STRUVITE HARVESTED AS A USEFUL BYPRODUCT

Ron Gearhart - Process Coordinator
Making Boise the Most Livable City in the Country
OUR CITIZENS VALUE IMPROVED OUTCOMES

76% of Boiseans voted “YES” to Foothills Open Space and Clean Water Levy

Wastewater survey results:
- Invest to recover water, energy, reduce carbon - ~75%
- Willing to pay for better outcomes - ~70%
OPERATIONAL OPPORTUNITIES AND CHALLENGES OF STRUVITE RECOVERY

WEST BOISE WRF

LASTING • INNOVATIVE • VIBRANT
STRUVITE

• Forms in water when ammonium ion (NH$_4^+$), magnesium ion (Mg$^{+2}$), and phosphate (PO$_4^{-3}$) are present
• Specific pH
• Favorable water chemistry (lack of calcium interference, etc);
• Forms NH$_4$MgPO$_4$·6H$_2$O as either dispersed or as a crystal
Unintentional formation follows Murphy’s Law … as a general rule of thumb

Lower Industry Nutrient Limits Result in operational challenges
WEST BOISE WRF - PHOSPHORUS MASS BALANCE

**Legend:**
- **TP** = Total Phosphorus
- **PI** = Primary Influent
- **PSD** = Primary sludge
- **WAS** = Waste Activated Sludge
- **RAS** = Return Activated Sludge
- (*) Indicates Calculated Value

**Incoming TP (to West Boise):**
- Raw Sewage: TP = 1017 ppd

**TP Leaving West Boise:**
- Plant Effluent: TP = 155 ppd
- Struvite: TP = 480 ppd

**Process Drain:**
- TP = 120 ppd

**Primary Influent:**
- TP 1137 ppd

**LS Sludge:**
- TP = 500 ppd (*)
- Biosolids: TP 845 ppd (*)
Common Struvite Reactor Chemistry
LOWER EFFLUENT NUTRIENT LIMITS RESULT IN HIGHER SIDE STREAM CONCENTRATIONS

- Anaerobic Digester Filtrate Ammonia concentrations approach 1000 mg/L
- Anaerobic Digester Filtrate Dissolved Phosphorous concentrations increased from 80 mg/L to 400 mg/L after EBNR was implemented at West Boise WRF
- Commissioning of the WAS P release process allowed for 50% release of acquired Phosphorous, resulting in Anaerobic Filtrate of 280 mg/L
- WAS P Release tank Phosphorus concentrations range from 160 mg/L to 200 mg/L
- Side stream treatment critical to permit compliance strategy
## Reactor Impacts and Success

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reactor Influent</th>
<th>Reactor Effluent</th>
<th>Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorous</td>
<td>600 Pounds Per Day</td>
<td>120 Pounds Per Day</td>
<td>80% : 480 Pounds</td>
</tr>
<tr>
<td>Ammonia</td>
<td>1350 Pounds Per Day</td>
<td>1080 Pounds Per Day</td>
<td>20% : 270 Pounds</td>
</tr>
</tbody>
</table>

- **Side Stream Treatment**
  - Reduced Phosphorous impact in Primary Effluent From 4 mg/L to 0.80 mg/L
  - Reduced Ammonia impact in Primary Effluent From 8.1 mg/L to 6.5 mg/L

- Reduction of unintentional struvite formation in pipes, anaerobic digesters, dewatering equipment, and storage basins.

- Reduced phosphorus content of biosolids and subsequent impacts to TMSBAS loadings and site longevity

- Recovery of a recyclable product contributing to the City’s sustainability goals by recovering this limited phosphorus-based resource
TRADITIONAL CHEMICAL ALTERNATIVE

- Metal Salts have undesirable consequences
  - Inert solids production increase
  - Unfavorable biosolids impacts
    - Increased solids handling
    - Non-bioavailable phosphorus
    - Increased metal content
  - Additional negative impacts
    - Carbon footprint
    - Compounding chemical use
    - Cost
    - U.V. inefficiencies and maintenance
    - Safety
    - Negative impacts to EBNR
STRUVITE PRODUCTION BENEFITS

• Extracting 480 pounds per day of Phosphorus and subsequent Ammonia (5000 pounds of struvite)
• Reducing nutrient loading in plant recycle stream
• Recovered nutrients have immense fertilizer value
• Limits chemical usage and their negative impacts
• Potential revenue
• Potential cost savings
• Meeting community expectations
• Positive environmental impacts vs Chemicals
STRUVITE PRODUCTION CHALLENGES

- Higher capital cost and footprint
- Additional staff and training
- Complexity, automation
- Product Handling
- Value and Marketing
- Regulatory uncertainty
- Upsets create chain reaction through entire process
REGULATORY CONSIDERATIONS
SUMMARY OF NACWA RECOMMENDATIONS

• Struvite does not fit the regulatory definition of sewage sludge
• Clean Water Act promotes beneficial reuse, local autonomy, flexibility and innovation;
  • Exempting struvite from 503 furthers these goals
• Regulating struvite as sewage sludge constitutes an unreasonable burden to producers of struvite
EPA LETTER - 2017

• “...EPA considers products extracted from sewage sludge that are not land applied, land disposed, or incinerated, but instead sold into a commodity market, outside the scope of Part 503”.

