

# 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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A program of the Cornell Center  
for the Environment

[www.cfe.cornell.edu/wmi](http://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 Env't
  - ◆ 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](http://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

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# 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 Methodology**
  - ◆ **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 nonylphenols, 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



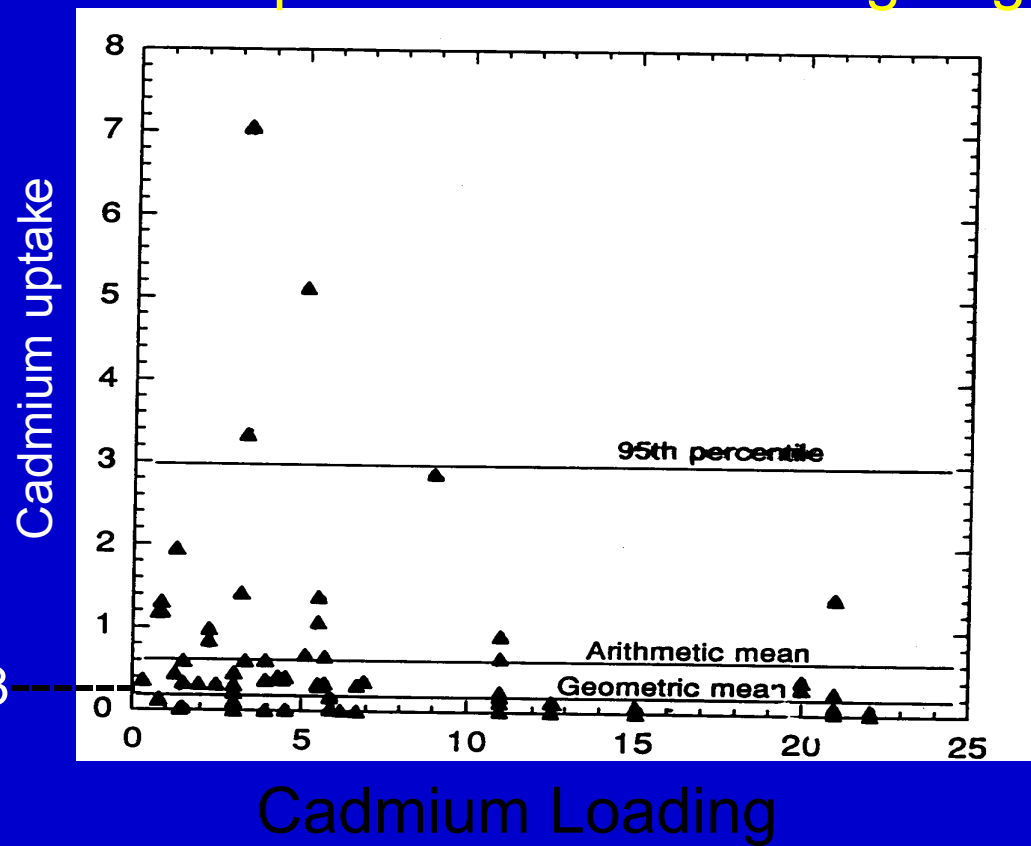
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# Cadmium Uptake into Leafy Vegetables

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

# 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)

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**15** simply changing to USDA diet

**5** changing to USDA diet  
and arithmetic mean uptake

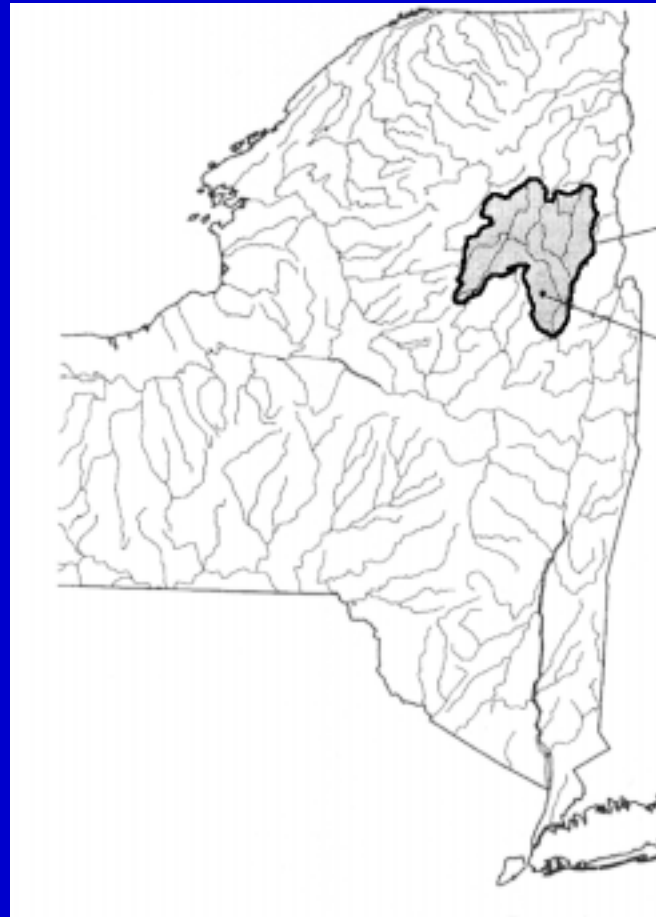
**1.5** changing to USDA diet  
and 90th percentile uptake

