

21ST ANNUAL NPS CONFERENCE
NONPOINT SOURCE MANAGEMENT
IN A CHANGING CLIMATE
MAY 17-19, 2010



Pharmaceuticals, Personal Care Products and other Organic Wastewater Contaminants and Septic Systems

(How to cover a huge issue in 30 minutes or less)

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and Environment

Various ways that the subject is referenced

PPCP (pharmaceuticals and personal care products)

OWC (organic wastewater contaminants)

EDC (endocrine disrupting compounds)

EC (emerging contaminants)

The universe of Emerging contaminants

Antimicrobials
Triclosan, Trimethoprim

Fluoxetine (antidepressant)

Steroids
Estradiol, Estrone

Fire retardants
TCEP

Pharmaceuticals
Carbamazepine, Acetaminophen

Clofibric acid

Fragrances
Galaxolide, Musk Ketone

Risperidone

Personal Care Products
DEET, Oxybenzone

Pesticides

Bezafibrate (Lipid regulator)

to name just a few....

PPCP are a broad class of compounds having a wide variety of chemical properties that influence

- their persistence in the environment
- their mobility in the environment
- their effect on organisms
- their detection

Various Sources of PPCP

Wastewater residuals use

Animal waste “recycling”
Manure spreading

Animal Operations
(feed lots, etc)



Wastewater Treatment Plants



Septic Systems

What does PPCPs Occurrence Mean?

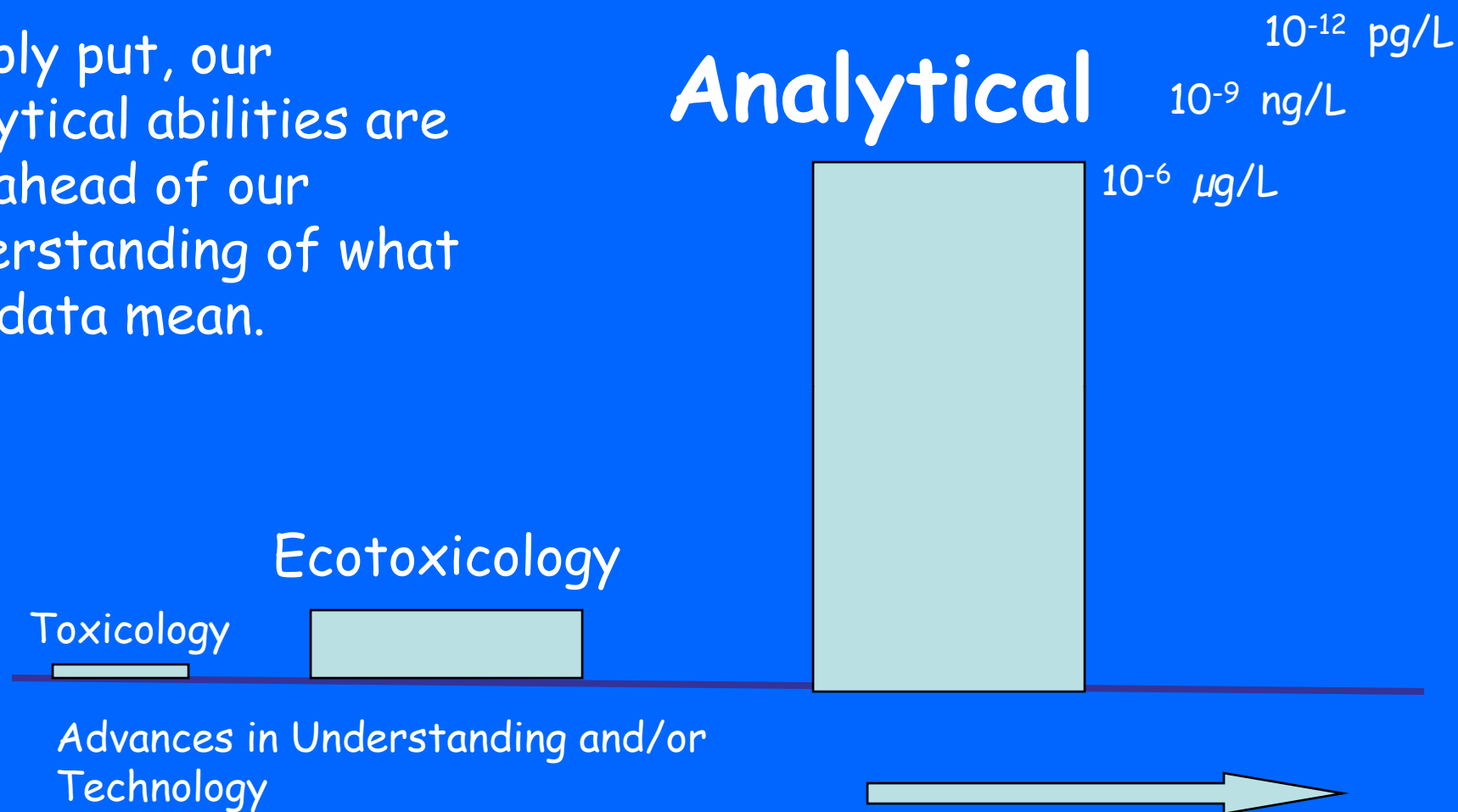


What does PPCPs Occurrence Mean?

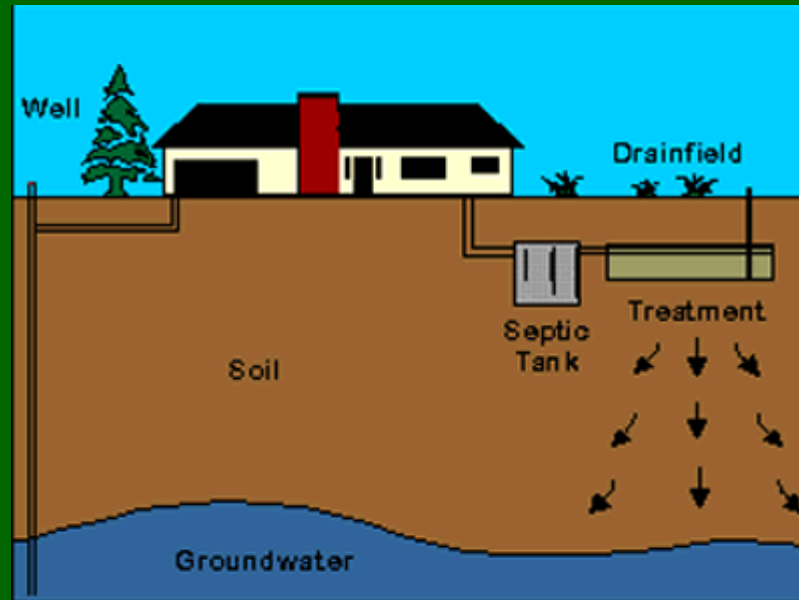


For the most part, we simply don't know !

Simply put, our analytical abilities are far ahead of our understanding of what the data mean.



Organic Wastewater Contaminants and Septic System Treatment



Research Review

But First

Remember when reviewing studies

- Analytical methods are variable and it is crucial to understand the method limitations in each study.



In other words...

