




# Wastewater Intensification Workshop

Developing and Implementing Intensification at Water Reclamation Plants

Sudhir Murthy, PhD, PE



# Innovation and Intensification are **Baked** in our Infrastructure

<b>Hares (lifecycle of 5 years)</b> 	<b>Horses (lifecycle of 20 years)</b> 	<b>Elephants (lifecycle of &gt;50 years)</b> 
<b>Devices</b> (sensors, tablets, industrial PCs, edge devices)	<b>Mechanical Technology</b> (mixers, aerators, scrapers, meters)	<b>Centralized Infrastructure</b> (systems and processes within water reclamation plants, drinking water plants, pump stations, buried infrastructure)
<b>Analytics</b> (controls, algorithms, machine learning)	<b>Hydraulic/Selection Technology</b> (pumps, screens, filters, cyclones, diffusers)	<b>Distributed Systems</b> (asset management, watershed management, cloud systems)

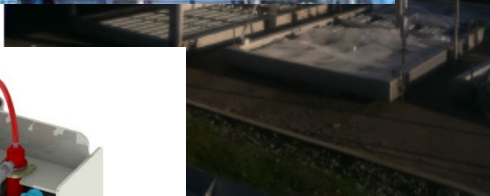
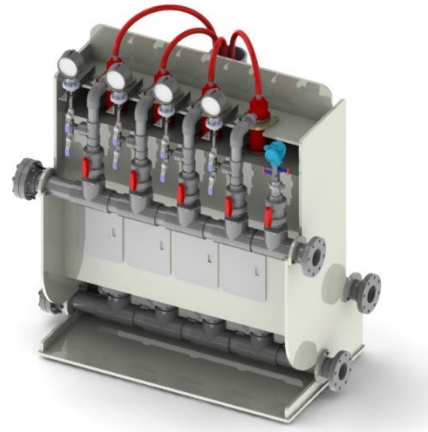
# Retrofit Equipment for Intensification

- Viscosity
- Flocculation
- Gravitational Force
- Compressibility
- Diffusion

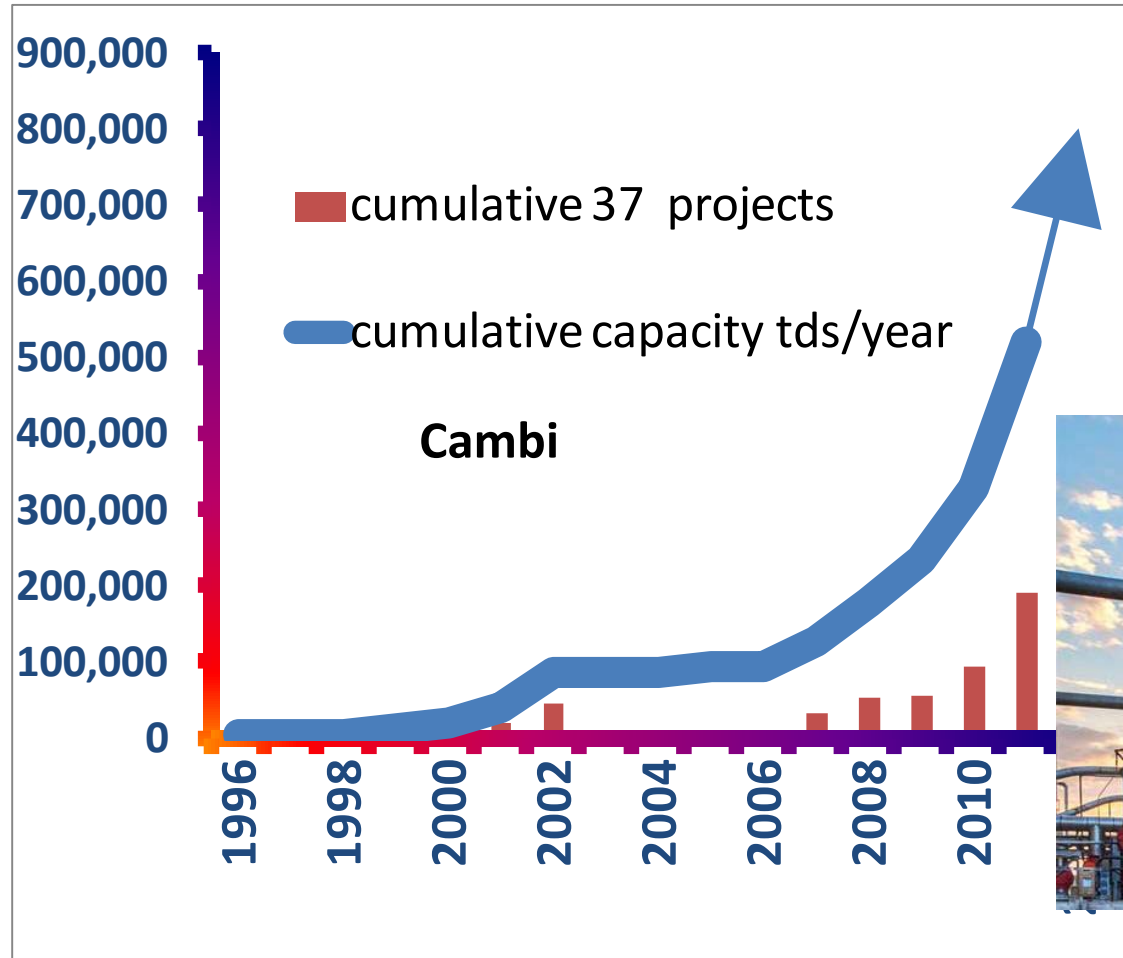


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# Thermal Hydrolysis



## Effect of thermal pretreatment on digestibility and dewaterability of organic sludges

Roger T. Haug  
LA/OMA Project, Whittier, Calif.

David C. Stuckey, James M. Gossett, Perry L. McCarty  
Stanford University, Stanford, Calif.