**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?



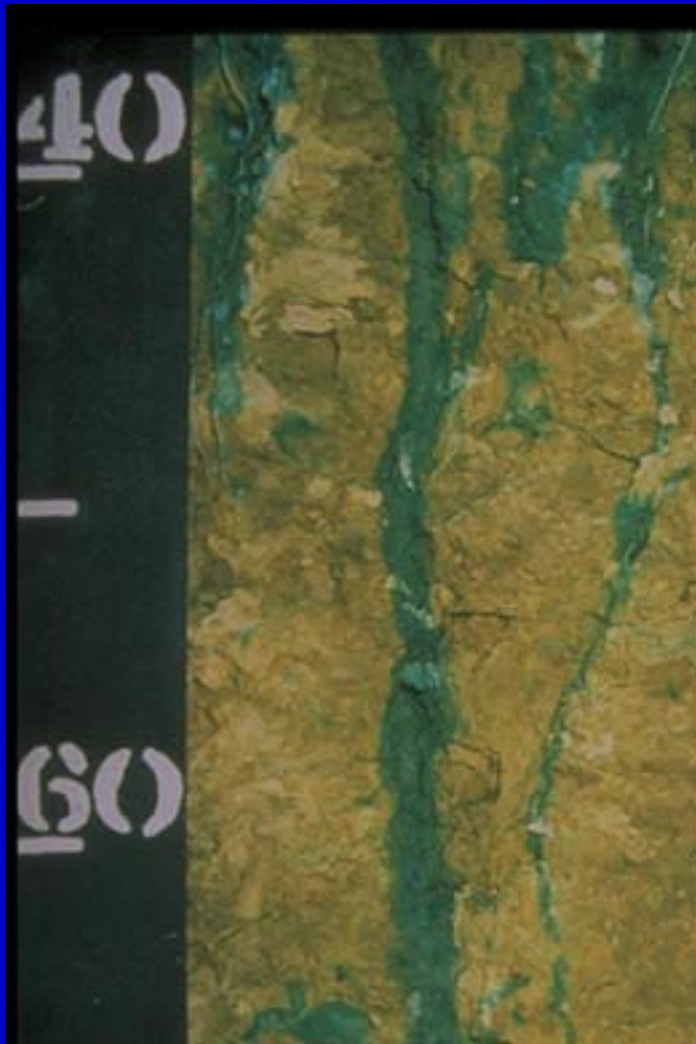
Watershed: 427,000 ha

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**

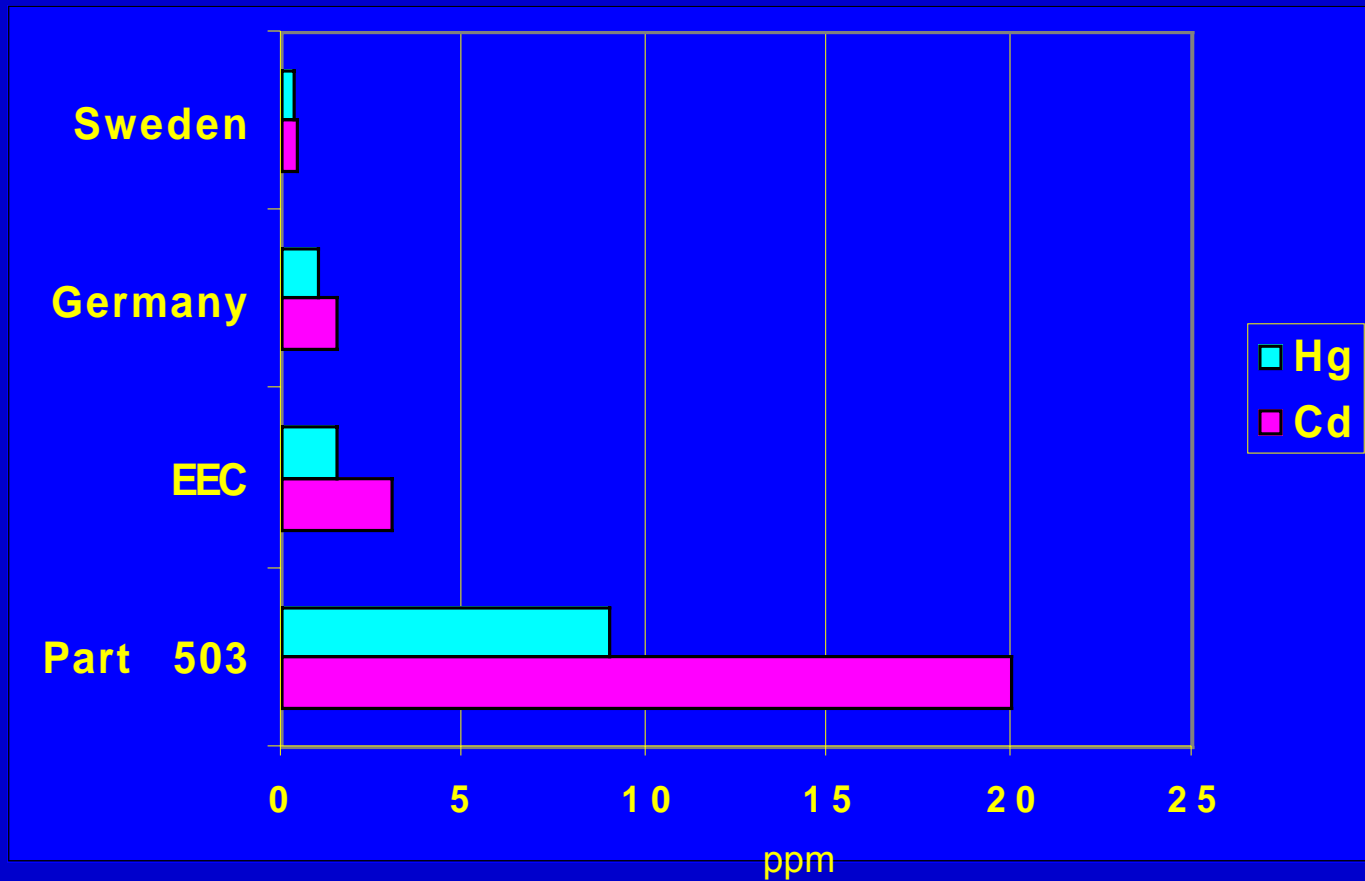
