

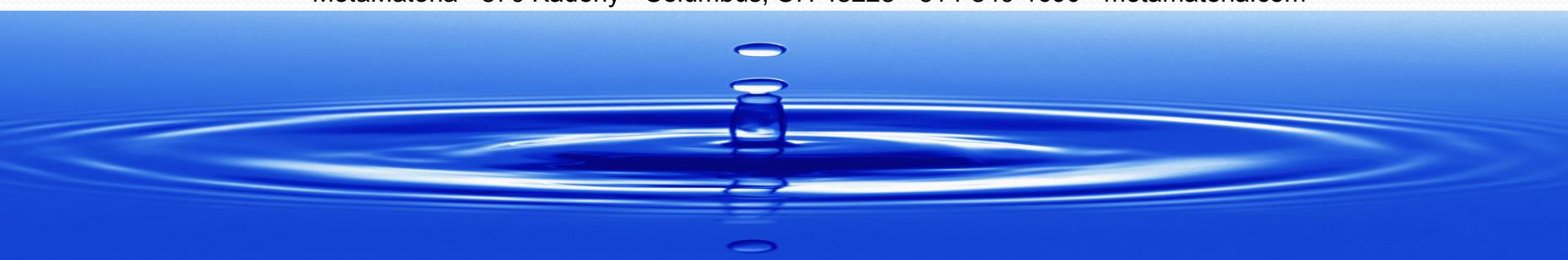


# MetaMateria

Environmental NanoTechnology

Tim Marth, VP Business Development  
Richard Schorr, CEO

MetaMateria • 870 Kaderly • Columbus, OH 43228 • 614-340-1690 • [metamateria.com](http://metamateria.com)



# Our Competitive Advantage

## Disruptive Improvement of Water Treatment

Lower Levels for Contaminant Removal

Lower Energy & Footprint Systems

Less Treatment Time = Smaller System

*Double or Triple Treatment System Output*

**New  
Market  
Opportunities  
with  
Bio-Lair  
PO4 Sponge**

# ***Enables New Solutions***

**Removes Nutrients • Increase Capacity  
High Hydraulic Conductivity**



## **Bio-Lair • Bacteria Factory**

- ❖ **1000 times more surface for bacteria growth**
- ❖ **“Supercharge” Bio-Treatment Systems**
- ❖ **More Nutrients Removed • 3-5 times faster**

## **P04 Sponge • Nano-Enabled**

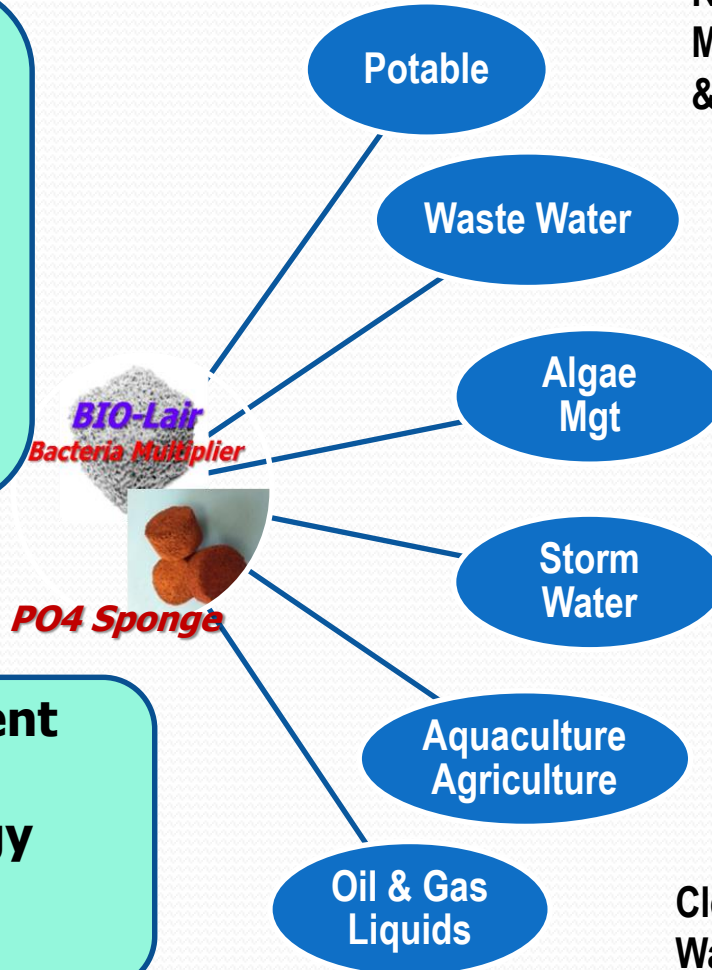
- ❖ **Enormous Surface for Phosphorus (P) Capture**
- ❖ **5-20 times more P/Kg than other media**
- ❖ **Can Reuse 15+ times - lower life cycle cost**
- ❖ **P is Recovered - for fertilizer, food products**



