Hazen

Contaminants of Emerging Concern in Biosolids

NJWEA 104th Annual Conference

May 6, 2019

Jay Surti, PE, Residuals Practice Lead – Northeast

Agenda

What are biosolids?

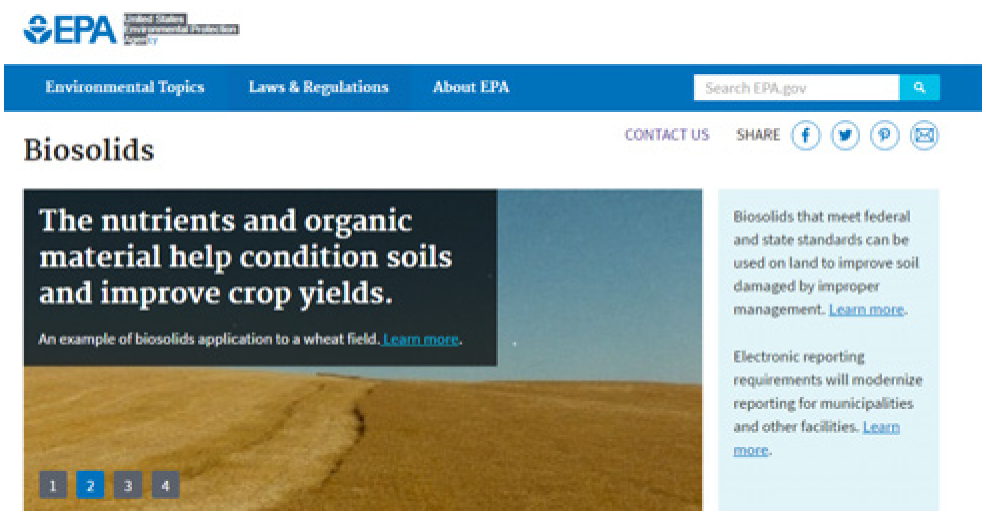
Trend in biosolids management – Opportunities and Challenges

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

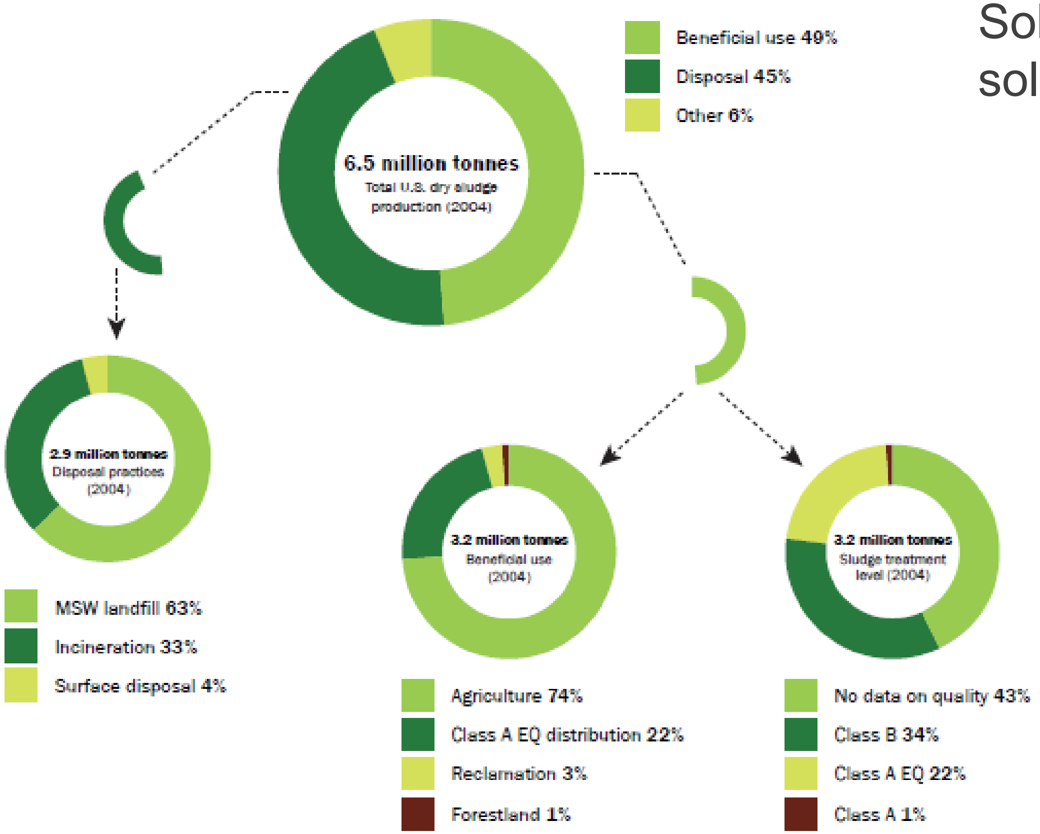
What does the future hold for biosolids?

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)**



Sludge Disposal, Treatment and Beneficial Use Landscape in the United States



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

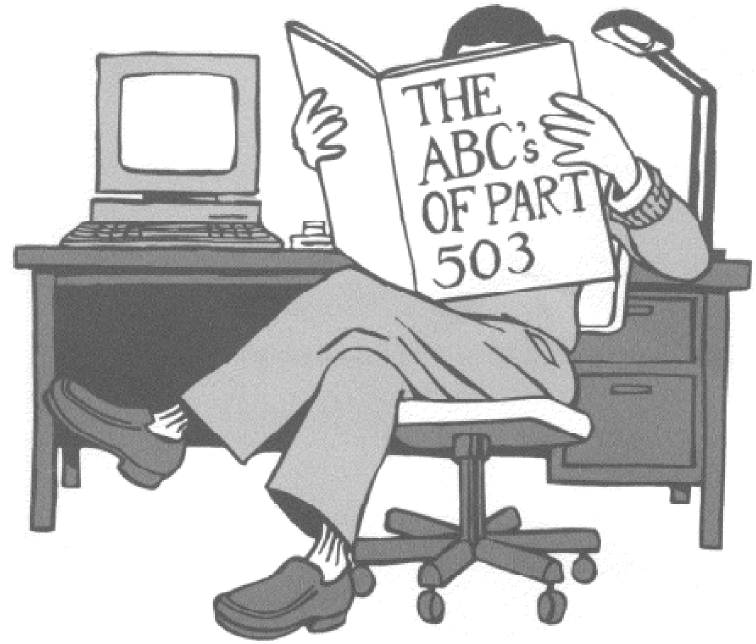
Biosolids are the ***nutrient-rich*** organic materials that are the product of ***treated domestic sewage sludge*** from a wastewater treatment facility. – US EPA (May 2018)

Current Regulations

United States Environmental Protection Agency | Office of Wastewater Management (4204) | EPA/832/R-93/003 September 1994