The management of organic sludges generated at wastewater treatment plants is receiving

study was to evaluate the effect of heat treatment before digestion, hereafter termed thermal

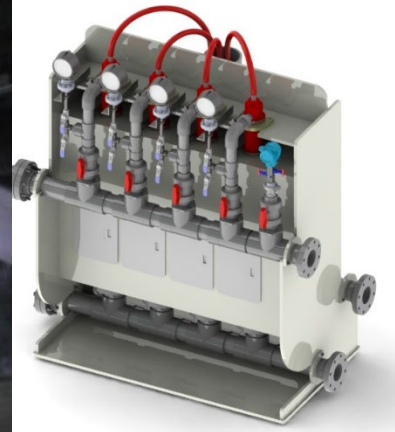
Haug, R.T., Stuckey, D.C., Gossett, I.M., McCarty, P.L. (1978)

Effect of thermal pretreatment on digestibility and dewaterability of organic sludges,

*J. Water Poll. Control Fed.*, 50, 73.

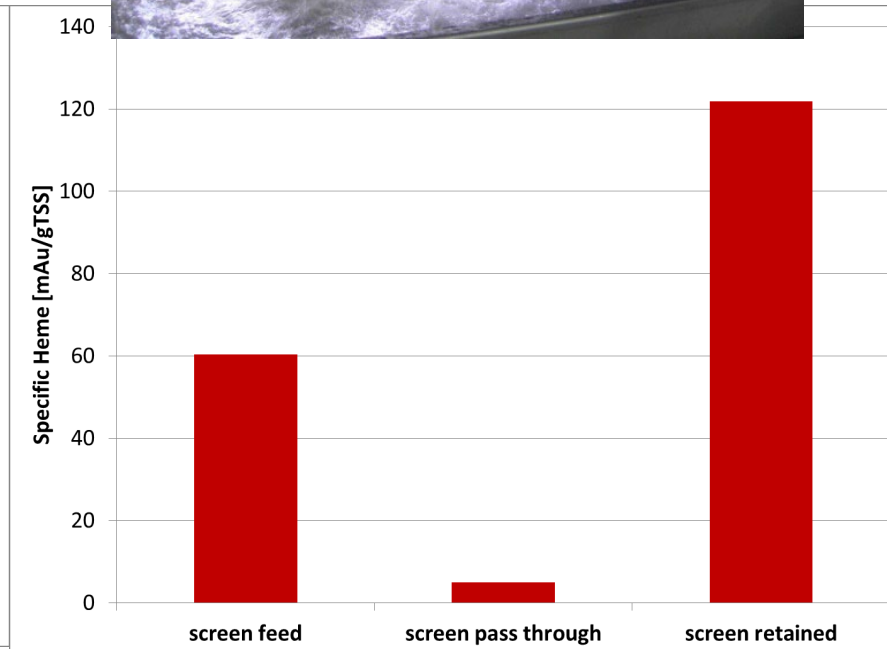
# Retrofit Equipment for Intensification

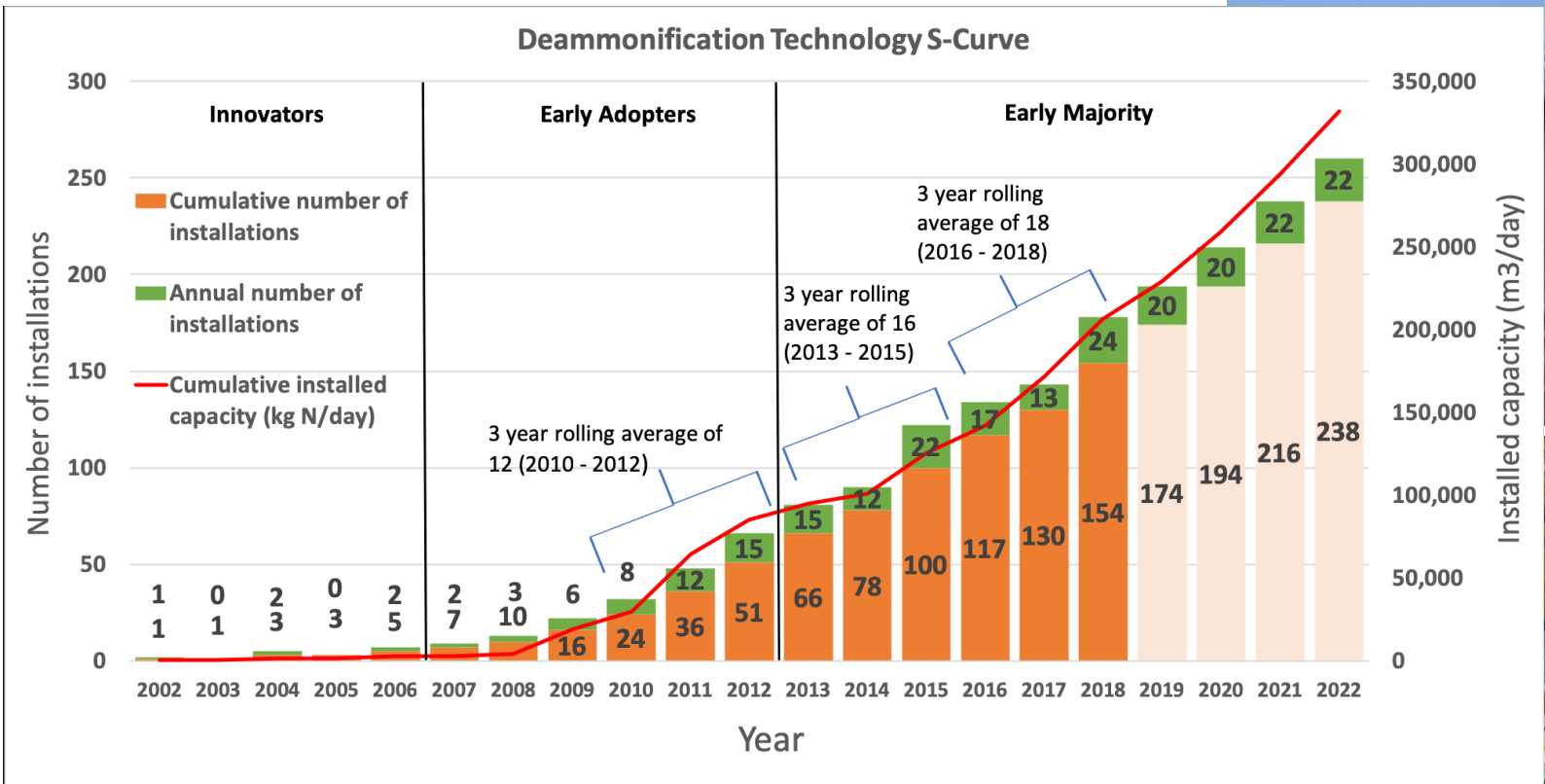
- Viscosity
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- **Compressibility**
- Diffusion



