PO Box 422 ■ Tamworth, NH 03886-0422
www.nebiosolids.org

nebra
North East Biosolids
& Residuals Association
Cooperatively promoting the environmentally sound recycling of biosolids and other residuals

phone 603-323-7654
fax 603-323-7666
info@nebiosolids.org

Information Update:
Options for Biosolids Use or Disposal in New England & Eastern Canada
March 8 & April 11, 2011

Introduction
A national survey of biosolids use and disposal (NEBRA et al., 2007) found that, in 2004, about 55% of the wastewater solids (sewage sludge) produced in the U. S. are treated and recycled to soils as biosolids. About 30% are landfilled and 15% are incinerated. Of the total beneficially used on soils, three-quarters is applied to agricultural land, 22% is distributed as Class A products, and 3% is used in land reclamation projects.

In many parts of the country, land application has long been, and remains, the simplest, most cost-efficient end use or disposal option for biosolids. However, in many areas, including in the densely-populated states on the coasts, there has been a steady reduction in land application of biosolids, especially Class B. For example, in Maine in 1997, Class B land application accounted for 52% of the wastewater solids produced in the state; in 2008, it accounted for 10%. During the same period, Class A biosolids production (composting and NViro) increased from about 30% to 60%, and landfilling increased from almost zero to 30%. Several factors have caused this reduction, including increases in state and local regulations, cost-competitive landfill disposal, concern about liability exposure (landfill disposal carries less), and public scrutiny of land application.

Meanwhile, in the past five years, sustainability and energy have become larger topics in the wastewater treatment profession. This has led to an increased focus on wastewater solids as a source of energy. As emphasized at the December, 2010 National Biosolids Partnership meeting on "Charting the Future of Biosolids Management," biosolids are increasingly recognized as a resource, and the goal is to maximize the use of all of the following potential beneficial attributes of biosolids, to the extent possible in the local situation:

- Nutrients (nitrogen, phosphorus, and micronutrients such as iron, magnesium, etc.)
- Organic matter (important for building healthy soils)
- Energy (a renewable source; 5,000 – 10,000 Btu / dry pound, similar to low-grade coal)
- Water (most valuable in dryland agriculture)
- Binding sites (reducing bioavailability of trace contaminants such as lead, mercury, and trace synthetic chemicals).

With the increased interest in sustainability have come advancements in research and technology. Tried and true biosolids treatment processes – such as lime stabilization, anaerobic digestion, composting, incineration, thickening, and dewatering – are being refined and enhanced to make them more energy efficient and cost effective. Newer treatment technologies are taking hold, including dewatering screw presses, a variety of smaller efficient heat drying systems, and systems for conditioning solids to improve anaerobic digestion. Technologies in the development stage include wastewater solids gasification and systems that harvest nutrients from side streams to create fertilizer products.

It is an exciting time for biosolids management! This document provides a summary of many of the current trends in technologies, end uses, and disposal options. See also the report from the "Charting the Future of Biosolids Management" forum held December 2nd and 3rd, 2010, in Alexandria, VA.

Priority Considerations in Biosolids Management

Decisions about management of biosolids are influenced primarily by the following forces:

- Cost
  - What are the up-front, capital costs?
  - What will be the operating costs?
  - What are the opportunity costs in comparison to other options?
  - Consider the market value of the biosolids products: soil amendment, water, energy, etc.
- Compliance
  - How do biosolids management decisions affect compliance with biosolids regulations and permitted effluent standards?
  - Aim for consistently high product quality
- Flexibility
  - Keep end use and disposal options open
  - Build in some redundancy (e.g. Middletown, OH can achieve Class A from both its ATAD and its combined alkaline drying system or both in series)
- Experience
  - Is the technology tried and true?
  - Is it proven in full-scale operations?
- Public Support
  - How will the public perceive potential risks?
  - What will be the impact of the biosolids management program on public perception?

Example of part of an analysis of biosolids management options conducted by AECOM for a Pennsylvania WWTP (Tepe-Sencayir et al., 2010).

