

OUR BAY AND RIVERS ON DRUGS

pharmaceuticals and illicit drugs as agents of ecological change

Emma J. Rosi, Senior Scientist and Director Baltimore Ecosystem Study LTER



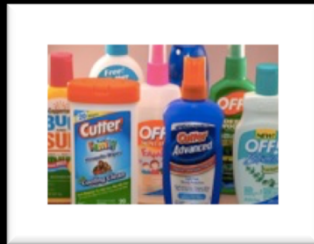
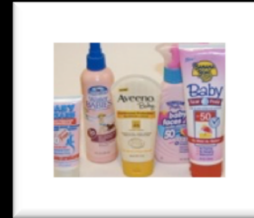
Cary Institute
of Ecosystem Studies



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

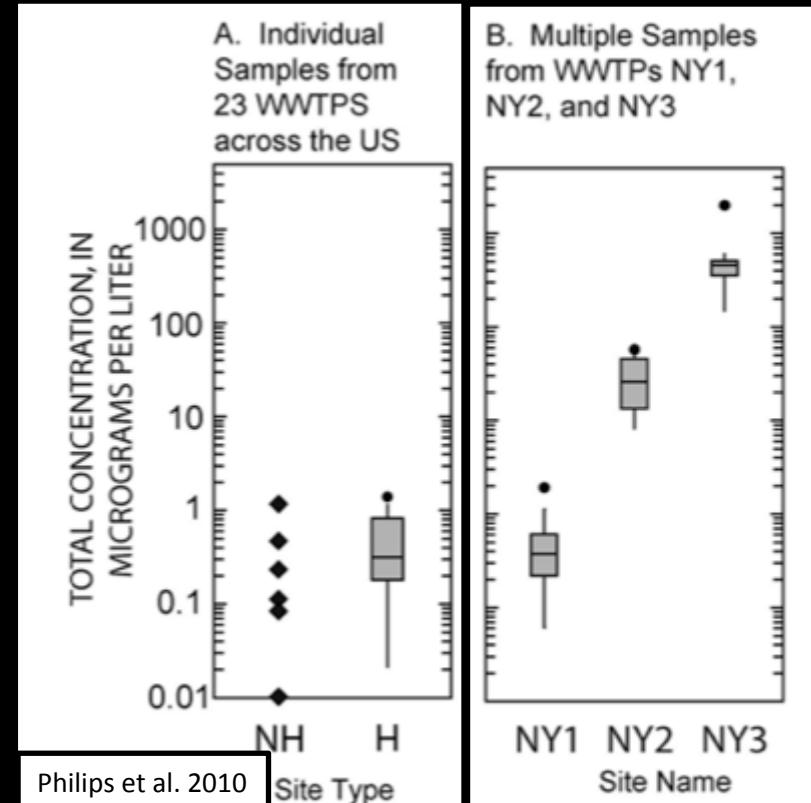
People

How do drugs get into rivers?

Manufacturing facilities



Streams in New York that have pharmaceutical manufacturing facilities have much higher concentrations of PPCPs



