

# PPCP Perspectives: *Emerging Knowledge on Emerging Contaminants*

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Pharmaceuticals and Personal Care Products:

State of the Science

Portland, Maine

# PPCPs

- **1 Acronym, 2 distinct issues**



<http://www.diamond.ac.uk/>



Image: Beyond Pesticides

# Environmental Pollution

**Q: What chemicals do we find in the environment?**

**A: All the ones we are using** (i.e., assuming we are looking for them)

Mostly those that are:

- Mass-produced
- Discharged into wastewater, soil & air
- Feature foreign chemical structures (i.e., organohalides)

**Detection does not automatically imply a problem, however**

## Today's Chemosphere

- Actual number of chemicals is unknown ( $\Rightarrow \infty$ )
- 26 million organic and inorganic compounds have been documented
- 9 million were commercially available in 2005
- 240,000 are inventoried or regulated by governments worldwide
- >4,800 are produced at quantities of >1 million lbs per year
- 2,800 earmarked for toxicity testing
- **Due to human activities, chemical complexity in the environment increases constantly**

# Necessity

**What do we need? What can we do without?**

**Case study:**

**Persistent biocides: societal necessity or avoidable environmental contaminants?**

- Halogenated aromatics
- Mass produced and consumed as components of personal care products
- Persistent environmental contaminants
- Potentially bioaccumulative
- Toxic
- Endocrine disruptors
- Not regulated; not routinely monitored

# Extracting Knowledge from the Safe Drinking Water Act (SDWA): What's Regulated?



Drinking Water and Health Basics

Frequently Asked Questions

Local Drinking Water Information

Drinking Water Standards

List of Contaminants & MCLs

Regulations & Guidance

Public Drinking Water Systems

Source Water Protection

Underground Injection Control

Data & Databases

Drinking Water Academy

Safe Drinking Water Act

National Drinking Water Advisory Council

Water Infrastructure Security

Drinking Water

## Ground Water & Drinking Water

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[EPA Home](#) > [Water](#) > [Ground Water & Drinking Water](#) > Current Drinking Water Standards

## List of Drinking Water Contaminants & MCLs

### National Primary Drinking Water Regulations

National Primary Drinking Water Regulations (NPDWRs or primary standards) are legally enforceable standards that apply to public water system by limiting the levels of contaminants in drinking water. Visit the list of regulated contaminants with links for more details.

- [List of Contaminants & their Maximum Contaminant Level \(MCLs\)](#)
- [Setting Standards for Safe Drinking Water](#) to learn about EPA's standard-setting process
- [EPA's Regulated Contaminant Timeline](#) (86 K PDF FILE, 1 pg) ([ALL ABOUT PDF FILES](#))
- [National Primary Drinking Water Regulations](#) [EXIT disclaimer](#) - The complete regulations regarding these contaminants available from the Cc

### National Secondary Drinking Water Regulations

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that r or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water syste comply. However, states may choose to adopt them as enforceable standards.

- [List of National Secondary Drinking Water Regulations](#)
- [National Secondary Drinking Water Regulations](#) [EXIT disclaimer](#) - The complete regulations regarding these contaminants available from the

### Unregulated Contaminants

This list of contaminants which, at the time of publication, are not subject to any proposed or promulgated national primary drinking water regulati regulations under SDWA. For more information check out the list, or vist the Drinking Water Contaminant Candidate List (CCL) web site.

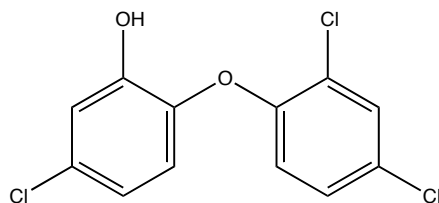
- [List of Unregulated Contaminants](#)
- [Drinking Water Contaminant Candidate List \(CCL\) Web Site](#)
- [Unregulated Contaminant Monitoring Program \(UCM\)](#)