EPA

A Plain English Guide to the EPA Part 503 Biosolids Rule



Numeric standards for 9 metals

- Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Zinc

Operational standards for microbial organisms

- Pathogen and vector attraction reduction

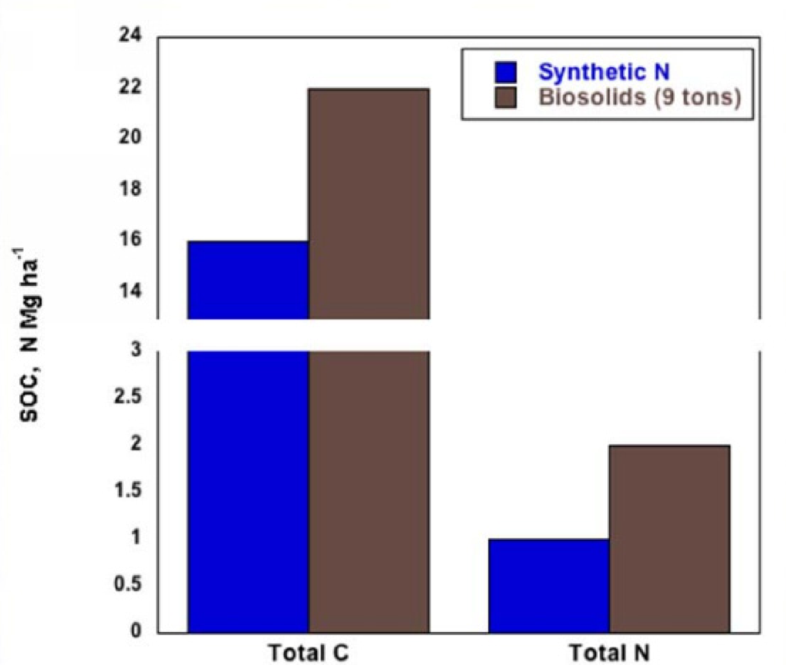
Promulgated in 1993
CFR Title 40 Part 503

The Biosolids Promise

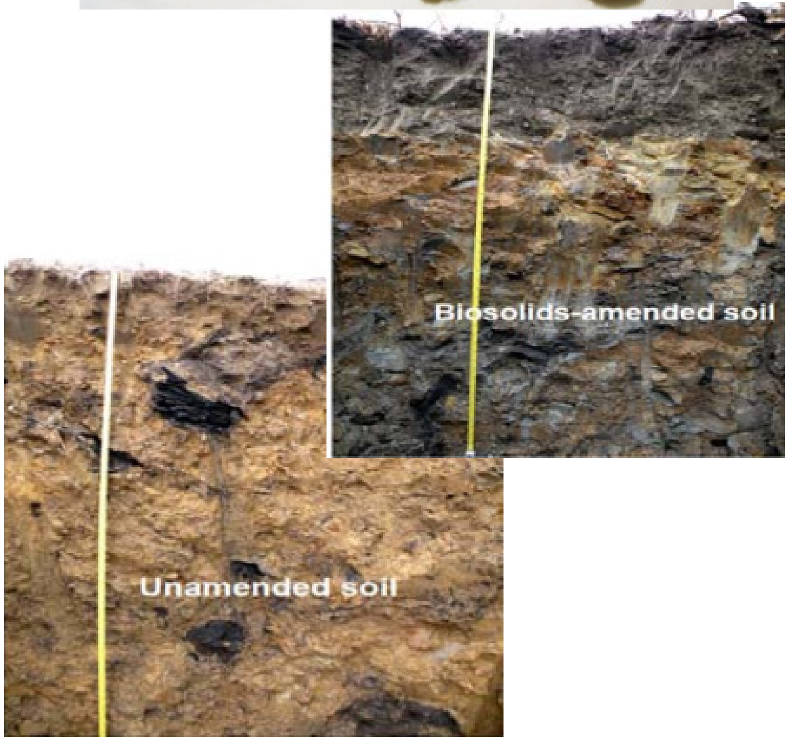
Organics and ***nutrients*** in biosolids improve soil quality

Sustain cropland productivity

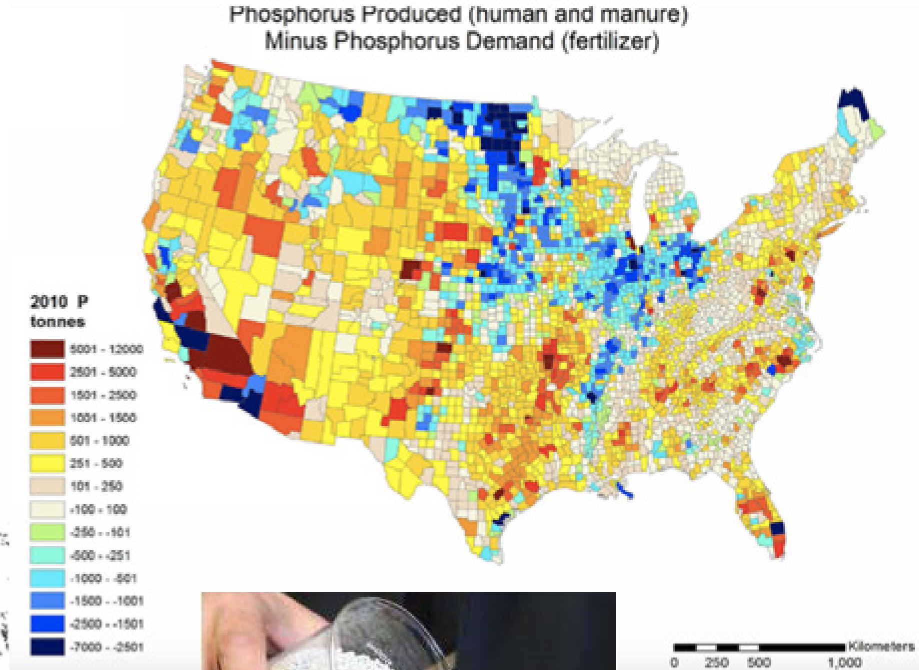
Reduce soil erosion

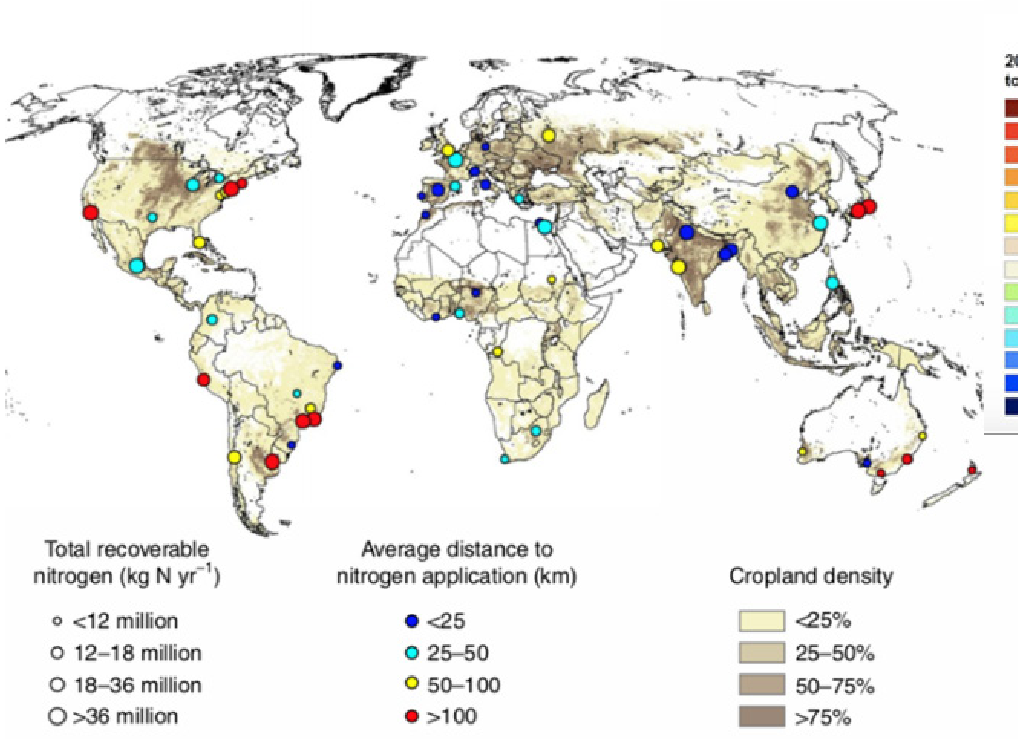


Source: Dryland wheat, WA (Pan et al. 2017)



Biosolids contribution to the Circular Economy and Climate Change





However, biosolids management, especially land application, is challenging!

