

33rd Annual Spring Biosolids Symposium
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Bio-P, Digestion and Dewatering: Unexpected Consequences?

Bill Marten and Eric Lynne

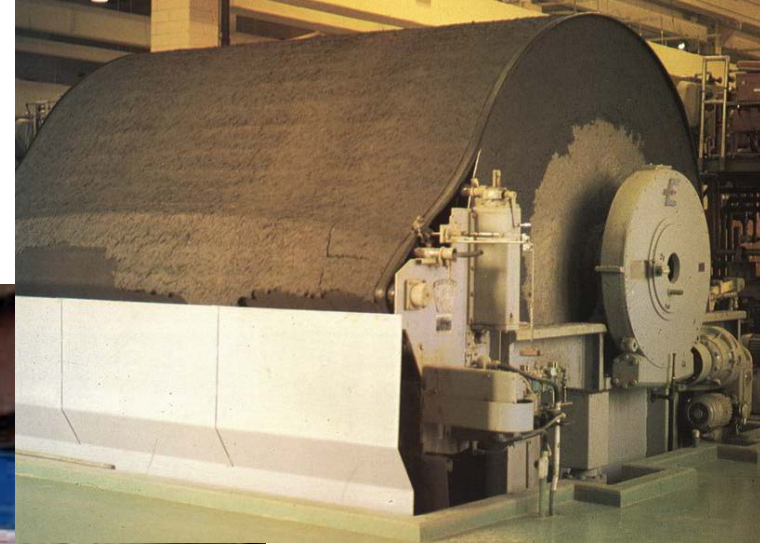


Presentation Outline

- History/Background Information
- Supporting Evidence
- Suspected Causative Factors
- Recent Results/Findings
- déjà vu?

But first, a trivia question...

Can anyone name these devices?



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
 - Poor Stacking Ability

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
 - Bio-P: April 2009/BFP: December 2009
 - 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???
 - =>Anaerobic Digestion Fed Mostly Primary Sludge

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
- Madison Metropolitan Sewerage District
- 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?

