

OUR BAY AND RIVERS ON DRUGS

pharmaceuticals and illicit drugs as agents of ecological change

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Baltimore
Ecosystem Study



Pharmaceuticals and personal care products are now a part of river ecosystems



Antibiotics
Antihistamines
Antidepressants
Painkillers
Anticonvulsants
Antimicrobials
Hormones
Fragrances

Insect repellents
Sunscreen
Detergents
Illicit drugs
Cosmetics
Other?

1467 Pharmaceuticals in US

\$80 Billion global industry

How do drugs get into rivers?

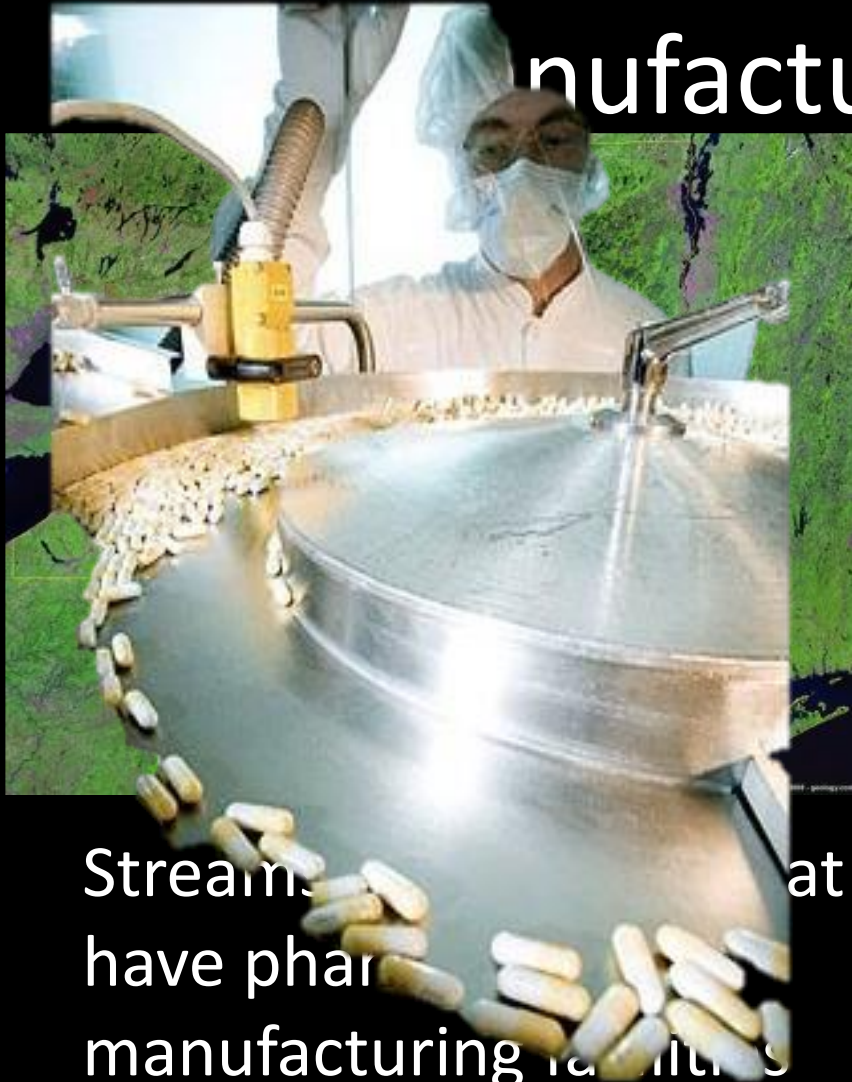


Hudson River, NY

People

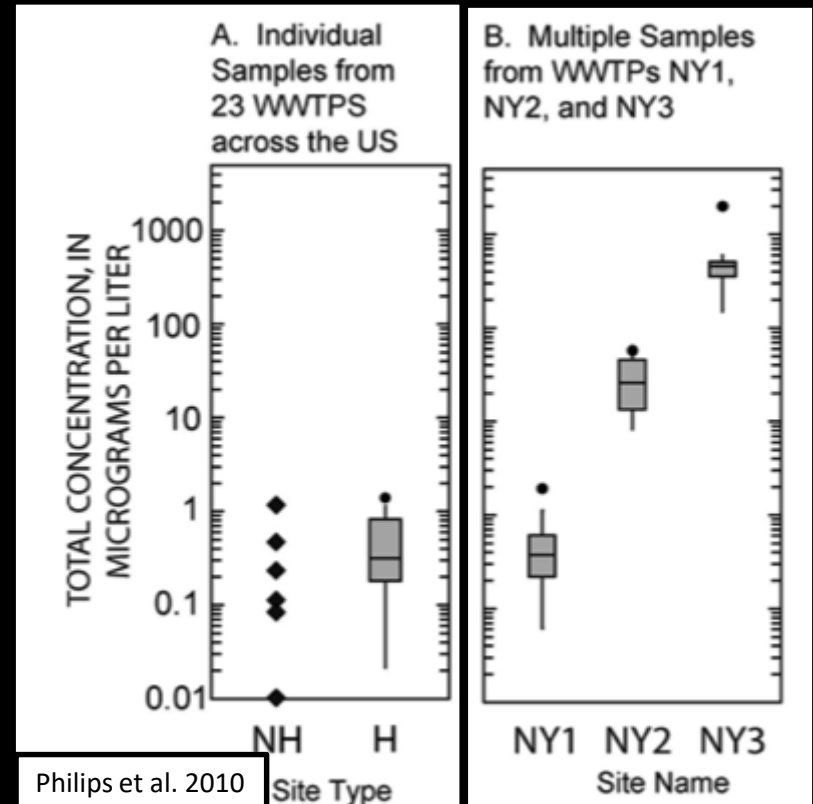
How do drugs get into rivers?

