Land Application of Sewage Sludges (aka Biosolids): The Case for Caution

Presentation to the National Research Council Panel on Sewage Biosolids

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Cornell Waste Management Institute

A program of the Cornell Center for the Environment

www.cfe.cornell.edu/wmi

Who is involved? And Why?

- **Cornell Participants:**
  - Bouldin, McBride, Baveye: Crop and Soil Sci.
  - Hay: Microbiology
  - Richards, Steenhuis: Ag and Bio Eng.
  - Tyler: Analytic Lab, Horticulture
  - Gillett: Natural Resources
  - Harrison, Levitan: Center for Envt
  - Woodbury: Boyce Thompson Inst.
  - Pimentel: Entomology
- **NE Regional Research Project**
- **Long history of involvement in land application of sewage sludges at Cornell**
- **Cornell is the Land Grant University for NYS**

Current Cornell Sludge-related Activities
<www.cfe.cornell.edu/wmi>

- **Research**
  - Fate and transport of contaminants
  - Plant uptake and response
  - Soil chemistry
  - Nonylphenols
  - Local ordinances
  - Undisturbed soil column expts
  - Field observations
- **Outreach**
  - Advice to growers and their advisors
  - Review and summarize findings
  - Work with NYS DEC
  - Analysis of data re land use at contaminated sites

Sewage Sludge Generation

- Influents are from homes, industries, businesses and streets
- Pretreatment of some industrial discharges to some WWTP improved sludge quality
- WWTPs are designed to clean water
- Contaminants preferentially deposited in sewage sludges (est. 90% of dioxins in influent end up in sludge)
- Sewage sludges are treated to reduce pathogens and vector attraction, not chemical contaminants
- Sewage sludges and sludge products are different depending on WWTP processes
- Sewage sludge quality varies over time at a single WWTP

- **Limitations of 503 Risk Assessment Methodolgy**
  - **Deterministic vs. probabilistic**
  - **No sensitivity analyses**
  - **Single pathway vs. multimedia cumulative exposure**
  - **Definition of HEI**
  - **Ignores contaminants with insufficient data**

- **Areas not dealt with under 503 rules**
  - **Airborne contaminants** (odors, gases, and pathogens)
  - **Other bioactive contaminants** such as nonylphenons, brominated flame retardants, pharmaceuticals, personal care products, organotin, radionuclides
  - **Volatilization of contaminants** (eg.Hg)
  - **Lack of consideration of non-cancer risks** (developmental and immunologic risks may exceed cancer risks for some contaminants)

Example of Bioactive Contaminant not Assessed

Nonylphenols in Sludges

- Endocrine disrupting chems
- Toxic to fish and wildlife
- Inhibits plant growth
- Less degradable than LAS

- **600-1800 ppm in 6 NYS sludges**
- **NP banned in Switzerland**
- **50 ppm Danish sludge std (going to 10 ppm)**
- **P&G doesn't use NPEs due to concerns re non-degradation**

EPA 1998 Response re Organic Surfactants

- Aware of the presence in “trace concentrations.”
- Recognizes lack of field data.
- Does not plan to further assess risks.
- If field data on impacts is submitted, they may modify the position.

- In sum, EPA (Office of Water) believes they pose “extremely low potential for negatively impacting human health and the environment.”

Examination of Several Assumptions that Dramatically Impact Calculated Risk

- **Risk of Cadmium in Crops to Home Gardener**
  - **How much does the HEI eat?**
  - **How much Cd uptake into the crops?**
- **Surface Water, Risk to Fish Eater**
  - **What % of watershed receives sludge?**
- **Groundwater**
  - **How mobile are contaminants?**

Comparison of Diet Used in EPA Risk Assessment and USDA Recommended Diet

How Much Does the Home Gardener Eat?

