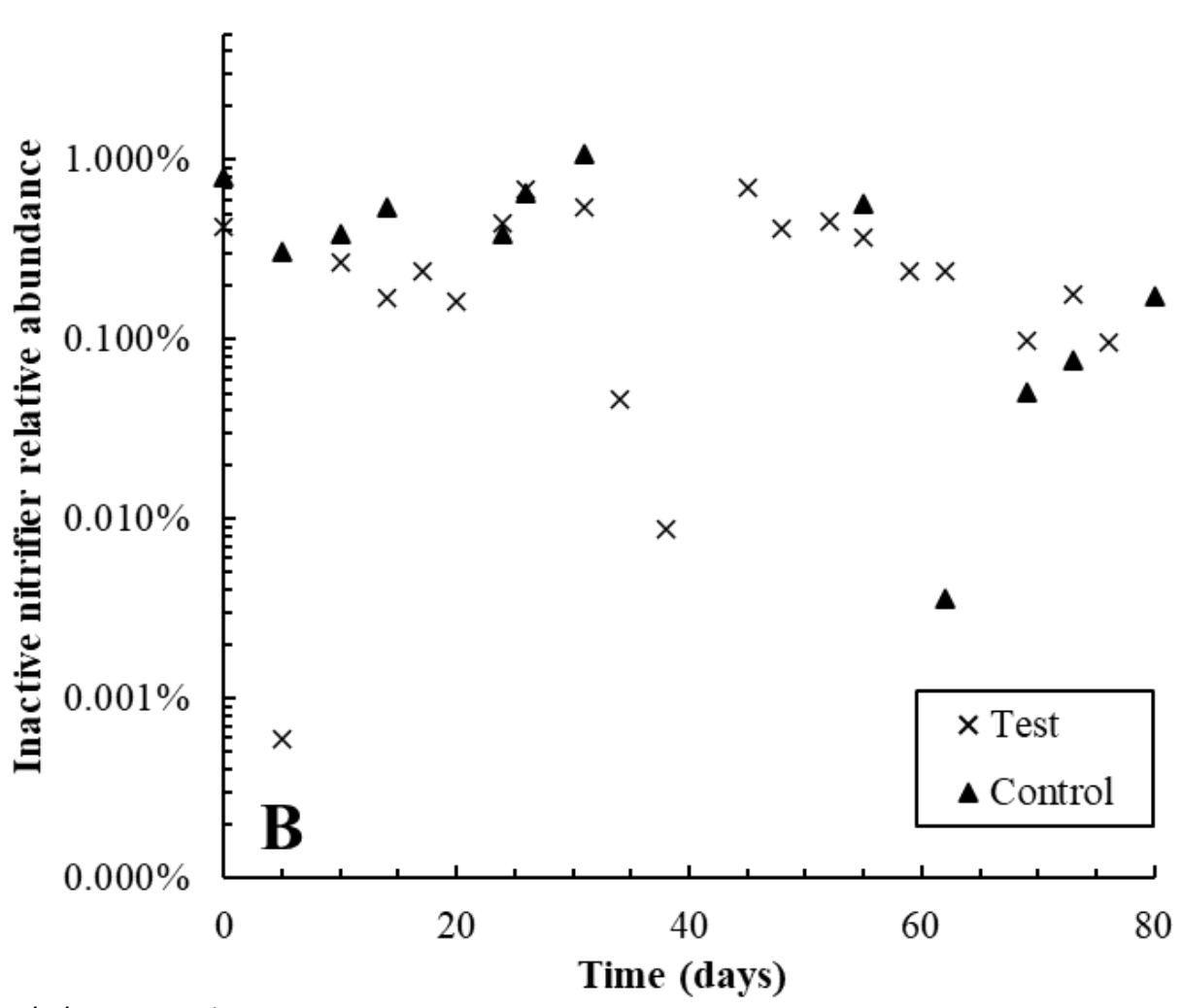
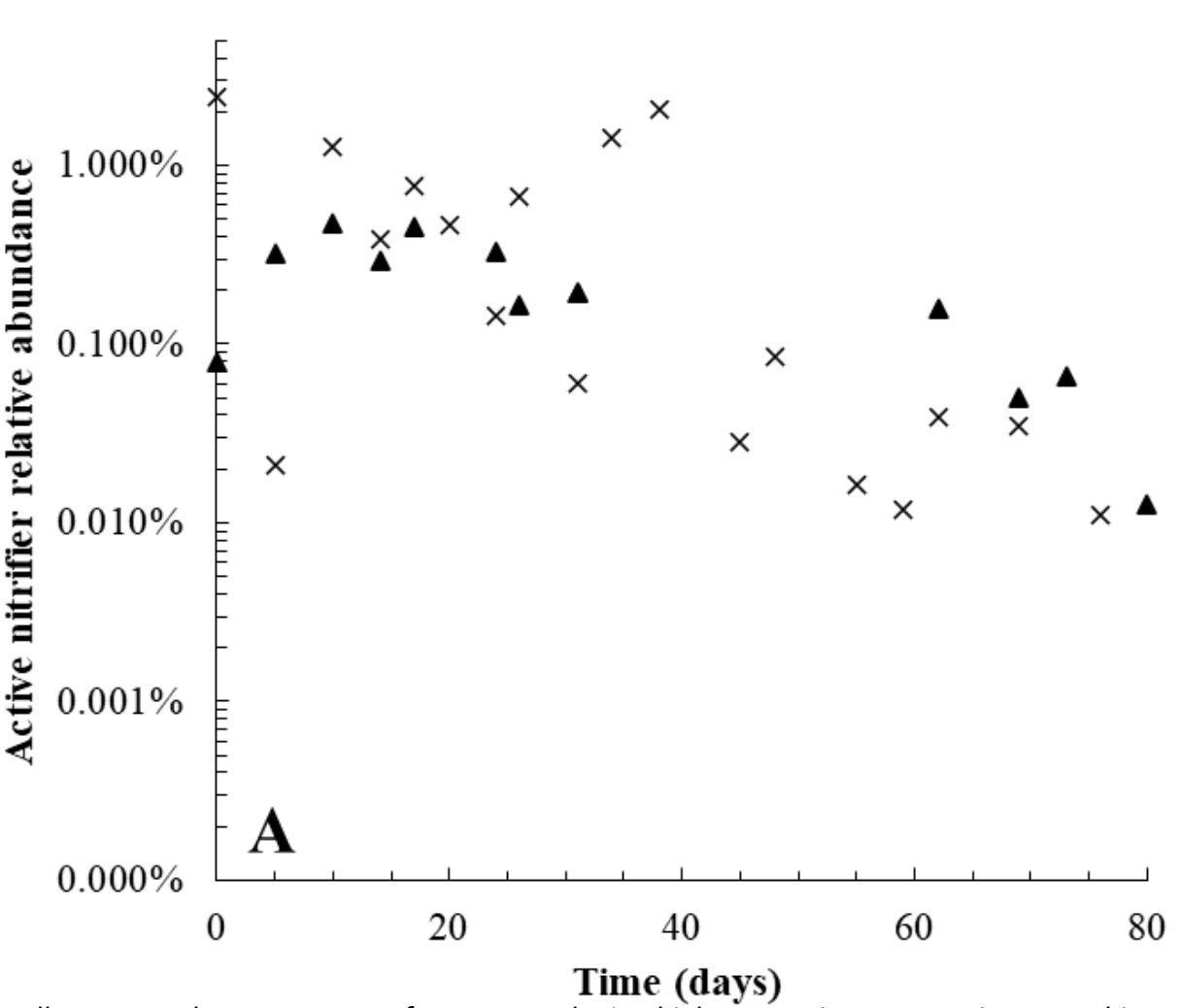


Shifts in relative abundance of active communities in lab granules



Bodle, K.B., et al., *Treatment performance and microbial community structure in an aerobic granular sludge sequencing batch reactor amended with diclofenac, erythromycin, and gemfibrozil*. *Frontiers in Microbiomes*, 2023. 2.

