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Next Generation Nitrogen Removing Biofilters (NRBs) treating onsite wastewater

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Next generation NRBs to remove/recover nutrients

Design and operational concern:

- Large footprint
- Maintenance frequency
- Longevity of the system
- materials sustainability

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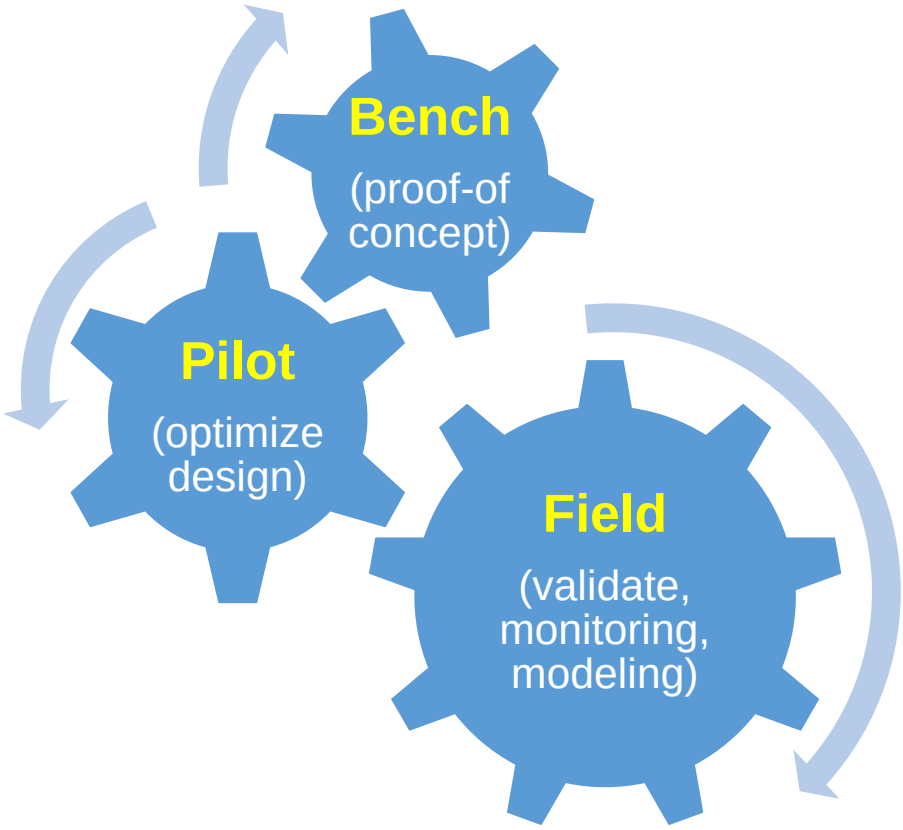

Next generation NRBs to efficiently remove/recover nutrients

Configuration and Operation

- Modular process
- Loading/recycle
- Optimal size/depth
- Math Modeling
- Sensor monitoring

Materials

- Amendment of natural-based media (e.g. biochar)
- Lignocellulose material & alternative C source

Mechanisms

- Chemical/physical
- Biomarkers to track bio-transformation
- Environmental factors (e.g. seasonal change)

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Enhanced N/P removal/recovery

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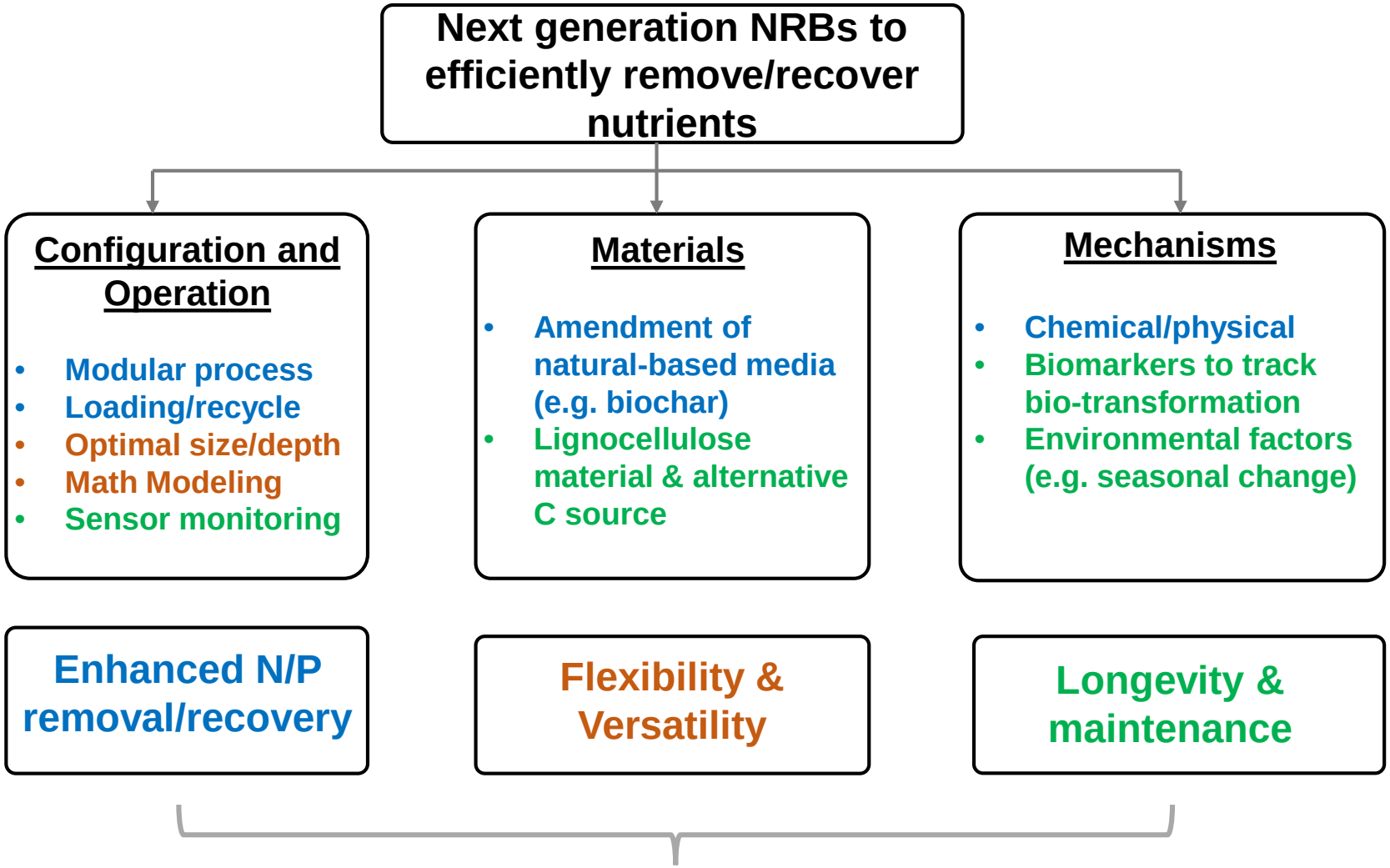
Enhanced N/P removal/recovery