Table 1 – Product Summary Table

Class	Product	Required Characteristics*	End Uses	Outlets	Acceptable %TS Range	Expenses		Revenues per wet ton
						Beneficial Use Transportation per wet ton	Beneficial Use, Per wet ton	
Energy	Pellets	BTU value	Energy and ash for cement	Lehigh Cement Company	>90%	$22	-	-
	Cake	BTU value	Energy for gasification	Gasification, MaxWest	>25%	-	$35.50	$0.12
EQ	Pellets	Low odor, low dust, consistent size, high nutrient content	Marketing, Landfill	Turf, golf, nurseries, agriculture, etc.	>90%	$15	$2.80	$20
	Cake (low dryness)	High nutrient content, low to moderate odor	Ag Use, Landfill	Local agriculture	>20%	-	$ 35.00	-
	Cake (high dryness)	Low odor, high nutrient content	Blending, Ag Use, Landfill	Local soil blender, agriculture	>30%	$10	$0.75	$5
Class B	Base Case (lime stabilized)	High nutrient content, low odor, lime content	Ag Use, Landfill	Local agriculture	>20%	-	$38.00	-
	Cake (digested)	High nutrient content, low odor	Ag Use, Landfill	Local agriculture	>20%	-	$38.00	-

*Characteristics required for product success in highest value/lowest cost market

- What potential interactions may the public have with the biosolids management program and will those interactions affect public support?
- Sustainability
  - Recycling of nutrients and organic matter
  - Utilization of energy value of biosolids
  - Social acceptability
  - Current and longer-term benefits, without compromising the future
  - Overall environmental soundness, as shown by life cycle analysis that considers toxics, greenhouse gas emissions, recycling, energy consumption, etc.
  - Triple-bottom-line analysis, considering economic, environmental, and social aspects.

Concerns Shared by Many Options

For each of the biosolids treatment and management options outlined below, there are shared concerns, including:

- Beneficial use of biosolids as soil amendments and fertilizers – no matter whether Class A or B – can generate public concern, depending on how the program is developed, presented, managed, and operated. Any program for beneficial use of biosolids must include proactive public outreach.
- Biosolids products for beneficial uses require marketing and distribution expertise, which must be included within the program or obtained from a contractor. Managers and operators need to be in the mind-set that they are creating consistent products for customers, not "getting rid of sludge."
- Legal concerns:
  - In general, the wastewater treatment facility (the generator) holds legal responsibility for final use and disposal of wastewater solids.
  - There is an increasing volume of legal opinions regarding how biosolids land application fits under the dormant Commerce Clause of the U. S. Constitution and federal and state preemption of local regulations (Slaughter and Doverspike, 2010). In general, these opinions support state and local regulations that are stricter than federal standards, as long as they are not outright bans or otherwise unduly restrictive.
  - There is an increasing volume of legal opinions from lawsuits brought by disgruntled neighbors or others claiming harm from biosolids, all of which have found no direct harm from modern biosolids applied in accordance with federal and state regulations.
- The regulatory playing field:
  - Federal regulations for biosolids management have been consistent since the 40 CFR Part 503 rule was promulgated in 1993.
  - New Clean Air Act regulations are affecting incineration of biosolids beginning in 2011.
  - In contrast, the regulations in most states have continued to evolve and have been changing over the past 15 years. In New England, several states have been planning biosolids rule revisions for some time and may act soon. For example, in Maine, biosolids quality standards have become significantly more stringent than the federal rules and a wide variety of management practices are required. Most recently, Maine has begun to recommend an odor monitoring regulation that would apply to biosolids and other organic residuals and facilities. While the stated policy of Maine DEP and OSP are to encourage recycling of biosolids (and most of the biosolids in the state are recycled), the regulatory hurdles are significant. Over the past decade, landfilling and

composting of biosolids have increased, while Class B land application has decreased (Maine DEP, 2009).
  - o The biosolids management program can affect compliance with wastewater treatment (NPDES) permits; for example, side streams from biosolids treatments like digestion can result in excess nitrogen loads at the treatment plant headworks, which can lead to exceeding permit levels in effluent.

