Wastewater as a Resource: Focus on Nutrient Recovery

Moderator: Susan Danzl, PE
Short Elliott Hendrickson, Inc

WEF Critical Objectives

Drive Innovation in the Water Sector
Enrich the Expertise of Global Water Professionals
Increase Awareness of the Value of Water

Introductions

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Vice President/Senior Principal Technologist
CH2M HILL

Chris Machado, PhD, PE
Project Manager
Carollo Engineers, Inc.

Alan L. Grooms, P.E.
Process & Research Engineer
Madison Metropolitan Sewerage District
Drivers and Barriers for Implementing Nutrient Recovery

Samuel S. Jeyanayagam, PhD, PE, BCEE
CH2M Hill

May 2, 2012

Presentation Outline

• Population Explosion
• The Nutrient Predicament
• Nutrient Recovery – Drivers & Barriers
• WWTP of the Future

Development of World Cities

1950 World Cities exceeding 5 million residents

Data Source: U.N. Population Division
Population Explosion

- 7 Billion (2011)
- 9 Billion (2050)

Data source:
U.N. Population Division

World Cities exceeding
5 million residents

Data source:
U.N. Population Division

Development of World Cities

Development of World Cities

2000

2015

2000

2015
Phosphorus Reserves and Production Worldwide

Vaccari, 2009

Current Phosphorus Use Profile

Fertilizer use expected to increase due to
- Rapid population growth
- Increased intensive agriculture

Present Phosphorus Use Profile

Phosphorus Cycle

Cornel et al (2009)
The Phosphorus Predicament

- Essential – no substitutes, natural or synthetic
- Non-Renewable
- Phosphorus resources are declining both in quality and accessibility
  - Poor quality sources have increasing amounts of contaminants (Cd, U, Ni, Cr, Cu, Zn)
    - Higher cost of recovery
- Global response:
  - Sweden: 60% of P recycled from wastewater by 2015
  - China: 135% export tariff

Nitrogen is Also Essential to Life

- Present as N₂ gas in the atmosphere – infinite source
- Unusable by most organisms
- Need to convert to Reactive N (Nr)
- Natural conversion of to Nr:
  - Lightening
  - N-Fixation
- Not adequate
Global Nr Production: Haber – Bosch Process

450°C, 250 atm

\[ \text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3 \]

Nitrogen loss = Increased fertilizer production:

- High energy demand = 12 kWh / kg ammonia N (Phillips et al, 2011)
- High embedded GHG emissions = 1.4 to 2.6 kg CO2e / kg ammonia N (Wood and Cowie, 2004)

The Fate of Reactive Nitrogen (Nr)

"new" Nr used for food production

Environment is also the sink for all of the Nr created by fossil fuel combustion.

adapted from Galloway et al (2004)
Continuing Business as Usual will..

- Continue to alter the global nitrogen balance
- Result in nitrogen accumulation in the environment causing environmental & health impacts.

Estimated social damage costs of environmental N\(_e\) emissions to European Union countries (mid-range values)

Human Intervention Needed to Minimize the Impact on Global N & P Balance

Nutrient Recovery Influences and Drivers

- Reduce recycle loads
  - Eliminate sidestream chemical-P removal & reduce additional solids production
  - Reduce nitrification aeration requirements
- Minimize struvite scaling
Struvite Scaling

- Struvite MgNH₄PO₄ is the main component of kidney stones
- First observed in sewer systems in 1845 in Hamburg, Germany
- Named after geologist Gottfried von Struve
- In WWTPs, it forms when adequate amounts of Mg, NH₄, & PO₄ are available at a pH of around 9.0
- Struvite scaling - an O&M nightmare at EBPR facilities:
  - Anaerobic digestion releases the necessary ‘raw materials’
  - Turbulence drives out CO₂ resulting in pH rise & struvite scaling

Nutrient Recovery
Influences and Drivers

- Need to conserve nutrients
  - Reduce fertilizer industry GHG emissions
- Lower biosolids P content - lower land application requirements
- Highly marketable end-product
Nutrient Recovery Influences and Drivers

- Future regulations may mandate nutrient recovery
- An integral component of sustainable WWTP of the future
- Potentially no additional O&M cost

Nutrient Recovery Barriers

- Inability to make a business case
  - Relatively long payback period
- Competing priorities
- Lack of regulatory drivers
- Lack of operational experience

Nutrient Recovery Barriers

- Follower vs. leader
- Staffing constraints
- Vague timeline
  - No consensus regarding peak phosphorus
- Lack of long-term facility planning
Our wastewater management approach for a global population of 2 Billion (1950s) can not be the approach for 10 Billion (2100), mostly urban & living in an increasingly resource & energy constrained world.