1=EPA daily diet

Used Avg. ~1980 consumption
Veg consumption has increased
Home gardeners eat high veg diet

1+2=USDA Recommended Diet

About 2 x as much veg

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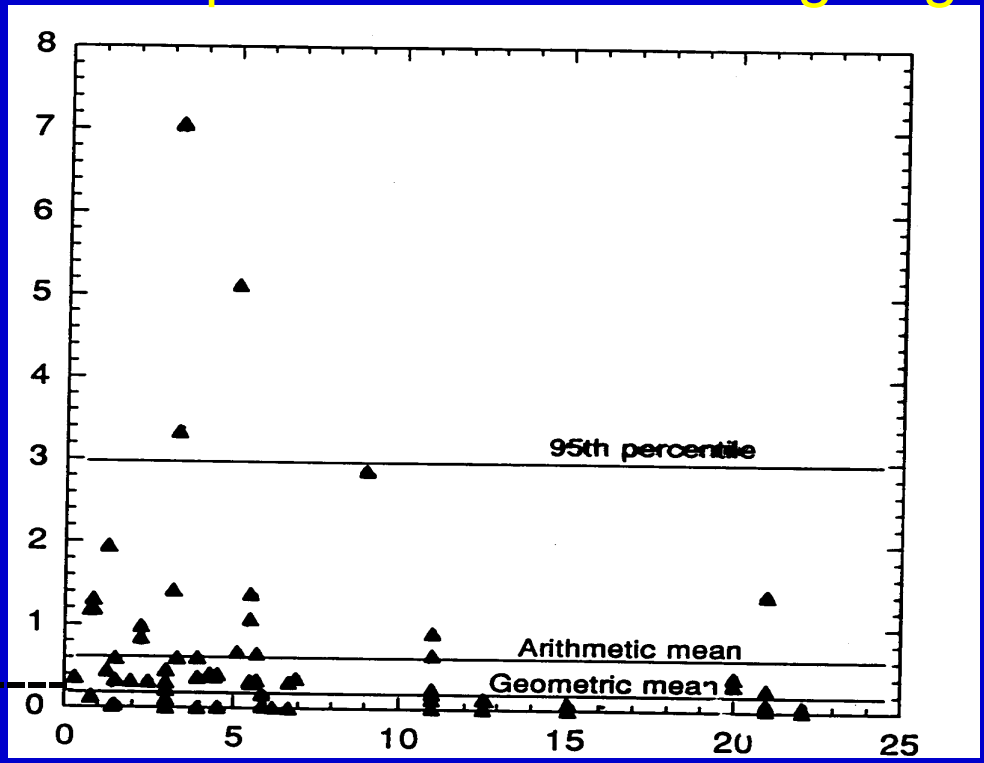
Cadmium Uptake into Leafy Vegetables

4 orders of magnitude difference measured in field experiments
(Different crops and cultivars, different soils, pH, not just Cd but other sludge constituents also applied)

503 used geometric mean, a very low value

Home gardeners eat from a specific and not averaged garden



Uptake value used in 503

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Cadmium Calculation for Home Gardener Eating Crops from Sludge-amended Soils

Allowable Sludge Cadmium (ppm)