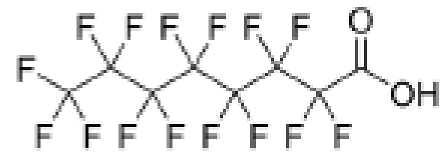
Odors

Persistent public opposition

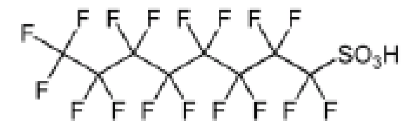
Land application errors

…and CECs (PFAS)

CECs in Biosolids

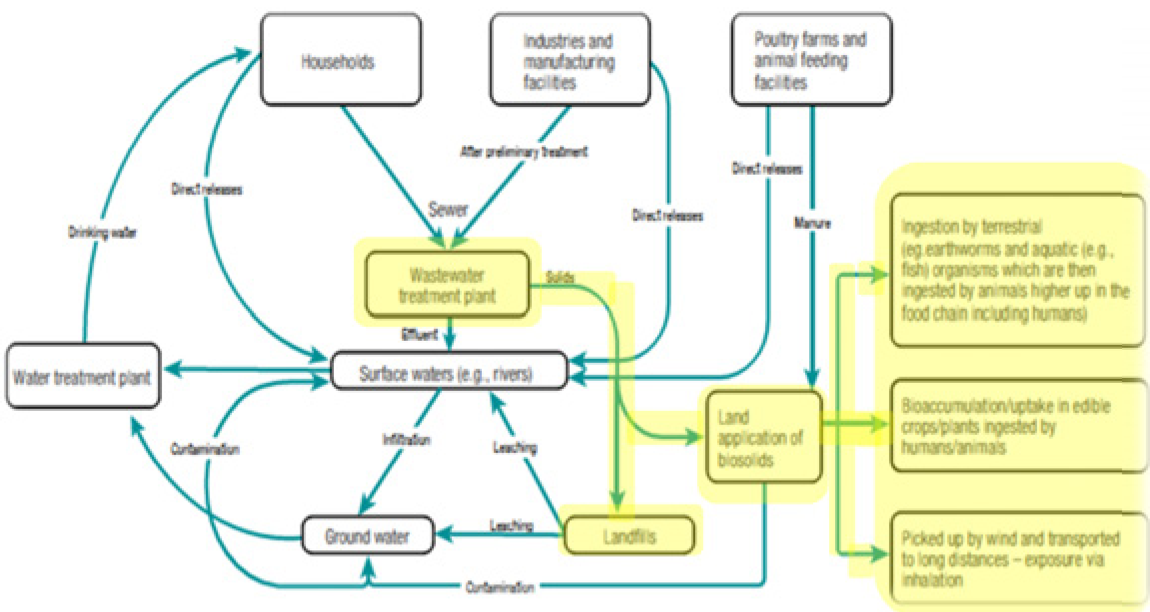


PFOA C8: Perfluorooctanoic acid

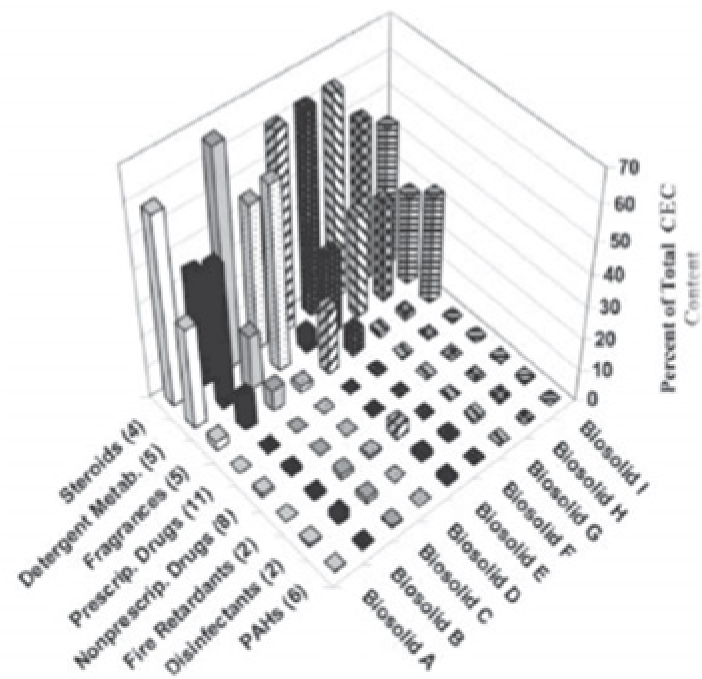


PFOS C8: Perfluorooctane sulfonic acid

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)

Safety and Effectiveness of Consumer Antiseptics; Topical Antimicrobial Drug Products for Over-the-Counter Human Use

A Rule by the Food and Drug Administration on 09/06/2016

PUBLISHED DOCUMENT

AGENCY:

Food and Drug Administration, HHS.

ACTION:

Final rule.

SUMMARY:

The Food and Drug Administration (FDA, we, or the Agency) is issuing this final rule establishing that certain active ingredients used in over-the-counter (OTC) consumer antiseptic products intended for use with water (referred to throughout this document as consumer antiseptic washes) are not generally recognized as safe and effective (GRAS/GRAE) and are misbranded. FDA is

DOCUMENT DETAILS

Printed version: PDF

Publication Date: 09/06/2016

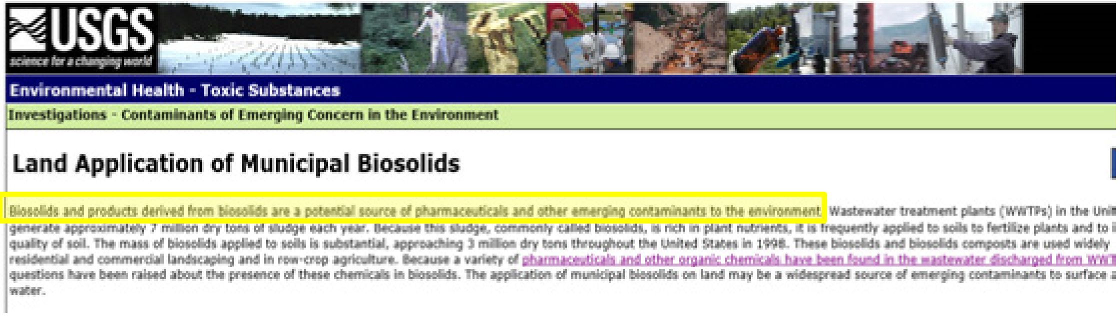
Agencies: Food and Drug Administration

Dates: This rule is effective September 6, 2017.

