



## Lystek technology

### An innovative biosolids management approach

By Ajay Singh, Ph.D., Andrew Lugowski, M. Eng., P. Eng.,  
George Nakhla, Ph.D., P. Eng., Owen Ward, Ph.D.

#### Introduction

Reducing the volume of biosolids produced within the wastewater treatment process reduces costs associated with storage and disposal, including costs associated with biosolids transport and beneficial land application or disposal in landfill. Being able to increase gas production to produce energy at the same time as reducing biosolid volumes is an important development for municipal plants experiencing increasing energy costs, coupled with limited storage capacity, limited land availability or application opportunities. Biosolids waste generators continue to face technical and financial challenges in treating, safe disposal or beneficial utilization of biosolids. More effective biosolids management technologies are continually being sought to improve recycling and utilization of stabilized biosolids.

#### The Lystek technology

Lystek biosolids processing technology is a patented process involving a combination of heat, alkali, and high shear mixing to produce a high-solid pathogen-free high-nutrient liquid biosolid product that meets the US EPA 'Class A' biosolids standard. The processed material is a potassium, nitrogen and phosphorus rich fertilizer product that can potentially be used as a soil conditioner and for land reclamation.

One of the most important benefits

of the Lystek process is associated with a breakthrough discovery to create a stable high-solid and low-viscosity liquid material, even at a solids concentration of >20%. The Lystek process can effectively treat thickened or dewatered raw or digested sludges. The process can yield a viscosity reduction from levels exceeding 2,000,000 centipoises (cP) to less than 6,000 cP in the processed biosolids, which is pumpable with conventional liquid handling equipment.

A schematic flow diagram for the Lystek system is presented in Figure 1. The proprietary process can be operated in a batch or semi-continuous mode. To operate, a conveyer and/or progressive cavity pump is used to transfer dewatered biosolids from a biosolids storage tank to the Lystek processing tank equipped with a mixer. An alkali solution (potassium hydroxide/KOH) is added for pH adjustment and the mixture is heated using a steam generator. The high-shear mixing contributes to particulate and microbial disintegration, as well as to creation of homogeneous conditions, including pH and temperature, throughout the resulting liquid product. Processing time for a batch is typically 30 minutes to one hour at optimum pH and temperature.

The operational costs related to chemical and energy inputs ranges from \$50-\$70 per dry tonne, depending on the volume, characteristics and final

processing and disposal criteria of the biosolids. The relative simplicity of the Lystek process and the small footprint (1000-1500 square feet) facilitates retrofitting into any existing wastewater treatment plant.