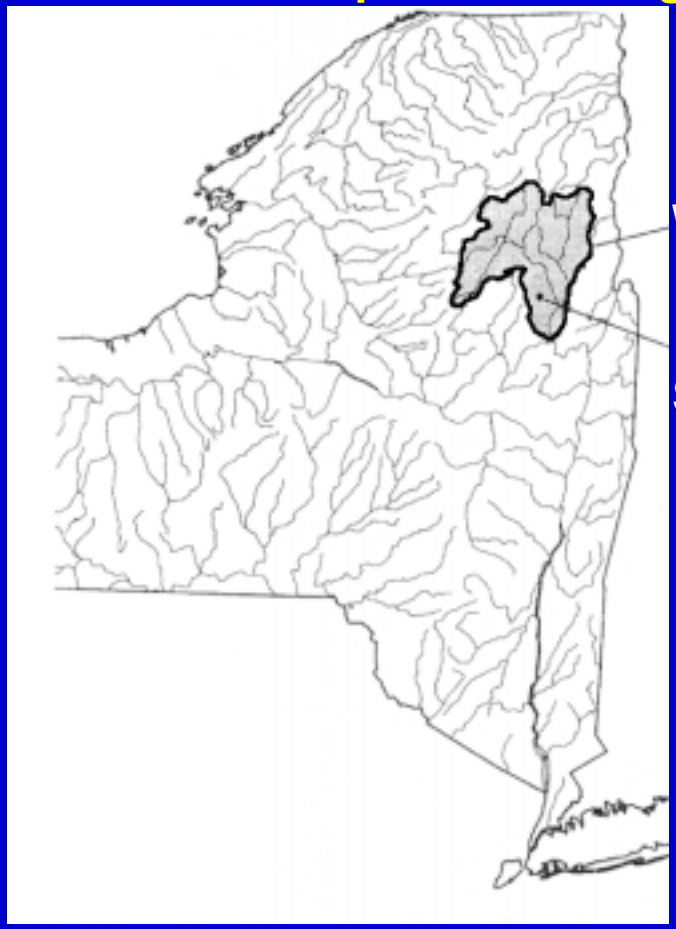
120	EPA home gardener path calc (not the limiting path)
39	503 limit (soil ingestion path)
15	simply changing to USDA diet
5	changing to USDA diet and arithmetic mean uptake
1.5	changing to USDA diet and 90th percentile uptake

Changing a few assumptions results in very different standard

Map of NYS Showing Relative Size of Watershed and Sludge Site Under 503 RA Assumptions

Only 0.24% of watershed assumed to receive sludge.

A small stream may have much greater %of watershed receiving receiving sewage sludges. What is the risk to person fishing such a stream?



