Low Temperature Thermal Hydrolysis Process for Biosolids and Organics Management

Lystek THP®
Enhancement of Anaerobic Digestion ad BNR With Your Existing Cake

PA Water & Wastewater Technology Summit
November 1st 2018
Lystek Overview

• Multi award-winning provider of proven solutions for biosolids & organics management

• Founded in 2000 at the University of Waterloo, Ontario with offices & numerous successful operations in the USA & Canada

• Patent protected Clean/Green technology that has been repeatedly recognized as environmentally responsible & sustainable

• Low temperature Thermal Hydrolysis Process (Lystek THP®)
## Current Installations

<table>
<thead>
<tr>
<th>Location</th>
<th>Status</th>
<th>Capacity (WT/Y)</th>
<th>Site</th>
<th>LysteGro Class A/EQ/CFIA</th>
<th>LysteMize Digester Enhancement</th>
<th>LysteCarb BNR Carbon Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guelph</td>
<td>2008</td>
<td>18,000</td>
<td>On-Site</td>
<td>Yes</td>
<td>Full-Scale Pilot</td>
<td>N/A</td>
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<tr>
<td>St. Marys</td>
<td>2010</td>
<td>3,500</td>
<td>On-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>Full Scale</td>
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<tr>
<td>*Southgate</td>
<td>2012</td>
<td>150,000</td>
<td>Off-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>*Iroquois</td>
<td>2012</td>
<td>40,000</td>
<td>Off-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Elora</td>
<td>2014</td>
<td>3,500</td>
<td>On-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
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<td>North Battleford</td>
<td>2014</td>
<td>3,500</td>
<td>On-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>*Fairfield</td>
<td>2016</td>
<td>150,000</td>
<td>On-Site</td>
<td>Yes</td>
<td>Full Scale</td>
<td>Future</td>
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<tr>
<td>St. Thomas</td>
<td>2018</td>
<td>5,600</td>
<td>On-Site</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Innisfil</td>
<td>2018</td>
<td>5,500</td>
<td>On-Site</td>
<td>Yes</td>
<td>Future</td>
<td>N/A</td>
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<tr>
<td>St. Cloud, MN</td>
<td>2018</td>
<td>15,000</td>
<td>On-Site</td>
<td>Yes</td>
<td>Future</td>
<td>Future</td>
</tr>
<tr>
<td>Goleta</td>
<td>2018</td>
<td>Demo</td>
<td>On-Site</td>
<td>Yes</td>
<td>Full-Scale Pilot</td>
<td>N/A</td>
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</tbody>
</table>

*Regional facilities serving cities*
- Ontario: Toronto, Ottawa, Waterloo, Niagara, Peterborough; Owen Sound
- California: Fairfield, San Francisco, EBMUD, Santa Rosa, Central Marin, Petaluma
Lystek THP - One System, Multiple Benefits

Produces a completely hydrolyzed, multi-use, end product:

- **LysteGro®**: Biofertilizer - Class A EQ (U.S. EPA), CDFA (California) & CFIA (Canada)
  - Nutrient rich, high solids (13-16%) liquid

- **LysteMize®**: Anaerobic digestion enhancement
  - Improves biogas yields, reduces solids

- **LysteCarb®**: BNR carbon source
  - Safer, cost effective, replaces commercial compounds such as methanol or glycerol
How Does it Work?

• Processing time = minimum 30-45 minutes – total 1 hr

• Processes 1%-35% biosolids and/or non-hazardous organics w/combination of:
  - Heat - low pressure steam injection (15 psi max), low temperature – 167°F (75°C) (Reactor Vessel Non-Pressurized)
  - High speed shearing/mixing (Max 1000 RPM)
  - Alkali for pH adjustment (9.5 - 10) to facilitate hydrolysis (~268 lb/dry ton)

• No additional waste (i.e. side streams/centrate) to further treat/manage
No proprietary or specialized equipment required
Overview – Lystek THP WWTP Integration

