Trace Chemicals in Biosolids:
Update on the Science

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Executive Director, North East Biosolids & Residuals Association

November 5, 2013

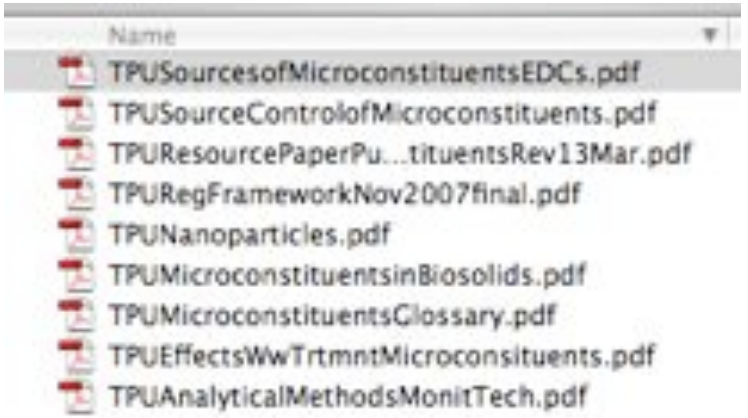
VT DEC Biosolids Forum

Waterbury, VT

Historic context

- Trace chemicals in biosolids are not new
- 30 years of research interest dating to before the federal biosolids rule - Part 503 (e.g. PCBs, priority pollutants)
- EPA dioxin risk assessment – early 2000s
- 2006-08: WEF Microconstituents Technical Practice Updates
- March 2008: Associate Press news
- 2008, 2011, & 2013 (soon): NEBRA Info Updates

Scroll down at http://www.nebiosolids.org/index.php?page=science for NEBRA coverage of topic.



The scientific process of evaluating the risk of toxicity…

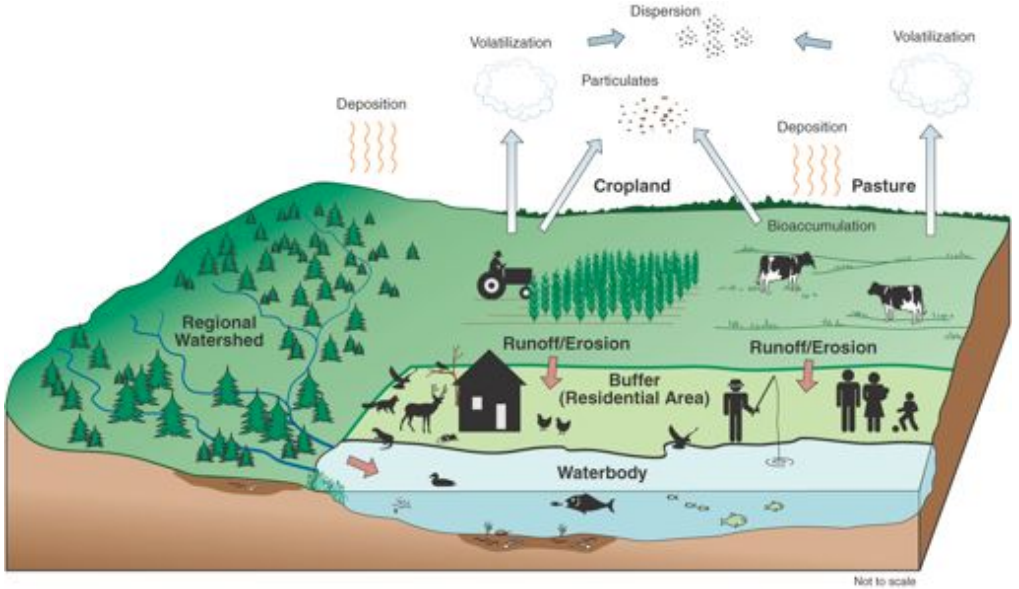
- The current research interest in trace organics in biosolids is developing in a typical fashion:

  1. Improving analysis identifies **presence**.
  2. Next: research into **fate & transport** has been going on for several years.
  3. Then: research into **impacts** has started in the last few years.

Toxicology requires the presence of a toxin and exposure of susceptible organism(s) to a high enough dose.

How to proceed with the research?

- Research… chemical by chemical and apply risk assessments…



- And… bioassays (Bioassays & biosolids workshop at WEF Residuals & Biosolids Conference, May 23, 2011, Sacramento: http://www.nebiosolids.org/index.php?page=applying-bioassays-to-biosolids-2)

Research suggests concerns…

the presence of trace chemicals in biosolids is shown with improved testing abilities (down to <ppt)

- Late 1990s – Microconstituents found in streams around the U. S. (famous USGS study)
- Xia et al., 2005 (state-of-science of biosolids land application conference, U. Florida): there are unknowns
- Buyuksonmez and Sekeroglu, 2005: composting (biology) certainly degrades microconstituents
- Heidler et al. / Halden 2006: TCC up to 50 mg/kg in biosolids

Research shows presence

biosolids contain small amounts (low ppm or less) of likely thousands of chemicals, natural & synthetic

- Kinney et al. 2006: USGS analyses of presence (http://toxics.usgs.gov/highlights/biosolids.html)
- Kinney et al. 2008: USGS study on fate: trace organics from biosolids & swine manure are found in worms (http://toxics.usgs.gov/highlights/earthworms.html)
- 2009: EPA Targeted Sewage Sludge Survey includes microconstituents – many were found in most samples in low parts per million (ppm) or parts per billion (ppb)

1 ppb = a second in >30 years

Research looks at fate & transport

chemicals are found in runoff & drainage, but at levels "far below toxic thresholds"

- Topp et al., 2009: "PPCPs are detected in tile drainage and in surface runoff, sometimes months after application. Maximum concentrations of PPCPs detected in effluent are generally lower following application of DMB than application of LMB. Incorporation of LMB eliminates the potential for loss via runoff. Application of LMB using an Aerway device reduces contamination via tile drainage, compared to surface applied and incorporated. The mass transport (fraction of chemical applied that is exported) varied widely. Maximum concentrations of PPCPs detected in effluents were generally far below toxic thresholds for a variety of endpoints drawn from the literature."

Research looks for impacts…

significant negative impacts on biota are not found

- Hundal et al. 2009, Chicago:

"The data suggest limited mobility of biosolids borne TCC, TCS, total PBDEs, and 4-NP in biosolids-amended soils. Although the concentrations of, TCC, TCS, 4-NP, and total PBDEs in soil were greater in the biosolids-amended plots than in the Control plots, the contaminants had no detrimental effects on the soil biota. Indeed, microbial community studies showed that the microbial populations were more diverse and much more biologically active in the biosolids-amended plots than in the control plots."

Research on plant uptake

plant uptake can happen in lab, but real-life field results are different (see Sabourin et al., below)

Uptake of Pharmaceutical and Personal Care Products by Soybean Plants from Soils Applied with Biosolids and Irrigated with Contaminated Water

- Wu et al., 2010
  - Soybean uptake
  - Greenhouse study
  - Spiked samples
  - Past research on trace metals and chemicals shows similar over-estimation of effect
  - Biosolids and soils adsorb and decompose contaminants over time, making them less and less bioavailable

Research on decomposition:

treatment processes break down chemicals

- Furlong et al.,2010

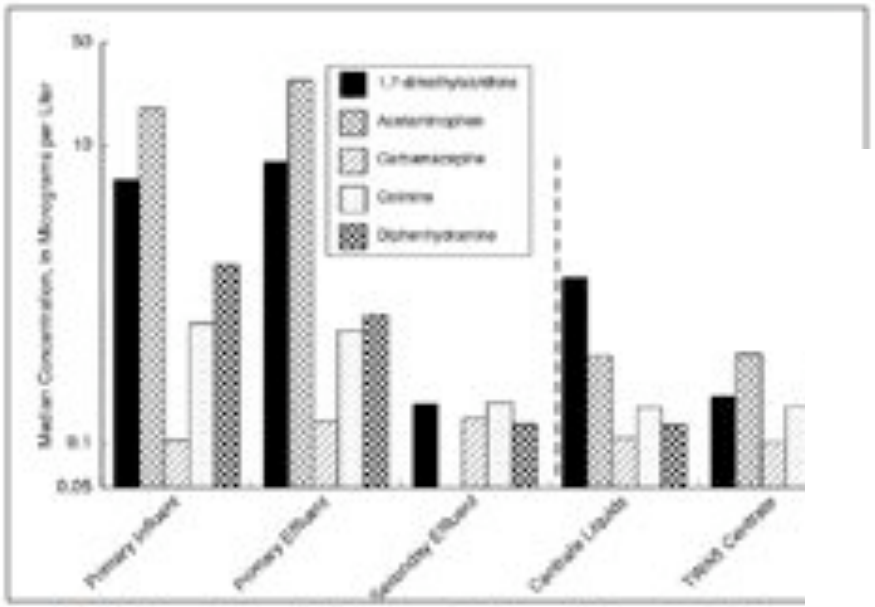


Figure 1. Median Concentrations of Select Pharmaceuticals from Unit Process Samples Comm
Plants A-D.