If they didn't see it, it
doesn't mean it wasn't there !



Studies from Cape Cod

Silent Spring (1998, 2006, 2008)

USGS (2005, 2006, 2008)

Barnstable County Department of Health and Environment (continuing)

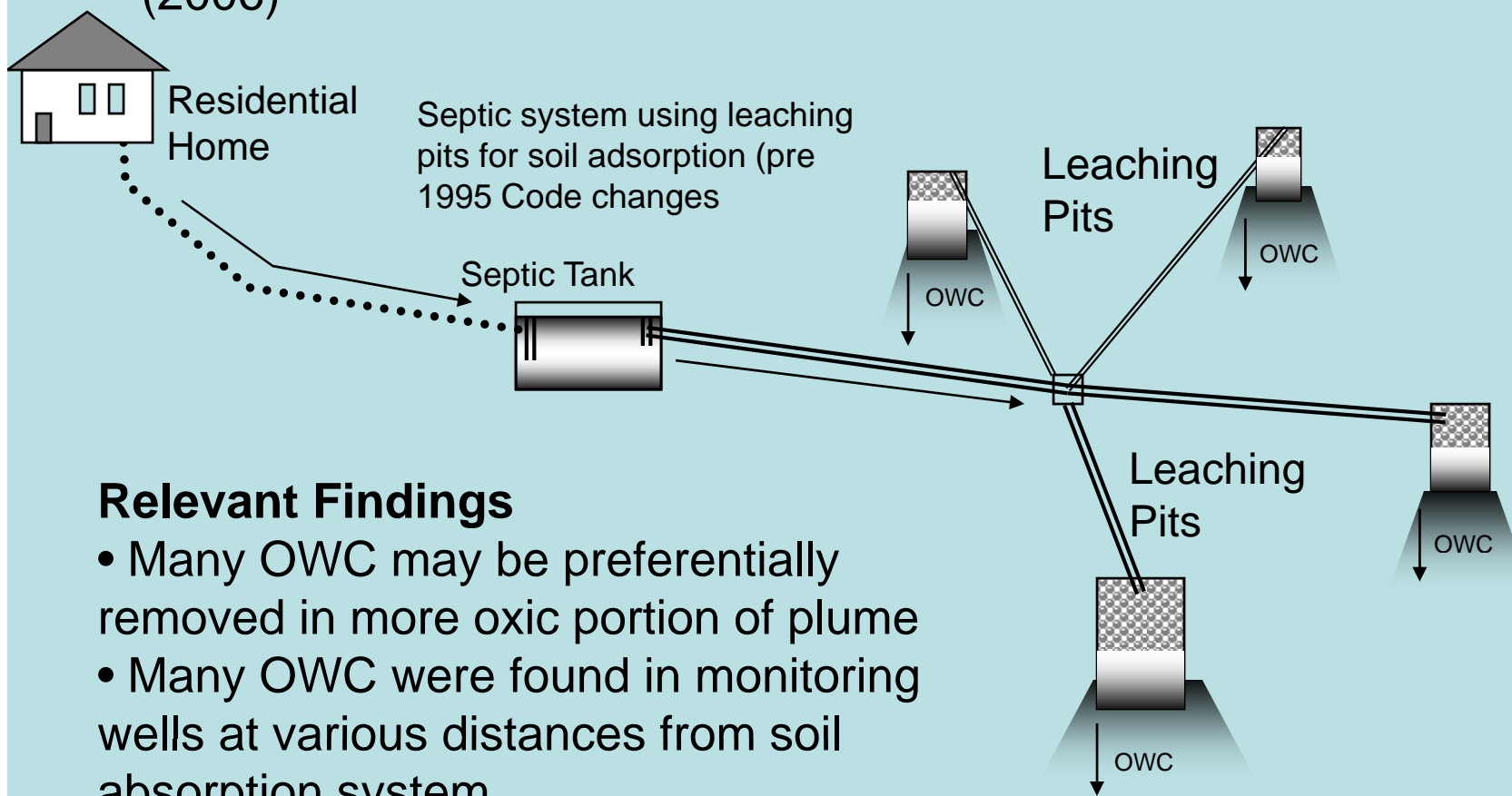
Organic Wastewater Contaminants, Pharmaceuticals, and Personal Care Products in Selected Water Supplies, Cape Cod, Massachusetts, June 2004,

- Of 85 compounds analyzed for, 43 were detected.
- 13 detected in low concentrations (less than 1 microgram per liter) from drinking-water supplies thought to be affected by wastewater because of previously detected high nitrate concentrations (wells on same lot as septic system)
- of two systems tested at the Massachusetts Alternative Septic System Test Center, a standard septic tank-soil absorption system was better at removing PPCP than recirculating sand filter

Zimmerman, M.J., 2005, U.S. Geological Survey Open-File Report 2005-1206, 16 p.
[<http://pubs.usgs.gov/of/2005/1206/>]

Only available online

STEROID ESTROGEN, NONYLPHENOL ETHOXYLATE METABOLITES, AND OTHER WASTEWATER CONTAMINANTS IN GROUNDWATER AFFECTED BY A RESIDENTIAL SEPTIC SYSTEM ON CAPE COD, MA (Environ. Sci. Technology Vol. 40, pp 4894-4902. (2006)



Relevant Findings

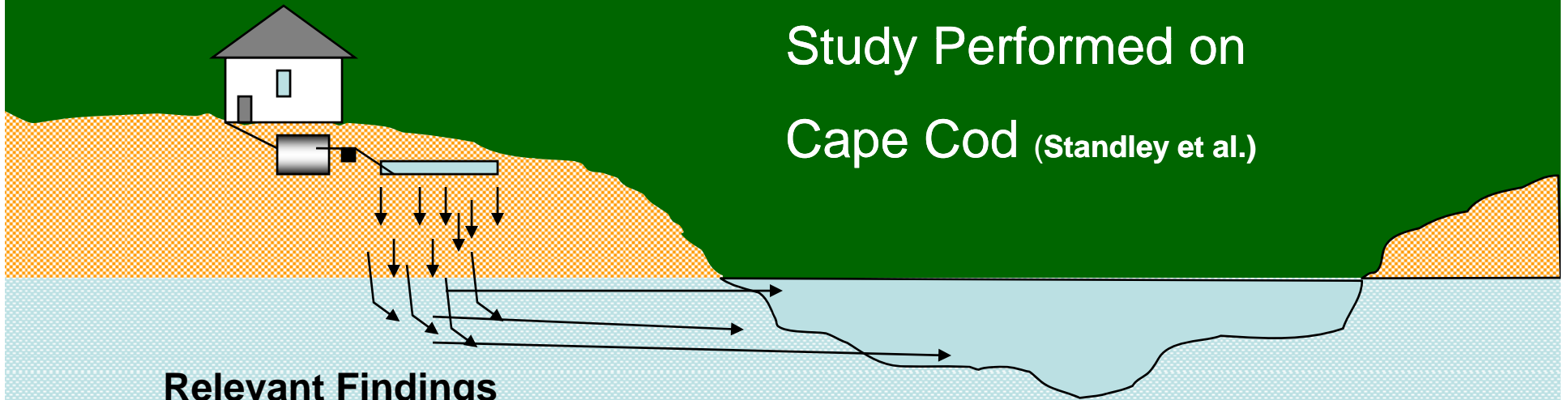
- Many OWC may be preferentially removed in more oxic portion of plume
- Many OWC were found in monitoring wells at various distances from soil absorption system

(Swartz et al, 2006)

WASTEWATER-CONTAMINATED GROUNDWATER AS A SOURCE OF ENDOGENEOUS HORMONES AND PHARMACEUTICALS TO SURFACE WATER ECOSYSTEMS (Env. Toxicology and Chemistry, Vol27(12), pp 2457-2468. (2008)

Septic systems studied of various and unspecified designs

Study Performed on
Cape Cod (Standley et al.)