Flexibility & Versatility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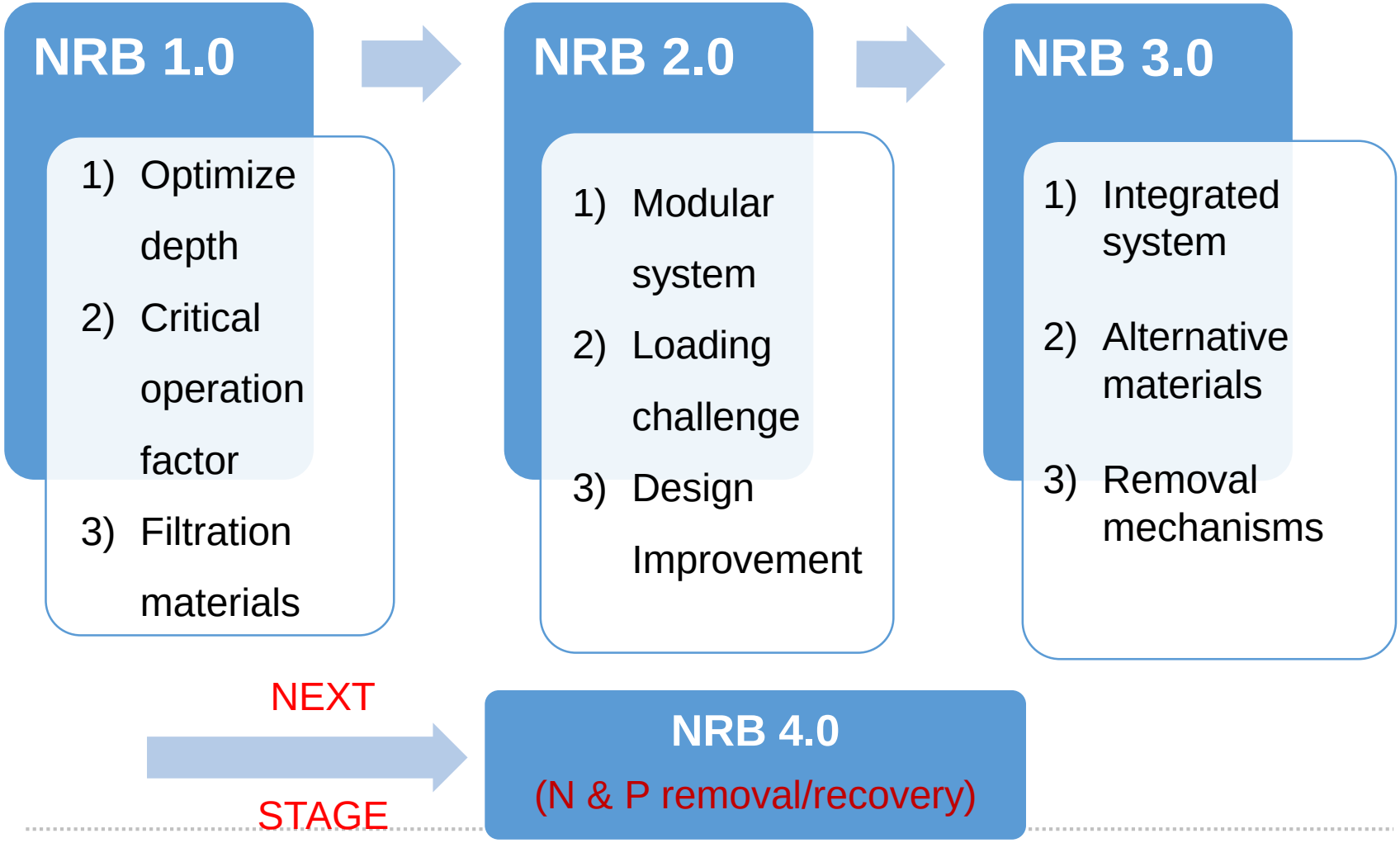
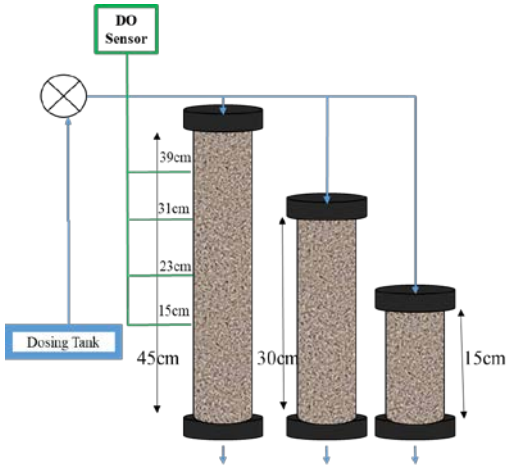
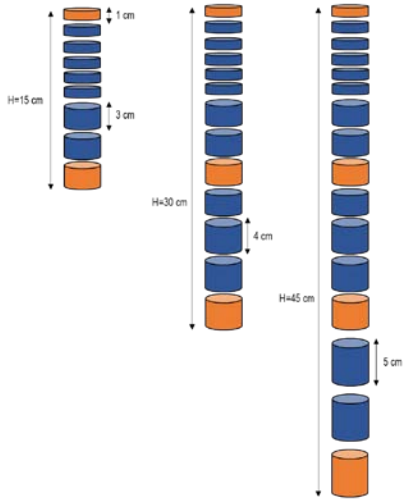
Enhanced N/P removal/recovery
Flexibility & Versatility
Longevity & maintenance
Cost-effective and sustainable onsite wastewater treatment

