Toxics - The Dirty Dozen

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University of Minnesota Onsite Sewage Treatment Program

1. Professional Training – Designers, Inspectors, Maintainers, Installers
2. Research and Demonstration
3. Homeowner Operation & Maintenance
4. Small Community Wastewater Solutions

Bacteria - You May Not Like Them

- But we need these guys
  - bacteria and fungi are the workhorses of wastewater treatment
  - they prefer their carbon source to be non-toxic

ORGANIC MATTER → CO_2 CH_4 H_2S NH_3

BACTERIA GASES + HUMUS

SEPTIC TANK SHOULD SMELL "SEPTIC" WHEN YOU OPEN THE LID

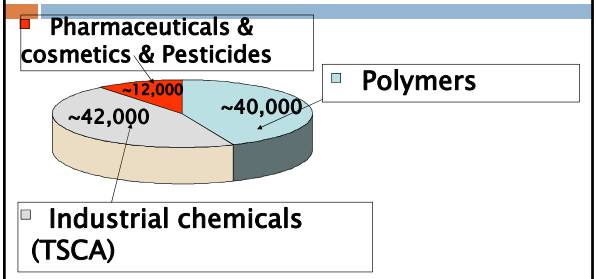
Anaerobic Digestion

They are Exposed to Everything We Put Down the Drain

- The good news
  - Most waste organic compounds can be degraded by the microbes
    - in the septic tank
    - in the soil
- The bad news
  - there are plenty of organic compounds that will kill them

http://www.medicinenet.com/bacterial_infections_101_pictures_slideshow/article.htm

Major Chemicals Registered for Commercial Use in US*



*The numbers here are for the US but are similar for Canada due to our integrated economies. Canada keeps a list which mirrors USEPA - it contains more than 58,000 entries

What are Contaminants of Emerging Concern?


Antibiotics
Hormones (synthetic and natural)
Metabolites (cotinine)
Psychoactive drugs
Lipid regulators
Pain relievers
Fragrances
Chemotherapy drugs
Fire retardants
Cleaning products
others





Chemicals of Emerging Concern (CECs)

- Those previously unidentified due to advances in analytical techniques
- Those previously identified but with new effects of concern
- Newly marketed chemicals

WHY DO WE CARE?

3 reasons

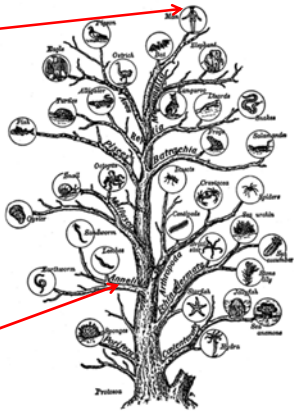
1

YOU ARE HERE

Nature conserves valuable work. Many of the metabolic and regulatory pathways that have evolved are conserved between classes of organisms.

This means that many of the drugs we invent to regulate our metabolic systems can also effect "lower" organisms and sometimes visa versa.

Earliest indication of the presence of estrogen and estrogen receptors



2

The effect of long term exposure to many contaminants of emerging concern is not known

(although some animal studies suggest some negative effects)

3

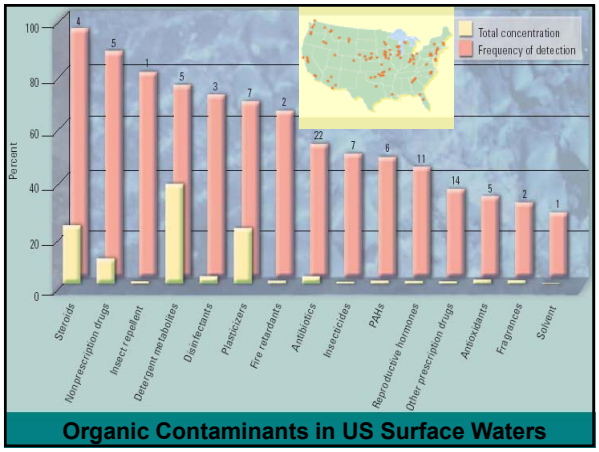
Because it turns out that you actually can fool Mother Nature.


