Relationship Between Industrial Pretreatment & Biosolids

18th Annual New England Pretreatment Coordinators Workshop

Ned Beecher • North East Biosolids & Residuals Association

Wednesday, October 26, 2016

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Pretreatment protects biosolids

- prevent the introduction of pollutants into a POTW that will interfere with its operation, including interference with its use or disposal of municipal sludge,
- prevent the introduction of pollutants into a POTW that will pass through the treatment works or otherwise be incompatible with it, and
- improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.

--from the U. S. EPA Pretreatment Program website

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Biosolids quality concerns

- “heavy metals”
- microconstituents, chemicals of emerging concern (CECs), pharmaceuticals & personal care products (PPCPs), antibiotics, flame retardants, etc., etc.
- pathogens
- public perception
  - being able to point to what you do for industrial pretreatment is huge in addressing questions about biosolids quality & impacts

Historic "sludges…" to "biosolids"

Next 2 slides courtesy of Rufus Chaney, PhD, U. S. Dept. of Agriculture.

Before Regulations, Bad Practices Occurred.

Cd in Crops Grown on Long-Term Biosolids Utilization Farms in the Northeast: City 13.

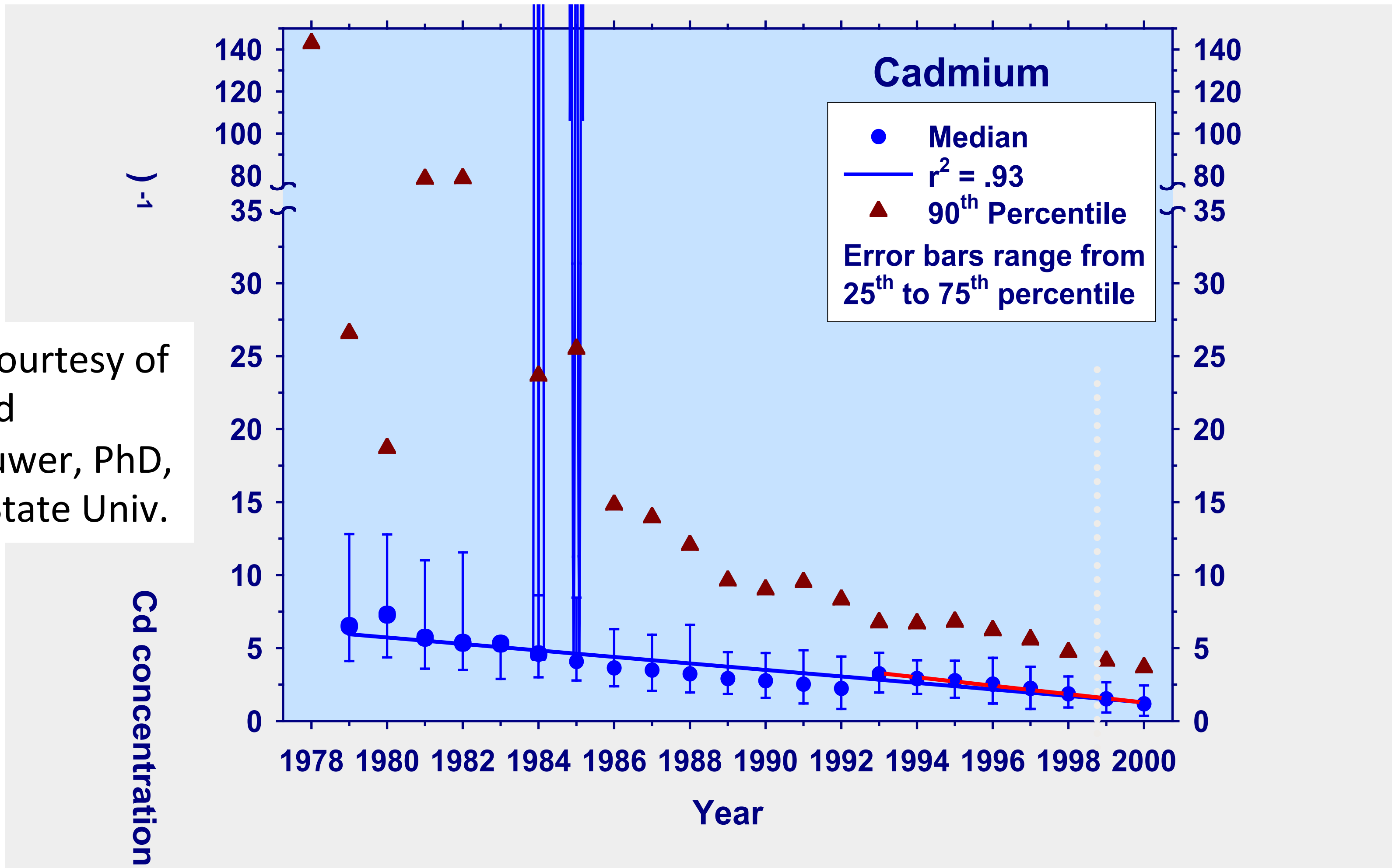
Biosolids applied 1967-1975; approx. 20 t/ha
Biosolids contained 700 mg Cd/kg, Cd:Zn=10%
Field soil contained 8.2 mg Cd/kg, Cd:Zn = 15%.

Farm Trt	pH	1975 Chard	1976 Lettuce	1975 Soybean	1976 Oat	1977 Soybean	1977 Oat
		-------------------------mg/kg DW----------------------					
Biosolids							
Nil	5.7	70.4	49.9	2.64	3.38	2.05	2.24
Limed	6.4	17.7	9.9	0.65	0.54	0.46	0.28
Control							
Nil	5.2	0.9	1.5	0.16	0.11	0.11	0.08
Limed	6.2	0.5	0.6	0.13	0.07	0.03	0.05

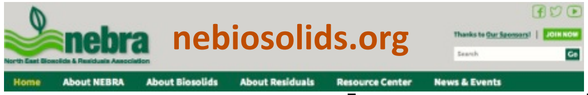
Cd Examples From Old Reports

- Long term sludge utilization farms in NE:
  - City 9 Elizabethtown, PA 169 Cd 0.033 Cd:Zn
  - City 13 Pottstown, PA 700 Cd 0.150 Cd:Zn
  - City 25 St. Marys, PA 970 Cd 0.780 Cd:Zn
  - City 1 York, PA 150 Cd 0.028 Cd:Zn
  - City 2 Harrisburg, PA 160 Cd 0.049 Cd:Zn
- Purdue study of high metal sludges:
  - Frankfort, IN. 284 Cd 0.042 Cd:Zn
  - Anderson, IN. 247 Cd 0.048 Cd:Zn
  - Merion, IN. 1210 Cd 0.637 Cd:Zn
- Literature reports:
  - Fort Collins, CO. 98 Cd 0.056 Cd:Zn
  - Chicago, IL 210 Cd 0.051 Cd:Zn

