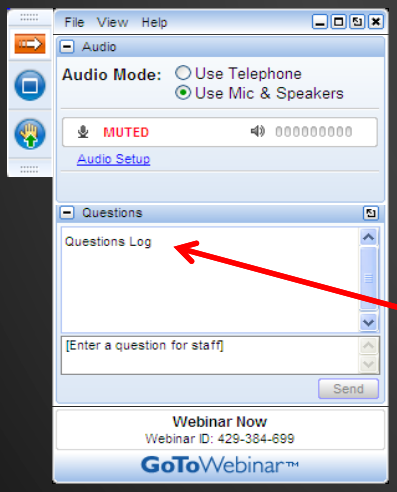
Emerging Contaminants in Biosolids

Wednesday, March 1st, 2017

1:00 – 3:00 pm EST

How to Participate Today



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- **Submit your questions using the Questions pane.**
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Today's Moderator

- Ben Davis, Renda Environmental

RENDA ENVIRONMENTAL

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Today's Speakers

- Ed Topp, Agriculture and Agri-Food Canada
  - *Pharmaceuticals and personal care products [PPCPs] in biosolids*
- Jeffrey L. Ullman, University of Utah
  - *Antibiotics in Environmental Systems*
- Kuldip Kumar, Metropolitan Water Reclamation District of Greater Chicago
  - *Land Application of Biosolids: Human Health Risk Assessment Related to Emerging Contaminants*

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PPCPs in biosolids

- Ed Topp Ph.D.

ed.topp@agr.gc.ca

London, Ontario Canada

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

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Pharmaceuticals and personal care products [PPCPs] in biosolids

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Presentation outline

- Overview of 'emerging contaminants'
- Quantities and types of PPCPs in biosolids
- Fate of PPCPs following land application
- Conclusions

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"Emerging organic contaminants"

- Varied terms- "microconstituents", "micropollutants", "contaminants of emerging concern", etc
- Can include…
- Endocrine-active chemicals.
- Pharmaceuticals
- Personal care products [fragrances, microbiocides..]
- Nanomaterials [inorganic, organic]
- Polybrominated flame retardants
- Perfluorinated chemicals [non-stick and surface-protective coatings]
- Plasticizers
- Etc..

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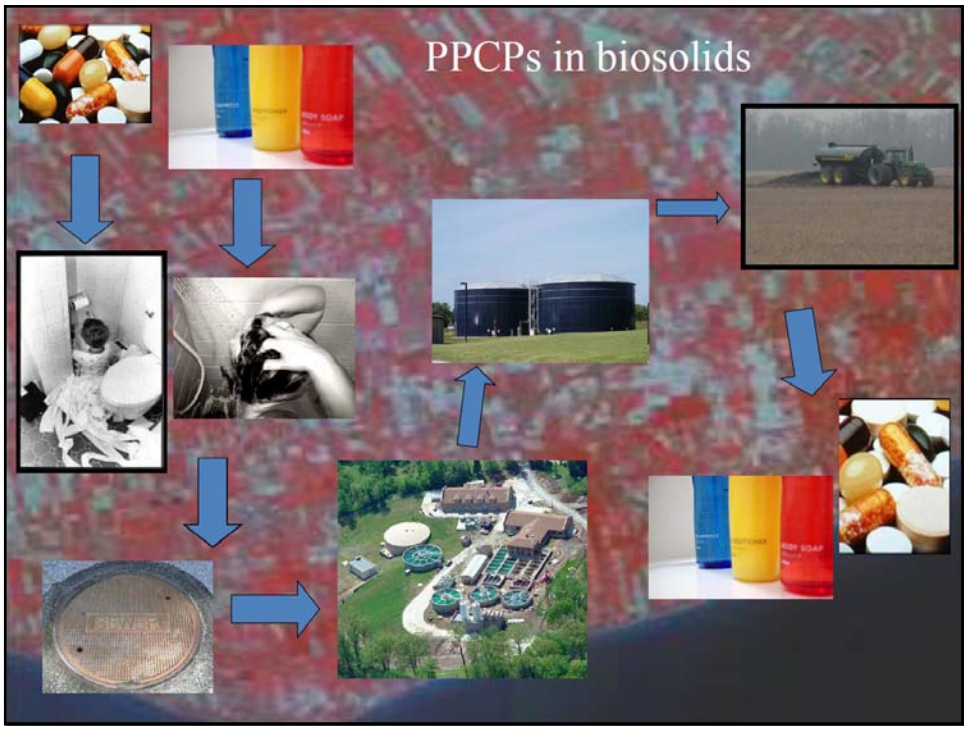

PPCP will be detected in biosolids if the following conditions are met

- Mass of the chemical used domestically is sufficient.
- Chemical is persistent during transit from home to STP, recalcitrant to the WWT process.
- Chemical partitions into organic matter, leaves WWTP via recovered solid rather than via aqueous effluent.

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Surveys of PPCPs in biosolids

EPA
United States Environmental Protection Agency

Targeted National Sewage Sludge Survey

Overview Report

January 2009

U.S. Environmental Protection Agency
Office of Water (4301T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

EPA-822-R-08-014

WATER RESEARCH 44 (2010) 658–668

Available at www.sciencedirect.com

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journal homepage: www.elsevier.com/locate/watres

ELSEVIER

WATER RESEARCH

Pharmaceuticals and personal care products in archived U.S. biosolids from the 2001 EPA national sewage sludge survey

*Kristin McClellan, Rolf U. Halden**

Center for Environmental Biotechnology, The Biodesign Institute at Arizona State University, 1001 S. McAllister Avenue, Tempe, AZ 85287-5701, USA

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Overall general conclusion from the surveys

- PPCPs are ubiquitous in biosolids

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PPCPs detected in biosolid (ng/g)

[Sabourin et al. STOTEN 431 (2012) 233-236]

