

Antimicrobial Agents in the Chesapeake Bay Watershed


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Overview

- Pesticides as pollutants
- Antimicrobials in the Chesapeake
 - Occurrence in streams
 - WWTP
 - Sludge
 - Sediments
- Discussion



<http://images.google.com/>

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The Chemosphere

- Actual number of chemicals is unknown (=> ∞)
- 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
- Are pesticides important pollutants?

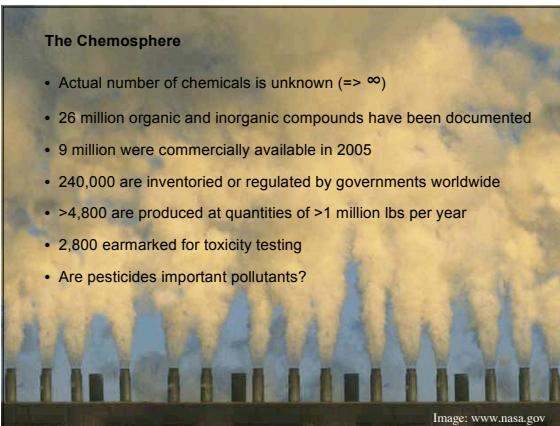


Image: www.nasa.gov

What's Regulated?

Ground Water & Drinking Water

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 systems 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 \(MCL\)](#)
- [Setting Standards for Safe Drinking Water to learn about EPA's standard-setting process](#)
- [EPA's Regulated Contaminants Timeline \(with PDF FILE Link\) \(last updated 10/2006\)](#)
- [National Primary Drinking Water Regulations](#) - The complete regulations regarding these contaminants available from the Code of Federal Regulations.

National Secondary Drinking Water Regulations

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

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

Unregulated Contaminants

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

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

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**

⇒ **45% of regulated organic DW contaminants are pesticides**

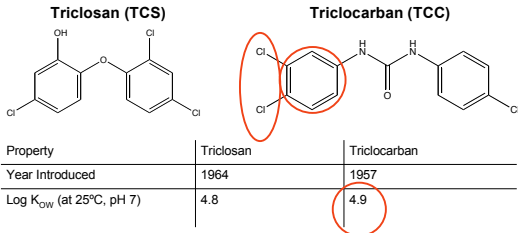
Potential Criteria for Blacklisting of Pesticides

- mass produced but ineffective
- widespread pollutant
- EDC, toxic at ng/L level
- carcinogenic impurities & degradates
- environmental persistence
- bioaccumulation



6

Case study: antimicrobials



For each molecule in water, there are ~10⁵ in octanol (fat)

Known / Potential Environmental and Human Health Risks of Triclosan

Degradates
(including chloroform)

✓

Persistent Environmental Contaminant

✓

Cross-resistance to Antibiotics

✓

Triclosan

Impurities

✓

Acts as Carcinogen, Mutagen or Teratogen
(No, at least not directly)

Bioaccumulation

✓

Endocrine Disruption

✓

Known / Potential Environmental and Human Health Risks of Triclocarban

Degradates

✓

Persistent Environmental Contaminant

✓

Cross-resistance to Antibiotics

✓?

Triclocarban

Impurities

? ✓

Acts as Carcinogen, Mutagen or Teratogen
? ✓
(Plausible Connection)

Bioaccumulation

?

Endocrine Disruption

?

1500 New Antimicrobial Products Since the Year 2000

- Production is increasing
- Benefits have been called into question (FDA, 2005)
- New risks are emerging

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Antimicrobials Can Act as Endocrine Disruptors



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

Nik Veldhoen^a, Rachel C. Skirrow^b, Heather Osachoff^b, Heidi Wigmore^b, David J. Clapson^a, Mark P. Gunderson^a, Graham Van Aggelen^b, Caren C. Helbing^{b,*}

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

Antimicrobials Can Act as Endocrine Disruptors



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

Laura Canesi^{a,*}, Caterina Ciacci^b, Lucia Cecilia Lorusso^b, Michele Betti^b, Gabriella Gallo^a, Giulio Pojana^c, Antonio Marcomini^d

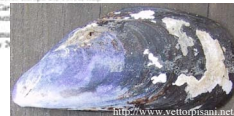
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<http://www.elsevier.com/locate/cbpc>

Antimicrobials Can Act as Endocrine Disruptors

Crofton et al. *Triclosan* <http://www.eahp.org.uk/> 04/23/07



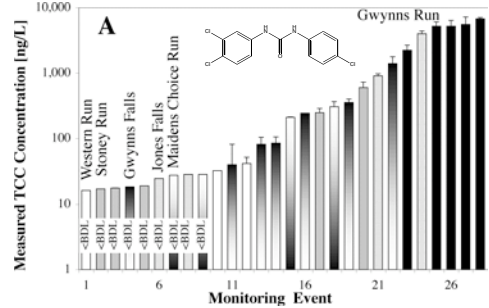
Short-Term *in Vivo* Exposure to the Water Contaminant Triclosan: Evidence for Disruption of Thyroxine

Kevin M. Crofton¹, Katie B. Paul², Michael J. DeVito³ and Joan M. Hedge⁴

¹Neurotoxicology Division and ²Experimental Toxicology Division,
National Health and Environmental Effects Research Laboratory,
Office of Research and Development, U.S. EPA, Research Triangle Park, NC;
³Curriculum in Toxicology, University of North Carolina, Chapel Hill, NC.