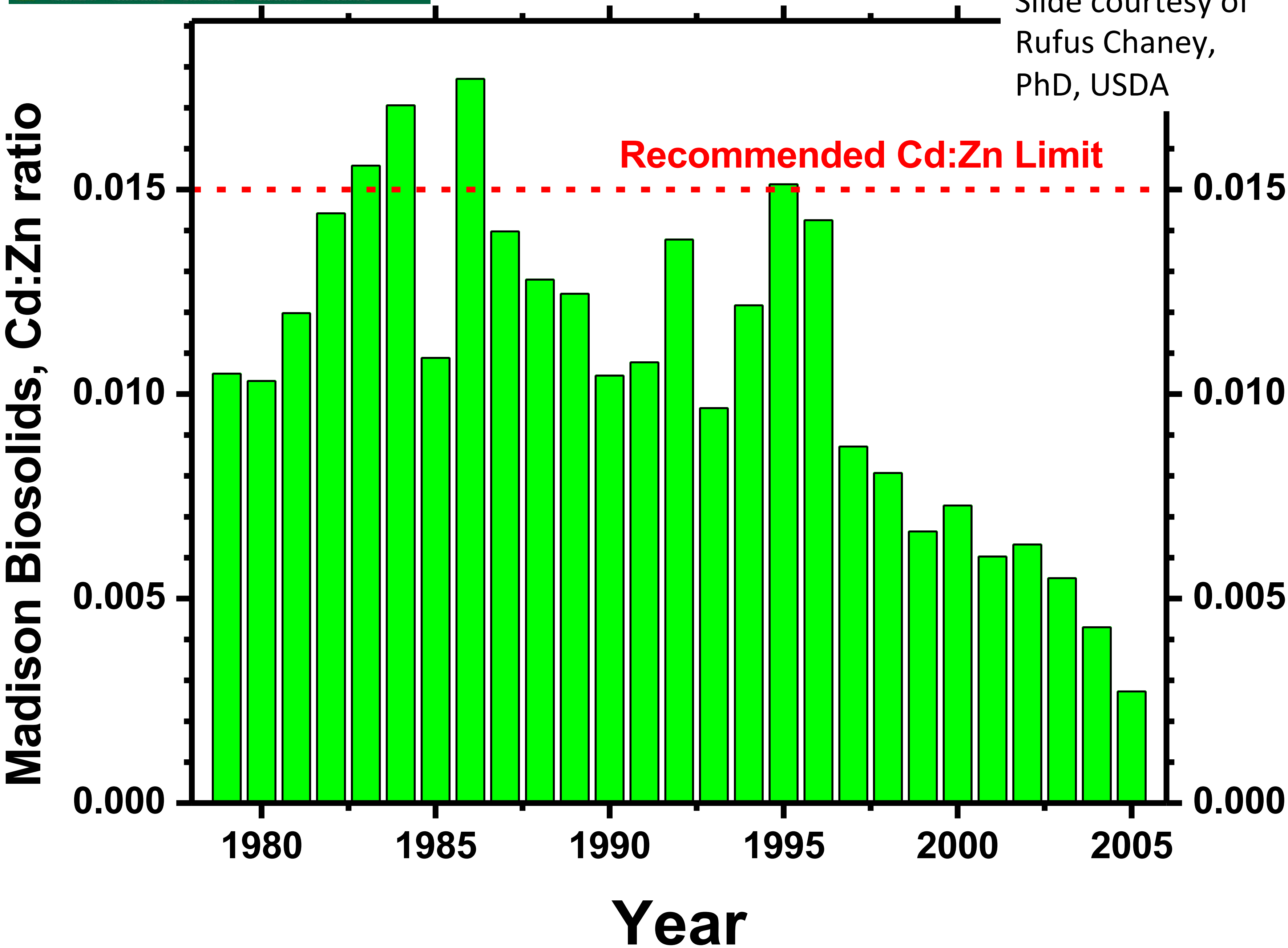
Pretreatment has worked



Slide courtesy of Richard Stehouwer, PhD, Penn State Univ.



Slide courtesy of Rufus Chaney, PhD, USDA



How much is little enough?

- "Heavy metals," other elements of concern, chemicals – they are inevitably there in measurable concentrations.
- What levels are acceptable in biosolids applied to soils, so as to not cause harm to human health or the environment?