Triclocarban	6030	Amlodipine	120	Atorvastatin	15.1
Ciprofloxacin	5870	Norverapamil	94.7	Cotinine	14.8
Triclosan	4680	Carbamazepine	94.3	Codeine	14.6
Norfloxacin	1750	Fluoxetine	89.8	Naproxen	14
Ofloxacin	1068	Valsartan	76.5	Hydrocodone	11
Diphenhydramine	781	Verapamil	70.2	Diltiazem	10.1
Sertraline	497	Clarithromycin	67.4	Enrofloxacin	10.1
Miconazole	477	Norfluoxetine	59.6	Gemfibrosil	7.89
Amitriptyline	448	Anhydrotetracycline	55.8	DEET	6.89
4-Epitetracycline	386	Doxycycline	42.4	Erythromycin-H_2O	4.06
Tetracycline	341	Cimetidine	42.1	Ranitidine	3.26
Azithromycin	213	Digoxigenin	38.1	Propoxyphene	2.9
Ibuprofen	167	Propranolol	35.4	Atenolol	2.88
Triamfarene	153	Anhydrochlortetracycline	32.9	Benztropine	2.46
Amphetamine	147	10-OH-amitriptyline	23.3	Desmethyldiltiazem	2.05
Paroxetine	130	Thiabendazole	16.5	Diazepam	0.845

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Many classes of pharmaceutical and microbiocidal agents in biosolids

- Antimicrobial
  - TCS, TCC
- Antibacterial
  - Fluoroquinolones
  - Tetracycline
  - Macrolides
- Antifungal
  - Azoles [miconazole]
- Neurological
  - Carbamazepine,
  - Tricyclic antidepressant- Amitriptyline
  - SSRI- paroxetine, norfluoxetine
- Cardiac-vascular
  - Atenolol, propanalol
  - Amlodipine
- Renal
  - Triamfarene
- Lipid, sterol metabolism
  - Gemfibrozil
  - Atorvastatin

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Process variables that could influence PPCP content in biosolids at time of application

- Wastewater treatment process
- Biosolids treatment process- (an)aerobic digestion, composting, alkaline stabilization, heat treatment & pelletisation.
  - Processes that encourage aerobic degradation are likely to be most effective in reducing PPCP load.

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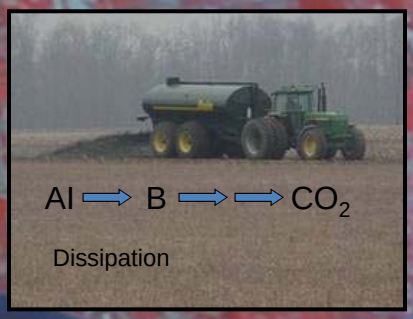
Understanding risk: Potential concerns



PPCPs vary widely in their environmental persistence and behavior- not to be considered one single agent

- Diclofenac
- Anti-inflammatory drug
- Half life in soil 1-3 days

- Diphenhydramine
- Antihistamine [Benadryl]
- Half life in soil 100-300 days

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Greenhouse studies reveal the potential for crop uptake

Environ. Sci. Technol. **2010,** *44,* 6157–6161

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

CHENXI WU,*,† ALISON L. SPONGBERG,† JASON D. WITTER,† MIN FANG,† AND KEVIN P. CZAJKOWSKI‡

Department of Environmental Sciences, and Department of Geography and Planning, University of Toledo, Toledo, Ohio 43606

Received April 8, 2010. Revised manuscript received June 25, 2010. Accepted July 12, 2010.

isms and humans (*1*–*3*). One
enter the environment is throu
cities, where the abundance
wastewater is commonly treat
plants (WWTPs) before discha
a result, much of the previou
understanding the fate and
wastewater treatment and in r
removal efficiency of PPCPs has
specific and affected by the
operating conditions. During
PPCPs have limited biodegrada
removal from the water phase, a
sludge instead of breaking dow
able amounts of PPCPs rema
treated sewage sludges (comm
residuals have been found at
levels in effluent and up to m
and as a result discharge o
contamination of receiving wa
Treated wastewater (comm

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Crop uptake of PPCPs Study Design

Harvest and analysis →

Tomato, carrot, potato, sweet corn →

Barley (*Hordeum vulgare*) cover crop →

Spring 2009	Fall 2009	Spring 2010	Fall 2010

Biosolids application

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Uptake not detected in field experiments

Off-set time presumably the critical management factor.

Science of the Total Environment 431 (2012) 233–236

Contents lists available at SciVerse ScienceDirect

Science of the Total Environment

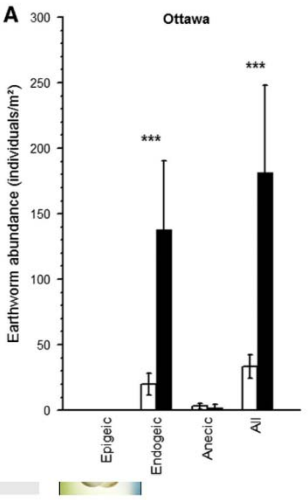
journal homepage: www.elsevier.com/locate/scitotenv

Uptake of pharmaceuticals, hormones and parabens into vegetables grown in soil fertilized with municipal biosolids

Lyne Sabourin [a], Peter Duenk [b], Shelly Bonte-Gelok [c], Michael Payne [d], David R. Lapen [e], Edward Topp [a,*]

Impacts of biosolids on soil biology

Earthworm abundance
44 months post-application



Science of the Total Environment 562 (2016) 312–326

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Biosolids applied to agricultural land: Influence on structural and functional endpoints of soil fauna on a short- and long-term scale

Anja Coors [a,*], Mark Edwards [b], Pascale Lorenz [a], Jörg Römbke [a], Rüdiger M. Schmelz [a,c], Edward Topp [d], Karolina Waszak [a], Graham Wilkes [b], David R. Lapen [b]

Transport from land receiving biosolids, key potential high risk pathways

Surface runoff

Preferential (macropore)flow to depth, tiled fields

Factors that will influence transport potential

- Soil texture, eg. heavy soil and macropores.
- Tillage incorporation and macropore disruption.
- Antecedent moisture, rainfall, water holding capacity.

