USA Biosolids Regulations & Practice
...and what the future may hold

Ned Beecher • North East Biosolids & Residuals Association (NEBRA)

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What is sewage sludge?

- Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works

Deer Island Wastewater Treatment Plant
Boston, Massachusetts USA
What are municipal biosolids?

“Municipal biosolids are municipal sludge which has been treated to meet jurisdictional standards, guidelines or requirements including the reduction of pathogens and vector attraction.” - CCME, 2012

biosolid n. (1990): "solid organic matter recovered from a sewage treatment process and used especially as fertilizer -- usually used in plural”

– Merriam-Webster’s Collegiate Dictionary, Tenth Edition
Many decades of experience

40+ years of focused research

Milorganite has been in use since the 1920s.
The U. S. EPA Biosolids Rule
40 CFR Part 503

• Effective in 1993
• Pollutants (metals/chemicals): standards from risk assessment
• Pathogens: standards based on technology demonstrated to reduce culturable pathogens
• Vector attraction reduction: standards to stop transmission
• A few management practices
• Monitoring, recordkeeping, and reporting.

Specifies requirements for three management options:

- Land application
- Incineration
- Surface disposal

Incineration with new energy recovery for electricity at New Haven, Connecticut

Heat-dried biosolids pellet used for turf grass production in Rhode Island.
Part 503: Improving on the EPA 1979 Regulations

- Risk assessment for pollutants (heavy metals/chemicals)
- Retain two classes of treatment (Class A & Class B), but set quantitative microbiological standards for the product
- Separate VAR from pathogen reduction
- Set quantitative standards for VAR (e.g. 38% VSR)
- Require VAR to occur with or follow Class A treatment
- Refine the PSRP/Class B restrictions
- Inadequate information was available for a risk-based approach for pathogen treatment
- Establish monitoring, recordkeeping, and reporting requirements
Ag Land-Application Exposure-Risk Model
Pathways for Risk Assessment - 1

Elements in soils and highly exposed individuals

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Highly Exposed Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soil → Plant → Human</td>
<td>Farm markets; 2.5% of food</td>
</tr>
<tr>
<td>2. Soil → Plant → Human</td>
<td>Home gardens; 60% of garden foods for lifetime; 1000 t/ha</td>
</tr>
<tr>
<td>3. Soil → Human</td>
<td>200 mg/day soil/dust ingestion; 1000 t/ha</td>
</tr>
<tr>
<td>4. Soil → Plant → Animal → Human</td>
<td>Farms; 45% home-grown meat; 1000 t/ha</td>
</tr>
<tr>
<td>5. Soil → Animal → Human</td>
<td>Grazing ruminants; soil is 2.5% of annual diet; 45% home-grown meat.</td>
</tr>
<tr>
<td>6. Soil → Plant → Livestock</td>
<td>100% of livestock feeds grown on soils; 1000 t/ha</td>
</tr>
<tr>
<td>7. Soil → Livestock</td>
<td>Grazing ruminants; 2.5% soil in diet.</td>
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### Pathways for Risk Assessment - 2

Elements in soils and highly exposed individuals

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### Land Application Pollutant Limits
(all weights are on dry weight basis)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Table in 503 Rule</th>
<th>Table #1</th>
<th>Table #2</th>
<th>Table #3</th>
<th>Table #4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ceiling Concentration Limits* (mg/kg)</td>
<td>Cumulative Pollutant Loading Rates (kg/ha)</td>
<td>&quot;High Quality&quot; Pollutant Concentration Limits** (mg/kg)</td>
<td>Annual Pollutant Loading Rates (kg/ha/yr)</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>75</td>
<td>41</td>
<td>41</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Cadmium</td>
<td>85</td>
<td>39</td>
<td>39</td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td>Chromium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>4,300</td>
<td>1,500</td>
<td>1,500</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>Lead</td>
<td>840</td>
<td>300</td>
<td>300</td>
<td></td>
<td>15</td>
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<tr>
<td>Mercury</td>
<td>57</td>
<td>17</td>
<td>17</td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>75</td>
<td></td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>420</td>
<td>420</td>
<td>420</td>
<td></td>
<td>21</td>
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<tr>
<td>Selenium</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>5.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>7,500</td>
<td>2,800</td>
<td>2,800</td>
<td></td>
<td>140</td>
</tr>
</tbody>
</table>

* absolute values
Key U. S. EPA Documents for Regulating Sewage Sludge (1980s)
Time / Temperature Relationships for Class A Pathogen Reduction

\[ D_{\text{days}} = \frac{221,330,000}{\text{VCF}^{0.67}} \]

*Note:* This equation applies only to sludge that is <2% solids content at 50°C.