Manufacturing facilities



Streams at pharmaceutical manufacturing facilities have much higher concentrations of PPCPs

Image from The Telegraph.com



More extreme examples of PPCPs associated with manufacturing abroad

Illicit drug production and disposal is an unknown source

How do drugs get into rivers?

Use and metabolism

In the US, 3.5 Billion
prescriptions filled/year

or 11.9/person (Musson and
Townsend 2009)

Non-prescription drugs and
personal care products

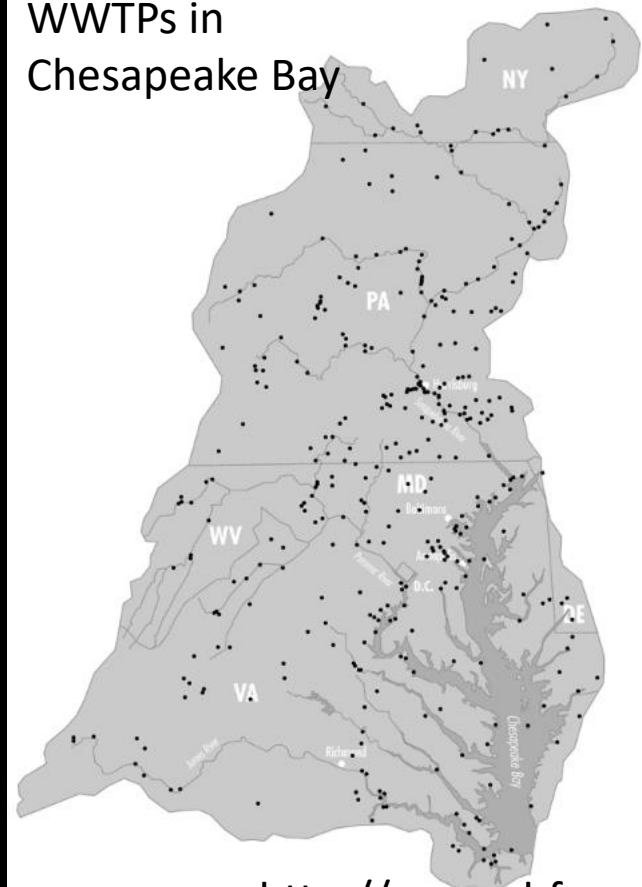


How do drugs get into rivers?