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Movement of PPCP to tile drains

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Application over tile

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Tile sampling pit

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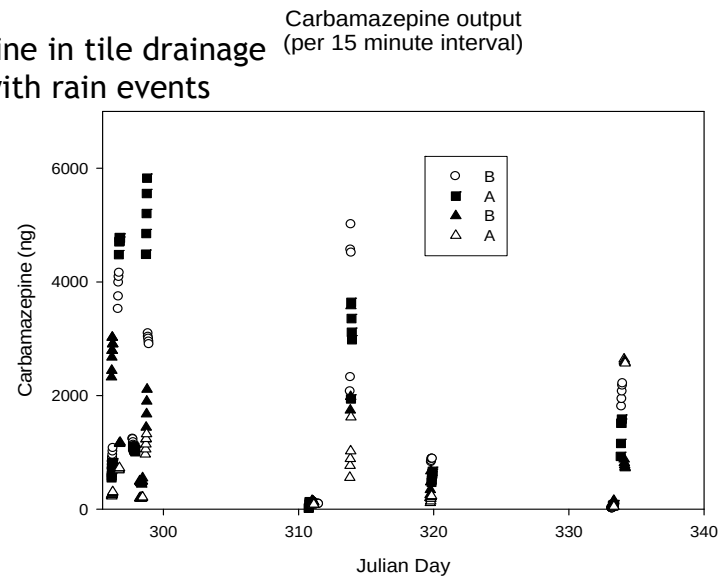
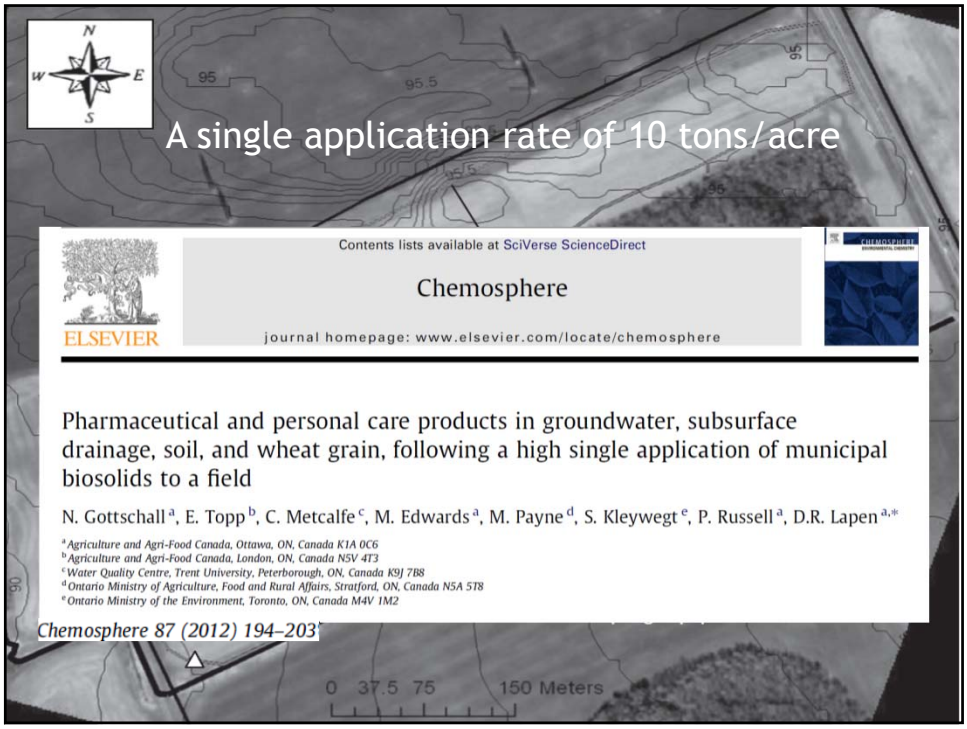
Carbamazepine in tile drainage
Associated with rain events

Trend down.



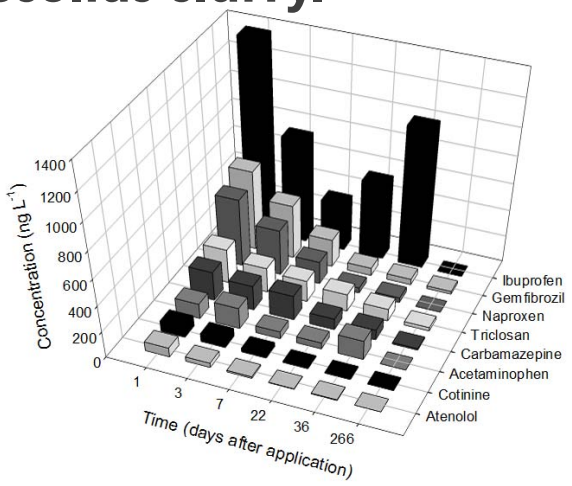


PPCPs detected in groundwater 24-days post biosolids application.

Chemical	Concentration (ng/l)
Analgesics	
Ibuprofen	10
Microbiocides	
Triclosan	19
Triclocarban	12
Antidepressants	
O-desmethylvenlafaxine	13

PPCPs in runoff from ground receiving biosolids slurry.

No incorporation.
Rain events
1,3, etc.. days post-application.



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There is the potential for movement of very low concentrations of PPCPs to adjacent water resources.

- These exposure assessments provide measured environmental concentrations that can then be used for a risk assessment.

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Management options to mitigate exposure concerns

- Application method, rate and timing; maximize contact with soil and minimize the opportunity for surface runoff or preferential flow to drainage tiles or subsurface water.
- A delay [of ≥ 1 year] between biosolids application and crop harvest will mitigate risk of crop uptake.
- Pre-application biosolid treatment can reduce PPCP loading rates.

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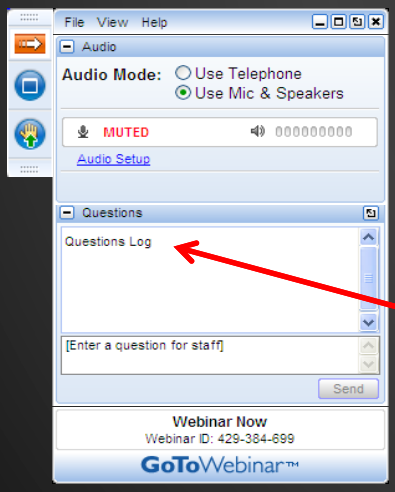
Questions?



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Thank you

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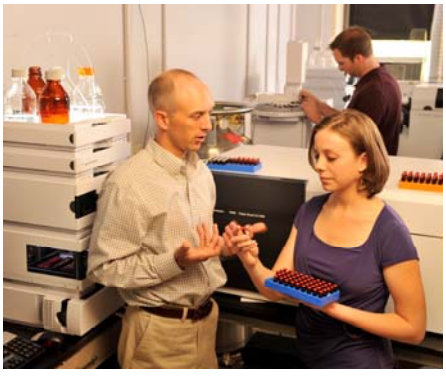
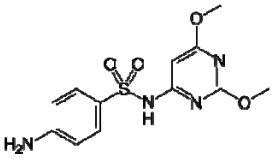
Antibiotics in the Environment



Jeffrey L. Ullman, Ph.D.