Source: 40 CFR 286, Section 503.32
Microbial standards

✓ Technology based
✓ *Salmonella* sp., fecal coliforms, enteric viruses, viable helminth ova

Class A:

✓ <1000 fecal coliform MPN / g (dry weight) or
  <3 *salmonellae* MPN / 4 g (dry weight) and PFRP, defined process, PFRP equivalent, or pre/post;

  ✓ <1 PFU enterovirus / 4 g (dry weight)
  ✓ <1 viable helminth ova / 4 g (dry weight)

Class B:

✓ Use of a PSRP or equivalent process or
  <2 million fecal coliform / g (dry weight)
Class B Biosolids Land
Applied + Management = A

Public access:
• 30 days – public access when there is a low potential for exposure
• 1 year – public access restriction when there is a high potential for exposure (e.g., turf)

Harvest:
• 30 days – food, feed, fiber crops harvest
• 14 to 38 months – depending on type of food crop and likelihood of touching amended soil

Grazing:
• 30 days – animals not allowed to graze
Vector Attraction Reduction

Employ one of ten options (8 process) designed as:

- Biological processes which break down volatile solids, reducing available nutrients for microbial activities and odor producing potential
  - 38 % VS reduction via treatment
- Chemical or physical conditions which stop microbial activity
  - Alkali to raise pH to at least 12
- Physical barriers between vectors and volatile solids in the sewage sludge
  - Soil barrier
Self-implementing rule
- Federally enforceable without a permit

States have adopted Part 503 or something more restrictive
- Typically additional requirements address environmentally sensitive areas (e.g., shallow ground water)
- Eight states are formally delegated (UT, OK, WI, TX, AZ, OH, MI,...)
Choice of use or disposal practice is a local decision.
As of today, are your state's biosolids regulations more restrictive than 40 CFR Part 503?
Biosolids use in North America

Biosolids compost use on White House lawn, Washington, DC

Mid-1980s - photos courtesy of Eliot Epstein, Ph.D., and Orgro
USA total wastewater solids: 7,180,000 dry U. S. tons/year

55% is used on soils
We need an update of these data.
Feed corn grown with liquid injected, Class B, anaerobically-digested biosolids, July 2012
In the drier west, biosolids improve the water-holding capacity of the soil.
Waco, Texas

Pasture, 1 year after application of bulk Class B, anaerobically-digested biosolids, December, 2012
Pennsylvania mine reclamation

before

after
Central Valley, California

Virginia
New Hampshire biosolids application between cuts of hay.

Central New Hampshire
New Hampshire biosolids - fall application for feed corn

http://youtu.be/b4yFdXjh-fc
My garden, central New Hampshire

April, 2012: biosolids compost delivered....

August 2012
What have we accomplished?

- Robust research programs – 40+ years
- Extensive international experience
- Capacity for excellent biosolids management within a diversity of organizations:
  - Regulatory agencies (federal, state, provincial, local)
  - Public sector (water resource recovery facilities)
  - Private sector (biosolids management companies, technology developers & vendors, non-profit professional associations – such as NEBRA)
Why use biosolids? The benefits

Biosolids make a difference in crop quality.

Darker grass crop is where biosolids were applied.
Biosolids improve soils.
Biosolids jump start healthy soils.

