Contaminants of Emerging Concern in Biosolids

NJWEA 104th Annual Conference

May 6, 2019

Jay Surti, PE, Residuals Practice Lead – Northeast
Agenda

What are biosolids?

Trend in biosolids management – Opportunities and Challenges

The **CEC Challenge** for biosolids and opportunities to address it

What does the future hold for biosolids?
Wastewater is Recognized as a Stream of Resources Waiting to be Recovered!

“Wastewater Treatment Facilities, which treat human and animal waste, should be viewed as renewable resource recovery facilities that produce clean water, recover energy and generate nutrients”  - US EPA (April 2012)
Solutions used currently for wastewater solids management:

- **Thickening and dewatering** solutions (GBTs, BFPs, centrifuges)
- High rate **anaerobic digestion** (mesophilic phase)
  - Biogas beneficial use for heating
- **Solids drying** (medium to large facilities)
- **Solids incineration** (large facilities)
- **Aerobic digestion** and **lime stabilization** (smaller facilities)

Source: Sludge Management, Opportunities in Growing Volumes, Disposal Restrictions & Energy Recovery, GWI, 2012
What are Biosolids

Biosolids are the *nutrient-rich* organic materials that are the product of *treated domestic sewage sludge* from a wastewater treatment facility. – US EPA (May 2018)
Current Regulations

Numeric standards for 9 metals
- Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Zinc

Operational standards for microbial organisms
- Pathogen and vector attraction reduction

Promulgated in 1993
CFR Title 40 Part 503
The Biosolids Promise

Organics and nutrients in biosolids improve soil quality
Sustain cropland productivity
Reduce soil erosion

Source: Dryland wheat, WA (Pan et al. 2017)
Biosolids contribution to the Circular Economy and Climate Change
However, biosolids management, especially land application, is challenging!

Odors
Persistent public opposition
Land application errors
…and CECs (PFAS)
CECs in Biosolids

Any synthetic or naturally occurring chemical or any microorganism that is not commonly monitored in the environment and can cause known or suspected adverse ecological and/or human health effects (USGS)

(Source: Arroyo 2013, Water Resources Research Center, The University of Arizona)
Addressing CECs is Critical for Public Acceptance of Biosolids

Over the counter consumer antiseptics (TCS, TCC)
Pharmaceuticals and endocrine disruptors
Personal care products
Polybrominated flame retardants
Plastics and plasticizers
Poly- and per fluoroalkyl substances (PFAS)
Recent Developments Resulting in Additional Challenges for Biosolids Land Application

The EPA OIG Report
– Are Biosolids Safe? Are the Current Part 503 Regulations Protective of Human Health and the Environment?

PFAS drinking water standards and presence of **PFAS in biosolids**
The EPA’s controls over the land application of sewage sludge (biosolids) were incomplete or had weaknesses, and may not fully protect human health and the environment.

The biosolids program is at risk of not achieving its goal to protect public health and the environment.

EPA doesn’t have the data to determine whether biosolids pollutants (beyond 9 heavy metals) with incomplete risk assessment are safe!

EPA scientists working on biosolids told us that without completing risk assessments on all of the pollutants found in biosolids they cannot say whether biosolids are safe.

Are Biosolids Safe?
Un-regulated Pollutants in Biosolids

• Un-regulated pollutants include:
  • Pharmaceuticals (e.g., ciprofloxacin, diphenhydramine and triclocarban);
  • Steroids and hormones (e.g., campesterol, cholestanol and coprostanol);
  • Flame retardants. Perfluoroalkyl substances (PFAS)

• Of the **352 biosolids pollutants**:
  • 32 are hazardous wastes under RCRA (four of which are acutely hazardous)
  • 35 are EPA priority pollutants.
  • 16 are NIOSH hazardous drugs.

EPA OIG Report dated Nov 15, 2018
## Important OIG Report Recommendations (Resolved)

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Description</th>
<th>Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Complete development of the probabilistic <strong>risk assessment tool and screening tool</strong> for biosolids land application scenarios</td>
<td>12/31/21</td>
</tr>
<tr>
<td>4</td>
<td>Develop and implement a plan to obtain the <strong>additional data needed to complete risk assessments and finalize safety determinations on the 352 identified pollutants</strong> in biosolids and promulgate regulations as needed</td>
<td>12/31/22</td>
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## Important OIG Report Recommendations (Unresolved)