Effective Date: 09/06/2017

Document Type: Rule

Document Citation: 81 FR 61106



USGS science for a changing world

Environmental Health - Toxic Substances

Investigations - Contaminants of Emerging Concern in the Environment

Land Application of Municipal Biosolids

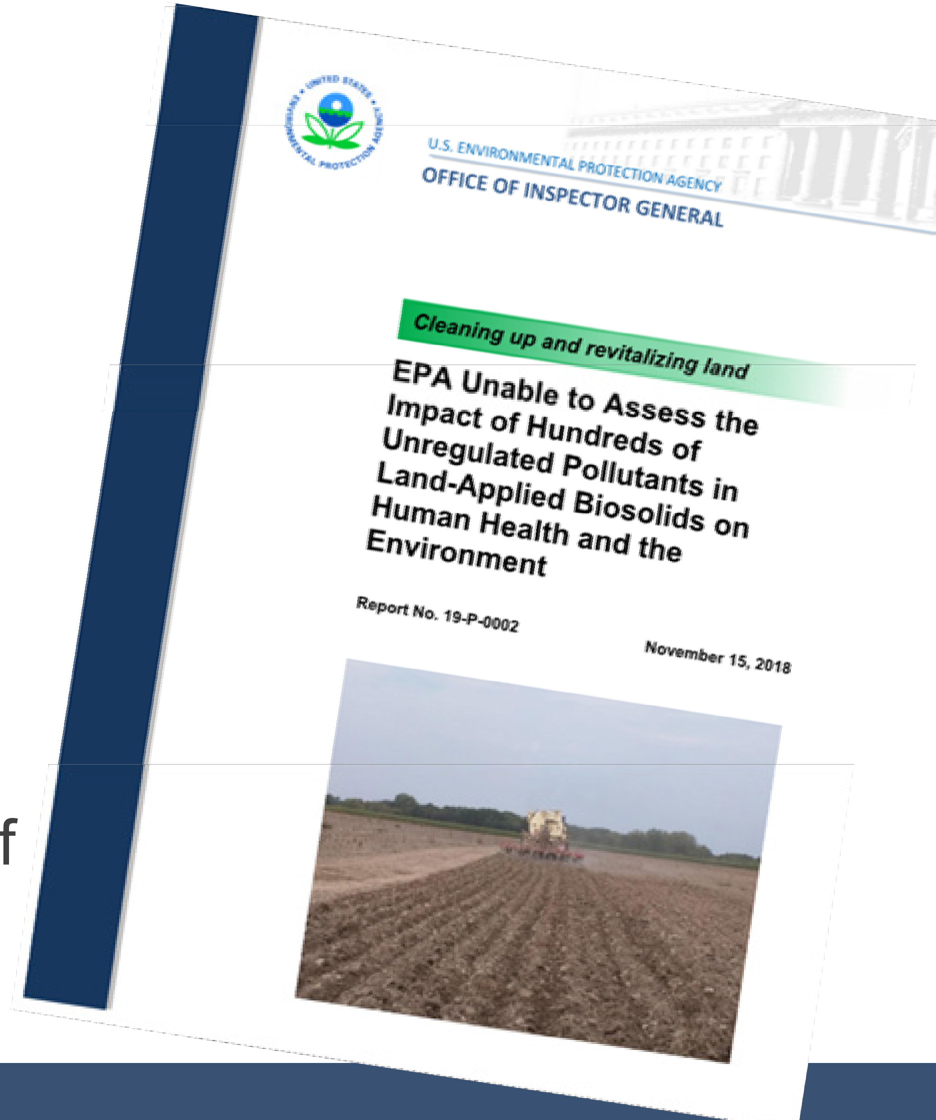
Biosolids and products derived from biosolids are a potential source of pharmaceuticals and other emerging contaminants to the environment. Wastewater treatment plants (WWTPs) in the Unit generate approximately 7 million dry tons of sludge each year. Because this sludge, commonly called biosolids, is rich in plant nutrients, it is frequently applied to soils to fertilize plants and to i quality of soil. The mass of biosolids applied to soils is substantial, approaching 3 million dry tons throughout the United States in 1998. These biosolids and biosolids composts are used widely residential and commercial landscaping and in row-crop agriculture. Because a variety of pharmaceuticals and other organic chemicals have been found in the wastewater discharged from WWT questions have been raised about the presence of these chemicals in biosolids. The application of municipal biosolids on land may be a widespread source of emerging contaminants to surface a water.

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***


U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF INSPECTOR GENERAL

Cleaning up and revitalizing land

EPA Unable to Assess the Impact of Hundreds of Unregulated Pollutants in Land-Applied Biosolids on Human Health and the Environment

Report No. 19-P-0002

November 15, 2018

OIG Report – Published on November 15, 2018

- 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

The EPA identified 352 pollutants in biosolids but cannot yet consider these pollutants for further regulation due to either a lack of data or risk assessment tools. Pollutants found in biosolids can include pharmaceuticals, steroids and flame retardants.

EPA OIG Report dated Nov 15, 2018

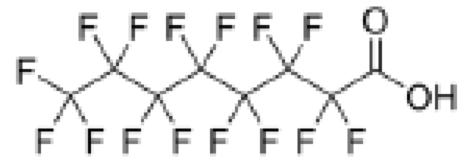
- Un-regulated pollutants include:
  - Pharmaceuticals (e.g., ciprofloxacin, diphenhydramine and triclocarban);
  - Steroids and hormones (e.g., campesterol, cholestanol and coprostanol);
  - **Flame retardants. Perfluoroalkyl substances (PFAS)**
- Of the *352 biosolids pollutants*:
  - 32 are hazardous wastes under RCRA (four of which are acutely hazardous)
  - 35 are EPA priority pollutants.
  - 16 are NIOSH hazardous drugs.

Important OIG Report Recommendations *(Resolved)*

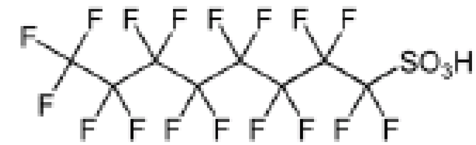
3	Complete development of the probabilistic **risk assessment tool and screening tool** for biosolids land application scenarios	12/31/21
4	Develop and implement a plan to obtain the **additional data needed to complete risk assessments and finalize safety determinations on the 352 identified pollutants** in biosolids and promulgate regulations as needed	12/31/22

Important OIG Report Recommendations (Unresolved)

9	Change the website response to the question *"Are biosolids safe?"* 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.
10	Modify the EPA's website responding to public questions on the safety of biosolids to: *(a) identify unregulated pollutants found in biosolids, (b) disclose biosolids data gaps, and (c) include descriptions of areas where more research is needed.* 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
11	Determine whether the impact on the safety and protection of human health justifies a requirement to *include a general disclaimer message on the biosolids labels and information sheets regarding unregulated pollutants* and a referral to the website for additional information. Publish the rationale for the determination on the EPA biosolids website



PFOA C8: Perfluorooctanoic acid



PFOS C8: Perfluorooctane sulfonic acid

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

Jurisdiction	PFOA limit (ppt)	PFOS limit (ppt)
EPA (advisory)	70	
New Hampshire (std)	70	
Vermont (std)	20	20
New Jersey (std)	14	13