EXECUTIVE SUMMARY

WERF

WATER ENVIRONMENT RESEARCH FOUNDATION BIOSOLIDS

Fate of Estrogenic Compounds During Municipal Sludge Stabilization and Dewatering

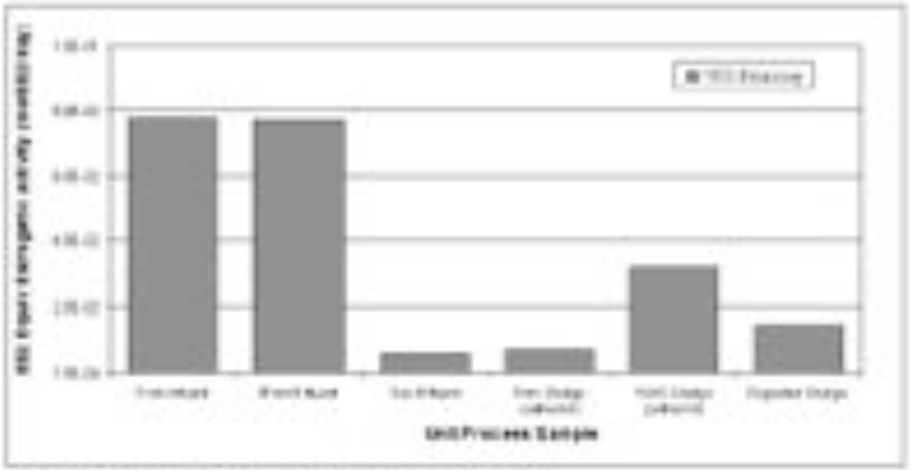


Figure 2. Daily Mass Flux of Estrogenic Activity at Plant D.
(Based on YES Bioassay Measurements – June 2006 Data Only)

Process Rankings for Microconstituent Removal (in order by removal of analyzed compounds, with best removal at top of list)

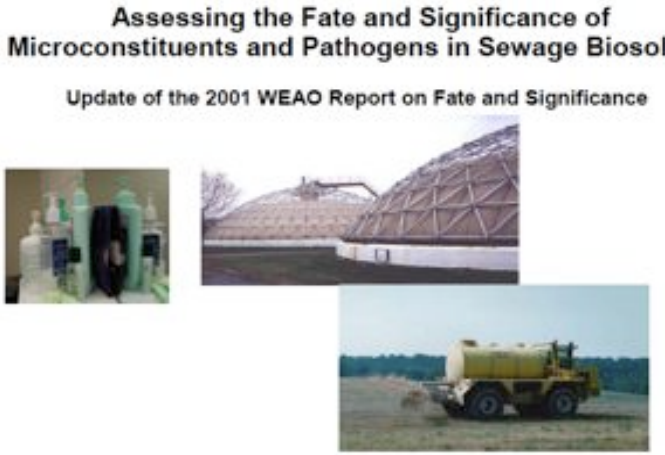
From Monteith, Nov 10. See "Monteith" under "Session 4" at http://www.nebiosolids.org/index.php?page=annual-north-east-residuals-biosolids-conference

Location	Treatment Process Assessed	Score total	Number of MCs (counts)	Reduction efficiency (avg score)
Gatineau Val.	Biological – compost	49	27	1.81
Moncton	Biological – compost	57	31	1.84
Prince Albert	Biological – compost	72	29	2.48
Halifax N-Viro	Phys.-chem. (alkaline stabilis'n)	116	35	3.31
Red Deer	Biological – meso. an. dig.	115	34	3.38
Eganville (Septage)	Physical – geotextile bag dewatering	97	28	3.46
Salmon Arm	Biological – ATAD	111	32	3.47
Saskatoon	Biological – meso. an. dig	118	34	3.47
Smiths Falls	Physical – thermal drying	100	27	3.70
Gander	Physical – filter press dew.	102	27	3.78
Saguenay	Physical – filter press dew.	108	27	4.00

Halden et al.

- Initiated research on triclocarban (TCC) and triclosan (TCS) in biosolids – found in low parts per million
- Analyzed historic samples of biosolids, finding 38 of 72 analytes
- After mixing with soil at 1:2 ratio (very high application rate), only 4 persisted after three years in mesocosm.

Summaries of the state of the science



Water Environment Association of Ontario

Hydromantis, 2010
Available free at
www.weao.org

WERF, 2010; see
http://www.werf.org/i/a/k/Search/ResearchProfile.aspx?ReportId=SRSK5T09

Scroll down at
http://www.nebiosolids.org/index.php?page=science for NEBRA coverage of topic.

Silver nanoparticles (antimicrobials)

- Schlich et al., 2013
  - "confirmed that at environmentally relevant concentrations >90% of AgNPs remain bound to sewage sludge"
  - No-effect concentration estimated to be 0.05 ppm dry soil
  - Experiment included spiked samples at lab scale, but did include the concept of aged contaminant transforming in biosolids and soil system
- Antibiotic resistance is a more significant potential concern with animal manures that are far more abundantly used.

Other nanoparticles

- Holden, Priester, et al. 2012
- Research on cerium oxide and zinc nanoparticles
- This research included the same issues created by using non-field, non-real-life conditions:
  - Soil samples spiked with fresh nanoparticles
  - Microcosm tests
  - High application rates (50 ppm, 100 ppm, 500 ppm)
- Some plant uptake of zinc found in soybeans. Zinc is tested for and controlled in real-life biosolids applications, based on risk assessments. Zinc is also an essential plant and human micronutrient.
- Higher application rates of cerium oxide (100 ppm and 500 ppm) showed reduced nitrogen fixation.
- Cerium oxide reaches agricultural soils due to the combustion of diesel fuel in farm machinery, to which it is added.

Carbamazepine (anticonvulsive)

a possible "worst-case" pharmaceutical

- In biosolids at low ppb (up to 258 ppb)
- Persistent because it binds to biosolids and soil organic matter (half-life = 108 days)
- Penn State study: 25 years of irrigation with reclaimed water → 2 – 5 ppb in upper layer of soil
- No plant uptake
- It stays where it is and slowly degrades.
- Possibly a "worst case" scenario, like dioxin.

Antibiotics in the environment

- Increasing interest
- Many sources: manures, carcasses, biosolids, treated water
- Research shows high levels of antibiotics in manure of treated livestock could temporarily retard composting. But the antibiotics were then biodegraded and composting using normal standards for completion and curing produced compost with very low residues of the antibiotics.
- The concentrations of antibiotics found in soils after biosolids application are likely far too low to cause significant impacts to soil biota.

Perspective

- USDA scientist Dr. Rufus Chaney gives an example (pers. communication, 2013): Biosolids contain on the order of 20 mg/kg dry weight (ppm) triclosan, and when biosolids are applied at fertilizer rates, the amended soil will initially contain 50 ug/kg (ppb) [10 mg/kg -x- 5 t biosolids/2000 t soil (one ha) soil = 50 ug/kg].
- In farm soils near Washington, DC, where DC biosolids were applied as fertilizer, freshly amended soils contained about 50 ppb, but one year later, soils contained only about 10 ug/kg (ppb), and the half-life was estimated at 107 days (Lozano et al., 2010). Thus at the concentration in biosolids amended soil, the compound is not an effective antibiotic.
- Concentration is important in all considerations of toxicity or risk.