Relevant Findings

- PPCP present in ponds in proportion to residential density in watershed
- Estrogenic hormones present at concentrations approaching those that induce physiological responses in fish.

Effectiveness of Selected Onsite Wastewater-Treatment Systems in Removing Pharmaceutical and Personal-Care Products

Marc Zimmerman

USGS MA-RI Water Science Center

and

George Heufelder

Barnstable County Department of Health and
Environment



Seven Technologies Studied

Standard Title 5

Aerobic Treatment Unit

Peat System

Single pass foam filter

Recirculating Sand Filter

Sulfur upflow filter

Two feet of ASTM C33 sand in single pass mode (Control)

Numbers of PPCPs detected by system

	Control	Title 5	Aerobic	Peat	Foam	Sulfur	RSF
Number of PPCPs detected	5	3	5	5	5	10	9

Number of systems with specific PPCPs (or metabolites) detected

<u>PPCP</u>	<u>Number of systems</u>
Acetaminophen	5
Caffeine	6
Carbamazepine	7
Codeine	1
Cotinine*	1
Dehydronifedipine*	5
Diltiazem	2
Diphenhydramine	3
Fluoxetine	2
p-Xanthine*	4
Ranitidine	1
Sulfamethoxazole	7
Trimethoprim	2

Summary

- Standard septic tank – soil absorption systems seem relatively effective
- Individual compound and substrate chemistries and physical properties may affect their interactions.
- A simple survey such as this may raise far more questions than it provides answers.

December – 2008 “mini-study”

Raw Wastewater

Drip Dispersal (modified following an aerobic treatment unit)

Ozone-Peroxide unit (following an aerobic treatment unit)

Summary of Findings

For many of the compounds investigated, a drip dispersal unit (which presumably incorporates plants to some degree into the wastewater treatment), reduced the majority of these compounds to the detection limit.

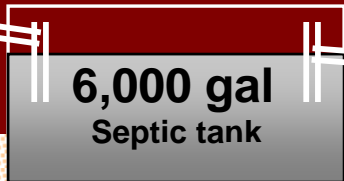
Studies from other states



PHARMACEUTICALS IN ON-SITE SEWAGE EFFLUENT AND GROUNDWATER, WESTERN MONTANA

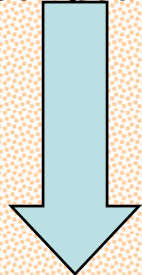
(Ground Water May-June 2007 (pp263-271))

High School



6,000 gal
Septic tank

12 Compounds



2 Compounds



3,000 gallons/day

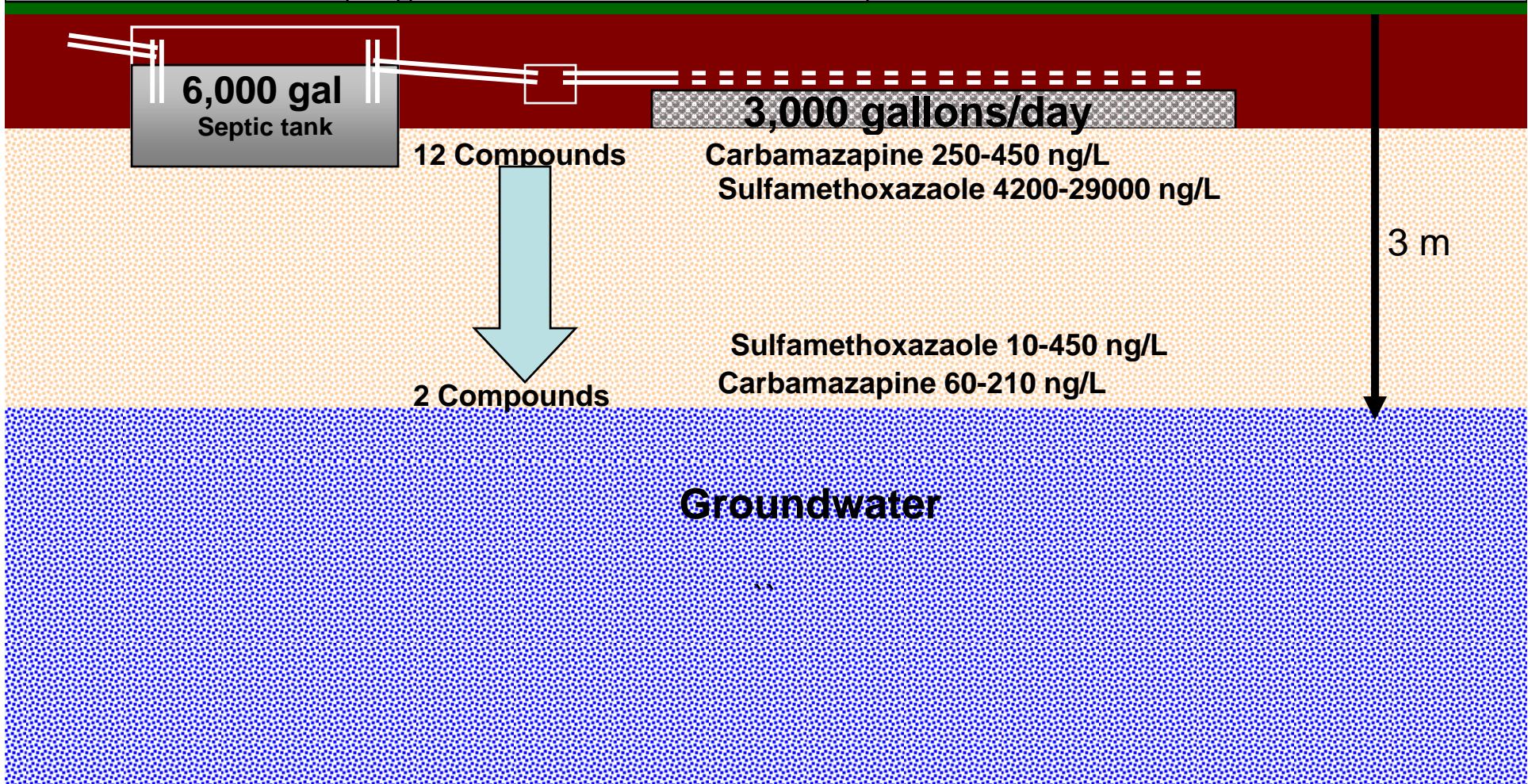
Carbamazapine 250-450 ng/L
Sulfamethoxazaole 4200-29000 ng/L