Wastewater treatment plants



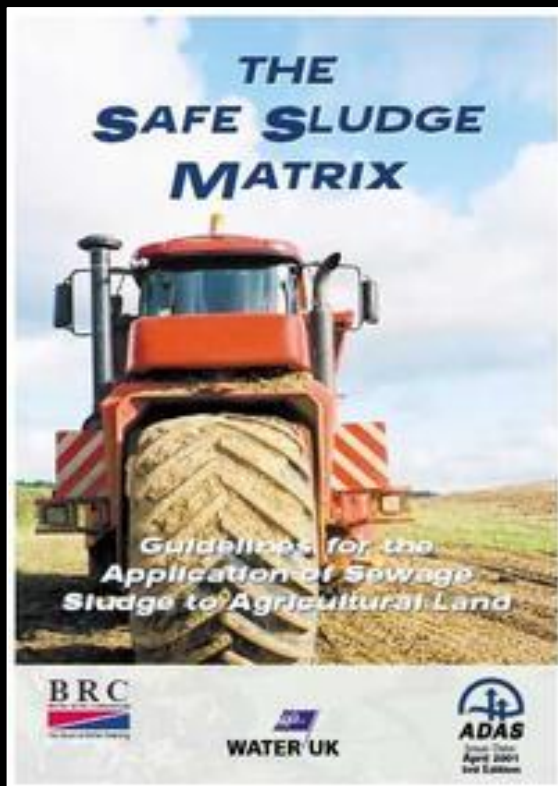
WWTPs in
Chesapeake Bay



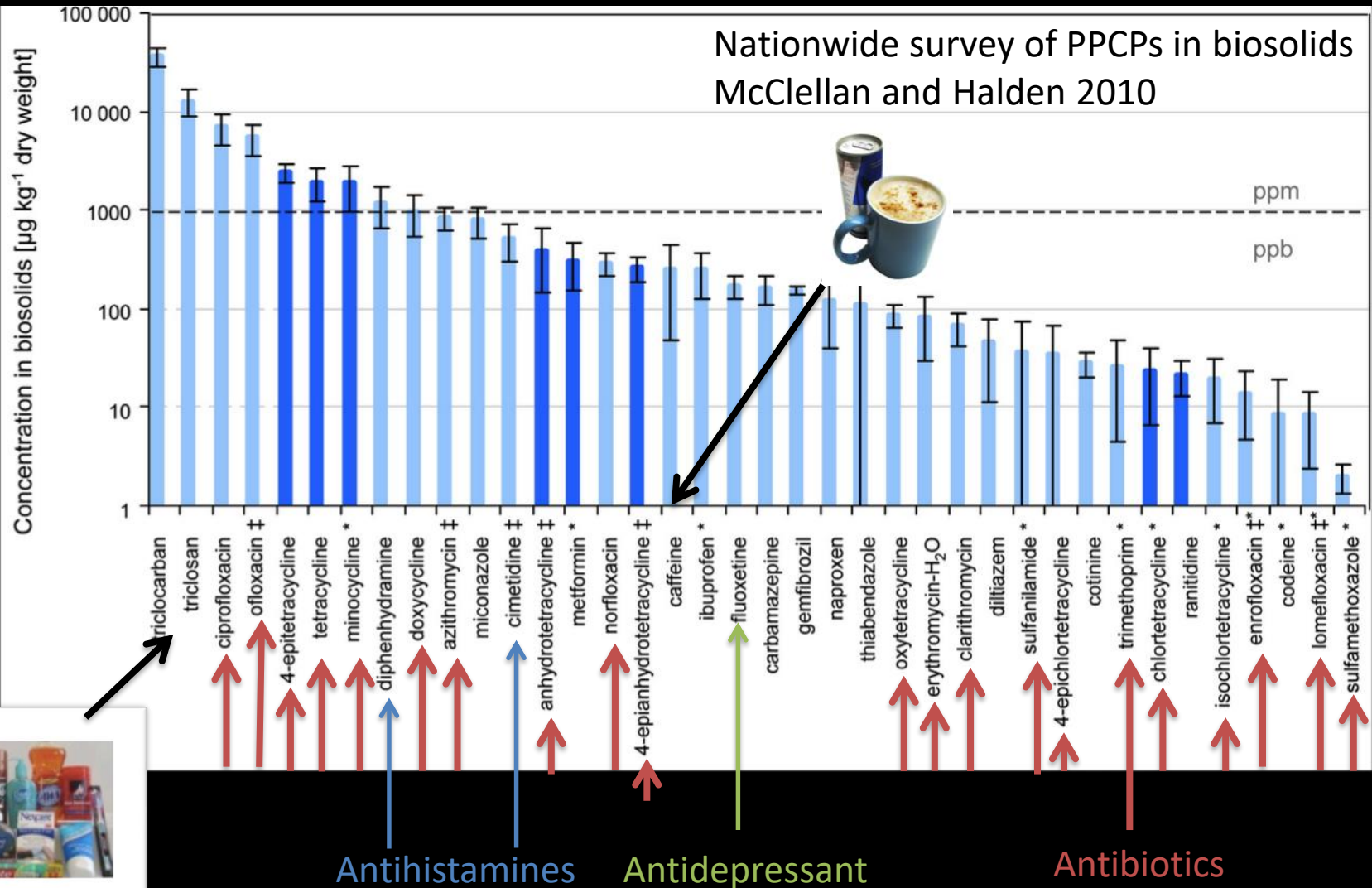
<http://www.cbf.org/>

Biosolids

~60% of US Biosolids are land applied (US EPA)
and in the Chesapeake Bay Watershed