First year of corn after new field was created

Additional new field being created

Use of Lawrence, MA Class A biosolids pellets & paper mill residuals (gray) to establish new corn field on former forest site, Rutland, Mass.
Numerous studies demonstrate the benefits derived from adding organic matter, such as biosolids, to soils: higher carbon content (carbon sequestration), increased microbial activity, increased water-holding capacity, and lower bulk density (which means easier tillage & handling).
Early growth of corn on control (left) and compost amended (right) plots on Woodstown silt loam soil (Epstein and Chaney, 1974).
Surface organic layer (thatch) on orchardgrass pasture which received fluid biosolids applications for 28 years without tillage; Hagerstown, MD, 1975.
Revegetated coal mine spoil at Frostburg, MD, treated with Composted biosolids (Armiger et al., 1975).
Bunker Hill, Idaho -- Smelter killed ecosystem Superfund Site.
Revegetation of Bunker Hill Hillsides using mixture of biosolids, woodash and logyard debris, after 2 years.
Palmerton, PA, 1980; Dead Ecosystem on Blue Mountain.
Appalachian Trail ("protected" area)

Palmerton, PA: Blue Mountain – 1999
Foreground = Biosolids+Limestone+FlyAsh; Background = untreated Control
Developments Since Part 503
Every 10 years: A state-of-the-science conference

U. S. EPA, U. S. Dept. of Agriculture, and land grant & other university biosolids research scientists

1973 – Univ. of Illinois
1983 – Colorado
1993 – Univ. of Minnesota – proceedings published by Soil Science Society of America
2004 – Univ. of Florida – proceedings in Journal of Environmental Quality
“In summary, society produces large volumes of treated municipal wastewater and sewage sludge that must be either disposed of or reused. While no disposal or reuse option can guarantee complete safety, the use of these materials in the production of crops for human consumption, when practiced in accordance with existing federal guidelines and regulations, present negligible risk to the consumer, to crop production, and to the environment.”
“There is no documented scientific evidence that the Part 503 rule has failed to protect public health. However, additional scientific work is needed to reduce persistent uncertainty about the potential for adverse human health effects from exposure to biosolids.”

The EPA developed an Action Plan in 2003:
- 14 projects, now completed
3 topics of greatest concern:

- **“heavy” metals**: regulated, non-regulated
- **chemicals**: PCBs, legacy, priority pollutants, microconstituents, PPCPs, radioactivity...
- **pathogens**: traditional, “emerging,” endotoxin, prions, antibiotic resistance, reactivation & regrowth...
Tips for quality programs...
Proactive public outreach & involvement
Resources: WERF Reports on Biosolids Public Perception & Strategic Risk Communications

Beecher et al., 2009

Eggers et al., 2011

Deeb et al., 2009
Most important: The Quality of YOUR Program

- Go beyond compliance
- Best management practices
- Be a good neighbor
- Proactive public outreach
- Network with other biosolids programs & interested parties (be a part of the community!)
  - Agricultural advisors,
  - Farm, horticultural, landscaping, mining groups
  - Environmental & community groups
Tips for quality programs...
Pay attention to details

- When biosolids go out to use on farms, parks, other sites, their quality and the quality of how you manage them represents our whole profession!
- Strict compliance with set-backs, signage,...
- Understand neighbor concerns and take proactive steps to address them (voluntary measures, such as increase set-backs)
- Good housekeeping (clean trucks, no spills, etc.)
National Biosolids Partnership - EMS

- Based on ISO 14001 – Environmental Management
The NBP Biosolids Management Program (BMP/EMS) Continual Improvement Cycle

www.biosolids.org
Celebrating NBP EMS Certification
What the future holds...

➡ Resource recovery:
  ➡ Energy
  ➡ Nutrients (P especially)
  ➡ Organic matter
  ➡ Water
Findings: Lower GHG emissions from use on soils

“Methane avoidance”

- **Landfill**
  - Energy recovery
  - Cold wet climate

- **Incineration 1**
  - 800°C
  - 25% solids
  - No recovery

- **Incineration 2**
  - 900°C
  - 30% solids
  - Energy recovery

- **Class A Alkali**
  - Ap
  - 65% heat
  - 30% elect.
  - 1% fugitive

- **Anaerobic dig.**
  - Land ap

Using virgin lime

- **if recycled lime** → total to
- -211**
Land application of biosolids may increase the potential for eutrophication of surface water, but is much less likely to do so than manure.

Composting can increase water soluble P of manures by hydrolyzing phytate-P.

Wheat yield increased with biosolids application with the exception of the limed composted biosolids on the Maryland soil which caused Mn deficiency; high Fe added during treatment.

Phosphorus concentrations in the wheat shoots tissue were “sufficient” for wheat even though P fertilizers had not been applied for many years.