Research and Development



NRB 1.0 Configuration and operation

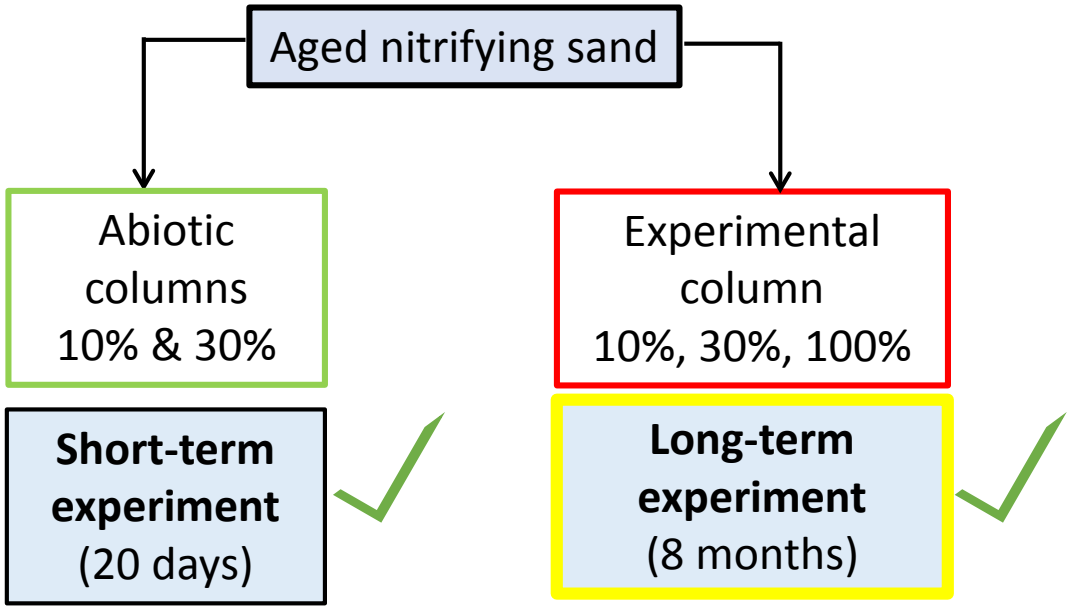




- Full nitrification was observed in the top of sand filters (15 cm) when alkalinity was sufficient.
- Majority of the microbial community was present at the top layer (15 cm).
- Nitrification efficiency was more sensitive to the hydraulic loading change than nitrogen loading change.

Maleki, Z., et al. (2021). *Ecological Engineering*, 168, 160271

NRB 1.0 Filtration materials (biochar)

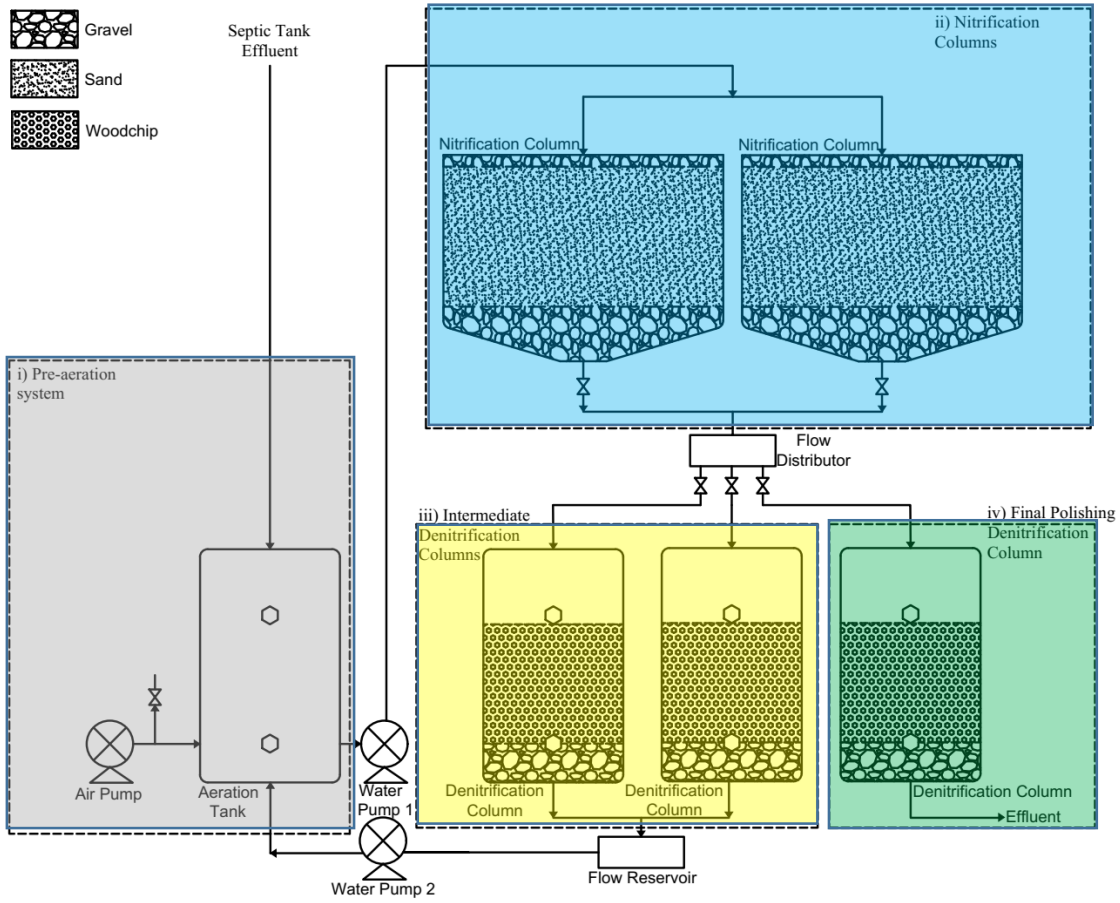


With biochar amendment:

- Increase water holding capacity
- Provide supplemental alkalinity
- Enhance NH_4^+ adsorption
- Serve as growth media for microbial growth

Maleki, Z., Mao, X. (2022). Journal of Environmental Quality 51 (2), 129-151
Maleki et al. 2022. Nitrogen Removal Mechanisms in Biochar-Amended Sand Filters treating Onsite Wastewater (in-prep)

NRB 2.0—Configuration and design (FlexTreat Biofilter™)