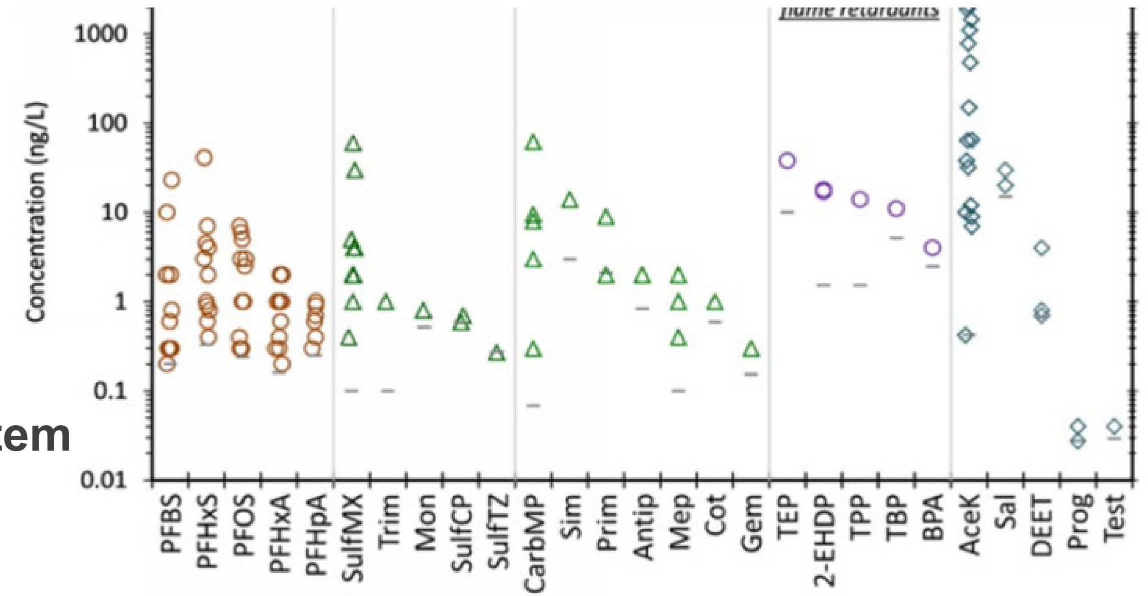
Groundwater Quality Standard

Jurisdiction	PFOS limit (ppt)
New Jersey (Interim std)	10

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

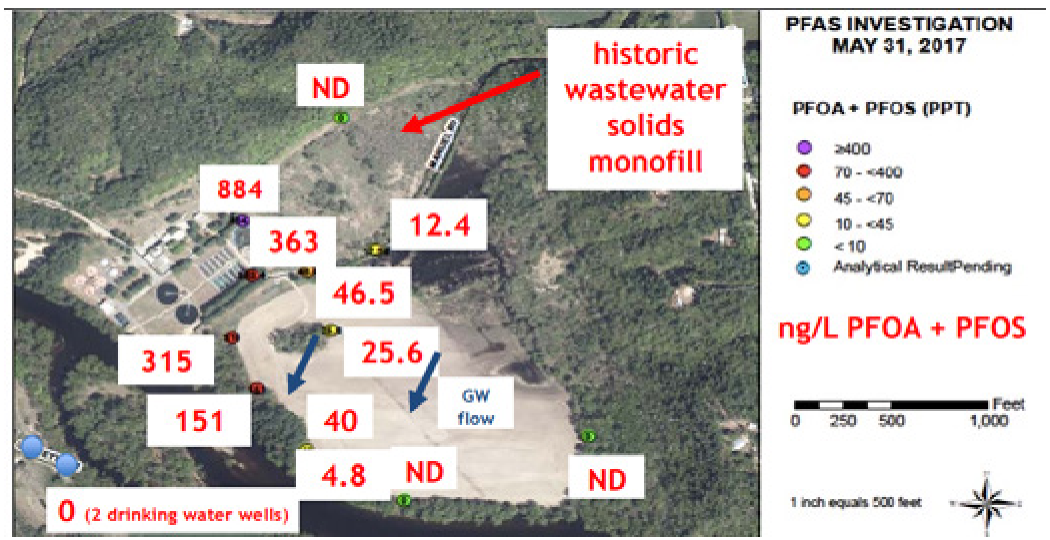
Provides septage management since 1980s. Septage stored in unlined, earthern lagoon.

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)

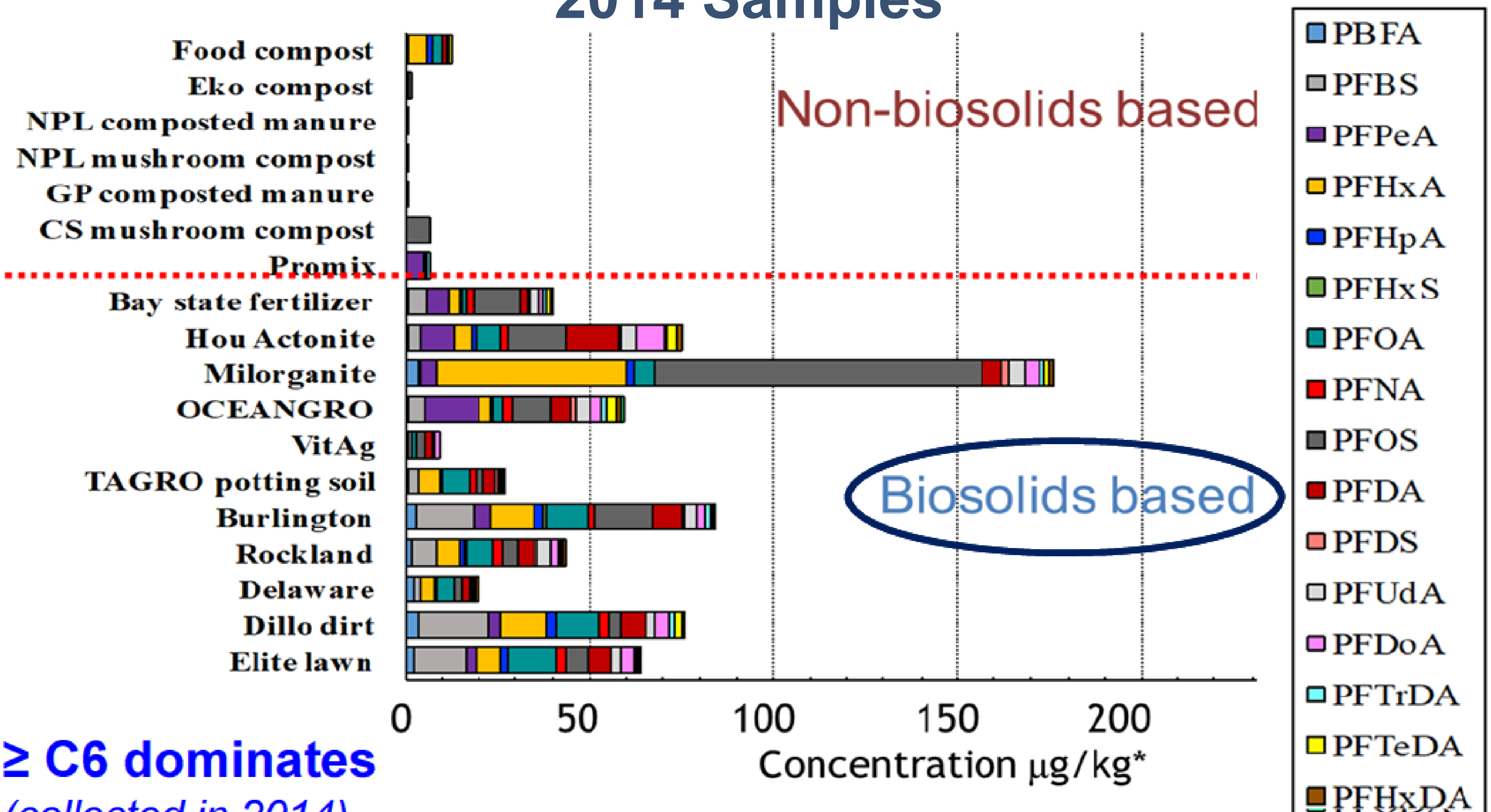
- Analyzed for 18 commercially available fertilizers
  - 11 biosolids based
  - 7 non biosolids based
- 10 commercially available nonbiosolids based compost
- Rigorous analysis process (not yet approved by EPA)

Biosolid and Non-biosolid Commercial Fertilizers

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

Brand name	Non-biosolid based
Promix	Peat/compost based growing mix
Country soil	Mushroom compost
New plant life mushroom	Mushroom compost
New plant life manure	Manure and peat
Gardener's pride	Manure
EKO compost	Compost with untreated wood products
OCRRA, WeCare	Food compost