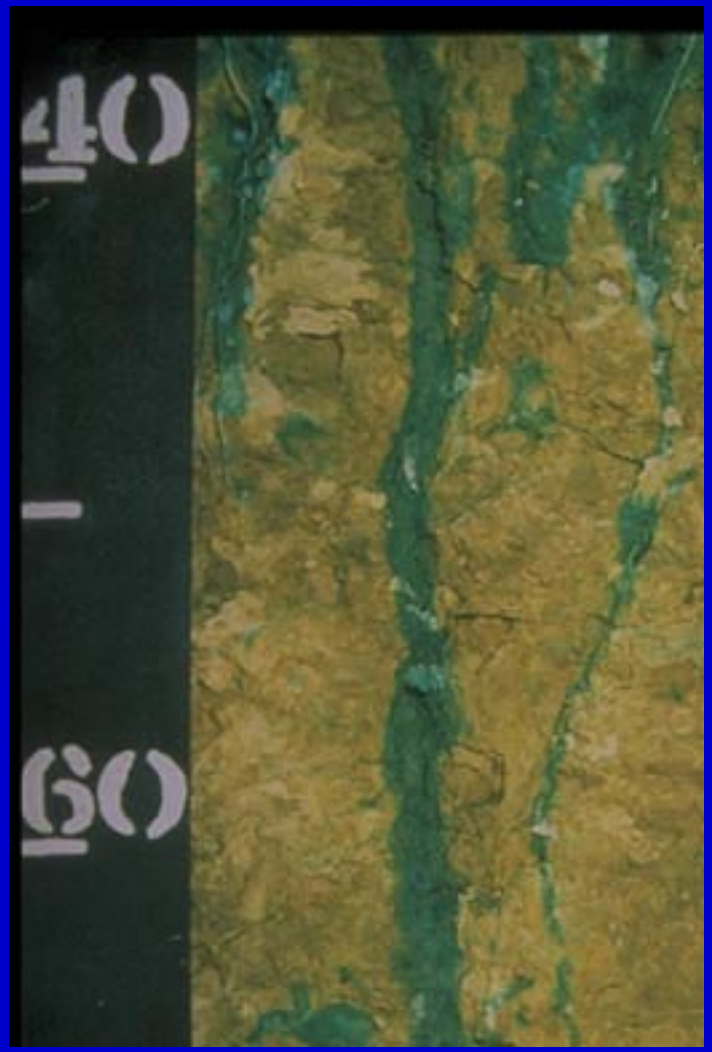
Watershed: 427,000 ha

Sludged Area: 1074 ha

Groundwater

- Rapid flow phenomena aren't accounted for in EPA model
- One test tube experiment with one sludge and one soil are basis for metal mobilities to groundwater in the EPA risk assessment
- Substantial dilution or attenuation of leachate before reaching receptor well is assumed (arsenic's leachate/well concentration ratio is 230)
- Field studies often cannot account for ~1/2 of applied metals suggesting leaching

