Hydrolysis Process Converts Dewatered Biosolids into a Liquid Class A EQ Product for Low Cost Land Application

December 3rd, 2015

Bill Mullin M.Eng., P.Eng. CPA, CMA
Mike Dougherty MSc P.Ag.,
Tim Shea Ph.D. PE, WEF Fellow
Ajay Singh Ph.D.
Content

- Learning Objectives
- Ontario Regulatory Environment Overview
- Post Digestion, Post Dewatering Hydrolysis
- Benefits of HS Liquid Land Application
- Case Studies & Costs
- Summary
Learning Objectives

• Introduce Post Digestion Hydrolysis
  - Simple Process with multiple benefits
  - Also works on undigested biosolids

• High Solids Liquid Land Application
  - very cost effective vs. dewatered cake
  - reduce odors & nutrient run-off
  - benefits to farmers can increase land available for your biosolids program
Lystek - The Company

• Owned by Management & RW Tomlinson (Ottawa)

• Overview of RW Tomlinson

  - 60 year old family owned company (construction & environmental services)
  - Constructor and operator (biosolids processing, liquid waste processing, landfills, composting, C&D waste recycling)
  - 20 years experience managing biosolids and organics
  - Project Financing, Bonding, Long Term Performance Guarantees
Ontario Overview

- Large Urban Center (Greater Toronto Area) on Lake Ontario, surrounded by suburbs and agricultural areas (corn, soybeans, wheat, hay)
- Population 13.6 Million
- Total Acres Being Farmed - Approx. 13 Million Acres
- Preference for Beneficial Use / Class A EQ Treatment (Long Term)
- Suburbs growing and encroaching on agricultural areas
- Public concern about odors / strict regulatory framework around any activity that generates odors
Ontario Regulatory Environment

• Government is generally supportive of land application
• Promotes the benefits to agricultural industry
• Focus on minimizing odors and piles in fields, to reduce public complaints (don’t see, don’t smell)
• Class B Land Application similar to US EPA, but managed by Ministry of Agriculture, enforcement by Ministry of Environment
• Class B biosolids can not be stored in field for more than 5 days (don’t see, don’t smell - minimizes complaints and run off)
Ontario Regulatory Environment

- Class A EQ biosolids are no longer a waste if they are registered by the Canadian Food Inspection Agency (CFIA) as a fertilizer product
  - Tested for pathogens (fecal coliforms, Salmonella), metals and Dioxins/Furans
  - Registered Label for Minimum Nutrient levels
  - Can be stored in farmer’s field or other 3rd party site
  - Fewer setbacks
  - No approvals required for land application
  - No regulatory reporting
Process Overview

• Low Temperature Alkaline Hydrolysis Technology
  - Post Digestion, installed after dewatering
  - Also produces a Class A EQ with Undigested Biosolids
• Produces a multi-purpose, hydrolyzed product for:
  - Liquid fertilizer – Class A EQ (USA) / CFIA registered (Canada)
    – high organic matter & NPK – much easier to land apply than a dewatered biosolid – no offsite odors or dust
  - BNR enhancement – a cost effective, alternative carbon source
  - Anaerobic Digester Enhancement (Post Digestion)
    • Improve biogas yields up to 35%
    • Reduce biosolids volumes up to 25%
LysteMize™ - Digester & BNR Optimization
Technical/Scientific Basis

• Cell disintegration & hydrolysis of complex organic molecules into simpler compounds
• Converts dewatered cake to a pumpable high solids liquid at 15% Class A EQ. Much cheaper to manage a liquid than a dewatered solid.
• Process makes the residual recalcitrant volatile solids in digested biosolids more amenable to further biodegradation when re-fed to anaerobic digester
• Hydrolyzed product provides readily available organics for AD and BNR system + nutrients for soil/plants
• Product contains >40% of the TCOD as SCOD
• Product contains 10-fold higher VFA vs. standard, biosolids cake
Lystek Process - Simple PFD