List of Contaminants & their MCLs

# Primary Chemical Contaminants in SDWA

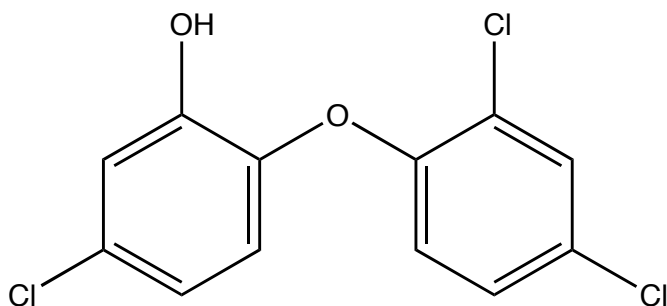
- Chemicals (~80 total)
    - Inorganic compounds (16)
      - Radionuclides (4 types/groups)
      - Elements (14)
    - **Organic compounds (~53)**
      - Non-halogenated compounds (12)
      - Halogenated compounds (~41)
      - Chlorinated compounds (40)
      - Pesticides (~24)
- ⇒ **75% of regulated organic DW contaminants are chlorinated organics**

# Examining Our Relationship With Nature...

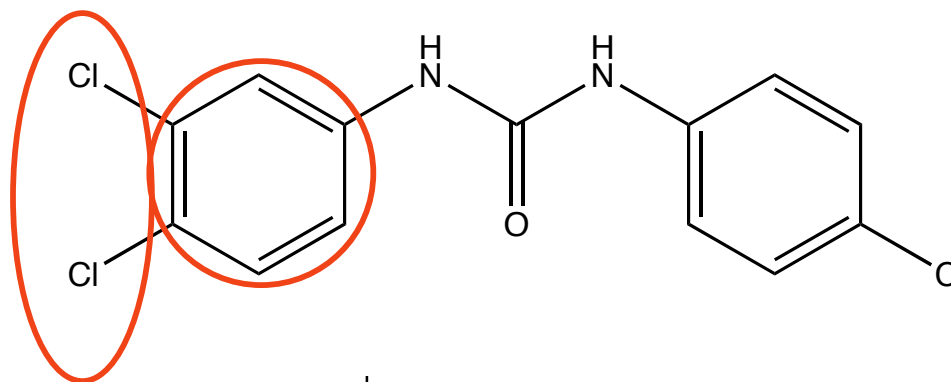


## ...By Entering the Antiseptic World of...

### Triclosan (TCS)



### Triclocarban (TCC)



Name	Triclosan	Triclocarban
Year Introduced	1964	1957
Log $K_{OW}$ (at 25°C, pH 7)	4.8	4.9

# Necessity: 1500 New Antimicrobial Products Since the Year 2000

- Production is increasing
- No benefits from use for the average consumer  
(FDA panel, 2005)
- New risks are emerging



# Risk Assessment: What It Can and Cannot Tell Us

- Assesses safety concerning known risks
- Changes with growing knowledge base
- Is NOT a “safety” certificate

Chemicals that are banned today were considered “safe” in the past (i.e., PCBs, DDT)

# Antimicrobials: Endocrine Disruption in Frogs



Aquatic Toxicology 80 (2006) 217–227



The bactericidal agent triclosan modulates thyroid hormone-associated gene expression and disrupts postembryonic anuran development

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Cell assay: concentrations of as low as 30 ng/L  
alter thyroid hormone receptor mRNA expression

# Antimicrobials: Endocrine Disruption in Mussels



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Comparative Biochemistry and Physiology, Part C 145 (2007) 464–472

**CBP**

[www.elsevier.com/locate/cbpc](http://www.elsevier.com/locate/cbpc)

## Effects of Triclosan on *Mytilus galloprovincialis* hemocyte function and digestive gland enzyme activities: Possible modes of action on non target organisms

Laura Canesi <sup>a,\*</sup>, Caterina Ciacci <sup>b</sup>, Lucia Cecilia Lorusso <sup>b</sup>, Michele Betti <sup>b</sup>,  
Gabriella Gallo <sup>a</sup>, Giulio Pojana <sup>c</sup>, Antonio Marcomini <sup>c</sup>

