In recent years, there has been scaremongering that phosphate rock reserves could be depleted in a matter of decades.

Are such claims valid?
In 2010, the US Geological Survey estimated approximately 90 years of reserves at current consumption rates.

In the same year, the International Fertilizer Development Center estimated sufficient reserves for at least 350 years at current usage rates.
Recoverable Phosphorus

- **Hyperion Wastewater Treatment Plant**: 50% reduction in pipe diameter after one year of operation (Jeffery et al. 2002).

- **Penggol Pigwaste Plant, Singapore**: Completely clogged pipes within months, (Mohajit et al. 1989).

- **Sacramento Regional Wastewater Treatment Plant**: Replaced 3.5 miles of pipe after failed struvite scaling removal attempts (Doyle et al. 2003)

Source: Sustainable Sewage Sludge Management Fostering Phosphorus Recovery and Energy Efficiency, P-Rex Deliverable D 5.1, EU
Economic drivers of P Recovery Systems are…

- Reduced Struvite Maintenance
- Reduced Coagulant Consumption
- Reduced N removal requirements (0.45 lbs NH$_4$N/lb P recovered)
  - Aeration/Supplemental Carbon
- Potentially Recyclable/Saleable end-product
  - 25 -28% as P$_2$O$_5$
  - Slow release fertilizer
Pilot Study and Project Cost Evaluation

South Durham Water Reclamation Facility
South Durham Water Reclamation Facility

- 1984: Initial Construction – 10 MGD Capacity
- 1990: Upgrade for Bio-P Removal
- 1995: Expansion/Process Upgrade
  - 20 MGD
  - Nitrogen Removal
- 1998: Biosolids Handling Upgrade
- 2012: Online Nutrient Monitoring
- 2014: Process Upgrades
  - Supplemental Carbon Facilities
  - Anitamox Sidestream Deammonification
  - Process Modifications to Secondary Treatment for improved N-Removal
Currently:

- **Flow** - $\approx 9.5 \text{ MGD}$
- **Effluent P** - $< 0.25 \text{ mg/L}$
  - BioP and Chemical Precipitation
- **Effluent N** - $< 7.0 \text{ mg/L}$
  - Online Process Control
  - Supplemental Carbon Addition
Impact of Centrate from Anaerobic Digestion

- **NH4-N**
  - 800+ mg/L, ≈ 450 lbs/day Recycle untreated
  - < 140 lbs/day since stabilization of Deammonification (≈70% reduction)

- **PO4-P**
  - 200 mg/L, ≈ 95 lbs/day Recycle untreated
  - Removed via Coagulant Addition
  - ≈$100K/yr in Chemical and Sludge Disposal
  - Issues with Struvite in Dewatering/Centrate handling facilities
Struvite Recovery Pilot Study in Fall of 2016
Typical Process Scheme
The Struvia Process

- **Reactor design**
  - Combined of a crystallization reactor + lamellar separator in the same reactor
- **Compact**: 1.0-1.5 hour HRT
- **Minimal Equipment Requirements**
- **Low Capex compared to other crystallization technologies**
- **Good product quality, easy to mix with other substrates for production of specific fertilizers**
The Struvia™ Reactor

- Effluent Trough
- Lamella tubes
- Anti-vortex plates
- Draft tube
- Axial flow agitator with downward thrust
## Typical Design and Operating Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor HRT</td>
<td>60 to 90 min</td>
<td>&gt; 45 min T &gt; 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 90 min T = 10 to 20 C</td>
</tr>
<tr>
<td>Crystal Retention Time</td>
<td>2-3 day</td>
<td>3 day</td>
</tr>
<tr>
<td>pH</td>
<td>7.0 to 8.5</td>
<td>~ 7.3-7.7</td>
</tr>
<tr>
<td>Mg/P (Molar)</td>
<td>1.0 to 1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Mg/Ca (Molar)</td>
<td>&gt; 2.5</td>
<td></td>
</tr>
<tr>
<td>Reactor Crystal Conc.</td>
<td>50 – 200 g/L</td>
<td>100 g/L</td>
</tr>
<tr>
<td>Power Input</td>
<td>1.1-1.4 kW-hr/kg-P removed</td>
<td></td>
</tr>
<tr>
<td>Effluent Recir. to Feed</td>
<td>when Infl PO4-P &gt; 300 mg/L</td>
<td>Generally not required</td>
</tr>
</tbody>
</table>
Struvite Product

