Lessons Learned from Applying Extractive Nutrient Recovery for Managing Phosphorus in Sidestreams and Biosolids

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Acknowledgments

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Embracing the new resource management paradigm

- **Source water**
- **Drinking Water Treatment**
- **Wastewater Generation**
- **Water Resource Recovery Facility**
- **Wastewater Treatment Plant**

**Water**

- **Biosolids**
- **Nutrient Products**
- **Energy**

Other products e.g., bioplastics, cellulose
Historically, phosphorus was removed from WRRFs in two ways:

- **Liquid Effluent**
- **Solids**

Degree of removal is a function of liquid effluent permit requirements.

Lower Liquid Effluent = Higher Solids P
Extractive nutrient recovery provides an additional outlet for phosphorus.
How do we perform extractive nutrient recovery?

Accumulation step to increase nutrient content
N > 1000 mg N/L and P > 100 mg P/L

Release step to generate low flow and high nutrient stream

Extraction step produces high nutrient content product

Recovered chemical nutrient product
How does this apply to WRRFs?

Consider a common scenario at WRRFs:
Solids stabilization generates nutrient rich liquid stream

- Sidestreams are typically returned to the head of the plant for treatment.

Examples of sidestream:
- BFP filtrate
- GBT filtrate
- Filter backwash
- Centrate
- Digester supernatant
Sidestream nutrient load can also negatively impact performance of the mainstream plant.

High nutrient recycle loads can upset the mainstream process.
Struvite can be a significant maintenance concern with anaerobic digestion

Struvite = Mg + NH$_4$ + PO$_4$

NH$_4$ & PO$_4$ released in digestion
Typically Mg limited
Mg addition (i.e. Mg(OH)$_2$) can promote struvite formation

Miami Dade SDWRF

NYC Newtown Creek WWTP
Struvite extraction can transform a nuisance into a valuable resource

Mg$^{+2}$\[\text{NH}_4^+\text{-N}\]

\[\text{PO}_4^{-3} - \text{P}\]

Struvite Recovery Reactor

Mg(NH$_4$)$_2$PO$_4$(s)

- Selectively extract P, N and Mg

- Reduce propensity to scale downstream of process
  - Reduce O&M requirements/chemical dosing requirements
Nansemond WWTP is a 30 MGD facility that employs a 5-stage BNR for N and P removal.
Sidestream load represents up to 30% of the plant influent P load
High P load negatively impacts TP removal

- Ortho-P Load (lb/day)
- Effluent TP (mg TP/L)
- Concentration (mg TP/L)
Two options were considered for sidestream P Treatment at NTP

**Ferric addition**
- Forms ferric phosphate and ferric hydroxide
- Non-proprietary
- Traditionally used for controlling sidestream P at this plant
- High O&M requirement

**Struvite recovery**
- Ostara Pearl
- Capital purchase option
  - NTP purchases equipment and receives annual payments from OSTARA
Struvite recovery was most favorable treatment option

<table>
<thead>
<tr>
<th>Cost Description</th>
<th>Do Nothing</th>
<th>Side Stream Chem Trmt</th>
<th>Ostara</th>
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<tbody>
<tr>
<td>Total Annual Savings</td>
<td>0</td>
<td>0</td>
<td>528,000</td>
</tr>
<tr>
<td>Total Annual Operating Costs</td>
<td>(392,000)</td>
<td>(429,000)</td>
<td>(91,000)</td>
</tr>
<tr>
<td>Net Annual Costs</td>
<td>(392,000)</td>
<td>(429,000)</td>
<td>437,000</td>
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<td>Capital Costs</td>
<td>(3,027,000)</td>
<td>(3,313,000)</td>
<td>3,926,000</td>
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<tr>
<td>Net Present Worth @ 10 years</td>
<td>(4,885,000)</td>
<td>(5,346,000)</td>
<td>1,520,000</td>
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</table>
Full scale struvite recovery facility at NTP

System has produced ~ 1,100 lb struvite/day
The SRF has reduced ortho-P concentrations by approximately 85%
Ammonia removal has averaged 25%
Struvite recovery has reduced the phosphorus content of the biosolids

Pre nutrient recovery = 39,000 mg/kg
Post nutrient recovery = 29,000 mg/kg

29% reduction in cake TP content
Lessons Learned from Nansemond Treatment Plant

- Reduced nutrient load (>25% of P and ~ 5% of ammonia) to the main plant

- Dewatering operations/performance directly impact nutrient recovery – solids removal is important

