Contaminants of Emerging Concern in Cape Cod Groundwater and Drinking Water

Laurel Schaider, Ph.D. Research Scientist, Silent Spring Institute Nantucket Sound Water Quality Workshop June 25, 2014

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Silent Spring Institute Cape Cod water research







Septic systems blic

Public wells

Private wells

Ponds





Silent Spring Institute Cape Cod water research questions

- What are the levels of endocrine disruptors and other emerging contaminants in Cape Cod drinking water and groundwater?
- What happens as these chemicals move through the ground and treatment systems?
- How should emerging contaminants be considered in future planning of wastewater treatment and drinking water protection?







Hormones



Fragrances

Pharmaceuticals



Emerging contaminants

Perfluorinated chemicals



Detergents



Antimicrobials

Silent Spring Institute research on CECs in Cape Cod water



Environmental Toxicology and Chemistry, Vol. 27, No. 12, pp. 2457-2468, 2008

WASTEWATER-CONTAMINATED GROUNDWATER AS A SOURCE OF ENDOGENOUS HORMONES AND PHARMACEUTICALS TO SURFACE WATER ECOSYSTEMS

LAUREL J. STANDLEY,** RUTHANN A. RUDEL,* CHRISTOPHER H. SWARTZ,* KATHLEEN R. ATTFIELD,* JEFF CHRISTIAN,§ MIKE ERICKSON,§ and JULIA G. BRODY* *Silent Spring Institute, 29 Crafts Street, Suite 150, Newton, Massachusetts 02458, USA *Stockholm Environment Institute, 11 Curtis Avenue, Somerville, Massachusetts 02144, USA \$Columbia Analytical Services, 1317 South 13th Avenue, Kelso, Washington 98626, USA

Environ. Sci. Technol. 1998, 32, 861-869

Identification of Alkylphenols and Other Estrogenic Phenolic Compounds in Wastewater, Septage, and Groundwater on Cape Cod, Massachusetts

RUTHANN A. RUDEL,*,[†] STEVEN J. MELLY,[†] PAUL W. GENO,[‡] GANG SUN,[‡] AND JULIA G. BRODY[†]

Silent Spring Institute, 29 Crafts Street, Newton, Massachusetts 02158, and Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78228-0510 Environ. Sci. Technol. 2006, 40, 4894-4902

Steroid Estrogens, Nonylphenol Ethoxylate Metabolites, and Other Wastewater Contaminants in Groundwater Affected by a Residential Septic System on Cape Cod, MA

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Pharmaceuticals and hormones in ponds

- Measure hormone and pharmaceutical levels in 6 Cape Cod ponds
- Compare ponds in high and low density residential areas
- Each pond tested up to 3 times

LJ Standley et al. (2008) Environmental Toxicology & Chemistry





Higher concentrations in ponds in more densely developed areas



LJ Standley et al. 2008. Environmental Toxicology and Chemistry, 27(12): 2457.

CECs in public (municipal) wells

Science of the Total Environment 468-469 (2014) 384-393



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Pharmaceuticals, perfluorosurfactants, and other organic wastewater compounds in public drinking water wells in a shallow sand and gravel aquifer $\overset{\backsim}{\asymp}$



Science of the Total Environment

Laurel A. Schaider^{*}, Ruthann A. Rudel, Janet M. Ackerman, Sarah C. Dunagan, Julia Green Brody

Silent Spring Institute, 29 Crafts Street, Newton, MA 02458, USA

HIGHLIGHTS

- We tested 20 public wells in a sand and gravel aquifer for 92 OWCs.
- Pharmaceuticals and perfluorosurfactants were frequently detected.
- Septic systems are the primary sources of OWCs into the aquifer.
- Maximum concentrations of two pharmaceuticals are as high as other U.S. source waters.

GRAPHICAL ABSTRACT



Public wells



- 20 wells, including range of impacts
- 18 of 92 chemicals detected:
 - 9 pharmaceuticals
 - 1 insect repellent
 - 2 perfluorinated chemicals
 - 5 flame retardants
 - 1 alkylphenol (detergent)
- 0 to 12 chemicals per well
- Parts per trillion levels

Schaider LA et al. 2014. Sci. Tot. Env. 468-469: 384-393.