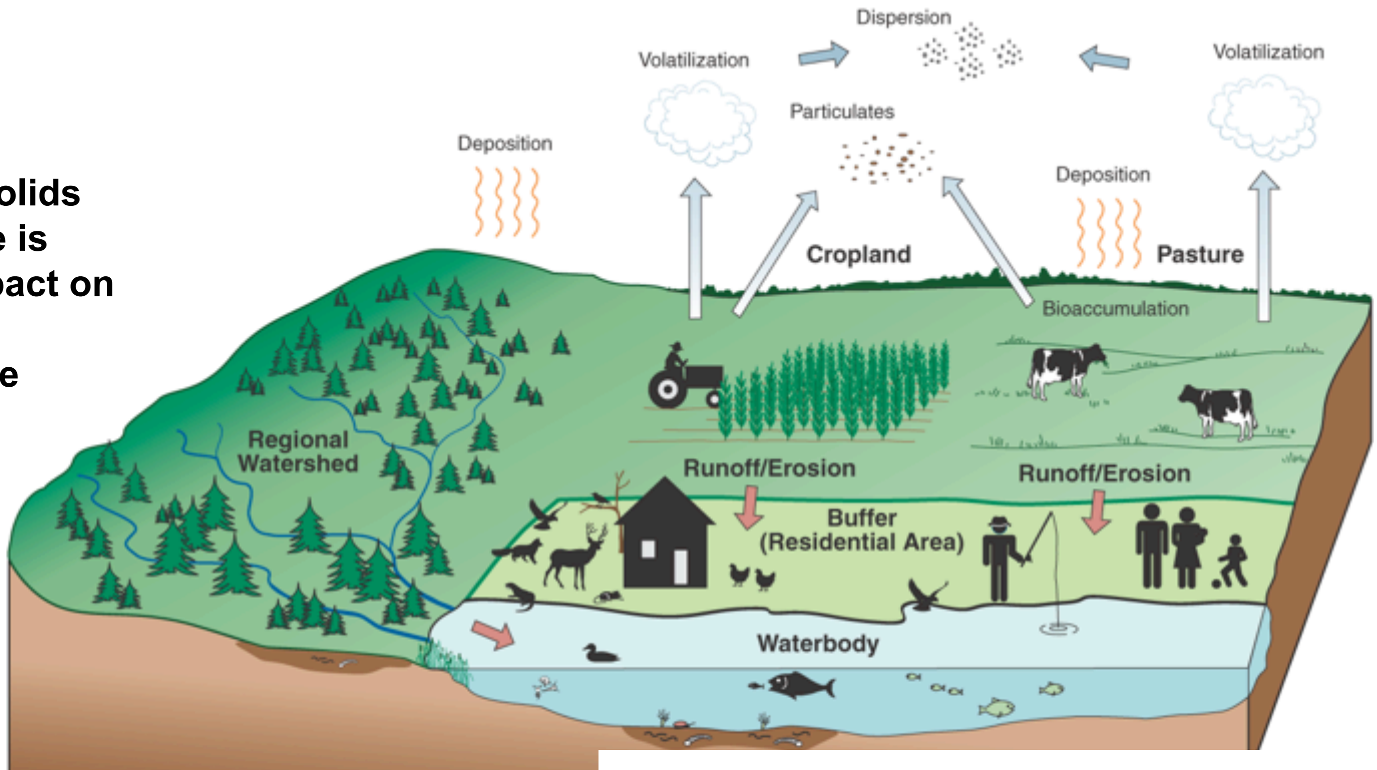
Federal Part 503 Regulations - 1993

- 40 CFR Part 503 defined acceptable levels of 9 (10) metals
- Based on risk assessment
- Require biosolids applications according to agronomic needs, which reduces total mass of contaminants
- Based on the principal of absorptive capacity of the soil

Risk Assessment

EPA Risk Assessment for Part 503:
Exposure Pathways Assessed
Agricultural Land Application Scenario to Assess Human Exposure

The presence of a contaminant in biosolids does not mean there is risk; its fate and impact on humans and the environment must be evaluated.



Next 2 slides courtesy of Rufus Chaney, PhD, U. S. Dept. of Agriculture.

Pathways for Risk Assessment of Elements in Soils, and Highly Exposed Individuals-1.

Pathway	Highly Exposed Individual
1. Soil➔Plant➔Human	Farm markets; 2.5% of food.
2. Soil➔Plant➔Human	Home gardens; 60% of garden foods for lifetime; 1000 t/ha
3. Soil➔Human	200 mg/day soil/dust ingestion; 1000 t/ha
4. Sol ➔Plant➔Animal➔Human	Farms; 45% home-grown meat; 1000 t/ha
5. Soil➔Animal➔Human	Grazing ruminants; soil is 2.5% of annual diet; 45% home-grown meat.
6. Soil➔Plant➔Livestock	100% of livestock feeds grown on soils; 1000 t/ha
7. Soil➔Livestock	Grazing ruminants; 2.5% soil in diet.

Pathways for Risk Assessment of Elements in Soils and Highly Exposed Individuals-2.

Pathway	Highly Exposed Individual
8. Soil➔Plant	Sensitive crops; strongly acidic; 1000 t/ha.
9. Soil➔Soil Biota	Earthworms; microbes; metabolic function of soil; 1000 t/ha.
10. Soil Biota➔Soil Biota Predator	Shrews; 1/3 of diet presumed to be earthworms full of soil; 1000 t/ha.
11. Soil➔Airborne Dust➔Human	Tractor operator; 1000 t/ha.
12. Soil➔Surface water➔Human	Subsistence fishers.
13. Soil➔Air➔Human	Farm households
14. Soil➔groundwater➔Human	Well water on farms.

Perspective on metals land applied

Table 5
Estimated Total Metals Applied to Land From Various Products
Applied Metals (tons/year) (1)

Metal	Biosolids (2)	Swine Manure (3)	Poultry Manure (4)	Phosphate Fertilizer (5)
Arsenic	14.2	33.3	189	49.7
Cadmium	12.59	22.5	33	286
Chromium	168	NA	NA	761
Copper	1,202	2,745	6,743	249
Lead	215	68.4	667	53.7
Mercury	5.07	NA	NA	0.0
Molybdenum	34.2	NA	NA	NA
Nickel	94.1	264	NA	121
Selenium	10.89	NA	NA	NA
Zinc	2,081	4,995	8,729	1,057

Notes:

Moss et al., 2002, WERF

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Pretreatment helps POTWs meet 503.

- Part 503 includes 2 tiers of metals standards.
- Almost all current biosolids in the U. S. meet the higher quality “EQ” standard (lower metals)
- New England states have even lower numerical standards for metals.
- Today’s biosolids are clean enough for widespread use – thanks to pretreatment & P2.

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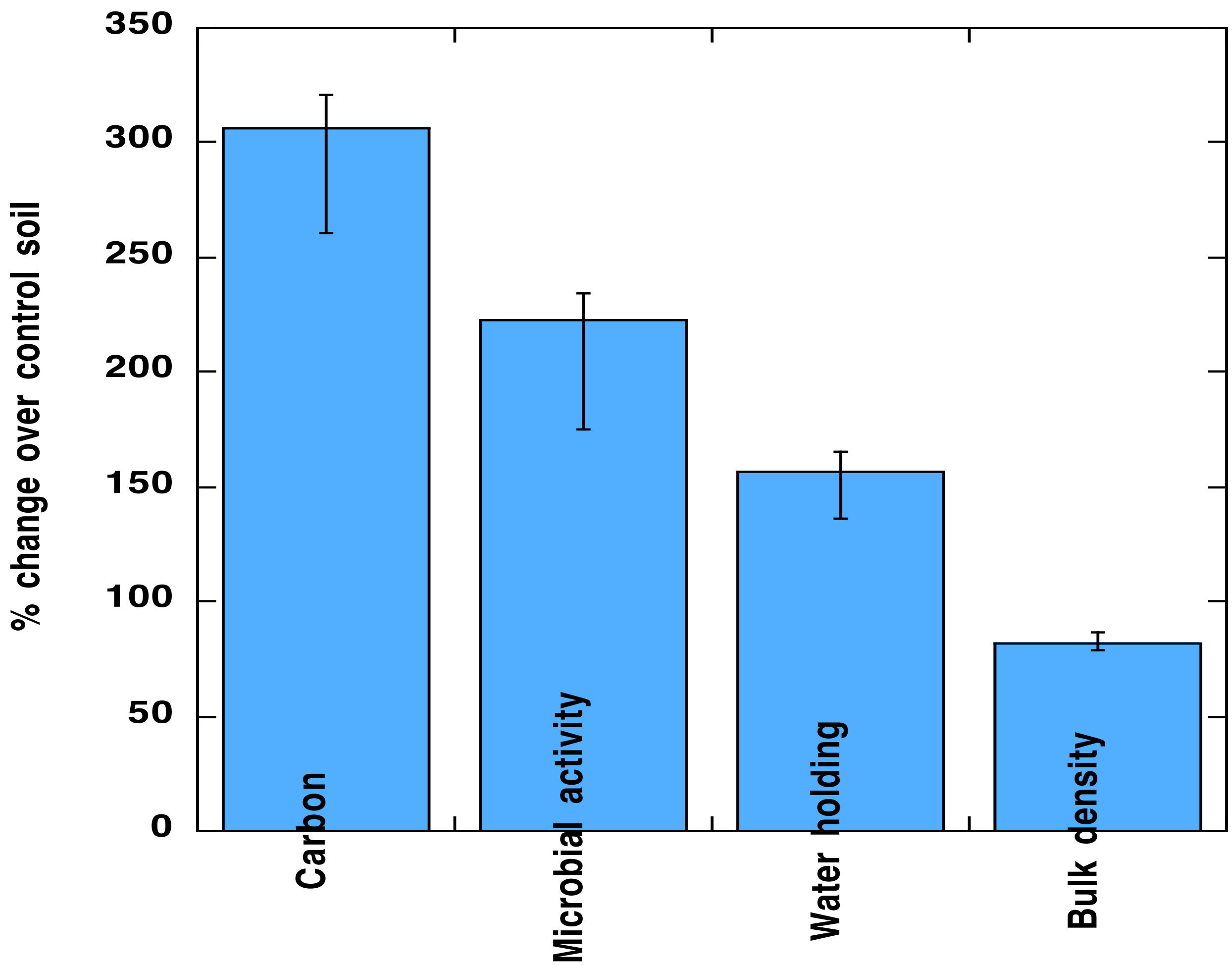
40+ Years of Research