# Sidestream Anammox

- Compressibility







# Retrofit Equipment for Intensification

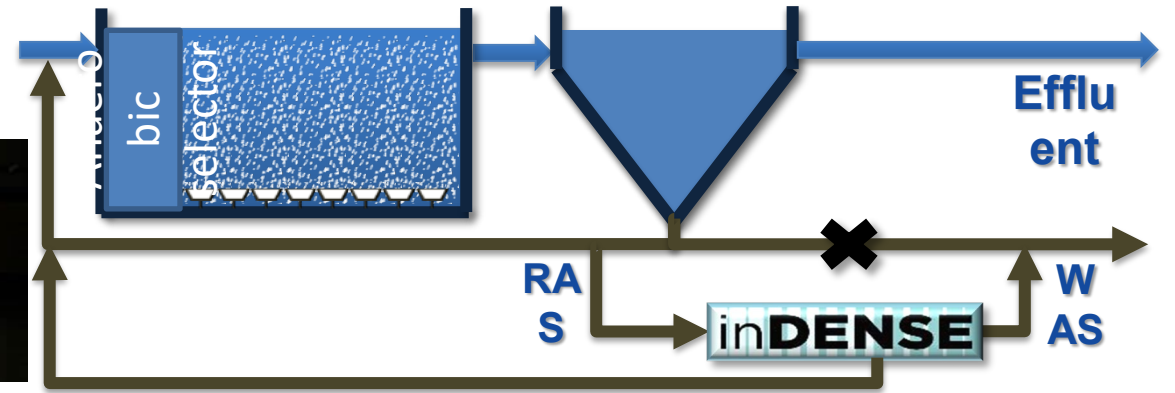
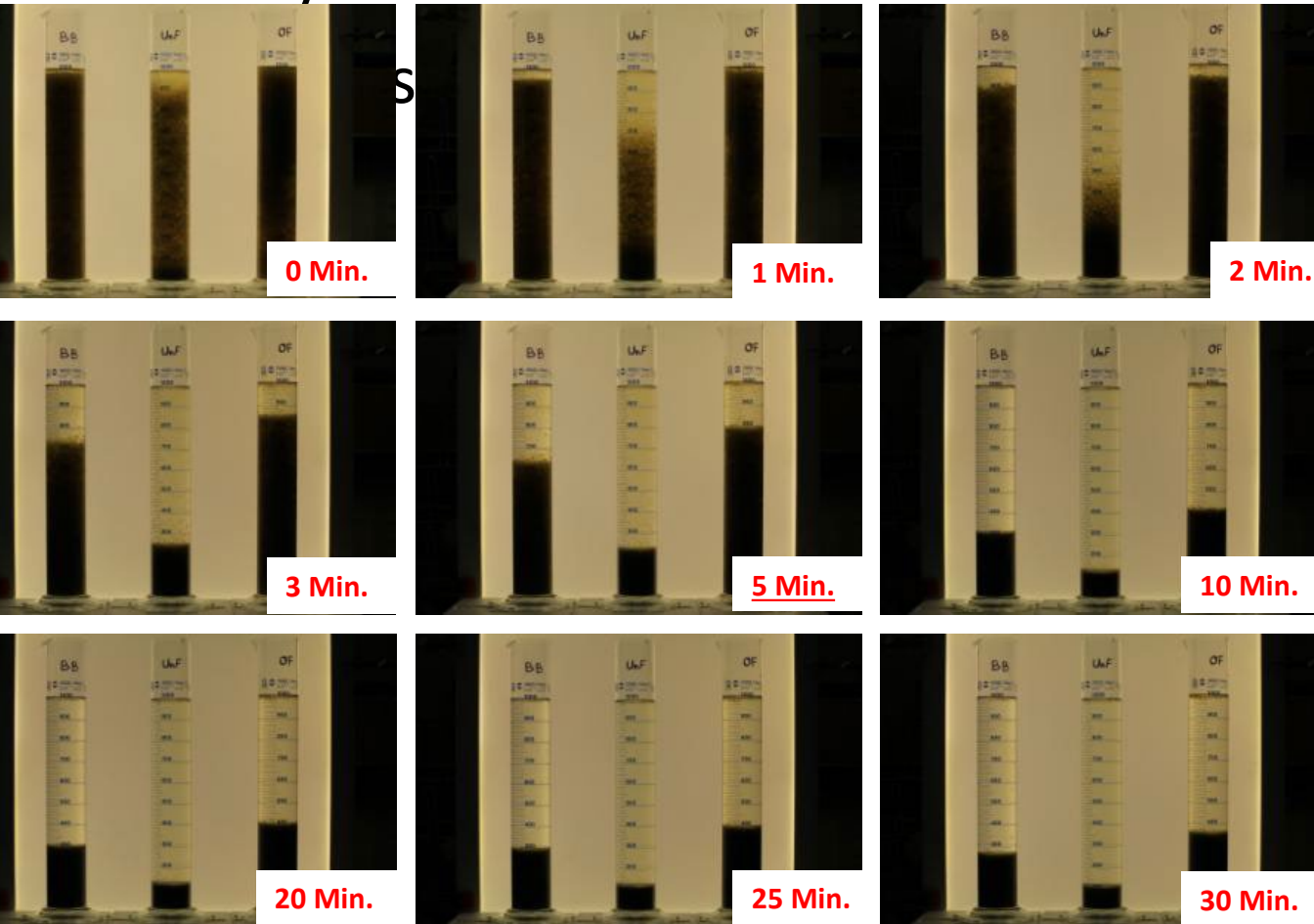
- Viscosity
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# Densification

- Sedimentation (Gravitational)