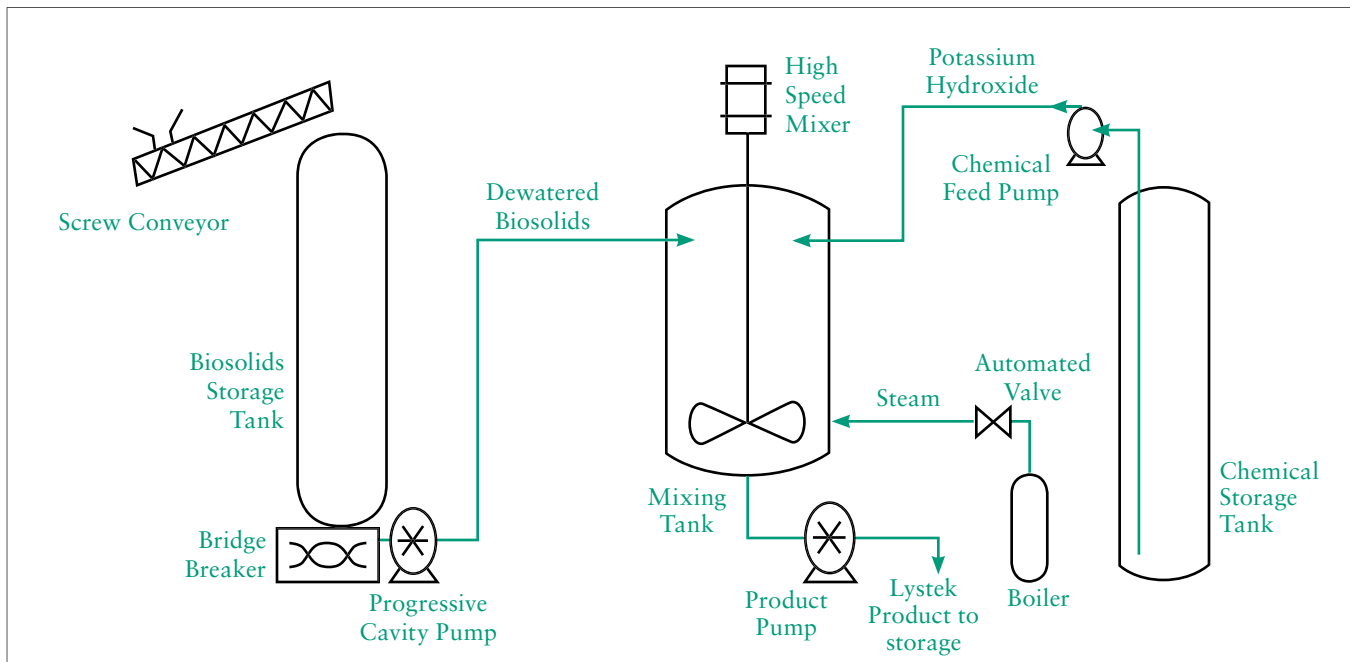
The City of Guelph Wastewater Treatment Plant (WWTP) has adapted Lystek technology as an alternative to the dewatered biosolids land application or landfill disposal through extensive pilot and full-scale tests. A full-scale Lystek system is successfully operating at the Guelph plant and the processed biosolids (15-18% solids) are being applied to the local farmers' fields. The technology provides substantial savings as compared to dewatered biosolids handling and disposal to landfill. The main economic advantage of implementing the Lystek process is the reduced operating costs associated with sludge handling, storage and land application.

#### Lystek processed biosolids

It is generally much cheaper to transport biosolids as a pumpable liquid rather than haul as dewatered biosolids. The liquefaction of dewatered biosolids via the Lystek process produces a homogeneous liquid, facilitating better process control, product handling, storage, and further processing, including homogeneous product formulation to predefined specifications, and/or further solidification/drying. Even drier centrifuged



**FIGURE 1** Schematic process flow diagram of the Lystek system



biosolids at solids concentrations of around 30% may be converted to liquid concentrates. The liquefaction also generates a product that, when recycled to the plant anaerobic digestion system, reduces the volume of biosolids, while at the same time increases the production of biogas (methane).

The Lystek processed biosolids are a homogeneous, safe and stable product for the farmers. Data on various pathogens analyzed before and after Lystek process are presented in Table 1. The process reduces common pathogens found in municipal wastewater sludges to below detectable limits in the treated biosolids. The processed biosolids have also been found stable for over two years at room temperature without any evidence of pathogen regrowth.

At present price levels, Lystek processed biosolids can provide farmers with more than \$400 per acre worth of fertilizer (with predictable NPK levels) that includes many essential organic nutrients not typically found in chemical fertilizers. The Lystek process not only reduces the odours in biosolids, but also modifies the odour to an 'earthy aroma.' Reduced and less offensive odours greatly enhance the public's acceptance of storage and land application of biosolids.

The Lystek process also makes the material faster to dry. Laboratory tests have indicated that the rate of drying

of the Lystek-treated biosolids is about double the corresponding non-treated, dewatered biosolids. The Lystek biosolids drying can be more effective at high-biosolids concentrations of 25-30%. The drying of the liquefied product should simplify dryer process handling, reduce heat energy costs, as well as facilitate the production of a range of dry formulated homogeneous products. The ease of handling and reduced energy requirements for drying of Lystek liquefied biosolids will also be exploited to optimize the use of the product as a liquid fuel to incinerators.