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>9</strong></td>
<td>Change the website response to the question “<em>Are biosolids safe?</em>” to include that the EPA cannot make a determination on the safety of biosolids because there are unregulated pollutants found in the biosolids that still need to have risk assessments completed. This change should stay in place until the EPA can assess the risk of all unregulated pollutants found in biosolids.</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Modify the EPA’s website responding to public questions on the safety of biosolids to: <em>(a) identify unregulated pollutants found in biosolids, (b) disclose biosolids data gaps, and (c) include descriptions of areas where more research is needed.</em> Make similar revisions in other EPA-published documents that include a response to the question “Are biosolids safe?” These changes should stay in place until the EPA can assess the risk of all unregulated pollutants found in biosolids</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Determine whether the impact on the safety and protection of human health justifies a requirement to <em>include a general disclaimer message on the biosolids labels and information sheets regarding unregulated pollutants</em> and a referral to the website for additional information. Publish the rationale for the determination on the EPA biosolids website</td>
</tr>
</tbody>
</table>
Poly- and perfluoro Alkyl Substance (PFAS)

PFAS contributors for municipal wastewater and biosolids (point source):

- Food packaging
- Commercial household products
- Stain- and water-repellent fabrics
- Non-stick products
- Drinking water

Drinking Water Limits

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>PFOA limit (ppt)</th>
<th>PFOS limit (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPA (advisory)</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>New Hampshire (std)</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Vermont (std)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>New Jersey (std)</td>
<td>14</td>
<td>13</td>
</tr>
</tbody>
</table>

Groundwater Quality Standard

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>PFOS limit (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Jersey (Interim std)</td>
<td>10</td>
</tr>
</tbody>
</table>
Residential Septic System – Non-point source of PFAS

Cape Cod Groundwater Impacted by Septic system (Schaider et al. 2016)

Biological Recycling Company, East Kingston, NH

Provides septage management since 1980s. Septage stored in unlined, earthern lagoon.

PFAS detected in nearby drinking water wells (NEBRA, May 2019)

NHDES asked BRC to provide bottled water and provide assistance to neighbors with affected wells
Application of typical biosolids

- (Gottschall et al, 2017. Sci Total Environ)
  - PFAS detected in both groundwater and tile discharge after single large biosolids application
  - Detected months after application
- Near a historic sludge monofill, groundwater shows levels of PFAS
- PFAS detected in groundwater near yard waste composting facility that also used paper mill sludge
PFAS levels in biosolids products (Prof. Linda Lee, Purdue University)

- Analyzed for 18 commercially available fertilizers
  - 11 biosolids based
  - 7 non biosolids based
- 10 commercially available nonbiosolids based compost
- Rigorous analysis process (not yet approved by EPA)
# Biosolid and Non-biosolid Commercial Fertilizers

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Biosolid-based</th>
</tr>
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<tbody>
<tr>
<td>Bay State Fertilizer</td>
<td>Tumble-dried granular biosolids</td>
</tr>
<tr>
<td>Hou-Actinite</td>
<td>Granular biosolids</td>
</tr>
<tr>
<td>Milorganite</td>
<td>Heat-dried granular biosolids</td>
</tr>
<tr>
<td>OceanGro</td>
<td>Granular biosolids</td>
</tr>
<tr>
<td>VitAg</td>
<td>Granular biosolids</td>
</tr>
<tr>
<td>Elite Lawn</td>
<td>Biosolids with plant material (composted)</td>
</tr>
<tr>
<td>Dillo Dirt</td>
<td>Biosolids with residential yard trimmings</td>
</tr>
<tr>
<td>Delaware biosolids</td>
<td>Composted</td>
</tr>
<tr>
<td>Rockland biosolids</td>
<td>Biosolids with woodchips</td>
</tr>
<tr>
<td>Burlington biosolids</td>
<td>Biosolids with wood, yard and food waste</td>
</tr>
<tr>
<td>TAGRO potting soil</td>
<td>Biosolids with maple sawdust and aged bark</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Non-biosolid based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promix</td>
<td>Peat/compost based growing mix</td>
</tr>
<tr>
<td>Country soil</td>
<td>Mushroom compost</td>
</tr>
<tr>
<td>New plant life mushroom</td>
<td>Mushroom compost</td>
</tr>
<tr>
<td>New plant life manure</td>
<td>Manure and peat</td>
</tr>
<tr>
<td>Gardener’s pride</td>
<td>Manure</td>
</tr>
<tr>
<td>EKO compost</td>
<td>Compost with untreated wood products</td>
</tr>
<tr>
<td>OCRRA, WeCare</td>
<td>Food compost</td>
</tr>
</tbody>
</table>
PFAAs in Biosolid & Non-biosolid Commercial Fertilizers
2014 Samples

≥ C6 dominates (collected in 2014)
Kim Lazcano et al.,
Manuscript in preparation

*Assumes PFAAs negligible in the > 2 mm fraction
PFAAs quantified in the < 2mm fraction (36-80%)
PFAA levels in biosolids composts were generally 2 to 10 times higher. (et al. Lee, Jan 2018)