One System
Multiple Benefits

Raw Sewage → Headworks → Screening & Settling

Aeration Tank
BNR Bioreactor → Secondary Clarification

Filtration & Disinfection → Final Effluent

Clean water to waterways

Waste Activated Sludge

Aerobic Digestion → Anaerobic Digestion

Dewatering (up to 55% solids)

Biogas Recovery

LYSTEK THP® MODULE
Overview – LysteGro Biofertilizer

One System
Multiple Benefits

Lystek
Nothing wasted. Everything to gain.
Overview – LysteMize AD Optimization

One System
Multiple Benefits

Raw Sewage → Headworks → Screening & Settling → Aeration Tank → BNR Bioreactor → Secondary Clarification → Filtration & Disinfection → Final Effluent

Clean water to waterways

LYSTEK THP® MODULE

LysteMize®
Anaerobic Digester Optimization

LysteMize
Nothing wasted. Everything to gain.
Overview – LysteCarb BNR Carbon Source

One System
Multiple Benefits

Raw Sewage → Headworks → Screening & Settling → Aeration Tank → BNR Bioreactor → Secondary Clarification → Filtration & Disinfection → Final Effluent

LysteCarb® BNR Carbon Source

LYSTEK THP® MODULE

Aerobic Digestion

Anaerobic Digestion

Dewatering (up to 3.5% solids)

Biogas Recovery

Clean water to waterways

LysteK
Nothing wasted.
Everything to gain.
Lystek THP – Operational Flexibility

One System
Multiple Benefits

- Raw Sewage
- Headworks
- Screening & Settling
- Aeration Tank
  - BNR Bioreactor
  - LysteCarb®
    - BNR Carbon Source
- Secondary Clarification
- Filtration & Disinfection
- Final Effluent
  - Clean water to waterways

LYSTEK THP® MODULE

- Aerobic Digestion
- Anaerobic Digestion
- Dewatering
  - (up to 35% solids)
- Biogas Recovery

LysteMize®
- Anaerobic Digester Optimization

LysteGro®
- Class A Biofertilizer Production
  - Product stored until application
  - Class A Biofertilizer sold to market

Lystek
Nothing wasted.
Everything to gain.
The Lystek System

Process Reactor & High Speed Shearing Blade
Regional Processing Center (OMRC)
Fairfield-Suisun, California, USA

• First US deployment
• Capacity = 150,000 tons/year
• LysteGro biofertilizer production
• LysteMize anaerobic digester enhancement
• Lystek Reactor – 16 WT/h Capacity
2018 New Lystek Installation

St. Cloud, Minnesota, USA

- Upgrade of biofertilizer product to Class A EQ
- Reduced solids production
- Enhancement alongside Ostara process
- 15,000 W/T per year processing capacity
Lystek Mobile THP® - 3 WT/h Capacity
LysteGro – Biofertilizer Product

- Homogeneous liquid/ high solid (13-16%) product
- Viscosity <5,000 cP
- Fully pumpable using conventional equipment
- Enhanced treatment = pathogen-free/Class A EQ
- Nutrient rich (NPK 4:3:2)
- Long-term storage stability
- No pathogen regrowth issues
BNR Enhancement - LysteCarb

- BNR enhancement can be realized utilizing the soluble COD in the carbon provided by the LysteGro product
- Practical application onsite – St. Mary’s Ontario
- Ability to complement nutrient management technologies existing currently (St. Cloud, MN)
- Multiple studies available – Manhattan College, Chicago MWRD, Western University, etc.
BNR Enhancement – LysteCarb Testing

- Manhattan College, New York: 2014
  - Independent study on potential of Lystek biosolids as a carbon source in BNR systems - using a variety of sludges
  - Lystek shows significantly higher specific denitrification rates (SDNR)
  - Additional, detailed studies underway