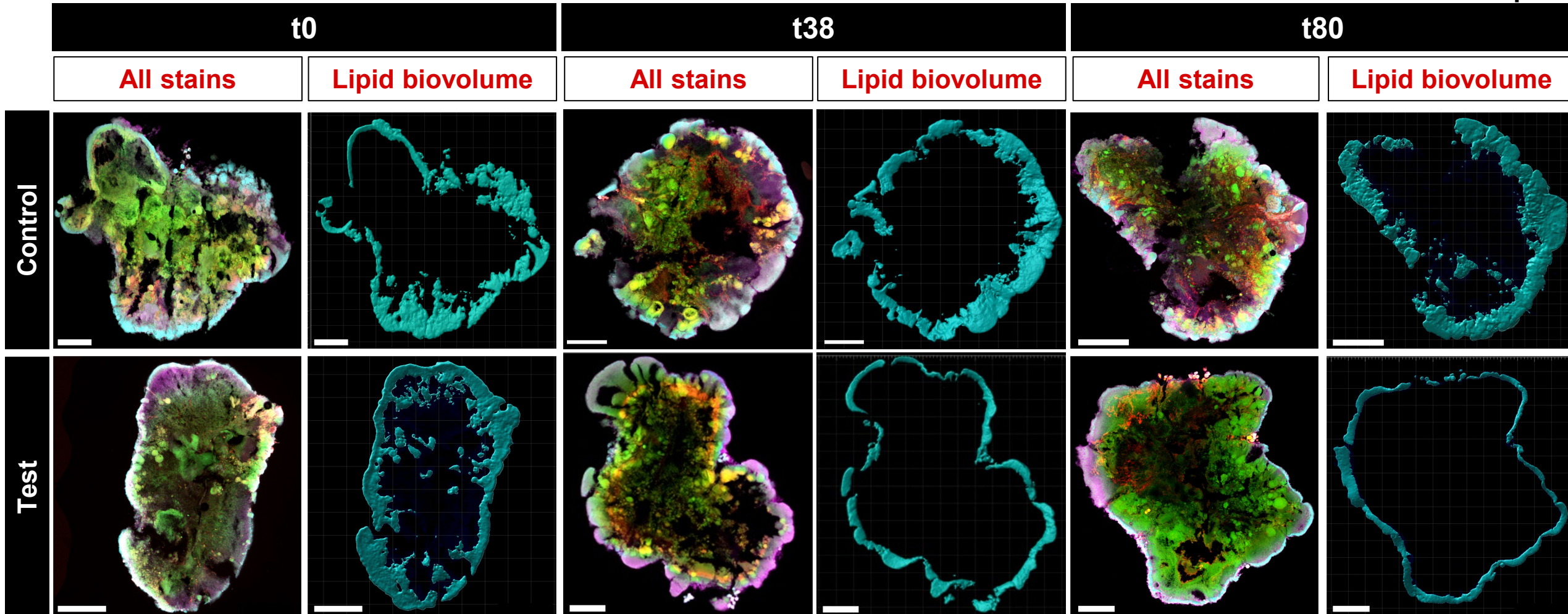
Lab granules – active vs. inactive nitrifiers’ relative abundance



Bodle, K.B., et al., *Treatment performance and microbial community structure in an aerobic granular sludge sequencing batch reactor amended with diclofenac, erythromycin, and gemfibrozil*. *Frontiers in Microbiomes*, 2023. 2.