PFAAs in Biosolid & Non-biosolid Commercial Fertilizers
2014 Samples

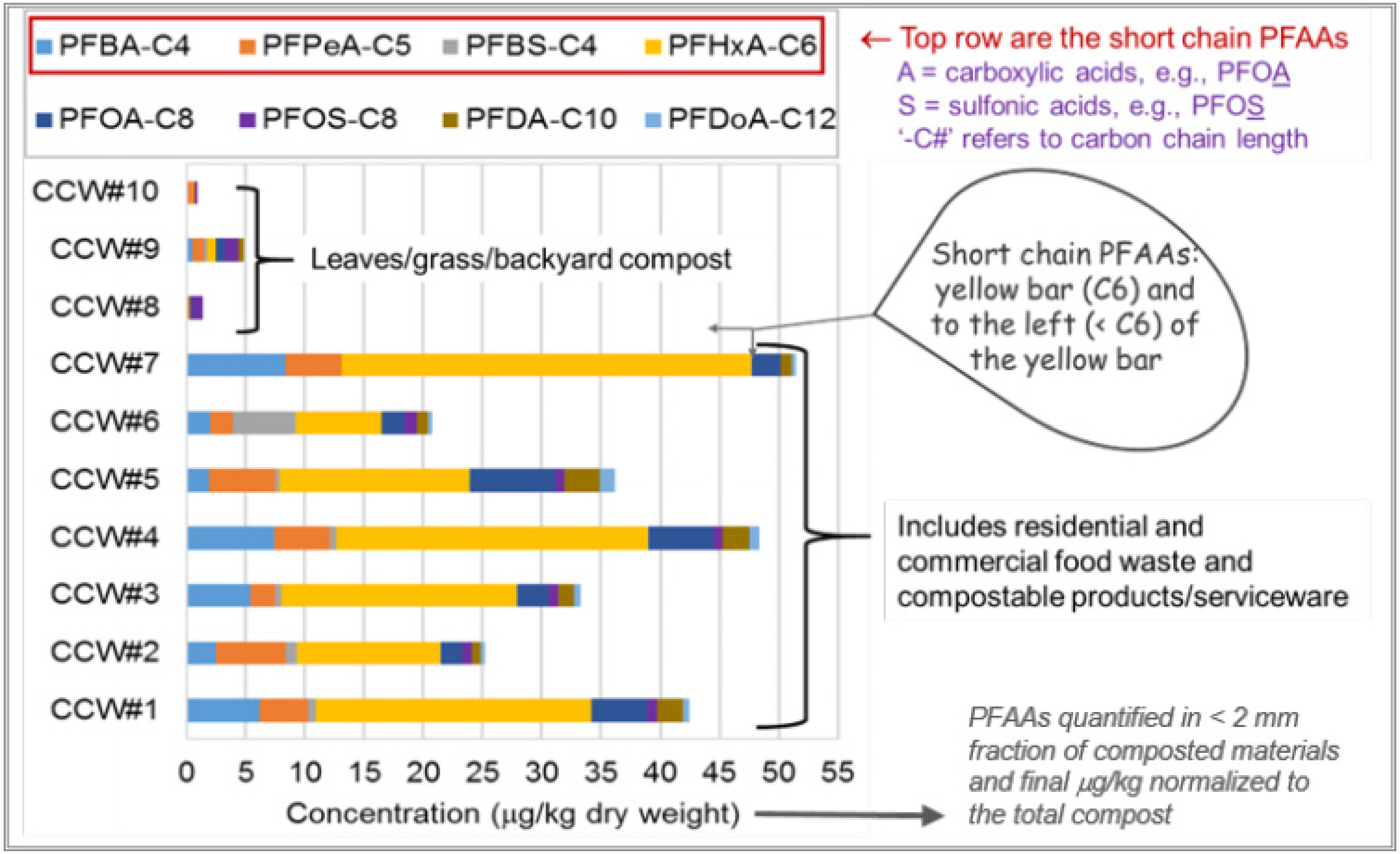


≥ C6 dominates

(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%)



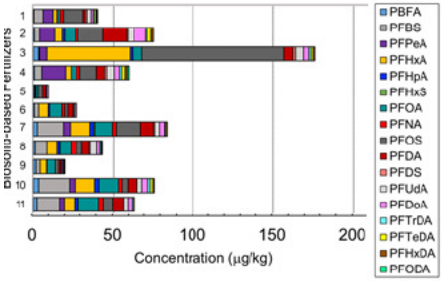
Commercially Available Non-biosolids based composts (et al. Lee, Jan 2018)

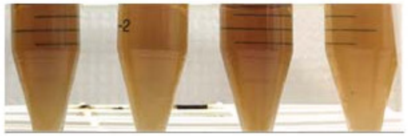
PFAA levels in biosolids composts were generally 2 to 10 times higher. (et al. Lee, Jan 2018)

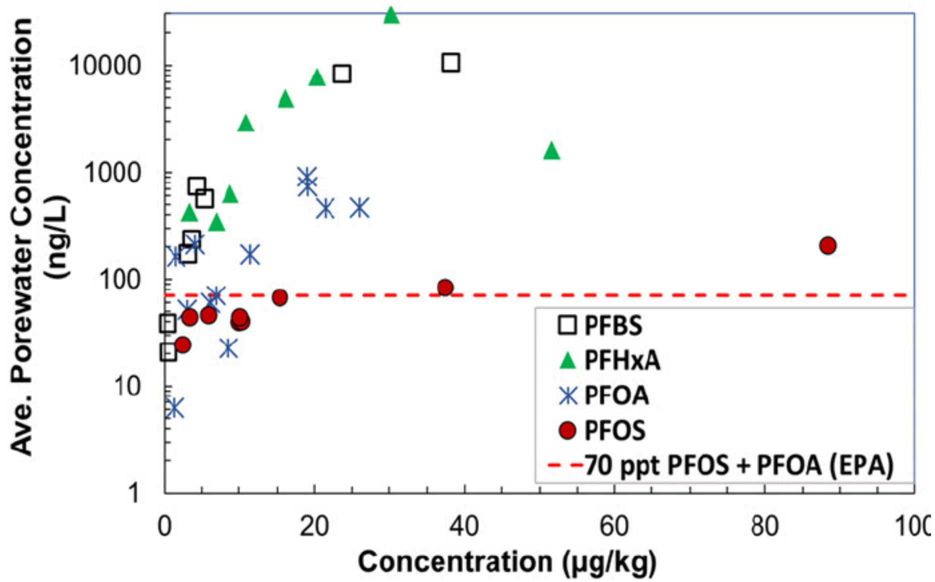
Milorganite

Year	Short chain (µg/kg)	Long Chain (µg/kg)	Total PFAAs (µg/kg)
2014	46.6	132.8	179.4
2016	52.2	48.6	100.8
2018	38.6	29.2	67.8

Selected PFAA Concentrations in Pore-water of Biosolid-based Commercial Fertilizers







Kinetic study (not shown) for residence times of a few hours to one week showed equilibrium reach in ≈1 day

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

Screening Concentrations for PFAS in Biosolids (Maine)	
PFOA	0.0025 mg/kg
PFOS	0.0052 mg/kg
PFBS	1.9 mg/kg