Colgate Total Toothpaste, 0.30 % Triclosan = 3000 ppm

Perspective

- Antibiotics and other chemicals are also in manures, which are used far more than biosolids.
- Human exposure is highest in direct use (see next slide) or in household dust (e.g. for flame retardants – PBDEs, etc.), interior spaces, etc.
- Biosolids application rates, which are based on nutrient needs, mean that the concentrations of any contaminants applied to soils is small.
- Biosolids pathway does not create significant risk to human health (as was found by the exhaustive U. S. EPA dioxin risk assessment)

2012 – Sabourin et al.

- Field experiment – real life biosolids application
- Soil fertilized with municipal biosolids at Ontario application rate
- Tomatoes, carrots, potatoes and sweet corn produced under normal farming conditions.
- One-year offset between biosolids application and the harvest of crops for human consumption (as required by Ontario regulation)
- Analytes: 118 pharmaceuticals and transformation products, 17 hormones or hormone transformation products, and 6 parabens.
- Analyte concentrations in the biosolids were consistent with those detected in other surveys.
- 8 of the 141 analytes were detected in one or two crop replicates at concentrations ranging from 0.33 to 6.25 ppb dry weight, but no analytes were consistently detected above the detection limit in all triplicate treated plots.
- "Overall, this study suggests that the potential for micropollutant uptake into crops under normal farming conditions is low."

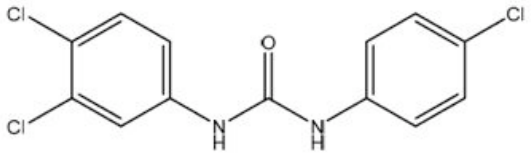
Bioassay work…

- Lynda McCarthy (Ryerson): lab bioassays in Ontario using earthworms, springtails, *brassica rapa*, beans, corn: "sub-acute, acute, chronic, and reproductive bioassays indicated no deleterious impact of selected biosolids on selected biota under controlled, laboratory conditions."
- 2010: University of Guelph – fate of endocrine disruption during biosolids treatment processes
- 2010: College of William and Mary: bioavailability of PDBEs using earthworms and crickets in laboratory
- Tom Young (UC Davis): triclosan (TCS) has "little relative impact on on overall community composition," but reduces ammonia oxidizing activity and shows up in runoff.

Current understanding
of microconstituents in biosolids

- Many of the high-production, most-likely chemicals of concern have been researched.
- Presence in biosolids is in the parts per billion or low parts per million range.
- There are various, predictable rates of degradation in biosolids treatment processes and soils over time.
- Biosolids pathway is unlikely to create impacts to human health through the food-chain.
- If there are any impacts on soil organisms, plants, or other environmental receptors, they are likely small.
- Human exposures are far greater through direct use, house dust, interior air, etc.
- No regulatory agency in No. America has regulated microconstituents in biosolids.

Soil attenuation…



All chemicals added to soils are subject to the same reactions/processes, including solid phase retention/ release, degradation, bioaccumulation, volatilization, runoff, and leaching. The reactions/processes of organics have been studied for decades and the corresponding risk to human and environmental health assessed/estimated. Examples of organic chemicals so studied include pesticides, priority pollutants, and others with chemical and physical properties similar to many of today's "emerging chemicals of concern", also know as "microconstituents."

– O' Connor, 2009, WEF Residuals and Biosolids Conference

Where biosolids may help…

Chemicals of highest concern have…

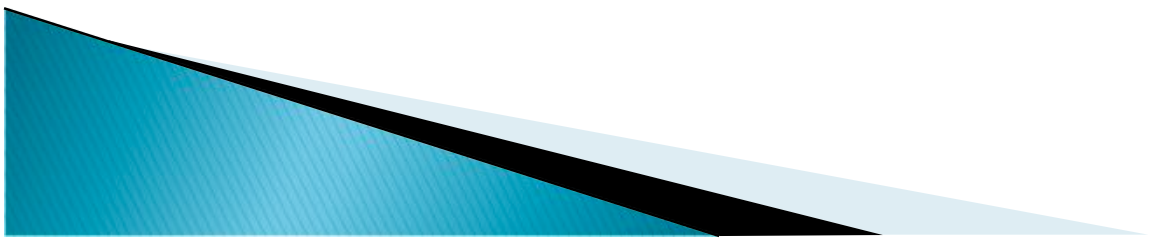
- Long half-lives (persistent)
- High log Kow values (bioaccumulative, in some biota)
- High toxicity (to some species)

The high log Kow values, however, also portend that solid phase retention is great and that release is small, that leaching through soils and subsequent groundwater contamination is small, that water solubility is very low, and that availability to organisms dependent on water solubility (plant uptake, degradation) is small.

Where do we want to put microconstituents if we can't remove them all?

"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



Contact information

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www.nebiosolids.org

A quick summary of biosolids

- Biosolids use on soils have been researched and experienced for decades
- No documented evidence that Part 503 has failed to protect public health
- State regulations are even more protective
- Biosolids use on soils has significant benefits:
  - Cost effective management of solids
  - Recycling of nutrients & organic matter
  - Reduced costs for mined/manufactured fertilizer
  - Greenhouse gas reduction
  - Putting a local resource to use

What's in municipal biosolids?

- Water ~ 5% (heat dried pellets) to ~ 95% (liquid biosolids)
- Organic matter ~ 20% to 70% dry weight biological molecules from foods, human waste, runoff, etc., including lipids, proteins, sugars, starches, etc., dissolved and suspended, *which contain…*
- Nutrients ~ 12% dry weight N, P, K, Ca, Fe, & micro-nutrients (Cu, Zn, etc.)
- Binding Sites reducing bioavailability of Pb, As, etc.
- Energy ~ 5,000-10,000 Btu/d lb. (when dry, similar to low grade coal)

Also:

- Inert sand, silt, grit, and synthetic particles
- Trace elements (mostly in compounds)
- Pathogenic micro-organisms
- Synthetic and natural organic chemical compounds (e.g. including polymers)

What's ideal for sustainability?

MAXIMIZE *RESOURCE RECOVERY* OF CONSTITUENTS

Constituent	Benefits	Concerns
Water	valuable in agriculture in arid climate	cost of transport
Organic matter	vital to soils	putrescible, odors
Nutrients	food for soil, plants & animals	impacts to water
Binding sites	valuable in soil remediation	longevity of binding
Energy	renewable, displaces oil/gas	air emissions, maybe no use of nutrients & organic matter

MINIMIZE POTENTIAL RISKS OF CONSTITUENTS

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

Solids management is a necessary part of wastewater treatment….

BMJ. 2007 January 20; 334(7585): 111.
PMCID: PMC1779856
doi: 10.1136/bmj.39097.611806.DB

BMJ readers choose the "sanitary revolution" as greatest medical advance since 1840