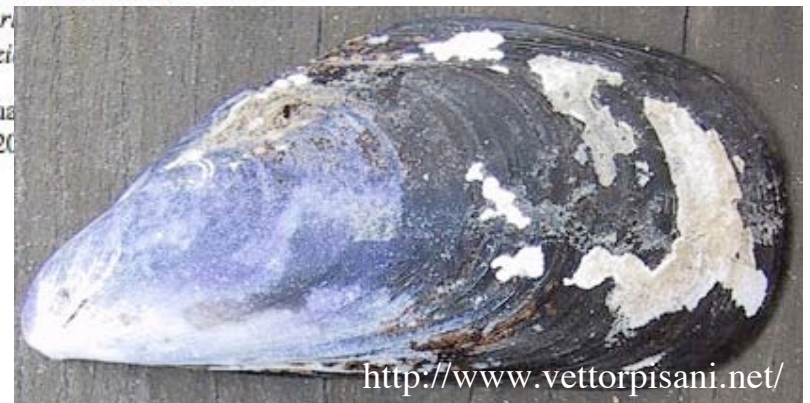
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Available online 9 February 2007



<http://www.vettoripisani.net/>

# Antimicrobials: Endocrine Disruption in Rats

Crofton et al Triclosan

<http://www.ealing.gov.uk/>

04/23/07



## Short-Term *in Vivo* Exposure to the Water Contaminant Triclosan: Evidence for Disruption of Thyroxine

Kevin M. Crofton<sup>1</sup>, Katie B. Paul<sup>2</sup>, Michael J. DeVito<sup>3</sup> and Joan M. Hedge<sup>1</sup>

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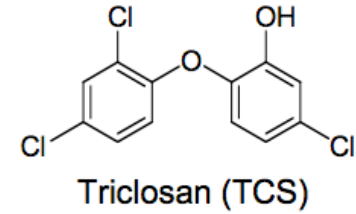
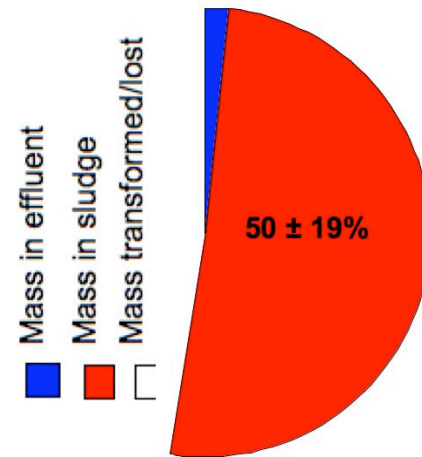


# Do Persistent Antimicrobials Cause Endocrine Disruption in Humans?



# Fate of Persistent Biocides

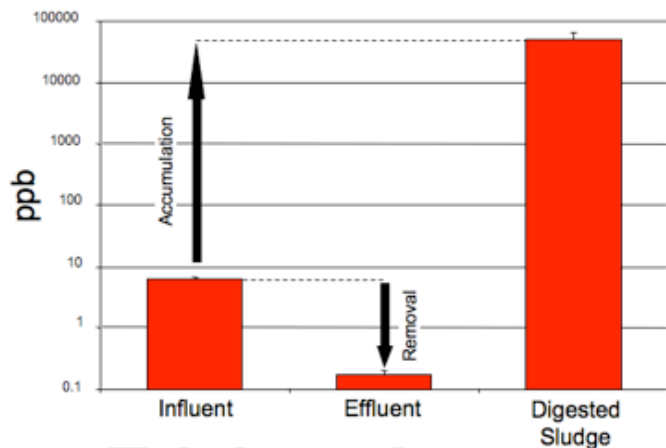
What is the Magnitude of Biocide Inputs to Agriculture from Sludge Recycling?