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

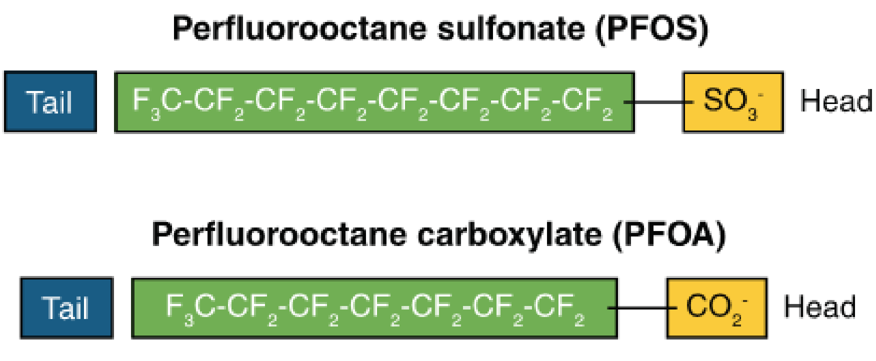
PFAS found in soil, hay, water, milk

Dairy farmer Fred Stone watches the milk collected the previous day go down the floor drain, after discovering the soil, hay, and the milk from the cows on the farm contain extremely high levels of PFAS chemicals resulting from a 1980's state program to fertilize the pastures with treated sludge waste and making the milk unsuitable for sale, at the Stoneridge Farm in Arundel, Maine, U.S., March 11, 2019. Picture taken March 11, 2019. REUTERS/Brian Snyder

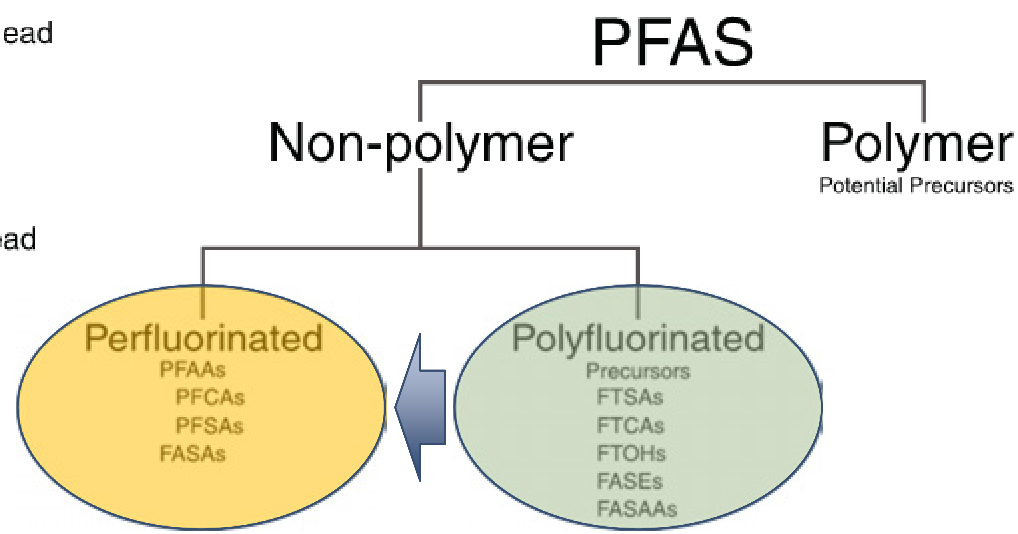
Treatment/Removal of PFAS Requires an Understanding of the PFAS Family & Chemistry

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



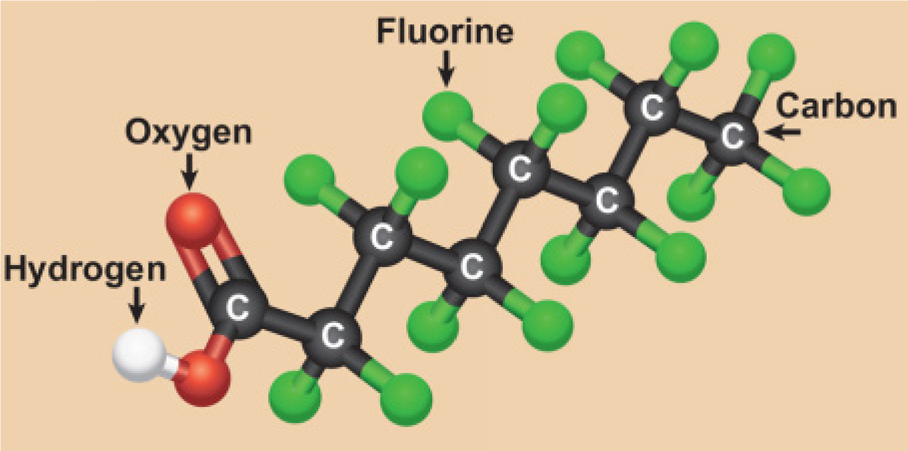
Treating PFAS Chemical – A tough nut to crack!

Terminal PFAAs are extremely ***stable*** compounds

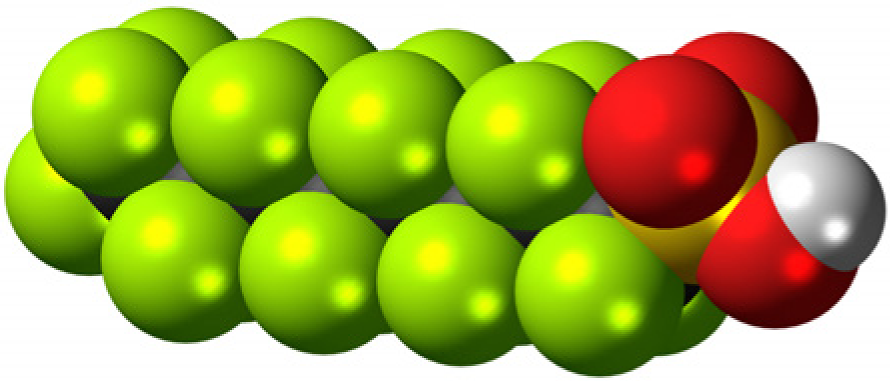
Strong ***C-F bond***, and ***carbon shielding***

