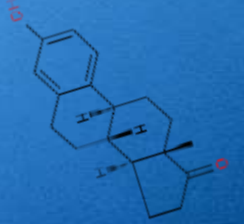
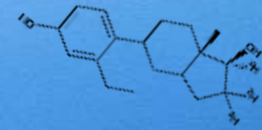
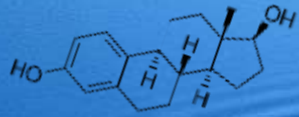


Contaminants of Emerging Concern: Challenges going forward – What we know and what we still don't know



George Heufelder
Massachusetts Alternative Septic System Test Center
Barnstable County Department of Health and Environment



Coming to terms with terms.

Micropollutants

Trace organic compounds

Contaminants of emerging concern (CEC)

Pharmaceuticals and Personal Care Products (PPCP)

OR

**“Things you don’t want to release untreated into the environment because you might end up drinking, swimming in, or otherwise being exposed to”
(not to mention what they might do to our wildlife)**



>87,000 commercially available chemicals (2,000 added annually)



WHY SHOULD WE CARE?

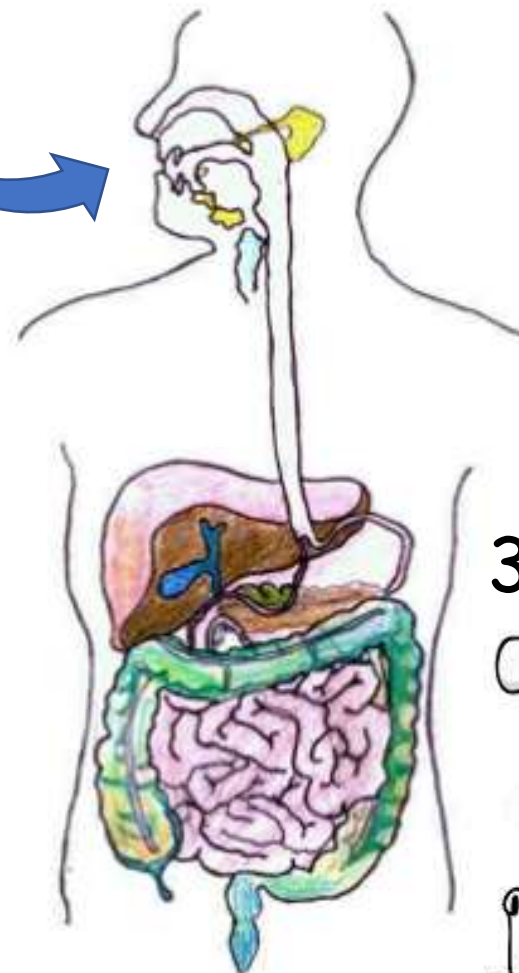
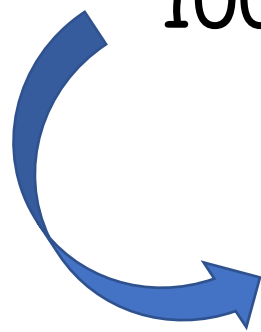
2 GOOD REASONS

Reason 1

One person's wastewater is another person's medication.



100 % ingested



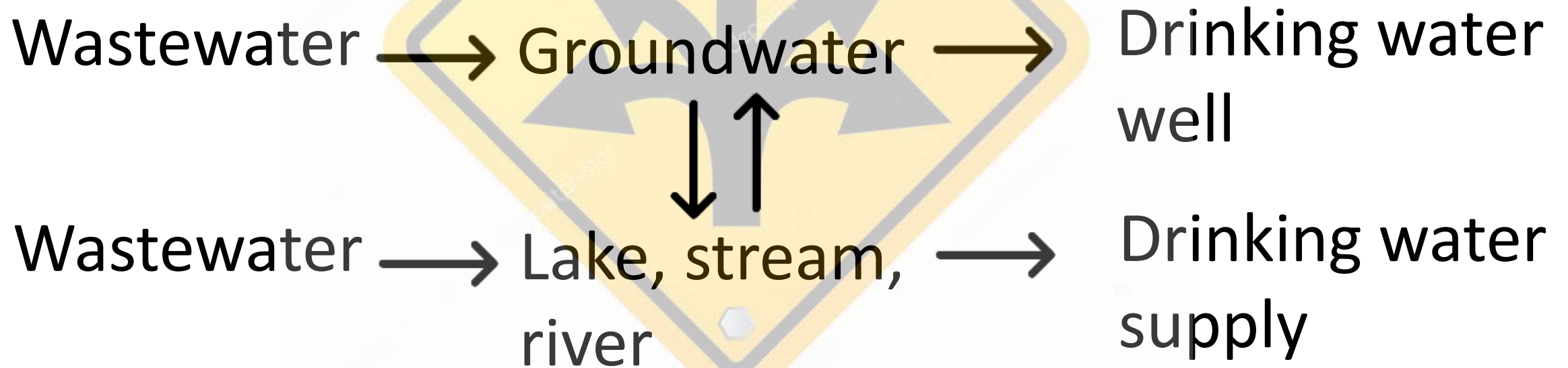
DEET, MUSK
PCP

30-90% Excreted



Reason 1

There are numerous pathways from wastewater to drinking water supplies that do not complete the removal of CEC.