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

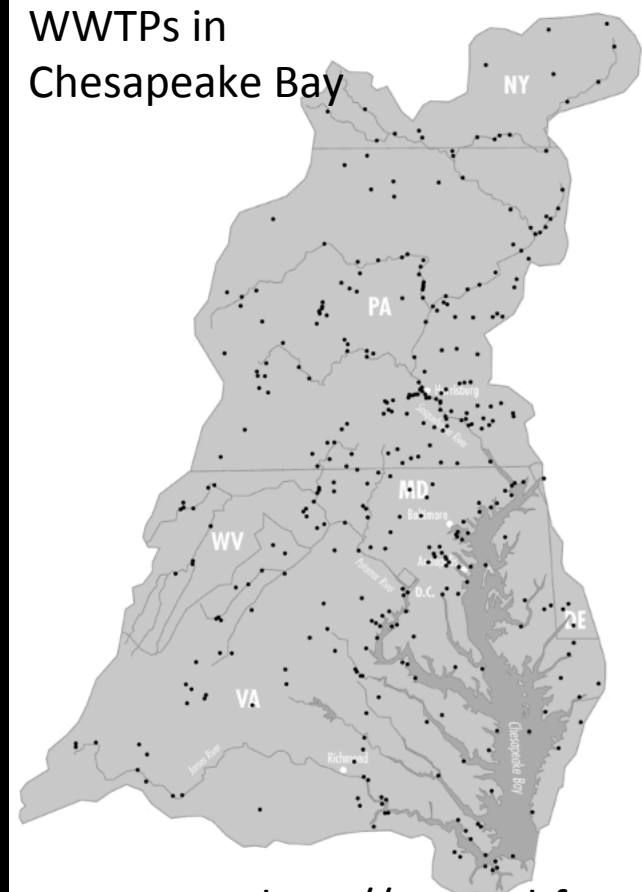
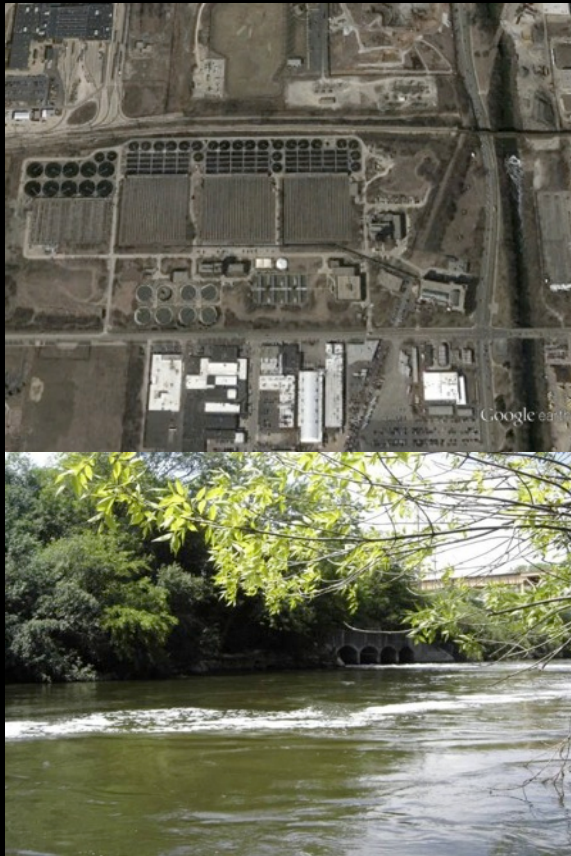
or 11.9/person (Musson and Townsend 2009)

Non-prescription drugs and personal care products



How do drugs get into rivers?