- Solid Feedstock Hopper
- Bridge Breaker
- Progressive Cavity Pump
- Dewatered Biosolids
- High Speed Mixer
- Mixing Tank
- Steam
- Boiler
- Product Pump
- Alkali
- Alkali Storage Tank
- Storage
LysteGro™ Product

- Homogeneous liquid/high solid (15-19%) product
- Viscosity <5,000 cP
- Fully pumpable using conventional liquid equipment
- Enhanced treatment = pathogen-free/Class A EQ
- Nutrient rich (NPK 4:3:2)
- Long-term storage stability
- No pathogen regrowth
- Huge demand from the agricultural sector
Diverse Products

- Can be used in compost processing & soil blending
- Produces a solid product for urban and suburban markets
  - Lawns
  - Gardens
  - Parks
  - Roadway Construction
Processing Equipment
Onsite Processing (20,000 wet tons/year)

Low Air Volume to Odor Control – about 250 CFM
Onsite Processing (20,000 wet tons / year)

Lystek Reactor – 5 WT/h
Alkali Dosing System
Liquid Loading Station
Cost Benefits - HS Liquid Land Application

How can a 15% HS liquid be cheaper to land apply than a 23% Class B Dewatered Biosolid?

• Dewatering Polymer Savings (less polymer at 15%)
• Simpler Equipment easier to operate & maintain
  - No conveyors or storage silos
  - Just pumps and pipes
• Pumps are able to accurately load at very fast rate
• Can construct multiple load facilities so trucks are not waiting
Cost Benefits - HS Liquid Land App

- Time is a more accurate cost driver than mileage
  - Faster loading (5 min vs 25 min to 2 hours)
  - Less waiting
  - Faster application rates in the field
- Liquid trailers tend to be about 10% lighter and allow a higher biosolids payload
- Liquids quantities can be accurately measured with a flowmeter so that each trailer is full but not overweight.
- Dewatered biosolids loads are often underweight if there is not a scale at the loading hopper
Cost Benefits - HS Liquid Land App

- Significantly less equipment, manpower & fuel used in the liquid field application

**High Solids Liquid**
- 1 Tractor & liquid spreader, 1 operator vs

**Dewatered Cake**
- 1 Tractor & cake spreader,
- 1 Front End Loader &
- 1 Tractor and incorporation equipment 2-3 operators
## Cost Summary

<table>
<thead>
<tr>
<th></th>
<th>Lystek ($/dry ton)</th>
<th>Dewatered Cake ($/dry ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lystek Operating Cost (lime, gas, elect.)</td>
<td>$35</td>
<td>NA</td>
</tr>
<tr>
<td>Polymer Savings (15% vs 23%)</td>
<td>- $20</td>
<td>NA</td>
</tr>
<tr>
<td>Land Application Costs</td>
<td>$70</td>
<td>$195</td>
</tr>
<tr>
<td>Lystek – Carbon Source for BNR</td>
<td>- $5</td>
<td>NA</td>
</tr>
<tr>
<td>Lystek – Reduction in Biosolids</td>
<td>-$15</td>
<td>NA</td>
</tr>
<tr>
<td>Lystek – Additional Biogas</td>
<td>-$10</td>
<td>NA</td>
</tr>
<tr>
<td><strong>NET COST</strong></td>
<td>$55</td>
<td>$195</td>
</tr>
<tr>
<td>Total Benefits of Post Digestion Hydrolysis</td>
<td>$140 /dry ton</td>
<td></td>
</tr>
</tbody>
</table>
Public/Safety Benefits - HS Liquid Land App

- No odors or dust during processing, storage, transportation and land application
- Truck tires stay clean
- No risk of trailer “roll over” in the field when unloading wet or sticky dewatered biosolid on uneven ground
- Liquid is safer to transport – NO risk of spill during a sudden braking event
Highway reopens after biosolids spill

- Traffic was at a near-standstill on the Linc at the noon hour Wednesday, hours after a truck spilled bio-waste.
Potential for Roll Over

If “Sticky” Biosolids get stuck at top of trailer on uneven ground
Enviro Benefits - HS Liquid Land Application