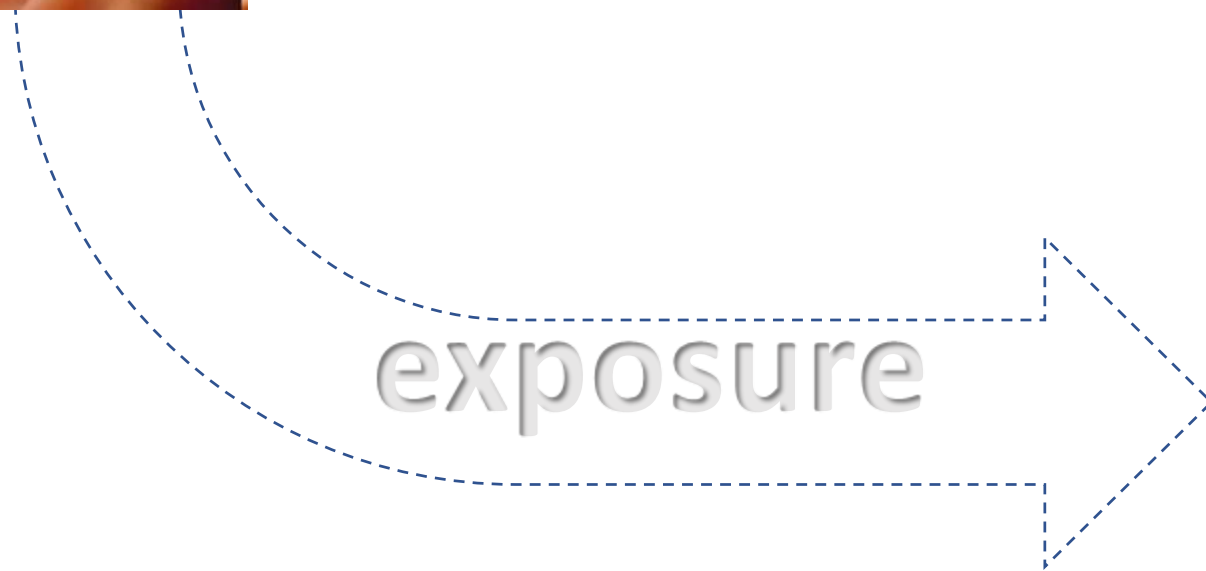


Reason 1



Although therapeutic doses are rarely encountered, the effect of long-term exposure to many contaminants of emerging concern on humans is not known

(although some animal studies suggest some negative effects)



Reason 2

Humans may not get a good dose but they do !



Reproductive effects of endocrine disrupting chemicals, bisphenol-A and 17 β -oestradiol, on *Cerastoderma edule* from south-west England: field study and laboratory exposure



Intersex occurrence in rainbow trout (*Oncorhynchus mykiss*) male fry chronically exposed to ethynylestradiol.



Carbamazepine disrupts molting hormone signaling and inhibits molting and growth of *Eriocheir sinensis* at environmentally relevant concentrations.



Effect of polycyclic musk compounds on aquatic organisms: A critical literature review supplemented by own data

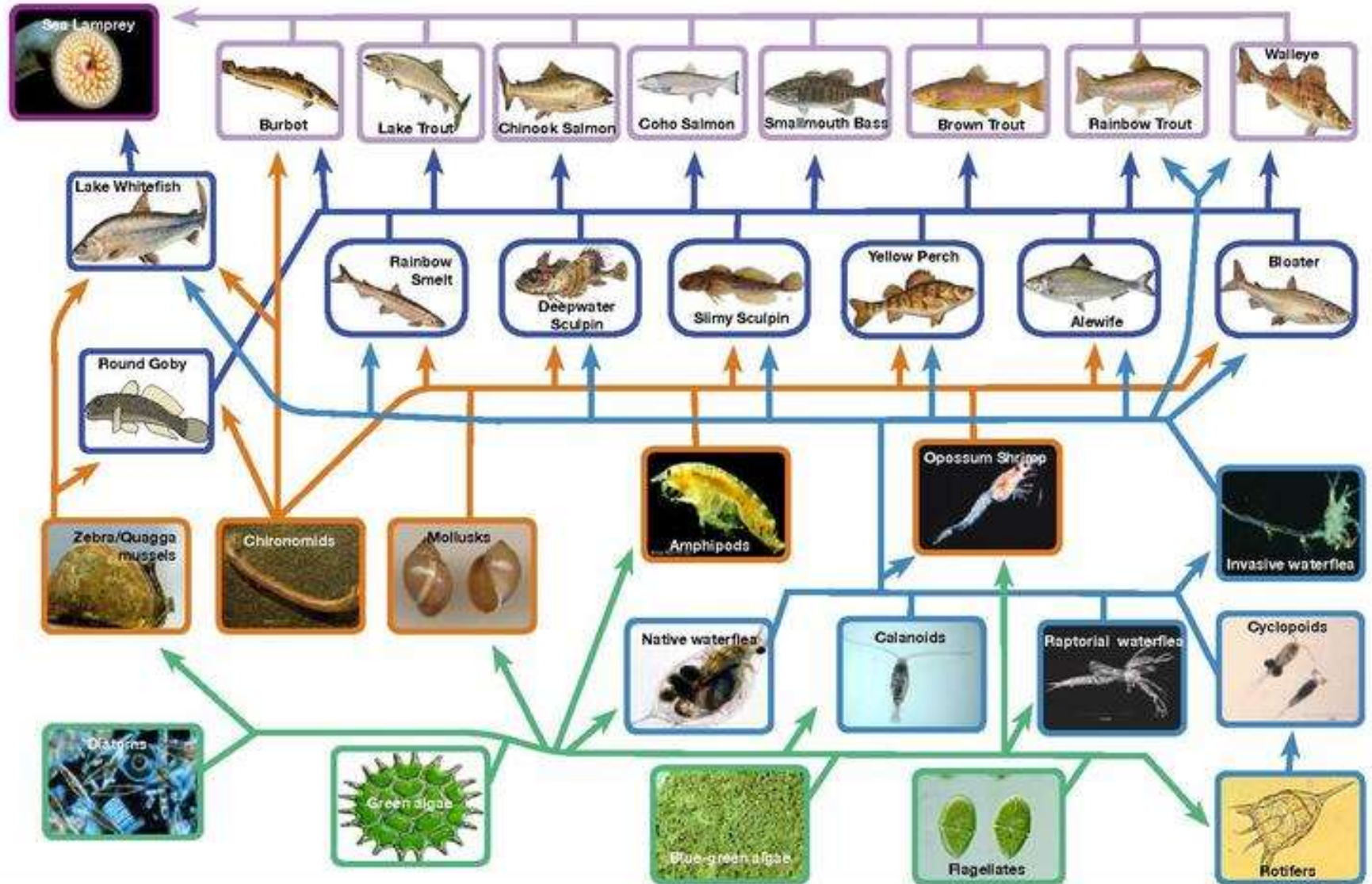
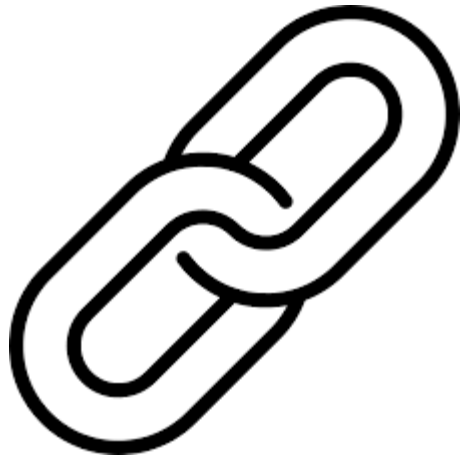
Reason 2