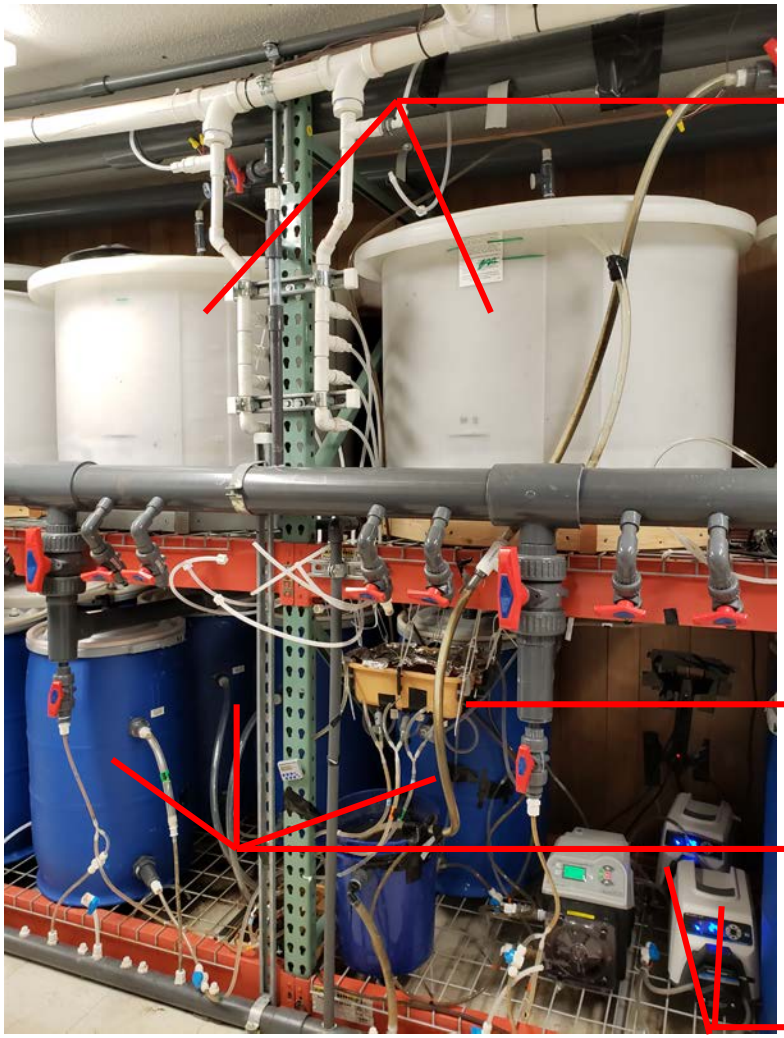


Unique features

- **Continuous Flow**
- **Internal Recycle**
- **Pre-aeration system**

Designed by Frank M. Russo P.E.

NRB 2.0 (FlexTreat Biofilter™) at WRIF



Nitrification Columns

Pilot-scale test:

- Hydraulic Loading Rate (HLR)
- Nitrogen Loading Rate (NLR)
- Recycle Ratio (R)

Flow Distributor

Denitrification Columns

Water Pumps

Designed by Frank M. Russo P.E.

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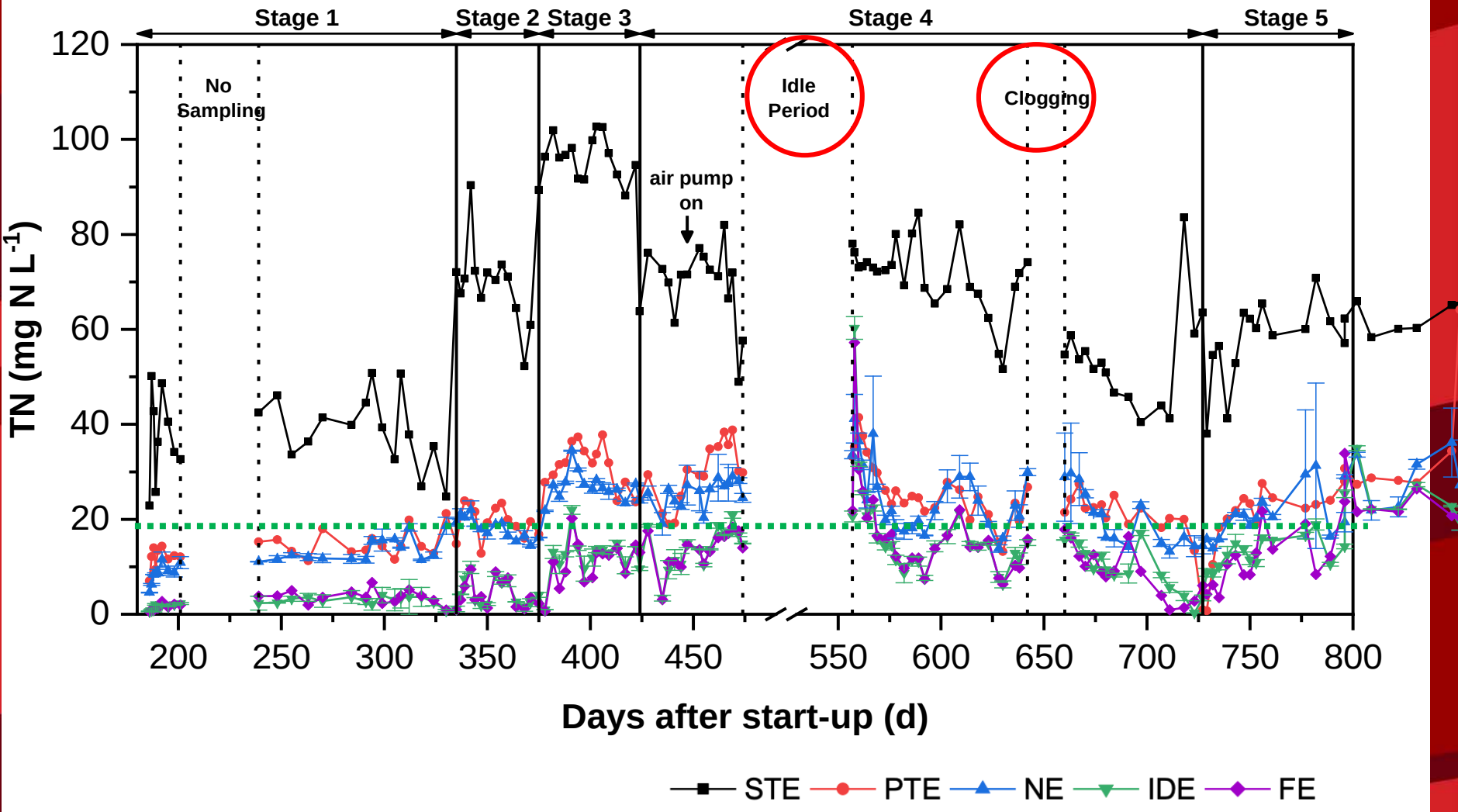
NRB 2.0 (FlexTreat Biofilter™) treatment performance



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NRB 2.0 (FlexTreat Biofilter™) treatment performance

	Recirculating Sand Filter	Constructed Wetland	Hybrid Adsorption and Biological Treatment	NRB 1.0	NRB 2.0
Flow Pattern	Dosing	Dosing	Dosing	Dosing	Continuous
Influent TN (mg N L^{-1})	35 – 55	31 – 82	22 – 50	37 – 45	30 – 100
HLR (m^3 m^{-2} d^{-1})	0.12 – 0.20	0.01 – 0.18	0.13 – 0.20	0.03 – 0.04	0.12
TN Removal Efficiency	40 – 70%	20 – 75%	60 – 80%	80 – 90%	> 80%
BOD removal efficiency	80 – 95%	50 – 95%	60 – 80%	80 – 90%	71 – 90%
Reference	(Christopherson et al., 2005; Urynowicz et al., 2007)	(Fan et al., 2013; Han et al., 2019; Saeed and Sun, 2012; Vymazal, 2013)	(Rodriguez-Gonzalez et al., 2020, 2015)	(Gobler et al., 2021)	This study