PPCPs in Biosolids



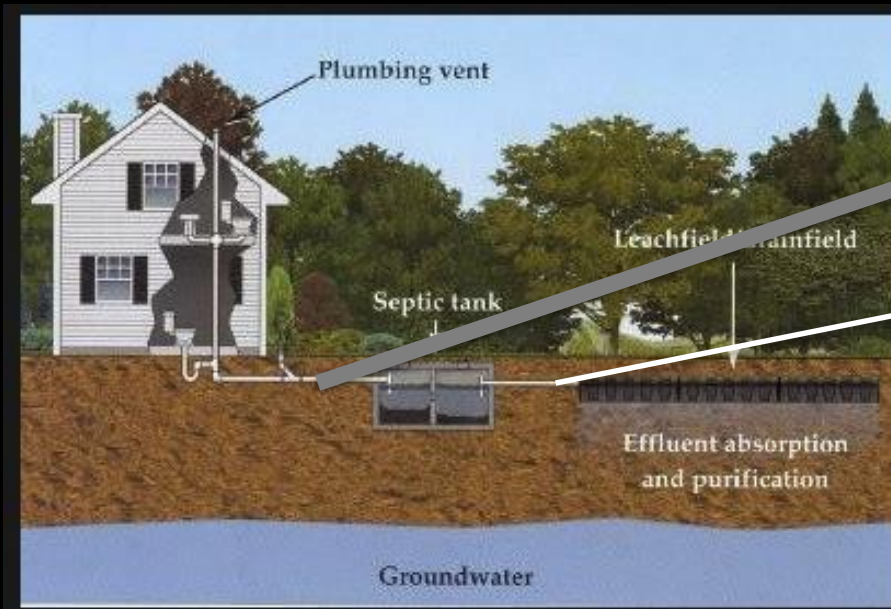
Solid Waste

- Disposal of unused PPCPs in US landfills
 - 1388 – 8432 tons of PPCPS/ year*

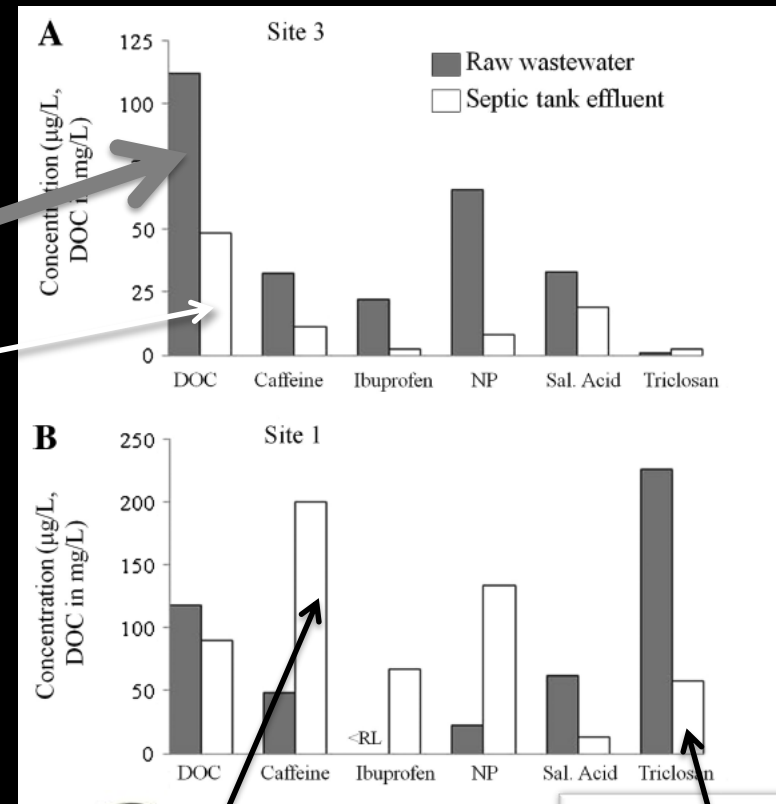


*Musson and Townsend 2009

Septic tanks

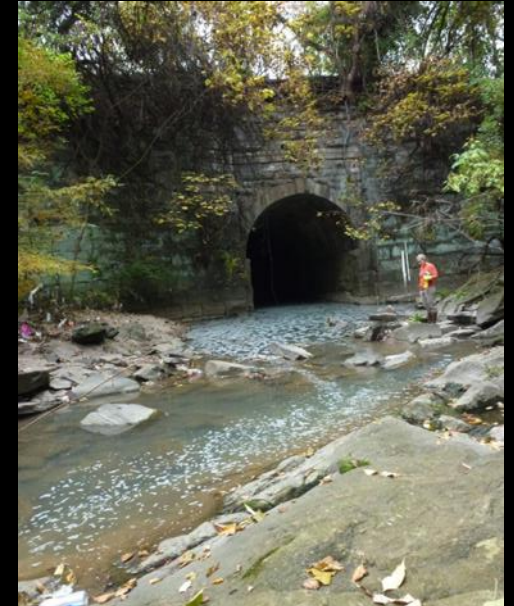


<https://www.thenaturalhome.com/septic.html>



Failing infrastructure in the US

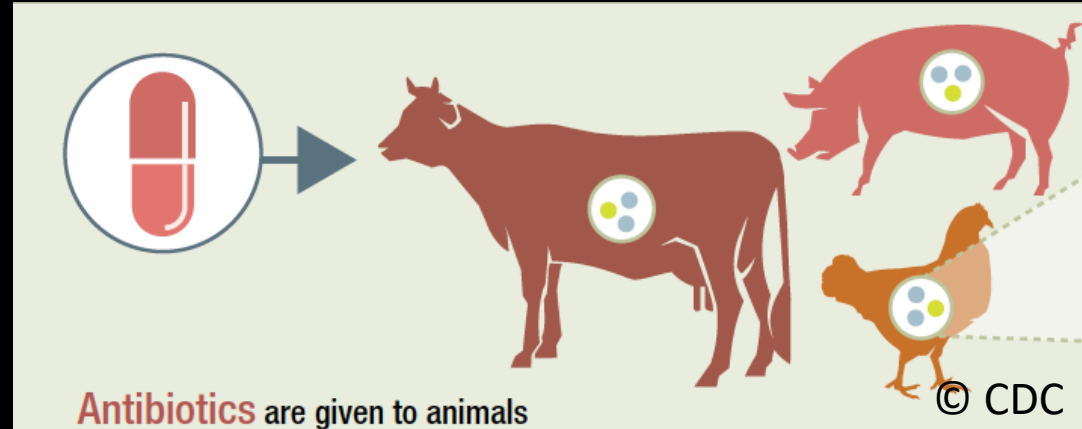
- Each day 32 billion gallons of this wastewater flows through 700,000 miles of underground pipes
- 900 billion gallons of sewage is released into the nation's rivers and streams each year
- American Society of Civil Engineers recently gave the US sewage infrastructure a "D"
- \$300 billion needed to upgrade the sewage systems
- Baltimore currently repairing infrastructure under a consent decree



Drugs in agriculture



By Larry Rana (USDA) [Public domain], via
Wikimedia Commons



Over half of antibiotics used in this country are for livestock (Lipsitch et al. 2002)