Wells with more residential development and higher nitrate had more emerging contaminants



Total pharmaceutical concentrations in parts per trillion

LA Schaider et al. (2014) Science of the Total Environment

CECs in private (domestic) wells

- 20 private wells
- Included range of nitrate levels
- Screened volunteers based on initial testing of N and B
- Tested for 121 CECs by Underwriters Laboratories
- Sampled February 2011



Emerging Contaminants in Cape Cod Private Drinking Water Wells

Laurel Schaider, Ph.D. Janet Ackerman Ruthann Rudel, M.S. Sarah Dunagan, M.A. Julia Brody, Ph.D.

November 2011

Most commonly detected chemicals

units: nanograms per liter (ng/L) = parts per trillion (ppt)

Chemical	Category/uses	No. of wells (%)	Maximum concentration	
acesulfame	Artificial sweetener	17 (85%)	5300 ng/L	
PFHxS	Perfluorinated chemicals	11 (55%)	41 ng/L	
PFBS	Present in non-stick and stain-resistant coatings for	11 (55%)	23 ng/L	
PFOS	textiles, paper, and other household products; fire-	11 (55%)	7 ng/L	
PFHxA	fighting foams and some industrial processes	10 (50%)	2 ng/L	
sulfamethoxazole	Antibiotic	9 (45%)	60 ng/L	

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Wastewater appears to be primary source of perfluorinated chemicals in private wells



Sulfamethoxazole (antibiotic)



GW = groundwater, SW = surface water, —= MRL, DL, or lowest value reported

Are these levels of concern?

 Pharmaceutical levels are far below therapeutic dose
 But... drugs are potent and intended for specific people and conditions

... can have side effects on cancer, development, etc.

- For chemicals in household products, direct exposure from product use may be higher
- Levels detected are much lower than typical regulations
 But... regulations don't consider low-dose endocrine disruption

... don't consider mixtures of multiple chemicals

CECs from septic systems

- Compiled 16 published studies of 30 emerging contaminants in septic systems
- Most removal occurs in leach field
- Removal efficiencies in leach fields ranged from 30% to >99%



	Median concentration in septic tank effluent (µg/L)	Median concentration in leach field effluent (µg/L)	Median concentration in WWTP effluent (µg/L)	Median percent removal in leach fields (%)	
Well removed in WV	VTPs (>80% remov	ıal)			
acetaminophen	40	0.1	0.1	>99%	
caffeine	40	0.1	1	>99%	
nonylphenol	30	7	0.3	80%	
triclosan	1	1 0.1 0.2		90%	
Moderately removed in WWTPs (50-80% removal)					
DEET	1	0.2	0.1	80%	
sulfamethoxazole	0.03	0.2 0.1		40%	
trimethoprim	0.6	0.01 0.03		70%	
Poorly removed in WWTPs (<50% removal)					
carbamazepine	0.9	0.08	0.5	40%	
ТСЕР	0.3	0.2	0.3	30%	

	Median concentration in septic tank effluent (µg/L)	Median concentration in leach field effluent (µg/L)	Median concentration in WWTP effluent (µg/L)	Median percent removal in leach fields (%)	
Well removed in WI	VTPs (>80% remov	val)			
acetaminophen	40	0.1	0.1	>99%	
caffeine	40	0.1	1	>99%	
nonylphenol	30	7	0.3	80%	
triclosan	1	0.1	0.2	90%	
Moderately removed in WWTPs (50-80% removal)					
DEET	1	0.2	0.1	80%	
sulfamethoxazole	0.03	0.2	0.1	40%	
trimethoprim	0.6	0.01	0.03	70%	
Poorly removed in V/WTPs (<50% removal)					
carbamazepine	0.9	0.08	0.5	40%	
ТСЕР	0.3	0.2	0.3	30%	

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sulfamethoxazole	0.03	0.2	0.1	40%
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Conventional septic system vs. conventional wastewater treatment plant



Applications to groundwater quality

- Modeled inputs of CECs into ground water
 - Public wells recharge areas
 - Coastal and freshwater watersheds
- Identify areas with greatest inputs of CECs
- Baseline for evaluating alternative solutions