<table>
<thead>
<tr>
<th>Year</th>
<th>Short chain (µg/kg)</th>
<th>Long Chain (µg/kg)</th>
<th>Total PFAAs (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>46.6</td>
<td>132.8</td>
<td>179.4</td>
</tr>
<tr>
<td>2016</td>
<td>52.2</td>
<td>48.6</td>
<td>100.8</td>
</tr>
<tr>
<td>2018</td>
<td>38.6</td>
<td>29.2</td>
<td>67.8</td>
</tr>
</tbody>
</table>
Once PFAAs leave the waste derived fertilizer, they will undergo leaching and sorption by soil.
State of Maine Imposes a Moratorium on Biosolids Land Application – March 22, 2019

Testing of PFAS (PFOA, PFOS and PFBS) required for all biosolids to be land applied

Initial sampling and testing to be completed by May 7, 2019

<table>
<thead>
<tr>
<th>Screening Concentrations for PFAS in Biosolids (Maine)</th>
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<tbody>
<tr>
<td>PFOA</td>
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<tr>
<td>PFOS</td>
</tr>
<tr>
<td>PFBS</td>
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Other New England and northeast states likely consider restrictions on biosolids land application
Curious Case of Tainted Milk with PFAS

Stoneridge Farm, Arundel, Maine – A generations old business at risk of closure!

Biosolids applied on 100 acres of property since the 1980s

Also received an application of paper mill (industrial) sludge

PFAS found in soil, hay, water, milk
Treatment/Removal of PFAS Requires an Understanding of the PFAS Family & Chemistry

Non-polymer PFAS appear to be the most prevalent at PFAS investigation sites, and most commonly detected in humans and biota.

Anionic form of PFAS commonly exists in the environment.

Terminal degradation products (biotic and abiotic) of precursor chemicals
Treating PFAS Chemical – A tough nut to crack!

Terminal PFAAs are extremely stable compounds

Strong C-F bond, and carbon shielding

Thermal destruction (mineralization) require temperatures greater than 1,000°C (1,832°F).

Chemical hydrolysis, oxidation and reduction is challenging due to the fluorine effect!
Can incinerators help treat/remove PFAS from biosolids?

Municipal wastewater sludge incinerators typically operate at 1,450°F to 1,550°F.
Can Emerging Technologies Help Treat PFAS in the Future?

*Produce better quality, stable and marketable biosolids, and diversification to produce valuable products!*

<table>
<thead>
<tr>
<th>Wet Solids Based Technologies</th>
<th>Dry Solids Based Technologies</th>
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<tbody>
<tr>
<td>• Hydrothermal Liquefaction</td>
<td>Gasification</td>
</tr>
<tr>
<td>• Hydrothermal Carbonization</td>
<td>Pyrolysis</td>
</tr>
<tr>
<td>• Thermal Hydrolysis (intermediate and post anaerobic digestion)</td>
<td></td>
</tr>
<tr>
<td>• Thermal and chemical hydrolysis</td>
<td></td>
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<tr>
<td>• Supercritical Water Oxidation</td>
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</table>
Wet Solids Based Technologies

Uses subcritical water stage to treat wet organics in wastewater sludge. Produce value added products (biocrude oil and natural gas) – *Hydrothermal liquefaction*

Supercritical water behaves as both a gas and a liquid and thus provides the condition for rapid diffusion and increased solubility of organics. – *Supercritical water oxidation*

Superheated steam used to promote hydrolysis and carbonization to form char and coke (carbon is conserved) – *Hydrothermal carbonization*

Thermal and chemical hydrolysis
Dry Solids Based Thermal Technologies

**Pyrolysis:**

Biomass + Heat → Charcoal, oil, gas

**Gasification:**

Biomass + Limited Oxygen → Syngas
Potential Implications

**Near to short term (up to 2021-2022)**

- Progressive utilities might start to take their **biosolids to the landfills** until risk studies from some of the 352 pollutants are conducted.
- Some utilities under pressure from its citizens (some groups are strong in certain states) could follow suit and start taking their biosolid to landfills.
- Some utilities would **continue to do business as usual**, and manage a rigorous public outreach program (risky!)
- **Research** would progress to demonstrate applicability of incineration and emerging technologies to treat CECs.

**Long Term**

- **Incineration** (similar to Europe) will come back to surface despite the Sewage Sludge Incineration (SSI) rule that was enforced for more air pollution control in 2015.
- **Emerging technologies** will start to get adopted if research and demonstration shows promise to destruct/remove CECs.
Thank You

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