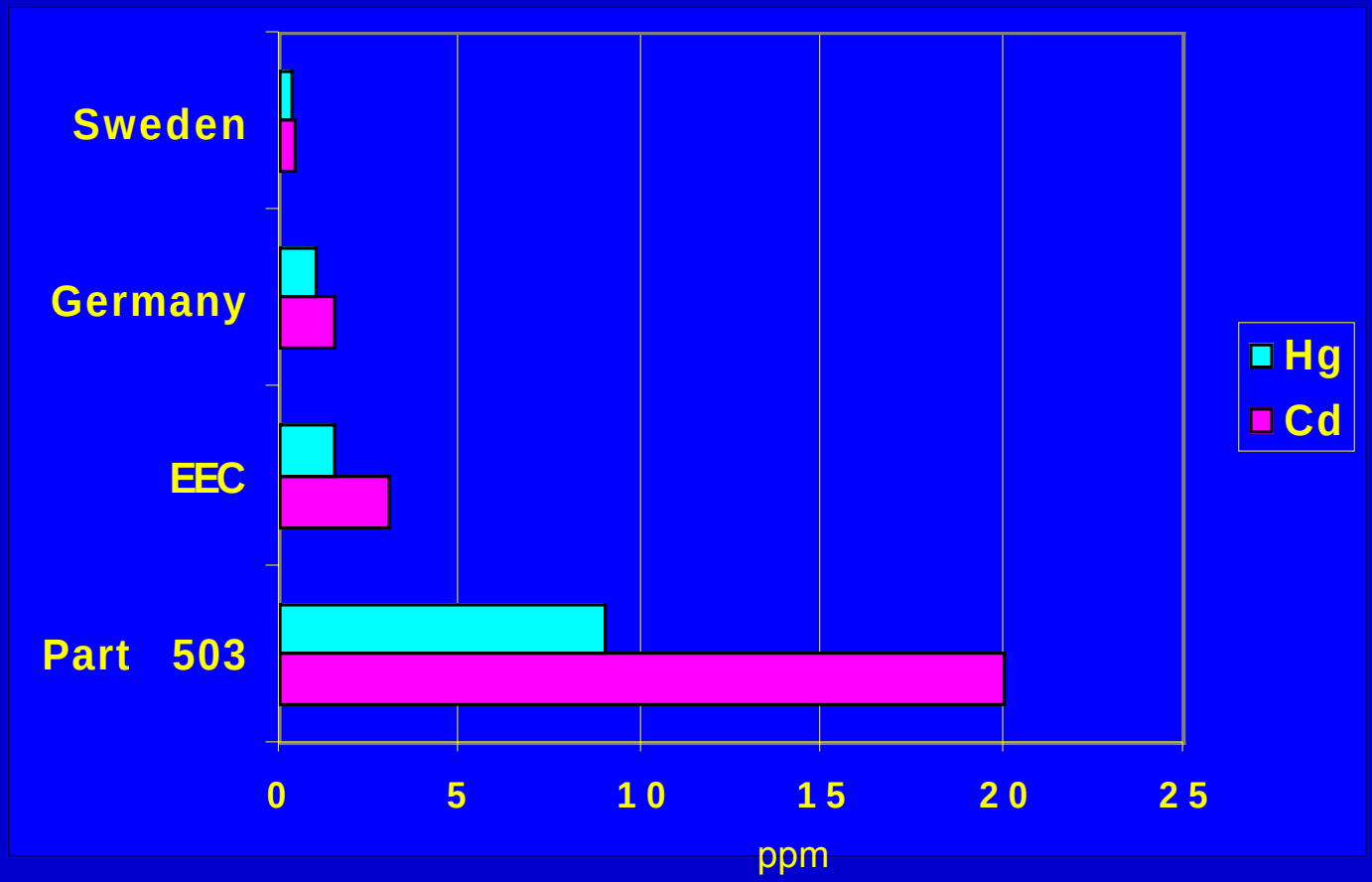
Preferential Flow Paths



Blue dye reached 6 feet in 1/2 hour
Model would predict ~3 years

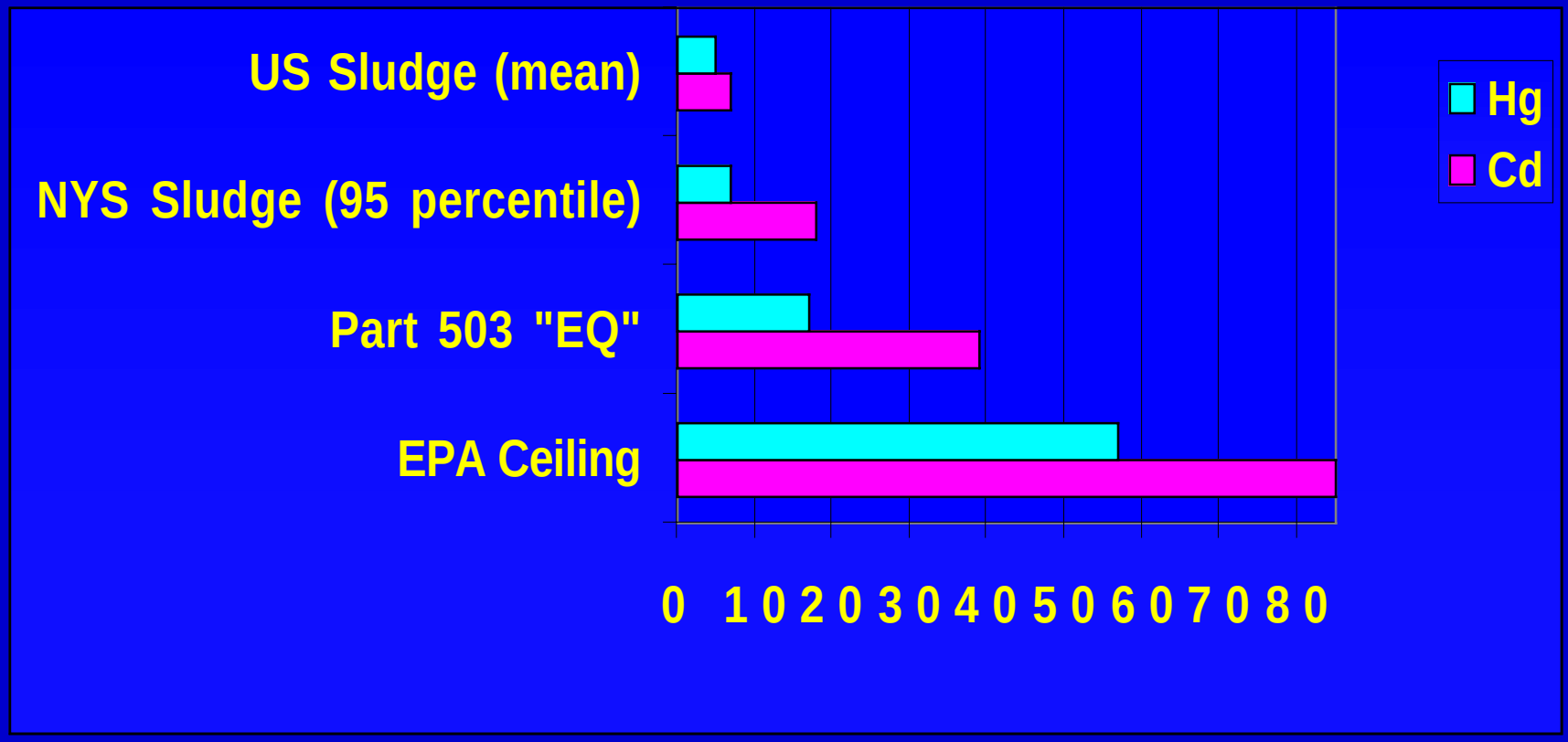
Comparative Soil Standards

European standards are Far More Stringent



Sewage Sludge Quality

Most sludges are far cleaner than even "EQ" standards



Areas of Uncertainty

Human Health

- Air borne contaminants
- Groundwater quality
- Sludge quality monitoring, variability
- Presence, fate and transport, and impacts of bioactive contaminants
- Risks other than cancer

Other Concerns

- Ecologic Risk Wildlife/soil organisms
- Making cleaner sludges
- Alternative uses for sewage sludges
- Reduced sludge generation

In 1993 EPA committed to "develop a comprehensive environmental evaluation and monitoring study."