Chen, S. et al. (2022) *Chemosphere* 300, 134642 ** poster

FlexTreat Biofilter™ in field testing

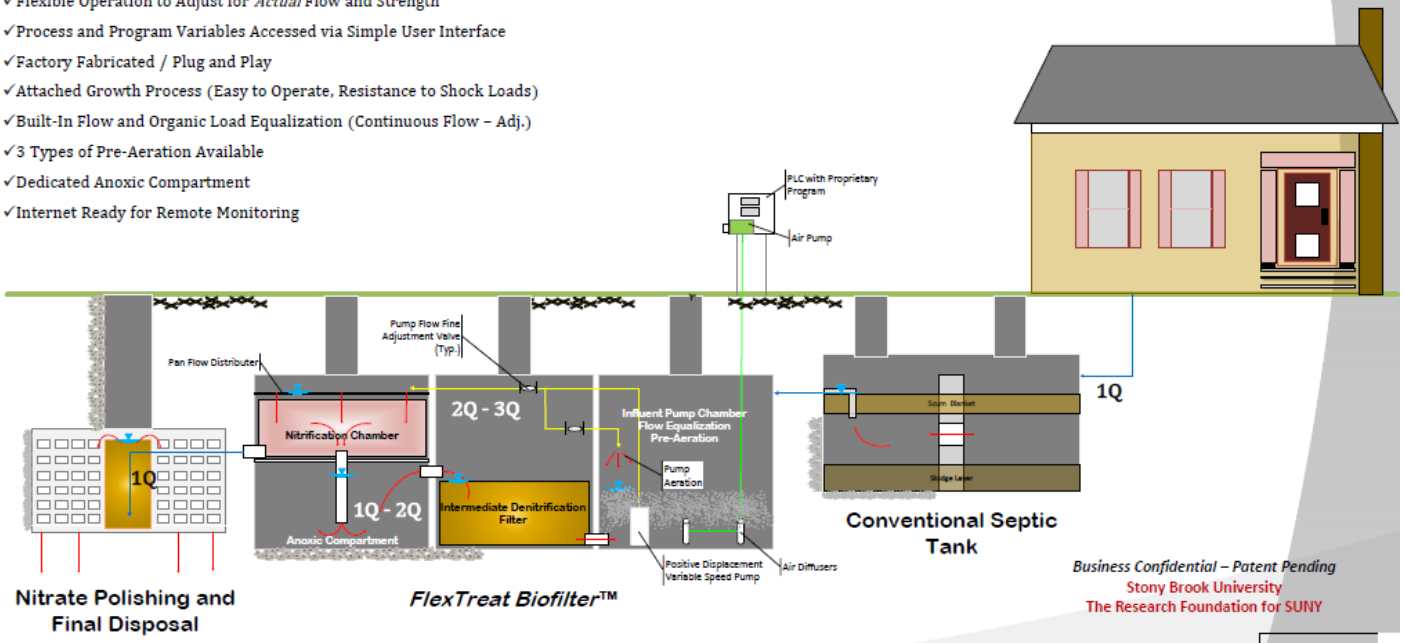
New York State Center for Clean Water Technology at Stony Brook University

Next Generation of Nitrogen Reducing Biofilters

FlexTreat Biofilter™

Process Features:

- ✓Price Comparable to other I/A Systems
- ✓Flexible Operation to Adjust for *Actual* Flow and Strength
- ✓Process and Program Variables Accessed via Simple User Interface
- ✓Factory Fabricated / Plug and Play
- ✓Attached Growth Process (Easy to Operate, Resistance to Shock Loads)
- ✓Built-In Flow and Organic Load Equalization (Continuous Flow – Adj.)
- ✓3 Types of Pre-Aeration Available
- ✓Dedicated Anoxic Compartment
- ✓Internet Ready for Remote Monitoring



Business Confidential – Patent Pending
Stony Brook University
The Research Foundation for SUNY

SUNY RF The Research Foundation for The State University of New York
Stony Brook University NYS Center for Clean Water Technology

Credit: Frank M Russo, P.E

NRB 2.0—Materials & Mechanisms

Explore alternative filtration materials

Gravel

Marble Chip
(ALK supplement)

Zeolite
(NH_4^+ & P removal)

Biochar
Enhance N & P removal

Explore the optimal filtration material to overcome the hydraulic challenge and achieve desired treatment performance.

