Bio-P, Digestion and Dewatering: Unexpected Consequences?

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Presentation Outline

- History/Background Information
- Supporting Evidence
- Suspected Causative Factors
- What the Future May Hold
- déjà vu?
History/Background Information
Sun Prairie WPCF

- **Major Plant Upgrade 2006**
  - RBC to Bio-P Nitrifying Activated Sludge
  - Anaerobic Digestion Improvements
  - Belt Filter Press Dewatering
    > Pilot Testing Before Construction => Dewatered Cake ~ 22% TS

- **Startup Last Quarter 2006/Early 2007**
  - Initial Dewatered Cake ~ 17-18% TS
  - Cake Solids Decreased Over Several Month Period
    > Currently Achieving 12-13% TS
Sun Prairie WPCF
Beloit WPCF

- Bio-P & Anaerobic Digestion Since 1992
- Added BFP in 2012
- Dewatered Cake Characteristics
  - Good Release From Belt
  - No Free Water (Appears Typical of 18% TS +/-)
  - 10-12% TS Typical
- Plant Staff Worked to Optimize Performance
Beloit WPCF

- **Dewatering Optimization Efforts**
  - Moved Polymer Injection & Mixing Valve Location
  - Added Belt Spray Bars in Washboxes
  - Increased Belt Hydraulic Pressure
  - Added PRV to Eliminate Gas Binding in Feed Line
  - Put Second Digester Online to Increase VS Destruction

- **Results: Currently Achieving ~ 15% TS**
  - At Similar Polymer Dosage & Sludge Feed Rate
Marquette (MI) WWTF

- **Major Plant Upgrade 2009**
  - RBC to Bio-P Nitrifying Activated Sludge
  - Anaerobic Digestion Improvements
  - Belt Filter Press Dewatering

- **Startup**
  - Initial Dewatered Cake ~ 12-14% TS
  - Changed Polymer Spring 2011
    > Currently Achieving 14-18% TS
Kiel WWTP

- Activated Sludge, Anaerobic Digestion, BFP Dewatering & RDP EnVessel Pasteurization
  - Dewatered Cake 15-19% TS

- Converted to Bio-P ~ April 2012
  - Dewatered Cake 15-16% TS

- What’s Different Than Sun Prairie, Beloit, Marquette???
  => Only Primary Sludge Goes to Anaerobic Digestion
However, there have been consequences...

Significant Reduction in Stack Height
Ok, Is This Real or Not???

Others Are Also Seeing This, Including:

- Hampton Roads Sanitary District Atlantic & Nansemond Plants
- Met Council Environmental Services Empire & Blue Lake Plants
- Metro Denver, CO

A number of plants in Europe as well...
HRSD Plants

- Nansemond
  - Anaerobic Digestion & High Solids Centrifuges
  - Originally VIP/MUCT With Supplemental Ferric
    > Dewatered Cake 22-24% TS Consistently
  - Conversion to 5 Stage Bardenpho, Ostara & No Ferric
    > Dewatered Cake 18-18.5% Solids
  - Was Ferric Addition Making a Difference, or Did Ostara Have an Impact?
HRSD Plants

- **Atlantic**
  - Originally HPO With CEPT (using Ferric & Polymer), Anaerobic Digestion, Centrifuge Dewatering
    > Poor Settleability Mixed Liquor
    > Dewatered Cake ~ 19% TS
  - Converted HPO to A/O, Eliminated CEPT, Acid/Methane Digestion
    > Bio-P & Struvite Formation
    > Excellent Settleability Mixed Liquor
    > Dewatered Cake 15-17% TS
  - Was Deterioration Related to Elimination of Ferric, Formation of Struvite, or Combination?
HRSD Atlantic Plant

Selector online

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Courtesy of Neethling, Benisch, 2013
MCES Empire Plant

Courtesy of Sprouse, 2013
MCES Thoughts to Date

Empire

- **Was Deterioration in Dewatering Due to:**
  - Going from two-stage to single stage activated sludge?
  - Bio-P?
  - New soluble waste streams increasing WAS/PSD ratio to digestion?
  - Combination?

Blue Lake

- **Bio-P, Dewatering, Added Anaerobic Digestion**
- **Dewatering Has Deteriorated Since Digestion Added**
Suspected Causative Factors

- **Divalent Cation Bridging is Primary Theory**
  - Prominent Divalent Cations Are $\text{Mg}^{2+}$, $\text{Ca}^{2+}$ and $\text{Fe}^{2+}$
  - Prominent Monovalent Cations are $\text{Na}^{+}$ and $\text{K}^{+}$
  - Post Digestion Struvite Formation Lowers Divalent Cation Concentration While Not Affecting Monovalent Cations

- **Alternate Theory: Soluble P Concentration of Digested Sludge**
  - Evidence that soluble Ortho-P binds water to solids
Divalent Cation Bridging Theory

Extracellular Biopolymers with (-) Functional Groups

More Interstitial water

Divalent Cations

Monovalent Cations

Courtesy of Sprouse, 2013
What’s The Future Look Like?  Focused Research Efforts Currently Underway…

- Bucknell University, HRSD & Clean Water Services
  - Lab Scale Digesters (M/D Cation Ratio & Concentrations, Effect of Specific Cations – Particularly K⁺)
  - National Survey (With Cooperation From Many)

- MCES
  - Role of Cations on Dewatering, & Impacts of Bio-P and Digestion
  - Other Factors Such As Belt Blinding, Dewatering Aids, Etc.

*We’re on a learning curve, similar to struvite a couple decades ago.*
Early Returns...MCES

▪ Unaerated Bio-P WAS Storage (3 Days HRT) with Ferric Addition
  – Cake Solids Increases of 0.5-4% TS
  – Soluble P in Digested Sludge Appears to Matter – Less Soluble P Results in Higher Cake Solids

▪ Digested Sludge Pre-Dewatering Treatment
  – CO2 Stripping Followed by Addition of Divalent/Trivalent Cations (Mg, Fe, Ca)
  – Cake Solids Increases of 2-3% Attained

MCES continues to experiment...
A Final Thought...

As with many issues in our industry – are we simply re-learning the past?
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Thanks for your attention!

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