Doing More with Less

Driving Towards Carbon Efficient BNR

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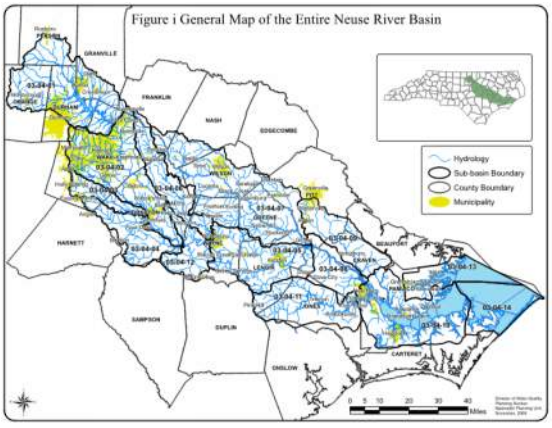
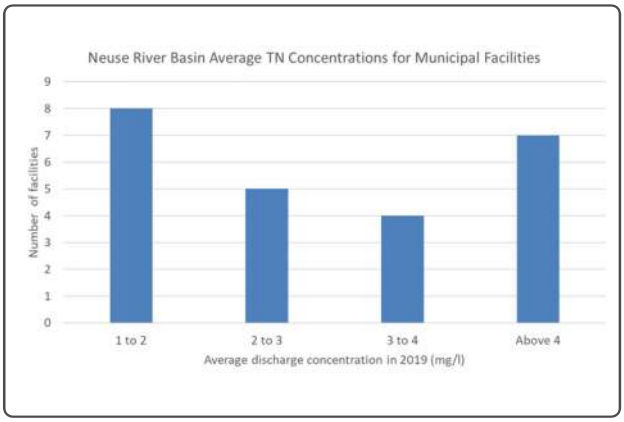
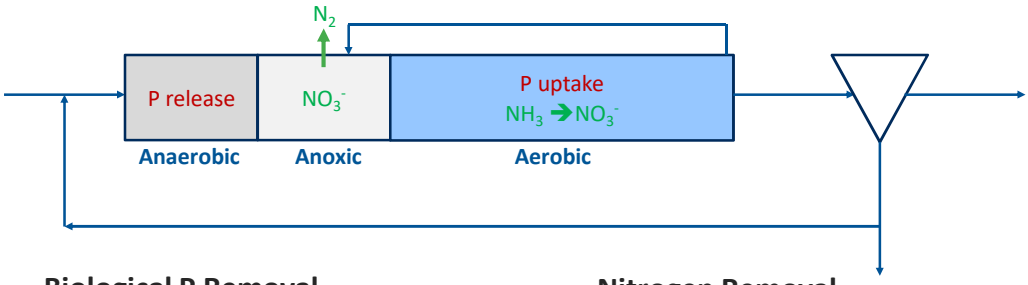
Neuse river basin

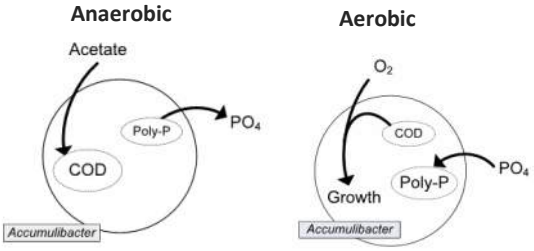




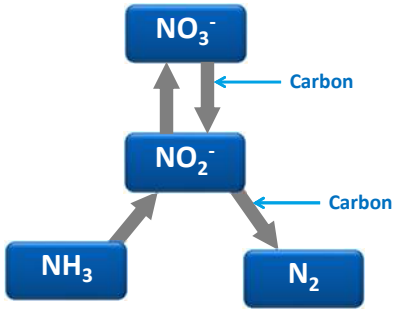
Traditional understanding of mechanisms for BNR