• “...EPA recognizes that some products...could conceivably be so heavily refined or processed that a significant transformation or change in quality has occurred that it would be unreasonable to describe those products as “derived from sewage sludge”.

• “...EPA is willing to consider on a case-by-case basis whether a particular product is ‘derived from sewage sludge’”.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average concentration (mg/kg)</th>
<th>Pollutant Concentration Limit from 40 CFR 503.13, Table 3</th>
<th>Maximum concentration (mg/kg)</th>
<th>Ceiling Concentration Limit from 40 CFR 503.13, Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>1.33</td>
<td>41</td>
<td>4.32</td>
<td>75</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.06</td>
<td>39</td>
<td>&lt;0.20</td>
<td>85</td>
</tr>
<tr>
<td>Copper</td>
<td>2.0</td>
<td>1500</td>
<td>4.32</td>
<td>4300</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt;0.48</td>
<td>300</td>
<td>&lt;1.57</td>
<td>840</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.002876</td>
<td>17</td>
<td>0.00961</td>
<td>57</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.37</td>
<td>--</td>
<td>1.18</td>
<td>75</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.30</td>
<td>420</td>
<td>0.65</td>
<td>420</td>
</tr>
<tr>
<td>Selenium</td>
<td>&lt;0.82</td>
<td>100</td>
<td>&lt;2.56</td>
<td>100</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.04</td>
<td>2800</td>
<td>10.2</td>
<td>7500</td>
</tr>
</tbody>
</table>

Struvite is a mineral with high purity - metals concentrations are consistently below 503 thresholds.
VECTOR ATTRACTION AND PATHOGEN REDUCTION

• No unstabilized primary solids; no organic material; no concern for vector attraction
• Fecal coliform concentrations well below Class A threshold without a pathogen reduction process
• No enteric viruses or viable Helminth Ova detected in raw struvite with no regrowth after up to 6 months
CLASS A HEAT TREATMENT PROCESS

- **Class A**
  - Not necessary, safe, Not a Bio-solid
  - Treatment technology is destructive
    - Material, LIV, revenue, ...
  - Bottleneck to marketing and reuse
  - High energy
    - 26% of West Boise WRF Natural gas consumption
  - Significant O&M cost
  - Storage and documentation of treated material
  - Deterrent to wider industry use
  - Requires manual batching and material handling
  - High failure rate (10-15%)
    - Seasonal
    - Mechanical
    - Product consistency
STRUVITE SUMMARY

- Critical to meeting effluent phosphorus limits
- Recovering nearly 1/3rd of our system phosphorus loading as Struvite
- 5 years of R&D, extensive data collection, process optimization, coordination with EPA HQ
  - First large scale product release in 2017
- P-release tank limits dewatering polymer consumption
- Incidental struvite in digesters reduced (less P and Mg)
- Safe and Sustainable resource
- Alternatives – Chemicals......? Additional farm/landfill loads (organic/inorganic). Not the ‘Right Way’
- Class A struvite complicated and messy, unnecessary, and a deterrent to others in the industry
QUESTIONS
TWENTY MILE SOUTH BIOSOLIDS APPLICATION SITE

Beneficially Recycling Biosolids to Grow Crops
INTRODUCTION

• The TMSBAS is owned and operated by the City of Boise for the reuse of biosolids generated at the municipality's two WWTFs.

• The original site, consisting of 2,325 acres, was purchased in 1994 and has always been permitted by the EPA for biosolids application.

• EPA Region X is the regulating authority (IDEQ seeking primacy).

• Biosolids reuse on the 1,620 acre Watkins land was not permitted due to language in Boise’s NPDES permits (1999, 2001 and 2003 versions.)

• In 2008, the City acquired the ‘Nicholson addition’ of 280 acres.
INTRODUCTION (CONTINUED)

• In 2013, IDEQ approved a Biosolids Management Plan for the entire 4,225 acres of the TMSBAS, including the original site, the Watkins Property, and the Nicholson addition.
BACKGROUND

- Primary crops are alfalfa (hay), corn, and winter wheat. All crops are sold to local dairies for feed and the grain is sold to a local elevator.

- In Idaho, about 60% of municipal biosolids are land applied.

- The TMSBAS is the only operation of its kind that we are aware of.

- Some farming tasks such as wheat combining and corn harvesting are done by outside custom harvesters but the City does everything else.
  
  - This controls and limits our regulatory liability.
  
  - We also get revenue to help keep sewer rates low for our ratepayers.
  