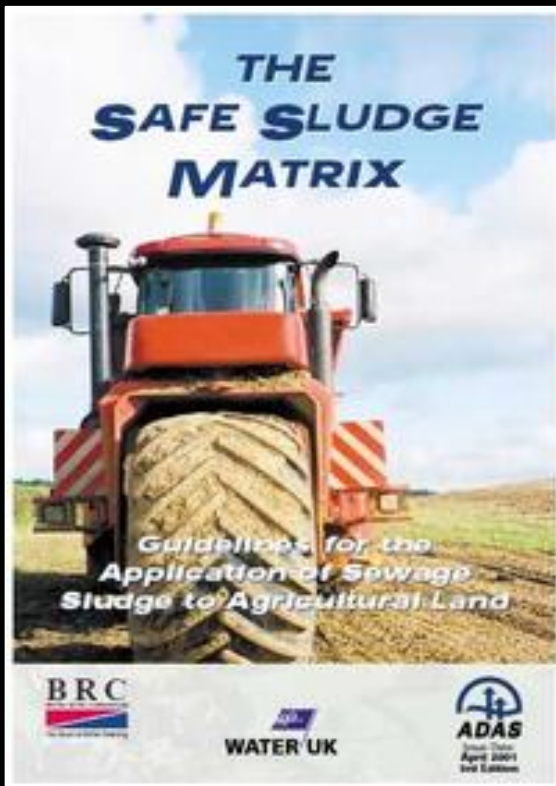
Wastewater treatment plants



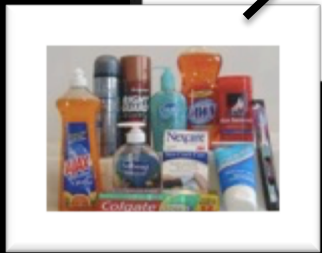
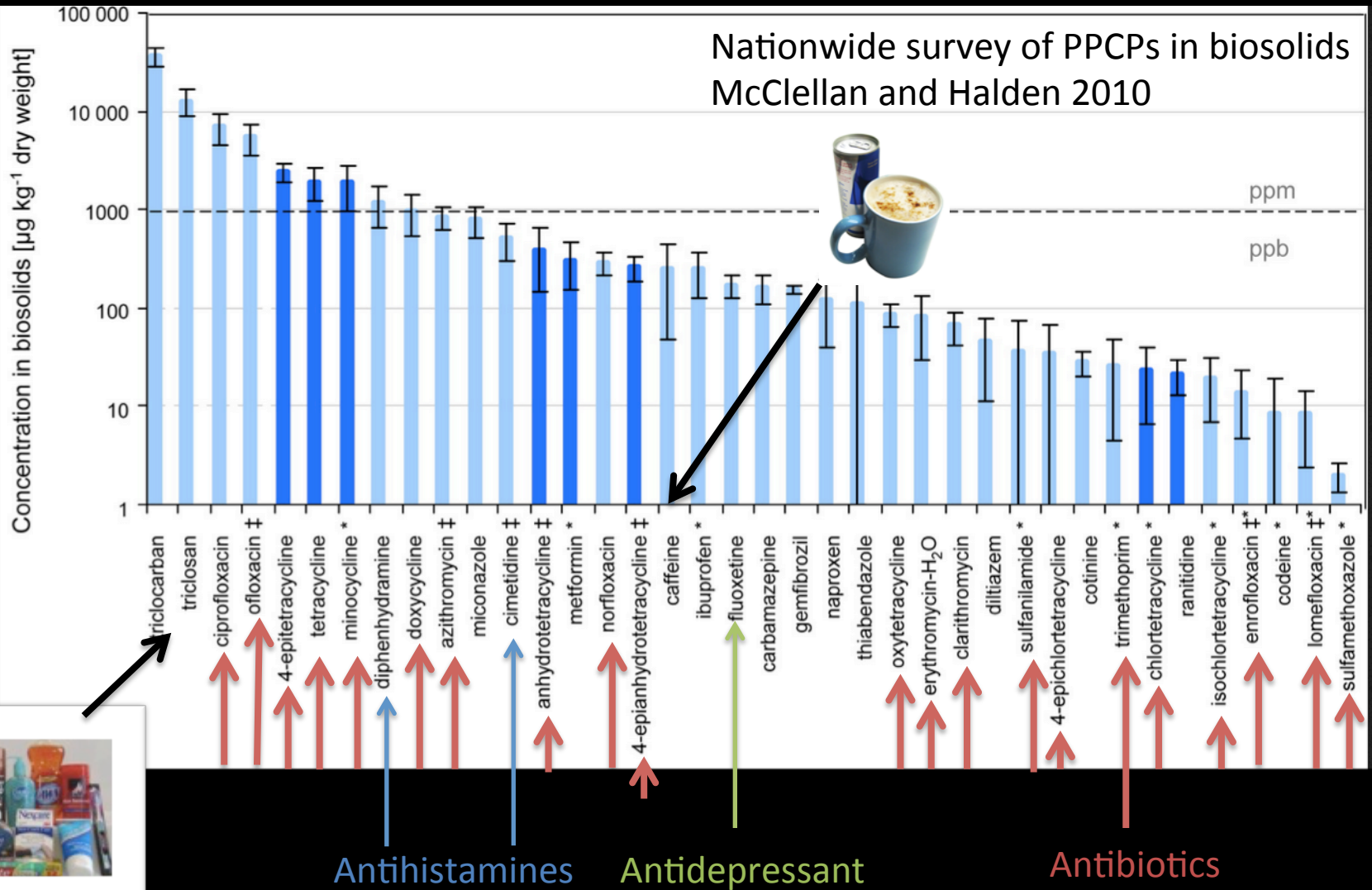
<http://www.cbf.org/>