Lake Michigan Food Web



We are all linked



The top three concerns of CEC in wastewater

- Endocrine disruption
- Direct toxicity
- Antibiotic/antimicrobial activity

Concern #1

Endocrine disruption is
one of the most insidious
impacts of any
wastewater contaminant

Personal opinion

Concern #1

Case in point....



A very little bit
goes a long long
way.

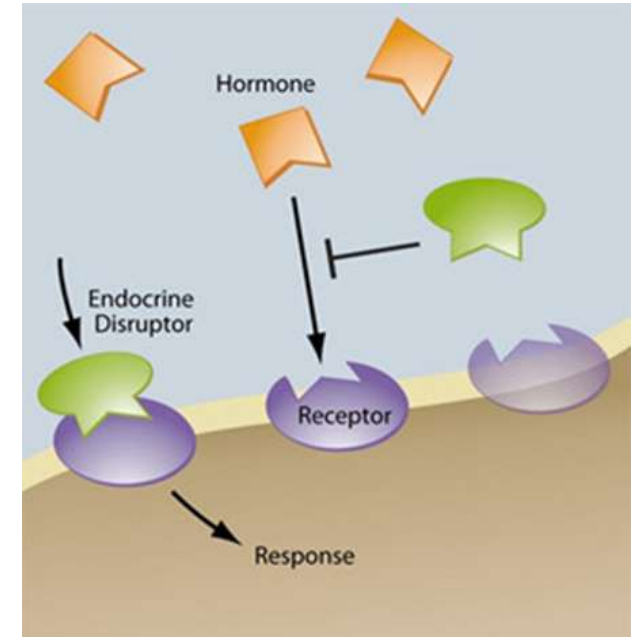
Collapse of a fish population after exposure to a synthetic estrogen

Karen A. Kidd ^{*}, [†], Paul J. Blanchfield ^{*}, Kenneth H. Mills ^{*}, Vince P. Palace ^{*}, Robert E. Evans ^{*}, James M. Lazorchak [†], and Robert W. Flick [†]



How does this happen? It turns out that you actually can fool Mother Nature.

Many hormones are regulated by feedback loops where the concentration of the hormone limits its further production.



Some CEC “lock into” receptors and hence may send the wrong signal to the body, either shutting off or ramping up the production of the hormone.

Concern #2

Direct Toxicity – includes impact to both to wastewater organisms and inhabitants of the receiving waters.