- Hydraulics

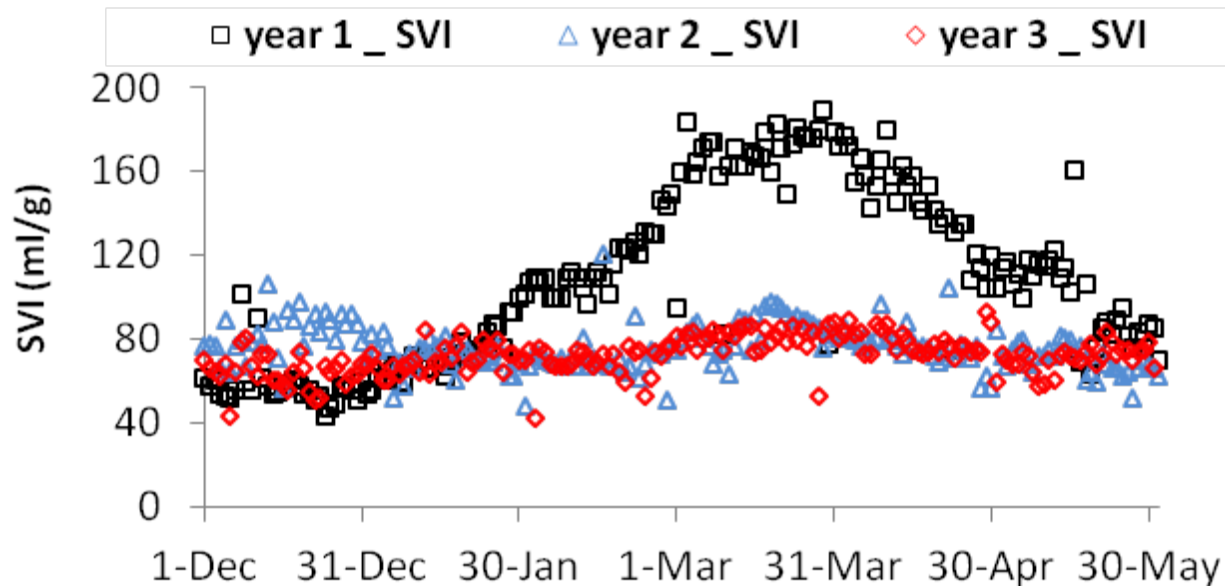




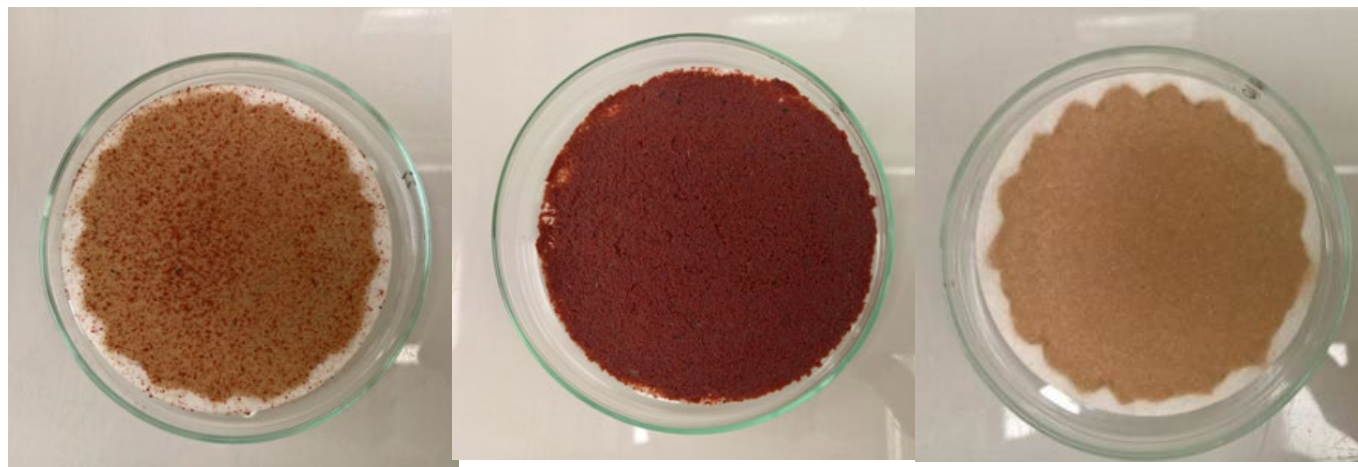
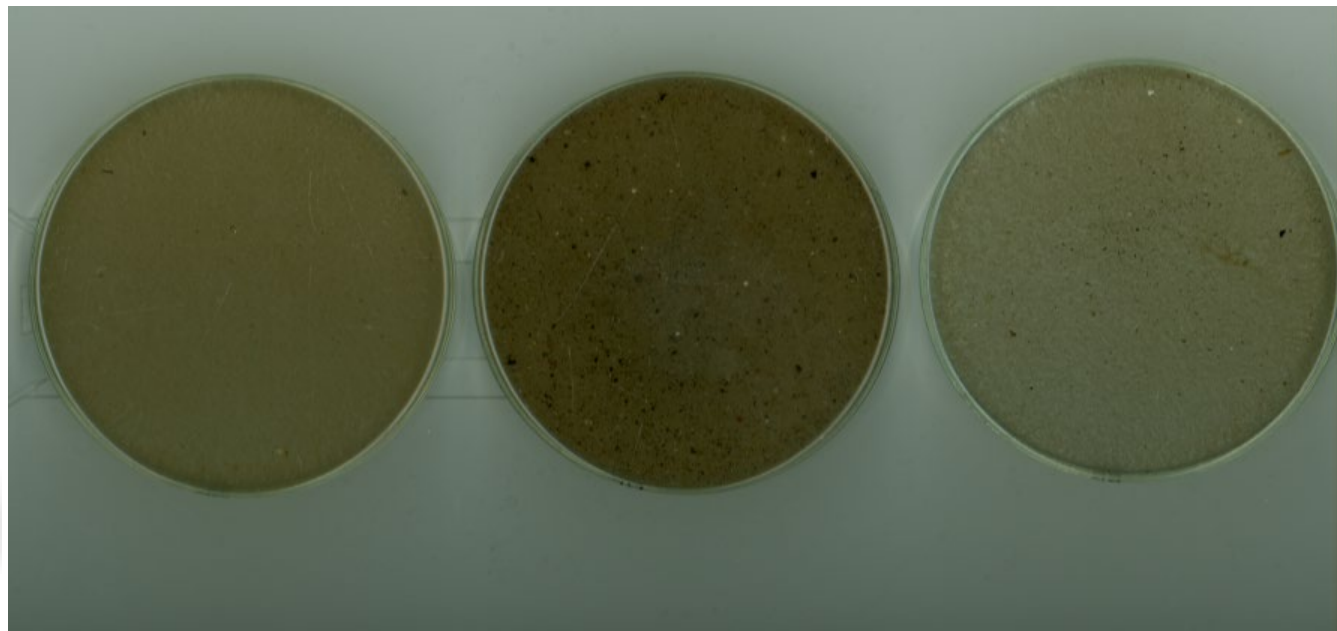
CASE STUDY

