Struvite, Turning a Potential Maintenance Problem into an Opportunity

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Outline

• Introduction
• Background on Formation
• Struvite Recovery and Benefits
• Overview of Technologies
• Summary and Final Thoughts
Introduction
What is Struvite?

- Magnesium Ammonium Phosphate Hexahydrate
- Fouling at WWTP’s with Anaerobic Digestion – Maintenance Issue
  - Pipes
  - Heat exchangers
  - Centrate after dewatering
- Forms where pressure is low, CO2 is released, raises pH (8-10)
- Bio-P exacerbates issue
- Kidney Stone (common in dogs)

\[
\text{Mg}^{2+} + \text{NH}_4^+ + \text{PO}_4^{-3} \leftrightarrow \text{MgNH}_4\text{PO}_4 \cdot 6\text{H}_2\text{O}
\]

Normally Limiting
Background on Formation
The Nutrient Merry-Go-Round – Contributor to Struvite

- 1% of Total Plant Influent Flow
- Rich in Nitrogen & Phosphorus
- 15 to 40% of the Total Plant TN load
- 50% TP load
- Often returned in slug loads – not equalized
- Ammonium Conc. 800 to 2,500 mg-N/L
- Temperature 30 - 38°C
- Alkalinity insufficient for complete nitrification
- Poor in rbCOD (rbCOD : TKN = 0.4 : 1)
Biological Phosphorus Removal

• In biological phosphorus removal, phosphorus is incorporated into cell biomass, and then wasted with the sludge.

• Normally, bacteria in the activated sludge contain approximately 1.5% - 2% phosphorus.

• However, certain types of bacteria are able to store phosphorus.....up to 20 to 30 % of their weight.

• These bacteria are called PAOs (phosphorus accumulating organisms)
**Anaerobic / Aerobic Cycle**

**Phosphorus Release / Uptake**

- **Anaerobic Zone**
  - Poly-P'
  - PHB
  - o-PO₄ release
  - VFA uptake

- **Leaving Anaerobic Zone**
  - Poly-P'
  - PHB

- **Aerobic Zone**
  - Poly-P'
  - o-PO₄ uptake
  - Bio-P organisms growth

RAS recycle to Anaerobic Zone

**PHB - Polyhydroxybutyrate**
Typical WWTP

Influent → Primary Clarifier → Biological Treatment → Secondary Clarifier → Tertiary Treatment → Effluent

Primary Thickening → WAS Thickening

Digester → Dewatering

Centrate/Filtrate

Area for potential struvite formation

Rich in $\text{o-PO}_4$
Struvite Recovery and Benefits
Phosphorus Recovery by Struvite Crystallization

Mg$^{2+}$ + NH$_4^+$ + HPO$_4^{-2}$ + 6H$_2$O $\leftrightarrow$ MgNH$_4$PO$_4$ • 6H$_2$O + H$^+$

Magnesium Ammonium Phosphate Hexahydrate
- Slow release fertilizer
- Metastable compound that will decompose to Newberyite (MgHPO$_4$•3H$_2$O)
- Molecular weight = 245.3 g/mole $\rightarrow$ 7.91 kg struvite per kg P

Chemical addition
- Mg(OH)$_2$, MgO, MgCl$_2$ (for Mg deficient wastewaters)
- NaOH (pH control) – Typically 8.0 to 8.8
- Aeration can be used for specific wastewaters to increase pH by way of CO$_2$ stripping

Operating Conditions and Performance
- Hydrodynamics and struvite residence time
- Crystallizer effluent TP = 10 to 40 mg/L
Enhanced Nutrient Recovery

- Until recently believed that there was less than 100 years of phosphorus reserves
- China recently imposed doubled tariffs on phosphorus exports
- Price of Phosphate rock has soared over past couple of years
- USGS recently revised its estimates to predict 400 years of reserves remaining

*Phosphorus production – 90% in 5 regions. Source IFDC.*
Current Phosphorus Cycle

1. PHOSPHATE ROCK
2. FERTILIZER PRODUCTION
3. AGRICULTURE
4. FOOD CONSUMPTION
5. WASTEWATER TREATMENT

MINING
Carbon-intensive process of a non-renewable resource

INDUSTRIAL WASTE
Disused phosphorus

FOOD PRODUCTION
Leaching and runoff into waterways

INCREASED WASTE
Phosphorus from humans

POINT SOURCE POLLUTION
Strict nutrient limits

DEAD ZONES
Point and non-point source polluters increase excess phosphorus in waterways creating algae blooms that destroy precious ecosystems

Issues with the current Phosphorus Cycle

Top Sources
Morocco
Iraq
China
Algeria
Syria

University of Delaware Cooperative Extension
Circular Phosphorus Cycle

1. RESOURCE RECOVERY FACILITY
   - PEARL® and WASSTRIP®: Transform phosphorus into market-ready fertilizer

2. SUSTAINABLE AGRICULTURE
   - CRYSTAL GREEN®: Root-Activated™ fertilizer reduces leaching and runoff

3. FOOD CONSUMPTION
   - RENEWABLE RESOURCE: Phosphorus from human waste

**CIRCULAR ECONOMY**

Ostara’s Pearl process recovers nutrients from a renewable source and transforms them into an environmentally friendly, high-value fertilizer.