THE UNIVERSITY OF UTAH



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Antibiotics in Environmental Systems

Implications for Land Application of Biosolids

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Antibiotic Use

- Annual antibiotic consumption worldwide estimated at 100,000 – 200,000 tons
- U.S. estimates of 16,500 – 19,000 tons
  - Majority used as veterinary pharmaceuticals
  - Human use still substantial with significant amounts excreted, entering wastewater stream
  - Commonly pass through WWTPs and enter environment

Koplin et al. (2002)

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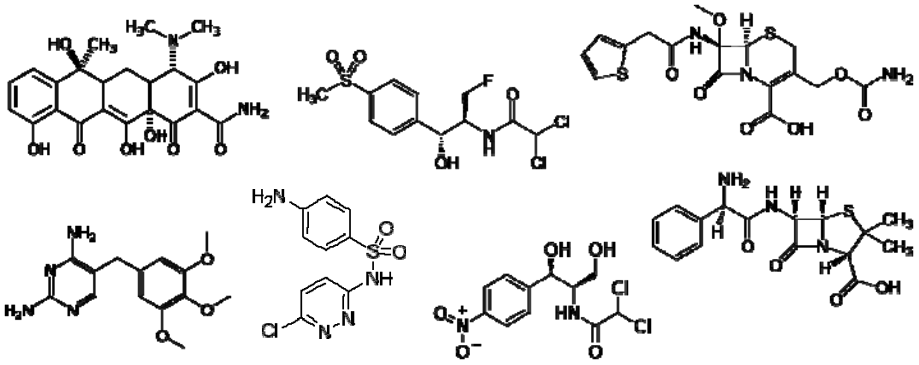
Types of Antibiotics

- Various antibiotic classes
  - Varying chemical structures that impact environmental fate & transport and risk



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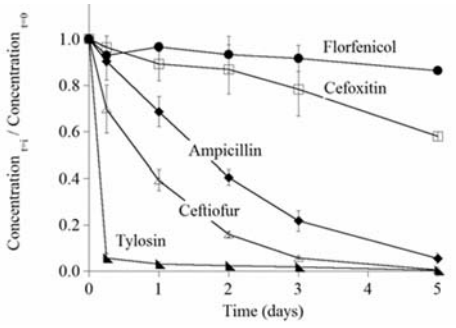
Antibiotic Behavior

- Environmental behavior varies considerably
  - Influences fate and transport
  - Persistence impacted by:
    - Photodegradation
    - Hydrolysis
    - Adsorption
    - Biodegradation
  - Influenced by environmental conditions (pH, temperature, moisture, etc.)



Ullman (unpublished data)

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Antibiotic Removal by WWTPs

Concentration and percent removal of three pharmaceuticals in raw municipal wastewater and treated wastewater.

Sample description	Treatment step	Concentration (ng/L)		
		Carbamazepine	Sulfamethoxazole	Trimethoprim
Raw municipal wastewater	--	291	4,850	246
Secondary activated sludge treatment effluent	2°	323 (-11.0%)[a]	901 (81.4%) [a]	211 (14.2%) [a]
Chlorinated-dechlorinated secondary effluent	2° + dis.	314 (2.7%) [a]	119 (86.8%) [a]	98 (53.6%) [a]
Conventional sedimentation effluent	3°	340 (-5.3%)	746 (17.2%)	269 (-27.5%)
Microsand ballasted sedimentation effluent	3°	318 (-1.5%)	514 (43.0%)	216 (-2.3%)
Magnetite ballasted sedimentation effluent	3°	310 (-4.0%)	479 (46.8%)	234 (-10.9%)
Continuous backwash upflow sand filtration effluent after conventional sedimentation	3°	335 (-3.7%)	649 (28.0%)	239 (-13.3%)
Duel-media granular filtration effluent after microsand sedimentation	3°	302 (6.5%)	753 (16.4%)	160 (24.2%)
Duel-media granular filtration effluent after magnetite sedimentation	3°	316 (2.2%)	506 (43.8%)	218 (-3.3%)
Ultrafiltration effluent after microsand sedimentation	3°	335 (-3.7%)	792 (12.1%)	255 (-20.9%)
Ultrafiltration effluent after magnetite sedimentation	3°	313 (3.1%)	482 (46.5%)	243 (-15.2%)

Note: The tertiary treatment systems were designed for enhanced phosphorus removal. Percent removal from secondary effluent to tertiary treatment is shown in parenthesis.

[a]Percent removal from raw wastewater to secondary effluent.

Mitchell, S.M and J.L. Ullman. 2016. Removal of phosphorus, BOD, and pharmaceuticals by rapid rate sand filtration and ultrafiltration systems. Journal of Environmental Engineering doi:10.1061/(ASCE)EE.1943-7870.0001137

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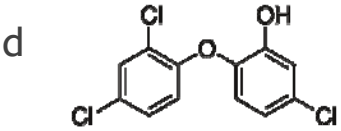
Antibiotic Risks

- Direct environmental and human health impacts
  - Interference with biogeochemical cycles
  - Impacts on biota
    - Earthworms uptake trimethoprim
    - Triclosan interferes with thyroid in frogs
  - Accumulation in crops and vegetables



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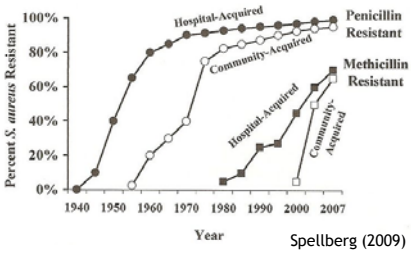
Antibiotic Risks

- Antibiotic resistance
  - At least 2 million people contract antibiotic-resistant infections annually in the U.S.
  - 23,000 people die as direct result
    (CDC, 2013)



Spellberg (2009)

USDA

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Antibiotic Resistance

- Typically, selection pressure considered an *in vivo* process
- Assumed drug residues can present additional selection pressure
  - Tests shown to occur at high concentrations, but not environmentally relevant
  - Essentially unknown

What are the risks of developing antibiotic resistance in relation to biosolids?