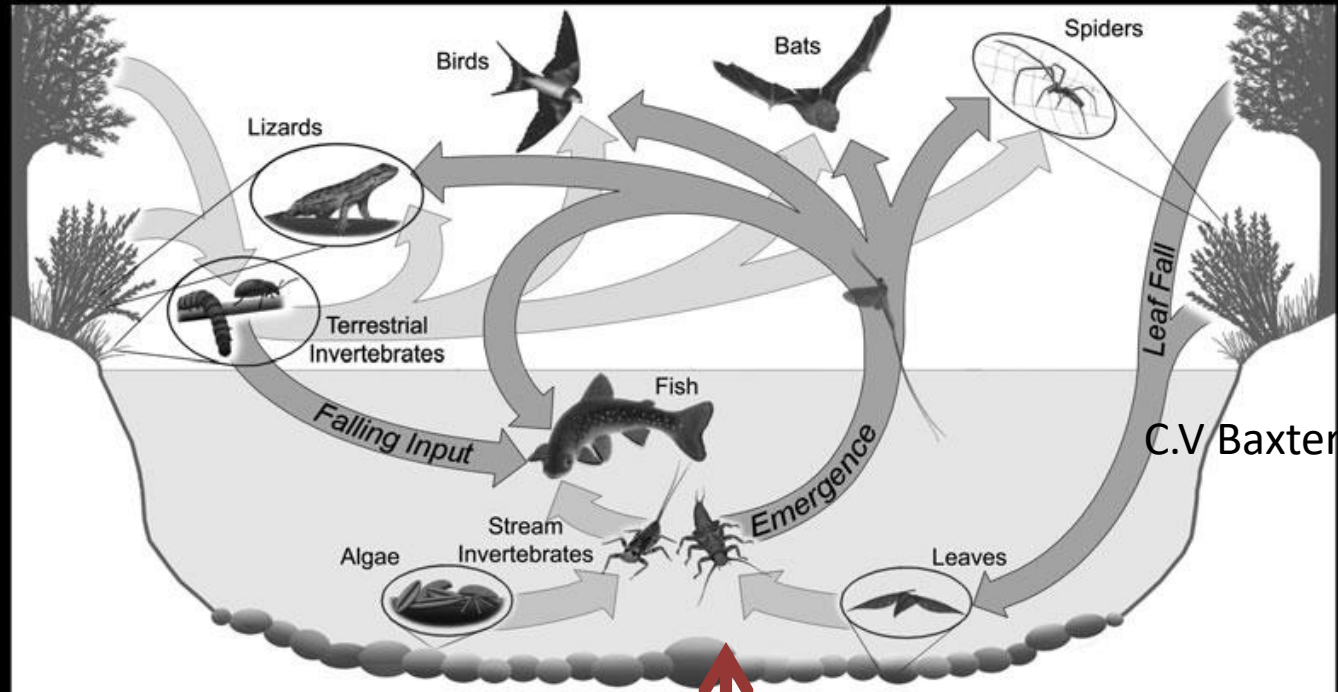
Animal wastes contribute pharmaceuticals to the environment

What do drugs do in rivers?

1,7 Dimethylxanthine
Antipyrine
Benzoylcholine
Acetaminophen
Caffeine
Carbamazepine
Cimetidine
Cocaine
Codeine
Cotinine
Diphenhydramine
Ditiazem
EDDP
Fluoxetine
Hydrocodone
MDA
MDEA
MDMA
Metformin
Methadone
Methamphetamine
Morphine
Nicotine
Norcocaine
Paraxanthine
Ranitidine

Salbutamol
Sulfamethoxazole
Trimethoprim
Thiabendazole

List compiled by
Paspalof, A. M.S.
Thesis



Many possible effects
Toxicological
Endocrine disruption
Ecological

Research Approach

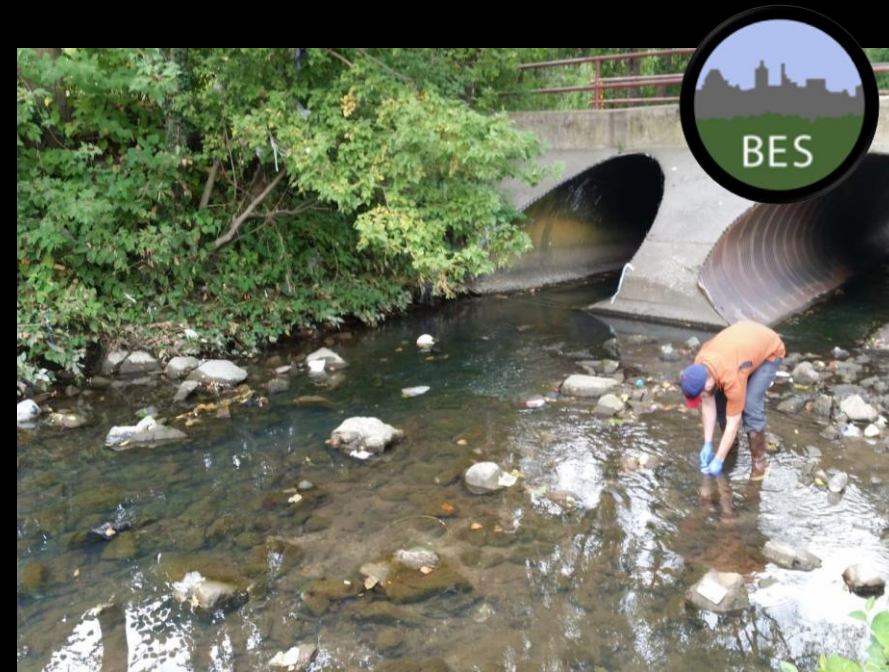
Field measurements in streams
in Baltimore