Where to Apply Controlled Struvite Precipitation?

Influent → Primary Clarifier → Biological Treatment → Secondary Clarifier → Tertiary Treatment → Effluent

- Primary Thickening
- WAS Thickening
- Digester
- Dewatering

- Centrate/Filtrate
- Dewatered Cake
Application of Controlled Struvite Precipitation - Centrate/Filtrate

Influent → Primary Clarifier → Biological Treatment → Secondary Clarifier → Tertiary Treatment → Effluent

- Primary Thickening
- WAS Thickening

Area for potential struvite formation

- Digester
- Dewatering

- Struvite Crystallizer

Breaks o-PO4 recycle

Dewatered Cake → Centrate/Filtrate → Struvite
Application of Controlled Struvite Precipitation - Digested Sludge

Influent → Primary Clarifier → Biological Treatment → Secondary Clarifier → Tertiary Treatment → Effluent

Primary Thickening → WAS Thickening

Prevents struvite in dewatering and sidestream

Struvite Crystallizer → Dewatering

Some struvite possible in Digester

Breaks o-PO4 recycle

Centrate/Filtrate
Struvite Technology Suppliers
Technology Suppliers

**Centrate**
- Ostara Pearl ®
- Multiform™ Harvest
- Struvia – Veolia
- Schwing (NuReSys®)
- ANPHOS®
- PHOSPAQ™
- Crystalactor®
- Phosnix®
- Schwing

**Digested Sludge**
- CNP AirPrex™
- Schwing (NuReSys®)
Ostara
Pearl® Process – Applied to Centrate

• Ostara Nutrient Recovery Technologies (Vancouver, BC)
• Pelletized product: Crystal Green®
• 14 Worldwide Installations
• 3 standard size reactors
Waste Activated Sludge Stripping to Remove Internal Phosphorus (WASSTRIP®)

Waste Activated Sludge Stripping to Remove Internal Phosphorus (WASSTRIP®)

Application of Controlled Struvite Precipitation - Centrate/Filtrate with WASSTRIP®
WASSTRIP Process Benefits

• Reduces potential for nuisance struvite formation in the Digester and Dewatering → Maximizes P-recovery

• Other Ostara claims:
  – 10-20% reduction in sludge production
  – Up to 4% increase in dewaterability
  – Reduction in polymer consumption
Multiform Harvest™
Mulitform Harvest - Cone-Shaped Crystallizer – Applied to Centrate

- Mulitform Harvest (Seattle, WA)
- Dry product processed offsite
- 4 US Installations
MULTI-WAS™ Alternative to WASSTRIP for EBPR Plants

Multiform Harvest’s proposed flow scheme for recovering P from WAS pre-digestion liquor at EBPR plants

http://www.multiformharvest.com/
AirPrex® Process – Applied to Digested Sludge

- Struvite directly crystallized and recovered from digested sludge
- Developed in Berlin, Germany
- Marketed by Centrisys/CNP (Germany)
- 7 Installations in EU
One of the larger benefits of this technology is to eliminate struvite fouling in the dewatering and sidestream while also improving dewaterability (increase dry solids content).
Struvite Precipitation AirPrex

Crude product quality requires further processing.
AirPrex Pilot Results

Orthophosphate

91% Average Reduction in PO₄-P!
Also 14 – 16% in NH₃-N
Airprex Pilot Results – Polymer Curve

- 2-4% Dewatering Improvement
- Polymer Reduction
AirPrex Pilot Results – Extended Run

Graph showing the comparison of Cake (% TS) and Feed (% TS) with and without Airprex. The graph shows:
- Without Airprex: Cake (% TS) is between 20.0% and 21.0%, Feed (% TS) is consistently at 17.0%.
- With Airprex: Cake (% TS) is between 19.0% and 20.0%, Feed (% TS) is between 17.0% and 18.0%.

Key points:
- 28 lb/DT without Airprex
- 28 lb/DT with Airprex
- 31 lb/DT with Airprex
Summary and Final Thoughts
Summary and Final Thoughts

• There are several ways to turn nuisance struvite to an opportunity but depends on drivers
  – Economics
  – Market for product
  – Reduced maintenance
  – Improved performance (improved dewatering)

• Numerous technology suppliers available with different configurations
  – Potential to combine options

• Options for struvite recovery will be compared to other methods
  – Dealing with maintenance
  – Use of chemicals such as Ferric
Questions?

IF YOU ASK ME QUESTIONS

THAT'D BE GREAT