## Preferential Flow Paths



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

# Comparative Soil Standards

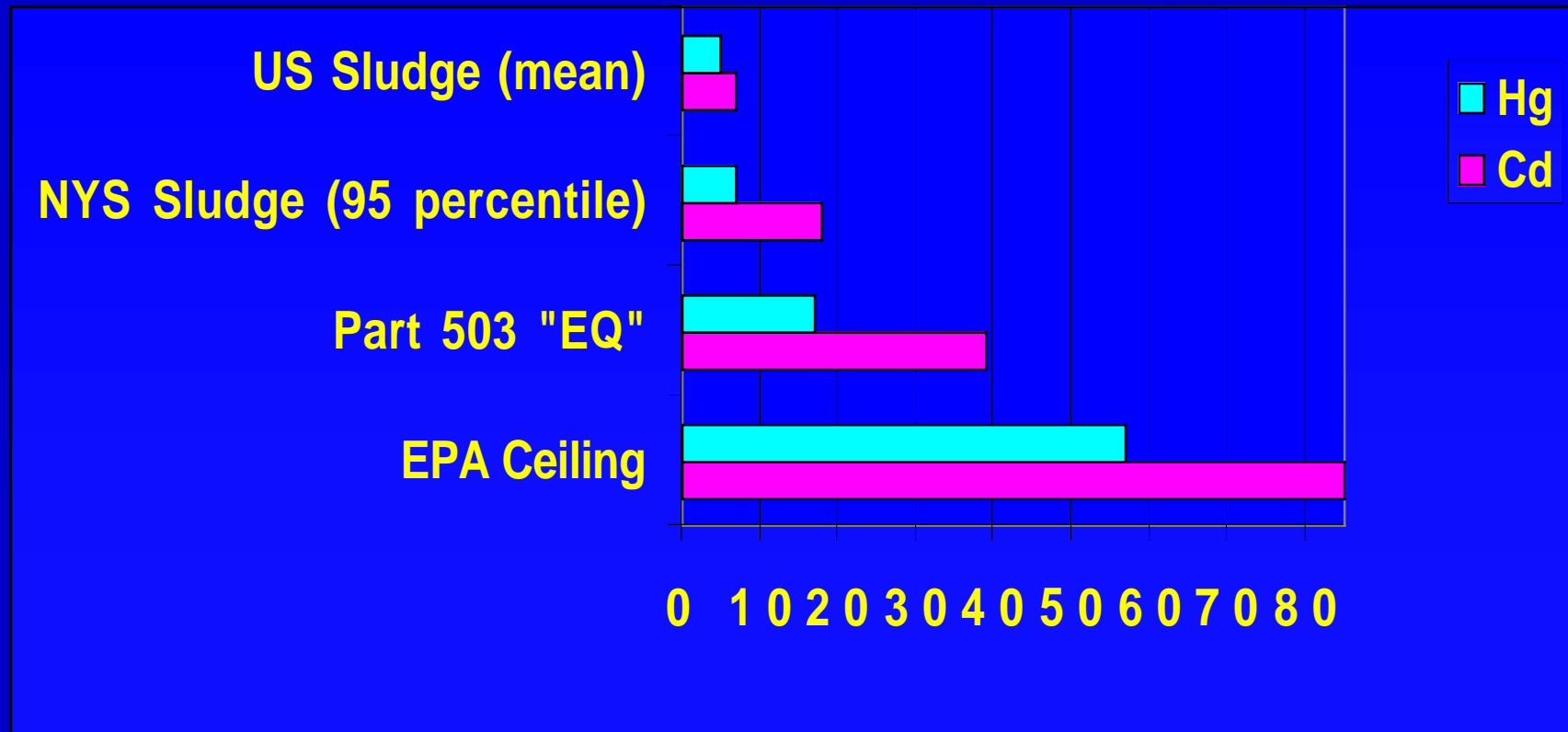
European standards are Far More Stringent