Annabel Ferriman

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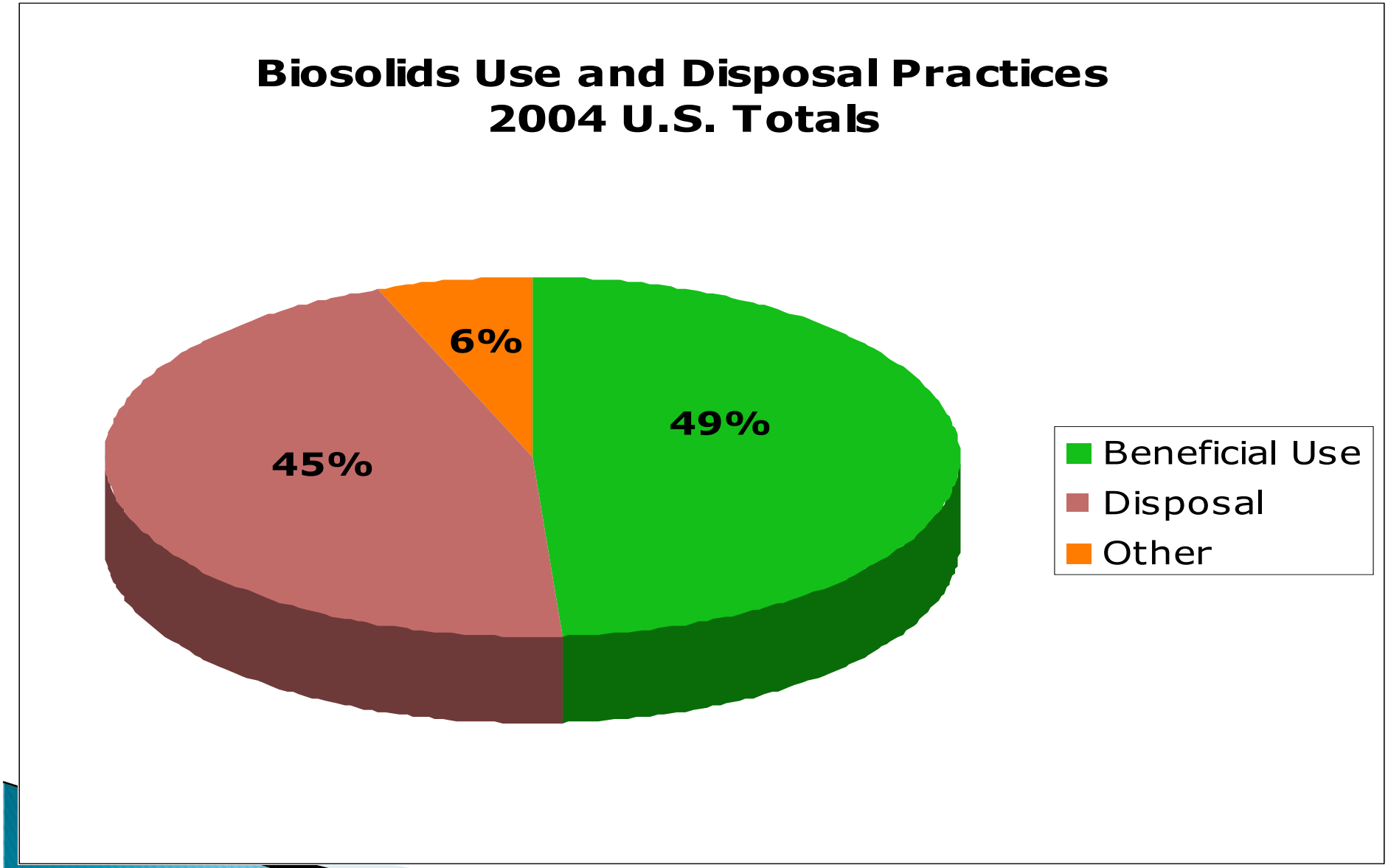
More than 11 300 readers of the *BMJ* chose the introduction of clean water and sewage disposal—"the sanitary revolution"—as the most important medical milestone since 1840, when the *BMJ* was first published. Readers were given 10 days to vote on a shortlist of 15 milestones, and sanitation topped the poll, followed closely by the discovery of antibiotics and the development of anaesthesia.

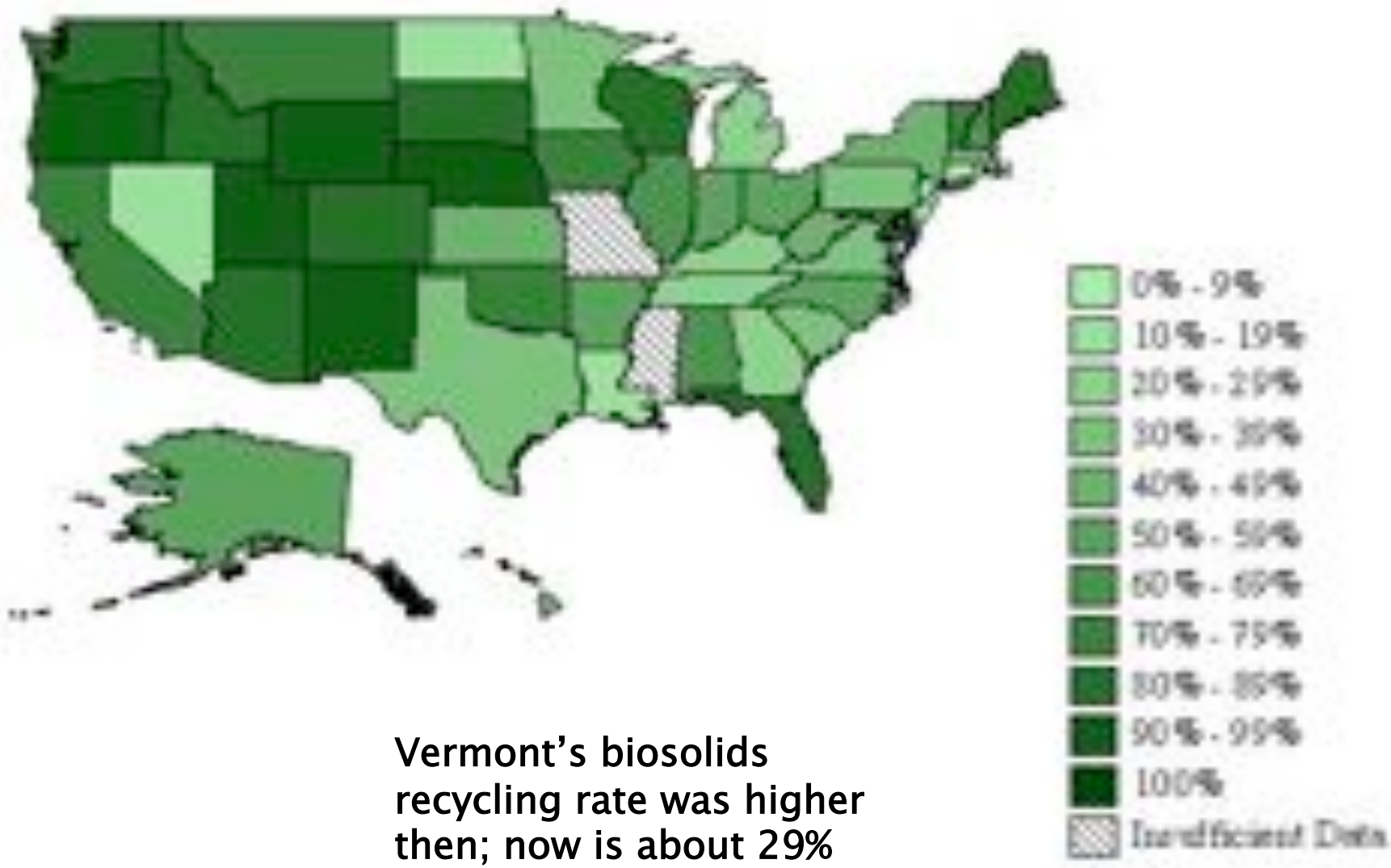
EcoSan is important in some places

- But diverse options are needed, including centralized treatment
- All systems produce liquid effluents and solids that must be managed
  - They all can have some PPCPs, antibiotics, metals, pathogens
  - Many composting toilets do not reach time & temperature necessary to kill pathogens (biosolids composting must meet strict time & temperature)
  - Choice is to train all homeowners to manage their waste safely or to train a smaller number of public utility staff to manage centralized wastewater safely.
  - Technically, solids from any system are subject to federal Part 503 regulations.