• Virtually eliminates risk of nutrient run off
  - no biosolids are stock piled in the field
  - liquid biosolids are immediately injected into the soil
• Less volatilization / loss of nitrogen
• Recover valuable nutrients
  - “peak phosphorus” only 50 – 100 year supply left
• Reduce energy, waste and GHGs needed to produce chemical fertilizers
Agricultural Benefits - HS Liquid Land App

• Less soil compaction in farmer’s field (no stockpiles)
• Very accurate application of nutrients to the root zone of the plant
  - Liquid application allows the product to metered into the soil
  - Better control for nutrient management
• Enough nutrients to support a corn crop without a second application of fertilizer
• Less soil disturbance – many farmers and regulators prefer “no till”
USDA promotes No-Till / Injection

The Natural Resources Conservation Service (NRCS) promotes the use of conservation-tillage technology. This technology uses minimum disturbance or no-till injection and incorporation equipment to:

- Preserve surface residue and soil conservation conditions
- Reduce Nitrogen and phosphorus losses

Provides financial incentives in certain areas for farmers that inject manure

Source: NRCS Fact Sheet
Case Study Pictures

High Solids Liquid vs Dewatered Cake
Cake     25 min to 45 min to load
Cake - (Limited Storage) Up 120 Minutes to Load

No Scale – Need to estimate weight
HS Liquid- Loads 5,000 gallons in 5 Minutes

Able to very quickly and accurately fill a liquid tank
Cake - 2 pieces of equipment, 1 - 2 Operators

Potential for odors & run off during storage
Inconsistent Application Rate – Source of Odors. Potential for “run-off”
Cake - 3rd piece of equipment, 3rd Operator

Incorporated into soil to controls odors and “run-off”
Liquid Biosolids Immediately Incorporated into Soil in a Single Pass
HS Liquid Injected – No Odors, No Run Off

Single Pass - Evenly Distributed in Field at Constant Application Rate, similar to Fertilizer
Minimal Soil Disturbance
Case Studies and Costs
Who Uses Lystek Now?

<table>
<thead>
<tr>
<th>Location</th>
<th>Guelph</th>
<th>St. Marys</th>
<th>Southgate</th>
<th>Iroquois</th>
<th>Elora</th>
<th>North Battleford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (WT/Y)</td>
<td>18,000</td>
<td>3,500</td>
<td>150,000</td>
<td>20,000</td>
<td>3,500</td>
<td>3,500</td>
</tr>
<tr>
<td>Location</td>
<td>On site</td>
<td>On site</td>
<td>Off site</td>
<td>Off site</td>
<td>On site</td>
<td>On site</td>
</tr>
<tr>
<td>Ownership</td>
<td>Guelph</td>
<td>St Marys</td>
<td>Lystek</td>
<td>DES/Third High Farms</td>
<td>Centre Wellington</td>
<td>North Battleford</td>
</tr>
</tbody>
</table>

Serving Cities of Toronto, Ottawa, Peterborough, Oakville, Burlington, and Regions of Waterloo ...and several other communities.
Fairfield (FSSD) California

- Lystek Equipment will installed in FSSD’s dewatering building
- Will process FSSD digested biosolids + 3rd party biosolids to produce a Class A EQ Liquid Fertilizer + Digester Enhancement
- Lystek processing equipment being installed by Lystek under a DBFOM (20 year agreement + 10 year renewal)
- FSSD pays a tip fee to Lystek to process their biosolids
- Lystek pays FSSD a host fee, a fee for every ton processed by 3rd party agencies and shares digester enhancement benefits (more biogas and reduction in biosolids)
- FSSD staff estimates annual net annual benefit of $675,000 at full capacity
Case Study – Guelph

• Was Paying about $70/ton (22% solids) T&D to landfill for their Class B? dewatered cake.
• Preferred Beneficial Use (cost is about $45/ton)
• Would need to spend about $6 - $8 million to construct onsite cake storage to meet odor regulations – space constraints
• Installed Lystek for about $2.5 million (2015) in unused building (1200 sq. feet)
• Lystek Operating Cost and Land Application Costs (22% solids) – $31.50/wet ton
• Savings of over $3.5 million in Capital, 30% reduction in land application costs ($31.50 vs $45), less space, no odors
Guelph Lystek Installation
Case Study – St Marys

• BEFORE - Running liquid land application program but did not have enough storage. Offsite storage very costly $110,000/year plus $63,000 for land application.
  