***Proprietary Processes (Trade Secrets) • 2 patents & patent pending***

# MetaMateria Media is Catalyst for Improved Water Treatment

**Enabling  
Decentralized  
Nutrient Removal  
& Recovery –  
using small  
footprint & low  
energy.**



Remove  
Metal Ions (As, Se, Cu, Pb)  
& Other Contaminants

On-Site Waste Systems  
Food & Industrial Water  
Municipal Waste

Manage Nutrients  
Remove Phosphorus

Remove Nutrients  
& Phosphorus  
Meet New Discharge Limits

Clean Water – Higher Yields  
Remove/Recover Nutrients  
Recycle Water

Clean Chemicals for  
Water Reuse

**Biological Treatment  
Ion Removal**

- Nano Technology
- Ligand Capture

**Antimicrobial**

# Ideal Porous Platform

- **High surface area:** 100's times higher than other media
- **Alumino-Silicate Bonded** >80% interconnected pores
- **Hierarchical Pore Structure**  
Large to nano in size - Allows easy, turbulent water flow
- **Composition & Shape for System Flexibility**
- **Cost-effective** - allows smaller footprint



Discs



Plate

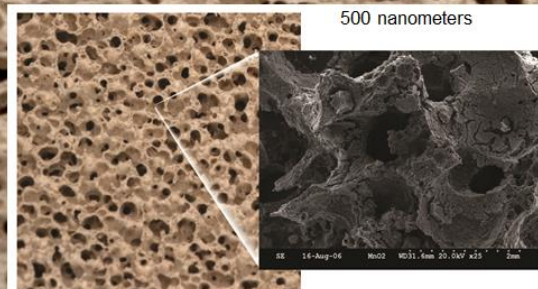


Logs



**Porous Support Structure**  
*Structure for Bacteria Colonies or Nanocrystals*

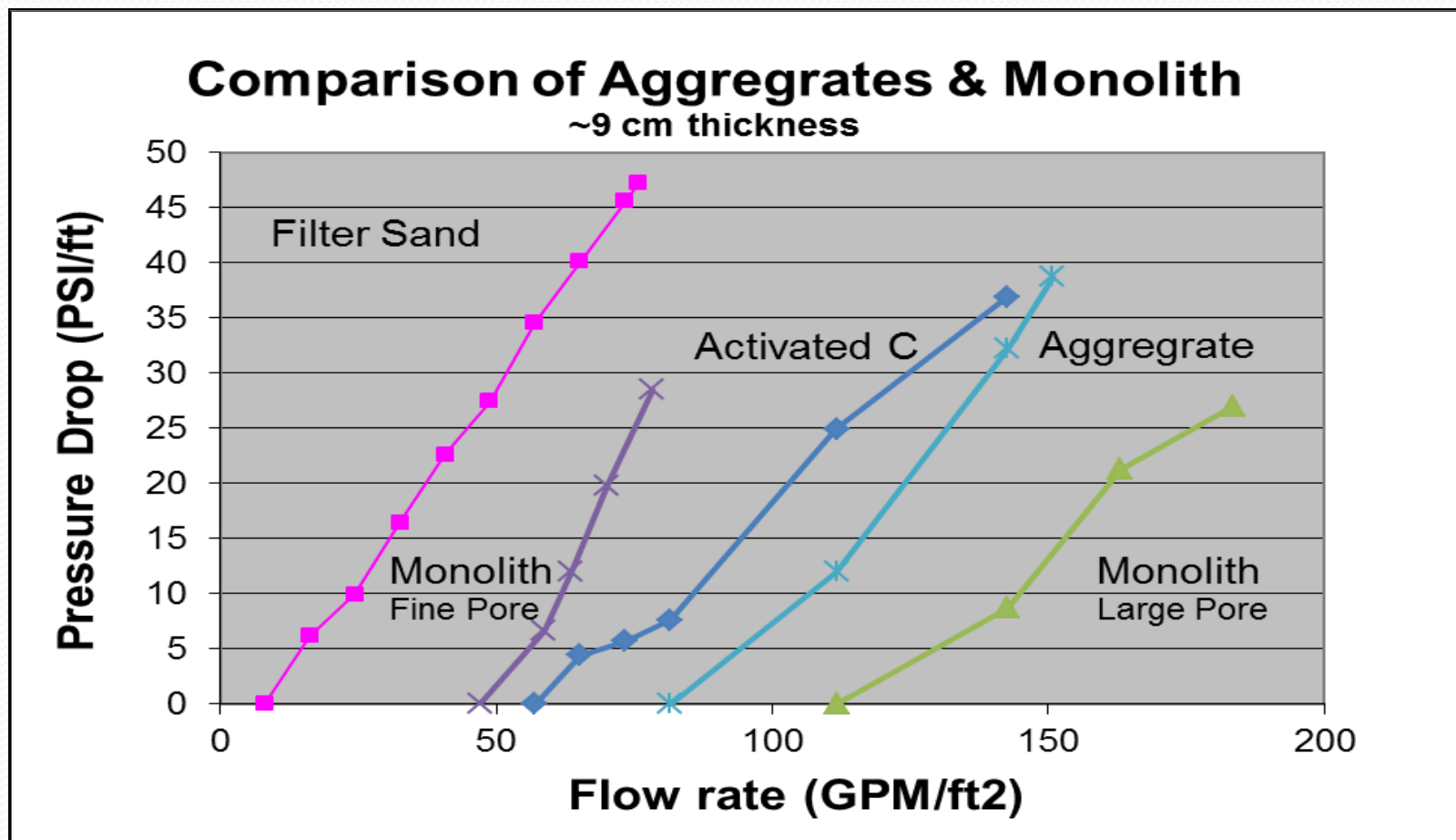
Major Large Pores	Interconnecting Pores	Cell Wall Porosity
200-500 $\mu\text{m}$	50-200 $\mu\text{m}$	0.5-5 $\mu\text{m}$