Biological P Removal



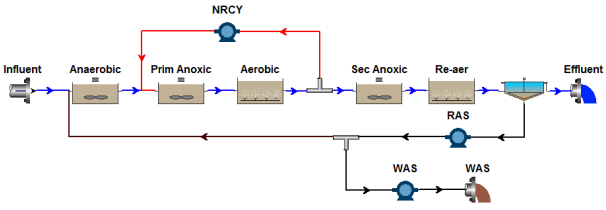
Nitrogen Removal

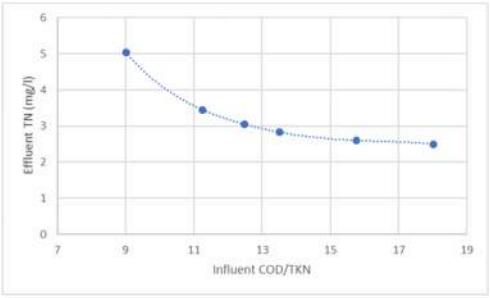


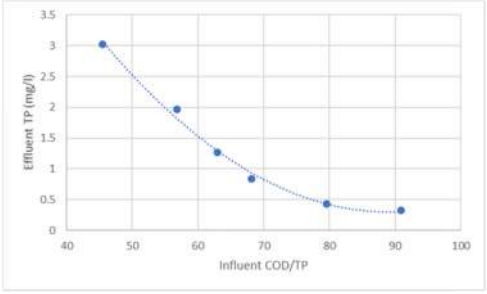
3

Carbon availability drives nutrient removal

- Carbon for denitrification
- VFA as energy source for PAOs
- Easier TN and TP removal with more influent carbon
- Supplemental carbon needed to drive low limits where influent carbon is insufficient







4

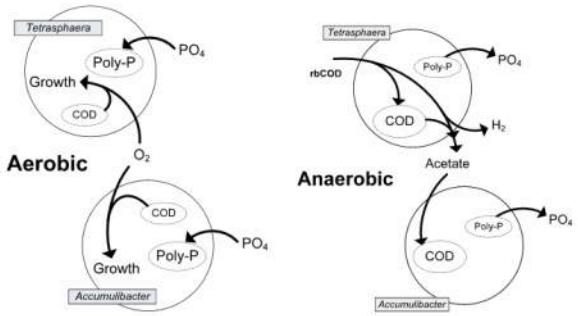
Developmental areas to better manage carbon for nutrient removal

S2EBPR	• Alternative EBPR pathway development (WRF) Project 4975 (PI – Leon Downing) • Development as part of Water Research Foundation (WRF) Project 4975 (PI – Leon Downing)
Low DO BNR	• Continued growth in industry • Next focus: settleability and formal design practices • Development as part of WRF Project 5083 (CoPI – Leon Downing)
Shortcut Nitrogen	• Application to mainstream processes • Current functional design in Australia
MABR	• Enhanced opportunities for simultaneous nitrification / denitrification • Pilot in Heyward, CA • Full scale installations in Israel

Goal: get more pounds of nitrogen removal per pound of influent carbon, while also achieving phosphorus removal

How does S2EBPR impact TN Removal?

S2EBPR for reliable and cost effective biological phosphorus removal



Historical focus on accumulibacter

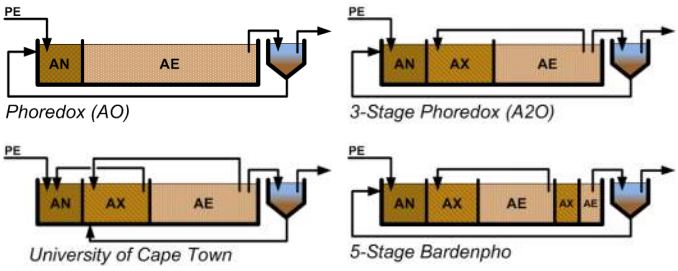
Recently gained a much better understanding of the role/importance of other PAOs

Evolution of EBPR….