BES LTER has been studying
these streams for 20 years

X

Artificial stream facility

20 streams can be used for
experiments to test drug effects
on algae, bacteria, nutrient
cycling, invertebrates, etc



Pharmaceuticals and Illicit Drugs in Baltimore Streams

We detected a range of drugs in Baltimore streams

Illicit drugs (e.g. morphine which is a metabolite of heroine use)

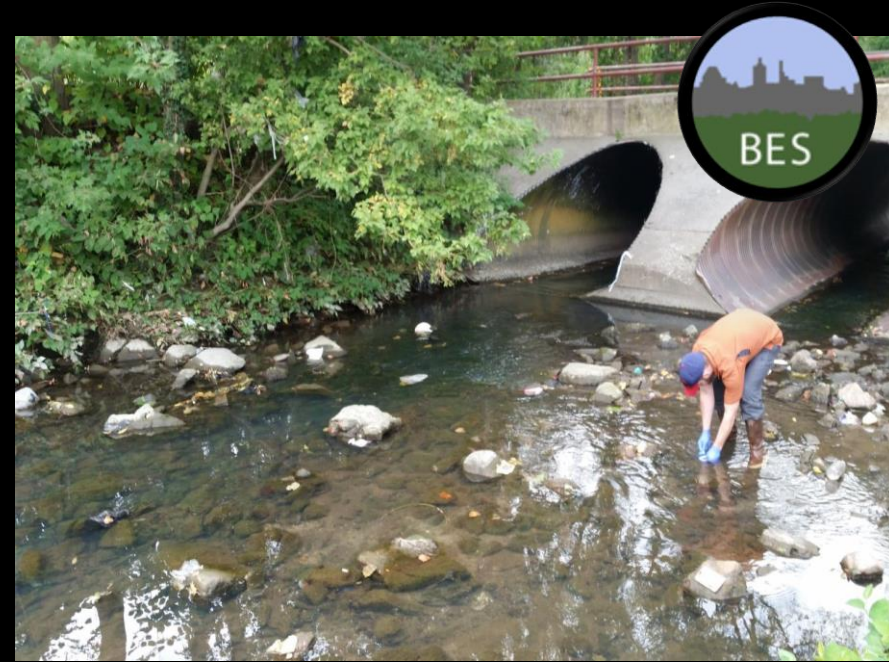
Amphetamines

Antibiotics

Antihistamines

Antidepressants

Other



Research Approach

We have conducted a range of experiments to investigate the effects of drugs detected in surface waters



Bacteria



Bugs



Algae on drugs

PPCPs that affect algae:

Triclosan (antibacterial in soap)