Biosolids

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



PPCPs in Biosolids

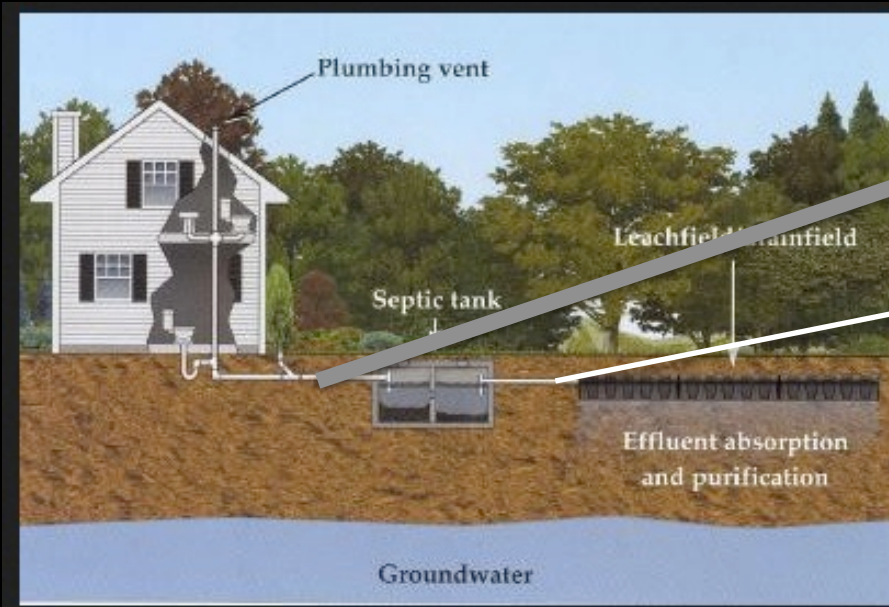


Solid Waste

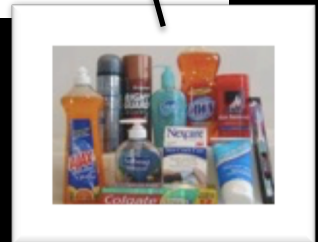
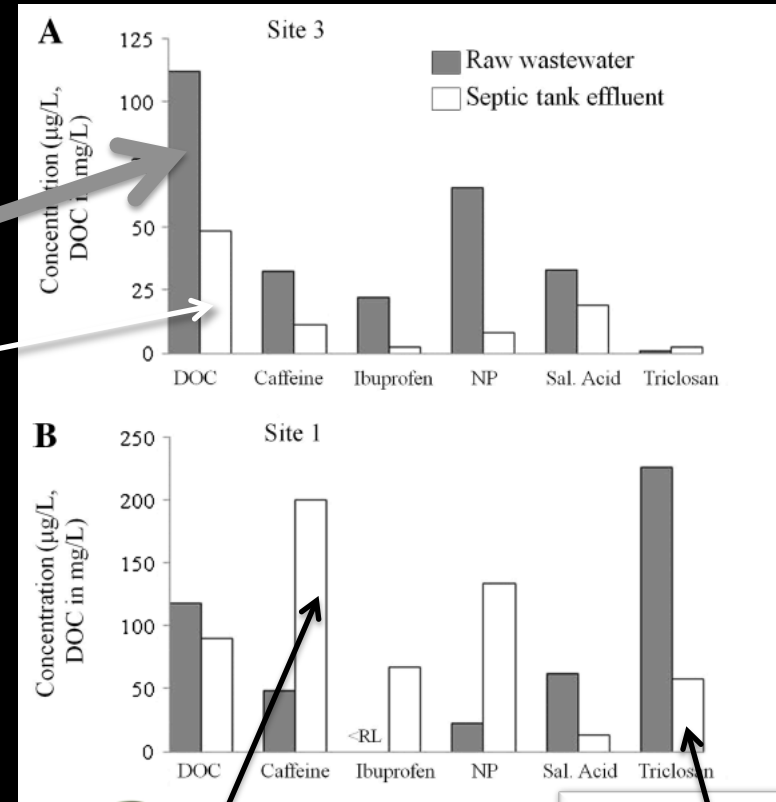
- Disposal of unused PPCPs in US landfills
 - 1388 – 8432 tons of PPCPS/ year*