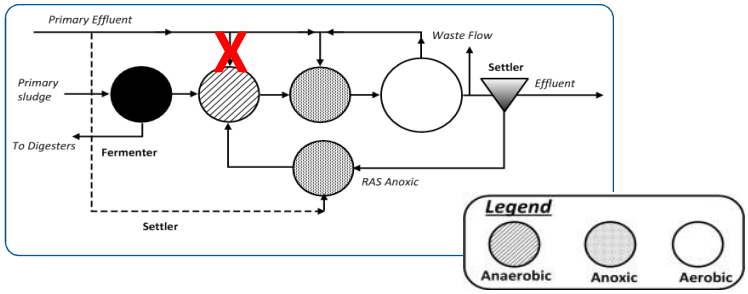
Early success was with sidestream ML fermentation

Dr. Barnard 100 m3/d pilot 1972

But mainstream configurations became the standard, and relied on influent VFA



Westside Kelowna BC (Westbank)

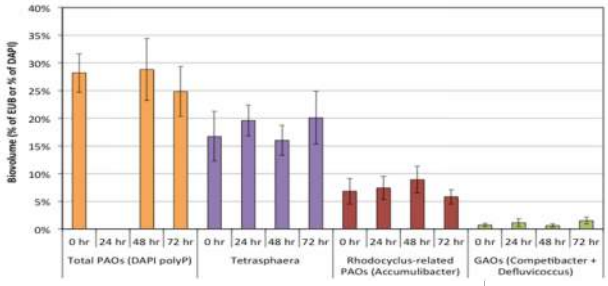


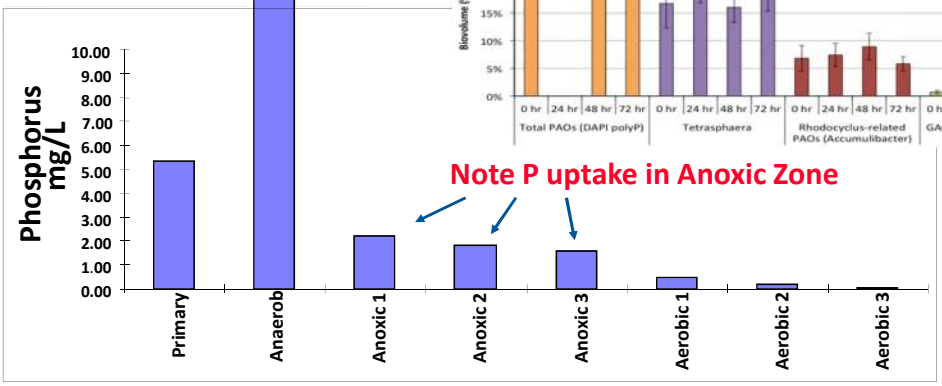
TN	< 6 mg/ℓ
BOD	< 5 mg/ℓ
TSS	< 2 mg/ℓ
TP	< 0.15 mg/ℓ

9

Profile through westbank reactor

Denitrifying PAOs can denitrify and uptake P under anoxic conditions

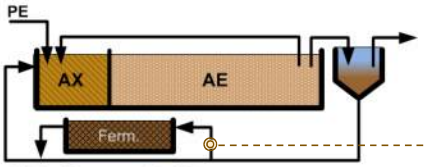




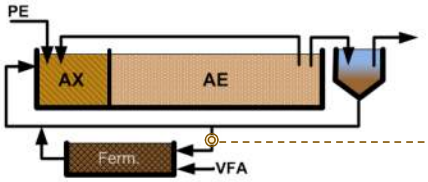
Bioreactor Profile Phosphorus by Zone

10

Sidestream enhanced biological phosphorus removal DIVERSIFIES carbon source for EBPR



Side-Stream RAS Fermentation (SSR)



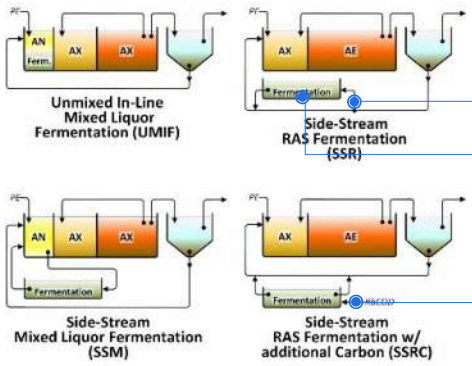
Side-Stream RAS Fermentation w/ Additional Carbon (SSRC)

1. Move the anaerobic zone to the sidestream with a portion of RAS
2. Relies on the carbon contained within biomass to drive PAO battery charging
3. If insufficient carbon in biomass, add external carbon

WRF 4975 is focused on practical considerations for sidestream enhanced biological phosphorus removal