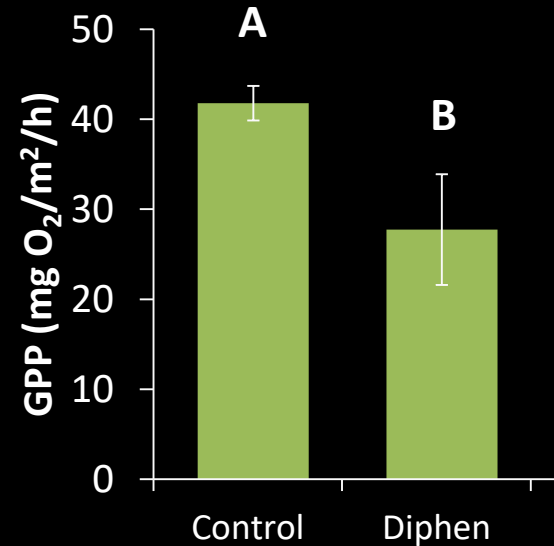
Diphenhydramine

Amphetamines

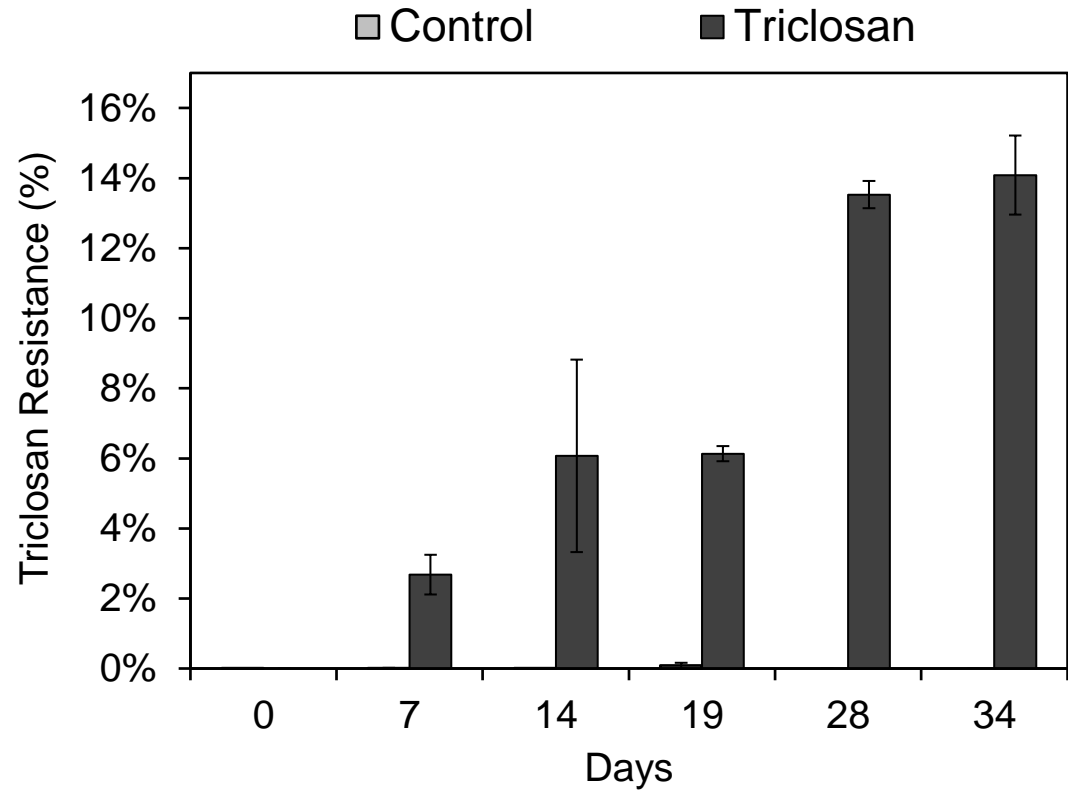
Antidepressants (SSRIs)

Combinations of drugs

Changed community composition

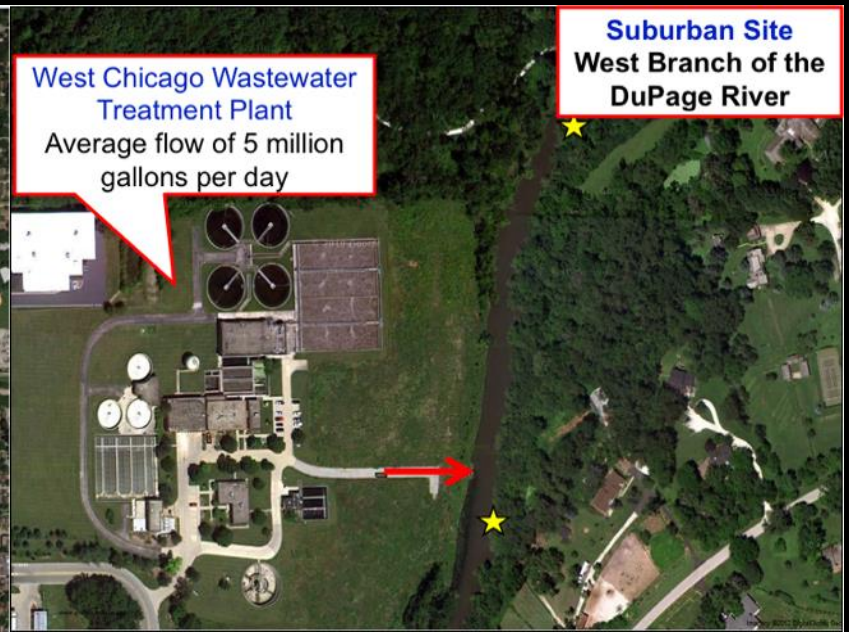
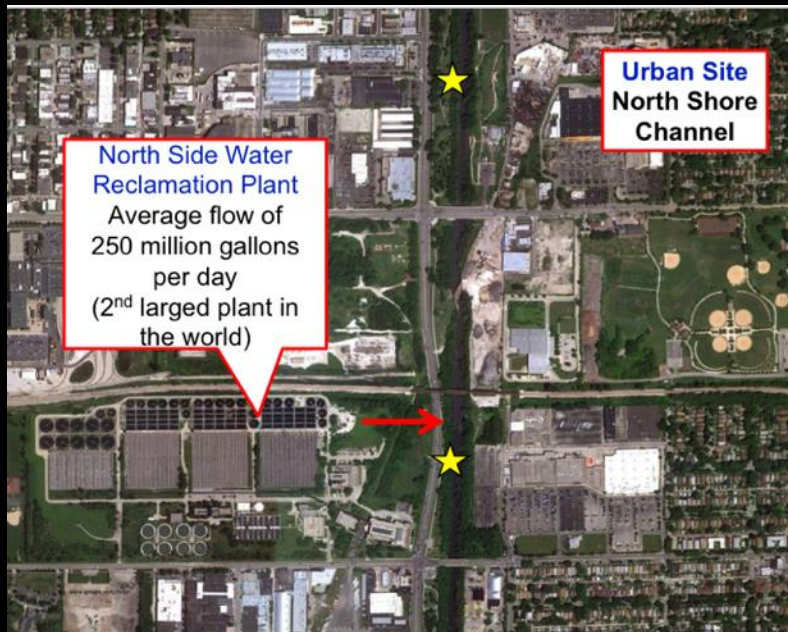
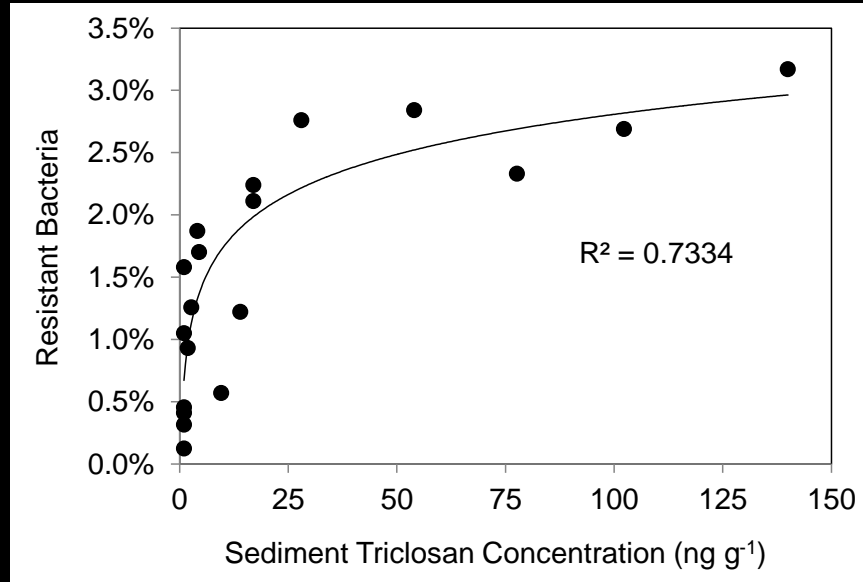