# 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

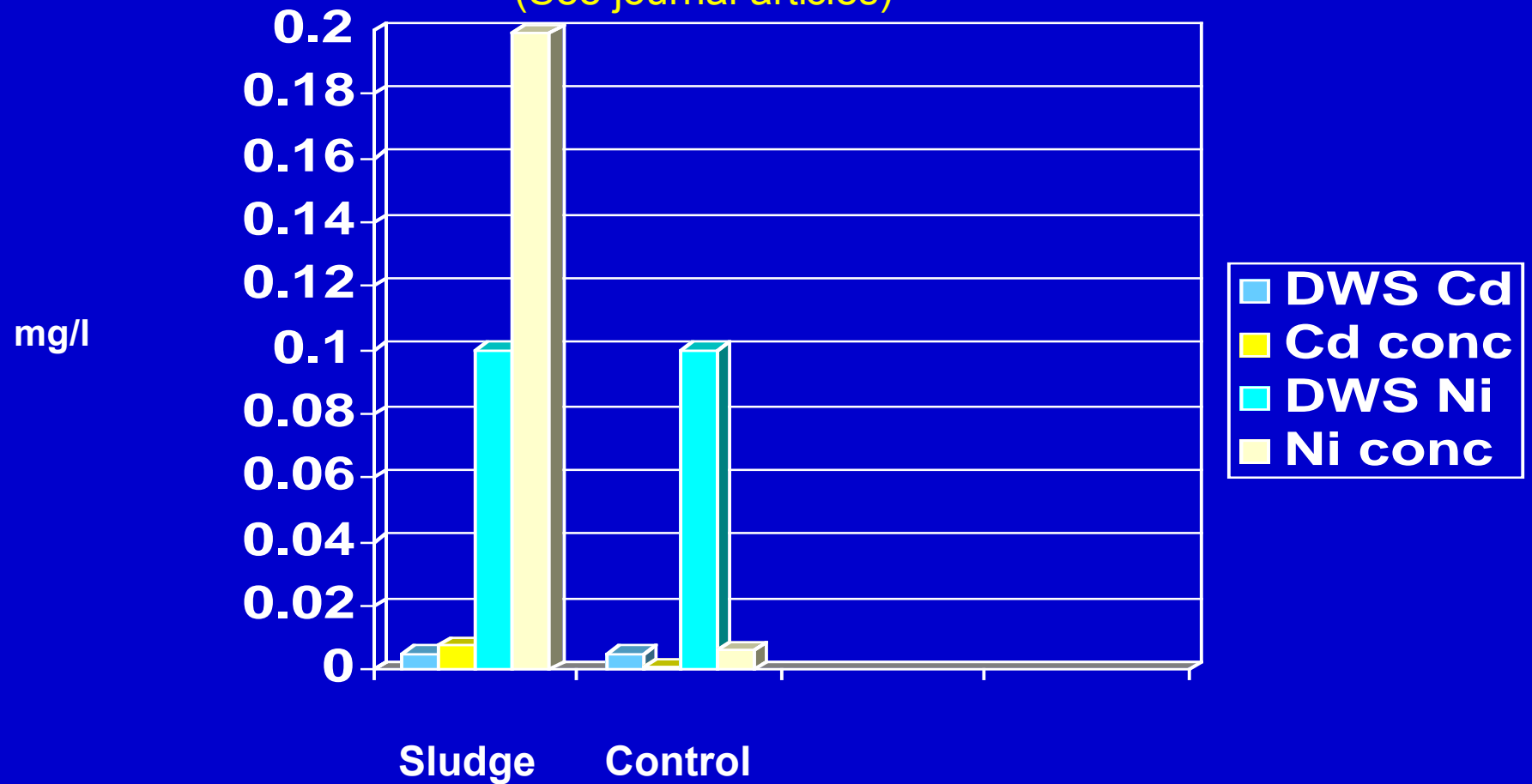
## Because:

- **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

<b>Date</b>	<b>ppm dw</b> <b>Se</b>	<b>Cd</b>	<b>Hg</b>
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

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# 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	<b>0.3</b>	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	<b>44.5</b>	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

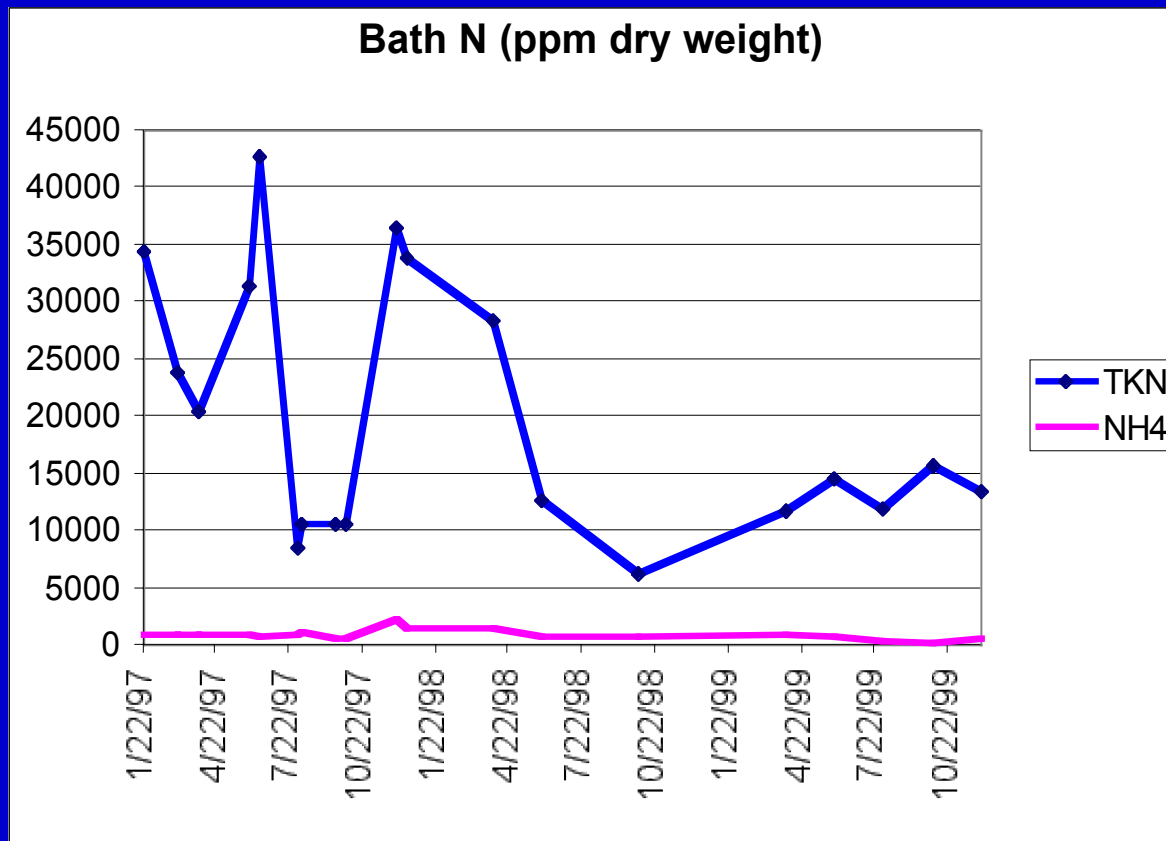
# N Variability from One WWTP

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

