Sustainable Struvite Control
Using Residual Gas from
Digester Gas Cleaning Process

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Jing Luo, PhD, PE
Manager, Sustainability and Energy Management Office (SEMO), Pima County Regional Wastewater Reclamation Department (PCRWRD)

Jerry Bish, PE, BCEE – Regional Optimization Master Plan (ROMP) Program Manager, Greeley and Hansen
Presentation Overview

- Project Background
- Biosolids Management
- Struvite Control
- Carbon Dioxide Considerations
- Research Objectives
- Research Plan
- Project Schedule
- Deliverables
- Questions
PCRWRD’s Mission Statement:
“Our mission is to protect the public health, safety, and the environment by providing quality service, environmental stewardship and renewable resources.”

Customers Served 900,000+
PCRWRD Integrated Sustainability Program

• Seven Building Blocks:
Project Background

- **Tres Rios WRF (formerly Ina Road WRF):**
  - Rated Treatment Capacity of 50 MGD
  - Tertiary Treatment with Biological Nutrients (N, P) Removal

- **Agua Nueva WRF:**
  - Rated Treatment Capacity of 32 MGD
  - Tertiary Treatment with Biological Nutrients (N, P) Removal
  - On-line January, 2014
  - No On-site Solids Treatment

- **Roger Road WRF:**
  - Rated Treatment Capacity of 41 MGD, Secondary Treatment
  - Decommissioned January, 2014

- **Regional Biosolids Management Facility**
  - Located at Tres Rios WRF
  - Centralizes Biosolids Handling and Treatment
  - Treats Majority of Biosolids Produced in Pima County
Anaerobic Digestion at Both Regional Facilities Produce Class B Biosolids

Digested Biosolids Pumped from Roger Road WRF to Tres Rios WRF for Dewatering and Beneficially Use Through Land Application

Green Valley WRF - 4.1 MGD Plant, Separate Biosolids Handling and Utilization Outlet
Biosolids Management - After

- Brand New Agua Nueva WRF Replaced Roger Road WRF
- Partially Thickened Raw Sludge Pumped from Agua Nueva WRF to Tres Rios WRF for Further Treatment
- Green Valley WRF Sludge Wet Hauled to Tres Rios WRF for Further Treatment
- All Sludge Treatment and Biosolids Agricultural Land Application Are Centralized
What is Struvite?

- Struvite is a Mineral Compound (MgNH₄PO₄+6H₂O) Formed by Combination of Magnesium, Ammonia, and Phosphate

- Challenging Chemistry:
  - Solubility of Struvite Decreases Dramatically with a Small Increase of pH in the Range of 7-8

- Without Proper Control, Struvite Formation Clogs Pipes and Process Equipment Increasing Maintenance Requirements/Costs
Struvite Formation in BNR Process

- Biological Nutrient (N, P) Removal = More Latent Struvite Potential
  - Especially with P Removal, P is Concentrated in Biosolids as Polyphosphate
  - Under Anaerobic Condition, $\text{PO}_4^{3-}$ and $\text{Mg}^{2+}$ Release from Polyphosphate and Increase the Concentrations in Digested Sludge and Centrate
Existing Side Stream Treatment and Struvite Control

- Side Stream is a Nutrient Rich Wastewater Stream Derived from Biosolids Thickening and Dewatering
- Currently, the Side Streams are Pumped to the Headworks and Treated in the Main Stream Processes
- Struvite is Controlled by Chemical Addition of Ferric Chloride at Strategic Locations
- Estimated Annual Ferric Chloride Cost is $926,000 - $1,075,000
Why Carbon Dioxide (CO₂)?

• CO₂ reacts with water to form carbonic acid, which subsequently dissociates to bicarbonate and carbonate ions, liberating protons.

• CO₂ is safe and less corrosive to use when compared to other chemicals.

• It is reversible without permanently bonding with phosphorus, which is subject to be recovered later.

• Wastewater treatment facilities, such as Stickney WRP, has gained some experience on using CO₂ for struvite control.
  • Lowered the pH from 7.2 to 6.5 in digested sludge
  • Lowered 7.9 to 7.2 in centrate.

• Most importantly, CO₂ is produced in most of WRRFs – Biogas!

<table>
<thead>
<tr>
<th>Digester Location</th>
<th>CO₂</th>
<th>H₂S</th>
<th>N₂</th>
<th>CH₄</th>
<th>Total</th>
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<tbody>
<tr>
<td>Roger Road</td>
<td>39.9</td>
<td>0.29</td>
<td>1.2</td>
<td>58.6</td>
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<td>Ina Road</td>
<td>39.6</td>
<td>0.28</td>
<td>0.7</td>
<td>59.4</td>
<td>99.94</td>
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* Gas composition data presented as percent of total volume
Statement of Importance

• Unintended struvite precipitation in digesters and associated piping/equipment is a common, costly problem especially in WRRFs with biological phosphorus removal.

• Struvite formed rapidly in Tres Rios WRF (formerly Ina Road WRF), in the first a few months after the new five-stage Bardenpho process was commissioned.

• Significant quantities of ferric chloride were needed to bind the orthophosphates to prevent struvite formation.

• Commercial ferric chloride is not a user friendly chemical to receive, store or handle.

• Biogas typically contains 40% CO₂.

• Usage of CO₂ from biogas represents a sustainable alternative without relying on commercial chemicals.
CO₂ Source from Biogas Production
(700,000 to 1,000,000 cubic feet per day biogas - 40% is CO₂)
Questions Leading to the Proposed Research:

Question #1: Can CO₂ Generated in Anaerobic Digesters be Beneficially Used?