- **21 participating utilities globally**
- **$1.3 M research project value**
- **Identified as one of the top 10 Water Innovations for 2020**
- **Principal Investigator: Leon Downing, B&V**
- **Co-PI: April Gu, University of Cornell**
- **Goals:**
  - **Develop design criteria for the processes**
  - **Identify operational tools for EBPR**
  - **Recommend process modeling guidelines**

Design guideline development is focused on consolidating information from as many facilities as possible



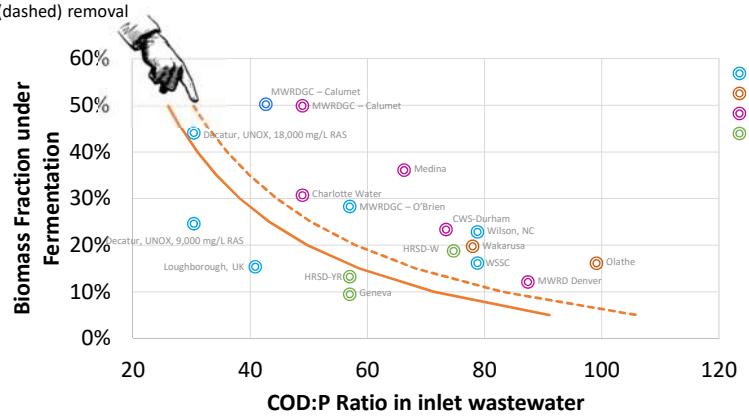
How much RAS do we divert?

How big is our fermenter?

How does carbon addition impact sizing?

The influent carbon impacts the biomass produced relative to influent phosphorus concentration

Preliminary curves are based on Danish experience for 85% (solid) and 98% (dashed) removal

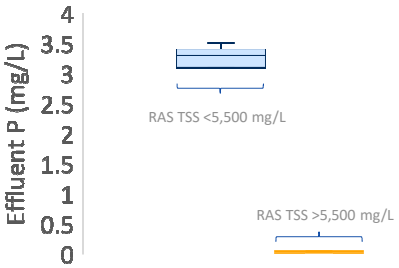


Things to consider

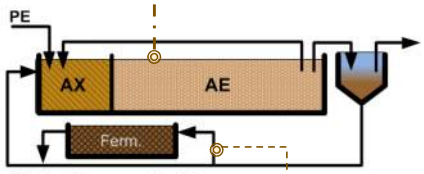
- **Biodegradable COD influent**
- **Biomass COD load into RAS fermentation tank**

Carbon source becomes the *biomass*, liberating influent carbon for other uses

Wheaton SD S2EBPR Performance:
P performance driven by solids into sidestream fermenter



Mainstream can be prioritize influent carbon for TN removal

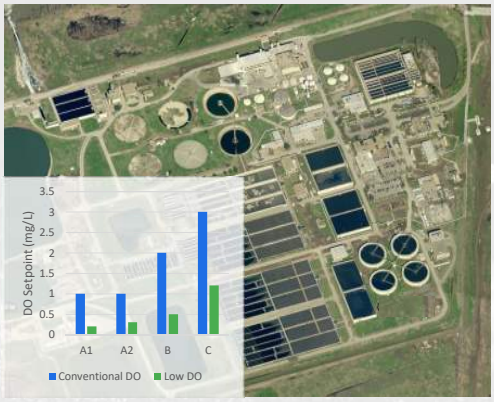


Side-Stream RAS Fermentation (SSR)

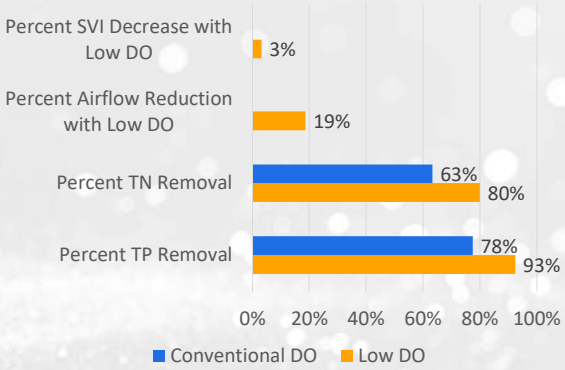
EBPR metabolism driven by *biomass* in sidestream

What does the future of DO look like?