500 nanometers

Human Hair is ~70,000 nanometers

# Flow Characteristics MetaMateria Porous Products





# **Bio Remediation**

## **Nature's Way to Clean Water**

## **Bio-Lair Enhances Remediation**

# BIO-Lair

## Novel Porous Platform

Surface Area  $>2,000,000 \text{ m}^2/\text{m}^3$   
 $>900,000 \text{ ft}^2/\text{ft}^3$

*Supports Large Bacteria Colonies*

**Hierarchical Pore Structure**

*Easy water flow at low pressure*

**Cost-effective**

*Less media Needed*

**Shapes, Sizes & Compositions**

*Flexibility for use in many systems*



					Comparison	
Pentair - Aquatic Ecosystems Catalog			Ship Weight		1 Kg BIO	1/4 Kg BIO
Product	Description	M <sup>2</sup> / M <sup>3</sup>	Kg	M <sup>2</sup> / Kg	Kg Needed	
Sporax	porous ceramic	268,990	0.5	21	14	3.5
BIO-FILL	shredded PVC ribbon	820	1.8	13	640	160.0
BIO-BALL	Plastic Ball Shape	321	5.4	2	4898	1224
BIO-BARREL	Polypropylene open barrel	210	2.7	2	3750	938
BIO-STRATA	Black PVC sheets in block form	361	2.3	18	455	114
<b>Meta BIO Media</b>	BIO - porous ceramic (Ca,DN)	2,296,257	6.8	8,192		
			1.7	2,048		



Plastic Packages



Petals



Plate



Discs



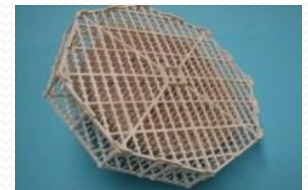
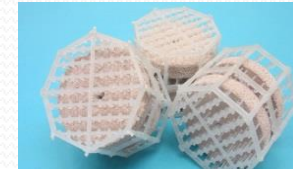
Logs



# Waste Water

## Fixed Film, MBBR, Lagoons, Retention Tanks

- **Biomass Immobilized**  
**Submerged High Surface Area Media**  
*Cut Treatment Time by Half or more*
- **Expand Plant Capacity with BIO-Media**  
*Improve waste treatment – Stabilize Process*  
*BIO-Media has less clogging*
- **Phosphorus & Nitrate Removal Higher**  
*BIO-Media sustains aerobic & anoxic bacteria*
- **Enzymatic and Other Bacteria**  
*Enhance Rapid Breakdown of Organics*
- **BIO-media can be packaged in Durable Plastic**  
*for submerged water circulation*
- **Considerably Less Media needed**  
*higher performance than other approaches*