It is clear that a paradigm shift is needed in how we design and operate WWTPs

Key Features of the WWTP of the Future

• Water Conservation
• Distributed Stormwater Management
• Water Reclamation and Recycling
• Energy Neutral or Energy Positive
• Carbon Sequestration for Energy Production
• Nutrient Recovery
• Source Separation
• Decentralized treatment

Key Elements of WEF Position Statement

1. Redefines wastewater treatment plants as water resource recovery facilities (WRRFs)
2. Affirms that energy derived from WRRFs is a renewable energy source
3. States that biosolids should be recognized as biomass under all applicable government and commercial definitions
4. Asserts that state and federal agencies should fully endorse all renewable energy associated with WRRFs
5. Encourages WRRFs to set a goal of becoming energy neutral or net energy producers
6. Encourages more research into emerging technologies on energy recovery from wastewater
7. Encourages continued participation by water sector in traditional energy conservation and recovery at WRRFs
A President Understood the Looming Phosphorus Crisis Over 70 years Ago

“I cannot overemphasize the importance of phosphorus not only to agriculture but also the physical health and economic security of the people of the nation.”

Franklin D. Roosevelt, 1938

Current State of Knowledge on Nitrogen and Phosphorus Recovery Technologies

Chris Machado and Rod Reardon
Carollo Engineers, Inc

May 2, 2012

Outline

• Nutrient Recovery in Different Perspectives
• Nutrient transformations in wastewater treatment
• Review of Recovery Methods
  – main stream wastewater
  – recycle streams
  – P enriched waste sludge
  – biosolids and ashes
• Summary
Nutrient Recovery in Different Perspectives

- **Combined Treatment and Reuse**
  - Example: cultivation of macrophytes, algae, fungi
  - Energy production, animal feed, biomedical applications

- **Reuse of Treated Waste**
  - Example: plant cultivation and aquaculture
  - Food production

- **Nutrient Extraction as a Component of Waste Treatment**
  - Example: fertilizer production
  - Commercial use

Wastewater Treatment Nutrient Transformations

- Physical
  - Soluble
  - Particulate
- Biological
- Chemical
- Low strength effluent
- High strength recycling streams
- Biosolids
- Gas Emissions

Typical Wastewater Treatment Process Configuration

- Potential Nutrient Recovery Locations
Reuse of Effluent with Different Degrees of Treatment

- Irrigation and plant cultivation
- Aquatic macrophytes cultivation
  - duckweed, water hyacinth, cattails
- Algae cultivation
- Fungi cultivation
- Aquaculture
Macrophytes Cultivation

Pre-treatment COD Removal

Nutrient Rich Effluent

High productivity
High protein content
Easy handling
Feed source for fish and livestock

Series of Ponds

Duckweed

Final Effluent
Irrigation / Aquaculture

El-Shafai S. A. et al. 2007

Algae Cultivation

Open Reactors

Smaller area required
Minimize water loss
Higher photosynthetic efficiency
Better process control
More complex and costly

Closed Reactors

Larger area required
Water loss though evaporation
Lower photosynthetic efficiency
Simple design

Sankaran et al. 2010

Fungi Cultivation

• Treatment of high strength wastewater
  – e.g. food industry, pulp mill, sugar refinery

• High value biomass
  – Biochemical applications
  – Food and brewing industry
  – Medicines and ointments

Seambiotic, Ltd (Israel)
Valcent Products Inc. (UK)
Recycle Streams

Preliminary and Primary Treatment
Influent
Solids Thickening
Secondary Treatment
Phosphorus Enriched WAS
Main Stream Wastewater
Solids Stabilization
Dewatering
Disposal
Biosolids/ Sludge Ashes
Recycle

Phosphorus Recovery from Recycle Streams

Precipitation/ Crystallization
Struvite
Apatite
Adsorption
Sorption
Ion Exchange
Chemical desorption
Magnetic separation

Phosphorus Precipitation

• Crystallization
  – Most common practice
  – Several configurations (eg. PHOSNIX, OSTARA, DHV CRYSTALACTOR)
  – Fertilizer product (MAP or CaP)
  – Mitigates pipeline scaling
What is the fate of phosphorus in the solids?