- Antibiotics
- Cancer therapies
- Pesticides

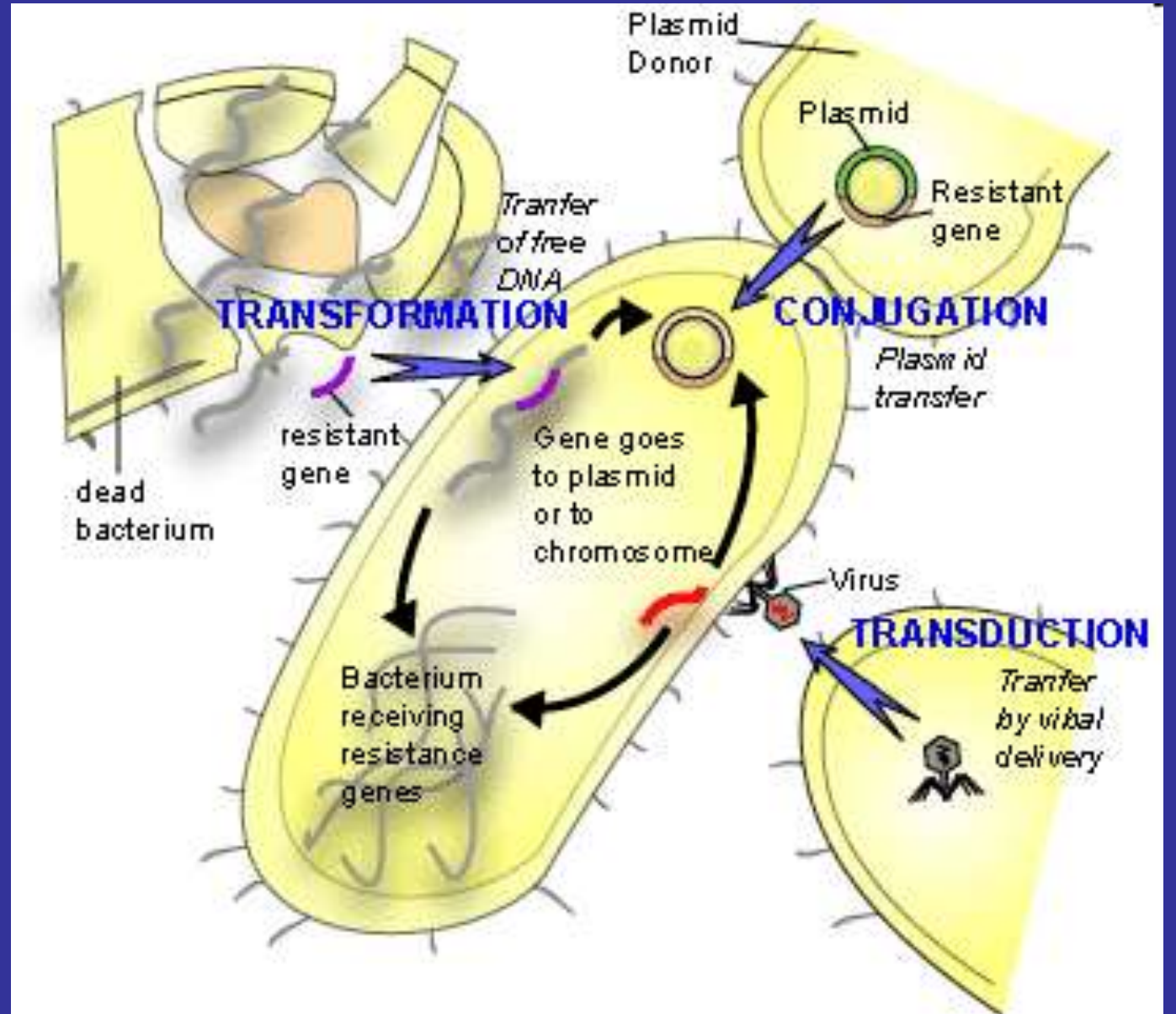
Concern #3

Issues with Antimicrobials/antibacterials

- Inducing antibiotic resistance (more of an issue with spreading of animal manure -veterinary medications)
- Direct effect on wastewater biology (generally episodic in nature)

Gene Swapping

Gene swapping undoubtedly occurs, but the implications of this are likely minimized by the nature of a septic system that has a soil absorption component.



So now what?

Reasons why the onsite septic system may be an efficient, sustainable way to treat for CEC and offer better treatments than centralized systems.

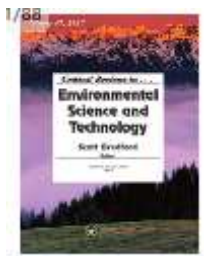


Review of Organic Wastewater Compound Concentrations and Removal in Onsite Wastewater Treatment Systems

Laurel A. Schaider,*¹ Kathryn M. Rodgers, and Ruthann A. Rudel

Silent Spring Institute, 320 Nevada Street, Suite 302, Newton, Massachusetts 02460 United States

**** Excellent meta-analysis of data**



A review of the fate and transport of nitrogen, phosphorus, pathogens, and trace organic chemicals in septic systems

Mary G. Lusk, Gurpal S. Toor, Yun-Ya Yang, Sara Mechtensimer, Mriganka De & Thomas A. Obreza

**** Excellent study review**

To cite this article: Mary G. Lusk, Gurpal S. Toor, Yun-Ya Yang, Sara Mechtensimer, Mriganka De & Thomas A. Obreza (2017) A review of the fate and transport of nitrogen, phosphorus, pathogens, and trace organic chemicals in septic systems, Critical Reviews in Environmental Science and Technology, 47:7, 455-541, DOI: [10.1080/10643389.2017.1327787](https://doi.org/10.1080/10643389.2017.1327787)

Must Reads



Present state of our knowledge regarding CEC treatment by onsite septic systems.

Reasons why the onsite septic system may be an efficient, sustainable way to treat for CEC and offer better treatments than centralized systems.

- They provide for longer residence times for treatment.
- They provide the possibility for more diverse biological community development.
- Possibly more opportunity for source management

Common theme



Oxygen
is the key

- Oxidic conditions provided by soil absorption systems and/or advanced treatment units promote better CEC removal (particularly for estrogen-like compounds).

Studies performed at MASSTC indicated better performance in shallow-soils based treatment for many CEC compared with wastewater treatment plants.