Septic tanks

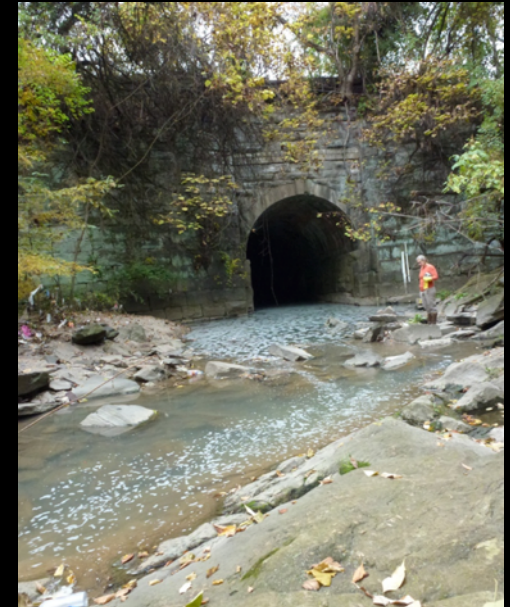


<https://www.thenaturalhome.com/septic.html>



Failing infrastructure in the US

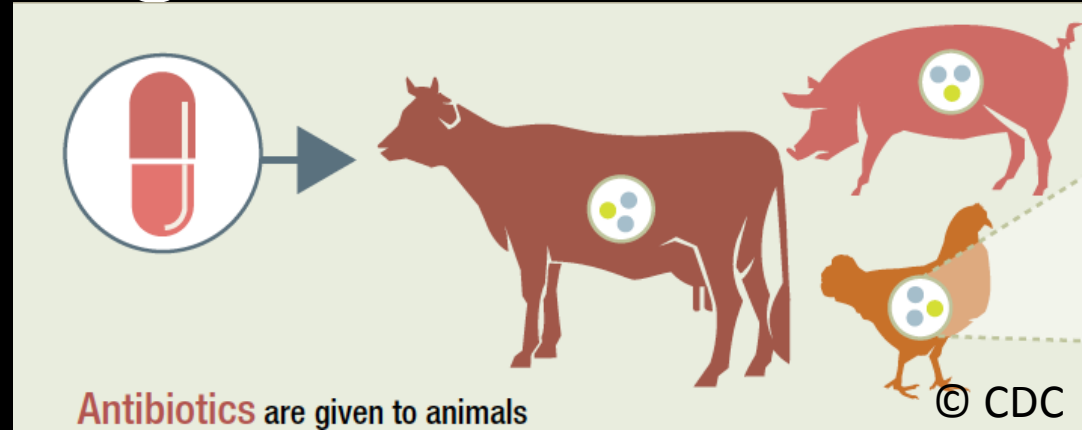
- Each day 32 billion gallons of this wastewater flows through 700,000 miles of underground pipes
- 900 billion gallons of sewage is released into the nation's rivers and streams each year
- American Society of Civil Engineers recently gave the US sewage infrastructure a "D"
- \$300 billion needed to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

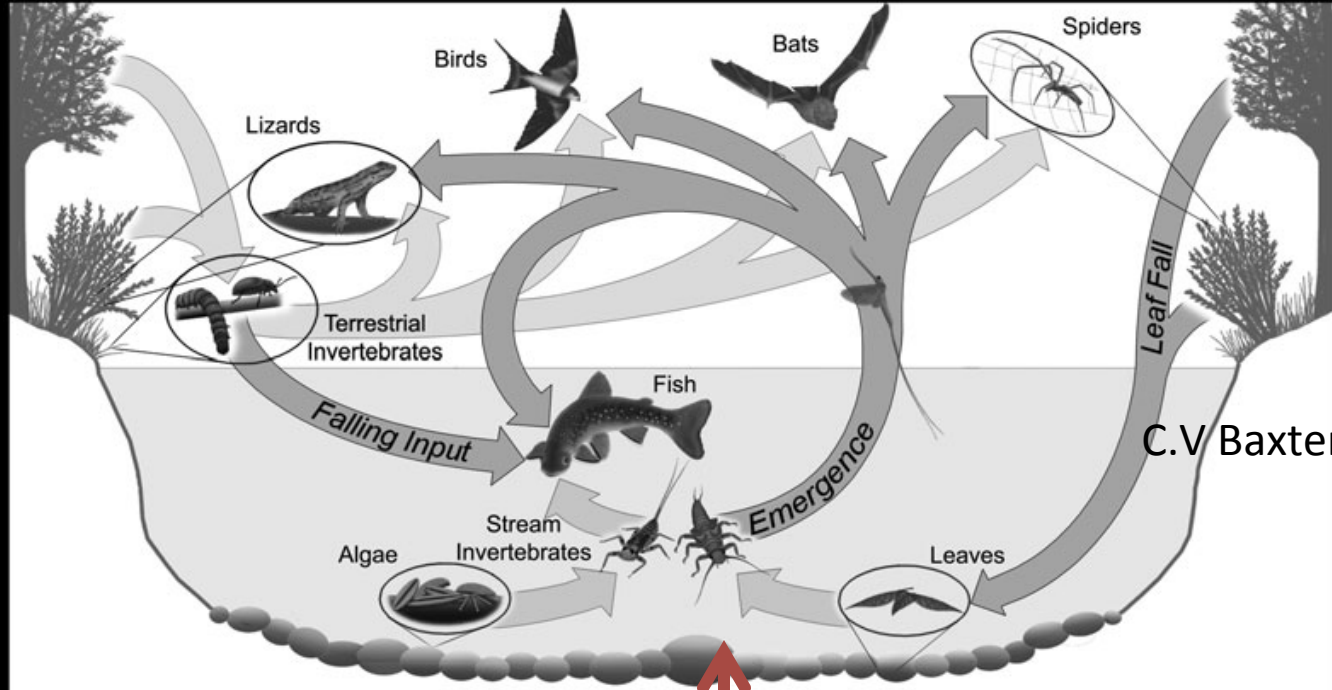
Animal wastes contribute pharmaceuticals to
the environment

What do drugs do in rivers?