BENEFICIAL USES

Below are brief discussions of current biosolids treatment and beneficial use practices, including benefits and concerns for each one.

Advanced alkaline stabilization

There are several established systems, including NViro and RDP. The latter has not worked well in two installations in New England, and it does not seem to be advancing at all. Meanwhile, the patent for NViro has expired.

Benefits:

- Proven processes for meeting regulatory requirements.
- Achieves Class A.
- Often relies on cost-effective recycled of bulking agent/feedstock (e.g. lime kiln dust)
- Product provides a liming agent for farmers, as well as some nutrients.

Concerns:

- Supplemental heat is sometimes required.
- Volume of final product created is greater than volume of original wastewater solids, which creates increased handling and transportation challenges and costs.
- Some products may not be as nice handling as others (sloppy, dusty)
- Products can have significant odors.
- Repeated farm use of lime-rich products can lead to excessive soil pH and/or calcium saturation.

Autothermal thermophilic aerobic digestion (ATAD)

This technology is gaining increased interest as the "second generation" of systems are proving successful.

Benefits:

- Reduces solids volume (up to 60% total solids reduction).
- Biological stabilization (digestion), which also further reduces microconstituents.
- Achieves Class A, low odor solids.
- Less complicated system in comparison to anaerobic digestion.
- Good dewatering of resulting solids.
- More compact system than conventional aerobic digestion and some other treatments.
- ~30 full-scale "second generation" operating systems since late 1990s.

Concerns:

- Relatively high energy requirement.

- "First generation" ATAD systems developed a reputation for significant foaming, impacts of side (return) streams (especially ammonia), and odor generation, as well as issues with process control.
- The final product may not be appealing in terms of handling, consistency, % solids, etc. May not be as user-friendly as other Class A products.
- No energy production benefit in comparison to anaerobic digestion.

Anaerobic digestion

The biosolids management profession is enthusiastic about anaerobic digestion right now. Biosolids conferences over the past few years have been dominated with presentations about various aspects of "AD," including solids conditioning prior to AD, staged AD systems, improvements in mixing technologies, affects of AD on solids dewatering, management of return streams, adding other substrates such as fats-oils-grease (FOG) to digesters, and more. In addition, there is huge interest in combined heat and power (CHP) and other ways to utilize biogas, which currently is underutilized across the U. S. (U. S. EPA Combined Heat & Power Partnership, 2011).

Benefits:

- Reduces solids volume.
- Biological stabilization (digestion), which also further reduces microconstituents.
- Achieves Class B.
- Thermophilic AD can achieve Class A.
- Many add-ons (e.g. thermal hydrolysis) have been developed to enhance digestion and maximize biogas production.
- Resulting biogas can produce renewable energy.

Concerns:

- Digesters can be finicky, requiring considerable O & M.
- Gas handling required and can be a safety issue (biogas/methane).
- High capital cost (although systems are beginning to be designed with smaller digesters similar to those long used in agriculture and industry).
- Extracting and managing energy requires different skills from normal WWTP operations.

A recent analysis of biosolids management options conducted for a Pennsylvania treatment plant estimated that the lowest total 20-year life cycle cost can be achieved with mesophilic anaerobic digestion (AD) followed by Class B land application or landfilling, with associated combined heat and power (Tepe-Sencayir et al., 2010). A life cycle analysis of biosolids management options for a city in China (Murray et al., 2008) also found AD with energy recovery followed by land application to have the least total triple-bottom-line cost.

Nutrient recovery

The first full-scale struvite nutrient recovery system in North America started operations in May, 2009 in Tigard, OR. This is a promising development that extracts a marketable fertilizer product rich in phosphorus (P, a limited natural resource) and nitrogen (N). The result is lower levels of P in return streams and the final biosolids product.