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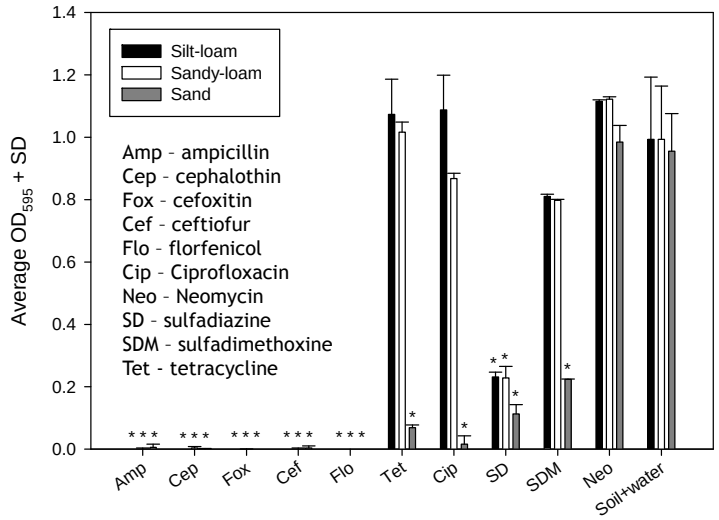
Bacterial Inhibition



Subbiah, M., S.M. Mitchell, J.L. Ullman and D.R. Call. 2011. Β-Lactams and florfenicol antibiotics remain bioactive in soils while ciprofloxacin, neomycin, and tetracycline are neutralized. Applied and Environmental Microbiology 77(20):7255-7260.

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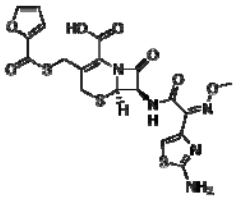
Summary of Ceftiofur Experiment

- Examined if excreted ceftiofur provides selective pressure for ceftiofur resistance (cef^R) in the environment



  - Ceftiofur metabolites (CFM) remain bactericidal in soil-feces (particularly at cooler temperatures)
  - Brief exposure to CFM selects for cef^R, and resistance conveys survivorship advantage against native bacteria in presence of CFM
  - Resistance transmitted back to livestock

Subbiah, M., D.H. Shah, T.E. Besser, J.L. Ullman and D.R. Call. 2012. Urine from treated cattle drives selection for cephalosporin resistant *Escherichia coli* in soil. PLOS ONE 7(11):e48919

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Implications

- Antibiotic-resistance can be promoted by *ex vivo* as well as *in vivo* mechanisms
  - However, this is a very particular circumstance
- Sludge and biosolid management can reduce antibiotic concentrations

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Anaerobic Digestion

- Investigated antibiotic impact on biogas production and antibiotic degradation
- Antibiotics considered:
  - Sulfamethazine
  - Ampicillin
  - Tylosin
  - Florfenicol

Mitchell, S.M., J.L. Ullman, A.L. Teel, R.J. Watts and C. Frear. 2013. The effects of the antibiotics ampicillin, florfenicol, sulfamethazine, and tylosin on biogas production and their degradation efficiency during anaerobic digestion. Bioresource Technology 149: 244-252.

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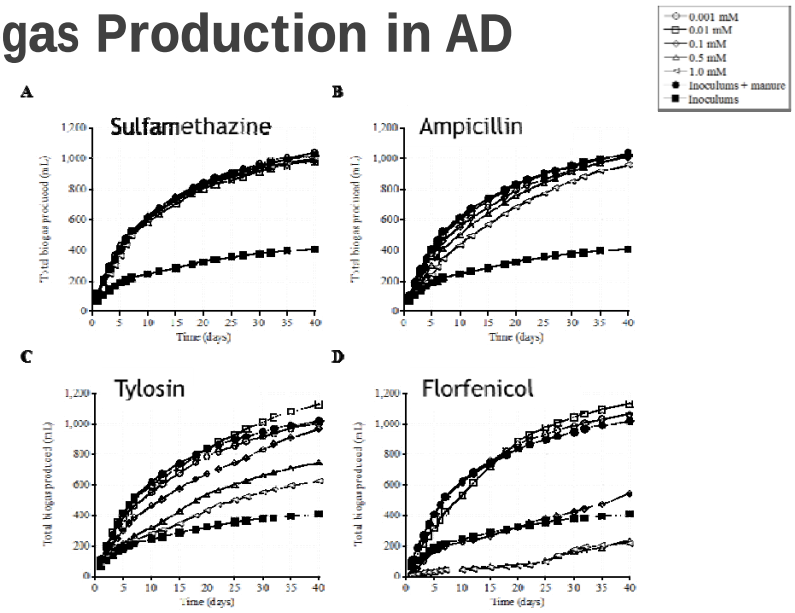
Biogas Production in AD



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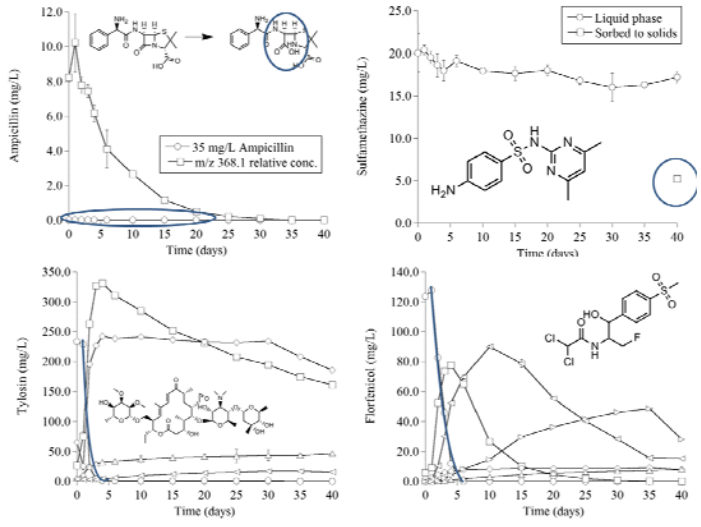
Antibiotic Degradation in AD



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Composting

- Investigated composting of biosolids and manures (aerated and non-aerated)
  - Considered the antibiotics sulfadimethoxine, sulfamethazine, florfenicol and tylosin



Mitchell, S.M., J.L. Ullman, A. Bary, C.G. Cogger, A.L. Teel and R.J. Watts. 2015. Antibiotic degradation during thermophilic composting. Water, Air, & Soil Pollution 226(2) Article 13. doi:10.1007/s11270-014-2288-z