# Waste Water Treatment System Design Considerations

- **High Surface Area** - 2,000,000 m<sup>2</sup>/m<sup>3</sup> (900,000 ft<sup>2</sup>/ft<sup>3</sup>)
- **High Biomass Retention**  
maintains high microbe population in waste water
- **High Volumetric efficiency** – need less media  
When nutrients/oxygen delivered uniformly to bacteria  
Reaction by-products removed from reaction sites
- **Multiple bacteria colonies** (aerobic & anaerobic)  
maintained simultaneously in media
- **Less Prone to Clogging Bio Films** - grow laterally
- **Aids in Maintaining System Balance & Upsets**

# ***Nitrate Removal Comparison***

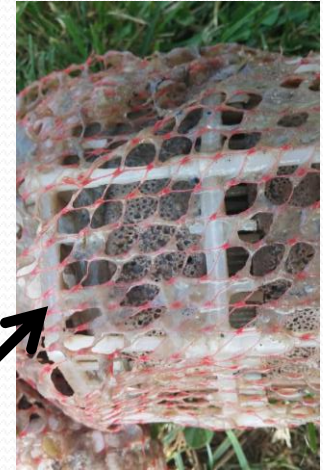
<b>MEDIA</b>	<b>Kg/m<sup>3</sup>/day</b>
<b>BIO-Lair CA media</b> Aerobic on surface & anaerobic inside	7.3
<b>BIO-Lair DN</b> – supports 3 types of bacteria aerobic (surface); anaerobic (low C:N ratio(1.25); sulfur used as electron donor + aragonite buffer	36
<b>Activated Sludge</b>	1.5
<b>Bio Silica Sand</b>	2.4
<b>2 stage heterotrophic/autotrophic reactor</b>	3.6
<b>Wood Chips</b> (used in agriculture runoff)	0.2

# Early Commercial Results: Primary Oxidation Contact Tank

## Aeration Tank

(~34,000 gal – 4500 CF)

- Bio-Lair to drive bio-augmentation
- Target: 5-7% Volume 8,000 cages vs. 30-50% Kaldnes
- Little BOD growth on BIO media
- 75% lower  $\text{NH}_3$  & 30% lower  $\text{NO}_3$



BOD Growth  
On Net/Plastic



# Other Bio-Lair Examples

## Water Channel Cleanup – China

*Media hung in nets – Paddle Aerators*

- |              |             |                     |
|--------------|-------------|---------------------|
| • Odors      | very little | down from strong    |
| • DO         | 3.1 mg/L    | up from 1.69 mg/L   |
| • Ammonia    | 0.3 mg/L    | down from 6.4 mg/L  |
| • Phosphorus | 0.57 mg/L   | down from 1.1 mg/L  |
| • COD        | 7.1 mg/L    | down from 17.2 mg/L |



## Water from Community Septic System

*Thick algae blooms formed each summer*



**AFTER TREATMENT**



**BEFORE TREATMENT**

## Pond Water

200,000 gal - Aerator  
Media (2 Kg Bio/PO<sub>4</sub>)  
Results (Jul-Oct)

**Nitrogen: - 51%**  
(0.87 to 0.42 mg/L)

**Phosphorus: -59%**  
(0.092 to 0.037 mg/L)

# ***Expected Benefits***

## ***Bio-Lair in Waste Water Treatment***

- **Smaller system footprint**
- **Lower energy consumption**
- **Synergy between partner & MetaMateria capabilities**
- Control of nitrogen compounds (ammonia, nitrite/nitrate)
- Environmentally safe formulation of non-pathogenic bacteria
- Can function at moderate dissolved oxygen concentrations (typically DO of <5 ppm) - aeration still best for oxidation
- Can work at lower C:N or BOD:N ratios
- Biomass does not clog porous Bio-Lair product under normal operating conditions as with competitive media.