- Small pellets, granular size, easy to dewater by gravity
- More than 80% DS after 24h drainage and more than 90% after 20 days natural drying
- Easy to dry at 98% DS at low T°C < 50°C
- Good product quality for incorporation into organo-mineral fertilizers fabricated by SEDE-ADS

Fresh struvite in the gravity dewatering bag
SEM images from crystals obtained
Dried struvite crystals
Fertilizer granules produced by Veolia's subsidiary SEDE-ADS including STRUVIA pellets
PO$_4$-P removal vs PH

Mg/P molar Ratio = 1.2, HRT = 1 hr, inlet Sol PO$_4$-P = 195 mg/L
Pilot Study - SDWRF

Optimized TP Reduction ≈ 85%

Avg Influent TP ≈ 194 mg/L

Avg Effluent TP ≈ 29 mg/L

Lost Mg Feed overnight

Overall TP Reduction ≈ 74%

Influent TP

Effluent TP

Influent OP

Effluent OP (Unfiltered)
# Phosphorous Recovery

<table>
<thead>
<tr>
<th></th>
<th>Reactor Influent</th>
<th>Reactor Effluent</th>
<th>Dewatering Bag Filtrate</th>
<th>Dewatered Struvite</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP (mg/L)</td>
<td>194</td>
<td>29</td>
<td>3000</td>
<td>NA</td>
</tr>
<tr>
<td>TP (lbs/day)</td>
<td>33</td>
<td>5</td>
<td>0.5</td>
<td>27.5</td>
</tr>
<tr>
<td>Overall Recovery</td>
<td></td>
<td></td>
<td></td>
<td>≈83%</td>
</tr>
</tbody>
</table>
System Design

- **Struvite Reactor**
  - 10.5 ft Dia x 17 ft high - 9800 gallons
  - 7.5 hp mixer
  - 110 GPM capacity (140 gpm peak)
  - Phosphorous Recovery – 220 lbs/day

- **CO2 Stripping Reactor**
  - 7.5 ft Dia x 20 ft high - 6600 gallons
  - 5 HP Blower - 40 SCFM

- **Chemical Feed**
  - $\text{MgCl}_2$ - 650 - 700 mg/L 15 gph
  - NaOH - 100-200 mg/L 2.5 gph

- **Slurry Dewatering**
  - Gravity Bag System
System Cost Estimate

**Struvia System**
- Centrate Pump Station
- Reactor/Drafst Tube/mixer
- Chemical Feed Systems
- Dewatering Equipment
- Instruments/controls
- Piping/Conduit

**Bulk Chemical Storage Systems**
- Tanks: NaOH, MgCl₂
- Unloading Facilities, secondary containment

**Buildings and Facilities**
- MCC/PLC
- Open Shelter for Struvite Dewatering/storage

**Total** $1,080,000
### Present Worth Evaluation

#### Assumptions

- Uniform Annual Flow increase
- Year 1 Flow: 9 MGD - 45% of Design
- Year 20 Flow: 15 MGD - 75% of Design
- Interest Rate: 4%
- Life cycle: 20 yrs

<table>
<thead>
<tr>
<th></th>
<th>Sludge/Struvite Disposal ($/Dry Ton)</th>
<th>Capital Investment</th>
<th>PW of Annual Costs</th>
<th>Total PW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Operations</strong></td>
<td>$ 400</td>
<td>$ 0</td>
<td>$ 1,703,000</td>
<td>$ 1,703,000</td>
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<tr>
<td><strong>Struvite Recovery</strong></td>
<td>$ 400</td>
<td>$ 1,080,000</td>
<td>$ 1,564,000</td>
<td>$ 2,644,000</td>
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<tr>
<td></td>
<td>$ -100</td>
<td>$ 1,080,000</td>
<td>$ 798,000</td>
<td>$ 1,878,000</td>
</tr>
<tr>
<td></td>
<td>$ -220</td>
<td>$ 1,080,000</td>
<td>$ 609,000</td>
<td>$ 1,689,000</td>
</tr>
</tbody>
</table>
Creating Value?

- Revenue Potential
  - *Struvite product locally valued at ≈$100 Dry ton*
- Undeveloped Market
- No payback for SDWRF on capital investment

**SDWRF not currently pursuing struvite recovery**

**Currently testing coagulant addition upstream of dewatering operations to assess impacts on dewatering and maintenance issues associated with Struvite**
Questions

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