<table>
<thead>
<tr>
<th>Carbon Source</th>
<th>Stamford</th>
<th>26th Ward</th>
<th>Battery E</th>
<th>Hunts Pt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endogenous</td>
<td>-0.0208</td>
<td>-0.0597</td>
<td></td>
<td>-0.0597</td>
</tr>
<tr>
<td>Primary Effluent</td>
<td>-0.0284</td>
<td>-0.0309</td>
<td>-0.0495</td>
<td>-0.1384</td>
</tr>
<tr>
<td>Methanol</td>
<td>-0.0443</td>
<td>-0.0462</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycerol</td>
<td>-0.0493</td>
<td>-0.0493</td>
<td>-0.0277</td>
<td>-0.0586</td>
</tr>
<tr>
<td>Lystek</td>
<td>-0.0491</td>
<td>-0.1832</td>
<td>-0.0656</td>
<td>-0.0920</td>
</tr>
</tbody>
</table>

Average SDNR Values (mg NOx-N/mg VSS)
Is Class A Sludge in my Future?

• I think producing Class A sludge sounds great

• I like the idea of reusing my biosolids as a fertilizer, **BUT**

• I currently get rid of my biosolids at a very low cost **OR**

• I have a sweetheart deal, I get rid of my sludge at low or no cost because I accept landfill leachate at a penny per gallon

• So do I really need Lystek Technology?
Why Not LysteMize Only?

• My anaerobic digester does a great job converting organic waste to biogas

• My anaerobic digester reduces my sludge volume reducing disposal by 30%+

• But when the anaerobic digestion process is complete, I am sending many tons of carbon and volatile solids to the landfill

• Can I get more energy out of my existing sludge?
The LysteMize Loop

Feed -> Anaerobic Digester

LysteMize

Dewatering

Disposal

30%

70%
Digester Performance Enhancement

- City of Guelph, Ontario – Full-scale pilot study:
  - >40% extra biogas and >25% solids reduction by re-feeding the Lystek product into the test digester
  - Biodegradability of VS in Lystek product was 65-70%

<table>
<thead>
<tr>
<th>Parameters (average of different feed rates over 6 months study)</th>
<th>Control Digester without Lystek biosolids</th>
<th>Test Digester with Lystek biosolids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent VSS primary sludge (kg/d)</td>
<td>2307</td>
<td>2278</td>
</tr>
<tr>
<td>Lystek VSS (kg/d)</td>
<td>0</td>
<td>921</td>
</tr>
<tr>
<td>Combined Influent VSS (kg/d)</td>
<td>2307</td>
<td>3199</td>
</tr>
<tr>
<td>Effluent VSS (kg/d)</td>
<td>1118</td>
<td>1222</td>
</tr>
<tr>
<td>VSS Destroyed (%)</td>
<td>51</td>
<td>62</td>
</tr>
<tr>
<td>Biogas production (m³/d)</td>
<td>1189</td>
<td>1977</td>
</tr>
</tbody>
</table>
TWAS Digestion Enhancement

- **St. Marys, Ontario 2013**
  - Independent lab study at Western University
  - >40% increase in VSS destruction efficiency and methane production
LysteMize Benefits

- Lystek and LysteMize names derived from the word lysis
- Cell lysis is used to break open cells
- LysteMize breaks open the cells, makes the sludge more soluble
- An anaerobic digester needs soluble COD
- LysteMize loop results in more organic destruction
- Lower VS = better dewatering
Dewaterability

Cake Percent

Volatile percent

Dewateability

Cake Percent

Volatile percent

Lystek

Nothing wasted. Everything to gain.
Additional LysteMize Benefits

• LysteMize back to the digester includes free heat

• LysteMize also automatically thickens your digester, replaces recuperative thickening

• LysteMize reuses your existing dewatering equipment

• LysteMize can be used at a higher recycle percent if you need more feed to an under loaded digester
Summary

• Lystek system is simple to operate & inexpensive to maintain

• Small footprint – easy to retrofit to existing facility infrastructure

• Can be deployed as post- or pre-digestion solution

• Can also be deployed as an alternative to AD systems

• One system – multiple beneficial applications for resource recovery

• Class A EQ fertilizer product registered with CFIA, Canada and CDFA, California

• Performance of Anaerobic Digesters and BNR systems can be improved by increasing biogas yield, reducing biosolids generation and by replacing commercial carbon requirement in BNR
Thank You – Q & A!