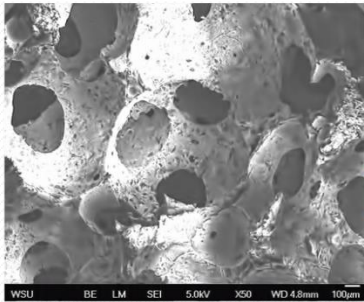
# **Soluble Phosphorus (SP) PO<sub>4</sub> Sponge Capture, Removal & Recovery**

## ***PROBLEM***

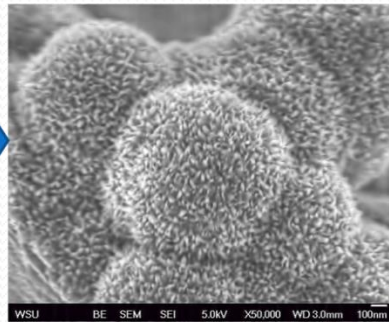
- ***Phosphorus Accumulates - Affects Water Quality***
- ***More Stringent Environmental Discharge Standards***
- ***Algae Can Impact Health & Water for Recreation***
- ***Diminishing Supply of Phosphorus Occurring  
More Interest in Recovery from Waste***

# ***PO4 Capture & Recovery Product***

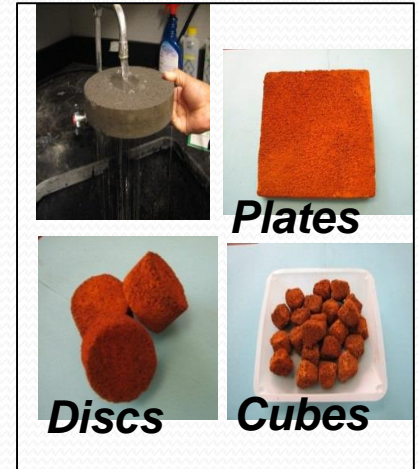
## **Porous Media**



## **Nano-Enhanced**



## **Nano-FeOOH Crystals in Porous Ceramics**



## ***Value Added***

- ✓ **Holds much more P/Kg** than other sorbents
- ✓ **Works at high and low concentrations** (0.03 – 100+ mg/L)
- ✓ **Can reuse multiple times** (15-20)
- ✓ **Long Life & Cost Effective** for most applications
- ✓ **Phosphorus can be recovered**

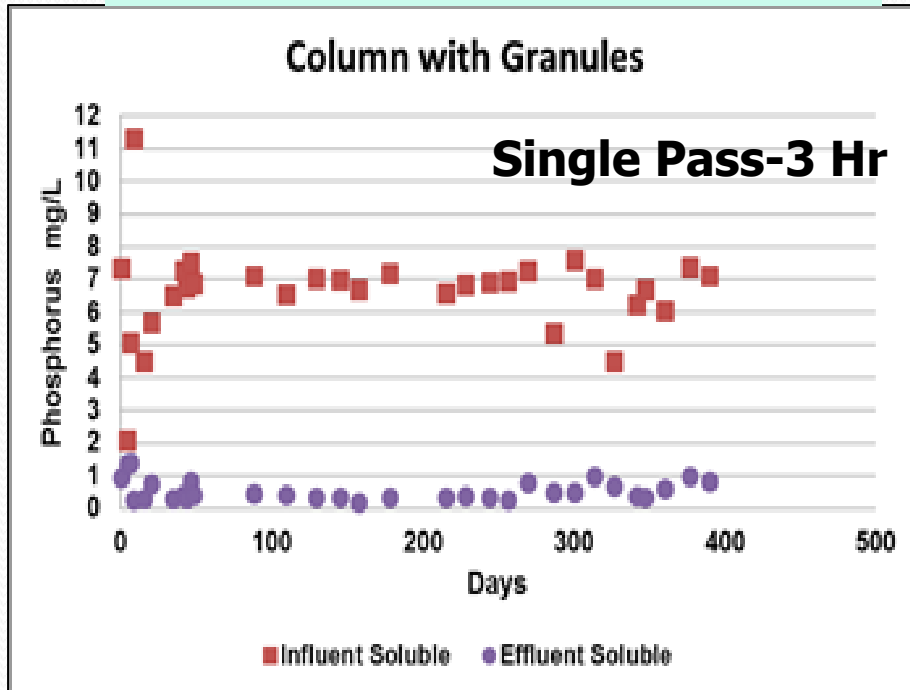


# ***Target Markets – P04 Sponge***

- **Waste Water Treatment**
  - decentralized waste treatment systems
  - food and industrial waste water
  - smaller municipal treatment plants (<2 MGD)
- **Water Body Remediation**
  - environmental impact of excess nutrients in lakes, streams and other water sources
- **Agriculture / Storm Water Runoff**
  - water from agriculture fields & animal wastes
  - Storm water applications
  - phosphorus removal from animal wastes

