An Abbreviated History of Biosolids-Organics Considerations

Microconstituents Workshop
Chicago, June 26, 2008

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Purpose

- Describe the history of organics risk assessment (Part 503)
- Describe new challenges
  - Emerging chemicals of concern
  - Analytical, experimental, and modeling
  - Loss of “institutional memory”

The Part 503 Risk Assessment Process

- 1982
  - Inter-agency Task Force develops management/regulation plan
  - "40 Cities Survey" – pollutants identified
- 1984
  - 200 pollutants chosen for consideration
  - Four panels identify 50 for further study
- 1984-85
  - Worse-case hazard profile assessment

Part 503 Process - Continued

- 1986-88:
  - Hazard Index developed
    - Est. conc. soil, plant, animal, water, air
    - Lowest toxic conc. to target organism
    - $HI_{pollutant/pathway} < 1$, dropped
  - Hazard ranking (HI > 1)
    - Detailed risk assessment
      - 22 chemicals
      - $HI_{biosolids}$ assigned
        - Some deferred (lack of data)
        - Additional chemicals added

Organics Remaining (Land Application)

- Aldrin/Dieldrin
- Benzene
- Benzo(a) pyrene
- DEHP
- Chlordane
- DDT/DDE/DDD
- Heptachlor
- Hexachloro-butadiene
- Lindane
- NDMA
- PCBs
- Toxaphene
- TCE

Part 503 Process - Continued

- 1989: Proposed 503 published
  - Detailed risk assessment (contractor)
  - Individual (MEI) risks used
- 1990: NSSS published
- 1990-92: Expert review; RESEARCH
- 1992: Organics deleted from Rule
  - Pollutant banned/not manufactured
  - Insignificant biosolids concentration
  - Biosolids conc.<risk assessment limit

Part 503 Process - Continued

- 1993: Rule published (Round One)
- 1993-95: Biosolids-organics database grows (research and biosolids analyses); additional consideration of dioxins, furans, and PCBs
- 1999: EPA proposes limits for dioxins based on deterministic risk assessment

Part 503 Process - Continued

- 2001: New NSSS focused on dioxins and dioxin-like compounds
- 2002: PRA applied to dioxins in biosolids
  - Data-intensive
  - Applicable to similar compounds
  - Concluded: "No numerical limit or management practices required to protect human health or environment from biosolids-borne dioxins"

Emerging Chemicals of Concern

- Pharmaceuticals
- Personal care products
- Endocrine disrupting chemicals
- Flame retardants
- Plasticizers
- Detergent metabolites
- Others, previously undetectable

Some Organic Contaminants in Biosolids

Compound	Concentration (mg kg^{-1})	Log Kow	Solubility (mg L^{-1})	Vapor Pressure (mmHg)
Antimicrobial Compounds				
triclosan	10.2	4.53	10	6.45×10^{-7}
Human Drugs				
carbamazepine	0.07	2.45	17.7	1.84×10^{-7}
Fragrances				
d-limonene	0.63	4.57	13.8	1.98
indole	19.6	2.14	3560	1.22×10^{-2}
Sex and Steroidal Hormones				
3b-coprostanol	126	8.82	0.000203	5.47×10^{-10}
cholesterol	209	8.74	0.095	7.79×10^{-10}
Plasticizers				
bis(2-ethylhexyl)phthalate	20 - 160	3.98	0.40	6.45×10^{-6}
diethylhexyl phthalate	10.5	7.88	0.27	1.42×10^{-7}
Polycyclic aromatic hydrocarbons				
anthracene	0.14	4.5	0.0434	6.53×10^{-6}
phenanthrene	0.342	4.52	1.15	1.21×10^{-4}
Others				
1,4-dichlorobenzene	5.3	3.52	79	1
phenol	2.1 - 54.7	1.5	82800	0.35
bisphenol A	4.70	3.32	120	3.91×10^{-7}
PCBs (Actual concentration – 95th %) Total toxic equivalent basis (TEQ)– 95th percentile	0.21 0.0000131	4.5 – > 8.0	0.000004 – 7.48	7.6×10^{-10} – 0.08
Penta dibrominated diphenyl ethers PBDEs (Sum)	<0.008 – 4.89	5.74 – 8.27	0.01 - 0.13	2.12×10^{-9} – 1.94×10^{-3}
Polychlorinated dibenzodioxins and Dibenzofurans (total TEQ)	0.0000333	6.8	0.0000193	7.4×10^{-4}

* Adapted from Xia, 2005; Kinney, 2006; Kester, 2005

EDCs Concentrations in Environmental Media

EDC	Surface Water (ng/L)	Wastewater Effluent (ng/L)	Sewage Sludge (µg/g)	Sediments (µg/g)	Manure Feedlot (ng/L)
Natural Estrogens					
Estrone (E1)	<0.1-17	0.1-19	0.00143 (Dewatered)	<0.04-2520	17-10500
17β-estradiol (E2)	<0.1-6.0	0.1-650	0.00057 (Dewatered)	0.9-2480	<20-211
Estriol (E3)	1.0-2.5	5.0-7.3	NA	0.5-1.5	<8-6290
Synthetic Estrogens					
Ethinylestradiol (EE2)	<0.1-5.1	0.1-8.9	0.00061 (Dewatered)	<50-500	NF*
Ethoxylates	<20-97600	320-1570	<0.5-250 (Dry weight)	<0.003-38	NF*
Estrogen Mimics					
Nonylphenol (NP)	<10-15000	18-770	5-1000 (Dry weight)	<0.003-154	NF*
Bisphenol A	0.5-250	4.8-258	NF*	NF*	NF*
Bis(2-ethylhexyl)phthalate	NF*	NF*	20-160	NF*	NF*
Diethylhexyl phthalate	NF*	NF*	10.5	NF*	NF*

***NF- Not found in literature**

Emerging Chemicals of Concern in Biosolids: Generalities

- Thousands likely present
- More will be found
  - Concentrations
    - ≤ mg kg^{-1} (biosolids)
    - 100-200 fold less in amended soils
  - Chemicals likely
    - Hydrophobic
    - Non-volatile
    - Anaerobically stable

Emerging Chemicals of Concern in Biosolids: Environmental Fate

- Largely undocumented, but not hopeless
  - Numerous studies with priority pollutants
  - Detailed risk assessments for similar compounds (see history provided)
  - Studies underway (but, beware!)
  - Models available
    - PBT Profiler and ECOSAR (EPA)
    - Require field validation

Challenges

- Analytical issues
  - Traditional approaches insufficient
- Experimental issues
  - "Worse case" approaches belie real world
  - Inexperience in working with biosolids
- Loss of "institutional memory"
  - Under appreciation of past work, including risk assessments and uniqueness of biosolids-borne chemicals