Sulfamethoxazaole 10-450 ng/L
Carbamazapine 60-210 ng/L

3 m



Groundwater





Prepared in cooperation with Oregon Department of Environmental Quality and
Deschutes County Environmental Health Division

Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Ground Water Receiving Discharge from Onsite Wastewater Treatment Systems near La Pine, Oregon: Occurrence and Implications for Transport

Scientific Investigations Report 2005–5055
Version 1.1, July 2009

U.S. Department of the Interior
U.S. Geological Survey

Partial Analysis of Data from LaPine Project

The green blocks indicate the reduction of compound from the indicated value to a value below the detection limit at the drainfield monitoring well

	3-beta-coprostanol	3-Methyl-1H-indole (FRAGRANCE OF STENCH)	Caffeine	Camphor (odor in ointments)	Cholesterol	D-Limonene (anti-microbial, anti- viral; a fragrance in Indole	coffee fragrance, inert ingredient in pesticides)	Menthol	Methyl salicylate (used in liniments, food, beverages, and U-V absorbing lotions)	DEET	Phenol	p-Cresol
Standard	11	82	140	3	33	2.8	220	24	0.9	14	630	820
Standard	2	7	2.2	NS	3	NS	NS	8.2	NS	NS	NS	3
Pressure	16	120	5.1	0.9	33	14	38	30	1.2	1.7	160	520
Pressure	38	57	90	0.5	110	0.8	38	NS	1.5	NS	88	340
Sand Filter	33	82	99	1.1	52	1.9	72	72	1.3	0.9	180	640
Sand Filter	12	28	8.8	1	24	0.8	7.6	16	NS	0.8	98	640
Textile Filter	NS	11	3.8	3.4	2	2	0.9	29	NS	NS	32	73
Rotating Biological Contactor	6	NS	9.2	NS	20	NS	4.1	5.9	NS	NS	42	93
Rotating Biological Contactor	15	4	1	NS	20	1.1	17	5.3	NS	NS	44	89
Enviroserver	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2
Enviroserver	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
FAST	53	24	34	NS	46	0.8	12	25	2	2.9	78	370
FAST	44	19	17	NS	48	1.2	19	24	NS	0.6	53	200
NAYADIC	11	52	18	0.8	32	8.9	34	62	NS	0.6	240	730
NAYADIC	10	17	9	0.9	15	2.7	14	4.3	0.7	52	74	200
Nitrex	7	28	4.7	4.1	16	NS	13	8.8	NS	3.6	56	310
Nitrex	11	66	12	0.6	36	NS	23	21	5.6	0.6	140	540
Puraflo	14	44	21	1.9	28	1.1	24	13	NS	1.4	84	310
Wert B	28	NS	320	19	46	2.9	90	160	6.7	1.1	550	1300
Wert B	12	NS	68	1.9	16	NS	11	24	1.1	NS	94	330

Partial Analysis of Data from LaPine Project

3-beta-coprostanol

3-Methyl-1H-indole (FRAGRANCE OF STENCH)

Caffeine

Camphor (odor in ointments)

Cholesterol

D-Limonene (anti-microbial, anti-viral;a fragrance in aerosols)

Indole coffee fragrance, inert ingredient in pesticides)

Menthol

Methyl salicylate (used in liniments, food, beverages, and U-V absorbing lotions)

DEET

Phenol

p-Cresol

For a number of OWCs, standard and alternative onsite septic systems, combined with their soil absorption systems, reduce the concentrations to below present detection limits

Wisconsin Study

Aerobic Treatment and Sand Filter Treatment

- OWC concentrations significantly less in aerobic (six suspended growth aerobic systems) or sand filter systems (seven single-pass sand filters) compared with septic tank effluent.
- Systems were not sampled below soil absorption system.

Wilcox, Jeffrey D. J.M. Bahr, C.J. Hedmen, Hemming, J D.C., and Barman, M.A.E. 2009. Removal of Organic Wastewater Contaminants in Septic Systems Using Advanced Treatment Technologies. J. Environ. Qual. 38:149-156.

Colorado Study

Septic tank, textile (“biofilter”) filter and wetland-based Treatment

- Biofilter-based systems had better removal of OWC with compared septic tank effluent.
- Systems were not sampled below soil absorption system.

Conn, Kathleen E., L.B. Barber, G.K. Brown, and R. Siegrist. 2006. Occurrence and fate of Organic Contaminants during Onsite Wastewater Treatment. J. Environ. Qual. 40:7358-7366.

Florida Study



Nutrients, Organic Wastewater Compounds, Pharmaceuticals, and Microorganisms Beneath Septic Tank Drainfields in the Woodville Karst Plain, Florida