Scaling Affects Performance and Increase Maintenance

Phosphate-Harvesting Systems Provide Sellable end Product
Phosphorus Adsorption

- Adsorbents: granular activated alumina, zirconium oxide, iron oxide, hydrated iron oxide, layered double hydroxides, fly ash, steel slag
- Ion exchange
  - Anionic resins
  - Phosphate selective polymeric exchangers
- Chemical regeneration → recovery

Sengupta and Pandit 2011, Park et al. 2010

Packed Adsorbent Columns

Mixed Reactors

Ion Exchange Followed by Crystallization Recovery

Nitrogen Recovery from Recycle Streams

- Stripping
- Adsorption
- Precipitation
- Vacuum Distillation
- Air
- Steam
- Sorption
- Ion Exchange
- MAP
- CASTion Process
Ammonia Stripping
- Air or steam stripping
- pHs 10 to 12 – NaOH or Ca(OH)₂
- Gaseous ammonia stripped
- Recover under acidic conditions
- Recover ammonium sulfate solution
- Used for high strength wastewater

Ammonium Adsorption
- Adsorbents: aluminum silicates, zeolites (clinoptilolite), furnace slag
- Packed columns
- High removal rates (>90%)
- Recovery – desorption
  - With chemical addition (Ca(OH)₂)
  - With water

Recovery from Phosphorus Enriched WAS

Bio-P Processes Produce Sludge with High P content
- Conventional activated sludge 2% P
- Bio-P sludge > 3 – 8% P
- Intracellular phosphate can be extracted from WAS before sludge digestion
- Concentrated solution is produced
- Recovery can be achieved through precipitation or adsorption
- Examples: PHOSTRIP, WASSTRIP
**Direct Application**
- Agriculture/land application
- Part 503 Rule - solids stabilization
- Presence of heavy metals and trace organic compounds
- Human health and environmental risks
- P application more often limiting

**Recovery from Biosolids**
- Phosphate extraction
- Chemical - strong acid
- Heat and pressure
- Heavy metal separation
- Recovery MAP or CaP
- Examples: KREPRO, SEABORNE, AQUA RECI

Source: Müller J.A. et al. 2007. WWTP Gifhorn – Germany. Seaborne
Recovery from Ashes

- Incineration concentrates phosphorus from sludge into ashes (15-20% P)
- Organics destroyed
- About 90% of phosphorus can be recovered
- Metals, iron and aluminum extracted, can be recovered
- Main processes
  - Wet-chemical (acid) extraction
  - Thermal-chemical treatment
- Examples: BIOCON, SEPHOS, PASH

Tan and Lagerkvist 2011; Takahashi et al. 2001

Summary

1. Large number of technologies available
2. Precipitation best developed
3. Attractive for Bio-P plants
4. Increasing number of full scale applications

Summary

<table>
<thead>
<tr>
<th>Recovery Strategy</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Main Stream       | • Agricultural water reuse  
|                   | • Alternative energy – Biofuel  
|                   | • Production of high value biomass  
|                   | • Simple process compared to side stream and biosolids  
|                   | • Low cost  
|                   | • Application in small communities  
|                   | • Health risk  
|                   | • High water loss through evaporation  
|                   | • Low nutrient concentrations  |
| Recycle Stream/WAS | • Direct use fertilizer product  
|                   | • Simple process compared to biosolids  
|                   | • Small and large scale applications  
|                   | • Preliminary treatment likely  
|                   | • Lower recovery compared to biosolids  |
| Biosolids         | • Higher recovery compared to side and main stream  
|                   | • Direct use fertilizer product  
|                   | • High cost not economical in small scale applications  
|                   | • Presence of heavy metals  
|                   | • Health and environmental risks  
|                   | • High chemical and/or energy consumption  
|                   | • Requires waste management  |
Feasibility and Costs

- Feasibility of implementation and costs are very case specific
- Difficult to quantify product value – How to factor the sustainability component?
- O&M Savings must be factored in the economical analysis