There are also systems in development that combine heat drying and/or pelletizing with additional enhancements that lead to a more complete and concentrated fertilizer product. Examples are VitAg and the Unity Envirotech fertilizer product.

Nutrient recovery could be significant in the future, especially since traditional land application of biosolids based on N loading can lead to an over-application of P, an increasing concern in sensitive watersheds.

Land application

The materials resulting from many of the above stabilization treatments are routinely land applied in agricultural and other settings throughout the U. S. Land application of Class B biosolids remains the single largest outlet for sewage sludge generated in the U. S. (NEBRA, 2007).

The variety of options for land application has grown. Uses in agriculture range from traditional biosolids-amended crops (corn, wheat, and grass for hay) to crops such as soybeans, hops, other grains, wine grapes, and more. In Washington state, biosolids have been used to grow a canola crop for making biodiesel.

In the Northwest, biosolids have been used in forestry applications for decades; such use has not caught on in the Northeast. However, in the Mid-Atlantic states, there is ongoing use of biosolids in highly-managed hybrid poplar plantations.

Land reclamation using biosolids has become routine across the continent, including in New Brunswick, Maine, New Hampshire, and Massachusetts.

Benefits:

- Land application is a simple, relatively low-tech use of biosolids.
- Mimics and supplements farm uses of animal manures.
- Often the lowest cost option for biosolids management.
- Recycles local resources to local soils.

Concerns:

- Some Class B biosolids generate significant malodors; these must be managed carefully to avoid upsetting neighbors and communities.
- Public perceptions can be negative.
- Class B biosolids products can be less appealing and harder to handle than many Class A products (although this is not always the case), and, generally, Class B products are perceived by the public and, sometime, regulators, as more problematic.
- Most states require site permits for use of Class B materials, including all New England states and the eastern provinces. For example, Vermont has very stringent regulations on Class B land application sites that make it difficult to site a new one; the regulations include a requirement for groundwater monitoring and some regulatory overlap with the state agriculture department.

Composting

There are 265 biosolids composting projects in the U. S. (Beecher and Goldstein, 2010). Most manage relatively small volumes of wastewater solids, but there are some larger, regional facilities. Aerated static pile systems are most common, followed by windrows and in-vessel systems. Composting facilities are operating in all regions of the country, from Fairbanks, AK to southern Florida. For example, there are 13 operations in Maine, including New England's largest regional compost facility at Unity.

Benefits:
- Simple, proven process.
- Achieves Class A.
- Strong and diverse markets for quality product.
- Can utilize yard and leaf waste as bulking agent, helping deal with another waste stream.

Concerns:
- Requires considerable space.
- Depending on system, may require considerable handling and operator time.
- Process odor control can be an issue.
- Requires careful attention; can be finicky.
- Some bulking agents – e.g. sawdust – are getting expensive and harder to secure.

Heat drying (including use for fertilizer and/or fuel)
There are several competing drying systems in the marketplace now, including rotary dryers, tray dryers, and heated-chamber indirect dryers.

Benefits:
- Volume and weight are reduced.
- Product is relatively easy to handle and can be a consumer-friendly product (e.g. Milorganite).
- Strong markets for biosolids pellets in New England and across the country.
- Rotary drum dryers have become widely accepted in the industry.
- Flexibility: product can be used as soil amendment/fertilizer and/or fuel.
- Some dryers are operated with digester gas or waste heat, reducing fossil fuel needs.
- Cement industry is becoming quite interested in long-term partnering in use of dried pellets for alternative cement kiln fuel.

Concerns:
- High energy costs for driving off moisture.
- Tray dryers are especially expensive and require more O & M.
- Tray dryers and heated-chamber dryers make lower quality, diverse-sized product.
- Rotary drums – and any dryer system – is complicated and may have significant O & M costs.
- Products may be dusty and/or have issues in storage (proper storage required to avoid combustion)
- Use of dried biosolids as fuel requires compliance with new standards under Section 129 of the Clean Air Act, unless a petition for legitimate fuel classification is approved by U. S. EPA.