• Added dewatering & Lystek Process
  
• NOW - Storing at >15% eliminated need for offsite storage
  
• Digester Enhancement reduced biosolids by >20 %
  
• Used 20% as carbon source for BNR
  
• Storage costs eliminated. Land Application cost reduced to under $10,000 year due to significant reduction in biosolids sent offsite
St. Marys Lystek Installation
Case Study – North Battleford SK
• Undigested biosolids going to municipal landfill
• Odor complaints at landfill forced WWTP to look at alternate treatment options to allow land application
• Received Bids for three options (see table below)
• Lystek, the only vendor that could fit inside existing building

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cap Cost</th>
<th>Annual Op Cost</th>
<th>Op Cost/Tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windrow Composting</td>
<td>$2,371,950</td>
<td>$2,647,186</td>
<td>$1102</td>
</tr>
<tr>
<td>Lystek</td>
<td>$3,197,250</td>
<td>$71,400</td>
<td>$21</td>
</tr>
<tr>
<td>Lime Stabilization</td>
<td>$5,659,950</td>
<td>$236,250</td>
<td>$118</td>
</tr>
</tbody>
</table>
North Battleford Lystek Installation
Summary

• Low Temp Alkaline Hydrolysis process can be used on undigested or digested biosolids (post dewatering)

• Produces a “high solids” liquid biosolids that eliminates odors and provides a cost effective alternative to dewatered cake

• In Ontario, Class A EQ biosolids can be registered as a CFIA fertilizer with the following benefits:
  - No storage restrictions
  - Fewer setbacks
  - No reporting requirements
Summary

• Hydrolysed biosolids provide a carbon source for BNR.
• When a digester is present, “post digestion” biosolids hydrolysis can:
  - Increase biogas up to 35%
  - Decrease biosolids up to 25%
• Many benefits to farmers
  - Less soil compaction
  - Less soil disturbance
  - Accurate application at root zone
  - No odors, no dust, no nutrient run off
Product Storage

Lined & Covered Storage Lagoons
Regional Facility (Off-Site)

Southgate, Ontario - 150,000 WT/year
Design, Build, Own, Operate:
LysteGro vs. Chemical Fertilizer Trial

With LysteGro - ear leaf strong color

With Chemical Fertilizer – ear leaf firing
Value of the LysteGro™ Fertilizer

- Balanced nutrient source, fertilizer value >$80/1000 gal
- N-P$_2$O$_5$-K$_2$O = 30-27-31 lbs/1000 gal, in the year of application
- S 10 lbs/1000 gal, Ca 40 lbs/1000 gal and other micronutrients such as Cu, Zn, B, Mg etc.
- Application rates = 3000 – 4000 gal/acre
- Organic matter = ~5%
A good news story...!
Class A EQ Letter – U.S. EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

February 27, 2014

Ward Janssens
Lystek International Inc.
1425 Bishop St, N, Unit 16
Cambridge, Ontario, N1R 6J9

Re: Demonstration of Vector Attraction Reduction using Option 2 for Lystek Thermo-Alkaline Treatment

Dear Mr. Janssens,

Thank you for your e-mail and attached paper from Dr. George Nakhla of February 3, 2014 with results of volatile solids reduction tests on anaerobically digested biosolids treated with the Lystek Thermo-Alkaline treatment process.

The results showed that for the sampling periods in question, VAR Option 2 was met, as the volatile solids were reduced by less than 17% during additional digestion. This option may be used in the future to demonstrate vector attraction reduction.

The frequency at which the test must be run is specified in 40 CFR 503.16, ranging from once per year for facilities producing less than 290 dry metric tons of biosolids per year, to once per month for facilities producing over 15,000 dry metric tons per year.