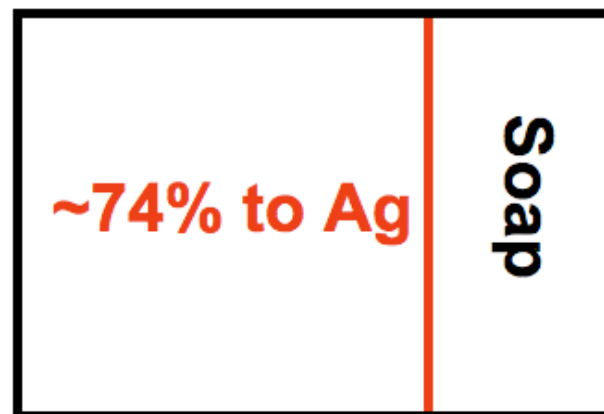
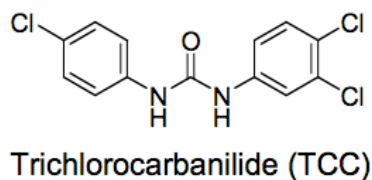
**Triclosan**



# Are Observations from the Mid-Atlantic Region Characteristic for the U.S.?



**Triclocarban**

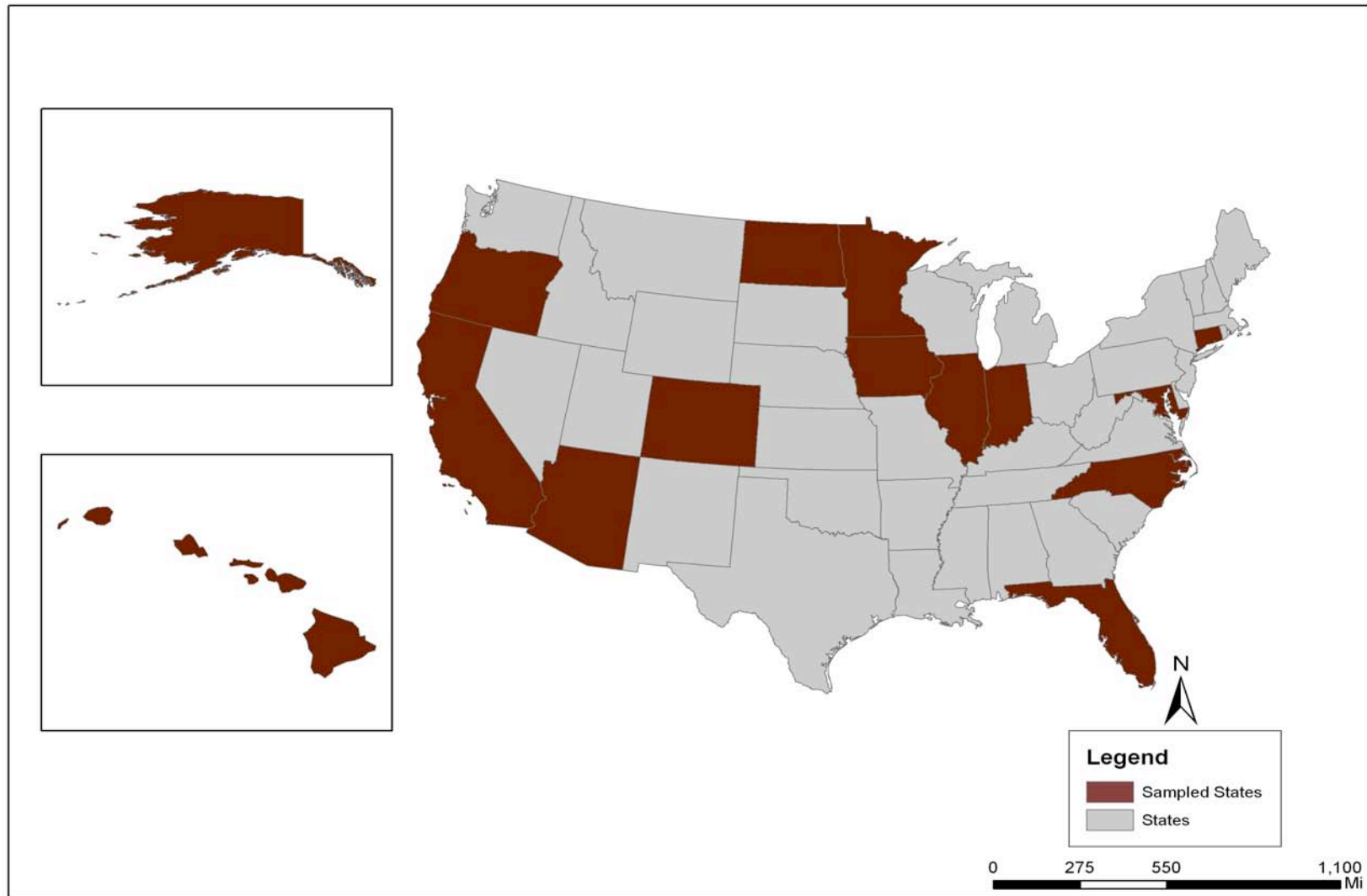


ES&T 2006, 40(11) 3634-39

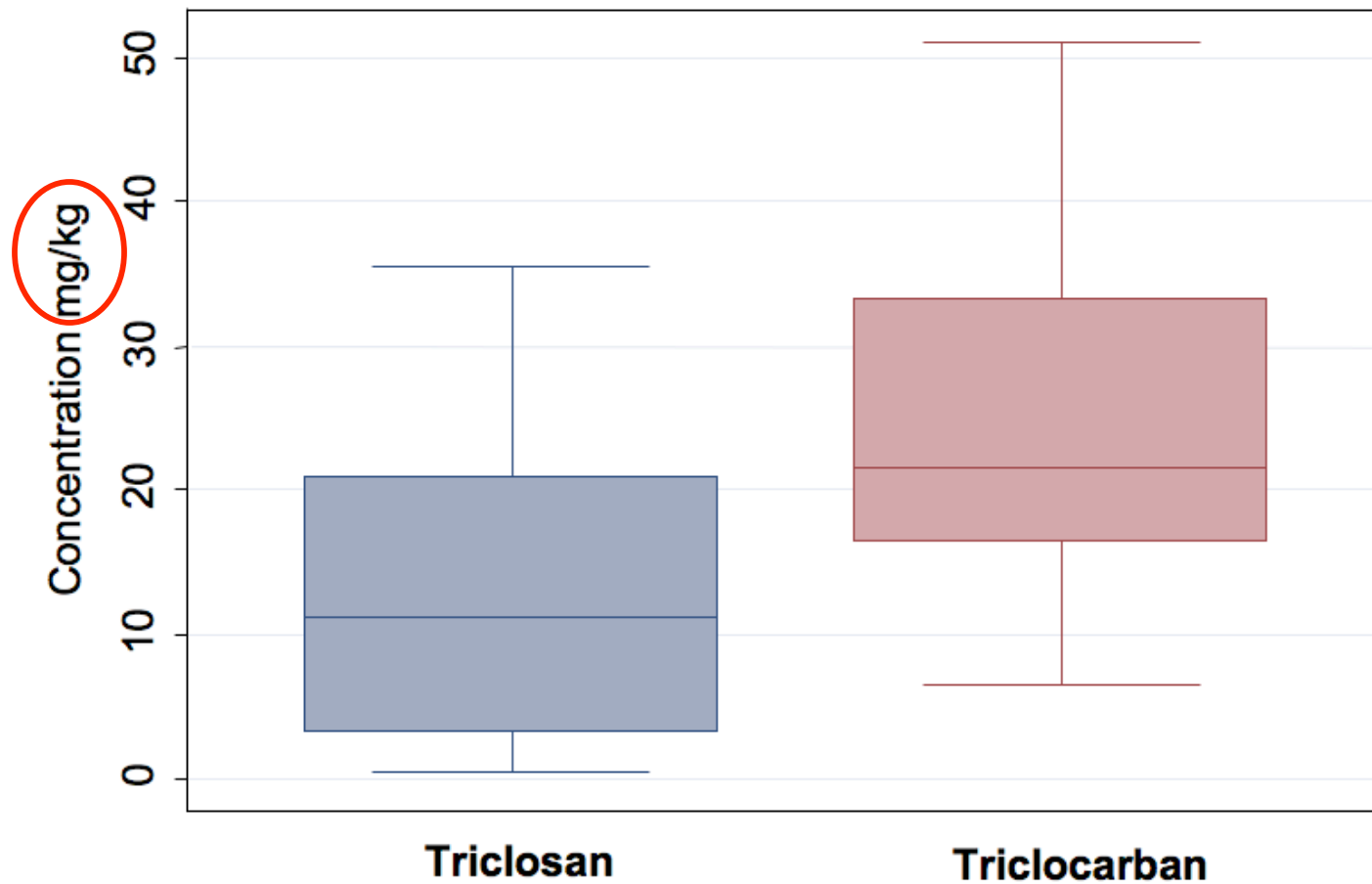
**What is the Magnitude of Biocide Inputs to Agriculture from Sludge Recycling?**