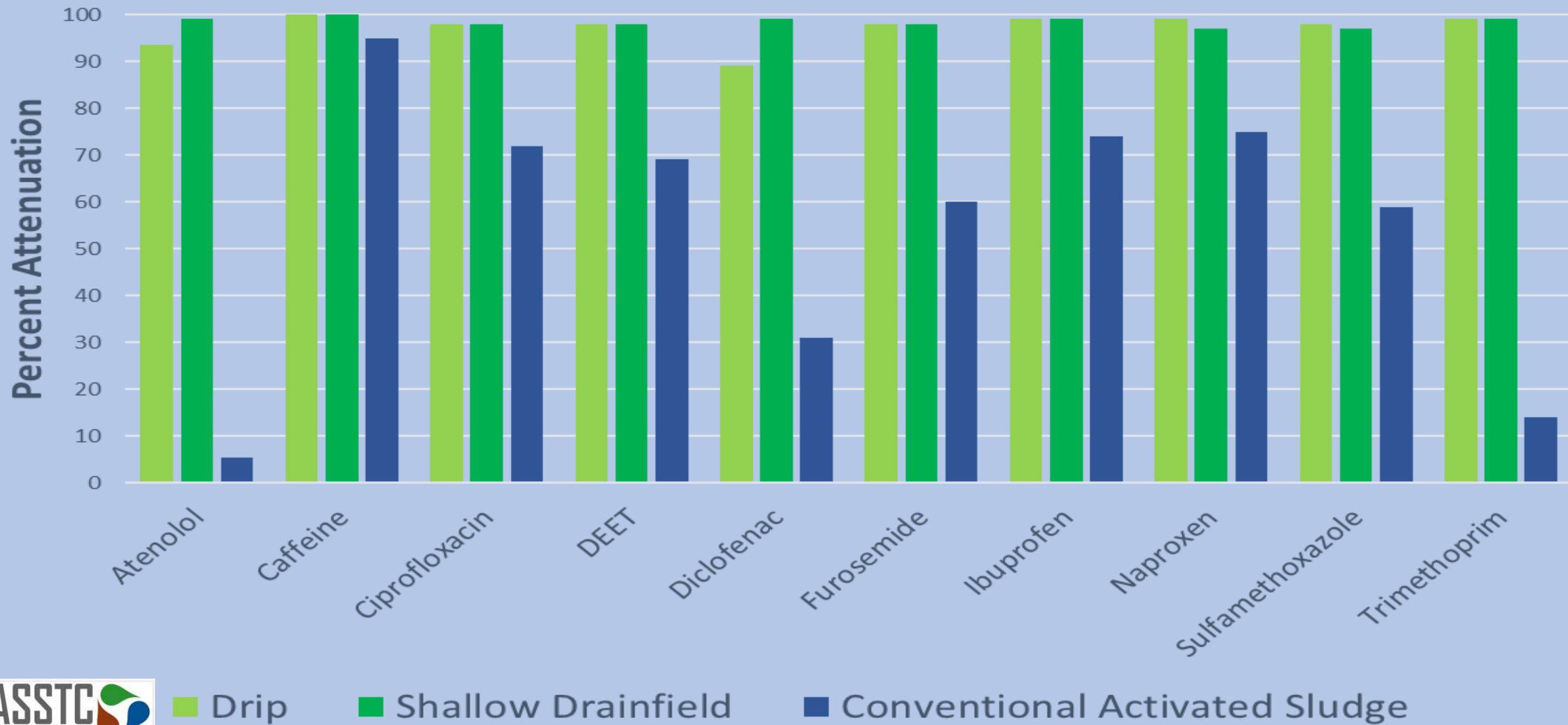
3 year study
2010-2012



3 year study
2011-2013



Comparison of Removal Efficiency of Drip Dispersal, Shallow Drainfield and Centralized Conventional Activated Sludge Treatment for Selected CEC

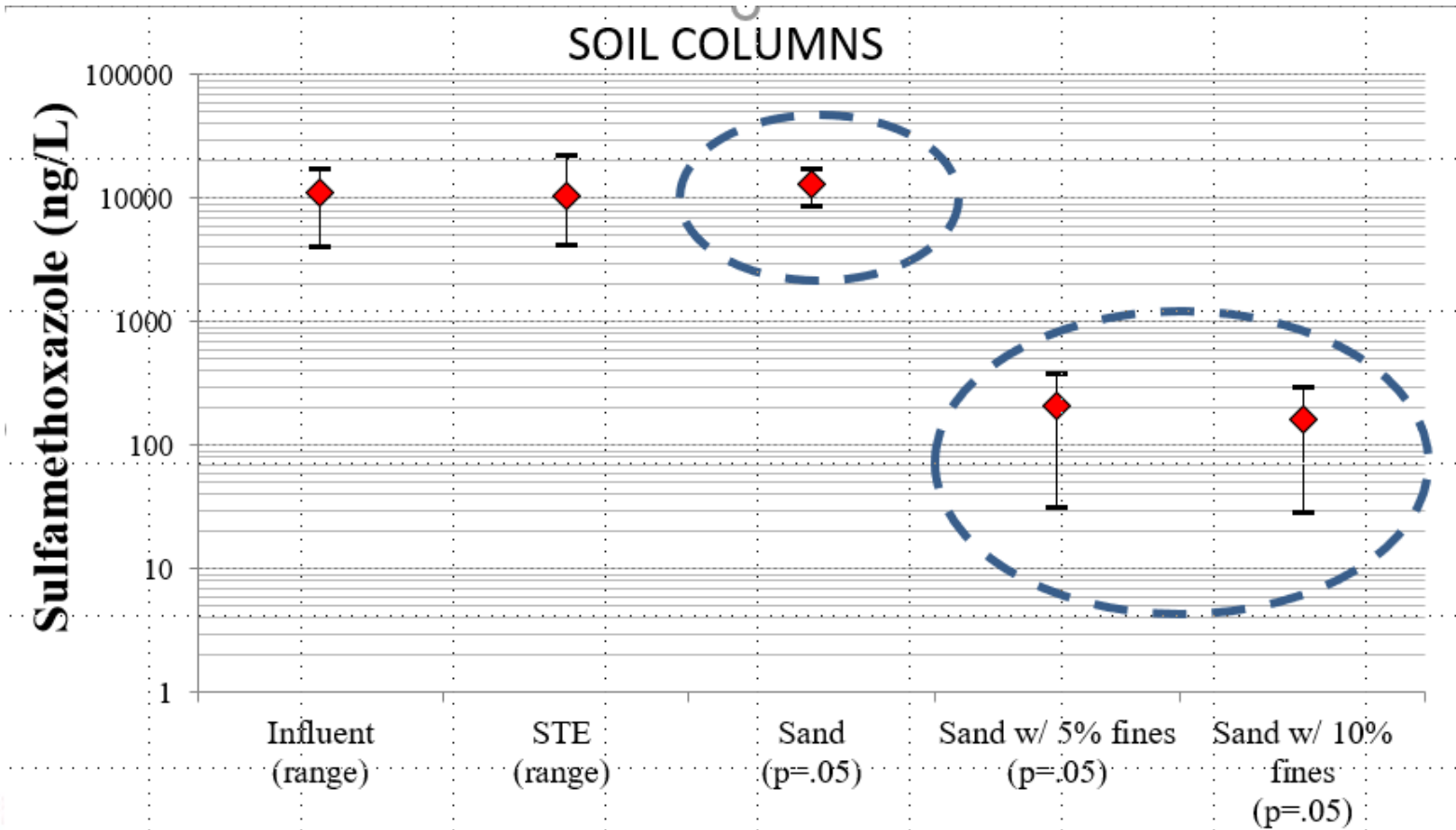


Soil Column studies at MASSTC indicated improved removal of many CEC with soil containing 5 – 10 % fine material compared with ASTM C33 Sand.