…has shown the benefits & manageable risks

Biosolids improve soils.

Findings: Organic residuals improve soils

Univ. of Washington study, 2011



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 easer tillage & handling).

Managing BIOSOLIDS & other organic residuals:

What's ideal for sustainability?

MAXIMIZE BENEFICIAL USES OF RESOURCES

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

MANAGE TO MINIMIZE POTENTIAL RISKS

Reduce/control/mitigate trace elements (e.g. metals), pathogens, synthetic and natural organic chemical compounds, odors, nuisances

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Examples of why your work is critical

- Look where biosolids are used; you want to protect those places.
- Look how biosolids solve important environmental concerns; you want to ensure biosolids can continue to be used.

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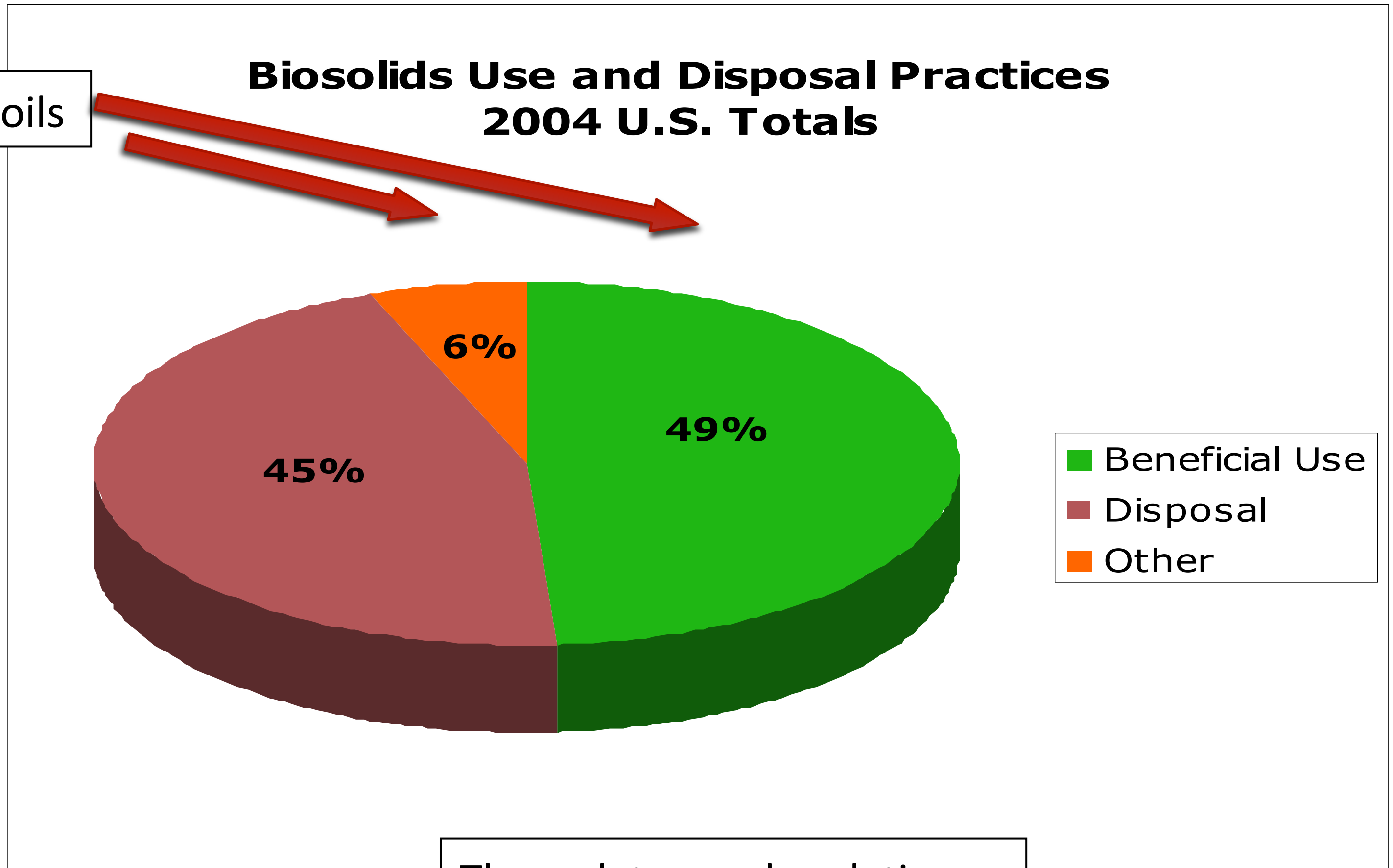
Biosolids management in U. S.:

7,180,000 dry U. S. tons/year (~35.9 million wet tons)

55% is used on soils

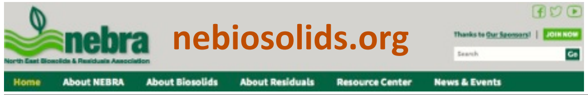


These data need updating...