# PO4 Sponge Performance

## Long Service Life



**P below 1 mg/L – 400 d  
P still removed  
for another 220 days**

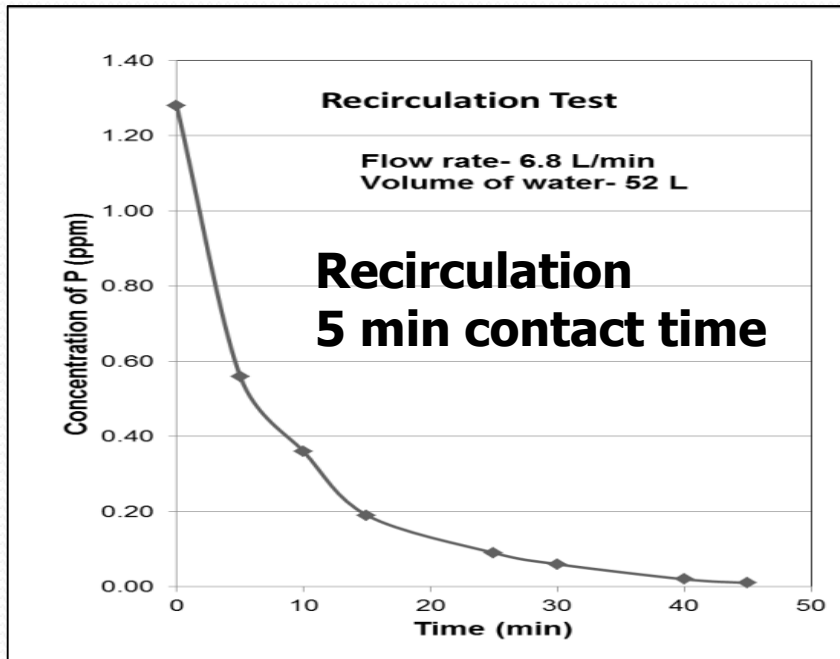
## High Capacity

Sorption Media	mg-P/Kg
<b>PO4 Sponge - Meta</b>	
High > 5mg/L	80,000
Low < 2 mg/L	25,000
Iron Ore (Hematite)	1,430
Iron Slag	420
Crushed Red Bricks	510
LECA (expanded clay)	800
Activated Fe Alumina	17,100
Filtra-D	2,500
Phostec	7,000