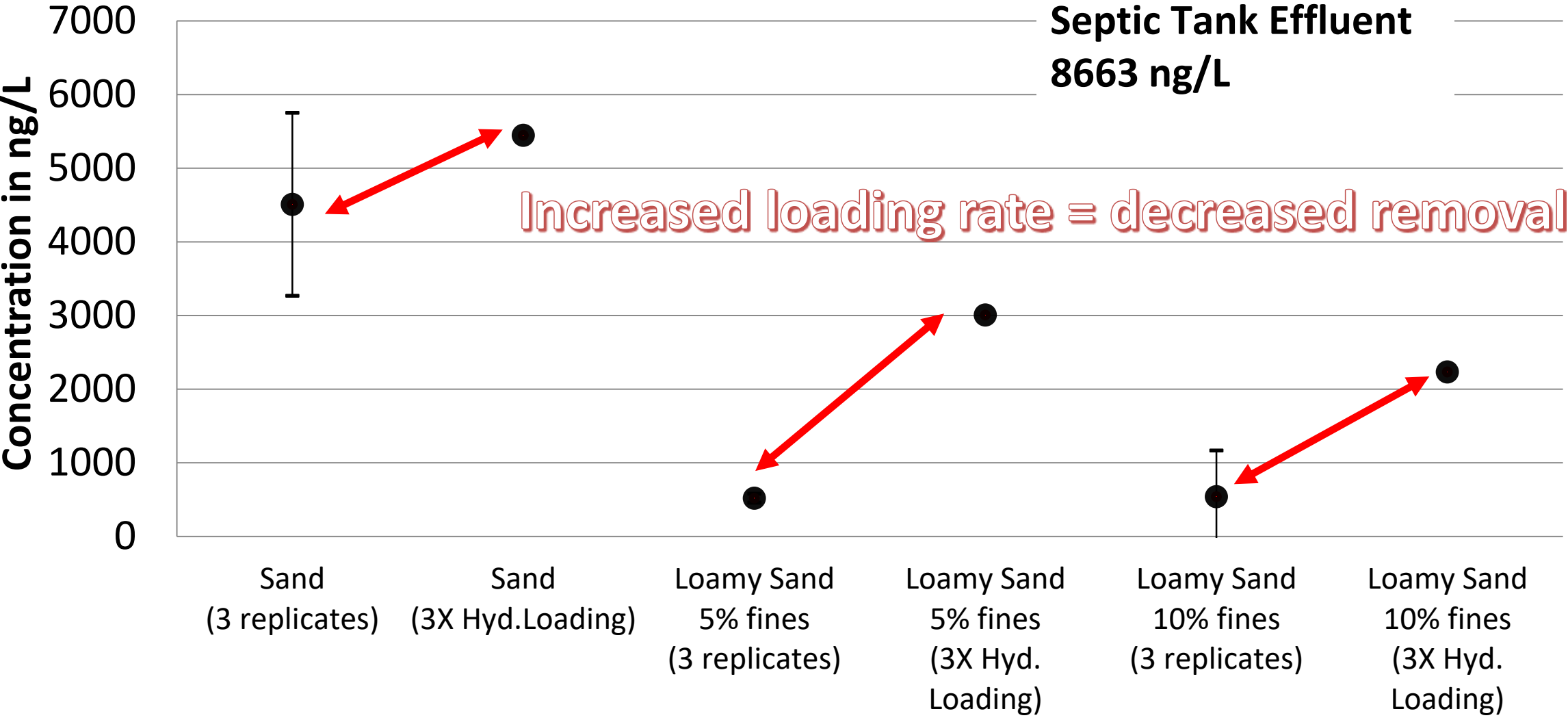


Findings

The general pattern of higher attenuation in soils containing 5%-10% fine material was found for acetaminophen, atenolol, atorvastatin, caffeine, DEET, diclofenac, ibuprofen, naproxen, sulfamethoxazole, and trimethoprim.



Sulfamethoxazole



Take Home Messages

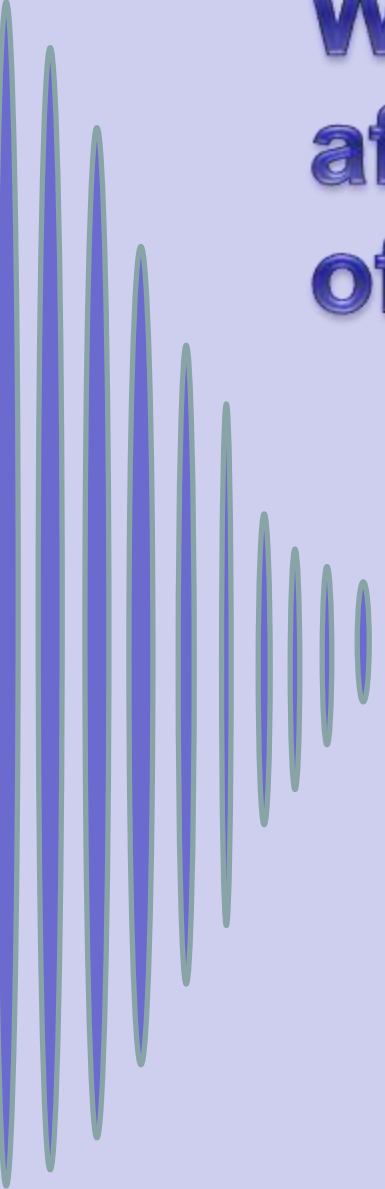


Finer textured soils remove a higher percentage of many, but not all CEC tested.

Removal for some CEC improves over time for some compounds tested (particularly in fine textured soils).

In general, higher hydraulic loading rates translates to less removal.





What we know about factors affecting the attenuation or removal of CEC in wastewater treatment

- Nature of the compound
- Oxygen availability
- Bacteria and other fauna diversity in the receiving environment
- Retention time during treatment

What we don't know

- The effect of varying hydraulic loading rates on CEC removal and transformation.
- The effect of various dispersal means, configurations (gravity vs. pressure-dosed) or dosing strategies on CEC removal.
- The effect of various advanced treatment options on CEC removal.
- Which coupling of treatment technology and soil absorption system configurations will optimize removal.
- Byproducts, sisters, daughters, conjugates and deconjugates




Why don't we know what we don't know? (some reasons)

- There are many variables involved
- Research needed at testbeds where variables can be isolated
- Analytical costs are high and research money scarce

But there is

A graphic featuring the word "HOPE" in a simple, black, sans-serif font, centered on a horizontal axis. The background is dark, with vibrant light trails in blue on the left and red on the right. These trails consist of numerous small, bright particles and several overlapping, glowing lines that create a sense of motion and energy. The light trails converge towards the word "HOPE", which is set against a bright, yellowish-white glow.