Adding Fe/Al during processing helped keep P in adsorbed forms; need to balance Fe and Mn in amendments added during composting.
What Chemicals do we find in the Environment / Biosolids?

All the ones we are using (i.e., assuming we are looking for them)

 Mostly those that are:
  • Mass-produced
  • Discharged into wastewater and the environment
  • Feature foreign chemical structures (i.e., organohalides / PFCs)

Detection does not automatically imply a problem
Colgate Total Toothpaste, 0.30 % Triclosan = 3000 ppm
Public interest remains high
  o What is their fate?
  o Do they have any impact?
  o Illustrate the connection of individuals’ activities with environment

What does it mean for biosolids management?
  o Similar reactions / processes for all chemicals
  o Persistent chemicals present highest level of concern

Biosolids land application as a tool for managing these
  o Assimilative capacities of soils
  o Best management practices
### “Emerging” Pathogens

<table>
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<tr>
<th>Bacteria</th>
<th>Viruses</th>
<th>Parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli-0157-H7</em></td>
<td>Picobirnavirus</td>
<td><em>Toxacara</em></td>
</tr>
<tr>
<td><em>E. coli-enterohemorrhagic</em></td>
<td>Picotirnaviruses</td>
<td><em>Baylisascaris</em></td>
</tr>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>Coronavirus</td>
<td><em>Echinococcus</em></td>
</tr>
<tr>
<td><em>Leptospira spp.</em></td>
<td>Toroviruses</td>
<td><em>Toxoplasma</em></td>
</tr>
<tr>
<td></td>
<td>Hepatitis E Virus</td>
<td><em>Microsporidia</em></td>
</tr>
<tr>
<td></td>
<td>Caliciviruses</td>
<td></td>
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<tr>
<td></td>
<td>Myxoviruses</td>
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</table>
Our Changing View of “Water Resource Recovery Facilities”

There is growing awareness that wastewater treatment plants are not waste disposal facilities or polluters, but rather water resource recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen), and have the potential to reduce the nation’s dependence upon fossil fuel through the production and use of renewable energy.

Download from www.biosolids.org
Wastewater treatment plants are not waste disposal facilities or polluters.

They are water resource recovery facilities that produce clean water, recover nutrients, and have the potential to reduce the nation’s dependence upon fossil fuel through the production and use of renewable energy.
Facilities producing biogas in the U. S.

- **14,886** total facilities in 50 states reported by 2008 Clean Watershed Needs Survey
- **3,208** Major facilities (>1 mgd), according to the 2008 Clean Watershed Needs Survey
- **1,238** facilities whose solids are treated with AD (some send solids to another facility) – we have a relatively high level of confidence in this number – almost all of these are Major facilities

### Percentage of Facilities Sending Solids to AD

- **82%** Confirmed or likely NO AD
- **10%** Yes - send solids to operating AD
- **8%** Level of Uncertainty

(Comparing survey data to CWNS 2008 total WWTPs)
Co-Digestion Example: Des Moines, IA

Other U. S. co-digestion programs:

East Bay MUD, Oakland, CA (large facility)
Gloversville-Johnstown, NH (mid-size)
Essex Junction, VT (small)
What’s ideal for sustainability?

MAXIMIZE BENEFICIAL USES OF RESOURCES IN BIOSOLIDS

<table>
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<tr>
<th>Constituent</th>
<th>Benefits</th>
<th>Concerns</th>
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<tbody>
<tr>
<td>Water</td>
<td>valuable in agriculture in dry times</td>
<td>cost of transport</td>
</tr>
<tr>
<td>Organic matter</td>
<td>vital to soils</td>
<td>putrescible, odor</td>
</tr>
<tr>
<td>Nutrients</td>
<td>plant &amp; animal food</td>
<td>impacts to water</td>
</tr>
<tr>
<td>Energy</td>
<td>renewable, displaces oil/gas</td>
<td>air emissions, no use of nutrients &amp; organic matter if incinerated</td>
</tr>
</tbody>
</table>

MANAGE TO MINIMIZE POTENTIAL RISKS

Reduce/control/mitigate trace elements (e.g. metals), pathogens, synthetic and natural organic chemical compounds, odors, nuisances
Acknowledgements
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North East Biosolids and Residuals Association (NEBRA)
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Orgro
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Philadelphia Water Department
Water Environment Federation
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