- Optimized bio P removal will result in maximized P recovery

- Nutrient recovery is a viable sidestream treatment strategy
F. Wayne Hill
WRC
F. Wayne Hill Water Reclamation Center

Gwinnett County, GA
60 MGD advanced WWTP
0.08 mg/L TP effluent limit
Bio-P and chemical trim for P-removal
In 2009, F. Wayne Hill Changed from Bioxide to Mg(OH)$_2$ in Collection System for Odor Control

Pros: Eliminated need for ALK addition at plant

Cons: Struvite formation in centrate lines, centrifuges, digester complex

Sludge from 22 mgd Yellow River Bio-P plant coming, which would substantially increase P load in sidestreams and SFP.
Balance - Limit effluent P while minimizing struvite formation

Phosphorus outlets:
- Effluent (Limit TP = 0.08 mg/L)
- Sludge cake (precipitated complex, biomass, struvite)
- Struvite solids from nuisance formation

Project Goal: Determine best solution for struvite issue
- Nutrient Recovery
- Metal salts
Five options were considered for sidestream P removal from F. Wayne Hill AWRF

- Do Nothing
- Ferric addition with and without Mg(OH)$_2$ addition
- Struvite recovery with and without WASStrip™
WASSTRIP™ concept minimizes nuisance struvite production

- Release P from sludge using VFA rich stream
- Low P content of sludge minimizes nuisance struvite formation from digester onwards
- Send P rich sidestream to recovery process
Bench scale testing of the WASSTRIP™ process was performed

- Determine levels and rates of PO₄ release from WAS
- Optimize parameters to maximize PO₄ release in pilot studies
  - Anaerobic retention time and WAS:PS blend ratio
P recovery provides equivalent struvite reduction compared with the ferric addition option

<table>
<thead>
<tr>
<th>Scenario</th>
<th>30 mgd</th>
<th>40 mgd</th>
<th>50 mgd</th>
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<tbody>
<tr>
<td>Do Nothing</td>
<td>8,000</td>
<td></td>
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</tr>
<tr>
<td>Ostara + WASSTRIP + Mag</td>
<td>6,000</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td>Ostara + WASSTRIP + No Mag</td>
<td>4,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ostara Centrate No Mag</td>
<td>2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferric Digesters Mag</td>
<td>2,000</td>
<td></td>
<td></td>
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<tr>
<td>Ferric Centrate No Mag</td>
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</tbody>
</table>

PPD of Struvite in Sludge Cake
Struvite recovery + WASSTRIP has lowest net present cost and 8-Year Payback
Full-Scale Facility Has Been In Operation Since 2015
Ostara feed – Orthophosphate
Ostara effluent – Orthophosphate

![Graph showing concentration of orthophosphate in Ostara effluent over time from 7/1/15 to 4/5/16. The graph compares R1 and R2 effluent OP_PRISM concentrations with 30 per. Mov. Avg. (R1 Effluent OP_PRISM) and 30 per. Mov. Avg. (R2 Effluent OP_PRISM).]
Plant Effluent

Lower, more stable effluent TP
Cake TSS content improvements have been observed

Avg ~ 22.5%

Avg ~ 25%

SRF online

Avg ~ 22.5%
Lessons Learned from F. Wayne Hill WRC & WASSTRIP™

- Mitigate nuisance struvite formation
- Minimized need for ferric addition
- Reduced sludge production
  - Decreased P content of biosolids
- Possible benefits to dewatering
  - Study underway to confirm
Benefits of Nutrient Recovery

1. Manipulate the nutrient content of the biosolids
2. Provide plant with alternative revenue stream
3. Regain digester capacity

1. Reduce energy and chemical consumption in the mainstream process
2. Provide factor of safety for mainstream nutrient removal process
3. Minimize nuisance struvite formation and reduce O&M costs

Sidestream treatment

Biosolids

To mainstream

Dewatering

Anaerobic Digestion

Thickening
Logistics of Implementation

- Equalization and solids pre-treatment are critical

- Locate struvite recovery facility as close to dewatering facilities and equalization tank as possible.

- Avoid traps and use long turn elbows

- Incorporate acid flushing of lines and provide flush connections on all pipe runs.

- Provide duplicate piping and pumps to minimize downtime during maintenance
Questions and Contact Information

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