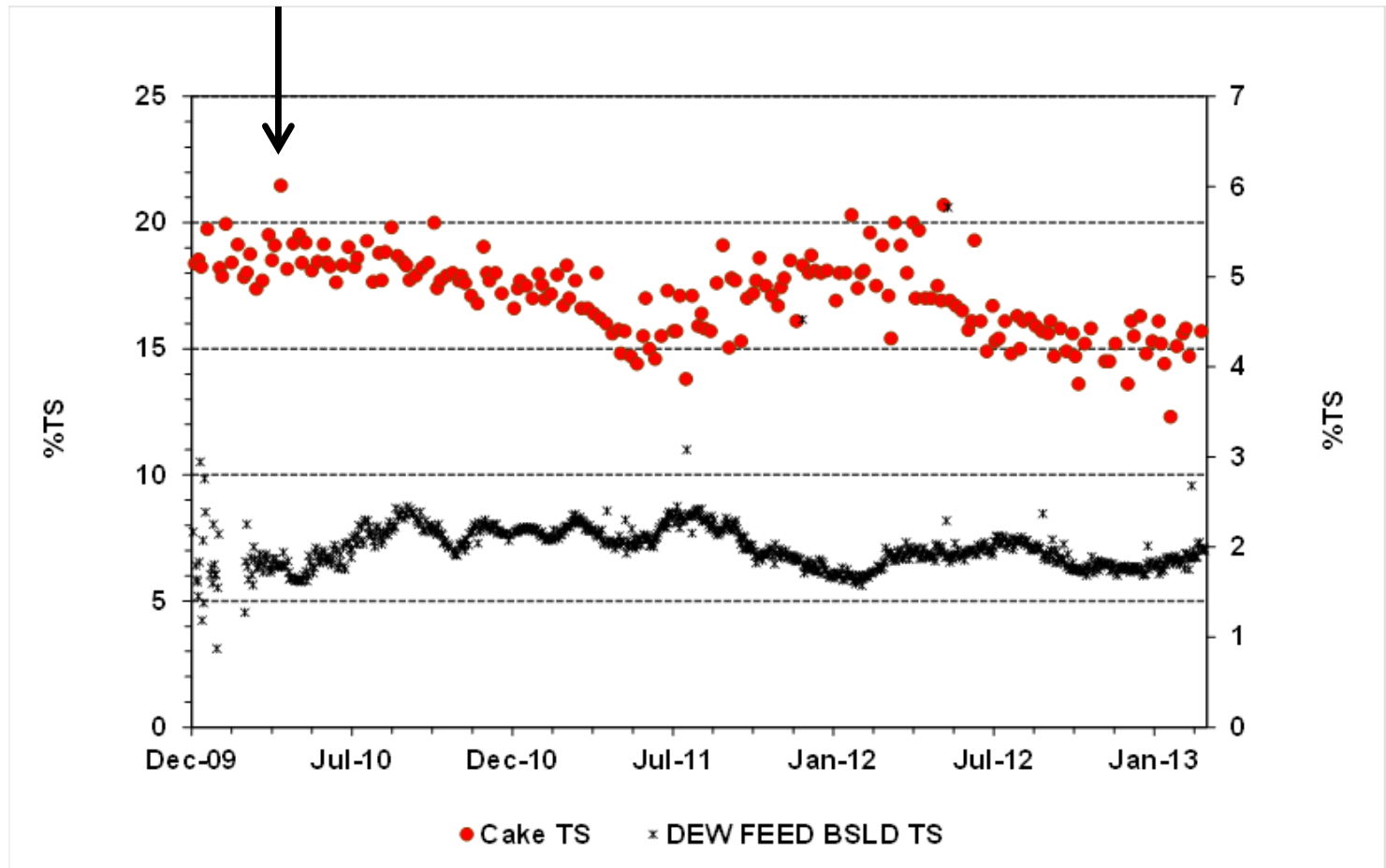
HRSD Plants

➤ 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

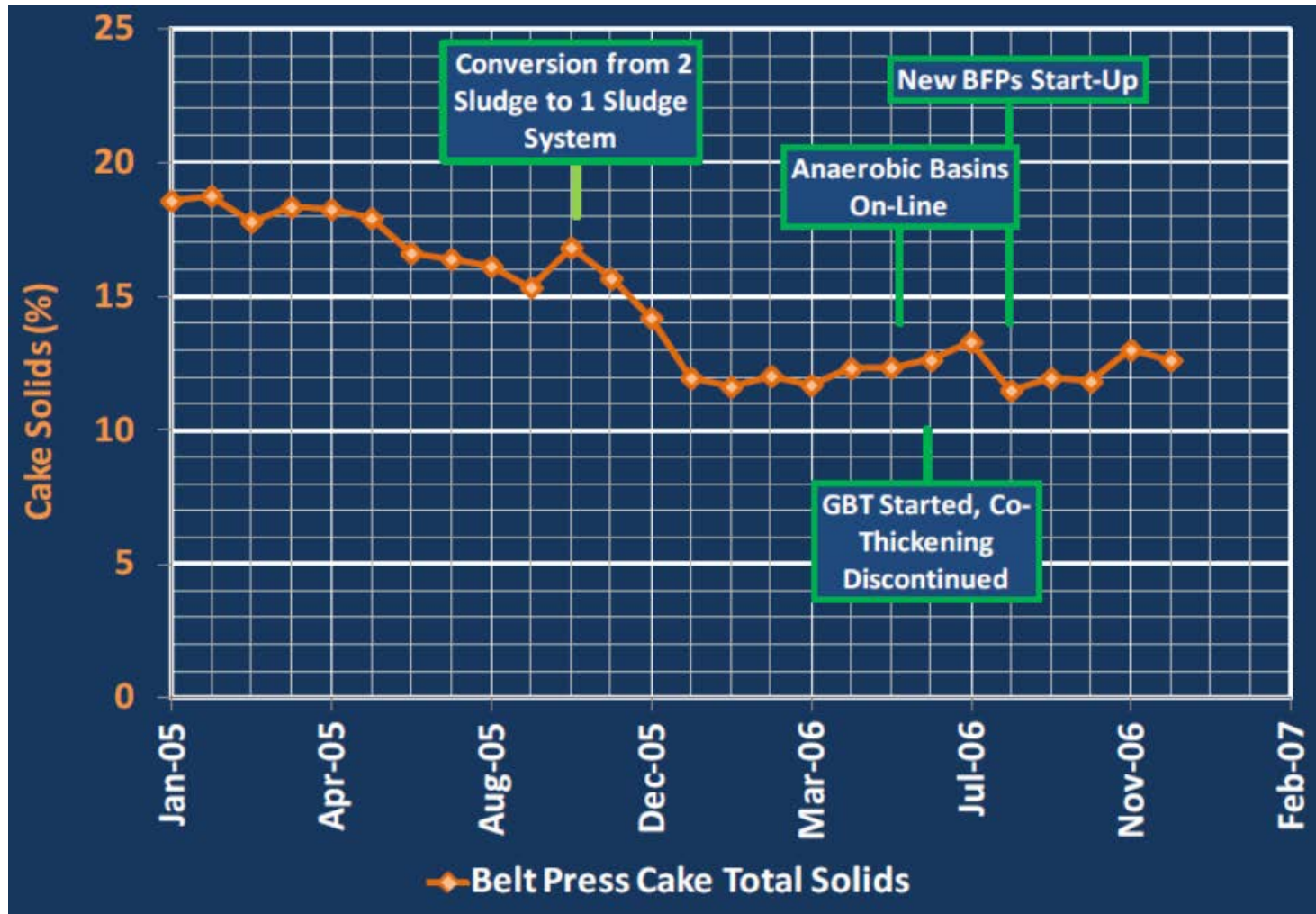
Selector online



Madison MSD

- Anaerobic Digestion for Decades
- Converted Activated Sludge to Bio-P in 1997
- Added Dewatering Centrifuge for Class A Biosolids in mid-decade 2000-2010
 - Piloting Showed 22% TS Achievable
 - Full-Scale Has Only Been Able to Achieve 19% TS
- Recent Solids Modifications Including:
 - Multi-Phased Digestion
 - Ostara Struvite Harvesting