- 1,7 Dimethylxanthine
- Antipyrine
- Benzoylechomine
- Acetaminophen
- Caffeine
- Carbamazepine
- Cimetidine
- Cocaine
- Codeine
- Cotinine
- Diphenhydramine
- Ditiazem
- EDDP
- Fluoxetine
- Hydrocodone
- MDA
- MDEA
- MDMA
- Metformin
- Methadone
- Methamphetamine
- Morphine
- Nicotine
- Norcocain
- 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



Algae on drugs

PPCPs that affect algae:

Triclosan (antibacterial in soap)

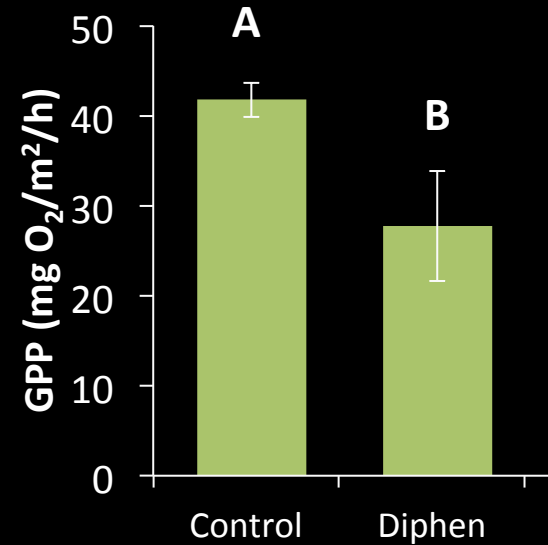
Diphenhydramine

Amphetamines

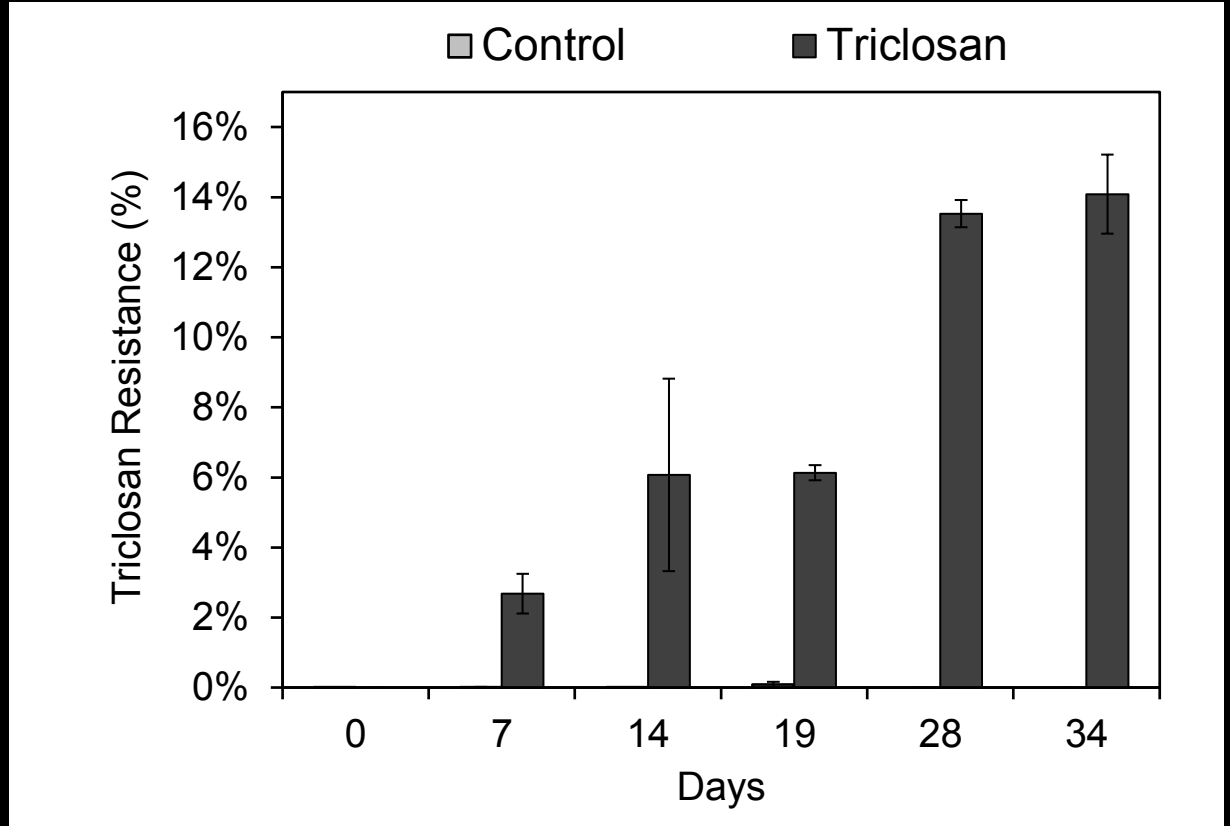
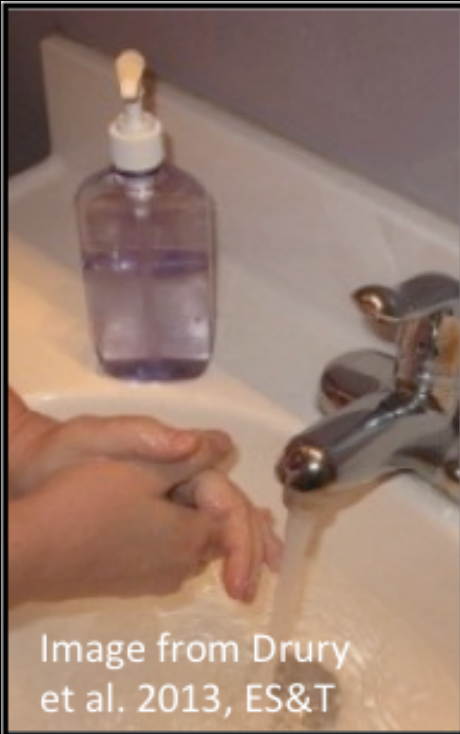
Antidepressants (SSRIs)