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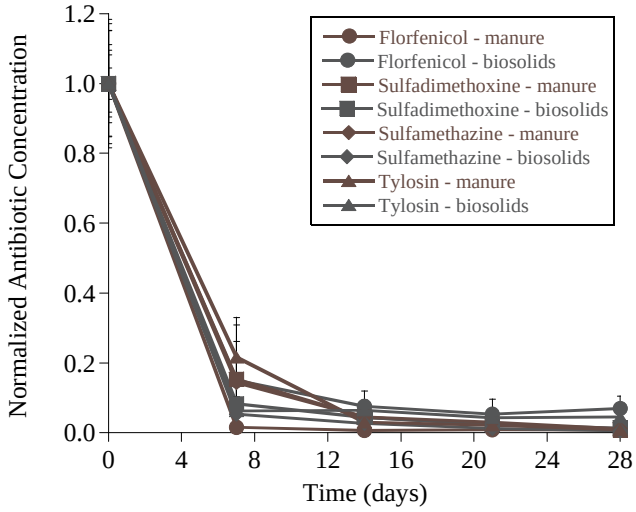
Antibiotics During Composting



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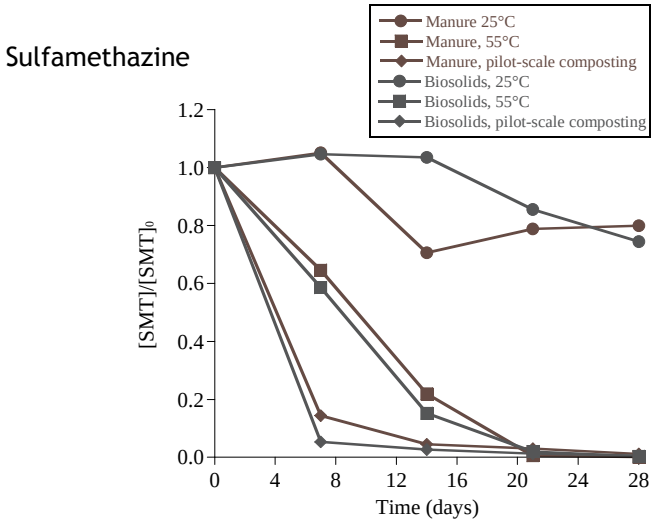
Temperature Effects



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Biochar

- Amendment obtained from thermochemical conversion of biomass
- Shown to effectively sorb nutrients, metals and organic contaminants

UC Davis

Michigan Biochar

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Average percent removal of ceftiofur and florfenicol from water by biochar (4 g biochar per mg antibiotic).

Biochar[a]	Ceftiofur removal (%)	Florfenicol removal (%)
Dairy fiber, 600	>99.98 *	>99.98 *
Pinewood, 550-600 (0.7 mm)	>99.98 *	>99.98 *
Pinewood, >550 with steam	>99.98	>99.98
Pinewood, 650	>99.98 *	>99.98
Hickory wood, 600	>99.98 *	99.90 *
Pinewood, 550-600 (3 mm)	>99.98	99.91
Brazilian pepper, 600	>99.98	99.86 *
Bamboo, 600	99.97	99.80
Hickory wood, 450	99.6 *	99.66 *
Mixed wood, 480-590	>99.98 *	99.60 *
Poplar wood, 600	>99.98 *	98.72 *
Pinewood, 600	99.94 *	98.51 *
Dairy fiber, 450	>99.98 *	96.25
Cherry pit, 600	97.65	95.95
Mixed wood, 700	99.98	94.77
Pine bark, 600	99.97 *	93.09
Dairy fiber, 350	98.56	90.81
Bamboo, 450	99.96 *	88.85
Peanut hull, 450	99.57	82.48
Poplar wood, 350	98.21	80.35
Poplar wood, 450	99.87	75.01
Pinewood, 450	97.95	72.57
Peanut hull, 600	99.59 *	68.04
Pine bark, 450	99.26	61.12
Pinewood, 350	90.68	60.74
Brazilian pepper, 450	92.60	41.39
Pine bark, 350	58.16	33.89
Control, no biochar	-0.07	-0.17

[a]Numbers following biochar feedstock type indicate pyrolysis temperature during production

**P*>0.05 for the bioassay results (see Fig. 2 and Fig. 3).

Mitchell, S.M., M. Subbiah, J.L. Ullman, C. Frear and D.R. Call. 2015. Evaluation of 27 different biochars for potential sequestration of antibiotic residues in food animal production environments. Journal of Environmental Chemical Engineering 3:162-169.

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Summary

- Many classes of antibiotics
  - Much remains unknown
- The possibility of antibiotic resistance developing due to antibiotics in biosolids extremely low
  - Difference between selecting for antibiotic-resistant bacterial populations and susceptible bacteria acquiring resistance
  - Horizontal transfer of genes may occur
- Other biological impacts may result
- Proper treatment can help minimize impact

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Acknowledgements

- Dr. Shannon M. Mitchell
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- Washington State University Center for Sustaining Agriculture and Natural Resources BIOAg program
- City of Spokane Wastewater Management Department

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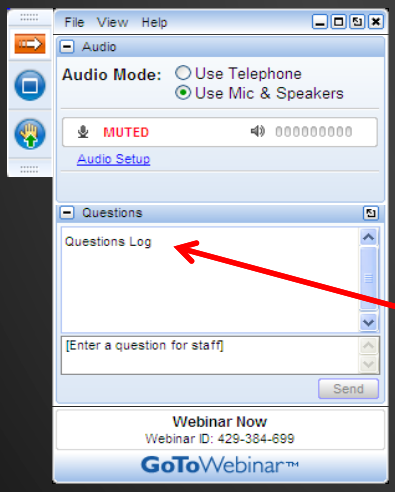
Questions?