**B.G. Katz¹, D.W. Griffin¹, P.B. McMahon¹, R.W. Hicks², E.Wade²,
H.S. Harden³ and J.P. Chanton³**

¹U.S. Geological Survey

²Florida Department of Environmental Protection

³Florida State University, Department of Oceanography

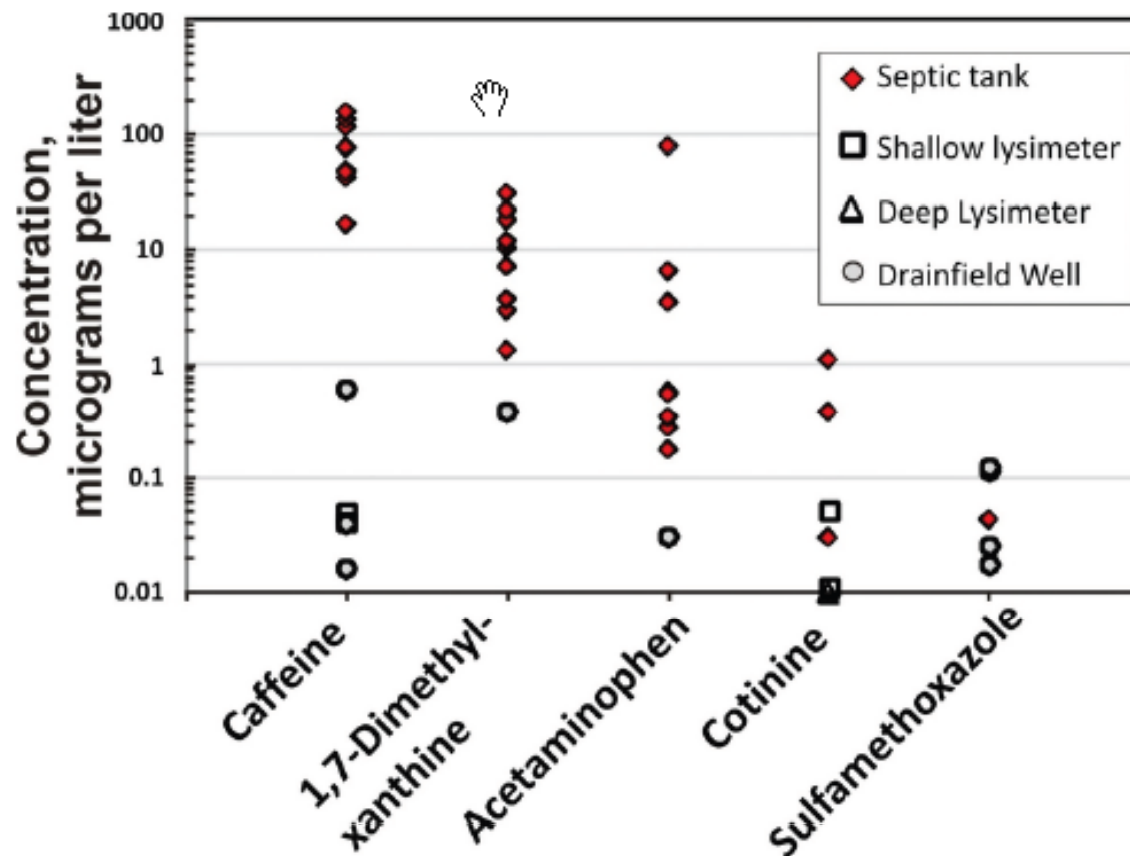


**Wakulla Springshed Workshop
Tallahassee, Florida
February 25-26, 2009**



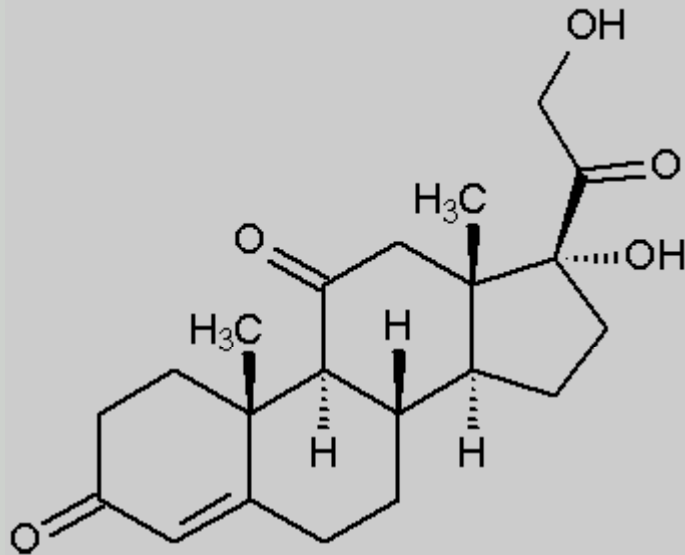
Florida Study

Pharmaceutical Compounds in Water Samples

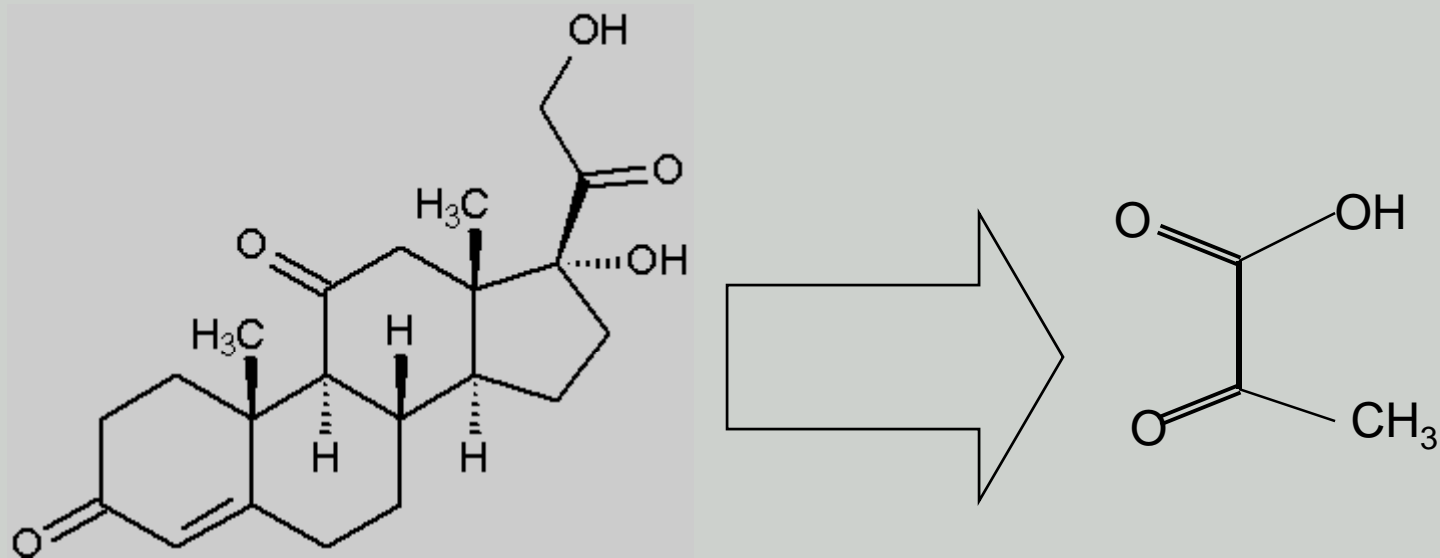


- Much lower concentrations of pharmaceutical compounds in lysimeter and drainfield well water samples than in septic tank effluent

- Sulfamethoxazole found in drainfield well samples at all sites, but only in septic tank effluent at 1 site

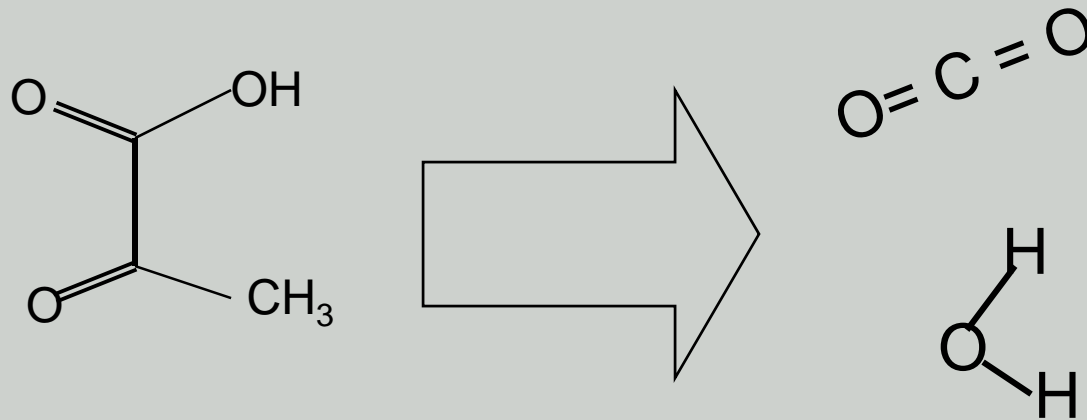


Collectively, what are all these studies telling us about the ability and potential ability of onsite septic systems to treat for organic wastewater contaminants ?