**Biological process architecture in continuous-flow activated sludge by gravimetry: Controlling densified biomass form and function in a hybrid granule–floc process at Dijon WRRF, France**

Clément Roche ✉, Sylvain Donnaz, Sudhir Murthy, Bernhard Wett



**Approximately  
80 inDENSE implementations**



**MLSS**

**Retained**

**Not Retained**

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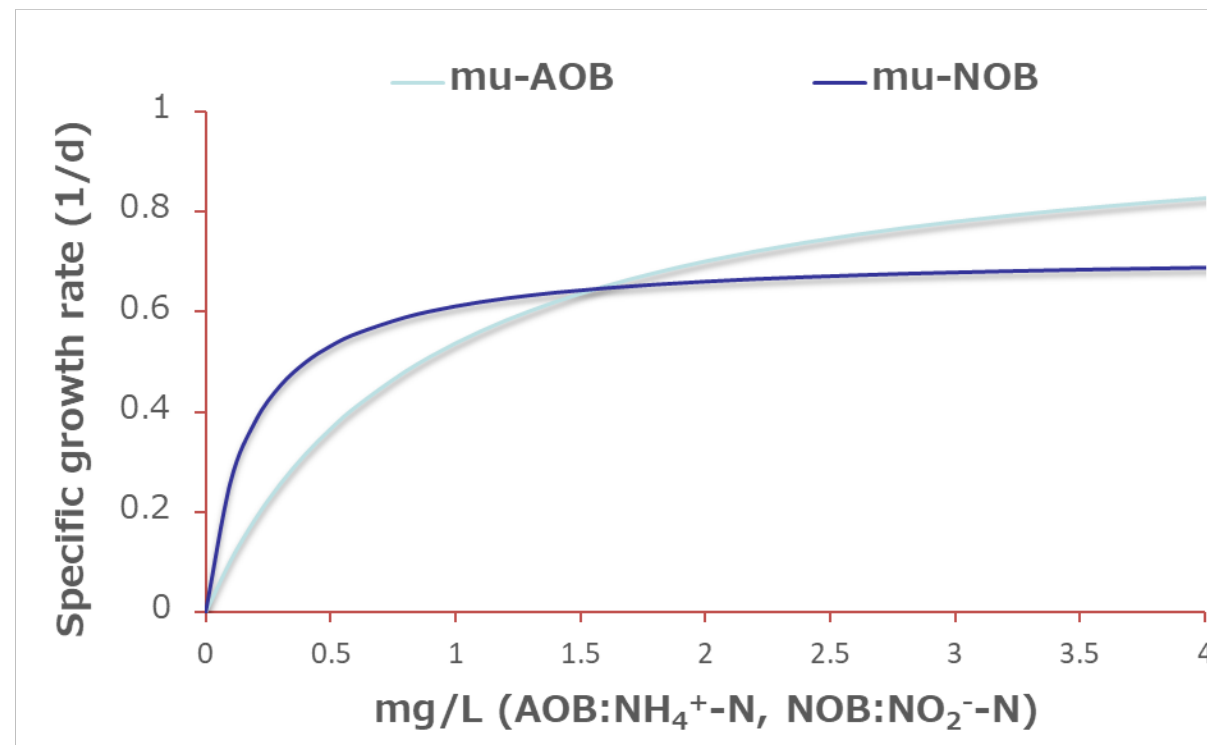
Modified ET installed



# Maximize Nitrification Rates

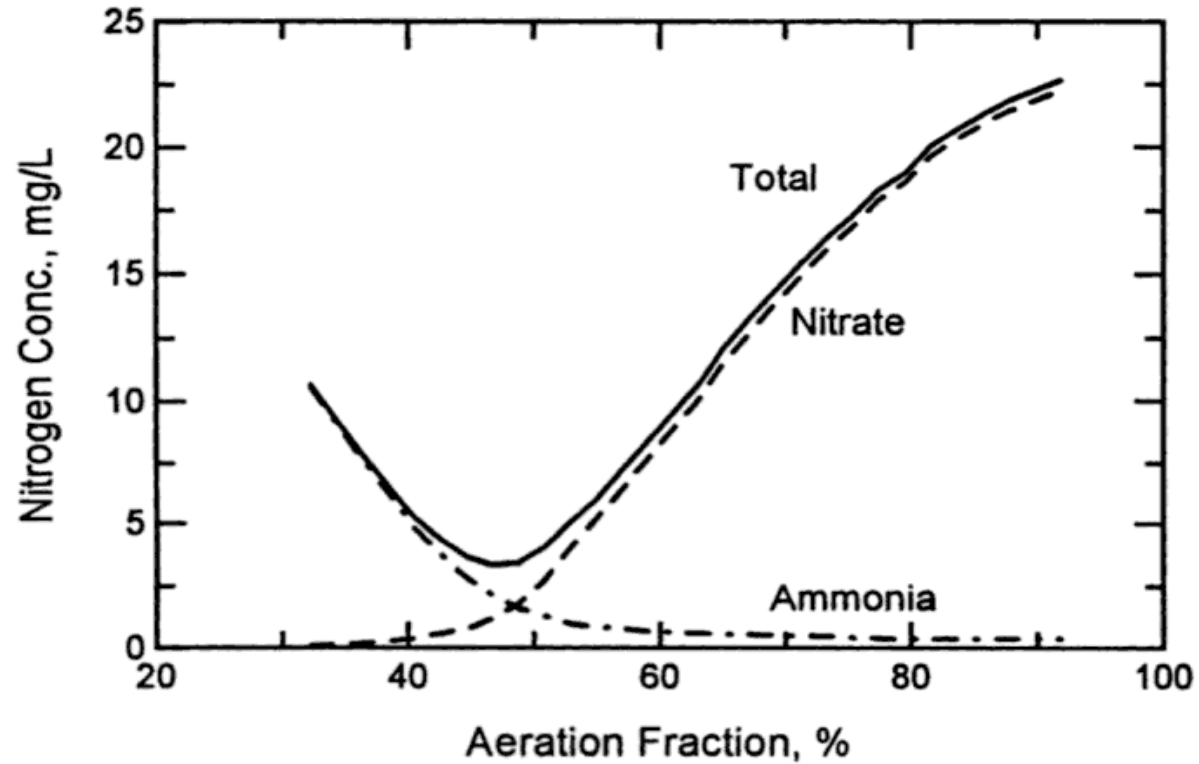
- ❑ Ammonia levels and temperature are too low for free NH<sub>3</sub> inhibition
- ❑ Residual ammonia allows AOB to grow closer to their maximum growth rate