# U.S. Nationwide Survey: Preliminary Findings

## Map of states sampled (n = 15 + New England)



# Concentration of Biocides in Digested Sludge from 19 U.S. Treatment Plants



States = 15  
Plants = 19  
Samples = 31

# Biocide Mass Applied in Agriculture Nationwide Due to Sludge Recycling

**Total mass of triclosan and triclocarban applied to U.S. soils:**

**approx. 581,000\*  $\pm$  174,000 U.S. lbs/year ( $\pm$  95% CI)**

\* Preliminary estimate

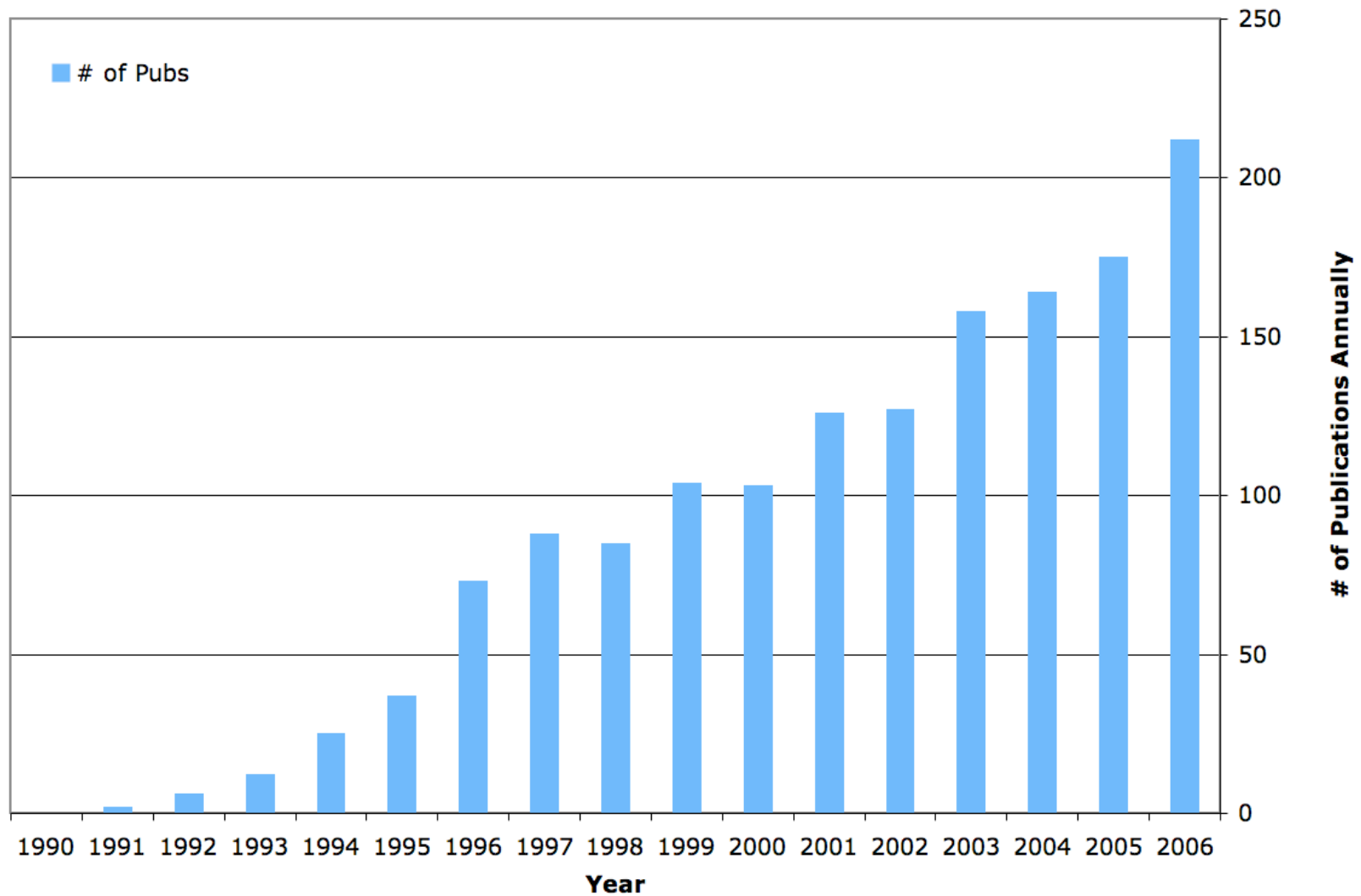
# Findings & Conclusions

- PPCPs in the environment: Dilution is not the solution
  - $\text{ppb}_{\text{WWTP Influent}} \Rightarrow \text{ppt}_{\text{WWTP Effluent}} \Rightarrow \text{ppm}_{\text{Biosolids}}$
- Significant releases (conc. & mass) to agricultural land
  - $581,000 \pm 174,000$  lbs/yr of TCS & TCC alone
- Several other OWCs were observed to accumulate in sludge
- PPCPs in biosolids is an emerging issue
  - represents a significant analytical challenge

# Biosolids: An Emerging Research Area

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ISI Publications Category "Biosolids"



# Sludge: what we know and don't know

- Sludge composition is largely unknown
- Sludge is a concentrate of hydrophobic and “hard-to-deal-with” compounds
- Sludge quality depends on wastewater quality
- Sludge is a resource of nutrients (N, P, C, etc.) and potentially valuable (but we have to protect its quality)

# Sludge: a Repository of Recalcitrant Chemistry

## The JHU National Biosolids Repository

Largest collection of U.S. municipal biosolids