Biosolids use: Agriculture

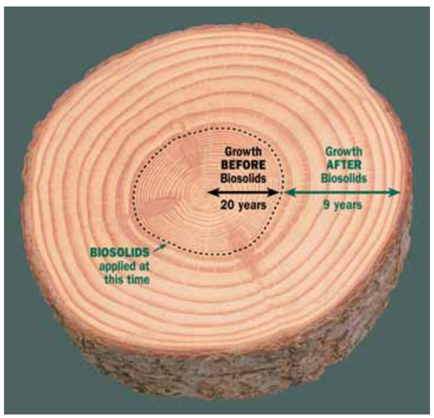
Moorhead, MN: Feed corn grown with liquid injected, Class B, anaerobically-digested biosolids, July 2012

- Bulk material markets: animal feed crops (corn, hay), grains (wheat, hops), soy, other commodity crops
- Prices:
  - Class B - $0 - $30 / wet ton
  - Class A – up to $60 / ton
- Trend: increasing demand; waiting lists in some areas



Biosolids use: Forestry

Photos courtesy of King County, WA
http://dnr.metrokc.gov/WTD/biosolids/



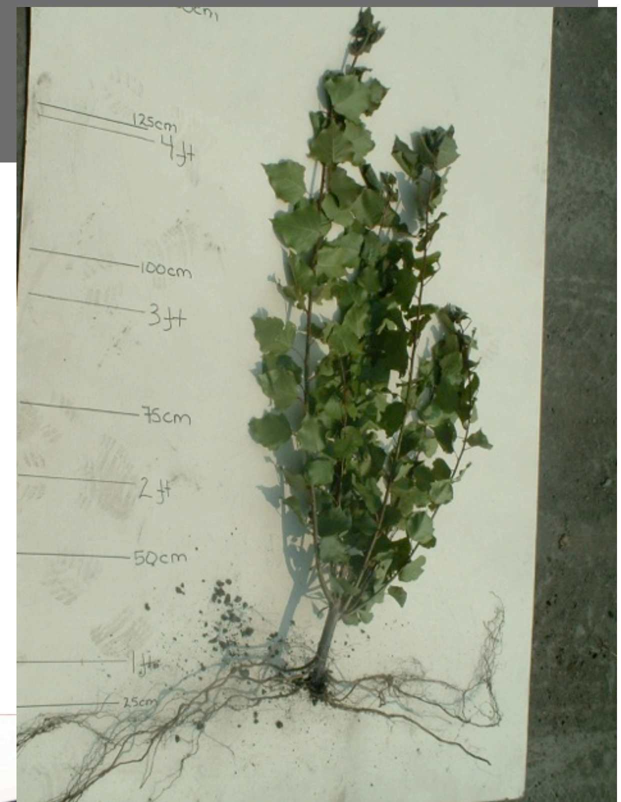


Photo courtesy of Philadelphia Water Dept.

- Only in some areas
- Speeds up harvest cycle in actively managed stands
- Price:
  - Class B $0 - minimal

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Biosolids use: Horticulture / Landscaping / Turf

Biosolids compost use on my home garden – raspberries, May 2014

- Class A bulk material markets: potting mixes (e.g. Tagro), golf courses (e.g. Milorganite), parks, lawns, growing turfgrass (e.g. in RI), sports fields (hi-spec turf)
- Prices:
  - Class A bulk – up to $60 / ton
  - Class A bagged/retail – up to $450 / ton
- Trend: increasing demand for quality, consistent products

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Horticulture, landscaping: Class A products are 22+% of beneficial use in the U. S.

Québec, 2003

Maine, 2003

Columbus, OH

Boston, MA

Davenport, IA

Making & using biosolids compost


The Great Lawn, Central Park NYC

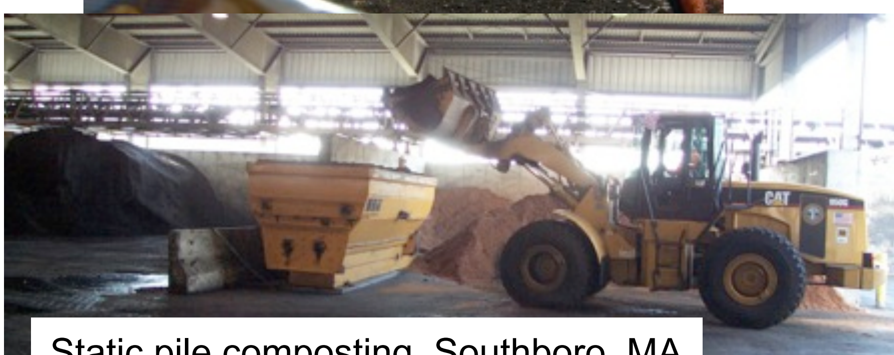

Residuals Composting

Central Valley, California


Spectacle Island, Boston, MA


Fabric-covered composting, Moncton, NB


Streambank stabilization, PA



Static pile composting, Southboro, MA


Co-composting w/ MSW, Marlboro, MA

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Making & using biosolids compost

before

after

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Biosolids Use: Topsoil Blending

Topsoil blending with paper mill residuals and biosolids, central MA, 2006

- Bulk biosolids given or sold to topsoil blenders
- Prices: vary, often $0
- A way to use less processed material
- Topsoils used for reclamation, landfill cover, highway embankments, construction sites
- Trend: steady use

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Reclamation of Disturbed Sites

Spectacle Island in Boston Harbor was reclaimed with biosolids compost and other recycled organics, 2004.

- Bulk material market
- Used to restore healthy soil ecosystem and either native vegetation or cropland
- Prices: vary, often $0
  - Uses a lot of biosolids
- Trend: increasing use, because of huge benefits – biosolids use is best practice for this kind of reclamation

Reclamation of Disturbed Sites

Pennsylvania mine
before

Same Pennsylvania mine
after

Photos courtesy Bill Toffey, MABA

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Biosolids Use:
Landfill Leachate Treatment

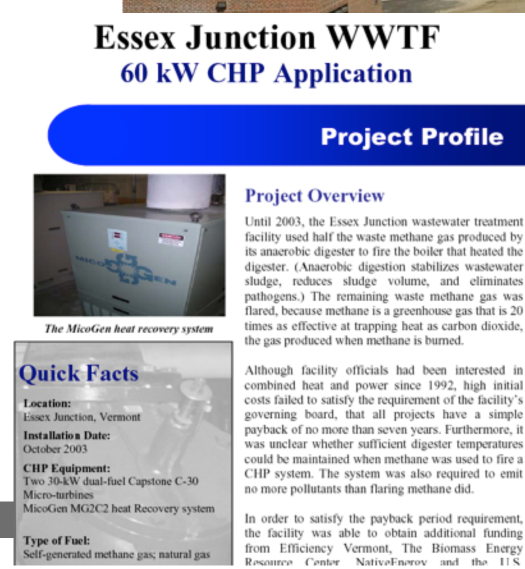
Slide courtesy of Sylvis, Vancouver, BC

Biosolids Use: Energy

Anaerobic digestion (followed by use or disposal)