## Monod Curves for AOB and NOB



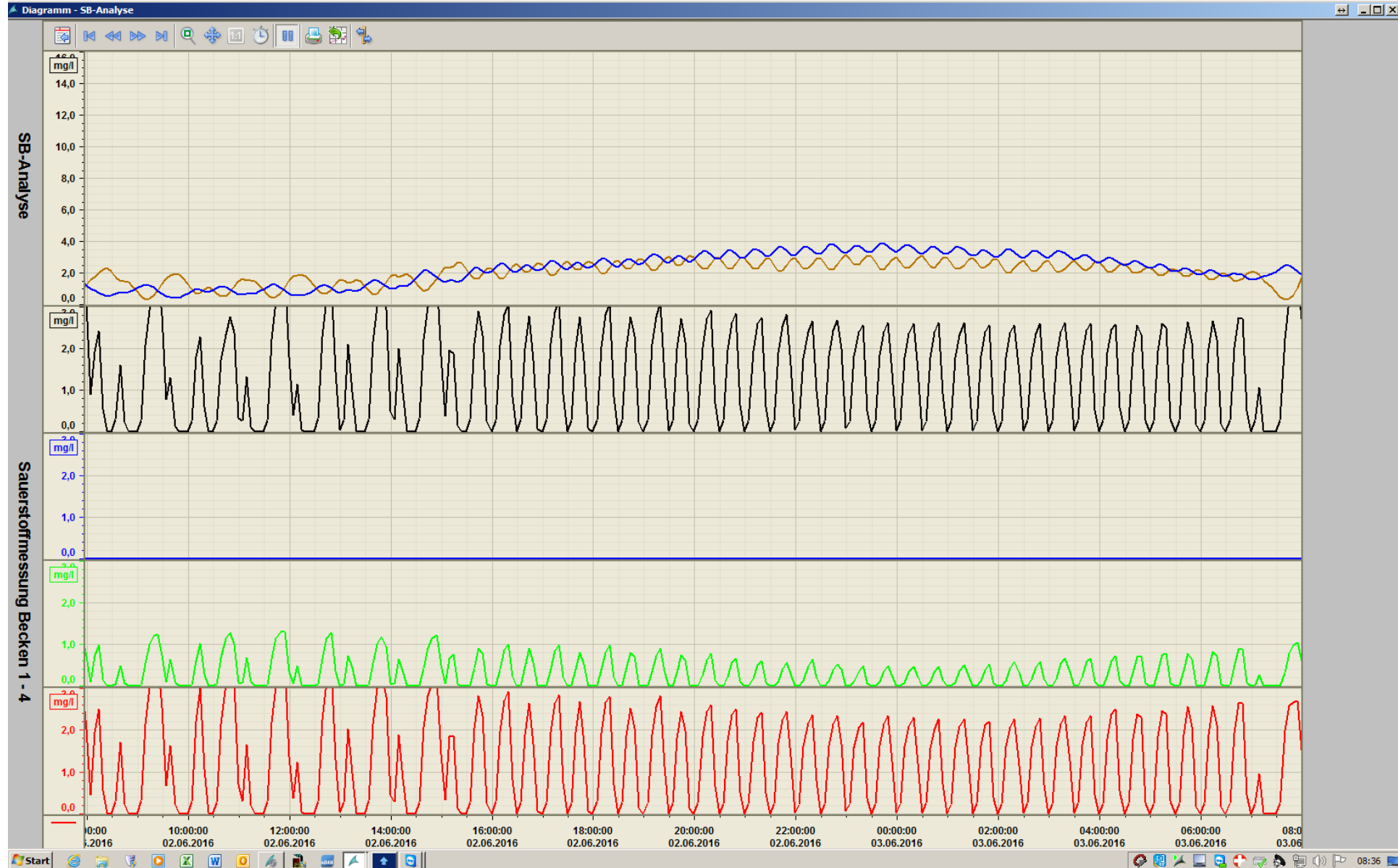
From: Kartik Chandran,  
Columbia University

# Maximize TN Removal



Batchelor, B (1983). Simulation of single-sludge nitrogen removal. Journal of Environmental Engineering