The Case for Caution

Because:

- **Our ability to confidently predict risks from land application is very limited**
  - **Many unevaluated contaminants in sludges (only pathogens and 9 elements regulated now)**
  - **Poor understanding of non-cancer, non-acute health and environmental impacts**
  - **Site conditions vary widely across the US**
  - **Sludge products differ significantly**

The Case for Caution

Because:

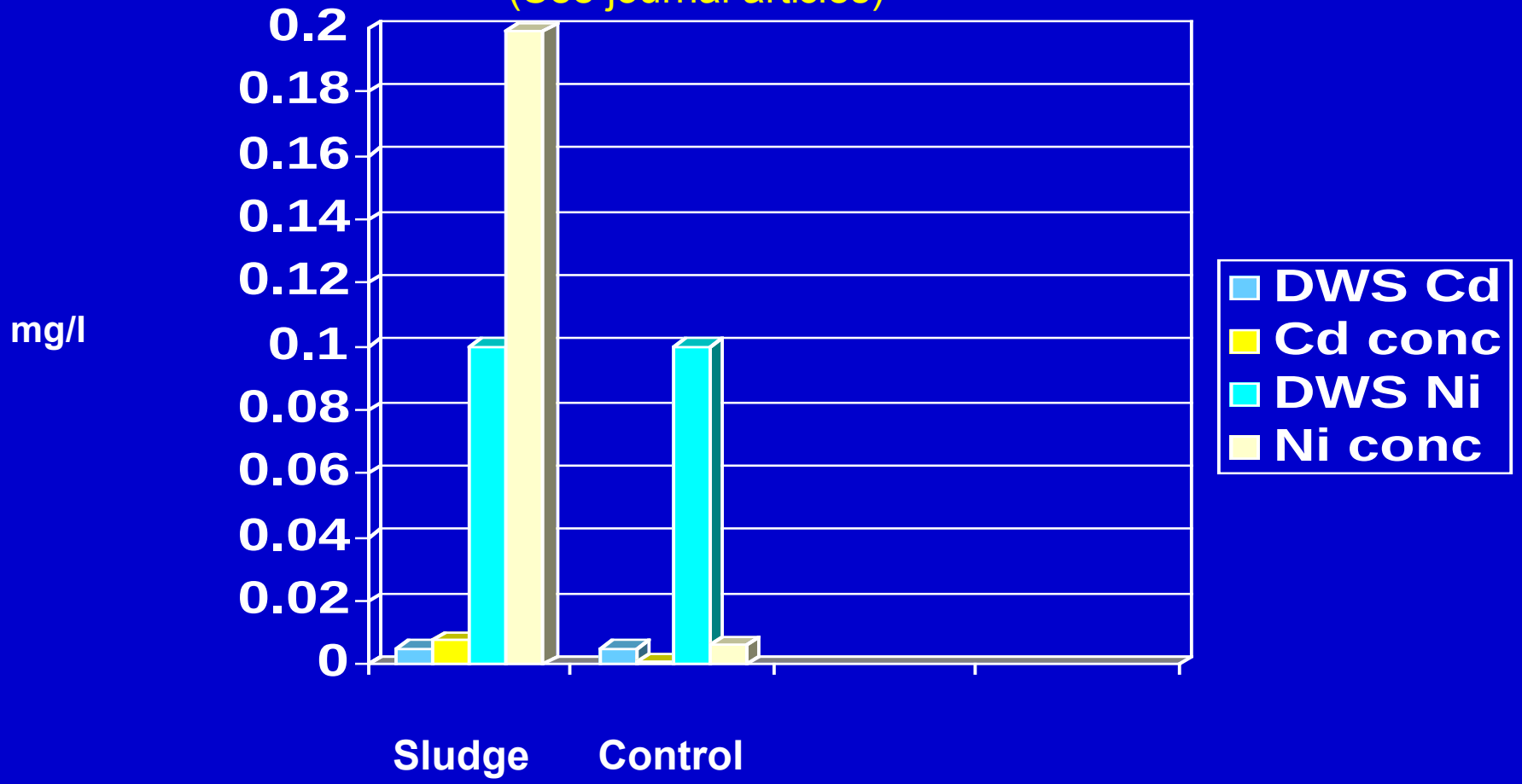
- Contaminants concentrate in sewage sludges
- Sludge is spread widely -- where we eat, play and live
- Present standards are based on RA with many short comings
- Stricter standards would not preclude application of many sludges
- Enforcement is inadequate