**Comparison  
milligrams of P  
per Kg Media**

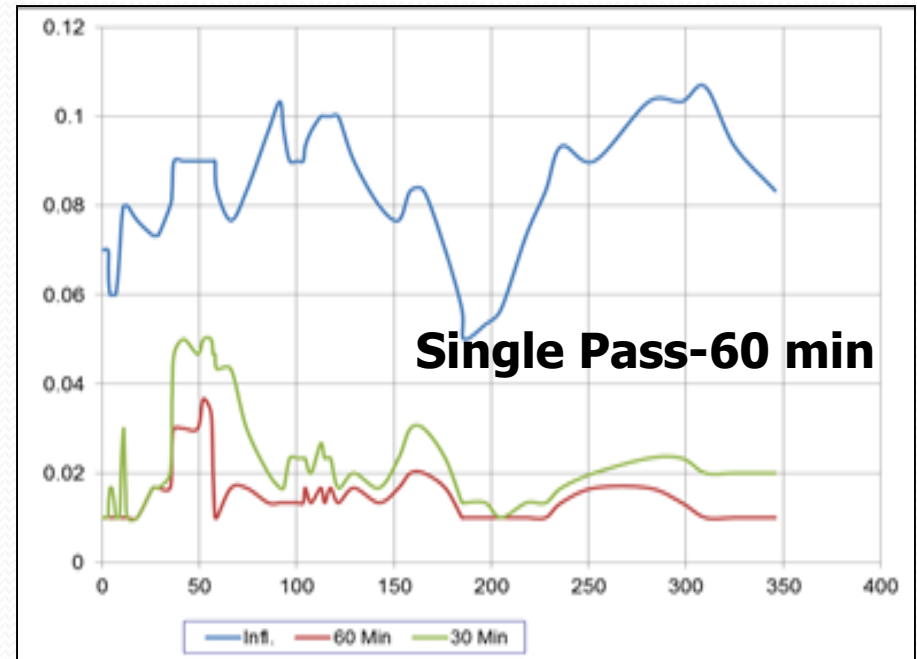
# P04 Sponge Performance

## P Removal to low levels



**P lowered to 0.1 mg/L  
in 25 min  
& 0.02mg/L in 45 min**

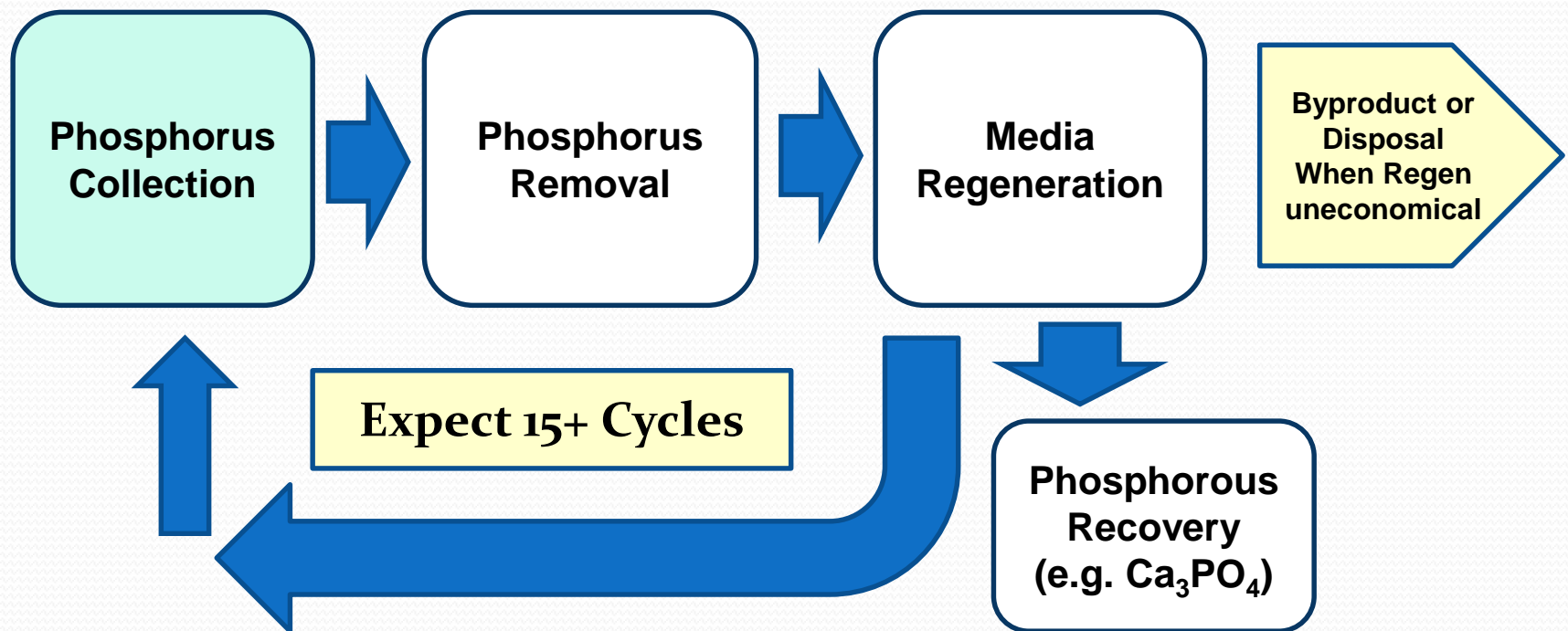
## P Removal under 0.1 mg/L



**Over 350 days  
Effluent < 0.02 mg/L  
no sign of saturation**

# ***PO4 Sponge***

***Removal • Regen/Reuse • Recovery***



# Pilot Testing – Cheese Plant

## Pilot Test Set up- Stage 1

4 drums - bulk media

70 mg/L P circulated

Effluent dropped to 25 mg/L



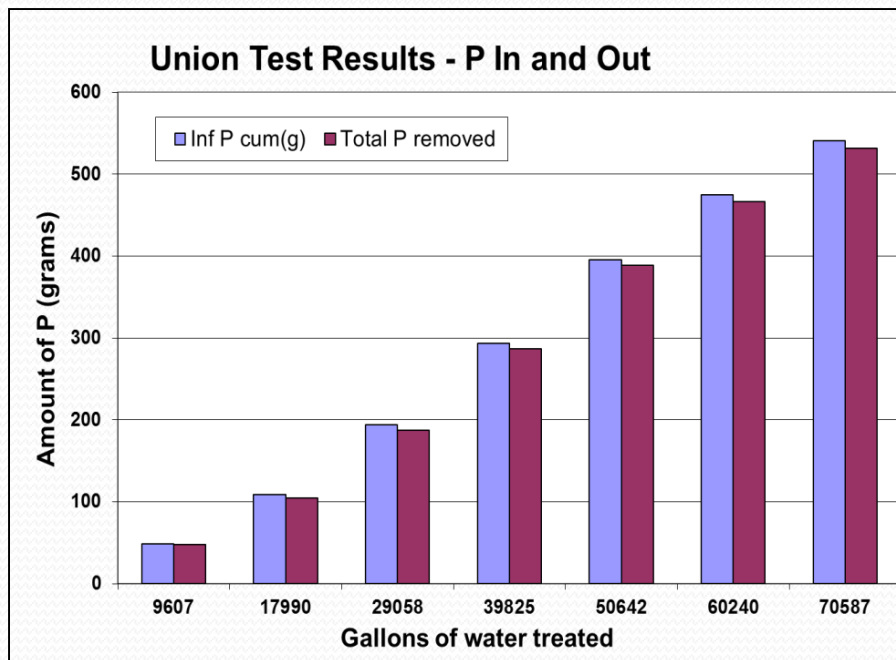
## Pilot Test - Stage 2

Sets of 4 columns  
placed in series.

Influent from Stage 1  
Effluent below 1 mg/L

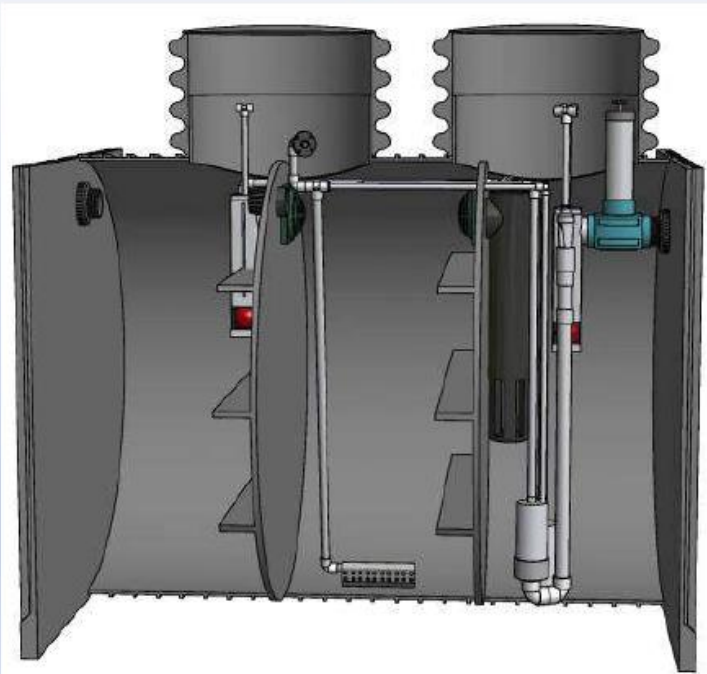
# *Muni Waste Treatment Pilot*

Cartridges in Series  
10 min EBCT/Column  
75,000 Gal at 900 GPD  
3 Cartridges removed 99% of P





## The Inceptor a 21<sup>st</sup> Century Solution for Wastewater



“MetaMateria’s capabilities enable us to double the water volume capacity of a given system design, with cleaner effluent. Our partnership dramatically improves our already attractive value proposition.” Dan Early PE, Apptech CEO & Founder

# *Summary*

## *Advantages of PO4 Sponge Media*

- Has very **High capacity** for Phosphorous capture
- Excellent Way to **Harvest Phosphorus**
- **Regeneration/Reuse** makes Product Affordable
- PO4 Sponge **Cost Competitive** for many uses
  - Due to High Capacity & Multiple Uses
- **Phosphorous Recovery** Attractive
- **Commercialization/Investment Partners** being sought to accelerate technology use in U.S. and Overseas





# ***Thank You***

## ***For more Information***

**Dr. J. Richard Schorr, CEO**  
614-599-0939 Cell  
jrschorr@metamateria.com

**Mr. Tim Marth, Vice President**  
614-499-2617 Cell  
tmarth@metamateria.com