<table>
<thead>
<tr>
<th>Phosphate</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery (crystallization) (Phillips et al. 2011)</td>
<td>$9 / kg P removed</td>
</tr>
<tr>
<td>Recovery (adsorption) (Phillips et al. 2011, Weinberg et al. 2011)</td>
<td>$60-$70 / kg P removed</td>
</tr>
<tr>
<td>Phosphate rock</td>
<td>$0.20 / kg</td>
</tr>
<tr>
<td>Diammonium phosphate fertilizer</td>
<td>$0.77 / kg</td>
</tr>
</tbody>
</table>

One Utility’s Experience Evaluating Phosphorus Recovery

Alan L. Grooms, P.E.
Madison Metropolitan Sewerage District

About Madison Metropolitan

- Located on south side of Madison, WI
- Sewerage District formed in 1930
  - Serves about 350,000 persons in 43 municipalities
  - Largest customer: City of Madison
  - 40 MGD flow current average
  - Fairly typical domestic waste
About Nine Springs WWTF

- Madison Metropolitan’s only WWTF
- Advanced secondary (EBPR) treatment, seasonal UV disinfection, anaerobic digestion, class “B” liquid biosolids program
- About 40 MG of biosolids applied to land in an average year
- Pump effluent to two surface discharges

Current Nine Springs Operation
Phosphorus Harvesting

Advantages

• Reduce
  – Phosphorus in land-applied biosolids
  – FeCl₃ usage for struvite control
• Recover a valuable mineral
• Reign in nuisance struvite formation
  – Plugging pipes
  – Fouling pumps and mixers

Struvite can be a problem…

Phosphorus Harvesting

Disadvantages

• Capital cost
• Additional complexity
  – Process
  – Personnel?
• Not a traditional “Core” mission
• Unfamiliar process
Basic phosphorus in a secondary treatment WWTF

\[ \text{Influent Phosphorus} = \text{PI} \]
\[ \text{Effluent Phosphorus} = \text{PE} \]
\[ \text{Biosolids Phosphorus} = \text{PB} \]
\[ \text{PI} = \text{PE} + \text{PB} \]
\[ 100 = 40 + 60 \]

Basic phosphorus in an EBPR WWTF facility

\[ \text{Influent Phosphorus} = \text{PI} \]
\[ \text{Effluent Phosphorus} = \text{PE} \]
\[ \text{Biosolids Phosphorus} = \text{PB} \]
\[ \text{PI} = \text{PE} + \text{PB} \]
\[ 100 = 10 + 90 \]

With phosphorus harvesting...

\[ \text{Influent Phosphorus} = \text{PI} \]
\[ \text{Effluent Phosphorus} = \text{PE} \]
\[ \text{Biosolids Phosphorus} = \text{PB} \]
\[ \text{Harvested Phosphorus} = \text{PH} \]
\[ \text{PI} = \text{PE} + \text{PB} + \text{PH} \]
\[ 100 = 10 + 40 + 50 \]
Evaluating Options

- Differing business models
  - Is struvite a finished product or an intermediate product?
  - Do we want to be in the fertilizer business?
- Differing state of the business itself
  - Relatively young suppliers
  - Some better established in this niche
  - Long term stability of business?

Typical Wastewater Treatment Process Configuration

Preliminary and Primary Treatment
Influent
Solids Thickening
Secondary Treatment
Solids Stabilization
Tertiary Treatment
Disposal
Phosphorus Enriched WAS
Recycle Streams
Recycle Streams

Potential Nutrient Recovery Locations Evaluated

Recycle Streams
Recycle Streams

Main Stream Wastewater
Biosolids/Sludge Ashes
Phosphorus Enriched WAS

Pilot Testing

- Two vendors piloted on site
- Each evaluated over two conditions
  - Present filtrate stream (post digestion)
  - Future “simulated” stream (post digestion plus pre-digestion WAS P-release)
- Checked removal efficiency and chemical usage versus vendor claims
Preliminary Quotes

- Decision made to pre-bid
  - Design with pre-bid vendor
  - Customize layout to accommodate
- Solicited proposals
  - Three vendors responded
  - Analysis—“apples-to-apples” comparison to extent possible
  - Capital cost important, but not overriding