		<u>4-NONYLPHENOL</u>		<u>TCEP</u>		SULFAMETHOXAZOLE	
		grams per year	grams per sq. mile per year	grams per year	grams per sq. mile per year	grams per year	grams per sq. mile per year
Whole Cape		200,000	500	8,000	20	7,000	20
Public wells							
BFD2 (BF2)	ZOC	50	300	2	9	2	9
(Barnstable)	Zone 2	700	100	30	4	20	4
Arena 3&4	ZOC	200	1,000	6	50	6	50
(C-O-MM)	Zone 2	3,000	800	80	30	90	30
Electric Station 1	ZOC	100	700	4	20	4	20
(Cotuit)	Zone 2	300	600	10	20	10	20
Lumbert Mill 9	ZOC	300	900	9	30	9	30
(C-O-MM)	Zone 2	2,000	1,000	70	30	70	40
Hyannisport	ZOC	900	1,000	30	60	30	50
(Hyannis)	Zone 2	2,000	2,000	300	200	100	70
Private well areas							
Eastham		1,000	2,000	40	70	40	80
Watersheds							
Lewis Bay system		10,000	900	900	70	500	40
West Falmouth Harbor		1,000	500	200	60	60	20
Lewis Pond		20	200	0.6	7	0.6	7
Ovster Pond		200	400	8	10	8	10

An alternative: Eco-toilets

- Composting or urine diverting
- Most nutrients in household wastewater come from human waste, so potential to divert nutrients, save water and energy
- Town of Falmouth, MA: pilot project to measure nitrogen in greywater after eco-toilet installation
- What happens to CECs?



CECs and eco-toilets

- Measure septic tank effluent before and after eco-toilet installed in 5 homes
- Survey residents

 about product usage
 (consumer products, medications) and
 cleaning behaviors



Implications and future work

- Presence of CECs in Cape Cod groundwater raises health concerns
- Evaluate how proposed solutions can alter location and amount of CEC inputs into Cape groundwater
- Eco-toilets study will provide information about CEC contributions from blackwater
- Further study needed of sources and fate of perfluorinated chemicals

Protecting water quality

- Minimize use of fertilizers, pesticides, and harmful chemicals
- Don't flush medications, hazardous products
- Support land conservation near water supplies
- Maintain septic systems



Acknowledgements



RESEARCHING THE ENVIRONMENT AND WOMEN'S HEALTH

MASSACHUSETTS ENVIRONMENTAL

TRUST

- Commonwealth of Massachusetts
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- Tom Cambareri
- Underwriters Laboratories

Contact information:

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A HEALTHIER FUTURE

View a brief introduction to Silent Spring Institute's research on the links between the environment and breast cancer, environmental health issues and the emerging field of green chemistry.



CLICK TO VIEW VIDEO



NEW STUDY: Priority breast carcinogens & biomonitoring methods

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FEATURED RESEARCH

New study identifies priority breast carcinogens and biomonitoring methods

Our letter in *Science* outlines the major advances over the past 20 years on breast cancer and the

Pharmaceuticals and consumer product chemicals found in drinking water wells, septic systems are main source

Experts Call for Federal Government to Increase Breast Cancer Prevention Efforts

Gathering Dust: Many Toxic Flame Retardants Linger in Homes, Sometimes at Levels

MEDIA COVERAGE

GreenSpace: Chemical exposure and breast cancer risk, *The Philadelphia Inquirer*

Reducing the Risk of Breast Cancer, *Living on Earth*

At 20 Silent Spring still making noise, Cape Cod Times

Researchers offer ways to avoid chemicals linked to breast cancer, *The Boston Globe*

17 Everyday Chemicals Could Be Linked to Breast Cancer, *Time*

A gift for mothers(and daughters, and all of us): New tools for breast cancer monitoring and prevention, *Environmental Defense Fund*

NEW AT SILENT SPRING INSTITUTE

Join our Research Scientist, Dr. Laurel Schaider, for a workshop on the environmental health of Nantucket Sound, June 25 at the Mashpee Public Library.

We're Hiring: Check out our employment opportunities here

Thank you for joining us for our 20th Anniversary Celebration, honoring Cape residents and legislators as pioneers in breast cancer prevention. May 15, 2014 in East Falmouth, MA.

Research Scientist Laurel Schaider, PhD participated in a panel discussion on chemicals in drinking water that pose health