Bacteria on drugs



- Next generation sequencing to identify bacteria
- Triclosan altered the composition of bacterial communities

Bacteria on drugs



Bugs on drugs



- Antihistamines reduced populations
- Antidepressants and amphetamines increased emergence



Important take home message: Rivers have a mix of drug “cocktails”

1,7 Dimethylxanthine
Antipyrine
Benzoylcholine
Acetaminophen
Caffeine
Carbamazepine
Cimetidine
Cocaine
Codeine
Cotinine
Diphenhydramine
Diltiazem
EDDP
Fluoxetine
Hydrocodone
MDA
MDEA
MDMA
Metformin
Methadone
Methamphetamine
Morphine
Nicotine
Norcocaine
Paraxanthine
Ranitidine

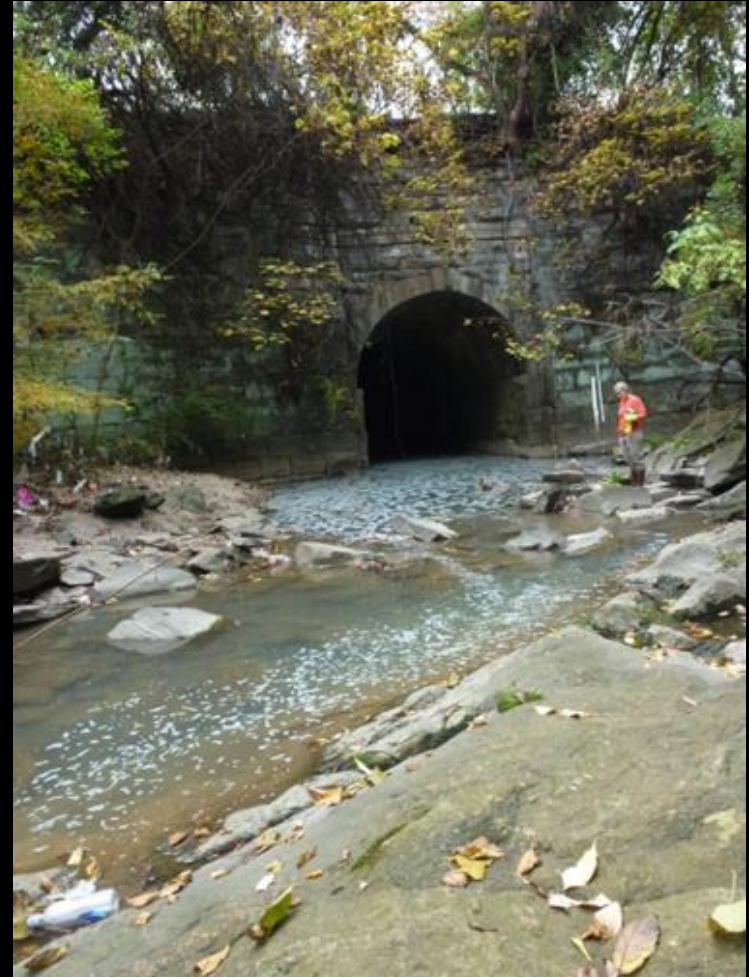
Salbutamol
Sulfamethoxazole
Trimethoprim
Thiabendazole



1467 Pharmaceuticals in US Plus other stressors...

Aren't PPCPs Regulated?

- EPA regulates the release of sewage, but not PPCPs specifically
- PPCPs are not listed aquatic contaminants
- FDA regulates safety of drugs



The effects of PPCPs on the environment are not well understood and currently not well regulated

What can be done?

- Reduce use of pharmaceuticals and personal care products when possible
- Develop and encourage proper disposal
 - “Take back” programs
- Maintain and upgrade sewage infrastructure and WWTPs
- Support this type of research- currently under funded



Thank you

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