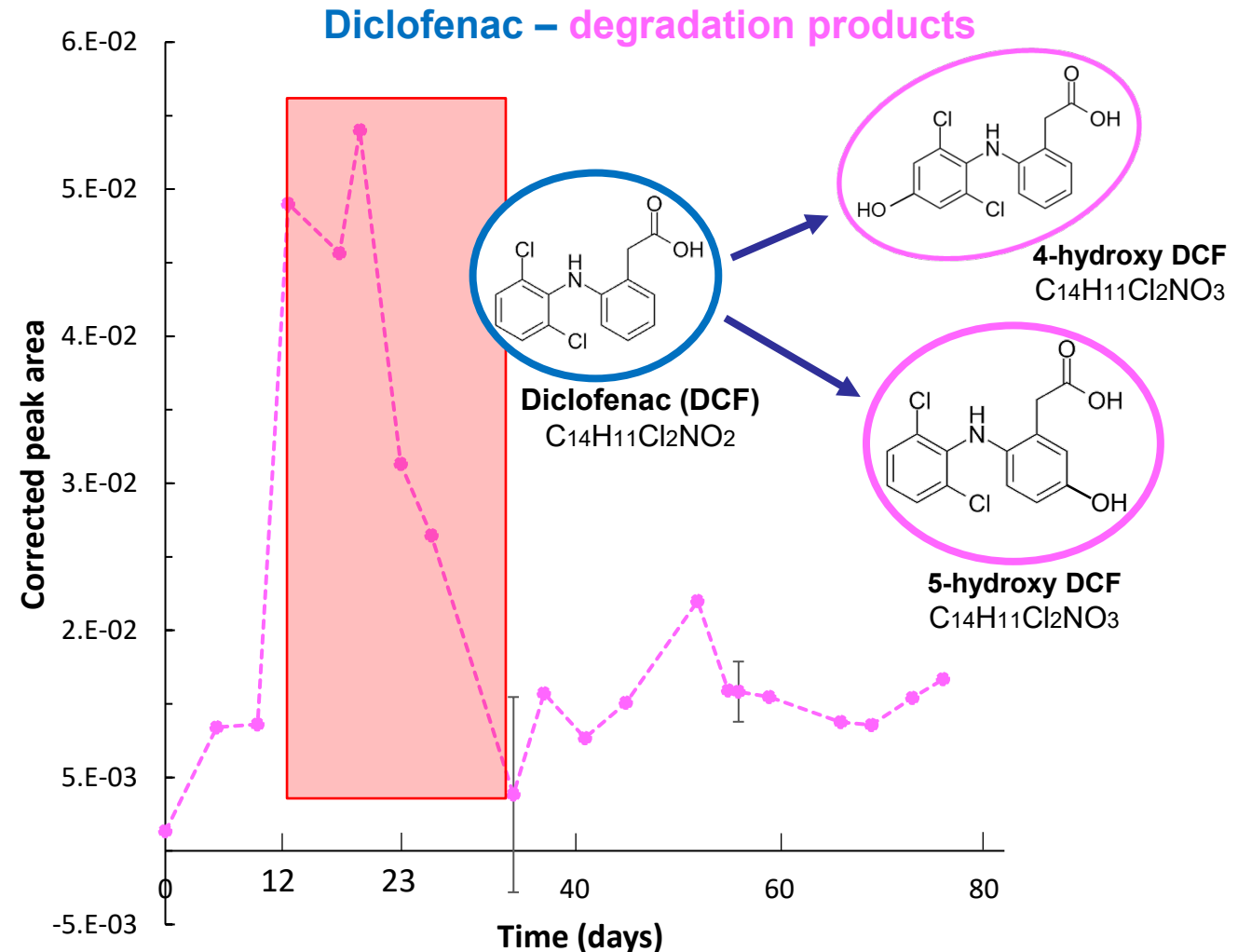
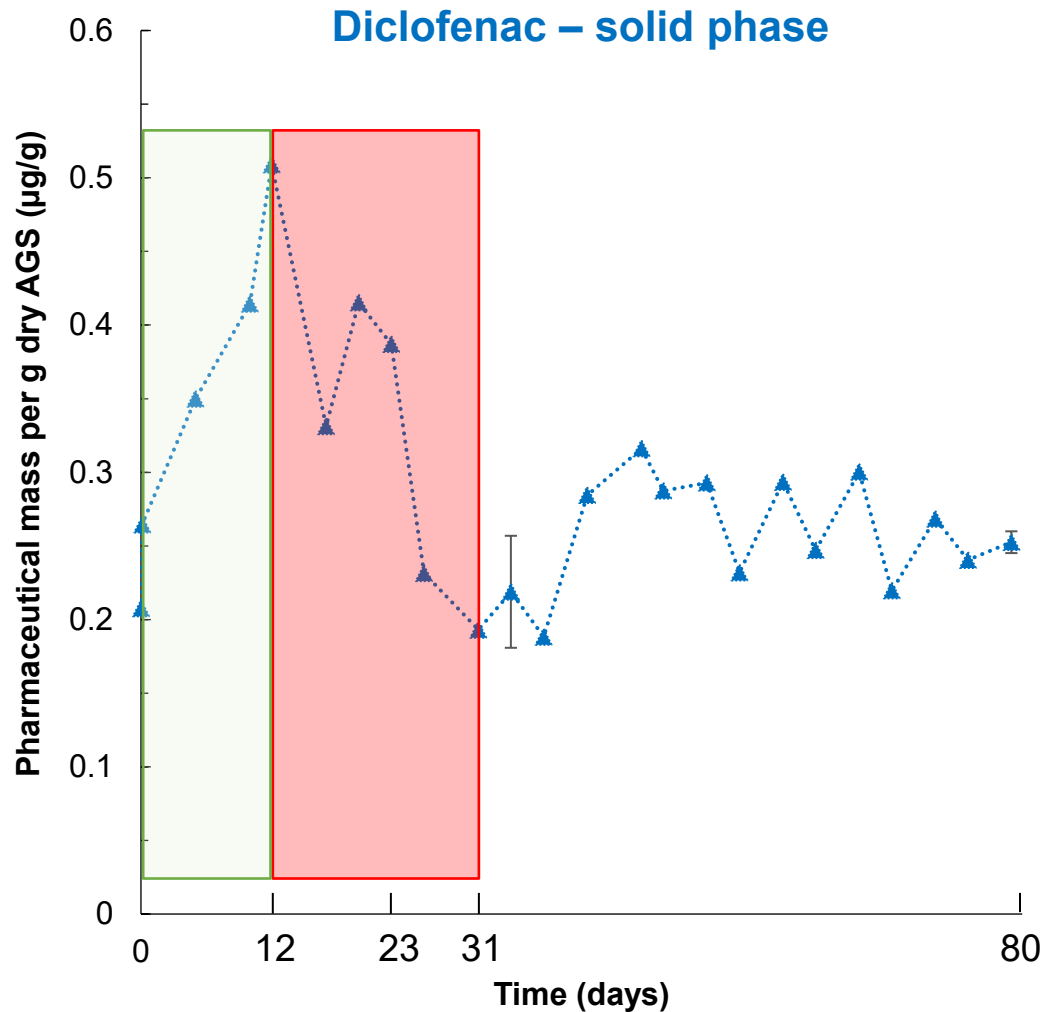
Lipids decrease throughout exposure