MCES Empire Plant



Courtesy of Sprouse, 2013

MCES Initial Thoughts

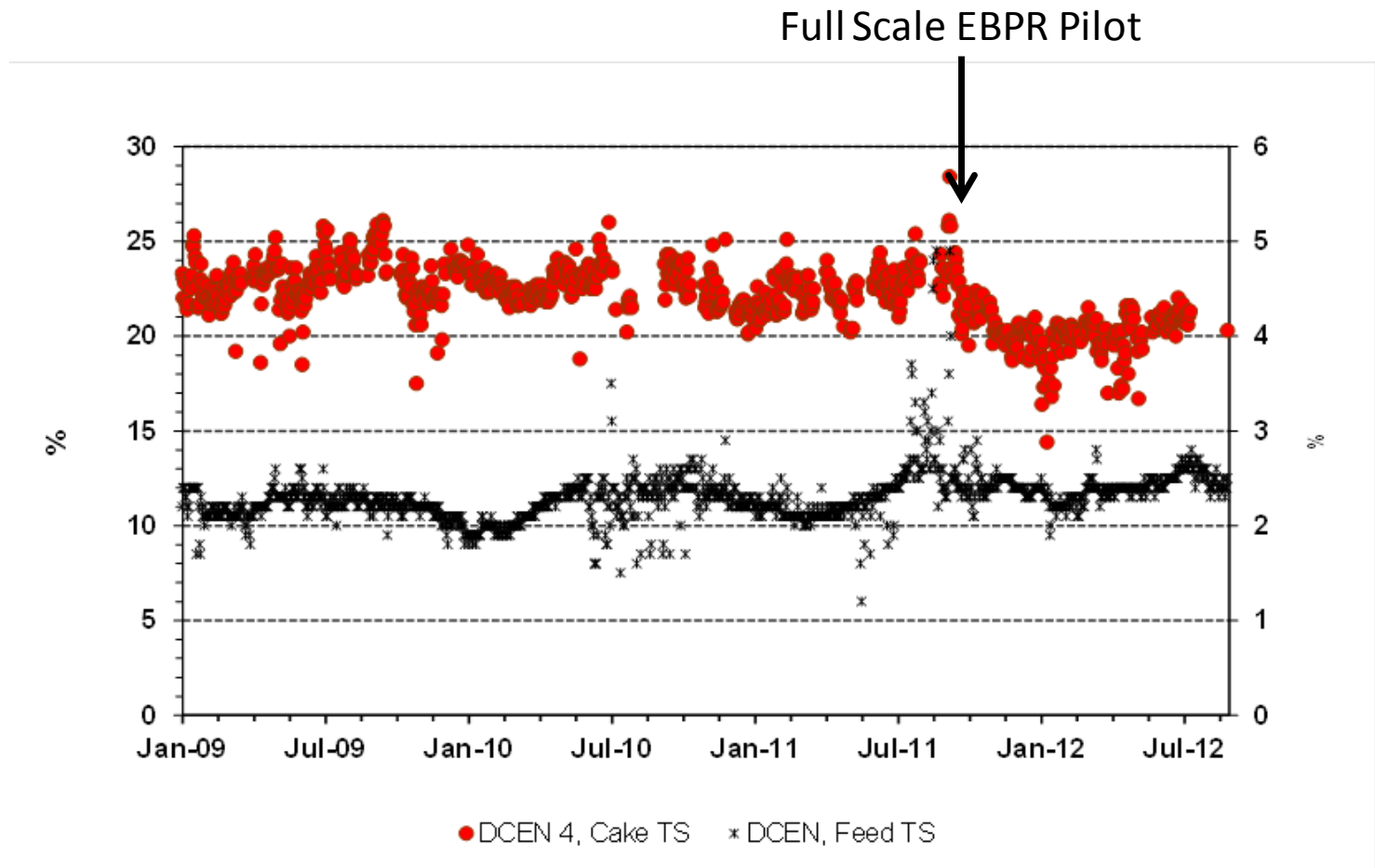
Empire WWTP

- 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 WWTP

- Bio-P, Dewatering, Added Anaerobic Digestion
- Dewatering Has Deteriorated Since Digestion Added