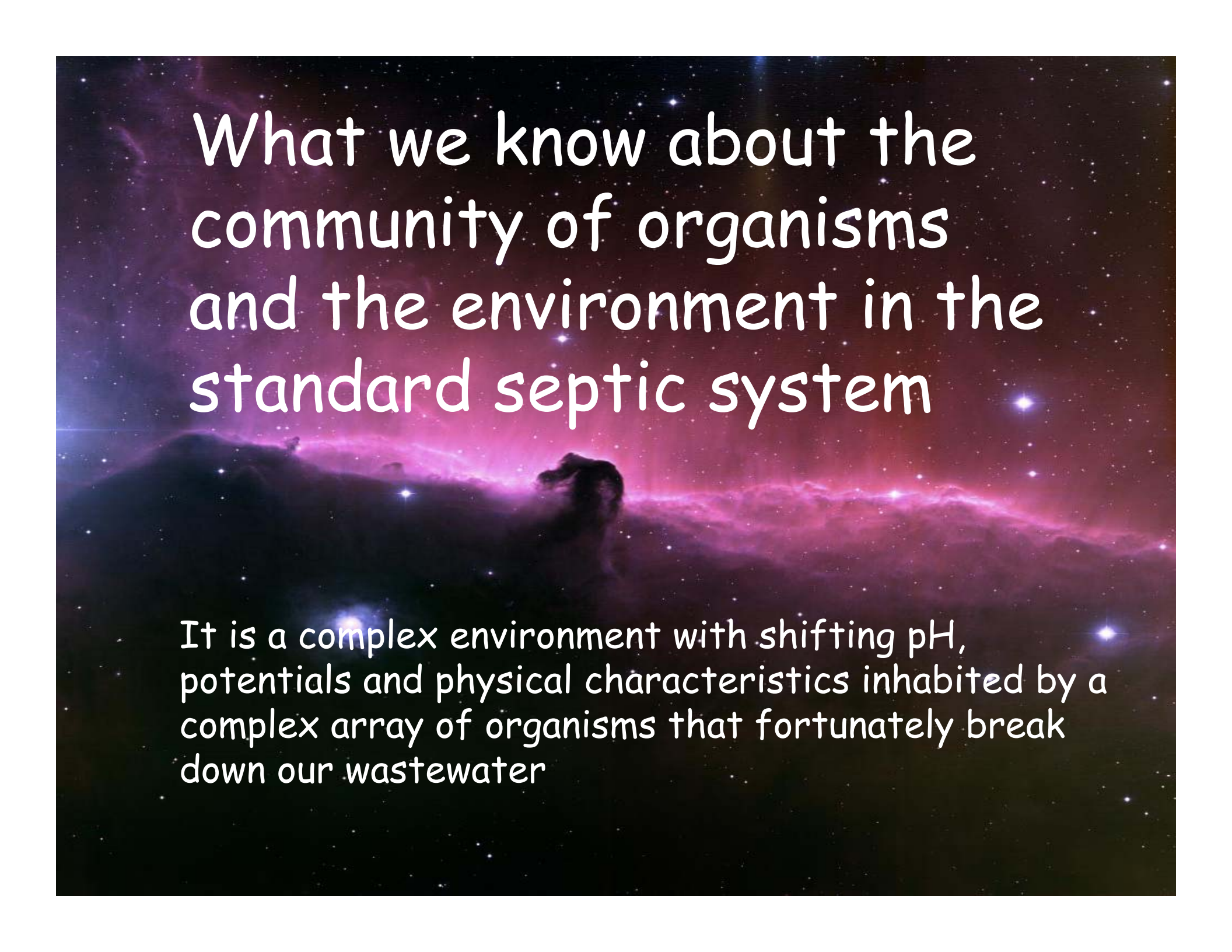


Perhaps there are metabolic pathways of bacteria, algae, plants and fungi that can be exploited to reduce OWC to harmless byproducts.

And.....



And perhaps the environments to encourage organisms and physical conditions that promote these organisms can be engineered into onsite systems.



What we know about the community of organisms and the environment in the standard septic system

It is a complex environment with shifting pH, potentials and physical characteristics inhabited by a complex array of organisms that fortunately break down our wastewater

Oxic conditions favorable to OWC breakdown ?

Compound solubilities

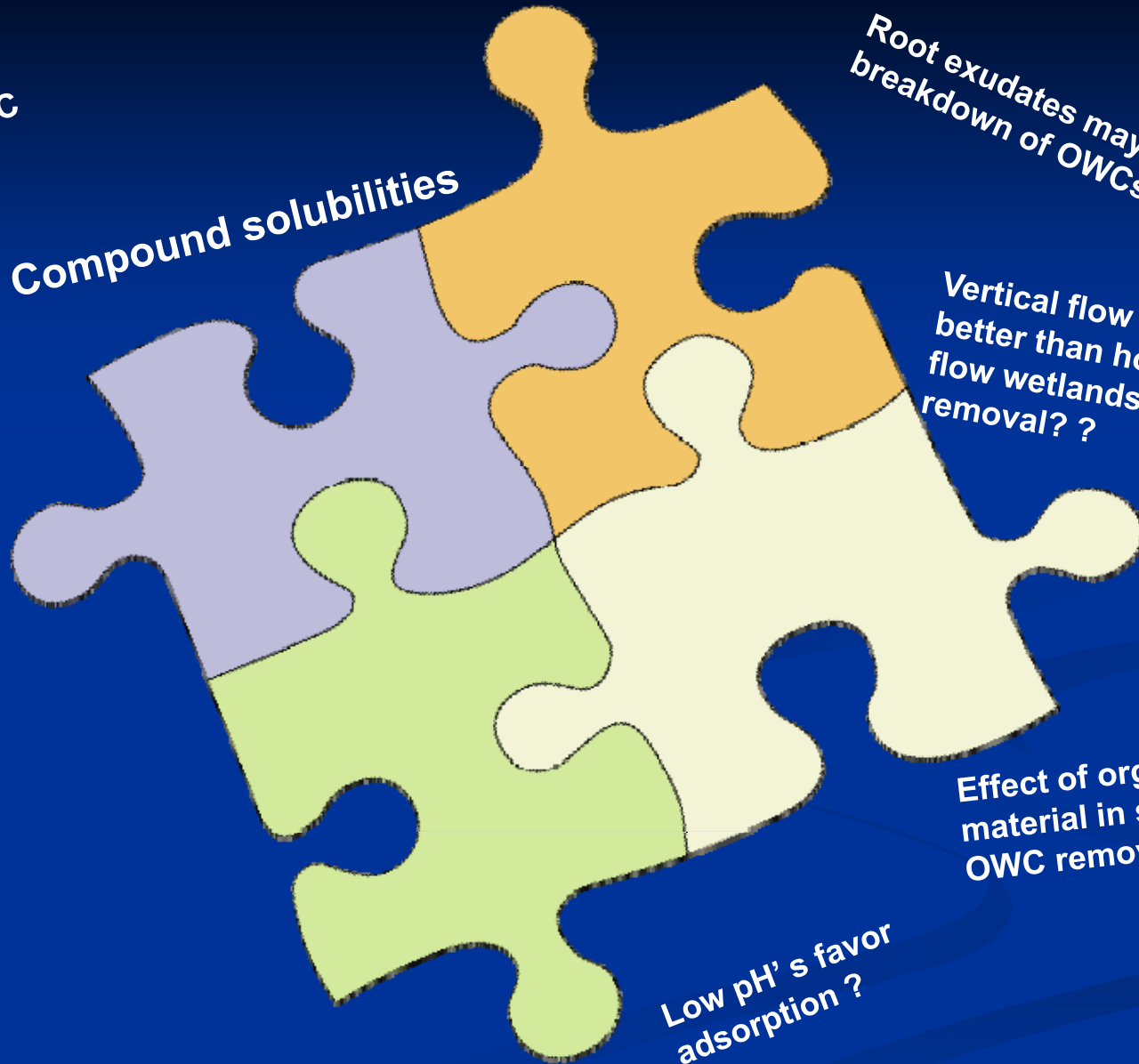
Root exudates may assist breakdown of OWCs ?