Additional slides to present if time allows……..

Percolate Exceeded DWS 20 Years After Heavy Sludge Application to Cornell Orchard

Application ~503 max loading

(See journal articles)



What Good are Standards if No One is Watching?

- Monitoring problems
  - How do we know if sewage sludges are meeting standards?
- Lack of oversight
- Inadequate enforcement

What's Wrong with this Picture?

Se, Cd, Hg values are identical

	ppm dw		
Date	Se	Cd	Hg
19980228	4	4	4
19980430	3	3	3
19980630	4	4	4
19980831	10	10	10
19981031	3	3	3
19981231	5	5	5
19990228	4	4	4
19990430	3	3	3
19990630	3	3	3
19990831	4	4	4
19991031	4	4	4
19991231	5	4	4

Data from NYS and EPA database

What's Wrong with this Picture?

Off by an order of magnitude

		ppm dw	
Date	**Se**	**Mo**	**TS (%)**
19970228	<4.3	7.0	17.1
19970430	<4.9	11.1	17.8
19970630	<4.7	13.0	20.8
19970831	4.1	14.7	22.1
19971031	<3.7	23.0	20.2
19971231	<4.5	24.5	19.0
19980228	4.9	20.5	18.6
19980430	5.7	22.5	19.0
19980630	<3.9	24.0	24.9
19980831	5.8	**0.3**	22.3
19981031	<8	19.0	22.2
19981231	4.0	27.5	21.5
19990430	3.0	14.5	19.8
19990630	3.0	29.0	18.8
19990831	4.0	39.5	17.8
19991031	**44.5**	23.5	19.9