Greater Lawrence San. Dist., Andover, MA

Nashua, NH



Essex Junction WWTF

60 kW CHP Application

Project Profile

The MicoGen heat recovery system

Quick Facts

Location:
Essex Junction, Vermont

Installation Date:
October 2003

CHP Equipment:
Two 30-kW dual-fuel Capstone C-30 Micro-turbines
MicoGen MG2C2 heat Recovery system

Type of Fuel:
Self-generated methane gas; natural gas

Project Overview

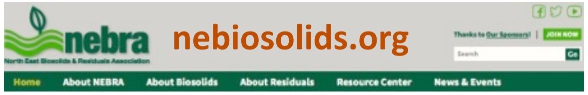
Until 2003, the Essex Junction wastewater treatment facility used half the waste methane gas produced by its anaerobic digester to fire the boiler that heated the digester. (Anaerobic digestion stabilizes wastewater sludge, reduces sludge volume, and eliminates pathogens.) The remaining waste methane gas was flared, because methane is a greenhouse gas that is 20 times as effective at trapping heat as carbon dioxide, the gas produced when methane is burned.

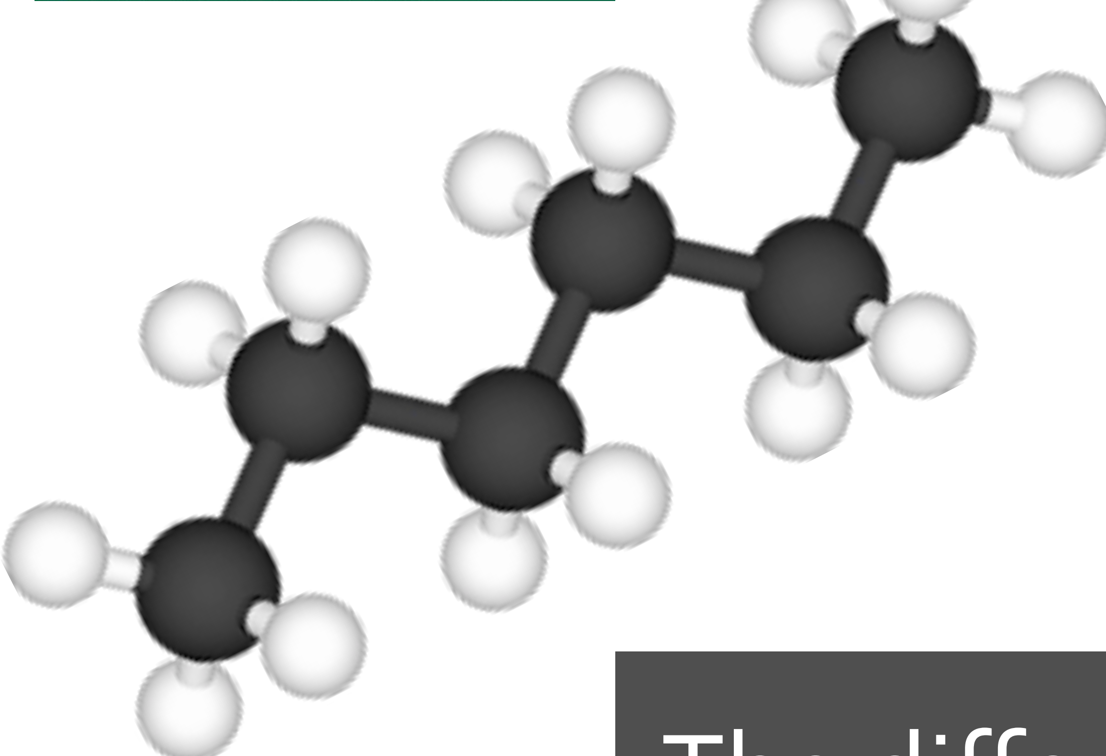
Although facility officials had been interested in combined heat and power since 1992, high initial costs failed to satisfy the requirement of the facility's governing board, that all projects have a simple payback of no more than seven years. Furthermore, it was unclear whether sufficient digester temperatures could be maintained when methane was used to fire a CHP system. The system was also required to emit no more pollutants than flaring methane did.

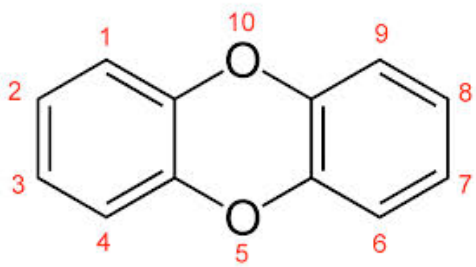
In order to satisfy the payback period requirement, the facility was able to obtain additional funding from Efficiency Vermont, The Biomass Energy Resource Center, NativeEnergy, and the U.S.

VT

- A biosolids treatment process that results in biosolids to be used or discarded.
- Trend: Huge interest & activity now, across the continent.