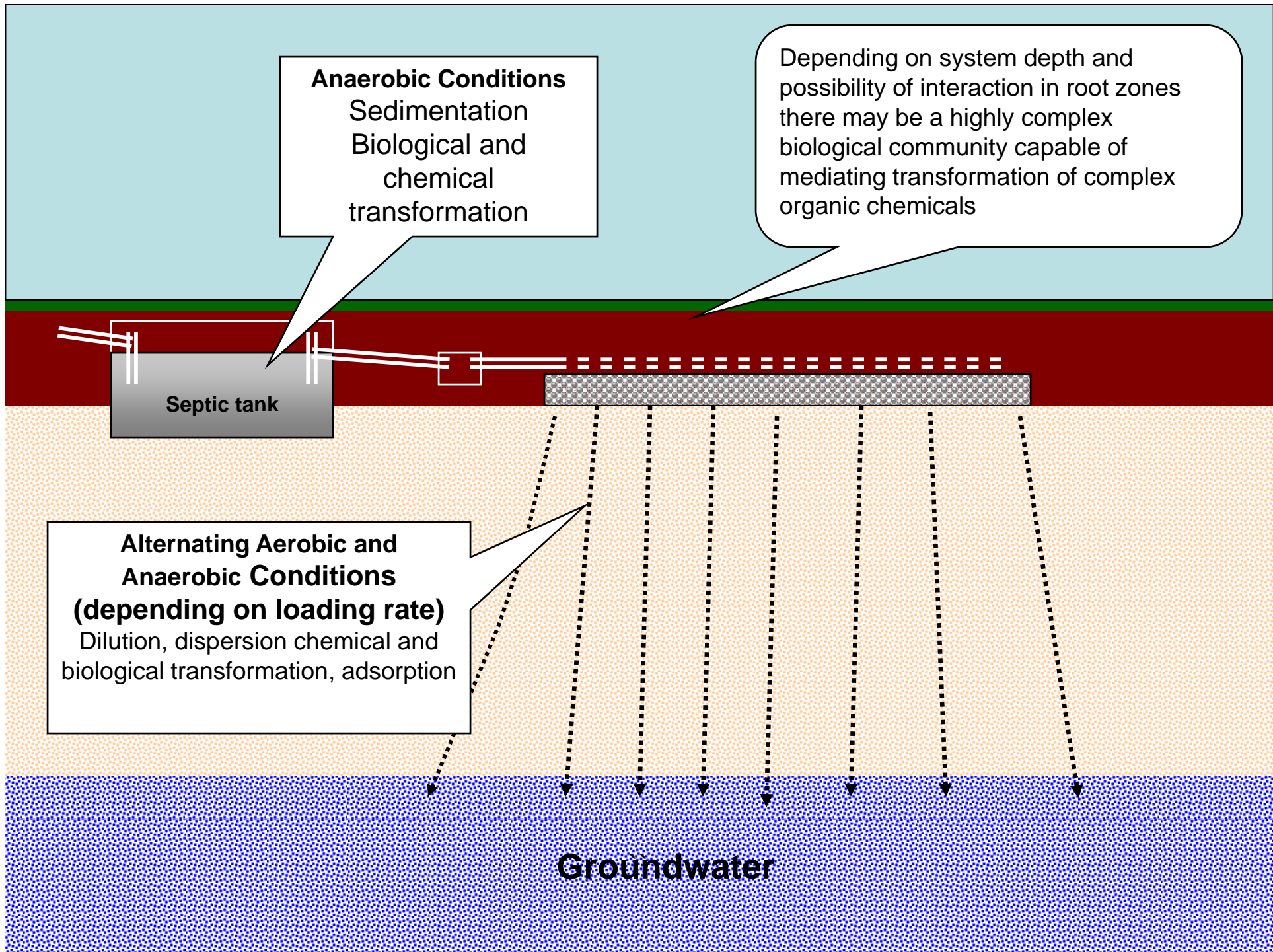
Vertical flow wetlands are better than horizontal flow wetlands for OWC removal? ?

Plant-soil interaction increases bacterial diversity ?

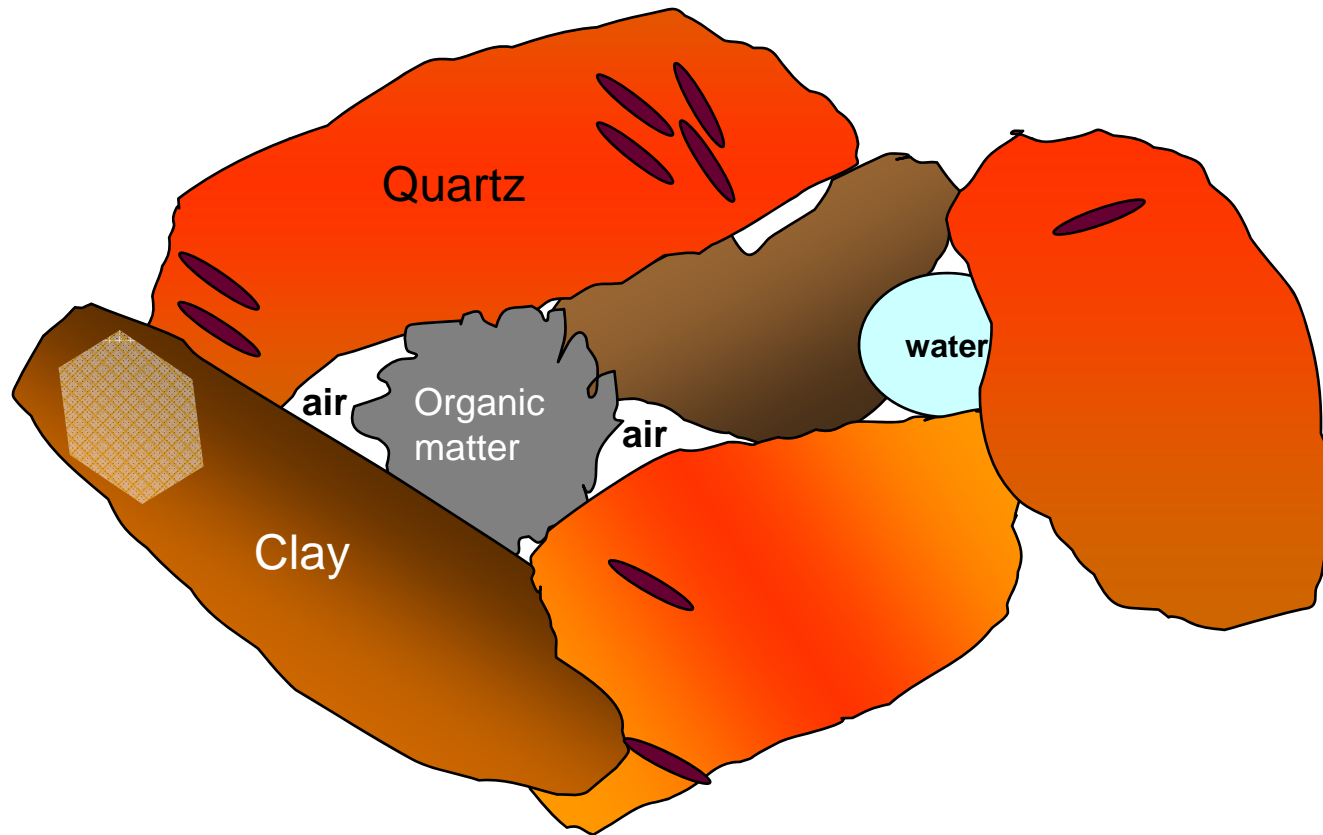
Low pH's favor adsorption ?