40+ Years of Experience



Percent Biosolids Beneficially Used by State, 2004

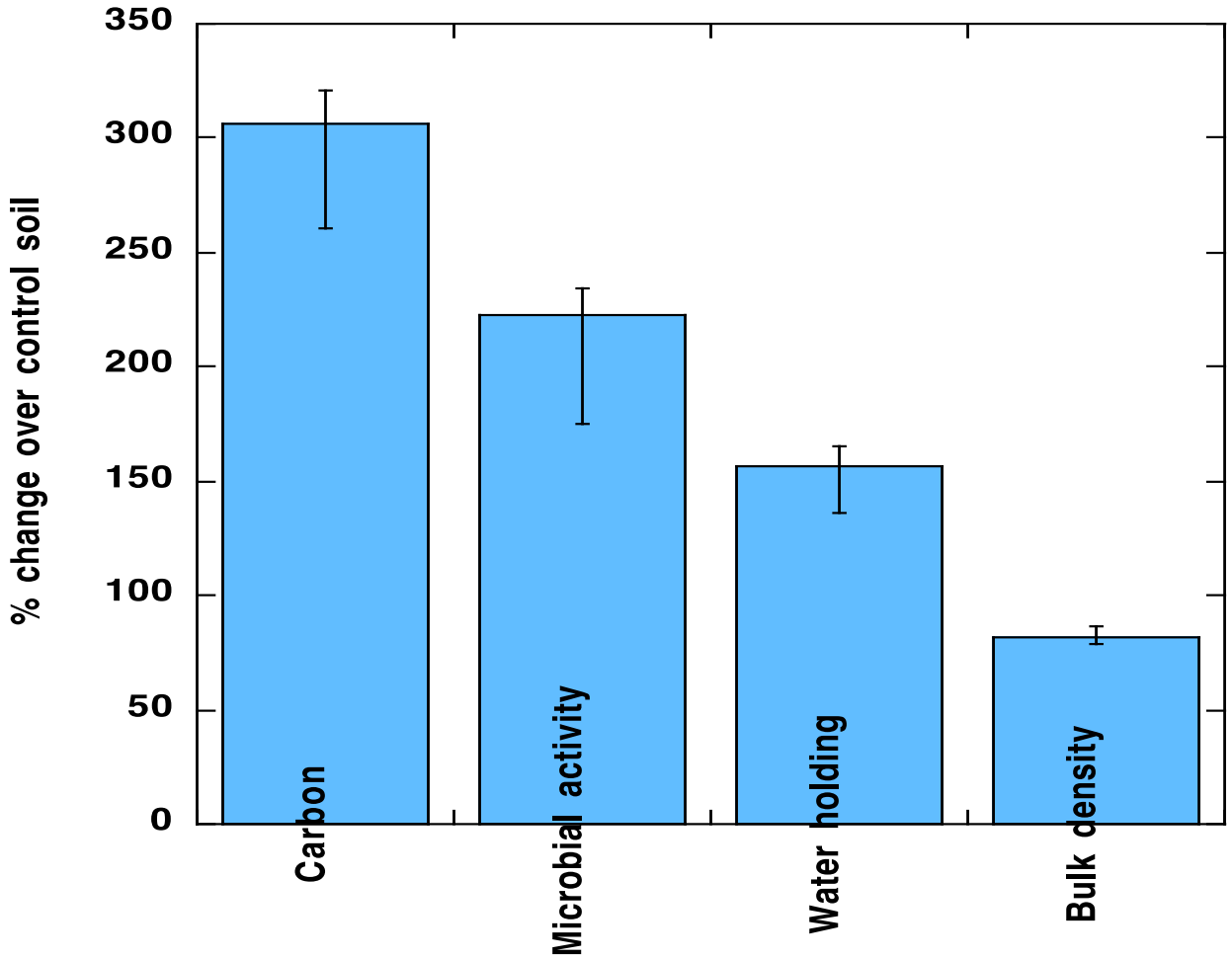


Vermont's biosolids recycling rate was higher then; now is about 29%

40+ Years of Research…

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).

GHG Emissions

comparing landfill disposal and land application

- 8000 wet tons per year at 25% solids (about what Burlington produces)
- Landfilling → 3700 metric tons more per year of CO_2 equivalents than land application
  - BEAModel calculation
  - Anaerobically digested biosolids
  - The landfill has methane collection system, capturing 75% when in place 3 years after disposal and generating electricity with the collected methane
  - Transport distances are the same for both options
  - The CO_2 cost for the region is 909 lb/MWh (New England region from e-grid)
  - The biosolids would be applied at agronomic rates with 50% on fine textured soils and 50% on coarse textured soils.

40+ Years of Experience

Agriculture: still ¾ of U. S. beneficial use

University of Nebraska-Lincoln Extension in Lancaster County

The NEBLINE

May 2012

444 Cherrycreek Road, Suite A, Lincoln, NE 68528 • 402-441-7180 • http://lancaster.unl.edu

Lincoln's Biosolids Land Application Program is 20 Years Old

What's in Biosolids That Makes it So Good?

Demand for Biosolids

Farmers are Paying for Biosolids

Teaching An Old Guy New Tricks

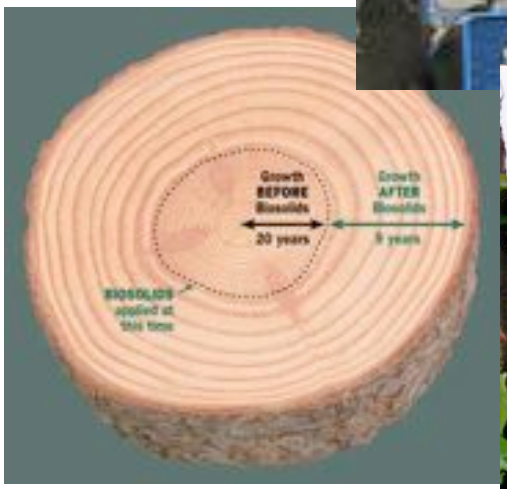
California, 2004

New Hampshire, 2006

Virginia

40+ Years of Experience

Forestry



40+ Years of Experience

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

Québec, 2003

Maine, 2003

Columbus, OH

Boston, MA

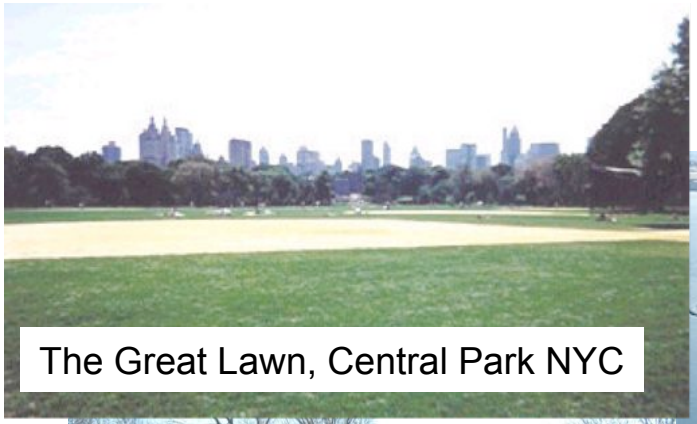
Davenport, IA

Biosolids Composting Facilities in the U. S.

U. S. EPA Region	States with Biosolids Composting Facilities	Number of Facilities
1	New England (CT, MA, ME, NH, RI, VT)	35
2	New York, New Jersey, Puerto Rico	30
3	Delaware, Maryland, Penn, Virginia, W. Virginia	26
4	Florida, Georgia, Kentucky, N & S Carolina, Tenn	32
5	Indiana, Michigan, Ohio, Wisconsin	10
6	Arkansas, New Mexico, Oklahoma, Texas	31
7	Iowa, Kansas, Missouri, Nebraska	14
8	Colorado, Montana, S. Dakota, Utah, Wyoming	38
9	Arizona, California, Hawaii, Nevada	20
10	Alaska, Idaho, Oregon, Washington	30
None:	Alabama, Illinois, Louisiana, Minnesota, Mississippi, N. Dakota	
	TOTAL	266

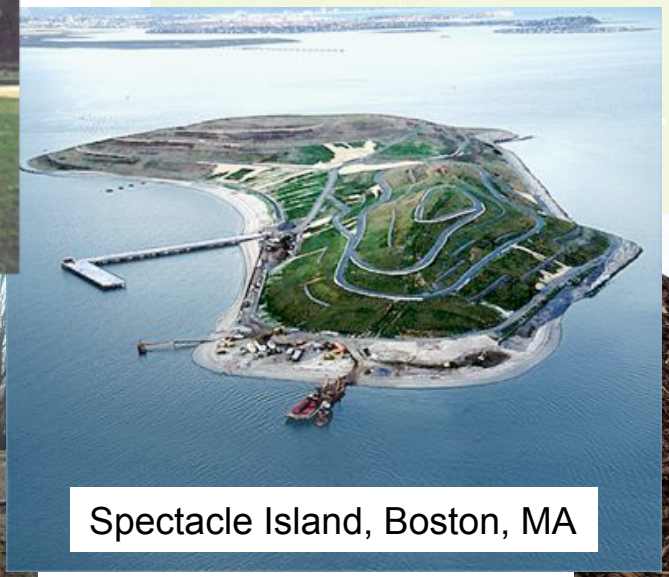
40+ Years of Experience

Making & using biosolids compost



The Great Lawn, Central Park NYC

Central Valley, California



Spectacle Island, Boston, MA

Streambank stabilization, PA

Fabric-covered composting, Moncton, NB

Static pile composting, Southboro, MA

Co-composting w/ MSW, Marlboro, MA

40+ Years of Experience

Making & using biosolids compost

before

after

40+ Years of Experience

Land reclamation: 3+% of beneficial use

Massachusetts, 2006

Idaho

Massachusetts
2004

Washington

40+ Years of Experience

What Philadelphia accomplished…

- Restored the productivity of 4,000 acres of stripped mine lands
- Utilized 1,000,000 tons of biosolids
- Additionally benefited waters and habitats
- Supported the mining economy with $40 million in reclamation services