Gasification
Sludge gasification has been piloted using heat-dried pelletized biosolids. While gasification is an old process, sludge gasification is still in its development, with only one sizable facility operating in the U. S. (built and operated by MaxWest in Sanford, FL). Operational and cost issues have challenged this and the potential gasification system at Stamford, CT. However, a recent analysis of biosolids management options conducted for a Pennsylvania treatment plant estimated that the 20-year life cycle cost of gasification could be similar to mesophilic anaerobic digestion followed by Class B land application or landfilling, with associated combined heat and power (Tepe-Sencayir et al., 2010).

Benefits:

- Extracts energy from biosolids.
- Large reduction in volume of residual.
- Final material is an ash, which is mostly inert, but may have trace metal contaminant issues; land application of ash is done, but landfill disposal is most common.

Concerns:
- Lack of experience and proof of concept at full scale, using biosolids.
- High capital cost.
- Complicated technology and operation.
- Does not utilize nutrient value of biosolids.
- Net energy benefit is uncertain when considering energy costs of drying biosolids to the required 90%+ dry solids.
- Extracting and managing energy requires different skills from normal WWTP operations.

Incineration with Energy Recovery
If as much energy as possible is recovered from a combustion process, it may be considered a beneficial use. There are about 210 sewage sludge incinerators (SSIs) in the U. S., and several in Quebec, many of which are looking to retrofit energy recovery systems.

Benefits:
- Tried and true technology.
- Can extract energy from biosolids.
- Large reduction in volume of residual.
- Final material is an ash, which is mostly inert, but may have trace metal contaminant issues; land application of ash is done, but landfill disposal is most common.
- Ability to manage large volumes of wastewater solids onsite at the wastewater treatment facility, with little to no interaction with the public.

Concerns:
- High capital cost.
- Requires compliance with air emissions regulations.
- Complicated technology and operation.
- Does not utilize nutrient value of biosolids.
- Net energy balance is uncertain and varies from facility to facility (fluidized bed units are generally more efficient than multiple hearth units).
- Extracting and managing energy requires different skills from normal WWTP operations.

Generating revenues
When a successful biosolids recycling program is in place, it is possible to build on the expertise of managing an organic waste and generate revenues for the treatment facility. This is not yet common, but there are some high profile examples. For example, East Bay Municipal Utility District (EBMUD) in California has expanded its purview to include digestion of food waste, using excess anaerobic digester capacity. Other co-digestion projects at WWTFS are under consideration around North America.

Benefits:
- Revenues from tipping fees
- Increased revenues from biogas utilization

- Providing solutions for regional organic waste management
- Assisting in reducing greenhouse gas emissions through waste diversion from landfill
- Potential for generating carbon offsets and/or renewable energy credits

Concerns:
- Increased volumes of incoming waste to manage
- Physical contamination in the added outside wastes (e.g. plastics in food waste)
- Odor concerns
- Public perception of taking wastes from outside sources
- Increased complexity of managing anaerobic digesters and biogas utilization
- Increased O & M requirements

DISPOSAL OPTIONS

Incineration
Southern New England relies predominantly on incineration for disposal of wastewater solids. As noted above, there is an increasing interest in recovering as much energy as possible from the combustion process. For example, the incinerator at New Haven, CT has a new, effective energy recovery system. The benefits and concerns are detailed above.

If no energy is recovered from an incinerator, then this is truly disposal, with no beneficial use. In New England, incineration is sometimes used as a back-up option for wastewater solids management.

Landfill Disposal
Disposal of wastewater solids in a landfill is widely used as a backup to other options. It is also a primary disposal option for many wastewater treatment facilities, especially smaller facilities that do not generate much each year and do not want the hassles of managing a land application or other beneficial use program.

There has been research during the past two decades on "bioreactor landfills," landfill cells designed to produce biogas that can be captured and used for energy production. Wastewater solids are seen as a benefit to such systems, as they provide moisture and organic matter that accelerates decomposition. The difficulty is, however, that managing such systems is far more challenging and ineffective than an anaerobic digester. So if energy extraction via anaerobic digestion is the goal, controlled digesters are superior.