Combinations of drugs

Changed community composition

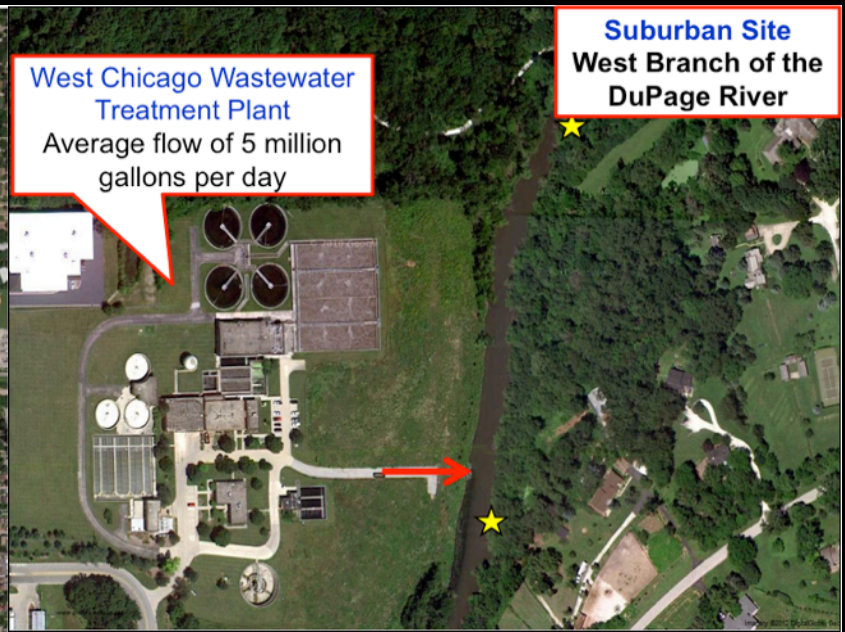
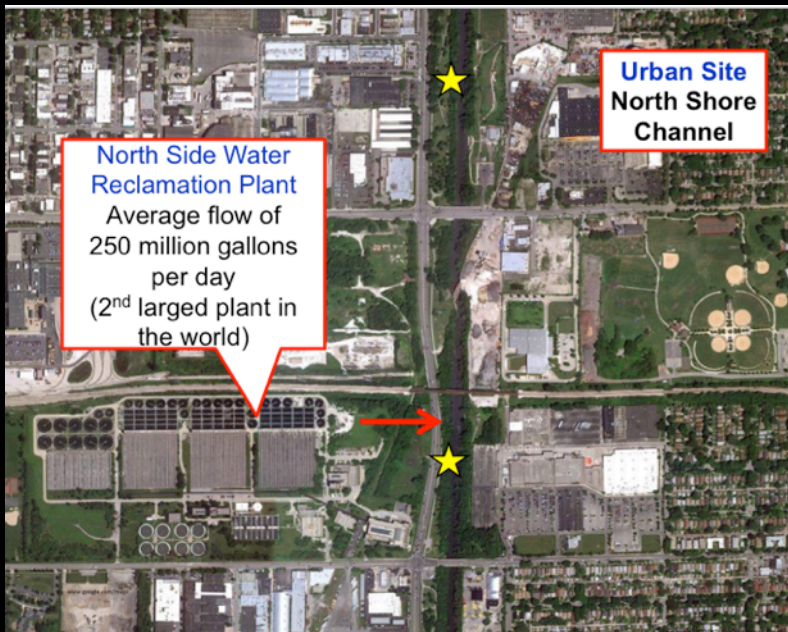
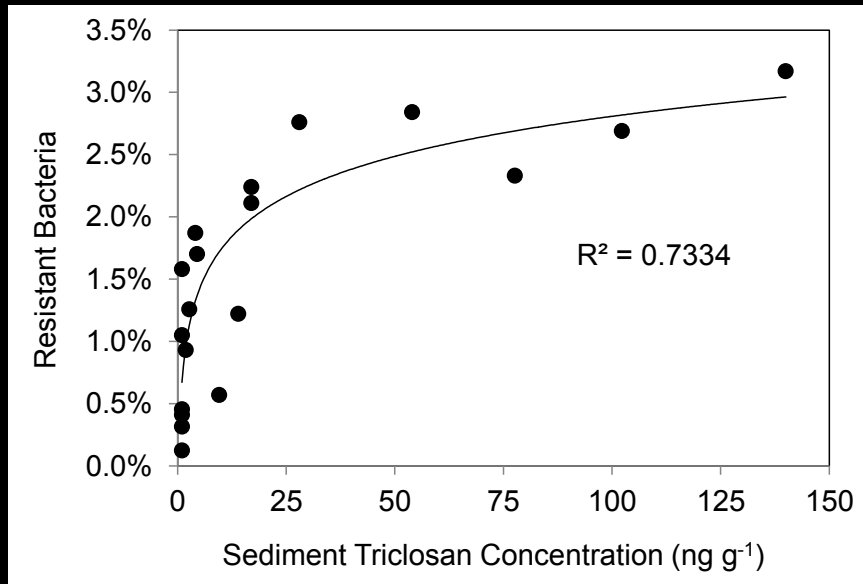