Surface Water Study

- Sampled downstream of urban areas, intense livestock areas, wastewater systems
- Sampled for 95 CEC
- 139 streams, 30 states
- 82 of 95 detected
- 80% of samples were contaminated

CEC units results

- Nanograms/liter
- 1 part per trillion
- 1 ng/l Analogy – 1 oz. in 7.5 billion gallons of water



Organic Contaminants in US Surface Waters

Tap Water Evaluation

- 19 utilities serving 138 million people
- 2006-07
- Sampled for 55 chemicals – found 11 most frequently at levels < 10 ng/L
- Atrazine found ~40-50 ng/L

Survey of 19 US Drinking Water Utilities

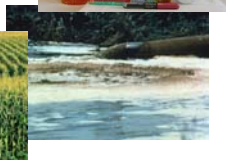
Top 11 of 55 compounds
Median concentrations generally <10 ng/L

- Atenolol - betablocker
- Atrazine - herbicide
- Carbamazepine - anticonvulsant
- Estrone - hormone
- Gemfibrozil –antilipidemic
- Meprobamate – antianxiety
- Naproxen – anti-inflammatory
- Phenytoin – anticonvulsant
- Sulfamethoxazole - antibiotic
- TCEP - flame retardant
- Trimethoprim - antibiotic

Benotti et al. ES&T 2009

….and where do they come from?

- Personal care products
- Detergents
- Industrial discharge
- Residential wastewater (SS)
- Agriculture



CECs Accumulate in Wastewater

- Wastewater Effluent
  - Estradiol & Birth Control Pills
  - Nonylphenol from detergents
  - Bisphenol A and phthalates from plastics
  - Triclosan from household cleaners
  - Musks from personal care products

An Example - Consumer Products

- Ingredients in shampoo
  - 1% pyrithone zinc, ammonium laureth sulfate, ammonium lauryl sulfate, sodium lauroyl sarcosinate, glycol distearate, sodium sulfate, fragrance, dimethicone, DMDM hydantoin, disodium phosphate, sodium phosphate lauryl alcohol, PEG-12, polyquaternium-10, sodium chloride
- It goes down the drain

And, of course, Pharmaceuticals

- If we are on drugs
  - so is our septic system

http://www.dreamstime.com/stock-photos-medicine-bottles-pills-image800963

We're not the Only Drug Users

Drug residues are excreted in the manure and left in the Environment

For Example - Triclosan

- Forth National Report on Human Exposure to Environmental Chemicals
- CDC (2003-2004)
  - 2,517 people studied
  - 75% had triclosan detected in their urine
- Did not suggest harm – it just suggested that it was in their bodies

Research on PPCPs & Septic Systems

- Colorado School of Mines Study
- Over 30 onsite systems serving a variety of wastewater sources monitored and the potential removal mechanisms evaluated
- Results:
  - Problematic compounds are prevalent in onsite systems
  - Wide range in concentrations based on facility - 0.5 to 4500 ng/L

- Results ~ a few highlights
  - Overall occurrence in septic tank influents: ng/L - mg/L

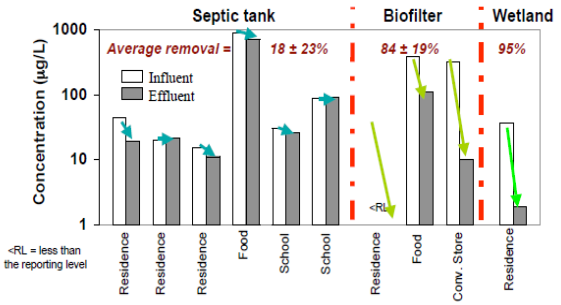
Compound	Use	Frequency of Detection (%)	Concentration Range (µg/L)
Caffeine	Stimulant	100	0.5 – E 9300
Coprostanol	Animal sterol	100	0.5 – E 7100
Cholesterol	Animal sterol	100	0.5 – E 2200
EDTA	Metal-chelating agent	100	0.5 - 1700
4-Methylphenol	Disinfectant	98	0.5 – E 4500
NPEC	Surfactant metabolite	95	2 - 320
NTA	Metal-chelating agent	82	0.5 - 130
4-Nonylphenol	Surfactant metabolite	77	2 – 340
NPEO	Surfactant metabolite	75	2 – 170
Triclosan	Antimicrobial agent	68	0.5 – 82

Results from 64 anaerobic septic tank wastewater samples collected in Fall 2003 and Spring 2004. 12
E = estimated value (concentration exceeded maximum value on standard curve).