The different microconstituents…

…antibiotics to pharmaceuticals to dibenzo-p-dioxins

Concentrations of TOrCs in biosolids

Clark and Smith, 2010

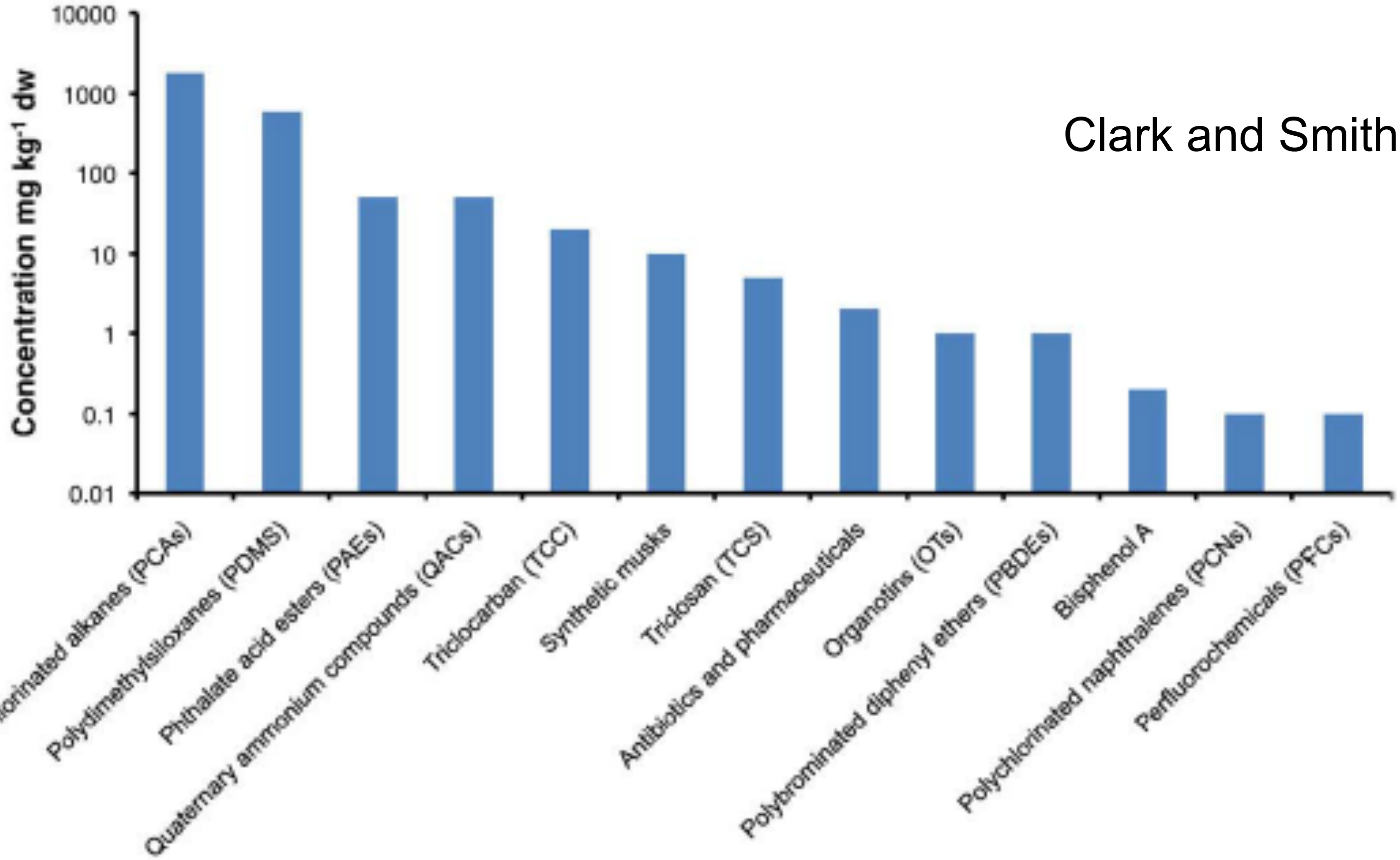


Fig. 1. Typical concentrations of selected 'emerging' organic contaminants in sewage sludge (mg kg^{-1} dw).

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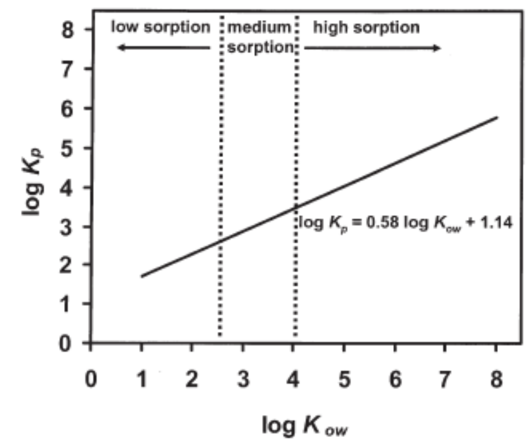
What does it mean?

Chemicals of greatest concern in biosolids have…

- High log K_{ow} - octanol-water partition coefficient
- High toxicity (to some species)
- Long half-lives (persistent)
- Bioaccumulative

Xia et al. 2005



- Dioxins/furans are excellent example: thoroughly studied and not found to require regulation (EPA, 2003)

Far greater concerns and impacts are in the WRRF effluent and receiving aquatic environment.

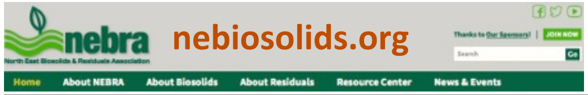
Kumar and Gupta, 2015

Greatest concern for plant uptake:

Absorption & membrane permeability are more likely when…

- Log K_{ow} < 3
- Molecular Weight < 300
- H-bond donors < 3
- H-bond acceptors < 6

Useful for screening compounds for further risk assessment. Vast majority of TOrCs in biosolids do not meet these criteria.



What does it mean?

Remember:

1 ppm = 1 second in 11.6 days

1 ppb = 1 second in 31.7 years

1 ppt = 1 second in 31,700 years

Healthy, microbially-active soils are the best medium for treatment of traces of organic chemicals.

Significant impacts to biota have been measured in aquatic environments, but not in biosolids-amended soils.

Risk to human health through biosolids-application-to-soil pathways appear to be negligible. Far greater human exposure to most are through daily use of products.

Source reduction should focus on persistent compounds with known or potential toxicity.

BPA – Bisphenol A

Save your credit card receipts?

BPA in credit card receipts = 8-17 g/kg

BPA in biosolids = 0.1-4.6 mg/kg

- **How much more concentrated is BPA in these receipts than in biosolids?**

a) Equal b) 400x c) **4000x**

Modified from Sally Brown, PhD, Univ. of WA

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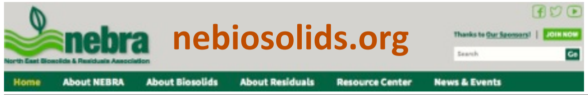
NORTHWEST BIOSOLIDS