All scale bars 200 μ m



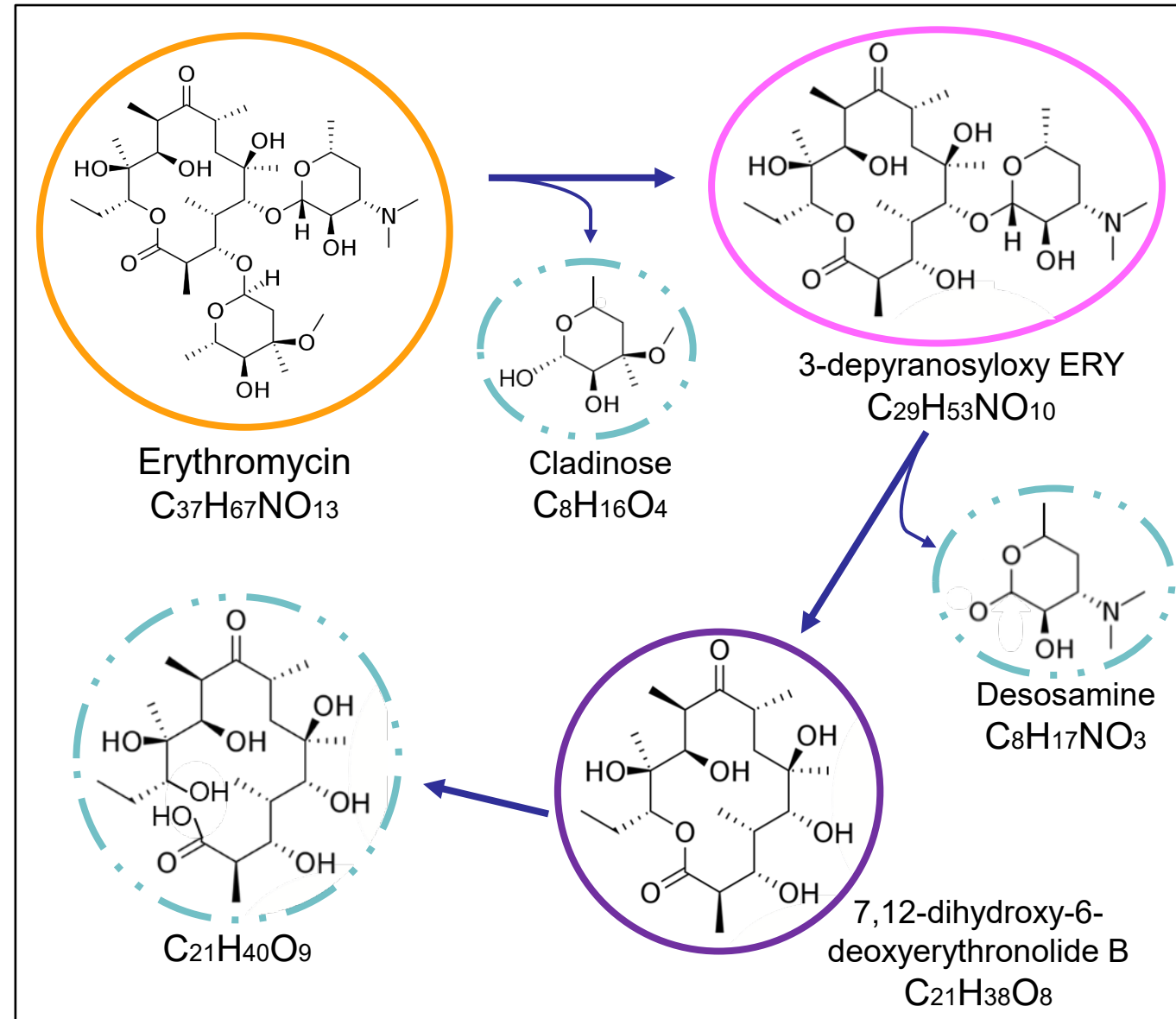
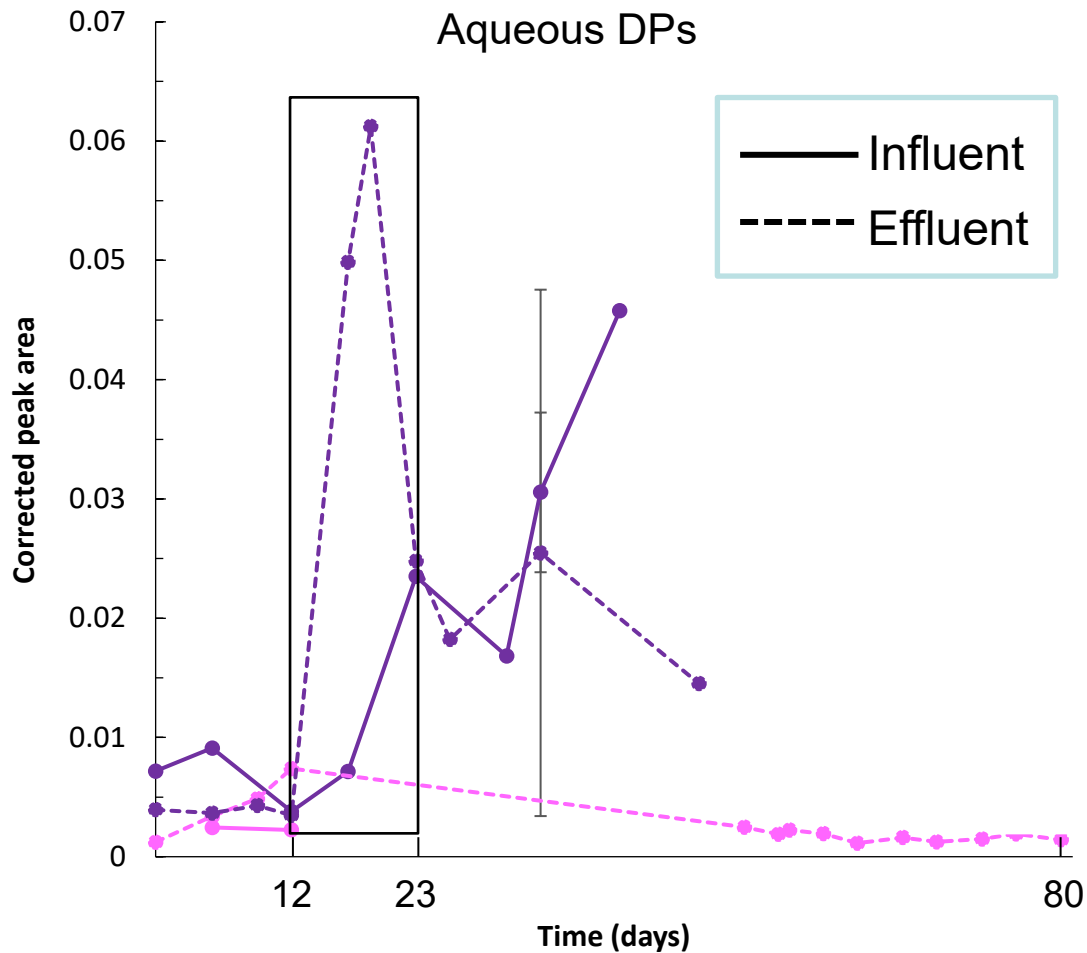
Proteins; lipids, α -polysaccharides, β -polysaccharides

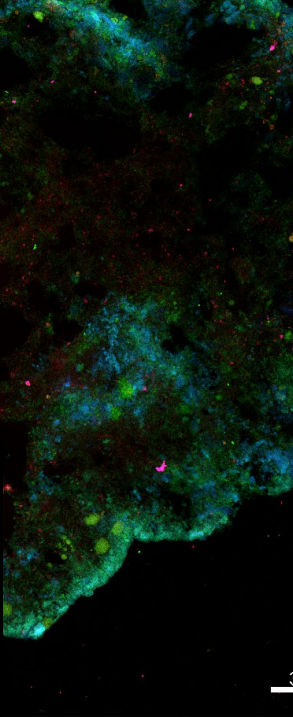
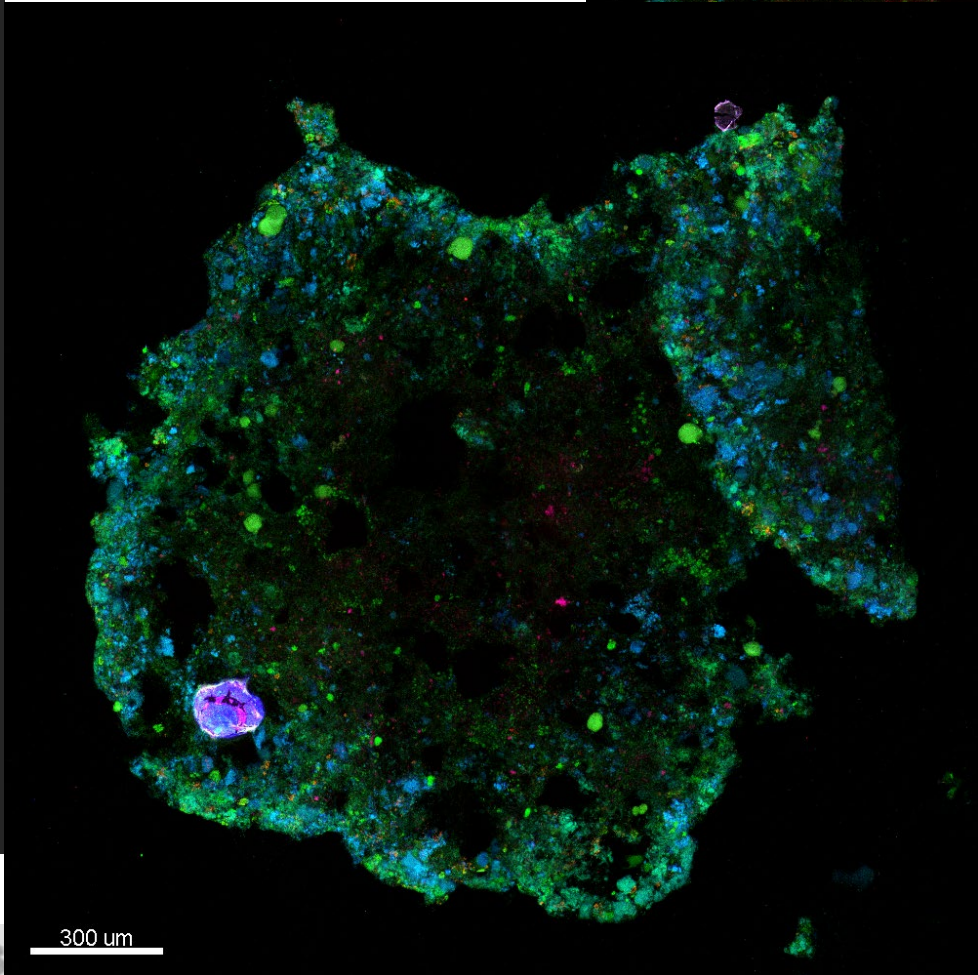