# Intermittent aeration control AvN



**AvN Control**



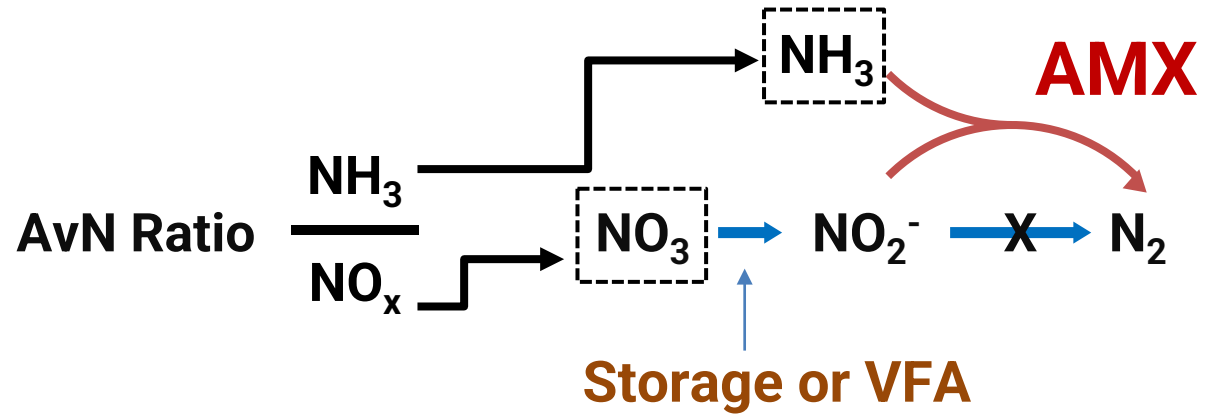
# Tschars, Italy

## AvN- Optimizing for Nitrogen/ Energy

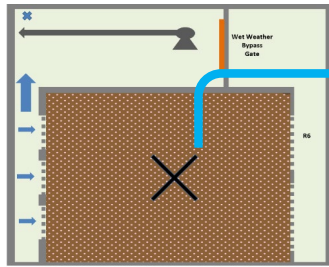
Control-type	NH <sub>x</sub> effluent	TIN-effluent	Blower energy	Power savings
DO-control	0.9 mg/l	7 mg/l	820 kWh/d	0
ABAC	0.9 mg/l	7 mg/l	782 kWh/d	-5%
AvN	1.4 mg/l	1.8 mg/l	542 kWh/d	-34%



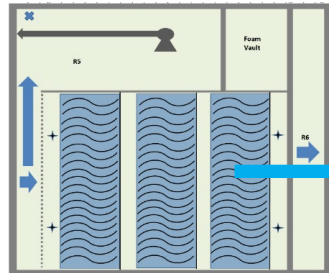
# Co-Diffusion



Moving Media IFAS

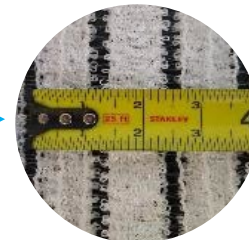
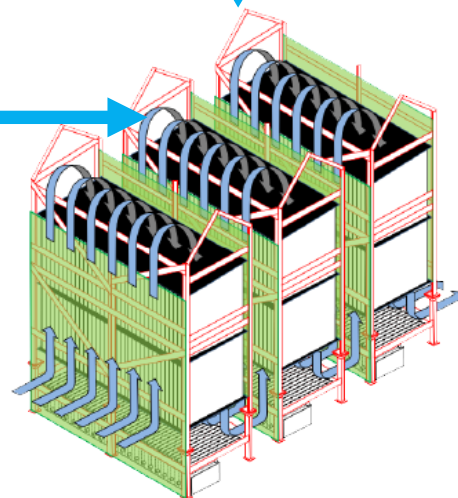


Plastic media biofilm carriers



Fixed Media IFAS

Modules



Biofilm attached to fabric sheets

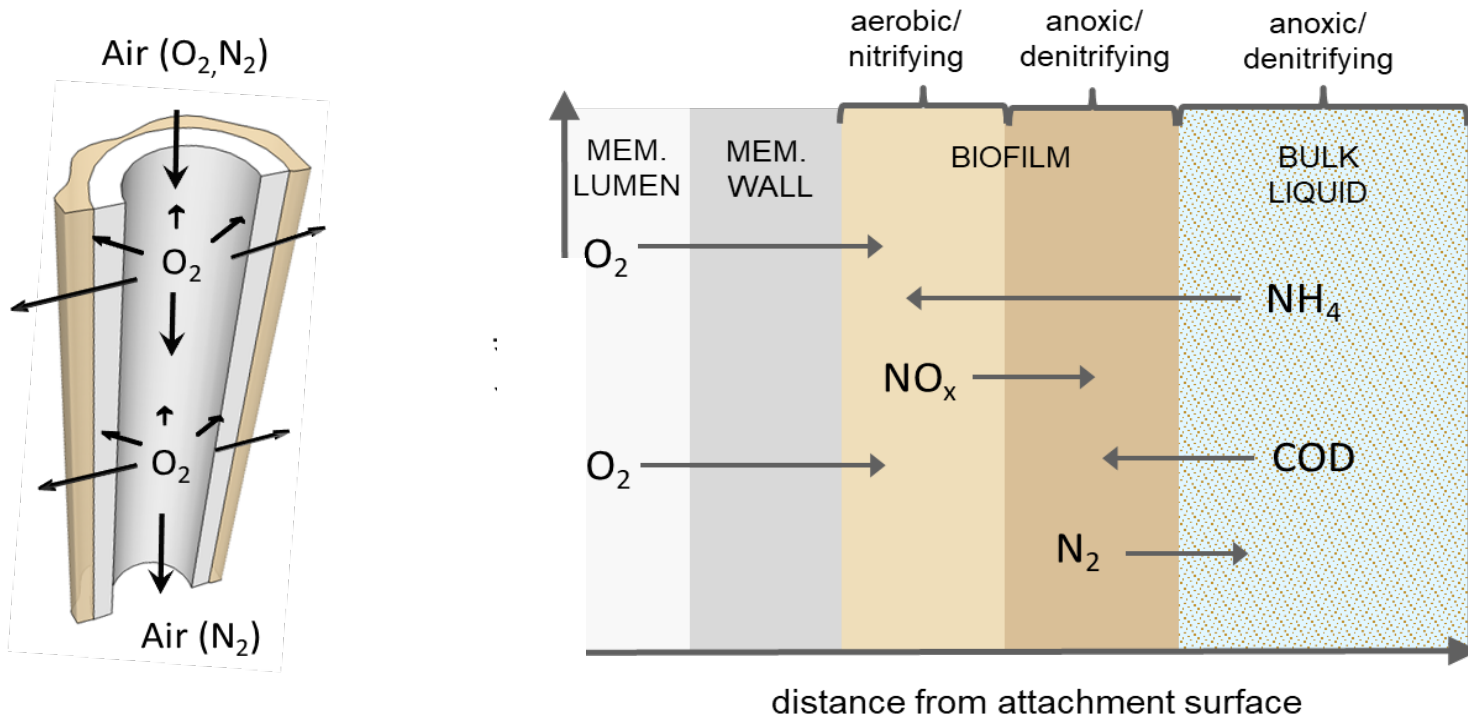
**DETOUR**  
partial denitrification anammox