Nothing wasted.
Everything to gain.

Jim Belcastero, Ajay Singh, George Bevington

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e: jbelcastro@lystek.com
w: www.lystek.com
## Pathogens Below Detection Limits

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>MDL</th>
<th>Class A Criteria</th>
<th>Untreated dewatered biosolids</th>
<th>Lystek treated biosolids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal coliforms (MPN/g dry wt)</td>
<td>1.8</td>
<td>&lt;1,000</td>
<td>&gt;1,600</td>
<td>&lt;1.8</td>
</tr>
<tr>
<td>Escherichia coli (MPN/g dry wt)</td>
<td>1.8</td>
<td>-</td>
<td>&lt;1,600</td>
<td>&lt;1.8</td>
</tr>
<tr>
<td>Salmonella (P-A/25 g)</td>
<td>1</td>
<td>&lt;3 MPN/4g</td>
<td>POS</td>
<td>NEG</td>
</tr>
<tr>
<td>Polio virus (pfu /4 g)*</td>
<td>1</td>
<td>&lt;1</td>
<td>776</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Ascaris eggs (per 4g)*</td>
<td>1</td>
<td>&lt;1</td>
<td>131</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>
## LysteGro Fertilizer Composition

<table>
<thead>
<tr>
<th>Product Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids (%)</td>
<td>14 - 16</td>
</tr>
<tr>
<td>Volatile Solids (% of TS)</td>
<td>55 - 60</td>
</tr>
<tr>
<td>Total Organic Carbon (%)</td>
<td>26 - 28</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>45 – 50</td>
</tr>
<tr>
<td>TCOD (mg/L)</td>
<td>105,000 – 150,000</td>
</tr>
<tr>
<td>SCOD (mg/L)</td>
<td>40,000 – 60,000</td>
</tr>
<tr>
<td>RbCOD (mg/L)</td>
<td>25,000 – 30,000</td>
</tr>
<tr>
<td>VFAs (mg/L)</td>
<td>10,000 – 15,000</td>
</tr>
<tr>
<td>Viscosity (cP) of product</td>
<td>4,000 – 6,000</td>
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</table>
# LysteGro Fertilizer Composition

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>LysteGro Average&lt;sup&gt;a&lt;/sup&gt;</th>
<th>EPA 40 CFR Part 503 Limits &lt;sup&gt;b&lt;/sup&gt;</th>
<th>% of maximum allowable concentration</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>5.00</td>
<td>41</td>
<td>12.20%</td>
<td>mg/kg</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>4.50</td>
<td>39</td>
<td>11.54%</td>
<td>mg/kg</td>
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<tr>
<td>Copper (Cu)</td>
<td>373</td>
<td>1500</td>
<td>24.84%</td>
<td>mg/kg</td>
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<tr>
<td>Mercury (Hg)</td>
<td>0.81</td>
<td>17</td>
<td>4.76%</td>
<td>mg/kg</td>
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<tr>
<td>Molybdenum (Mo)</td>
<td>13.21</td>
<td>75</td>
<td>17.62%</td>
<td>mg/kg</td>
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<tr>
<td>Nickel (Ni)</td>
<td>27.80</td>
<td>420</td>
<td>6.62%</td>
<td>mg/kg</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>22.65</td>
<td>300</td>
<td>7.55%</td>
<td>mg/kg</td>
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<tr>
<td>Selenium (Se)</td>
<td>5.79</td>
<td>36</td>
<td>16.09%</td>
<td>mg/kg</td>
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<tr>
<td>Zinc (Zn)</td>
<td>915.33</td>
<td>2800</td>
<td>32.69%</td>
<td>mg/kg</td>
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</tbody>
</table>

<sup>a</sup> Values represent the mean of weekly samples throughout 2017

<sup>b</sup> As per EPA 40 CFR Part 503 Regulations Table 3