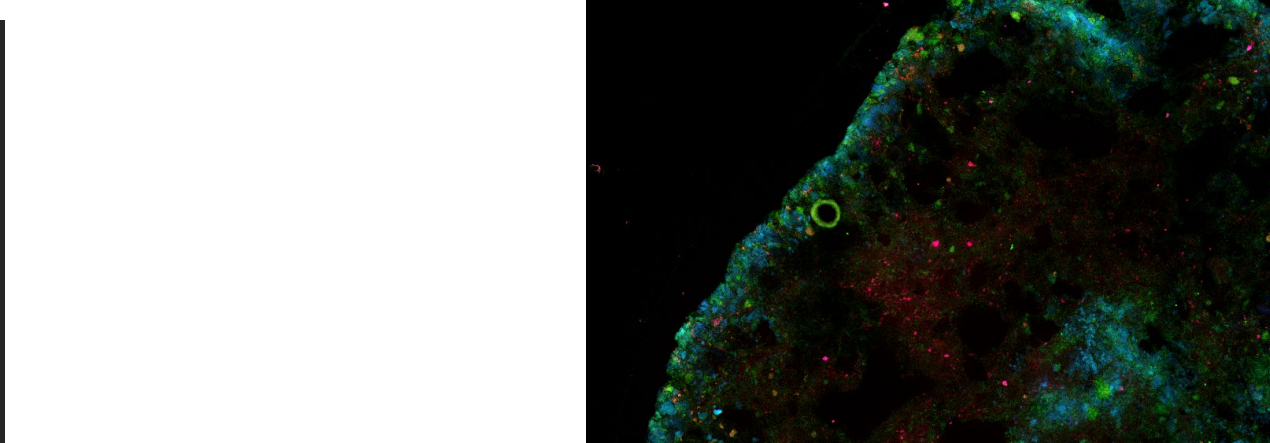
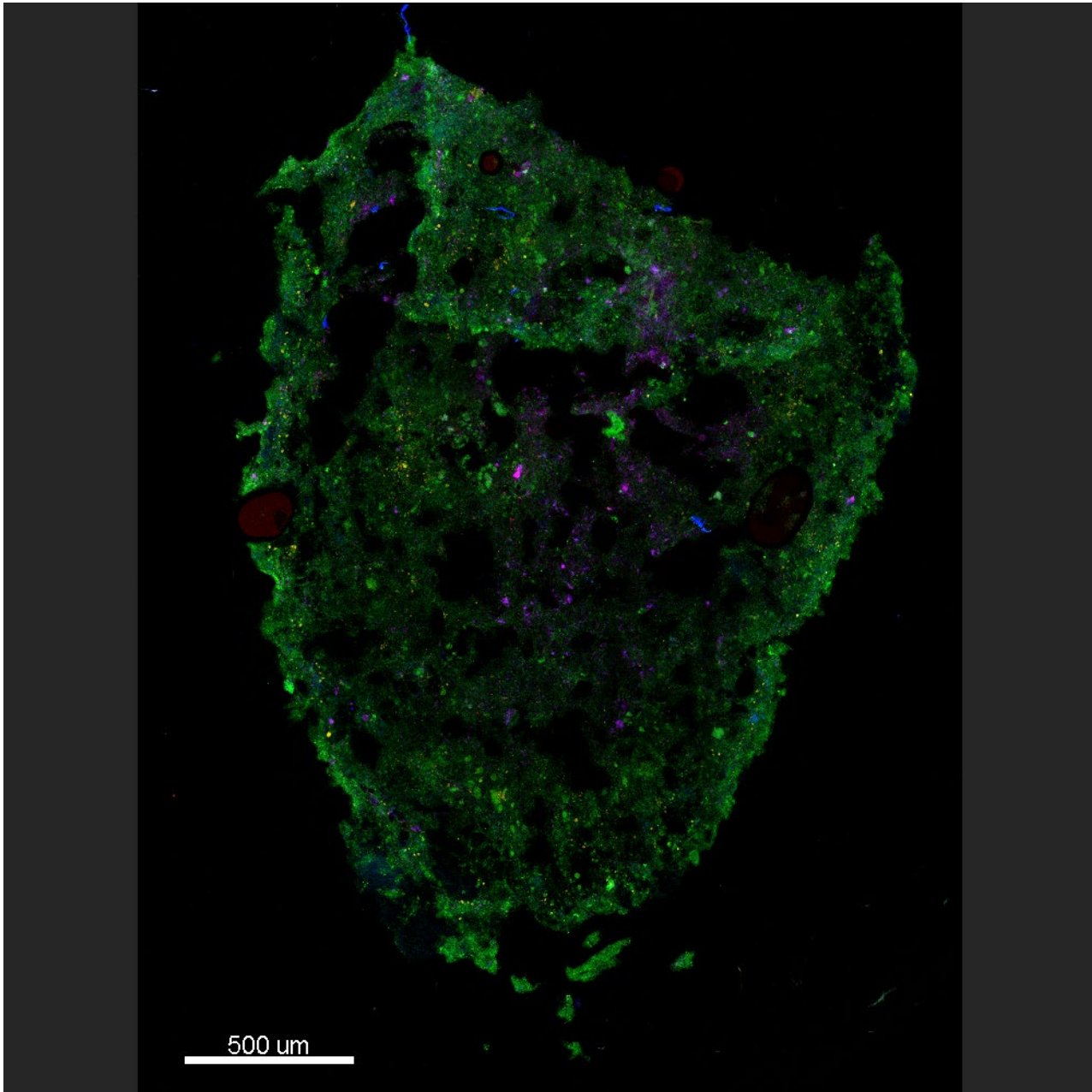
Removal occurs via degradation + adsorption