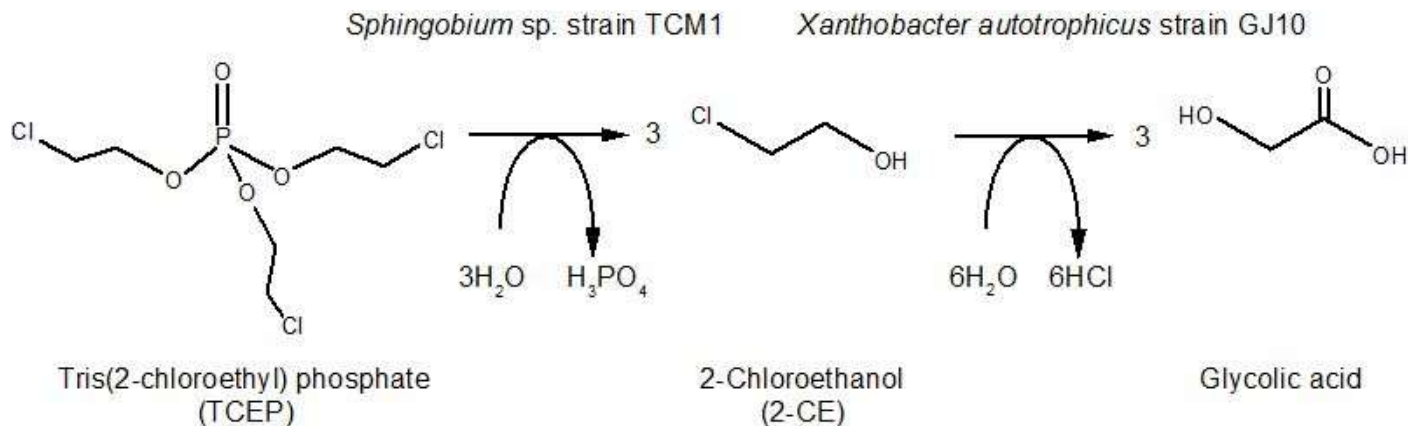
HOPE

A microscopic image showing a dense population of bacteria. The bacteria are stained in shades of blue and cyan, appearing as various rod-like shapes and some spherical forms. The background is dark, making the individual bacterial cells stand out. The text is overlaid on the upper left portion of the image.

If you give a bacteria community long enough, they will eventually find a way to extract their energy requirements from just about anything.

Case in Point

TCEP

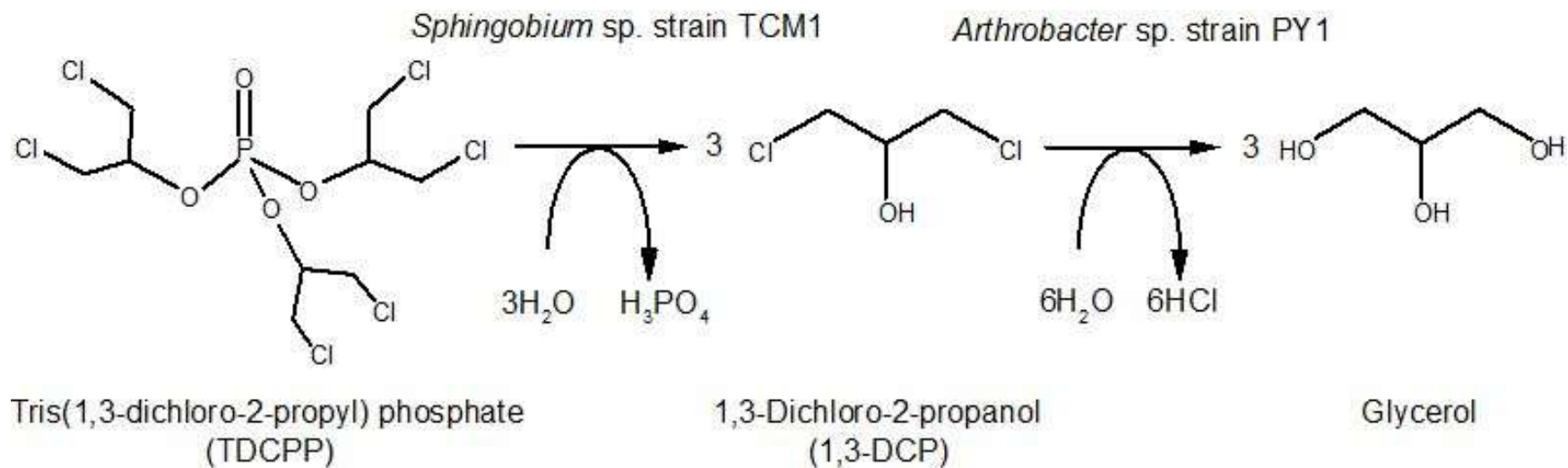


[Biochemistry, Genetics and Molecular Biology](#) » "[Environmental Biotechnology - New Approaches and Prospective Applications](#)", book edited by Marian Petre, ISBN 978-953-51-0972-3, Published: February 7, 2013 under [CC BY 3.0 license](#)

Chapter 5

Microbial Degradation of Persistent Organophosphorus Flame Retardants

By Shouji Takahashi, Katsumasa Abe and Yoshio Kera
DOI: 10.5772/53749





[Environmental Science and Pollution Research](#)

pp 1–15 | [Cite as](#)

Biodegradation of persistent environmental pollutants by *Arthrobacter* sp.

Genetically engineered pseudomonas strains capable of metabolizing ethylene glycol and its metabolic intermediates

Abstract

Presented herein are genetically engineered *Pseudomonas* strains capable of metabolizing ethylene glycol and producing polyhydroxyalkanoates.