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Land Application of Biosolids: Human Health Risk Assessment Related to Emerging Contaminants

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March 1, 2017

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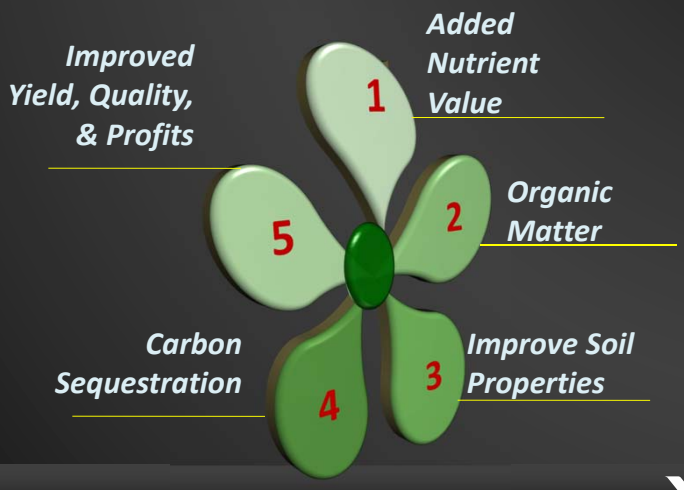
Benefits of Using Biosolids in Agriculture



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Biosolids, Fertilizers, Compost, & Manure

Total Land in US - 2.3 Billion Acres
Under Agriculture - 315 Million Acres

7 Million Ton — 0.2% Ag Land Receives Biosolids

30 Million Ton

55 Million Ton

140 Million Ton — 7 % Ag Land Receives Manure

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Beneficial Biosolids Use

Wastewater

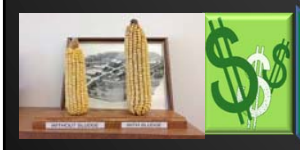
- *Heavy Metals*
- **Emerging Contaminants**
- *Nano-g/L to micro-g/L*

Biosolids

- *Concentrate in Biosolids*
- *Degrade During Processes*
- *Metals in mg/L and Organics < micro-g/L*

Soil

- *Agronomic Rates*
- *100 Times Dilution*
- *Biotic & Abiotic Processes*



Edible Grain Or Fruit

- *Root Uptake Barriers*
- *Plant Requirement*
- *Very Low Accumulation in Edible Parts*

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The Chemical Universe

The *KNOWN* Universe

- As of October 2005, over 26 million organic and inorganic substances had been documented.
  - (indexed by the American Chemical Society's Chemical Abstracts Service in their CAS Registry; excluding bio-sequences such as proteins and nucleotides)
- ~ 9 million were commercially available.
- Fewer than a quarter million (240,000) were inventoried or regulated by numerous government bodies worldwide - -
  - representing less than 3% of those that are commercially available or less than 1% of the known universe of chemicals.

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"Sola Dosis Facit Venenum (Latin)"

IN 1500s SWISS DOCTOR

- *Philippus Aureolus Theophrastus Bombastus von Hohenheim* (commonly called Paracelsus) pointed out
  - "All things are poison and nothing is without poison; only the dose makes a thing not a poison"

BASIC PRINCIPLE OF TOXICOLOGY
The Dose Makes the Poison

PUBLIC HEALTH

- All chemicals—even water, oxygen, coffee and spinach—can be toxic if too much is eaten, drunk, or absorbed
- This finding provides the basis for public health standards, which specify maximum acceptable concentrations of various contaminants in food, public drinking water, and the environment

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CWA & 40 CFR Part 503 Risk Assessment Included:

- Heavy Metals
- PCBs
- Furans/dioxins
- Benzo(a)pyrene
- Benzo(a)anthracene
- Phenanthrene
- Chlordane
- Aldrin/Dieldrin
- Toxaphene
- Malathion
- DDT/DDD/DDE
- Methylenebis(2-chloroaniline)
- Bis(2-ethyl hexyl)phthalates
- n-nitrosodimethylamine
- Vinyl Chloride
- Pentachlorophenol
- Trichloroethylene
- Chloroform
- Heptachlor
- Carbon tetrachloride
- Benzene
- Hexachlorobenzene
- Hexachlorobutadiene

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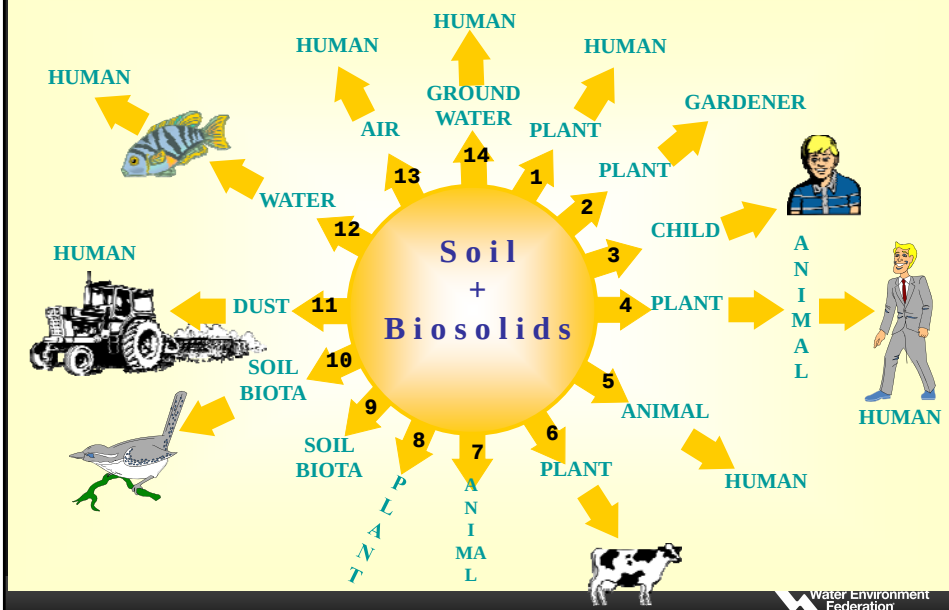
14 - Pathway Risk Assessment



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40 CFR Part 503

- 1993: Initial Hazard Assessment for 12 Organic Compounds
  - None was regulated
- 2001: Further screening for Dioxins and Dioxin like compounds
- 2003: Dioxins and Dioxins like compounds posed no significant risk to human health or the environment
  - Not to regulate in land applied biosolids

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Hazard Quotient (HQ) of OCs in The Edible Tissue

- Prosser and Sibley (2015) Based on Extensive Review on Plant Uptake of OCs Calculated HQs:
- Estimated Daily Intake (EDI) for OCs for Adult or Toddler
- EDIs compared to ADI (Acceptable Daily Intake)
- ADI Were calculated :
  - Drugs = Lowest Therapeutic Dose (LTD, mg/d)/1000
  - Drugs (Endocrine Disruptors) = LTD/10,000
  - Other OCs = NOAEL/300

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Calculated HQs for Various OCs

OCs	Crop	Adult HQ	Toddler HQ
Atenolol	Tomato	0.01	0.02
Carbamazepine	Collard	1.5*[a]	3.7*[a]
Ciprofloxacin	Carrot	0.0001	0.0003
Diphenhydramine	Tomato	0.03	0.07
Naproxen	Corn	0.0001	0.0002
Norfloxacin	Carrot	0.0002	0.0004
Progestrone	Corn	0.01	0.04
Salbutamol	Cabbage	1.5*[b]	3.8*[b]
Testosterone	Tomato	0.08	0.2*[c]
Triamterene	Carrot	0.0001	0.0002
Triclocarban	Collard	0.002	0.005
Triclosan	Radish	0.05	0.1*[d]

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Quantitative Human Health Risk Analysis for OCs

Northwest Biosolids (2015) Conducted a quantitative exposure assessment for uses of biosolids using general risk assessment methodology by the USEPA. The following scenarios of exposure from dermal contact and ingestion were evaluated:

- Child exposed while playing in a home garden or lawn fertilized with Class A biosolids compost.
- Adult gardener exposed while working in a home garden fertilized with Class A biosolids compost.
- Occupational worker exposed while applying Class B biosolids to agricultural land.
- Adult hiker exposed while hiking in a forested area fertilized with Class B biosolids.