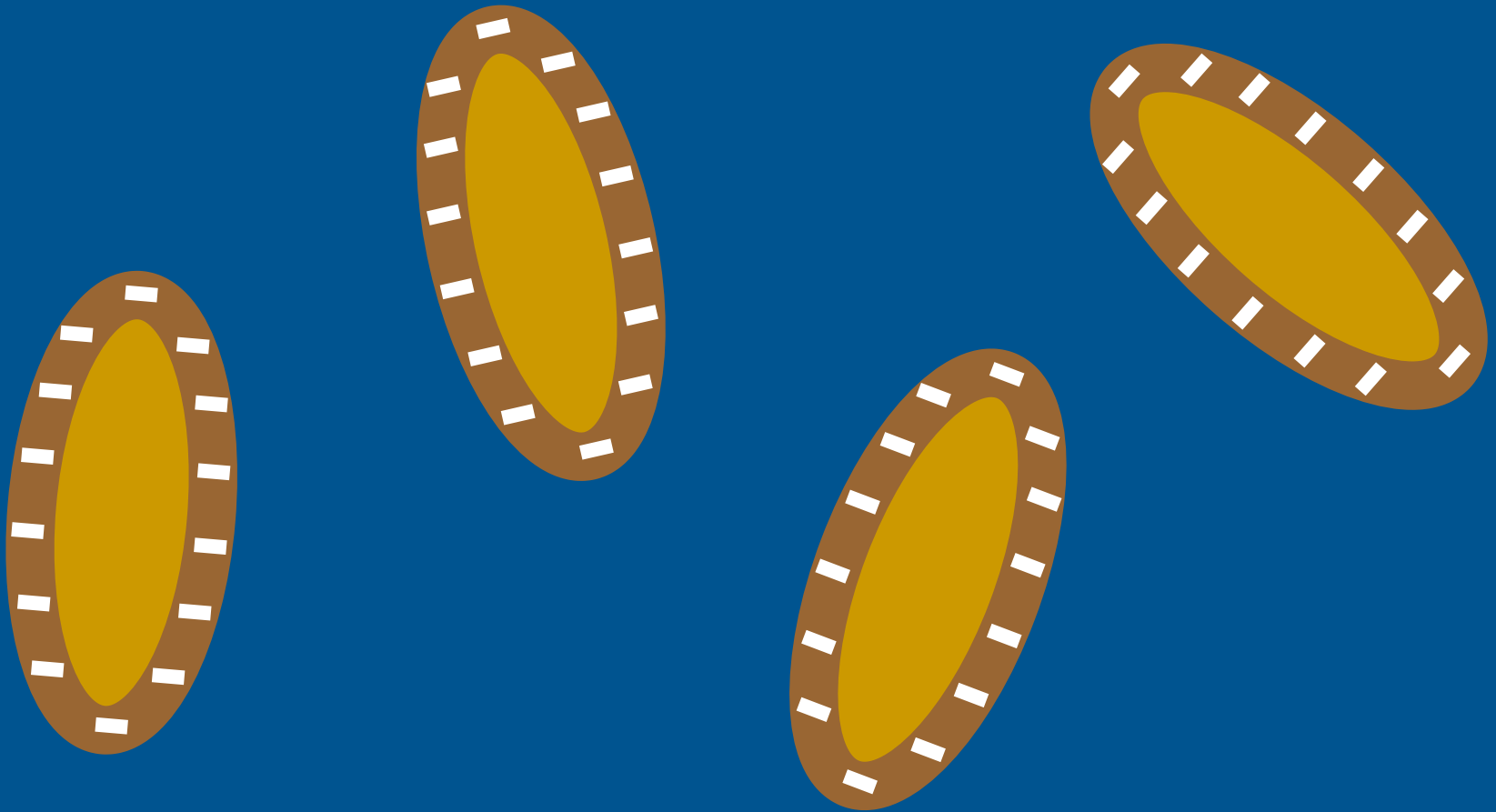
Metro Denver, CO Robert Hite WWTF



Suspected Causative Factors

- Soluble P Concentration of Digested Sludge
 - Evidence that soluble Ortho-P binds water to solids
- Divalent Cation Bridging (DVC)
 - Prominent Divalent Cations are Mg^{2+} , Ca^{2+} and Fe^{2+}
 - Prominent Monovalent Cations are Na^+ and K^+
 - Decreased Divalent Cation content results in deteriorated flocculation, settling, dewatering

Most Sludge Floc Surfaces Are Anionic

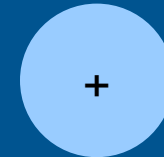


Common Cations in Wastewater

Monovalent – Single Plus (+) Charge:

Sodium

Potassium



Divalent – Double Plus (++) Charge:

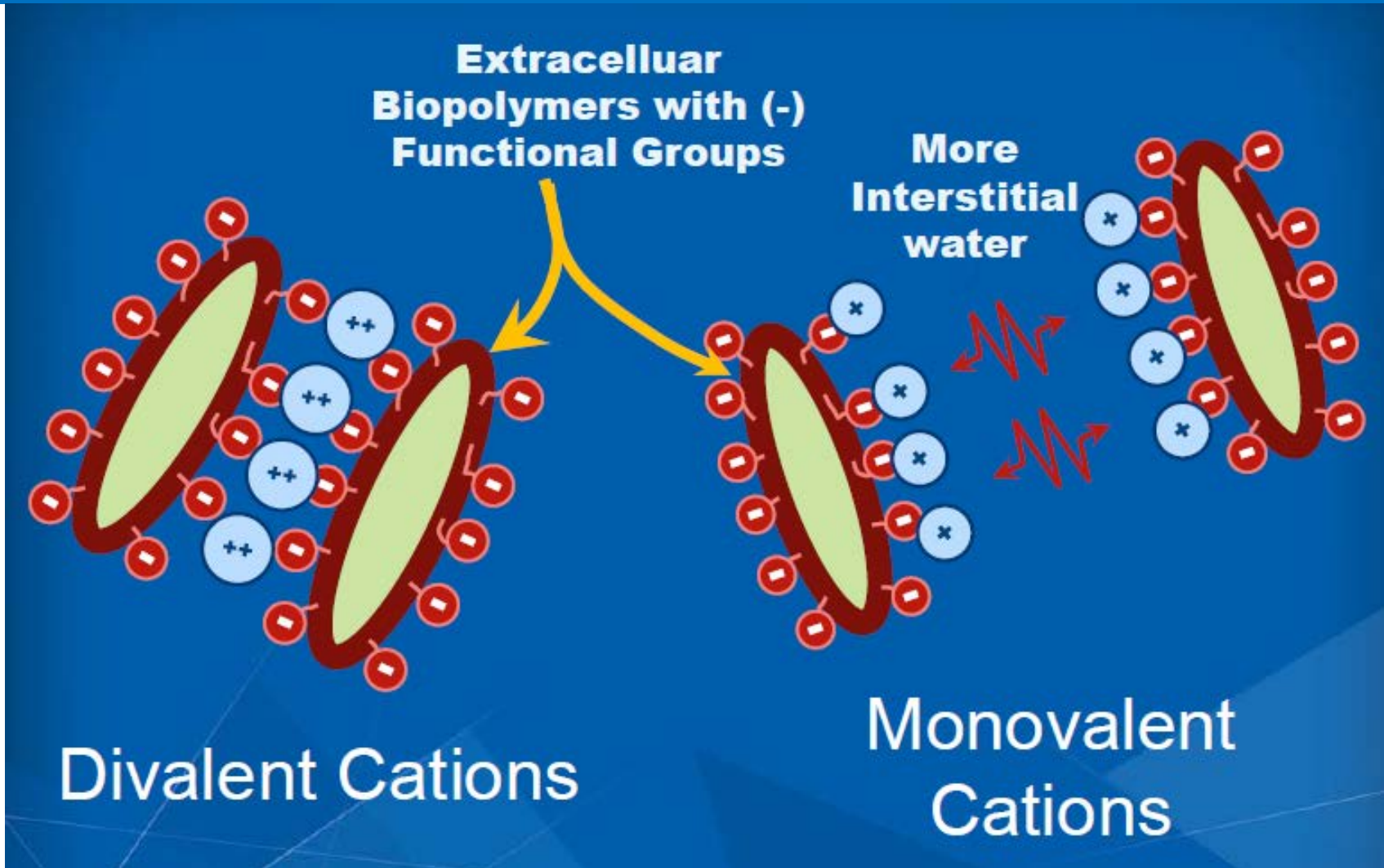
Magnesium

Calcium

Iron

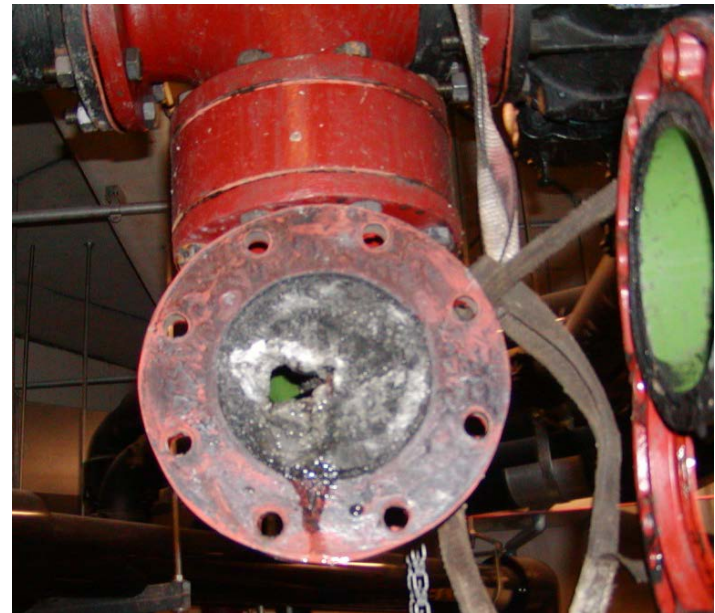
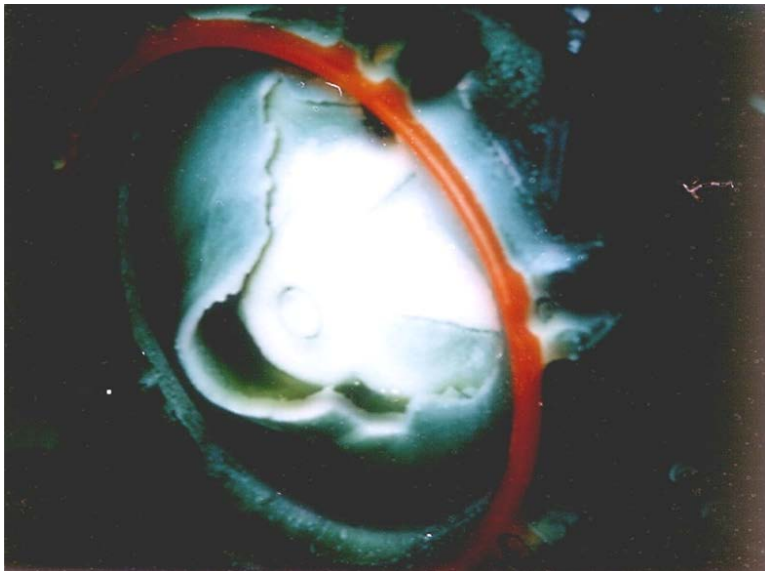