- Information
- Confidentiality
- Continuity



# The Long Journey From Science to Policy

## Case Study: Triclosan & Triclocarban

- no proven benefit (for most current uses)
  - detectable in most U.S. surface waters
  - > 1M lbs/year; production up; >1,500 different products
  - toxic to aquatic biota at ng/L level
  - bioaccumulate in algae & earthworms
  - endocrine disruptors
  - contain dioxin & carcinogenic impurities
  - degrade to form additional carcinogens
  - persistent
  - accumulate in sludge and sediment to high ppm levels
  - detectable in fish, food, house dust, fetal blood and in
  - 97% of U.S. breast milk samples.
- => Regulatory actions pending

# Lessons (To Be) Learned

- **Produce and use** chemicals that:
  - have natural counterpart or origin
  - degrade rapidly
  - have a good safety record
- **Avoid** chemicals that are
  - halogenated (Cl, Br, F substituents)
  - rare in nature / have random structure / mixtures
  - structurally related to chemicals of concern
- **“Wastewater”** is “raw” drinking water

# Lessons (To Be) Learned

- Control chemical inputs into wastewater more tightly
- Have reasonable expectation; WWTPs are designed to clean water, not clean sludge. Treatment process sequesters pollutants in biosolids (e.g., metals and persistent biocides)
- **Pollution prevention** is the fastest, most economical and most effective way of reducing environmental pollution
  - Applicable to biocides, pharmaceuticals, personal care products, and other compounds

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