US20190024126A1

United States

[Download PDF](#) [Find Prior Art](#) [Similar](#)



Environmental Pollution

Volume 247, April 2019, Pages 534–540



Removal of seven endocrine disrupting chemicals (EDCs) from municipal wastewater effluents by a freshwater green alga ☆



Chemosphere

Available online 15 March 2019
In Press, Accepted Manuscript



Bacteria-assisted removal of fluoroquinolones from wheat rhizospheres in an agricultural soil

Developing a CRISPR/CAS9-assisted recombineering system for natural soil pseudomonads

Hansen, Morten Lindqvist; Jelsbak, Lars

Published in:

The Danish Microbiological Society Annual Congress 2018 - programme & abstracts

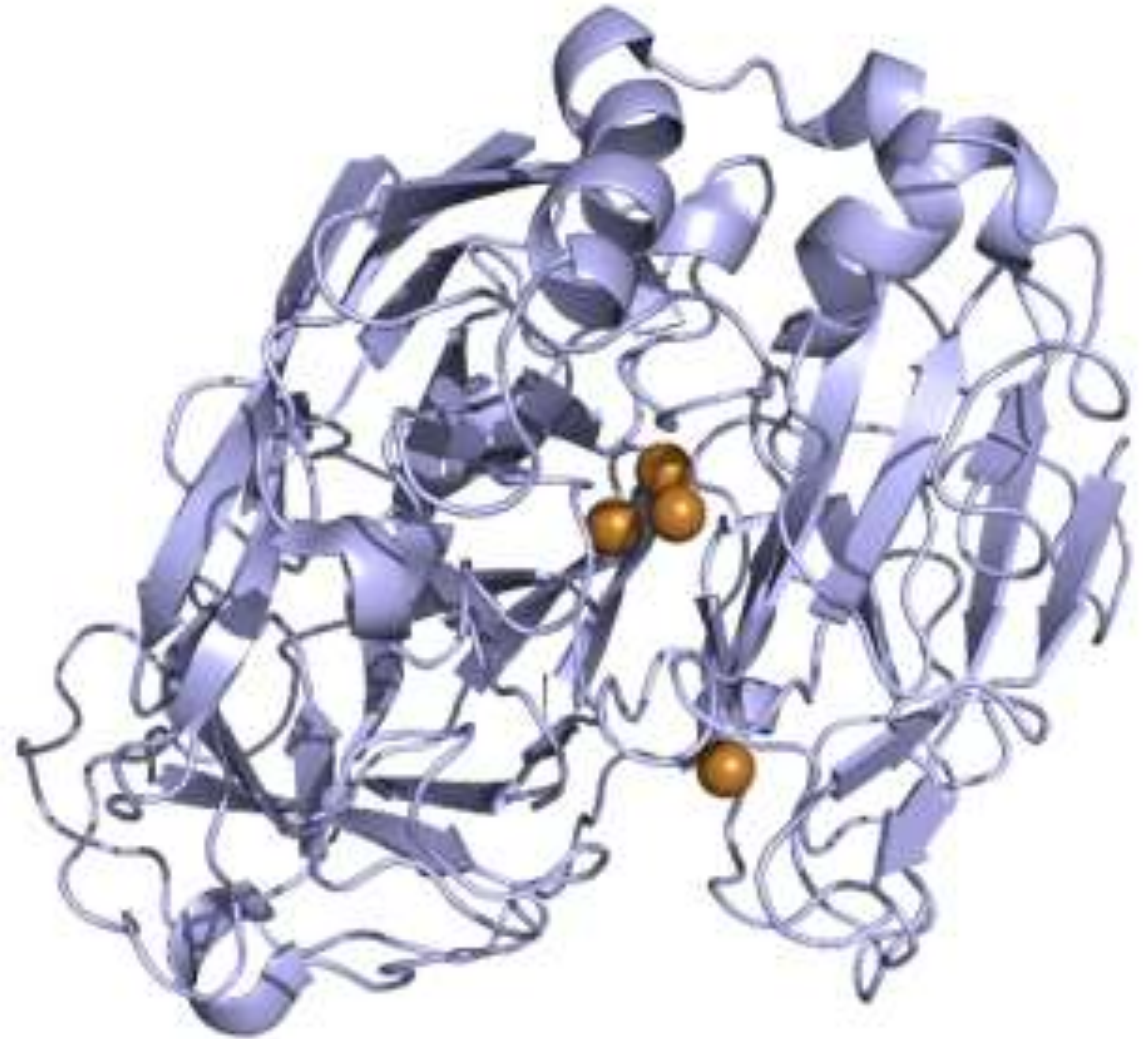
Finally

**Breaking
News !**



Breaking News

Laccase and other
ligninolytic enzymes
Possible wildcards in the
race to treat CECs



Laccases are copper-containing oxidase enzymes found in many plants, fungi, and microorganisms. Laccases act on phenols and similar types of substrates, breaking them down

Laccases and other peroxidases are the enzymes that facilitate the cellulose-based carbon sourcing for denitrification in wood-based systems.



Enzymes



advanced oxidation processes

VS



Enzymatic processes

Nature's subtle way to de-construct complexity

Laccase and other enzymes prevalent in cellulose-based denitrification may be recruits in the plight to break down the recalcitrant CEC



[Enzyme Res.](#) 2011; 2011: 217861.

PMCID: PMC3132468

Published online 2011 Jun 21. doi: [10.4061/2011/217861](https://doi.org/10.4061/2011/217861)

PMID: [21755038](https://pubmed.ncbi.nlm.nih.gov/21755038/)

Laccase: Microbial Sources, Production, Purification, and Potential Biotechnological Applications

[Shraddha](#), [Ravi Shekher](#), [Simran Sehgal](#), [Mohit Kamthania](#), and [Ajay Kumar](#)*

[Author information](#) • [Article notes](#) • [Copyright and License information](#) [Disclaimer](#)



Journal of Environmental Management

Volume 239, 1 June 2019, Pages 48-56



Research article

Application of denitrifying bioreactors for the removal of atrazine in agricultural drainage water

Questions ?