Approach:
- White Paper Study – “Beneficial Utilization of the CO₂-rich Residual Gas from Biogas Cleaning Process” conducted by the University of Arizona
- Preliminary answer is: Possible

Question #2: Can CO₂ be Used to Control Struvite?

Approach:
- Reached out to the industry and other municipalities for similar application
- Learned the practices at Stickney WRP in Chicago
- Answer is Yes.

Question #3: Is it Feasible to Use Impure CO₂ Generated in Anaerobic Digesters to Control Struvite?

Approach:
- WERF Research Proposal “Sustainable Struvite Control Using Residual Gas From Digester Gas Cleaning Process” was born.
Research Objectives

Water Chemistry Objectives:
• Determine target pH level and acid demand for mitigating struvite deposition.
• Evaluate the effectiveness (both equilibrium and kinetics) of pH adjustment at multiple points within solids processing, including the digested sludge and dewatering side-streams by CO₂ injection.

Design Objectives:
• Determine the impacts of the impurities (ammonia, hydrogen sulfide, etc.) and variation in the residual gas, on the effectiveness of pH adjustment in digested sludge and dewatering side-streams.
• Determine the impact of gas phase impurities and variation on equipment including: (i) CO₂ injection equipment; and (ii) automatic control systems. Meanwhile, assess potential to optimize the digester gas cleaning process to be more compatible with the utilization of the residual gas.
• Estimate the lifecycle cost of using residual gas to mitigate struvite formation. And verify/quantify the environmental benefits of the proposed practice. Develop a framework to allow a rapid viability screening and implementation of the projects of the same nature.
**Bench Scale Testing**

- Experiments with pure CO$_2$ and mixed gases.
- Liquid phase with DI water (for model validation) and centrate.
- Simultaneous experiments performed on strong acid titration of centrate to determine proton demand.
Experiments performed in plant.
Liquid phase from the centrate line.
Gases include commercial CO$_2$ and treated biogas from the plant.
Project Team and Collaborators

WERF Program Management
- Dr. Amit Pramanik – Sr. Program Director

PCRWRD Principal in Charge
- Jackson Jenkins – PCRWRD Director

Project Management/Reporting
- Dr. Jing Luo, PE – PCRWRD
- Michael Gritzuk, PE – PCRWRD

Modeling and Bench Scale Studies
- **Task 1: Modeling**
  - Dr. Robert Arnold – UA
  - Dr. Dimitrios Katehis, PE – Greeley and Hansen

- **Task 2: Identify Optimum pH**
  - Dr. Eduardo Saez - UA
  - Dr. Michael Kostrzewski, PE – PCRWRD
  - Dr. Jeff Prevatt - PCRWRD

- **Task 3: Performance and Impact of Impurities**
  - Dr. Eduardo Saez - UA
  - Dr. Michael Kostrzewski, PE – PCRWRD

Pilot Scale Studies (Task 4)
- **Subtask 4.1: Performance and Impact of the Impurities**
  - Dr. Eduardo Saez - UA
  - John Sherlock - PCRWRD

- **Subtask 4.2: Equipment Evaluation**
  - Dr. Chris Wilson, PE – Greeley and Hansen
  - Dr. Michael Kostrzewski, PE – PCRWRD
  - Steve Wirtel, PE – Ostara

Economics
- **Task 5: Lifecycle Cost and Environmental Benefits**
  - Jerry Bish, PE – Greeley and Hansen
  - John Sherlock - PCRWRD

- **Task 6: Feedback to Digester Gas Vendor**
  - Jerry Bish, PE – Greeley and Hansen
  - Sean Mezel, PE – Greenlane Biogas, Ltd.

- **Task 7: Develop Protocols**
  - Dr. Dimitrios Katehis, PE – Greeley and Hansen
  - Dr. Chris Wilson, PE – Greeley and Hansen
Proposed Project Schedule

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<tr>
<th>Task</th>
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<tr>
<td>Project NTP</td>
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<td>Task 1: Modeling</td>
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<td>Task 2: Identify optimum pH level</td>
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<td>Task 3: Bench scale investigations</td>
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<td>Task 4: Pilot scale investigations</td>
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Deliverables

- Monthly project status reports.
- Final report with a 900-word executive summary at the end of the project.
- Minimum of two conference presentations in major water/wastewater associated conferences.
- Minimum of one paper/article submission to technical journals.
- A stand-alone protocol for rapid viability screening wherever utilization of residual digester gas (primarily CO₂) is considered for prevention of nuisance struvite deposition in the wastewater utilities.
- This research offers a sustainable solution to a common problem (struvite management) among wastewater treatment utilities. The primary target audiences are utilities management and operations in organizations like PCRWRD. The secondary target audiences are practicing engineers and academics.
Request for Financial Assistance !!!! 😊

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PCRWRD Sustainability Program – A Systematic Approach…

- Biosolids
- Biogas
- Nutrients
- Energy
- Technology
- Waste Reduction
Acknowledgement:

- Allison Deines – Director, Special Project, WERF
- Amit Pramanik, PhD. BCEEM – Acting Director of Research, WERF
- Thomas Kunetzk, MWRDGC
- CH₂M Hill
- Ostara
- Greenlane
- Greeley and Hansen
- Jackson Jenkins, Director, PCRWRD
- Michael Gritzuk, Former Director, PCRWRD
Questions...

Contact:

Jing Luo, PhD, PE – PCRWRD Sustainability Manager
Phone: (520) 724-6537
Email: jing.luo@pima.gov