DVC Theory, in a Nutshell



DVC Theory

- When Divalent to Monovalent Cation Content Decreases, Dewatering Deteriorates
 - e.g., Struvite formation, reducing soluble Mg^{2+} content in sludge



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)
- Madison MSD
 - Effect of Ferric, Digestion Phasing, Dewatering Polymers & Struvite Harvesting on Dewatering Performance
- MCES
 - Effect of Cation Addition & Dewatering Pretreatment Aids on Dewatering Performance

We're on a learning curve, similar to struvite a couple decades ago.

Madison MSD Findings

It's Complicated...

- Adding Ferric Improves Thickening & Dewatering Performance
 - Is This Due to Less Soluble Phosphorus or More Divalent Cations?
- Ferric Addition is Constrained by Desire to Produce Marketable Struvite Product
 - Either Precipitate Reduces Soluble Phosphorus
 - Struvite Reduces Divalent Cation Content

Early Returns...MCES

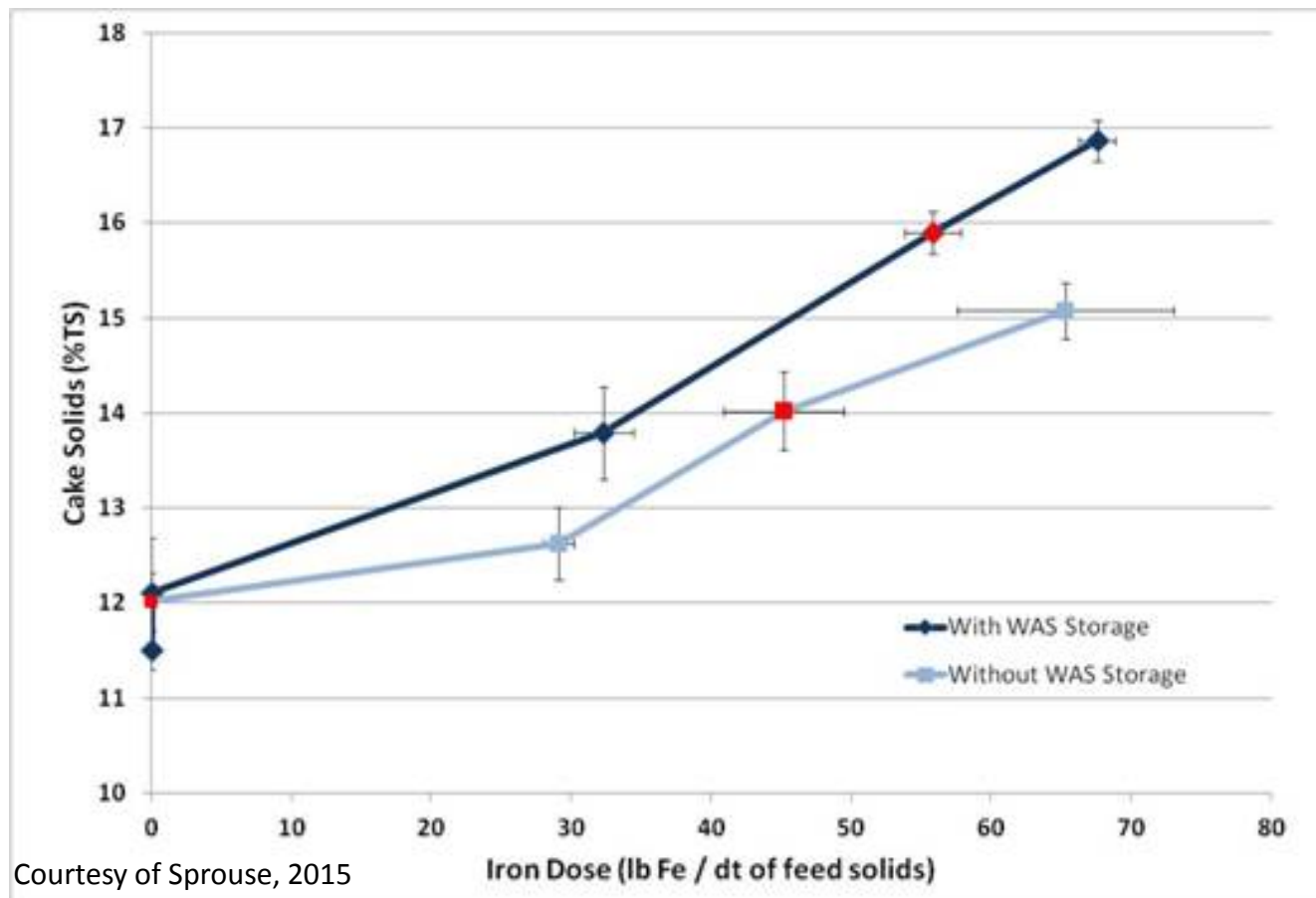
- Unaerated Bio-P WAS Storage (3 Days HRT) with Ferric Addition
 - Cake Solids Increases of 0.5-5% TS
 - Type of Cation Addition Matters (e.g., FeCl_3 vs $\text{Fe}(\text{OH})_3$ vs AlCl_3)
- Digested Sludge Pre-Dewatering Treatment
 - CO_2 Stripping Followed by Addition of Divalent/Trivalent Cations (Mg, Fe, Ca)
 - Cake Solids Increases of 2-3% Attained

MCES continues to experiment...

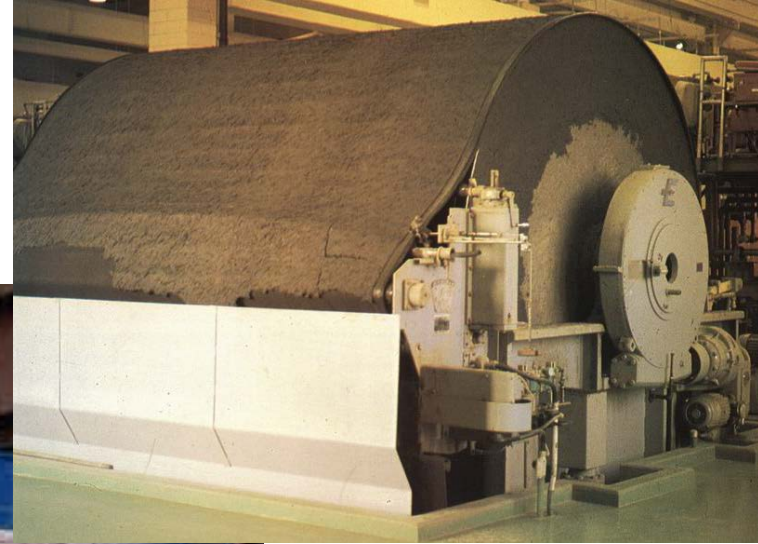
Recent MCES Research Results

Empire WWTP

- Ferric Chloride & WAS Storage Both Improve Dewaterability



A Final Thought...



As with many issues in our industry – are we simply re-learning the past?

Acknowledgements

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Thanks for your attention!

Bill Marten, PE, BCEE
Donohue & Associates, Inc.
731 N. Jackson Street, Suite 610
Milwaukee, WI 53202
Phone: 414.217.6909
Email: wmarten@donohue-associate.com