Consultant Technical Memo

- Capital costs
- Projected O&M costs
  - Chemicals—Added MgCl₂ & NaOH, potential to reduce FeCl₃ addition
  - Power
  - Personnel (pros & cons)
  - Offsetting revenue (sales)

Phosphorus recovery economics – Capital Costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filtrate Wells</td>
<td>$161,600</td>
</tr>
<tr>
<td>WAS Pre-treatment Tanks</td>
<td>$650,900</td>
</tr>
<tr>
<td>Struvite Harvesting System &amp; Building</td>
<td>$5,969,800</td>
</tr>
<tr>
<td>Site Work</td>
<td>$339,120</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$7,121,420</td>
</tr>
<tr>
<td>Undefined Details Allowance</td>
<td>$356,080</td>
</tr>
<tr>
<td>Total Construction Cost</td>
<td>$7,477,500</td>
</tr>
<tr>
<td>Engineering, Legal, and Administrative Costs</td>
<td>$747,750</td>
</tr>
<tr>
<td>PRESENT WORTH CAPITAL COST</td>
<td>$8,225,250</td>
</tr>
</tbody>
</table>

Numbers derived from Applied Technologies, Inc. Proposal Evaluation (May 2011) and Final Estimate of Cost (Oct 2011)
Phosphorus recovery economics
– Operations & Maintenance

<table>
<thead>
<tr>
<th>Annual O&amp;M Cost Item</th>
<th>Our Estimate</th>
<th>Comments</th>
<th>Vendor Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor</td>
<td>$68,640</td>
<td>$1 FTE @ $33/hr</td>
<td>$20,590</td>
</tr>
<tr>
<td>Energy</td>
<td>$32,850</td>
<td>NG pellet drying</td>
<td>$49,275</td>
</tr>
<tr>
<td>Chemicals (NaOH)</td>
<td>$412,500</td>
<td>@ $550 / dt</td>
<td>$343,750</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$45,000</td>
<td></td>
<td>$20,000</td>
</tr>
<tr>
<td>Struvite Buy-Back</td>
<td>($410,625)</td>
<td>@ $300 / dt</td>
<td>($410,625)</td>
</tr>
<tr>
<td><strong>TOTAL O&amp;M COSTS</strong></td>
<td><strong>$148,365</strong></td>
<td></td>
<td><strong>$22,900</strong></td>
</tr>
</tbody>
</table>


Phosphorus recovery economics
– Cost Per Unit P Recovered

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>Our Estimate</th>
<th>Comments</th>
<th>Vendor Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Annual O&amp;M</td>
<td>$148,365</td>
<td></td>
<td>$22,900</td>
</tr>
<tr>
<td>Present Worth Factor</td>
<td>7.722</td>
<td>10 years @ 5%</td>
<td>7.722</td>
</tr>
<tr>
<td>O&amp;M Present Worth</td>
<td>$1,145,675</td>
<td></td>
<td>$176,900</td>
</tr>
<tr>
<td>PW Capital Cost</td>
<td>$8,225,250</td>
<td></td>
<td>$8,225,250</td>
</tr>
<tr>
<td><strong>TOTAL 10-YR PW COSTS</strong></td>
<td><strong>$9,370,925</strong></td>
<td></td>
<td><strong>$8,402,150</strong></td>
</tr>
<tr>
<td><strong>10-YR PW COST / KG P REMOVED</strong></td>
<td><strong>$5.32</strong></td>
<td>1.76 Mkg P removed 10 yr</td>
<td><strong>$4.77</strong></td>
</tr>
</tbody>
</table>

Estimated savings attributable to harvesting phosphorus

<table>
<thead>
<tr>
<th>Item</th>
<th>Current Est. Savings</th>
<th>Future Est. Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeCl₃ @ $650 / dt</td>
<td>$6,000 $711,750</td>
<td>8,000 $949,000</td>
</tr>
<tr>
<td>MetroGro Biosolids</td>
<td>$3,025 $55,200</td>
<td>4,050 $73,900</td>
</tr>
<tr>
<td>Reduced DBT Polymer</td>
<td>$6,750 $9,000</td>
<td>$9,000</td>
</tr>
<tr>
<td>Reduced Aeration from Decreased Ammonia</td>
<td>$9,200 $12,000</td>
<td>$12,000</td>
</tr>
<tr>
<td><strong>TOTAL ANNUAL SAVINGS</strong></td>
<td><strong>$182,800</strong></td>
<td><strong>$1,043,500</strong></td>
</tr>
</tbody>
</table>