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!***

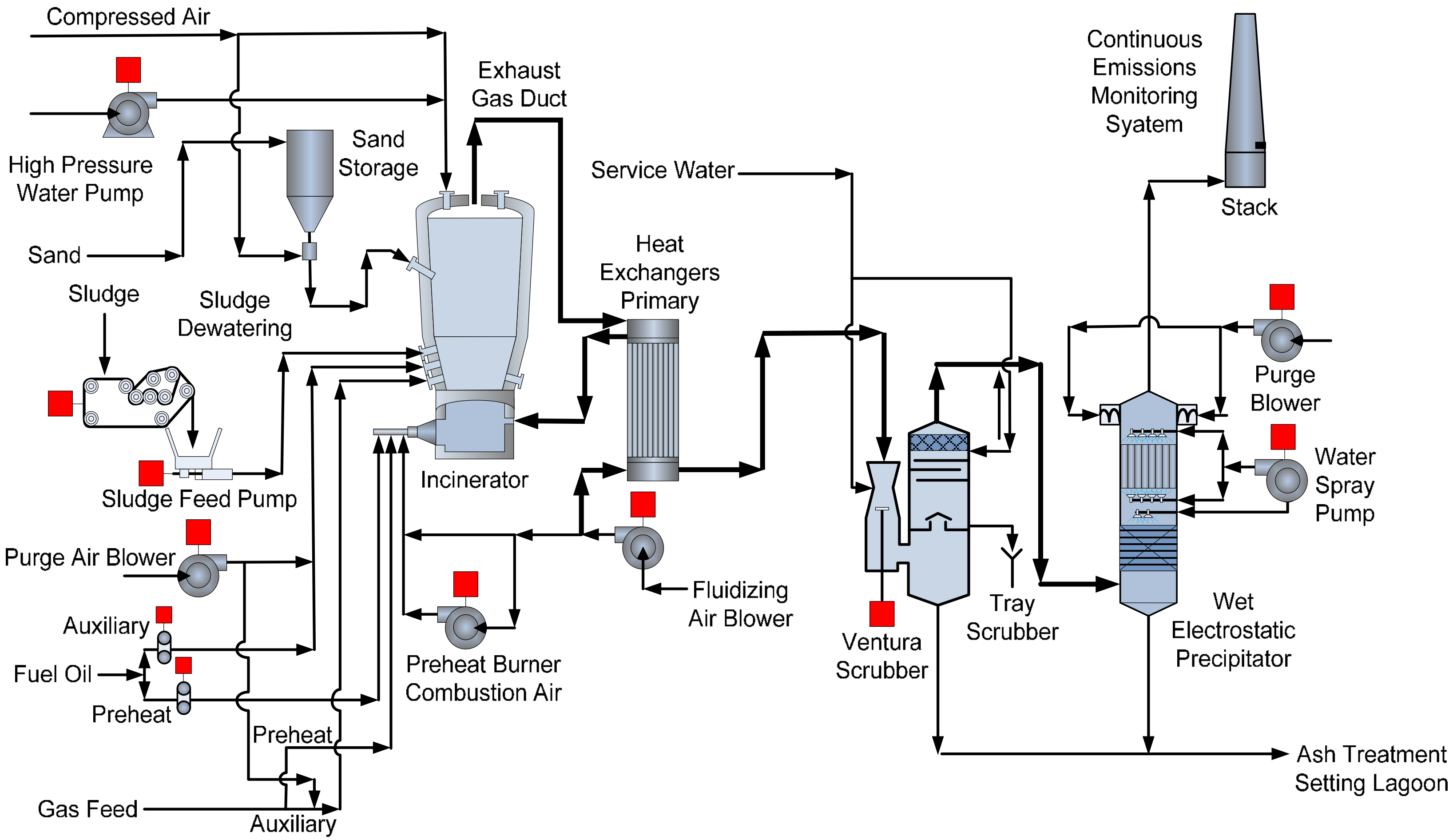


Perfluorooctanoic Acid (PFOA)



Can incinerators help treat/remove PFAS from biosolids?

Municipal wastewater sludge incinerators typically operate at ***1,450°F to 1,550°F.***



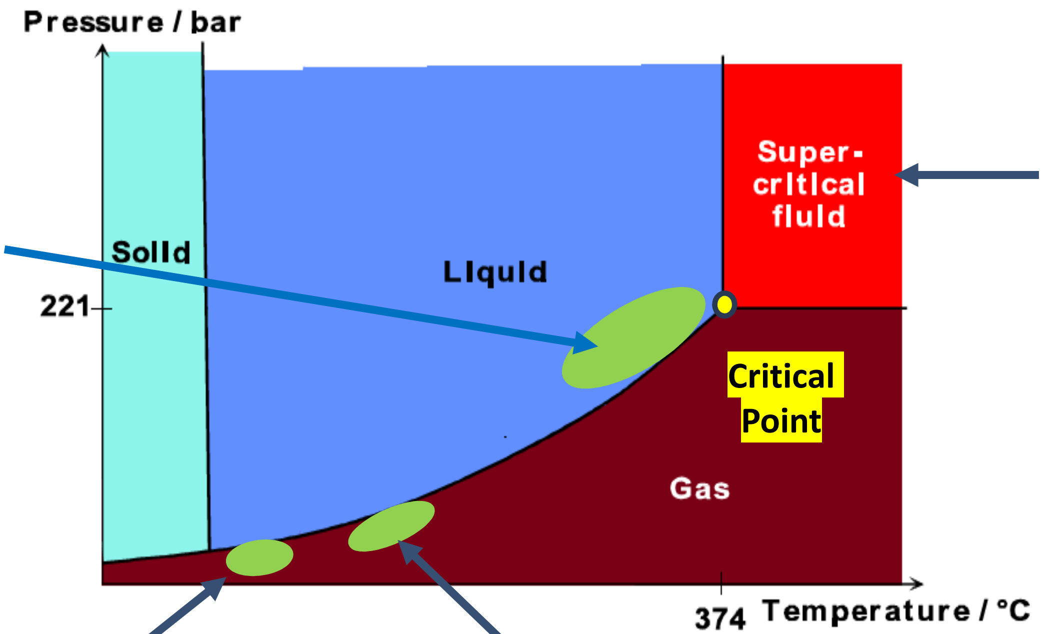
Can Emerging Technologies Help Treat PFAS in the Future?

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

Wet Solids Based Technologies	Dry Solids Based Technologies
• Hydrothermal Liquefaction • Hydrothermal Carbonization • Thermal Hydrolysis (intermediate and post anaerobic digestion) • Thermal and chemical hydrolysis • Supercritical Water Oxidation	Gasification Pyrolysis

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***

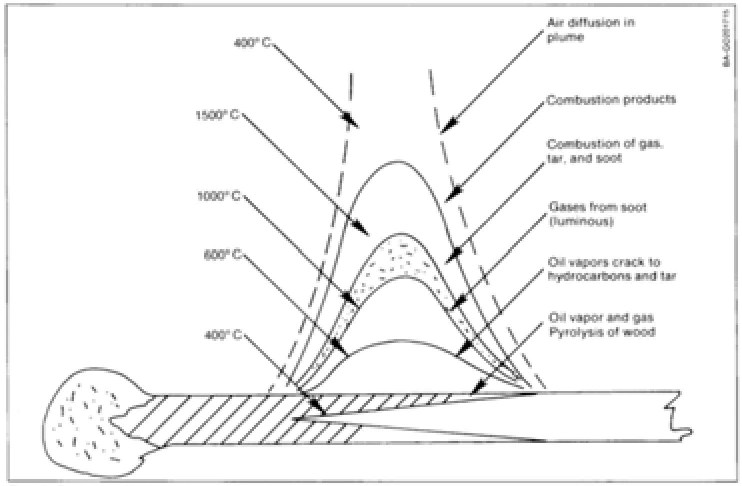
Thermal and chemical hydrolysis

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

Dry Solids Based Thermal Technologies

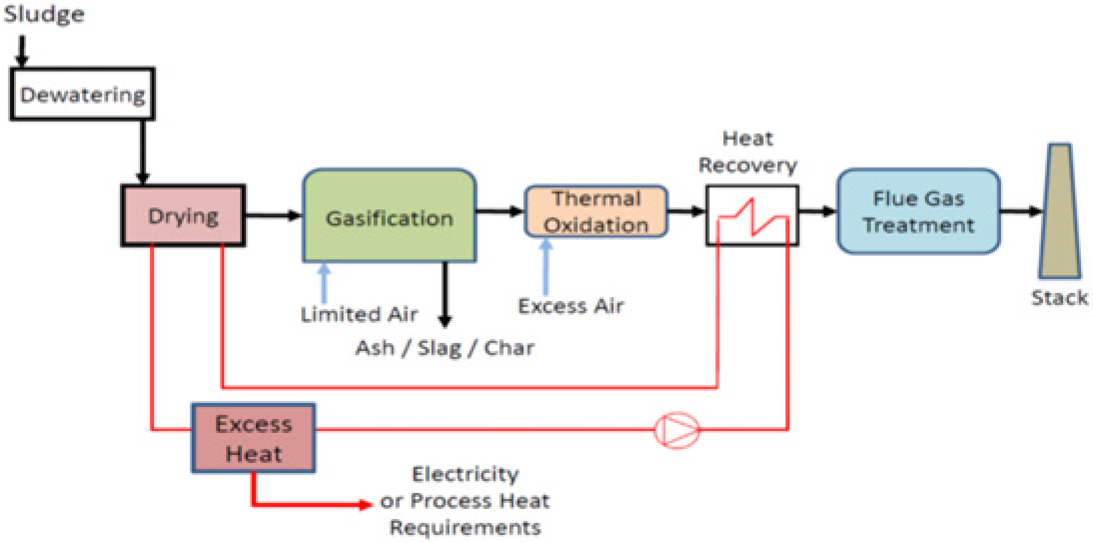
Pyrolysis:

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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