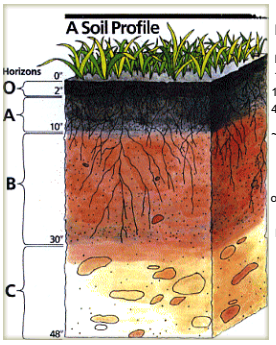
Research Results on PPCPs Cont'd

- Generally low removals were observed in the anaerobic septic tank (less than 35%)
- Higher removals for some compounds observed in textile filter effluent (aerobic treatment)
- High removals (>90%) were observed in 24 inches of sandy loam soil (a few exceptions)

- Removal efficiencies depend on TOrC properties and relevant removal processes within treatment unit operations, e.g.:
  - Caffeine - removal enhanced by aerobic biotransformation
    - Triclosan, dichlorobenzene, NTA,...similar



Bacteria (and other microbes) – the real workhorses of the terrestrial ecosystems



Attenuation VS Removal

- Adsorption
- Conjugation (with possibility of deconjugation)
- Chemical breakdown
- Biodegradation

An important distinction

Contaminants of Emerging Concern Treatment in Shallow Soil-based Septic Systems

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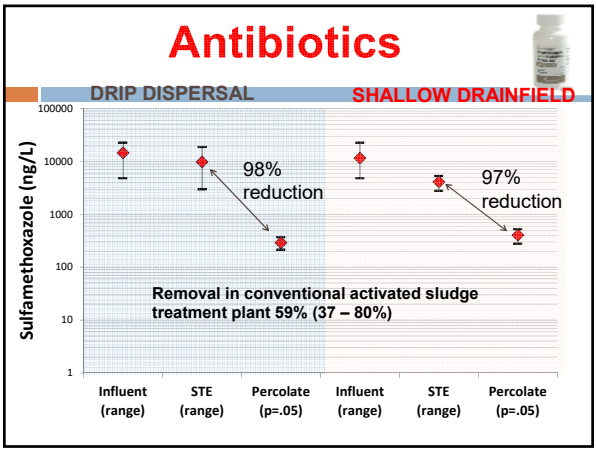
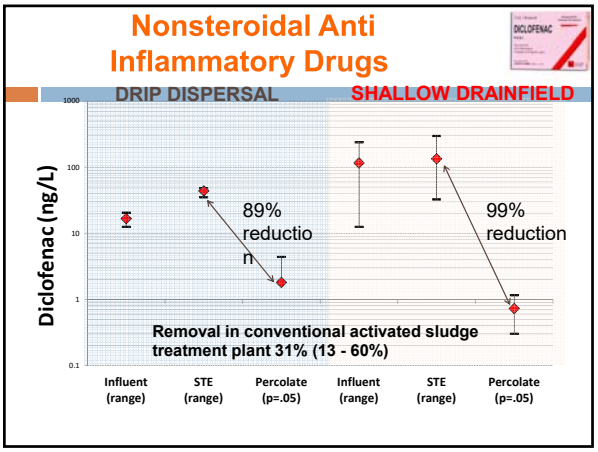
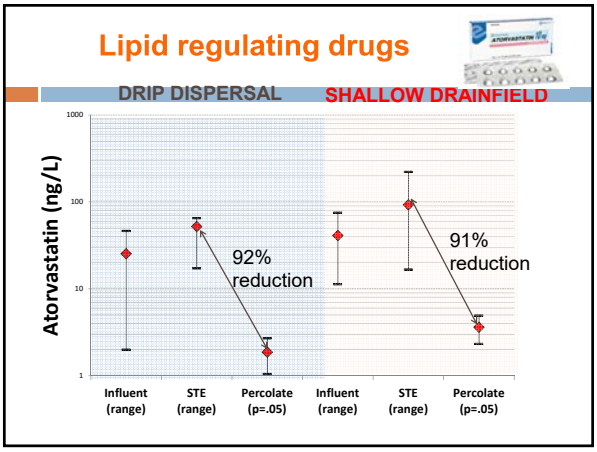
Antibiotics