# Retrofit Equipment for Intensification

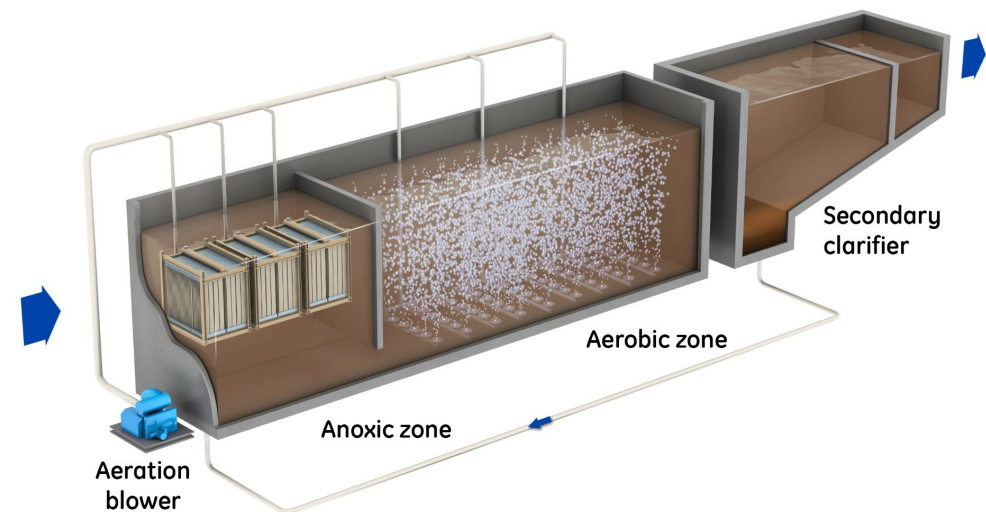
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# MABR - counter diffusion

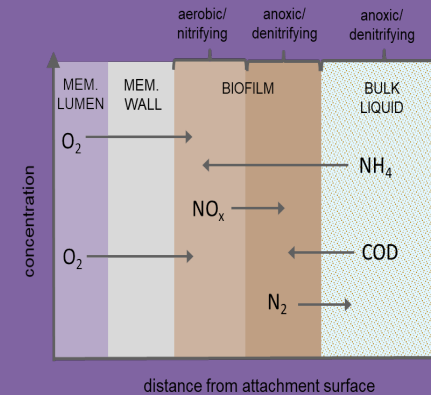
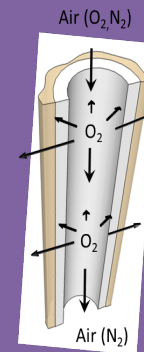
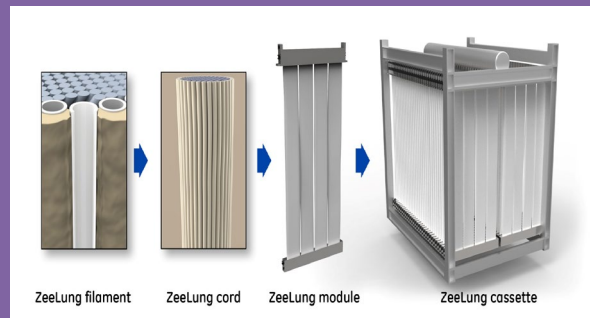


Downing and Nerenberg (2008) Applied Microbiology and Biotechnology, 81:153–162



# Biological Treatment **Systems** Architecture

Look for synergies (1+1>2)



# Example Retrofit Equipment Building Blocks






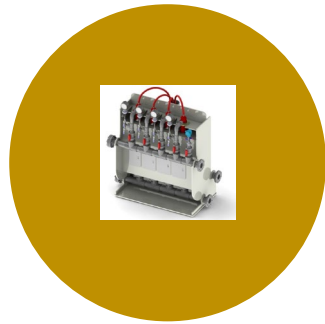
Process

- Activated Sludge





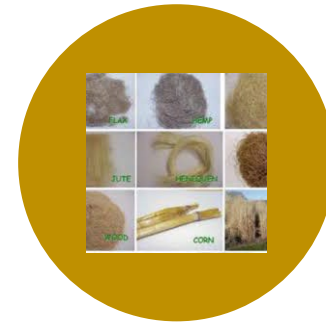
Separator

- MBR 
- Decanters 
- Clarifier 





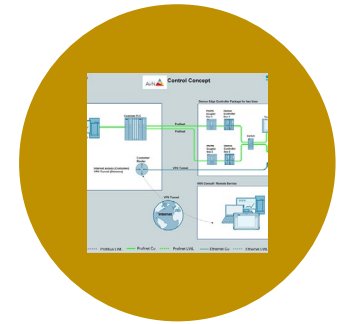
Physical Selector

- Hydrocyclones 
- Screens 



Media Selector

- MABR 
- IFAS 



Control




- AvN Control
- PdN Control
- pH Control



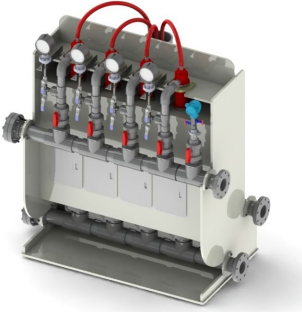
Tremendous Opportunities for Intensification in Existing Infrastructure

# Intensification Theme

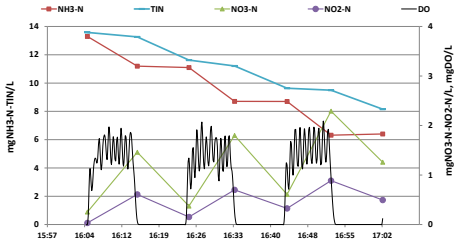
- Horizontilize Lifecycles

Hares (lifecycle of 5 years) 	Horses (lifecycle of 20 years) 	Elephants (lifecycle of >50 years) 
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- Mechanical and Hydraulic Equipment



- Sensors and process control



- Biofarming can be leveraged in a systems approach for any bioreactor