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Representative concentrations of OCs in Class A compost biosolids (mg/kg) and resulting exposure without adverse effects in years (from NW Biosolids, 2015)

OCs	Represe-ntative Conc.	Exposure Without Adverse Effects YEARS	
		Adult Gardner	Child Resident
Acetaminophen	0.0015	143,000,000	4,494,000
Fluoxetine	0.036	91,000	3,000
17 -a ethinylestradiol	0.0011	3,000	98
Bisphenol A	9.0	437,000	14,000
Ibuprofen	0.35	94,000	3,000
Deca-BDE	0.24	1,470,000	159,000
Azithromycin	0.035	2,350,000	74,000
Ciprofloxacin	0.93	35,000	1,000
Erythromycin	0.0060	13,709,000	432,000
Ofloxacin	0.66	100,000	3,000
Sulphamethoxazole	0.001	131,000,000	4,148,000
Triclosan	1.2	4,935,000	156,000

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Representative concentrations of OCs in Class B biosolids (mg/kg) and resulting exposure without adverse effects in years (from NW Biosolids, 2015)

OCs	Represe-ntative Conc.	Exposure Without Adverse Effects YEARS	
		Adult Hiker	Occupational
Acetaminophen	0.29	4,334,000	292,000
Fluoxetine	0.087	222,000	15,000
17 -a ethinylestradiol	0.0011	18,000	1,000
Bisphenol A	9.0	2,566,000	173,000
Ibuprofen	0.35	552,000	37,000
Deca-BDE	4.1	556,000	11,000
Azithromycin	0.46	1,051,000	71,000
Ciprofloxacin	3.4	58,000	4,000
Erythromycin	0.020	24,171,000	1,630,000
Ofloxacin	1.8	217,000	15,000
Sulphamethoxazole	0.0056	137,000,000	9,265,000
Triclosan	17	2,023,000	136,000

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Representative and acceptable concentrations of MCs in Class A and Class B biosolids (mg/kg) and number of years of exposure to reach an equivalent dose (from NW Biosolids, 2015)

OCs	Therapeutic Dose or Typical Daily Intake (mg)	Years of Exposure to Receive Equivalent Dose			
		Class A Compost		Class B Biosolids	
		Adult Gardner	Child Resident	Adult Hiker	Occup-ational
Acetaminophen (Analgesic)	1,000 2 Tylenols	90,143,000	50,514,000	2,740,000	147,000
17-aethinylestra-diol (Birth control)	0.01 Lo Loestrin	1,000	700	7,500	400
Ibuprofen (NSAID)	200 1 Tablet Advil	77,000	43,000	454,000	24,000
Ciprofloxacin (Antibiotic)	250 Lowest Daily Dose	36,000	20,000	59,000	3,000
Erythromycin (Antibiotic)	1,000 Lowest Daily Dose	22,535,000	12,628,000	39,734,000	2,144,000
Triclosan (Anti-microbial)	87 Soap Single Use	10,000	5,000	4,000	200

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Other Recent Risk Assessments

Norwegian Risk Assessment - 2009

- Norwegian Food Authority evaluated
  - Six classes of organic pollutants
    - Phthalates, Octylphenols and ethoxylates, NP, NPEs
    - PCBs, PAHs
  - 14 pharmaceuticals (atorvastatin, carisoprodol, chlorprothixene, ciprofloxacin, dipyridamole, fexofenadine, gabapentin, levetiracetam, losartan, mesalazine, metoprolol, ranitidine, sotalol,tetracycline).

Conclusion

- Exposure risk from all pollutants evaluated
  - Well below PNEC
  - Promotion of antibiotic resistance in biosolids-amended soils unlikely

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Other Recent Risk Assessments

Danish Government Risk Assessment - 2012

- Danish EPA evaluated
  - Five classes of organic pollutants
    - BFRs, Musks, PFCs
    - Pharmaceuticals
    - PCBs
  - Used margin of safety (MoS) to calculate quotient of predicted soil concentration and NOAEL
  - Used MoS value of between 10 and 1000

Conclusion

No significant risk to soil dwelling organisms and soil quality in general

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Exposure Risks - What Do We Know!

- Levels of most Emerging Contaminants in biosolids are low
- Land application further results in 100 fold dilution
- OCs are sequestered in organic matrix of biosolids and thus have limited bioavailability
- Experience with similar organics from Part 503 Risk Assessment shows that risk to humans is *de minimis*

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Take Home Messages

- Land application of biosolids is a beneficial practice and it does not result in human exposure to Emerging Contaminants.
- We can minimize exposure to Emerging Contaminants by becoming smart consumers and reducing indiscriminate use of chemicals in our daily lives.
- DEA released data on National Rx Take-Back Day (May, 2016)
  - PROUD to say that Illinois was at No. 5 and our efforts kept 24 tons of drugs out of our biosolids, waterways and landfills

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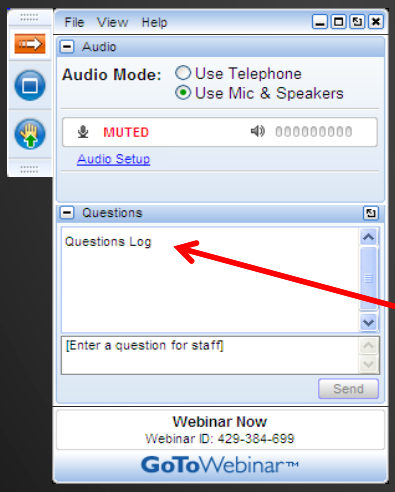
Questions?



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