Low DO operation has been shown to benefit aeration, denitrification, and maintain settling rates

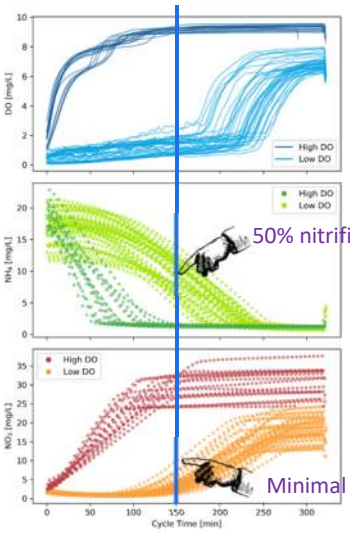


TRA CRWS Treatment Plant



How do we understand nitrification capacity?

Nitrification rate testing throughout the day, every day, generates a large amount of nitrification rate data

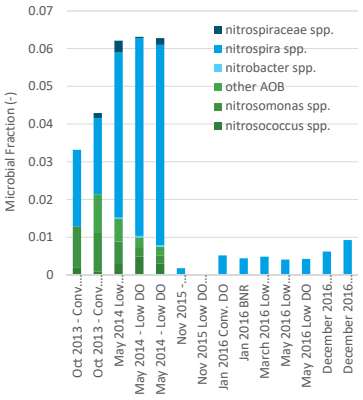


50% nitrification achieved

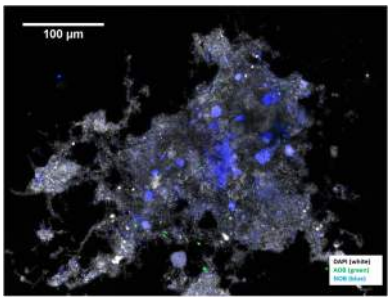
Minimal nitrate formation, high level of SND

- Aeration manually controlled for DO targets
- Understand nitrification rate
- Understand SND impacts of DO

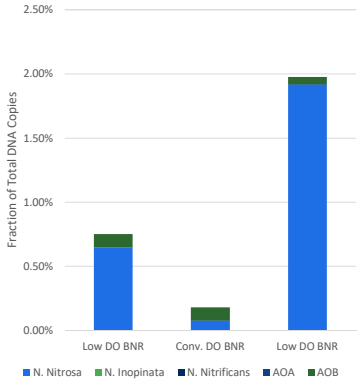
A different nitrifying community does occur at low DO conditions



Long term next generation sequencing: progression towards non-conventional nitrifiers (Microbe Detectives)



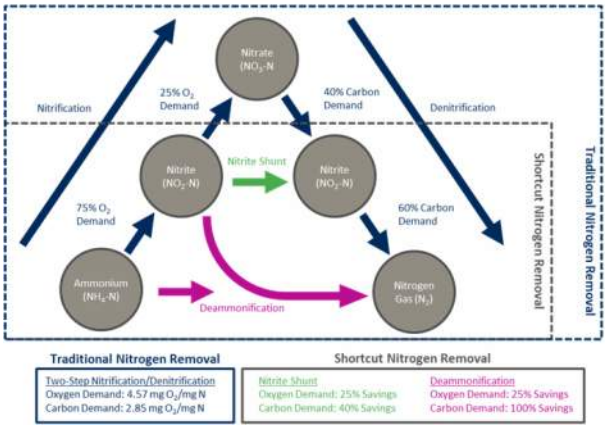
Fluorescence in situ hybridization: Minimal conventional AOB, NOB cluster on the inner floc/granule (indicator of k-strategist) (Wells Lab, Northwestern University)