Demonstration of VAR using this method, in conjunction with demonstration of Class A pathogen reduction and pollutant concentrations meeting 40 CFR 503.13 Tables 1 and 3 limits, demonstrates “exceptional quality” biosolids that may be distributed without further restrictions.

Please contact me at 415 972-3514 or Fondahl.lauren@epa.gov with any questions regarding this.

Thank you,

Lauren Fondahl
Biosolids Coordinator, WTR-5
Lab Testing - Potential C Source for BNR

- 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>Early Rates - First 30 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stamford</td>
</tr>
<tr>
<td>Endogenous</td>
<td>-0.0208</td>
</tr>
<tr>
<td>Primary Effluent</td>
<td>-0.0284</td>
</tr>
<tr>
<td>Methanol</td>
<td>-0.0443</td>
</tr>
<tr>
<td>Glycerol</td>
<td>-0.0491</td>
</tr>
<tr>
<td>Lystek</td>
<td>-0.0491</td>
</tr>
</tbody>
</table>

Average SDNR Values (mg NOx-N/mg VSS)
Summary of Benefits

• **Strict Odor Control**
  - Totally enclosed facility – feedstock material receiving and processing area, enclosed reactors, air handling and odor abatement train
  - Storage: enclosed storage tanks, covered lagoons
  - The product: stable, homogeneous, reduced odor, no pathogen regrowth, limited exposure to air
  - Transport: enclosed tanker vehicles
  - Land application: sub-surface injection
Performance Indicators

- (Un)digested biosolids & source separated organics - up to 35% biosolids @ 15-19% solids level in the reactor
- **Power input** (pumps/mixer): 52-58 KWH per dry ton
- **High speed shear**: Tip speed >3000 ft./min
- **KOH/NaOH input** (45-50% sol): 175-195 lbs/dry ton to pH 9.5-10.0
- **Natural gas** (low pressure boiler) input: 13-15m³ per dry ton to 70-75°C / 158-167°F / 30 min / Class A regime
- **Labour**: <1 man hours per day; Fully automated SCADA – minimum operator attention
- Small footprint: 1000 sq. ft - 25,000 WT / 2500 sq. ft. - 100,000 WT
- Side streams: none
Digester 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 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>
Digester Performance Enhancement

• **Los Angeles County, California: 2012/2015**
  - Independent lab study at Western University, Ontario (2012/13)
  - Lystek biosolids ~65% biodegradable; compared to control, 30-50% more biogas potential with Lystek product
  - Onsite lab and pilot trial underway by LA County staff

• **New York City: 2014/2015**
  - Independent lab study at Manhattan College, New York
  - Lystek biosolids >50% biodegradable; higher biogas production compared to TWAS
  - Additional studies being executed in 2015 to further quantify
# Lystek vs. Typical Thermal Hydrolysis

<table>
<thead>
<tr>
<th>Items</th>
<th>Typical Thermal Hydrolysis</th>
<th>Lystek Thermal Hydrolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>High temperature, high pressure hydrolysis</td>
<td>Low temperature, high shear, physical-chemical hydrolysis</td>
</tr>
<tr>
<td>Process condition</td>
<td>320-338°F for 20 - 60 min @ 100 - 130 psi, multiple steps</td>
<td>158–167°F, 45 min, pH 9.5–10.0, high shear, atm. Press., one step</td>
</tr>
<tr>
<td>Heat source</td>
<td>High pressure steam boiler</td>
<td>Low pressure steam boiler or CHP</td>
</tr>
<tr>
<td>Installation</td>
<td>Prior to anaerobic digestion, interferes with existing WWTP processes</td>
<td>After anaerobic digestion and dewatering, no interference with existing WWTP processes</td>
</tr>
<tr>
<td>Side stream / residues</td>
<td>High N centrate from second stage dewatering - extensive treatment required</td>
<td>None</td>
</tr>
<tr>
<td>Dewatering</td>
<td>Two stage: pre- and post-AD</td>
<td>One stage conventional after AD</td>
</tr>
<tr>
<td>Footprint</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>Capital cost</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>