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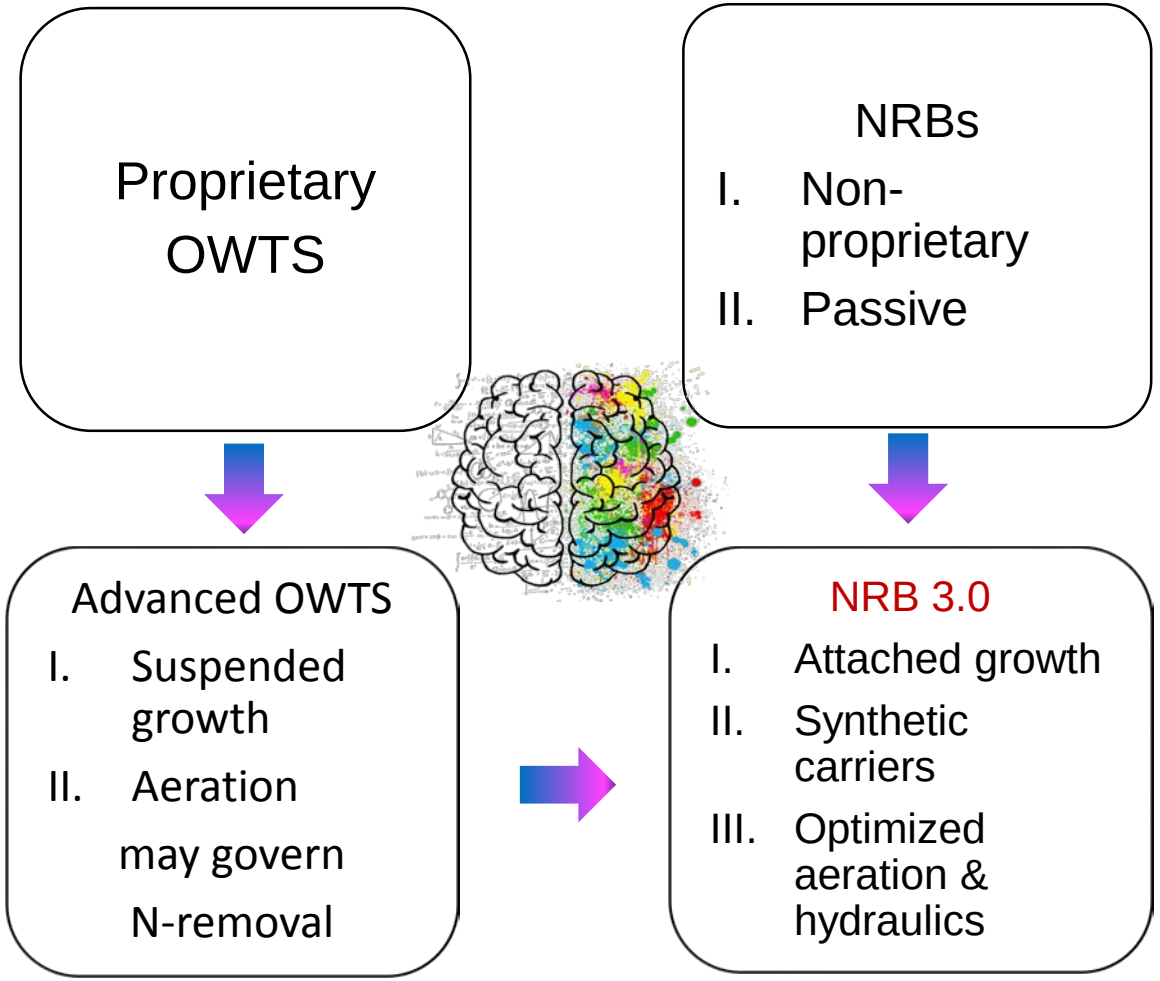
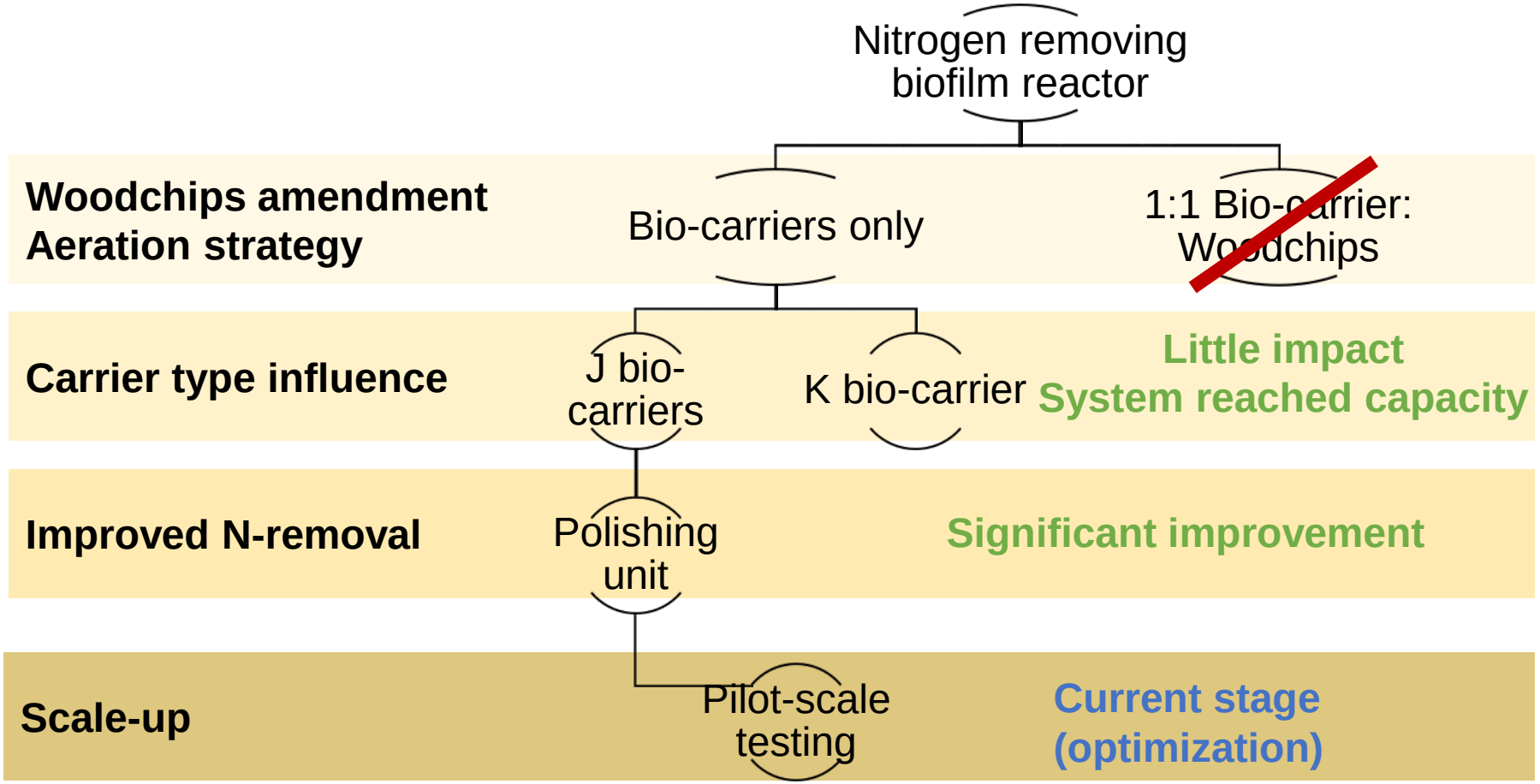
NRB 3.0—Proof-of-concept

- Compact
(Small footprint & High treatment capacity)
- Filtration media
(Less woodchip used).
- Flexibility
(off-the shelf product)
- Aeration pattern
(energy efficient)