Benefits:
- Simple process, requiring only dewatering and minimal testing.
- Can be relatively inexpensive in some parts of the U. S. and some parts of New England.
- Can provide benefit to engineered bioreactor systems.

Concerns:
- Does not put to use any of the resources in biosolids.
- Generates methane rapidly soon after disposal, making it difficult to capture or control, resulting in significant fugitive greenhouse gas emissions.
- Limited landfill space and significant challenge of siting more landfills.

References

(available from NEBRA upon request)

Beecher, N. and N. Goldstein, 2010. Biosolids Composting in the United States – 2010 Update. *BioCycle*. December 2010.

Garcia, Aaron (Director of Alternative Fuels, CEMEX, Inc.). 2010. Biosolids in the Cement Industry. Proceedings of the WEF Residuals and Biosolids 2010 Conference, Savannah, GA.

Maine DEP (Dept. of Environmental Protection). 2009. Spreadsheet presentation of data on the use and disposal of wastewater solids in Maine, 1997-2008.

Murray, A.; A. Horvath; and K. Nelson. 2008. Hybrid Life-cycle Environmental and Cost Inventory of Sewage Sludge Treatment and End-Use Scenarios: A Cast Study from China. *Environ. Sci. Technol.*

New Hampshire Legislature. 2008. FINAL REPORT of the Commission to Study Methods and Costs of Sewage, Sludge and Septage Disposal (HB 699, Chapter 253, Laws of 2007)

NEBRA (North East Biosolids and Residuals Association), *BioCycle,* Northwest Biosolids Management Association, and Wisconsin Dept. of Natural Resources. 2007. A National Biosolids Regulation, Quality, End Use & Disposal Survey. Available at http://www.nebiosolids.org.

Oerke, D.; C. Olsen; J. Kirk; and C. Maines. 2010. "Second Generation" ATAD – A-Tad Better? – Two Case Studies of Conversion from "First Generation" to "Second Generation" ATAD Systems. Proceedings of the WEF Residuals and Biosolids 2010 Conference, Savannah, GA.

Pevec, Tony and Ed St. John. 2010. Largest Municipal ATAD – Class A Biosolids at Middletown WWTP. Proceedings of the WEF Residuals and Biosolids 2010 Conference, Savannah, GA.

Slaughter, J. B. and S. Doverspike. 2010. Biosolids 2010: Mastering the Legal Landscape for Land Application and Beneficial Use. Proceedings of the WEF Residuals and Biosolids 2010 Conference, Savannah, GA.

Tepe-Sencayir, N.; R. Eschborn; M. Abu-Orf; R. Mastowski; C. Foreman; T. Johnston; E. Winzeler; M. Kyle. 2010. Energy from Residuals – Comparing Anaerobic Digestion to Drying/Gasification Model. Proceedings of the WEF Residuals and Biosolids 2010 Conference, Savannah, GA.

U. S. EPA Combined Heat & Power Partnership. 2011. Draft report update on use of biogas by U. S. wastewater treatment facilities.

U. S. EPA. 2008. Turning Food Waste into Energy at the East Bay Municipal Utility District (Fact Sheet)

U. S. EPA Region 9. 2008. Anaerobic Digestion of Food Waste. (Report regarding East Bay MUD)

The North East Biosolids and Residuals Association (NEBRA) is a 501(c)(3) non-profit professional association advancing the recycling of biosolids and other organic residuals in New England and eastern Canada. NEBRA membership includes the environmental professionals and organizations that produce, treat, test, consult on, and manage most of the region's biosolids and other large volume recyclable organic residuals. NEBRA is funded by membership fees, donations, and project grants. Its Board of Directors are from MA, ME, NH, VT, and New Brunswick. NEBRA's financial statements and other information are open for public inspection during normal business hours. For more information: http://www.nebiosolids.org.