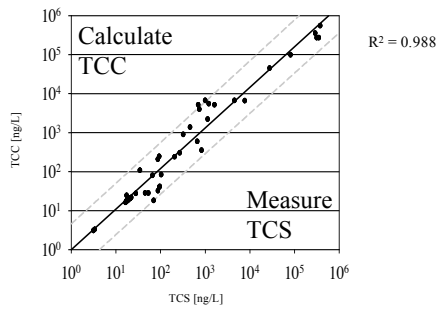
TCC Found in All Baltimore Streams Sampled



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Halder & Paul, *ES&T* 38(18):4849-4855 (2004)

Triclocarban & Triclosan Co-Occurrence



Halder and Paul, 2005, *Environ. Sci. Technol.*, 39(6): 1420-1426

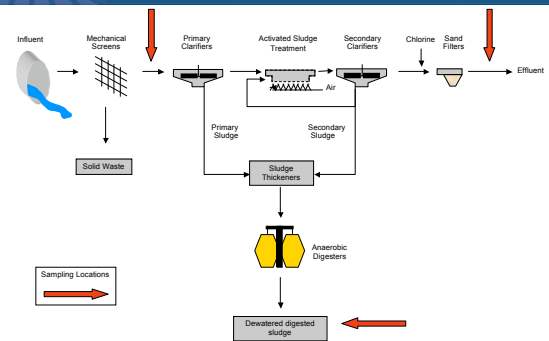
Antimicrobials & Wastewater Treatment



- Activated sludge WWTP
- 600 ML/D (180 MGD)
- Population served: 1.3 M

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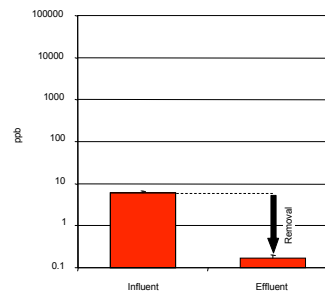
Process Diagram of Activated Sludge Wastewater Treatment Plant



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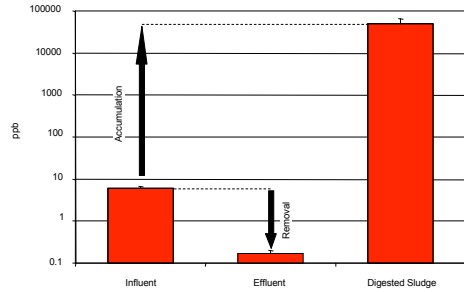
ES&T 40(11) 3534-39 (2006)

Triclocarban Is Removed From Wastewater



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...Only to Accumulate in Sludge



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

Mass Balance Calculation



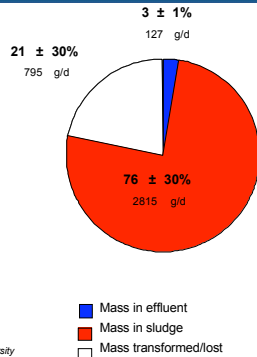
$$M_{trans} = (Q_{inf} \times C_{inf}) - (Q_{eff} \times C_{eff}) - (TS_{dig} \times Q_{dig} \times C_{dig}) - M_{vol}$$

M = Mass loading (kg/d)
 Q = Flow rate (L/d)
 C = Concentration (g/L)
 TS = Total solids (%)
 M_{vol} = negligible

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

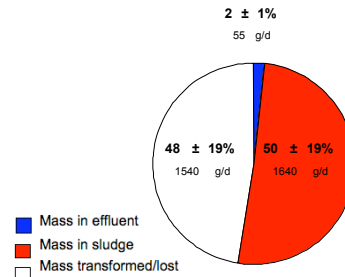
TCC Mass Balance in a Chesapeake Plant



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

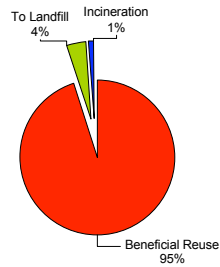
Triclosan Mass Balance in a Chesapeake Plant



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Heider & Halden, Chemosphere, 2007

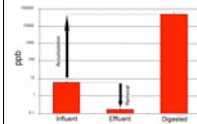
Fate of Sludge Produced by the WWT Plant



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

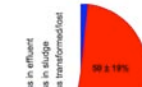
Biocide Inputs to Agricultural Soils



Triclocarban

~74% to Ag
Soaps

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

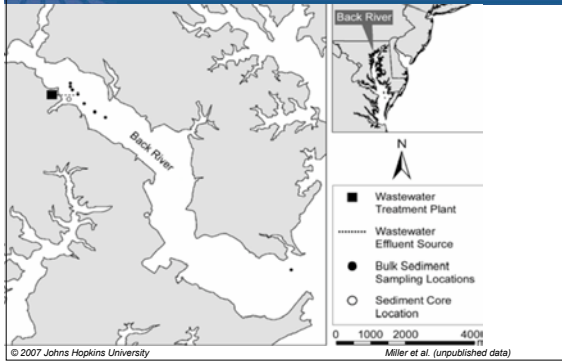


Triclosan

~10⁵ Kg/year to Ag
Soaps

Chemosphere 2007

Antimicrobials in Chesapeake Sediments



Summary

- Antimicrobials occur throughout the Chesapeake watershed
- Originate from sewer leaks, WWTP effluent & sludge disposal
- Accumulate to ppm levels in sediments
- Potential target for pollution control

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