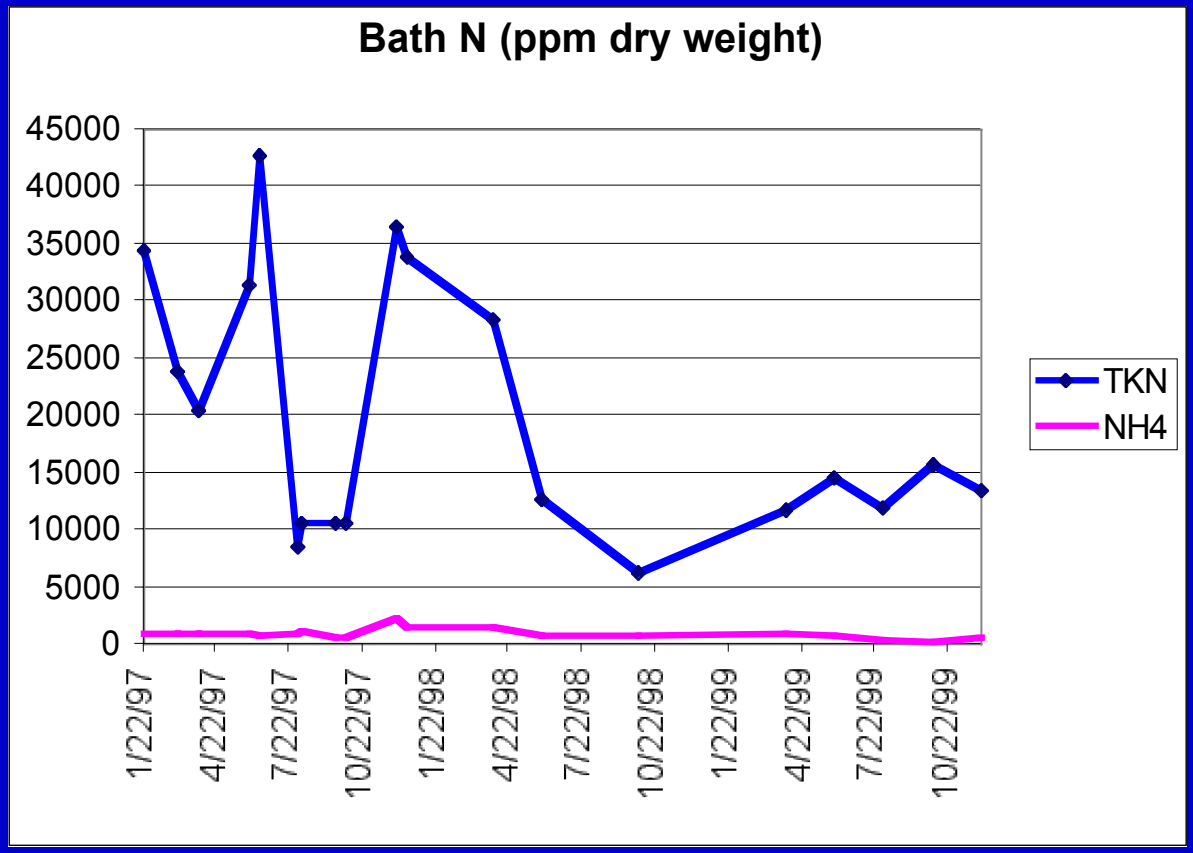
What's Wrong with this Picture?

Lead levels way below achievable

Date	ppm dw Pb	Ni	TS (%)
19970228	<75	<94	2.65
19970430	<28	<72	3.48
19970630	<3	<85	2.93
19970831	<30.	<80.	3.11
19971031	<3	<80	3
19971231	<4.	<100.	2.51
19980228	<4.	<100.	2.46
19980430	<3.	<80	3.21
19980630	<4.	<96.	2.6
19980831	<10	<246	0.91
19981031	<3.	<57	3.5
19981231	<5.	<130.	1.9
19990228	<4.	<4.	2.7
19990430	<3.	<76.	3.3
19990630	<3.	<80.	3
19990831	<4.	<90	2.8
19991031	<4	<96	2.6
19991231	<6.	<85.	2.6

N Variability from One WWTP

How can agronomic rate be achieved?
The load delivered to a farm is not an average.
Are contaminant levels similarly variable?
Does current testing provide info to assess that?



Same Standards Apply to All Sewage Sludges and Sludge Products

But Different Products Behave Differently

- Wastewater and sludge treatment processes vary
- Sewage sludges and sludge products include high lime, high iron, compost, etc
- 503 does not differentiate

Different Sludge Products Behave Differently

Example:
TCLP Leachability of Metals as % total metals