Savings works out to about an 8-year payback.
Selection of Pre-Bid Vendor

• Ostara Nutrient Recovery Technologies proposal selected
  – Selection in May 2010
  – Assessed as most advantageous overall to the District's interests
  – Comfort in "established" company

• Signed agreements (including terms for product purchase)

WAS phosphorus release alternative

• Less dissolved P and Mg to digestion
• Advantage *should be* reduced formation of struvite in digesters, etc.
• Worked on with University of Wisconsin (Madison) research teams since 1999
• Acid sludge found more effective at lower volume, ∴ more concentrated feed stream

Phosphorus release triggers

• Known P release triggers for WAS:
  – Primary sludge (or overflow)
  – Acid sludge (or filtrate)
  – External VFA source
    • Acetic acid
    • Propionic acid
  – External carbon source (QLF, others?)
Trigger effectiveness (MMSD)

- At 6-hours time from addition:
  - Primary sludge (or overflow) – 30%-35%
  - Acid sludge (or filtrate) – 40%-45%
  - External VFA source
    - Acetic acid – 40%-45%
    - Propionic acid – 40%-45%
  - External carbon source (QLF, others?)
    - QLF alone – 40%-45% (dose dependent)
    - QLF with acid sludge – 50%+?

QLF is Quality Liquid Feeds supplement

Acid sludge trigger data:

<table>
<thead>
<tr>
<th>Time from addition, minutes</th>
<th>TP Released from WAS, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>30</td>
<td>5%</td>
</tr>
<tr>
<td>60</td>
<td>10%</td>
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<tr>
<td>90</td>
<td>15%</td>
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<tr>
<td>120</td>
<td>20%</td>
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<tr>
<td>150</td>
<td>25%</td>
</tr>
<tr>
<td>180</td>
<td>30%</td>
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<tr>
<td>210</td>
<td>35%</td>
</tr>
<tr>
<td>240</td>
<td>40%</td>
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<tr>
<td>270</td>
<td>45%</td>
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<tr>
<td>300</td>
<td>50%</td>
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<td>330</td>
<td>55%</td>
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<td>360</td>
<td>60%</td>
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<tr>
<td>390</td>
<td>65%</td>
</tr>
<tr>
<td>420</td>
<td>70%</td>
</tr>
<tr>
<td>450</td>
<td>75%</td>
</tr>
<tr>
<td>480</td>
<td>80%</td>
</tr>
</tbody>
</table>

Acid sludge (VFA ~ 5,000 mg/l as acetic) dose added to 1 L WAS.

Non-VFA trigger data:

<table>
<thead>
<tr>
<th>Time from addition, minutes</th>
<th>TP Released from WAS, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</table>

Dose added to 1 L WAS. Acid sludge VFA content ~ 5,000 mg/l as acetic.
Trigger additive observations

• “Less is more” – for VFA an inhibitory effect was observed at Nine Springs
• Cost effectiveness of additives will vary case-by-case
• Chemical additives (or non-VFA additives) may allow more facilities to consider harvesting

Modifying our plans

• Acid phase digestion had already been selected for expansion
• Changes to in-progress design:
  – Added WAS P-release tanks to design
  – Added piping and pumps for acid sludge dosing and provided for separation of WAS filtrate from digested sludge filtrate
  – Separate or combined pumping to struvite harvesting?

Nine Springs Future Operation
Going Forward

• Construction underway
• Phosphorus recovery projected to be ready Summer 2013
• Anticipate removal of about ½ ton of phosphorus per day, translating to a production of about 4 tons of struvite per day

Lessons Learned

• Consider all impacts—for us reduction in biosolids phosphorus alone made this an attractive path to follow
• Evaluate the “worst case scenario” and make sure you are prepared to address
• See us in two years for more!

Thank You

Moderator: Susan Danzl, PE
Short Elliott Hendrickson, Inc
WEF Committees

- [http://wef.org/committees/](http://wef.org/committees/)
- Committee Membership Application

Municipal Wastewater Treatment Design Committee

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