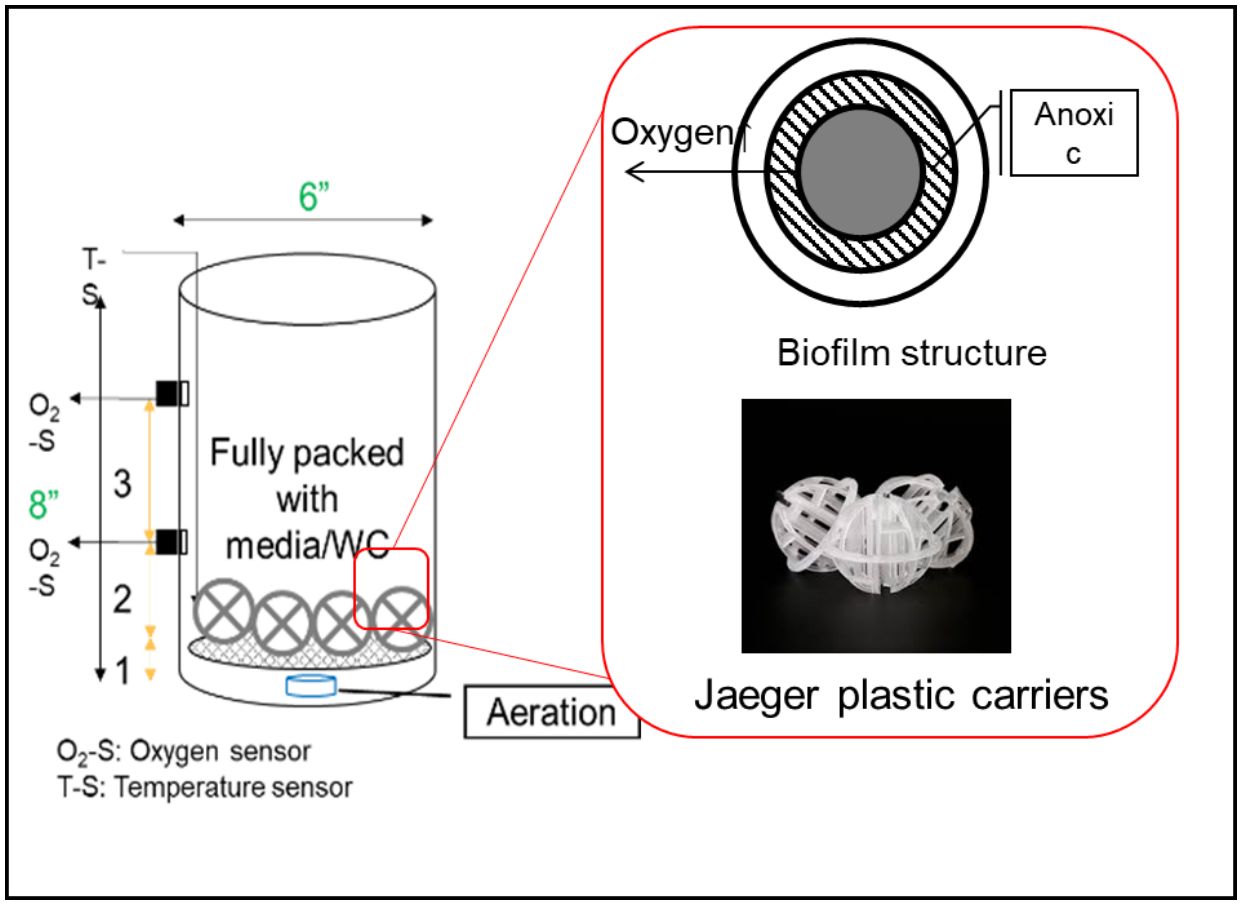


NRB 3.0—Operation Strategy



Lotfi et al. 2022. Efficient nitrogen removal from on-site wastewater using a sequencing aerated biofilm reactor (*in-preparation*) *** poster*

NRB 3.0—Materials & Aeration



sNRB-J

sNRB-K

Kaldnes-K1 micro

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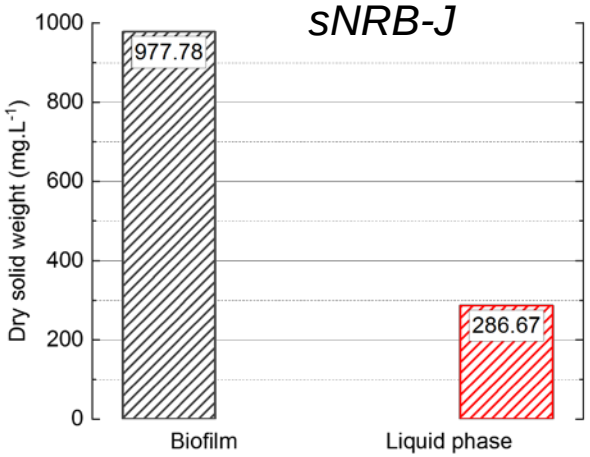
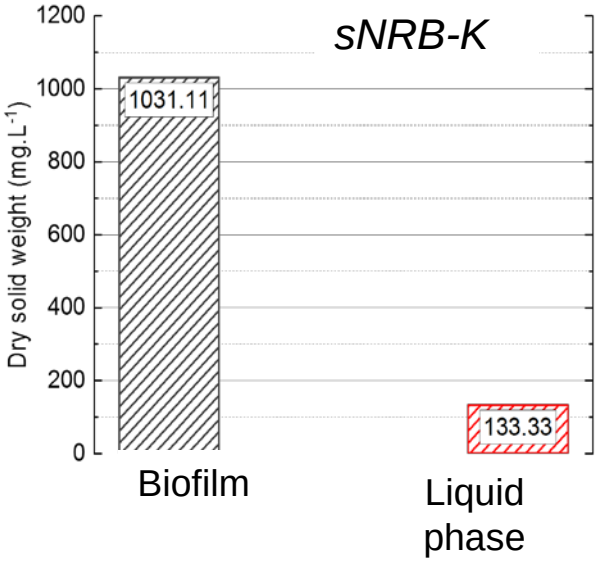
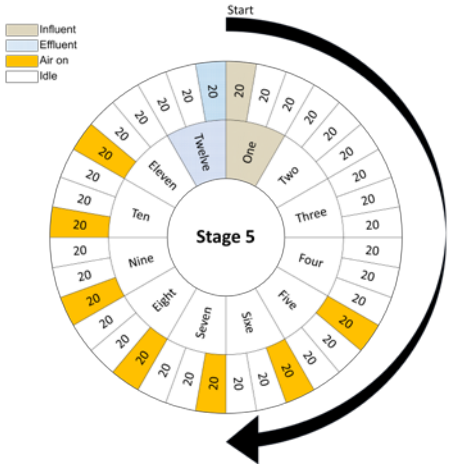
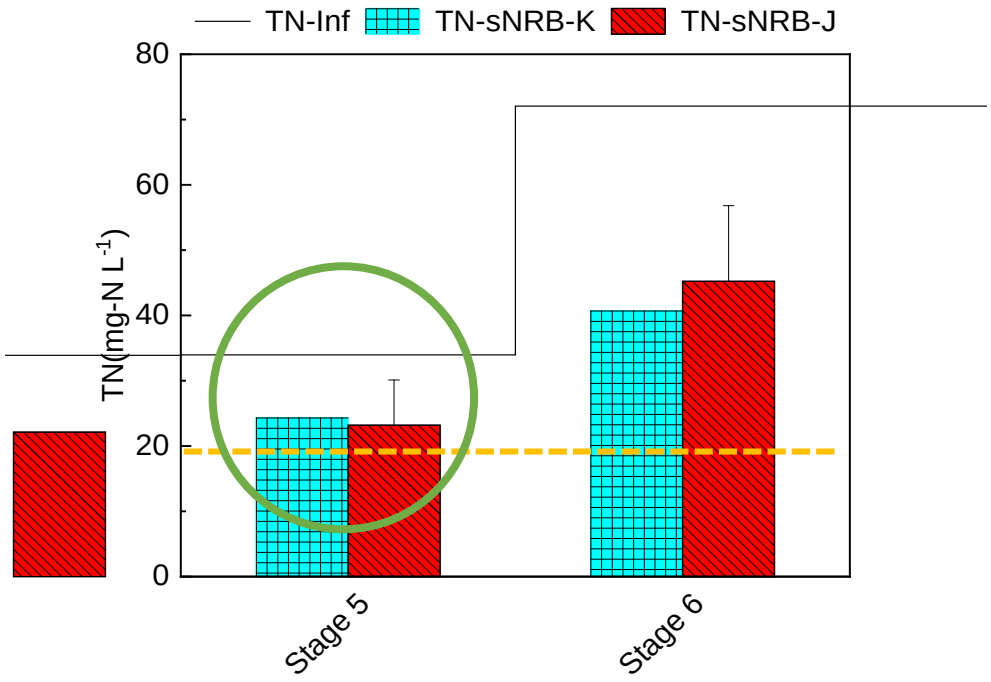
NRB 3.0—Biomass distribution and system performance