before

after

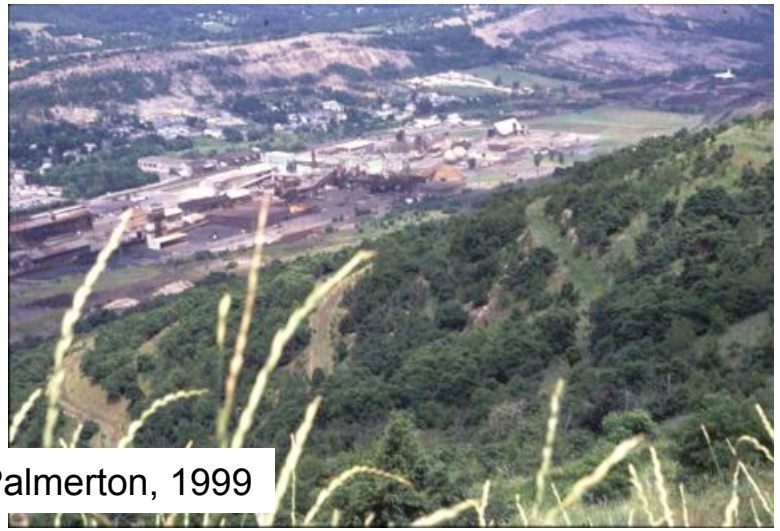
40+ Years of Experience

More mine reclamation experience in PA…

before

Palmerton, 1980

after



Palmerton, 1999

40+ Years of Experience

More mine reclamation experience in ID…

Highly Zn-phytotoxic smelter and mine waste contaminated soils at Bunker Hill, ID;

Background = Biosolids+Wood-Ash Remediated

Foreground = Seeded control hazardous soil.

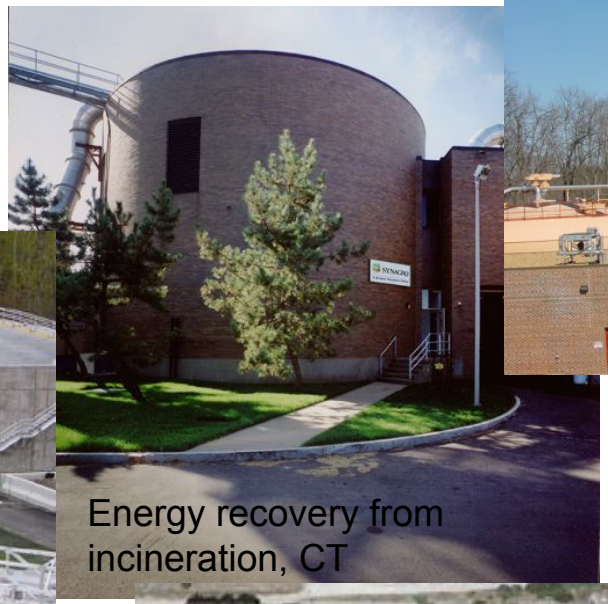
40+ Years of Experience

Mine reclamation in NE PA, including deep trench biosolids application and poplar planting

Biosolids were used for the plantings under the 2010 Vancouver Olympic rings.

Energy from biosolids

Egg-shaped digester, NH



Energy recovery from incineration, CT

Circular tank digesters, MA

East Bay MUD, Oakland, CA

Gasification

Energy from biosolids

Energy recovery from incineration, Metropolitan Council, Minnesota

Dried biosolids are used as alternative fuel in coal-fired cement kilns.

Biofuel crops grown with biosolids are pressed to make biodiesel to fuel biosolids transport trucks.

Policy

- The Canadian Approach (2012)
  - Promotes the beneficial use of biosolids
  - Recognizes valuable resources in biosolids: nutrients, organic matter, & energy potential
  - Provinces are adopting it in regulation & guidelines
- U. S. EPA
  - Identifies 3 options for biosolids: beneficial use on soils (land application), landfill disposal, or incineration
  - Each option has its impacts; there is no zero risk.
- U. S. FDA accepts biosolids as one fertilizer option; biosolids set the standard for proper treatment and management (applied to manures)
- U. S. Dept. of Ag
  - Biosolids are not allowed in certified organic agriculture (they contain synthetic substances)
  - USDA is supportive of biosolids use on soils in accordance with regulations and best management practices.
  - Include biosolids in nutrient management planning (Code 590).

Resources

EPA Biosolids Program / Part 503

Part 503 regulations & EPA regulatory activities

(Office of Water – Science & Technology)
http://water.epa.gov/scitech/wastetech/biosolids

Part 503 & EPA biosolids program guidance

(Office of Water – Wastewater Program)
http://water.epa.gov/polwaste/wastewater/treatment/biosolids/

NAS / National Research Council Reviews of Part 503

1996: Use of Reclaimed Water and Sludge in Food Crop Production
2002: Biosolids Applied to Land: Advancing Standards and Practices

EPA Response to NRC 2002 Review

http://water.epa.gov/scitech/wastetech/biosolids/dec03factsheet.cfm

Resources

Other U. S. Government Regulations, Guidance, & Policy

U. S. Food & Drug Agency

Guidance for Industry: Guide to Minimize Microbial Food Hazards for Fresh Fruits and Vegetables (1998)
http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/ucm064574.htm

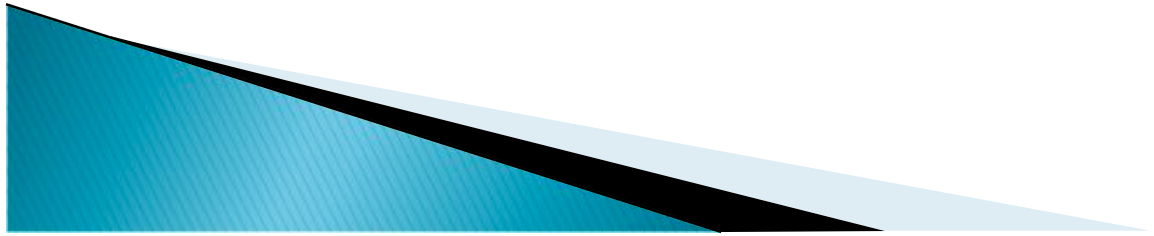
CDC – National Institute for Occupational Safety and Health (NIOSH)

Guidance for Controlling Potential Risks to Workers Exposed to Class B Biosolids (2002)
http://www.cdc.gov/niosh/docs/2002-149/

U.S. Dept. of Agriculture: National Organic Program

National Organic Program website
http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateA&navID=NationalOrganicProgram&page=NOPNationalOrganicProgramHome&resultType=&topNav=&leftNav=NationalOrganicProgram&acct=nop

7 CFR Part 205 – National Organic Program Regulations
http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&SID=89420dada951a542e98f097da8b8a214&rgn=div5&view=text&node=7:3.1.1.9.32&idno=7



Resources

Greenhouse Gas (GHG) Emissions Regulations & Estimation Tools

U. S. EPA Office of Air & Radiation

Greenhouse Gas (GHG) Emissions Reporting Program
http://www.epa.gov/ghgreporting/index.html

Greenhouse Gas (GHG) Prevention of Significant Deterioration (PSD) & Title V Tailoring Rule
On the following website, see under "2010" and more recent actions:
http://www.epa.gov/nsr/actions.html

Greenhouse gas (GHG) emissions & biosolids management

The Biosolids Emissions Assessment Model (BEAM) developed by Sylvis Environmental and partners fro the Canadian Council of Ministries of the Environment (CCME) is a tool for estimating emission from various biosolids management treatment and management options.
http://www.ccme.ca/ourwork/waste.html?category_id=137

See also Env. Sci. & Tech. paper: http://pubs.acs.org/doi/abs/10.1021/es101210k

NEBRA: GHG Emissions and Biosolids Management page:
http://www.nebiosolids.org/index.php?page=biosolids-management-greenhouse-gas-emissions