Effect of organic material in soil on OWC removal ?



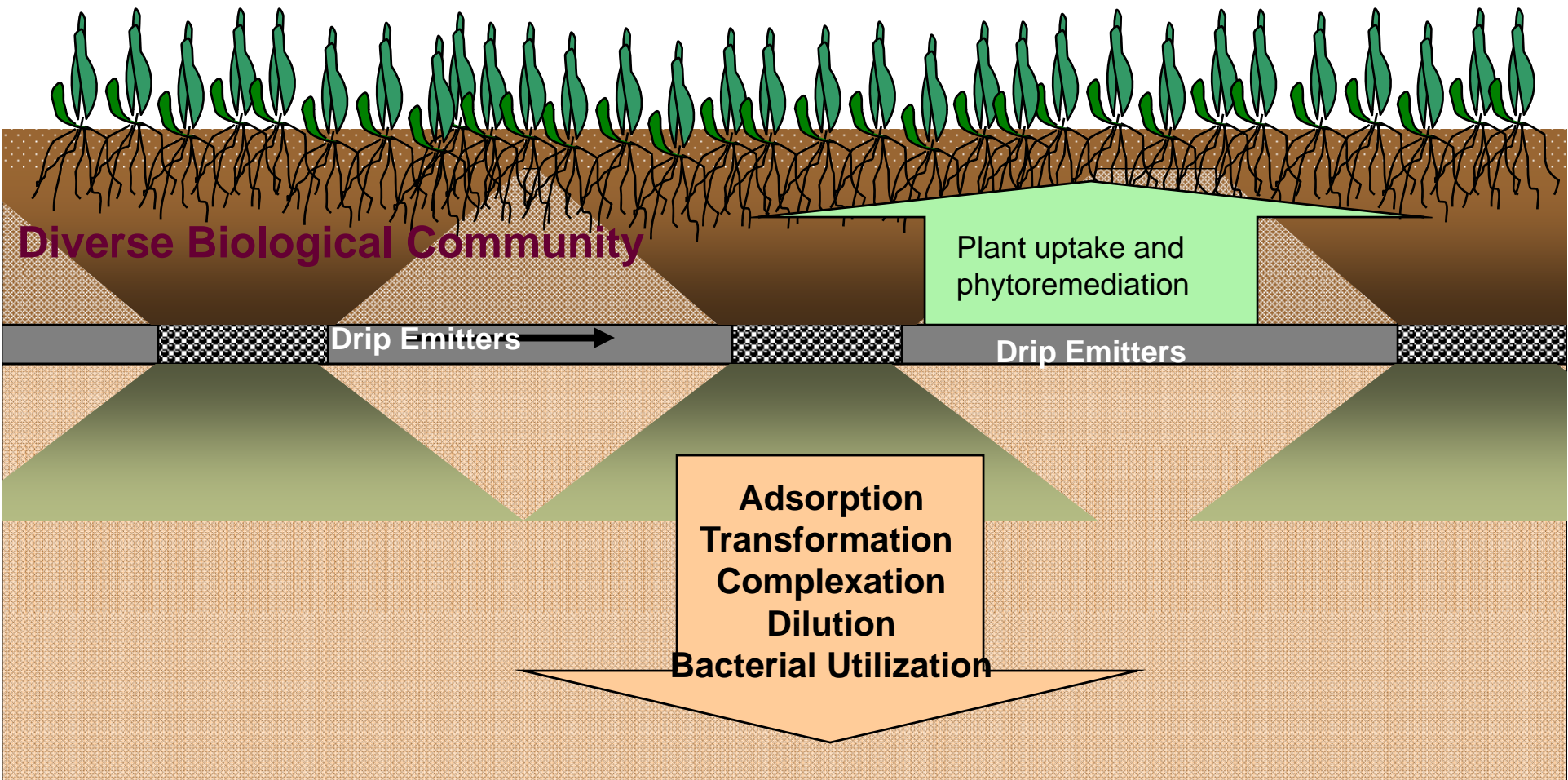
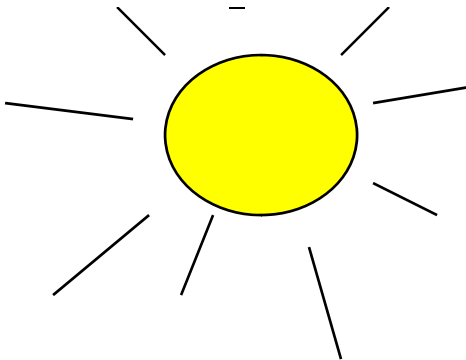


Soil structure can offer a wide variety of microcosms that may provide conditions that are conducive to various modes of OWC reduction.





Complex rhizosphere interactions



Diverse Biological Community

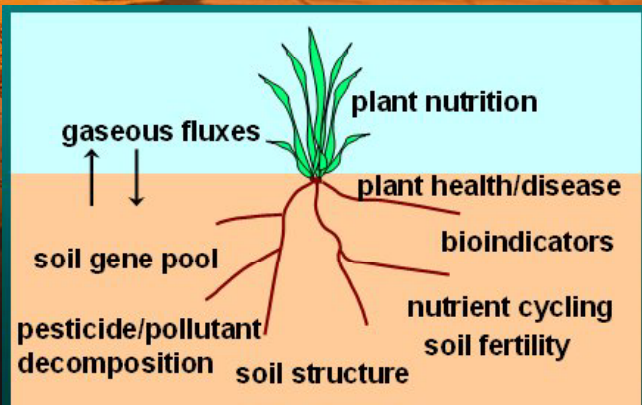
Plant uptake and phytoremediation

Drip Emitters

Drip Emitters

Adsorption
Transformation
Complexation
Dilution
Bacterial Utilization

The diversity of the soil layers and the ability of those biological communities to process or assimilate many man-made compounds is largely unexplored



What does the future hold for the PPCP issue ?

- Continued monitoring projects
- Development of a framework for the assessment of effects (State of California on leading edge due to their water recycling needs).
- Development of better analytical methods
- Development of toxicological and ecotoxicological information.
- Someday standards?

Questions?