  - We strive to be revenue neutral for biosolids recycling operations.
TMSBAS IS AN IDEAL LAND APPLICATION SITE

- No surface waters of the US on site.
- Approximately 270 feet to groundwater.
- Few neighbors and partially bordered by BLM.
  - Minimal nuisance complaints.
  - Site security – 4 families live on site.
- Relatively short hauling distance ~20 miles each way to West Boise.
- 23 years of extensive data collection
**Biosolids are a nutrient rich, valuable material**

Select macronutrients and micronutrients provided by the City of Boise’s biosolids

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Provided by 1 dry ton of biosolids (lbs/dry ton)</th>
<th>Provided in a typical application at TMSF* (lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (1st year)</td>
<td>42.5</td>
<td>170</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>51.1</td>
<td>204</td>
</tr>
<tr>
<td>Potassium</td>
<td>6.1</td>
<td>24</td>
</tr>
<tr>
<td>Iron</td>
<td>34.0</td>
<td>136</td>
</tr>
<tr>
<td>Boron</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Copper</td>
<td>1.4</td>
<td>5.4</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.3</td>
<td>5.4</td>
</tr>
</tbody>
</table>

* - Typical application assumed at 4 dry tons/acre.
BIOSOLIDS ARE A NUTRIENT RICH, VALUABLE MATERIAL

COMMERCIAL FERTILIZER VALUE OF CITY OF BOISE’S BIOSOLIDS

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Total Nutrient (% dry wt.)</th>
<th>Plant Available Nutrients from Biosolids (lbs/dry ton)</th>
<th>Equivalent Fertilizer (lbs/dry ton)</th>
<th>Bulk Fertilizer List Price ($/lb)</th>
<th>Nutrient Value ($/dry ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)₁</td>
<td>6.89%</td>
<td>42.5</td>
<td>132.8 NH₄NO₃</td>
<td>$0.27</td>
<td>$36.25</td>
</tr>
<tr>
<td>Phosphorus (P)₂</td>
<td>2.55%</td>
<td>20.4</td>
<td>46.7 P₂O₅</td>
<td>$0.38</td>
<td>$17.93</td>
</tr>
<tr>
<td>Potassium (K)₃</td>
<td>0.23%</td>
<td>4.6</td>
<td>5.5 K₂O</td>
<td>$0.33</td>
<td>$1.83</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>$56.01</strong></td>
</tr>
</tbody>
</table>

The City of Boise applied 3,634 dry tons in 2015 giving the biosolids a total fertilizer value of $203,556!

1 – Assumes 50% of ammonium & 25% Org-N is available to crop
2 – Assumes 40% of P is plant available in year 1
3 – Assumes 100% of K is plant available
TMSBAS NUTRIENT MANAGEMENT PROGRAM

- Main Goal: Want to maintain max nutrients in the soil when the crop is actively growing and end the season with minimal residual nutrients.

- What About Phosphorus???
  - There is uncertainty on how the regulators (EPA, IDEQ) will address P in Idaho, if at all.
  - Very low phosphorus effluent limitations are increasing the concentration of P and volume of biosolids
TMSBAS NUTRIENT MANAGEMENT PROGRAM

- TMSBAS has continued to manage biosolids application based on soil phosphorus levels as follows:
  - Target for a maximum of 30 ppm of Olsen Phosphorus in the 16-24” soil layer through management practices
  - If EPA or IDEQ use NRCS Code 590 or similar to regulate land application of biosolids in the future, the site may be limited based on soil P levels.
  - Regardless of future EPA/DEQ requirements for biosolids application, for the long-term sustainability of the TMSBAS, soil P levels should continue to be managed to keep P in the root zone (top 24” of soil).
  - NRCS Code 590 was referenced in Phosphorus in Biosolids: How to Protect Water Quality While Advancing Biosolids Use. WEF Sustainable Residuals Use Subcommittee, May 2014.
SUSTAINABILITY

• We are in the business of nutrient recycling.

• Is there a better example of sustainability than using our own treated human waste to produce food?

• The Treasure Valley is an agricultural community and we take pride in owning and operating the largest contiguous farm in Ada County.

Graphic Courtesy of Northwest Biosolids
BENEFITS OF BIOSOLIDS LAND APPLICATION

• Feeding the soil vs. feeding the plant.

• Reduces or eliminates the need for commercial fertilizers.

• Improves the physical qualities of the soil.

• Keeps biosolids out of landfills.

• Biosolids application sites are managed to protect surface and ground water sources.

• Land application is generally lowest cost option for managing Class B biosolids.
SUSTAINABILITY

• New Office and Maintenance Facility Completed in July, 2016.

  • 56.4 KW solar array on the roof makes this the first Zero Net Energy (ZNE) Commercial Building in Idaho.

  • Cost $3.2 million to construct.

  • Will save approximately $24,000 per year in energy costs.

  • It was estimated that the “extra” investment in the building envelope and solar array will be recouped in about 14 years.

  • From July 2016 to July 2017, the facility produced 165% of the power it consumed. Therefore, this payoff will be even less!
CONTACT INFORMATION

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Photo courtesy of the Nature Conservancy