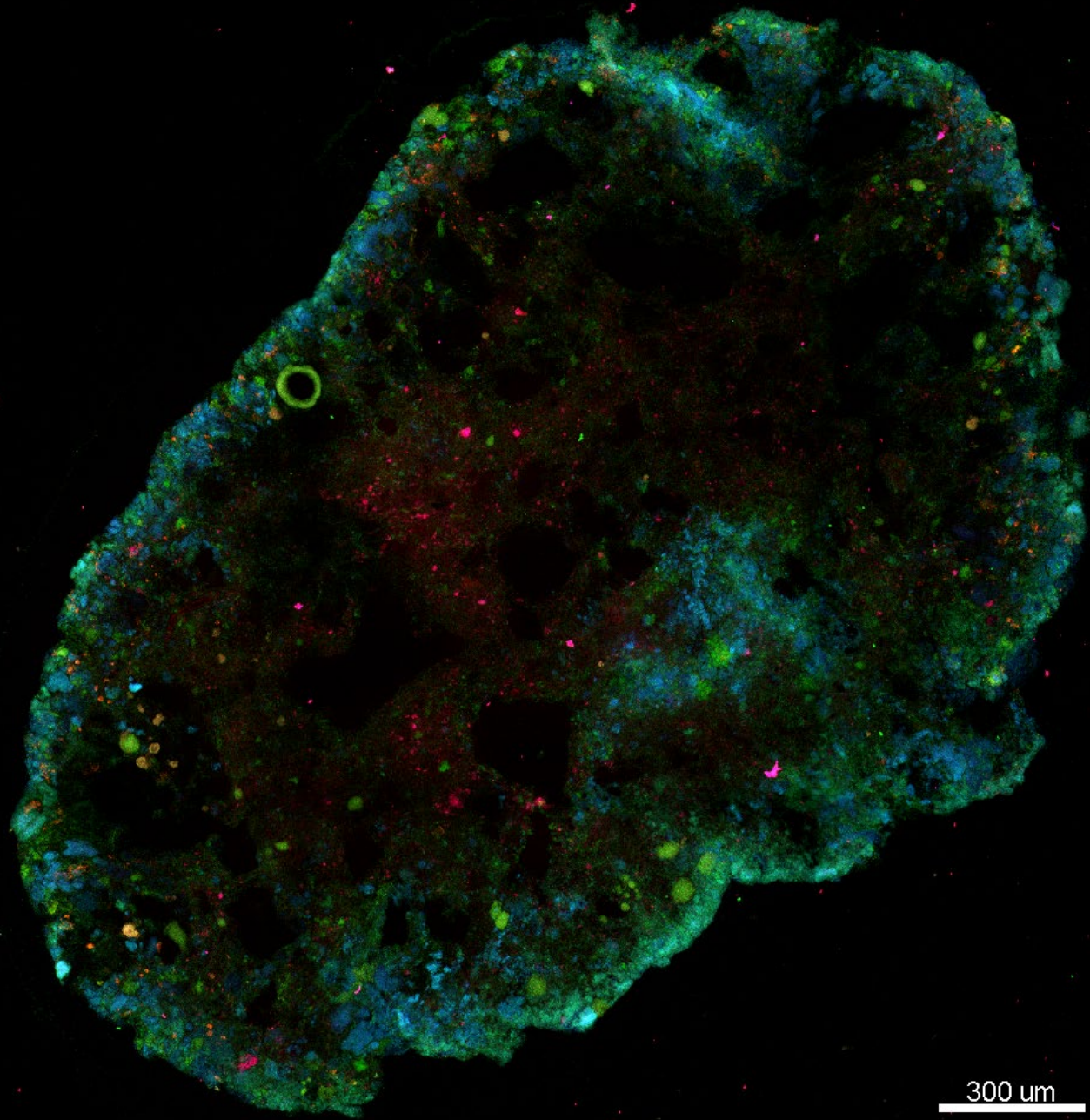


Jewell, K.S., et al., *Transformation of diclofenac in hybrid biofilm-activated sludge processes*. Water Research, 2016.

Erythromycin degradation products wash out over the same time frame







300 um

300 um