The current standard for municipalities to calculate GHG emissions, including from wastewater treatment & solids management, is at The Climate Registry:
http://www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/

Resources

Biosolids Use & Trends

A National Biosolids Regulation, Quality, End Use, & Disposal Survey

A collaborative report by NEBRA, NBMA, *BioCycle*, and WI Dept. of Natural Resources

Report (with Executive Summary):
http://www.nebiosolids.org/uploads/pdf/NtlBiosolidsReport-20July07.pdf

State-by-state details (regulations and use & disposal data):

Alabama – Missouri
http://www.nebiosolids.org/uploads/pdf/NtlBiosldsRpt-AppD-AL-MO.pdf

Montana - Wyoming
http://www.nebiosolids.org/uploads/pdf/NtlBiosldsRpt-AppD-MT-WY.pdf

Resources

Federal & State biosolids contacts & regulations

State and Regional Biosolids Contacts:

http://www.wef.org/Biosolids/page3.aspx?id=7555

EPA Headquarters and ORD Biosolids Contacts:

http://www.wef.org/Biosolids/page.aspx?id=7808

Biosolids State Regulations:

http://www.wef.org/Biosolids/page.aspx?id=7542

Technical Resources:

http://www.wef.org/Biosolids/page.aspx?id=7522

Regional Biosolids Associations

http://www.wef.org/Biosolids/page.aspx?id=7691

Resources

Biosolids Use & Trends

Charting the Future of Biosolids Management (2011)

A report from the National Biosolids Partnership
http://www.wef.org/cfbm_finalreport/

Enabling the Future of Biosolids Management (2013)

A report from the National Biosolids Partnership
http://www.wef.org/uploadedFiles/Biosolids/PDFs/ENABLING%20THE%20FUTURE.pdf

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Montana - Wyoming
http://www.nebiosolids.org/uploads/pdf/NtlBiosldsRpt-AppD-MT-WY.pdf

Resources

WERF Biosolids Research

http://www.werf.org/c/KnowledgeAreas/Biosolids/Biosolids_Research_at_a_Glance.aspx

Find WERF reports, tools, and updates on ongoing projects. At this time, presentations and other WERF documents may be found by browsing our Knowledge Areas.

- biosolids land application,
- compounds of emerging concern,
- emerging contaminants, endocrine disrupting compounds, energy production,
- green infrastructure,
- microconstitutents, odors and aerosols,
- pathogen detection & indicators,
- pharmaceuticals & personal care products,
- residuals management,
- resource recovery,
- solids disinfection, solids reduction, solids treatment, risk communication

Research reports >2 years old are available for free download at http://www.werf.org

Resources

WEF General Resources

WEF Technical Practice Updates (TPUs):
http://www.wef.org/TPUs/

WEF No Charge Webcasts:
http://www.wef.org/OnlineEducation/page_webcasts.aspx?id=124

WEFTEC Proceedings: Hosted on the IngentaConnect website
Proceedings of the Water Environment Federation is an archival library of the papers presented at the annual WEF Technical Exhibition and Conference (WEFTEC) and other conferences held between 2000 and 2010. These proceedings are not peer-reviewed. No charge for WEF members.

This Week in Washington from WEF: No charge
http://www.wef.org/GovernmentAffairs/ThisWeekInWashington/

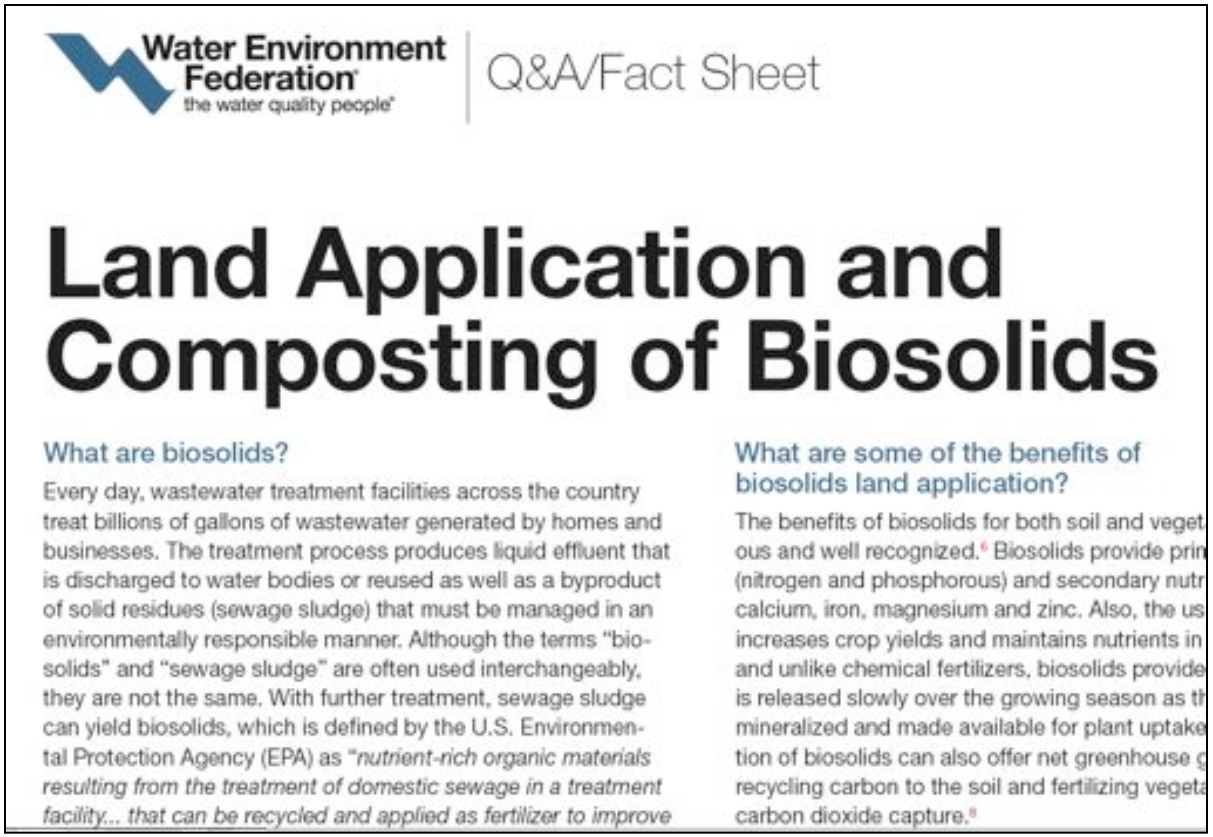
Web Resources:

- NBP webpage: http://www.wef.org/biosolids/
- NBP Webcasts: http://www.wefnet.org/nbp/
- NBP Biosolids Resources – Biosolids News Center: + Monthly E-Newsletter http://www.wef.org/biosolidsnews/
- NBP Biosolids Management Program Documents: http://www.wef.org/Biosolids/page.aspx?id=7554
- NBP Technical Resources: http://www.wef.org/Biosolids/page.aspx?id=7522
- Anaerobic digestion and biogas production: http://www.biogasdata.org
- NEBRA information on greenhouse gas emissions and biosolids management http://www.nebiosolids.org/index.php?page=biosolids-management-greenhouse-gas-emissions

Additional web resources

- www.nebiosolids.org North East Biosolids & Residuals Association
- www.nwbiosolids.org Northwest Biosolids Management Association
- www.virginiabiosolids.com Virginia Biosolids Council
- www.mabiosolids.org Mid-Atlantic Biosolids Association
- http://www.ccme.ca/ourwork/waste.html?category_id=137 Canadian Council of Ministries of the Environment – Biosolids Task Force
- http://www.weao.org/committees/biosolids/biosolids.html Water Environment Assoc. of Ontario – biosolids page
- http://water.epa.gov/polwaste/wastewater/treatment/biosolids/index.cfm EPA Biosolids Page
- http://faculty.washington.edu/slb/biosolids_basics.html Univ. of Washington research
- www.loopforyoursoil.com King County biosolids brand “loop”

Resources



Water Environment Federation
the water quality people

Q&A/Fact Sheet

Land Application and Composting of Biosolids

What are biosolids?