Nonsteroidal Anti Inflammatory Drugs



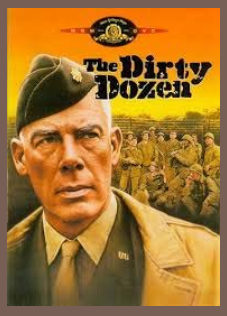
Lipid regulating drugs



Compound	Drip	Shallow Drainfield	Conventional activated sludge treatment
Acetominophen	99.99%	99.82%	> 90% - 99.9% (b)
Atenolol	93.62%	99.03%	5.5% (2-20%)(a)
Atorvastatin	92.60%	91.18%	85-95% (d)
Caffeine	99.97%	99.93%	94.9% (c)
Ciprofloxacin	97.96%	98.17%	72% (59-85%)(a)
DEET	98.45%	98.24%	69% (48-90%) (e)
Diclofenac	89.16%	99.37%	31% (13-60%)(a)
Furosemide	97.60%	98.40%	59.8% (c)
Ibuprofen	99.94%	99.93%	74%(44-100%)(a)
Miconazole	0.00%	0.00%	
Naproxen	99.50%	96.80%	75% (59-92%)(a)
Propranolol	71.20%	96.89%	96% (a)
Sulfamethoxazole	97.90%	96.50%	59% (37-80%)(a)
TCEP	0.00%	0.00%	
Trimethoprim	99.20%	99.80%	14% (0 - 40%)(a)

Take Home Message about CECs

- Many pharmaceutical and personal care products, contain compounds that can disrupt the normal functioning of hormones in humans and wildlife
- Although a major route for CEC entrance into the environment is wastewater, the septic systems present opportunity for significant treatment
- Shallow-placed soil absorption systems remove > 90% of many CECs found in household wastewater
- A more complete understanding of the principles of CEC removal in soils may offer opportunities to design optimization



Cleaning Products

- Problems
  - Sanitizing
  - pH impacts
- Antibacterial
- Raises owner awareness
- They have **cumulative** effects on system performance

1. Liquid Fabric Softeners

- Petroleum based
- Contain quats
- Adds additional salts
- Should not be used
- Emulsification
- Recommendations:
  - Add a ½ cup of baking soda
  - Drier balls
  - Add a cup of vinegar
  - Anti-static- aluminum foil ball

Cleaning Product Labels

- DANGER: Means the chemical will kill the bacteria, and its use should be minimized or eliminated
- WARNING: Means limited use should have a minimal impact on the system
- CAUTION: Typically means the product will have little effect

2. Drain Cleaners

- Toxic drain cleaners can impact ability to properly treat wastewater
- Affect bacteria activity
- Recommendation: Use a plunger, metal snake or remove & clean the trap

3. Toilet Cleaners

- Most are toxic, harsh cleaners
- Read the labels
- Automatic cleaners
  - Not recommended
  - Continual impact causes long-term problems
- Recommendation: Sprinkle on baking soda or Bon Ami, then scrub with a toilet brush
  - Bon Ami is non-scouring, biodegradable, nontoxic and hypoallergenic

What Should go in the Bowl

- Single ply toilet paper because it breaks down in the septic system faster and better then higher ply count toilet paper
- No lotions
- No whipes
- Human waste
- Nothing else!

Septic Safe?

- Even if items are marked as "septic safe" do not flush them
- For example, some wipes, toilet bowl cleaners and cat litter may be labeled this way
- In many instances it means they will flush

4. Spray Shower Cleaners

- By spraying or at the push of a button the shower cleaner will spray a cleaning mist, and remove soap scum, mildew and other buildup from your shower walls
- Daily dose of sanitizer and emulsifier
- Recommendation: Sprinkle baking soda on a damp sponge or add 4 Tbs. baking soda to 1 qt. warm water or use Bon Ami

5. Degreasers

- At home, limit use of dishwashing soaps
- In a restaurant, should be avoided
- Recommendations:
  - Use distilled vinegar
  - Make a baking soda paste to cut grease

7. Quaternary Ammonia?

- Typically known as “Quats”
  - Many individual chemicals
  - Present in thousands of end-use formulations, many of which are blends of various Quats
  - Varying levels, some are worse than others
- Common uses include disinfectants, surfactants, fabric softeners, antistatic agents, and wood preservation

More About Quats

- Compounds are very stable and hard to break, so has long lasting biocidal effect
- Certain quats will biodegrade
  - Biodegradation poor under anaerobic conditions
  - Biodegradability of QACs under aerobic conditions
  - 90% removal cited in literature
- Toxic/Inhibitory to Nitrifying Bacteria - in concentrations < 2 mg/l