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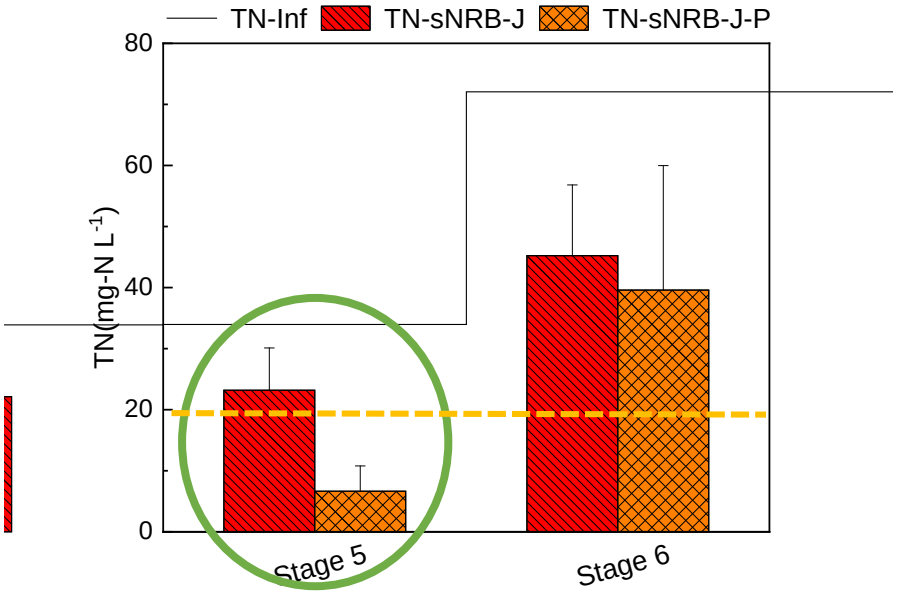
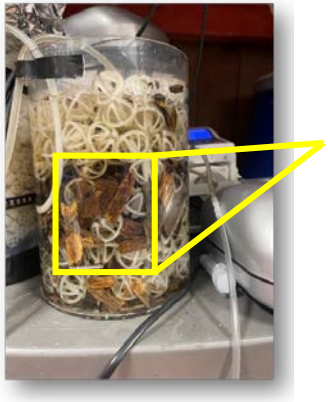
NRB 3.0—Polishing unit & pilot-scale



sNRB-JP



10% woodchip amendment

Pilot-scale sNRB-K-P

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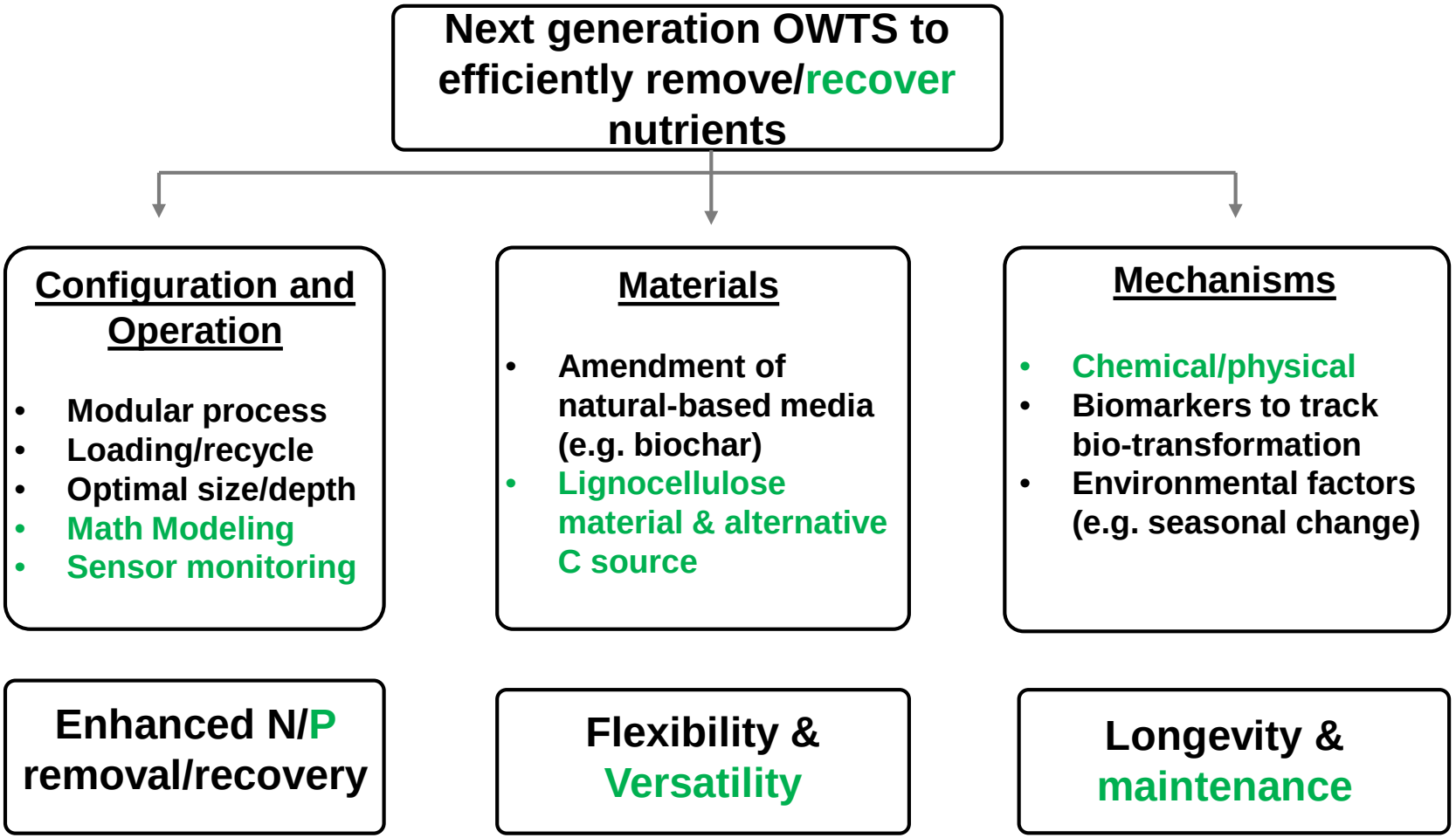
Other ongoing effort…



Thanks!

Questions & Comments