Every day, wastewater treatment facilities across the country treat billions of gallons of wastewater generated by homes and businesses. The treatment process produces liquid effluent that is discharged to water bodies or reused as well as a byproduct of solid residues (sewage sludge) that must be managed in an environmentally responsible manner. Although the terms "biosolids" and "sewage sludge" are often used interchangeably, they are not the same. With further treatment, sewage sludge can yield biosolids, which is defined by the U.S. Environmental Protection Agency (EPA) as "*nutrient-rich organic materials resulting from the treatment of domestic sewage in a treatment facility... that can be recycled and applied as fertilizer to improve*

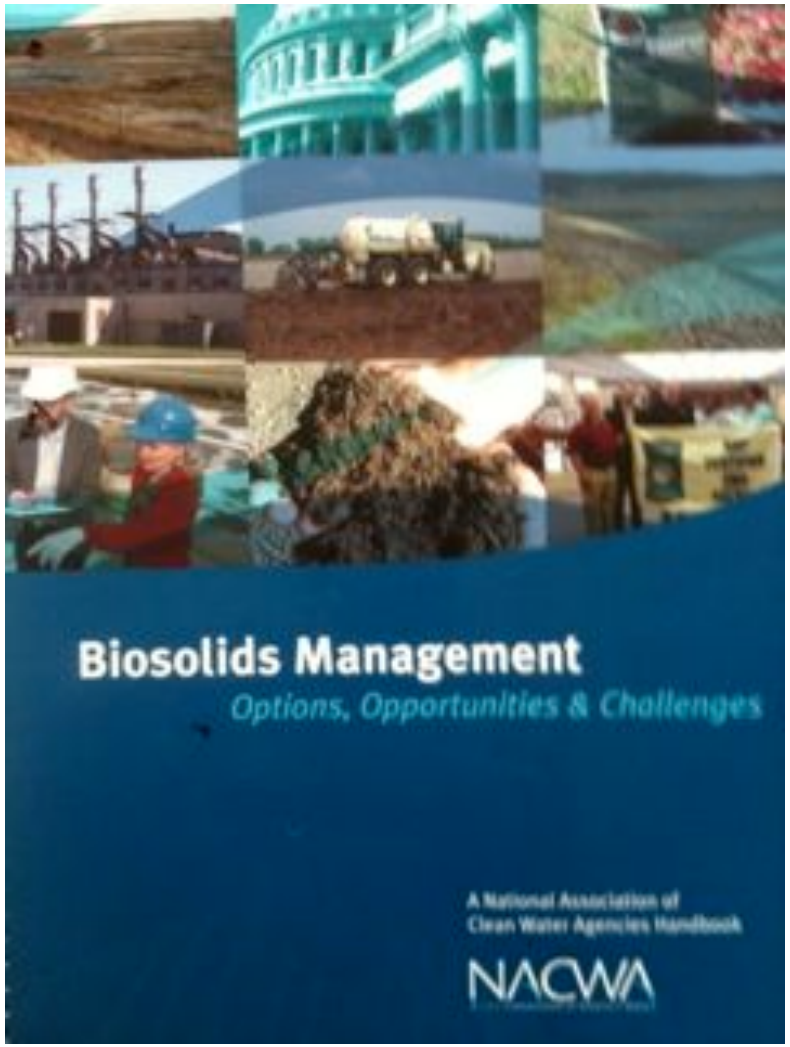
What are some of the benefits of biosolids land application?

The benefits of biosolids for both soil and veget
ous and well recognized.[6] Biosolids provide prin
(nitrogen and phosphorous) and secondary nutr
calcium, iron, magnesium and zinc. Also, the us
increases crop yields and maintains nutrients in
and unlike chemical fertilizers, biosolids provide
is released slowly over the growing season as th
mineralized and made available for plant uptake
tion of biosolids can also offer net greenhouse g
recycling carbon to the soil and fertilizing vegeta
carbon dioxide capture.[8]

Download many of the documents noted in this powerpoint, including this fine fact sheet, from the WEF/NBP website: http://www.wef.org/Biosolids/page.aspx?id=7522

Resources

Order this 2006 document and see additional resources at the NACWA website:
http://www.nacwa.org/index.php?option=com_content&view=article&id=338%3Abiosolids-management-options-opportunities-a-challenges-companion-online-library&catid=11%3Aoperation-utility-management&Itemid=27

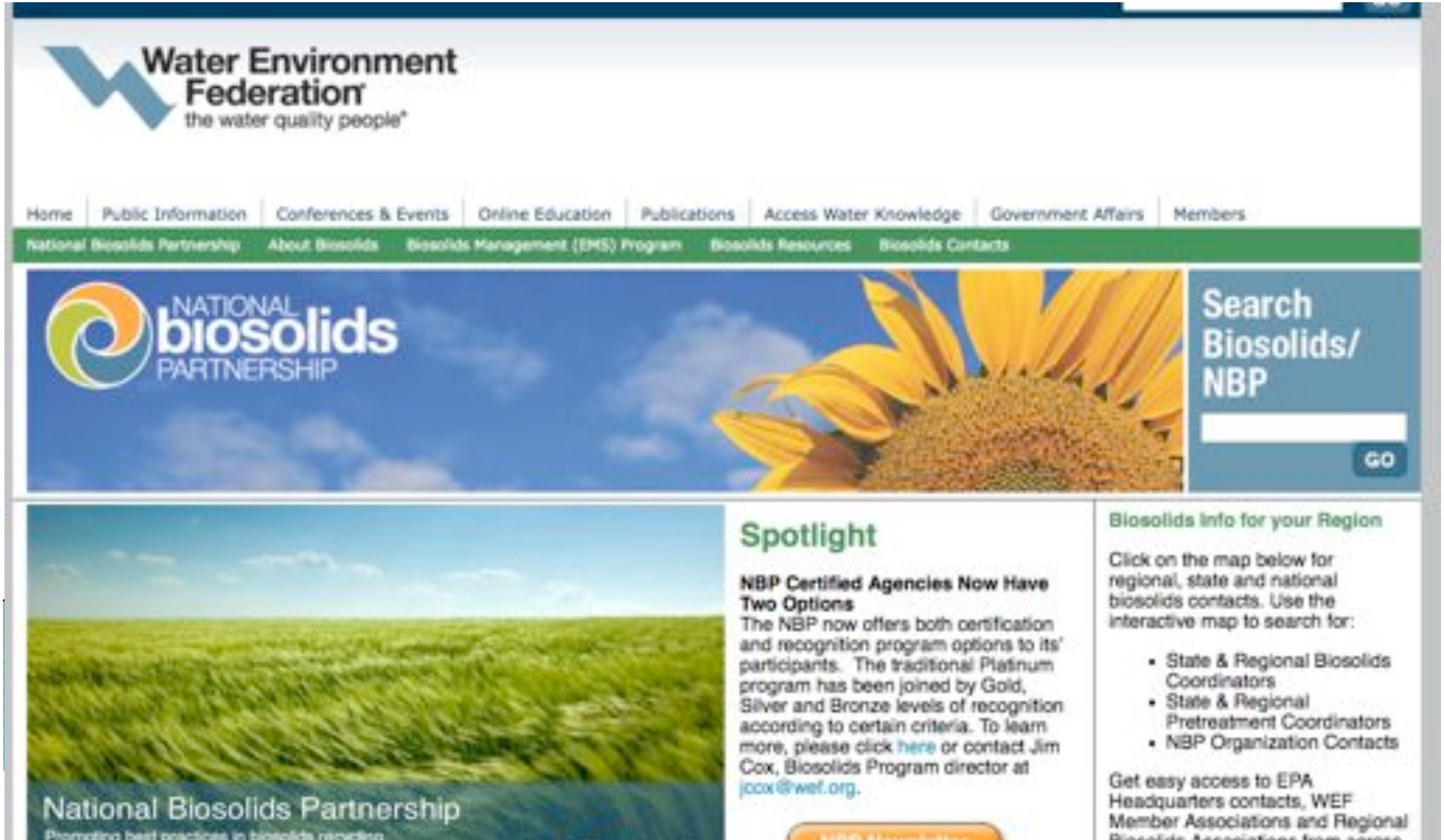


Resource

Biosolids: Naturally Sustainable

http://www.endless-films.com/site/?portfolio=biosolids

Resource: www.biosolids.org



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