Quat Alternatives

- In home disinfectant - Use borax: 1/2 cup in a gallon of water; deodorizes also
- Commercial sanitizing is done by either a chemical or with high temperature
  - Chlorine
  - 165 degrees F

8. Prescriptions Drugs

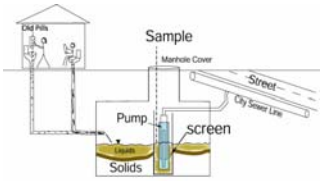
- Average American fills 12 prescriptions each year
- On average, people age 45 and older say they take four prescription medications daily

Prescription Drugs and Antibiotics

- Can kill microbes living in system
  - Won't discriminate against organisms living in the system
- Additional treatment components may be necessary
- Increase maintenance

Antibiotics and Similar Meds

- Antibiotics are not selective in which bacteria are killed
- While antibiotics help a patient by killing harmful bacteria, the medicine often kills good bacteria also
- Recommendations: Use them only when needed, dispose of unused ones properly (Do NOT flush)



National Drug Take-Back Day

- According to a press release from The US Department of Justice in May, the fourth national drug take-back day (last spring) collected a record 276 tons of prescription drugs

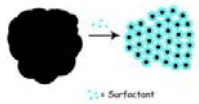
9. Antibacterial Soap and Products

- Antibacterial ingredients have been added
- These chemicals kill bacteria and microbes but are NO more effective at deactivating viruses than any other kind of soap or detergent, and they also kill nonpathogenic bacteria
- Antibacterial soap affects biology of tank
- Liquid soaps tend to be overused
- Use is promoting the developing of "super" bugs

10. Powdered Laundry Detergent

- Dry detergent may have fillers or extenders that clog the drain field
- Less expensive dry laundry detergents actually contain montmorillonite clay which is used as a sealant as a form of filler
- This clogs the drain field as well as sodium and other extenders found in powdered detergents

11. Surfactants



- In many soaps/cleaners
- Surfactants are found in almost every laundry detergent because they help separate the body soil or oily stains from the fabric
- Two types
  - natural or oleochemical surfactants derived from plant oils such as palm or coconut oil.
  - synthetic or petrochemical surfactants are derived from crude oil
- Recommendation: Choose natural one with a zero phosphate content

Surfactant Affects

Concentration (mg/L)	Potential Effects
≥1.0	Risk of long-term accumulation of surfactants in soil, leading to decreased hydraulic conductivity and increased water repellence
10	Inhibition of hydrolysis, leading to greater accumulation of solids in anaerobic sewage treatment systems
30	Direct degradation of soil structure and decrease in hydraulic conductivity

Example from 6 Adult Care Facilities in MN

Site	Anionic Surfactants mg/L
A.	2.0
B.	0.76
C.	3.8
D.	8.6
E.	1.5
F.	3.4
G. Control Site	2.7

General Cleaning Recommendations

- Use non-chlorine, non-ammonia, non-antibacterial, non-toxic and bio-degradable cleaning products
- Most all-natural cleaners are septic safe
- Use the least amount you need to get the job done
- When it comes to chemicals, it's a good idea to remember that if you only feel safe wearing gloves when you handle them, then it's a good bet that you won't want to put these items down your drain

12. Paint and other remodeling debris

- Flushing household chemicals, gasoline, oil, pesticides, antifreeze and paint can stress or destroy the biological treatment taking place in the system or might contaminate surface or ground water
- Unused products should be dropped off at hazardous waste clean up centers
- Clean paint brushes outside rather than in the sink

Myths and Additives

- Tanks typically do not require additives
  - No need to "start" a tank with a dead chicken
  - Adding yeast, while harmless, is not needed
  - Commercial additives are normally not needed
- Beware of any additive that suggests it will reduce pumping frequency
  - Normal function means some accumulation
    - Nonbiodegradables – e.g. synthetic fabric lint
  - Solids may be washed out to next downstream treatment component
  - Independent research shows no benefit

Take Home Message

- As an industry, we need to keep educating folks
  - take extra medications to collection
  - don't pour pesticides down the drain
- The septic system and soil has a tremendous potential to capture trace organics
  - but it's not bulletproof
  - someday we may have to evaluate more contaminants

QUESTIONS & MORE INFORMATION

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H2OandM.com

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