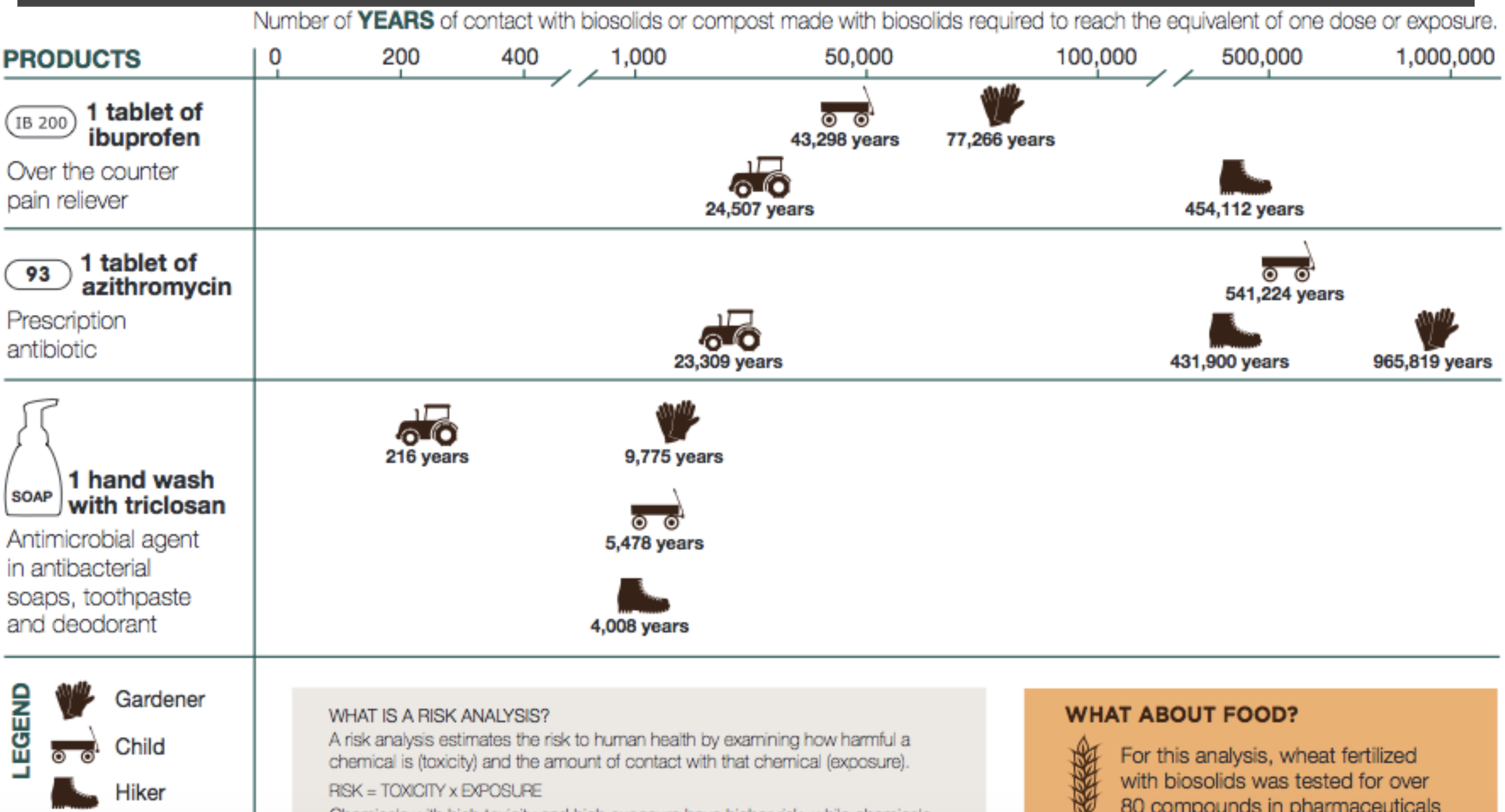
Biosolids: Understanding the risk

Putting it into perspective - how does using biosolids or compost made with biosolids compare to chemical exposures in everyday life?

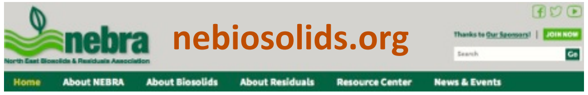
http://www.nwbiosolids.org/EventPubs/NWbiosolids_RISKbrochure.pdf

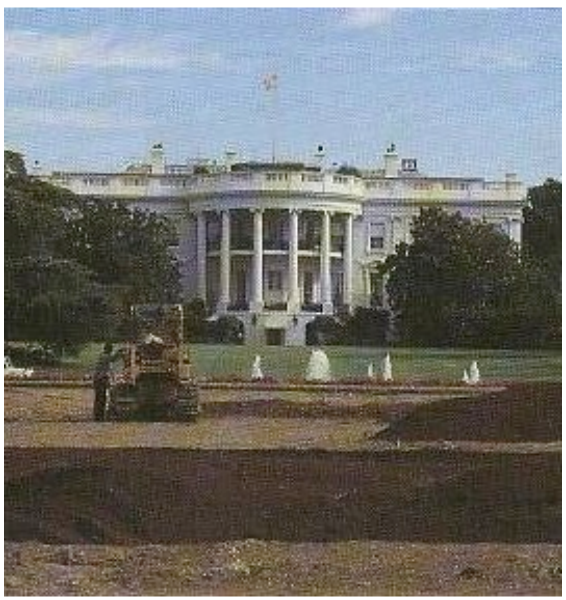


Number of years of contact = 1 dose

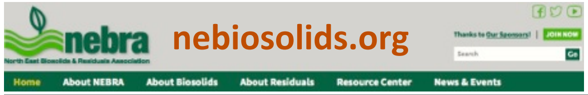


From NW Biosolids fact sheet





Biosolids & soils: Remarkable media for managing TOrCs!



Q: Where do we want to put TOrCs?

(We can't remove every bit from wastewater.)

A: Get them into the solids…and into soils…

…because healthy soils (e.g. enriched with biosolids and/or other organic amendments) are the best media for degrading most TOrCs.

"These terrestrial systems have orders of magnitude greater microbial capability and residence time to achieve decomposition and assimilation compared with aquatic systems."

– Overcash, Sims, Sims, and Neiman, 2005

Best management to address TOrCs

Focus on biosolids quality.

Source reduction works. Enforce industrial pretreatment. Support phase-outs of persistent TOrCs.

Year	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
1973	33	712	700	1,261	148	2,031
1983	12.5	360	361	421	79	1,701
1993	7.3	209	764	225	51	1,444
2000	4.2	115	566	178	53	1,619

Philadelphia Water District biosolids quality over time, courtesy of Bill Toffey.

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What biosolids generators & managers can do…

Focus on biosolids quality.

- When possible, use treatment processes that degrade TOrCs: biological processes are most effective.
- Use multiple processes, e.g. anaerobic digestion followed by composting & application.

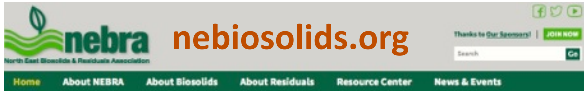
+

+

What biosolids managers can do…

Use Best Management Practices.

- Apply at agronomic rate*, which limits total mass of TOrCs while providing optimum level of benefits.
- Maintain setbacks from surface & groundwater*, which keeps TOrCs out of the more sensitive aquatic environment.
- Apply to aerated soils and incorporate when possible, which aids decomposition of TOrCs and avoids direct ingestion.
- Use the same BMPs for manures/other residuals.
- Follow research & update BMPs.



Thanks for… your invitation, your attention, & your questions and comments.

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