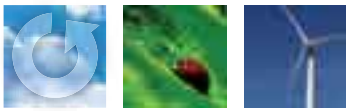
#### Reduced waste and increased biogas production at the WWTPs

In the summer/fall of 2006, a pilot project and full-scale studies were initiated. These studies conducted jointly by Lystek International, Conestoga Rovers & Associates and The University of Western Ontario at the St. Marys and Listowel WWTP in Ontario have demonstrated that, relative to a conventional activated sludge system with dewatering, an integrated sludge management approach using biological nutrient removal (BNR), anaerobic digestion and Lystek technology has the potential to volumetrically reduce as much as 78% of the net dewatered sludge disposal volumes in a fully-optimized plant. Respirometric studies confirmed that recycling Lystek processed biosolids to

the anaerobic digesters can potentially increase methane gas production by 50-100%. The integrated system process was also found capable of significantly improving effluent quality well beyond current standards and any anticipated future standards in Ontario.

BNR is a next-generation activated sludge treatment process that employs a non-aerated zone, or anoxic zone, to create an environment in which bacteria are able to remove nutrients such as nitrogen and phosphorus from wastewater. Nitrification and denitrification are achieved through an internal recirculation stream whereby nitrates generated in an aeration tank are recycled to an anoxic tank where they are reduced to atmospheric nitrogen and removed from the system. The BNR process provides many advantages over conventional activated sludge treatment, including expanded treatment capacity, nitrification/denitrification, enhanced phosphorus removal, improved process stability, and significantly reduced sludge yield.

Lystek-processed sludge is an excellent source of readily biodegradable carbon for denitrification in the anoxic tanks and conversion to volatile fatty acids in the primary digestion for increased methane production. Batch denitrification studies conducted at 20°C, with Lystek biosolids in the range of 0.05-0.3% by volume, revealed that the maximum biomass specific denitri-



fication rates were identical to acetate at 0.75 g NO<sub>3</sub>-N/gVSS-d. Furthermore, continuous-flow laboratory anaerobic digestion studies with Lystek biosolids confirmed a 25% enhancement in volatile solids destruction efficiencies to about 50%. Table 2 highlights the volumetric biosolids reduction per ton of influent wastewater chemical oxygen demand (COD), attributed to Lystek and BNR integration illustrated in a simplified process flow diagram Figure 1.

Based on the feasibility studies conducted during the pilot and full-scale studies of Lystek and BNR technologies, the Town of St. Marys is moving forward to implement this innovative

sludge management approach for its wastewater treatment plant that will offer an exciting opportunity to reduce treatment costs and improve the environmental performance. The integrated sludge management strategy will provide the following benefits to the Town:

- The integrated BNR/Lystek sludge management strategy will increase sludge storage capacity from 60 to 300 days without expanding the plant's existing sludge storage facility.
- The Lystek process will produce a high-solids, pathogen-free, nutrient-rich liquid fertilizer product for beneficial agricultural land application.
- Sludge produced by the plant, which currently meets Ontario's Class 'B' biosolids criteria, will meet and exceed more stringent US EPA criteria for Class 'A' biosolids, including reduced odour, pathogens, and vector attraction that are future target objectives for Ontario/Canada.
- BNR will reduce sludge yield at the plant by up to 30% and provide increased nitrogen and phosphorous removal.
- BNR will allow the plant to expand from its current maximum design capacity of 5,560 m<sup>3</sup>/day to approximately 8,000 m<sup>3</sup>/day with minimum capital investment.

**TABLE 1** Microbiological analysis of Lystek processed and unprocessed biosolids/sludge

PATHOGENS	RAW SLUDGE	ANAEROBICALLY DIGESTED/ DEWATERED BIOSOLIDS	LYSTEK-PROCESSED DIGESTED/ DEWATERED BIOSOLIDS
Escherichia coli (MPN/g)	>1,600	>1,600	<1.8
Fecal coliforms (MPN/g)	>1,600	>1,600	<1.8
Salmonella (P-A/25 g)	Positive	Positive	Negative
Giardia	Empty cyst like objects	Empty cyst like objects	Empty cyst like objects
Cryptosporidium	No oocyst-like objects	No oocyst-like objects	No oocyst-like objects
Clostridium perfringens (CFU per g)	<10	<10	<10
F+ Coliphage (PFU per g)	<1	<1	<1
Somatic Coliphage (PFU/g)	18	<10	<10
Ascaris	Not detected	Not detected	Not detected
Enteric viruses (pfu/4g)	-	776	< 1
Helminthes ova (numbers/4g)	-	130.8	< 1