Bacteria on drugs



- 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”

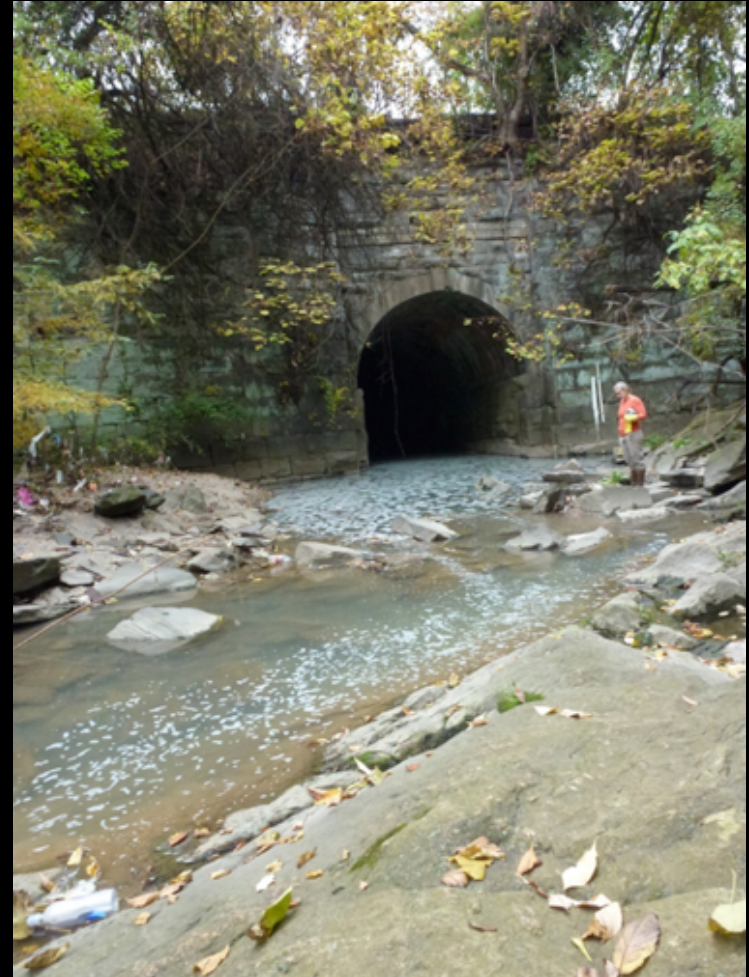
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Diltiazem
EDDP
Fluoxetine
Hydrocodone
MDA
MDEA
MDMA
Metformin
Methadone
Methamphetamine
Morphine
Nicotine
Norcocaine
Paraxanthine
Ranitidine
Salbutamol
Sulfamethoxazole
Trimethoprim
Thiabendazole



**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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Baltimore
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