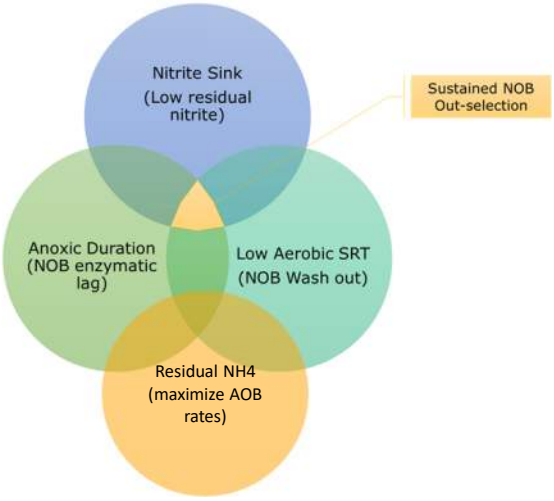


Quantitative PCR: Confirmation of dominance of Nitrospira nitrosa, a confirmed comammox (CMX) organism (Noguera Lab, University of Wisconsin)

Shortcut Nitrogen Removal

Four pillars of nitrite shunt

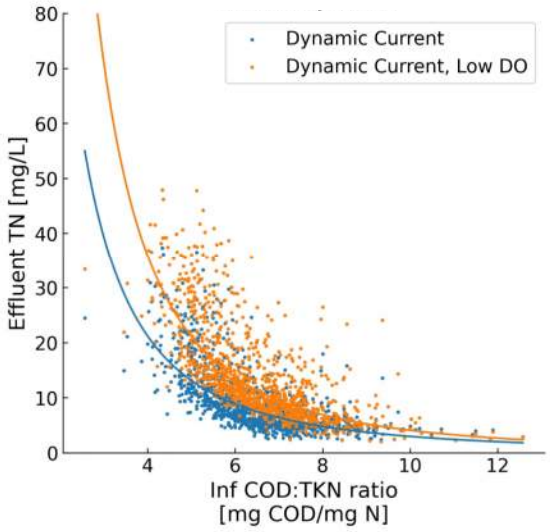




Based on global academic work – high loading rates and residual NH4

Producing alternating aerobic and anoxic reaction volume

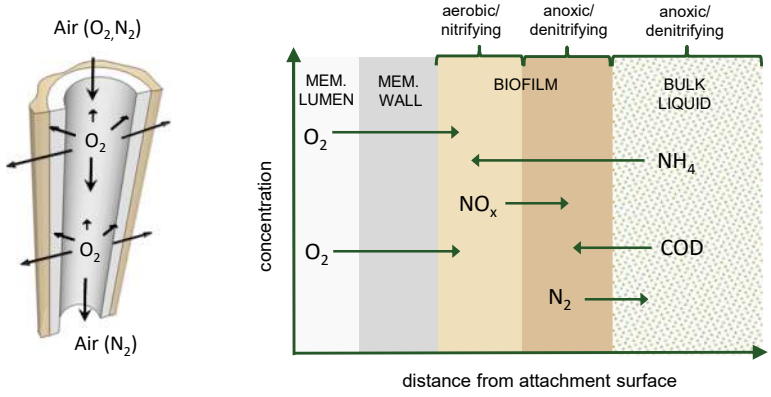
- NOB suppression
- AOB growth
- Nitrite 'sink' with carbon
- Lower effluent TN for the same influent COD



Results from Melbourne, Australia

MABR

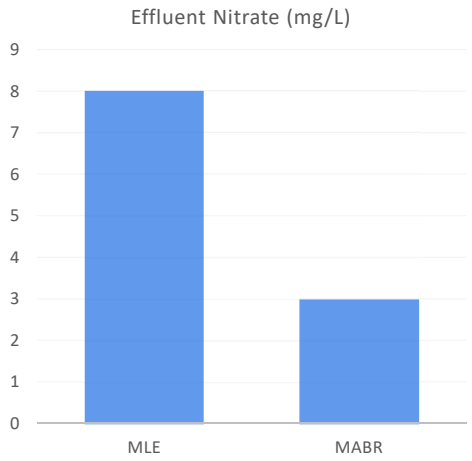
The MABR supports total nitrogen removal.



Oxygen is consumed within the biofilm, supporting anoxic conditions for denitrification in outer biofilm and/or bulk liquid.

Demonstration testing has been advancing the MABR for nearly a decade

Side-by-side testing in Isreal demonstrates benefit of MABR for carbon



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Key conclusions

- Carbon drivers BNR
- Finding more efficient ways to use carbon is key for the future
  - Diversification of carbon sources
  - Reduction in carbon needs
- Many process focus on operations, not technology “widgets”

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Your Local Contacts

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