**NOTE:** 1. <Indicate below detection limit 2. Data on the enteric viruses and helminthes ova are from a seeding test

**TABLE 2** Comparative sludge production in an integrated BNR-Lystek process

PARAMETER	INTEGRATED BNR-LYSTEK PROCESS	CONVENTIONAL ACTIVATED SLUDGE PROCESS WITH DIGESTION AND DEWATERING
Sludge yield, gTSS/gCOD	0.37	0.66
VSS destruction in digester, %	50	40
Dewatered sludge flow, m <sup>3</sup> /d	1.63 @ 15 wt%	2.96 @ 15 wt%
Lystek Sludge flow, m <sup>3</sup> /d	1.77 @ 14 wt%	N/A
Recycled Lystek to BNR, m <sup>3</sup> /d	0.65	N/A
Recycled Lystek to Digester, m <sup>3</sup> /d	0.46	N/A
Disposed Sludge, m <sup>3</sup> /d	0.66	2.96



- The integrated technology system will reduce plant operation costs associated with sludge hauling and land application by up to 50%.
- Recycling Lystek-processed sludge to the primary digester will increase methane gas production and reduce the plant's reliance on natural gas for heating the primary digester and proposed sludge management facility in addition to enhancing volatile solids destruction and COD removal efficiency by 20% and 30%, respectively.

Additionally, the implementation of the integrated Lystek-BNR approach, solely based on the sludge reductions, is estimated to reduce the 'carbon footprint' of the plant by decreasing greenhouse gas emissions from 6.3 to 2.3 tons CO<sub>2</sub>/per ton of WAS.

### Conclusions

The Lystek process produces a valuable nutrient-rich and pathogen-free concentrated liquid fertilizer product which is easily pumped, stored, transported and applied beneficially to agricultural land. The liquid concentrate is amenable to fertilizer formulation strategies and to compositional quality control procedures. Potential exists to extend product range with a series of dry fertilizer products.

Lystek technology and the product characteristics are currently being evaluated by the Canadian Food Inspection Agency (CFIA) for recognition and certification as a standard pathogen-removing biosolids treatment process for production of fertilizer product. This would result in classification of Lystek processed biosolids as a product rather than as a waste, which can have significant beneficial regulatory implications.

Incorporating the innovative Lystek technology integrated with BNR and anaerobic digestion is a cost-effective sludge management approach that provides great benefits to overall operations at a municipal WWTP. In addition to meeting the sludge storage requirement, the integrated system can increase the plant's treatment efficiency and process stability. These processes may be implemented at the municipal WWTP or in an off-site central processing facility.

There are more than 17,000 wastewater treatment plants across North America, about 10% of which are in Canada. These plants produce more than 10 million dry tonnes of biosolids each year, at a cost of more than \$3 billion. The integrated BNR/digester/Lystek approach can be directly applied to the majority of these facilities. The combination of the benefits noted above offer exciting prospects throughout North America. ♦

*Ajay Singh, Ph.D., Lystek International Inc.  
107-279 Weber Street North, Waterloo,  
Ontario N2J 3H8 (asingh@lystek.com)*

*Andrew Lugowski, M. Eng., P. Eng.  
Conestoga Rovers & Associates  
651 Colby Drive, Waterloo, ON N2V 1C2*

*George Nakhla, Ph.D., P. Eng.  
University of Western Ontario, Faculty of  
Engineering, London, ON N6A 5B8*

*Owen Ward, Ph.D.: Lystek International Inc.  
107-279 Weber Street North  
Waterloo, Ontario N2J 3H8*



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**26-505 Hood Road, Markham, Ontario L3R 5V6**  
**(905) 415-3878 FAX (905) 415-2721 env@envinc.ca**