2020 WEBINAR SERIES

Contaminants of Emerging Concern – Webinar Series

CECs 101: What are they?

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July 30, 2020

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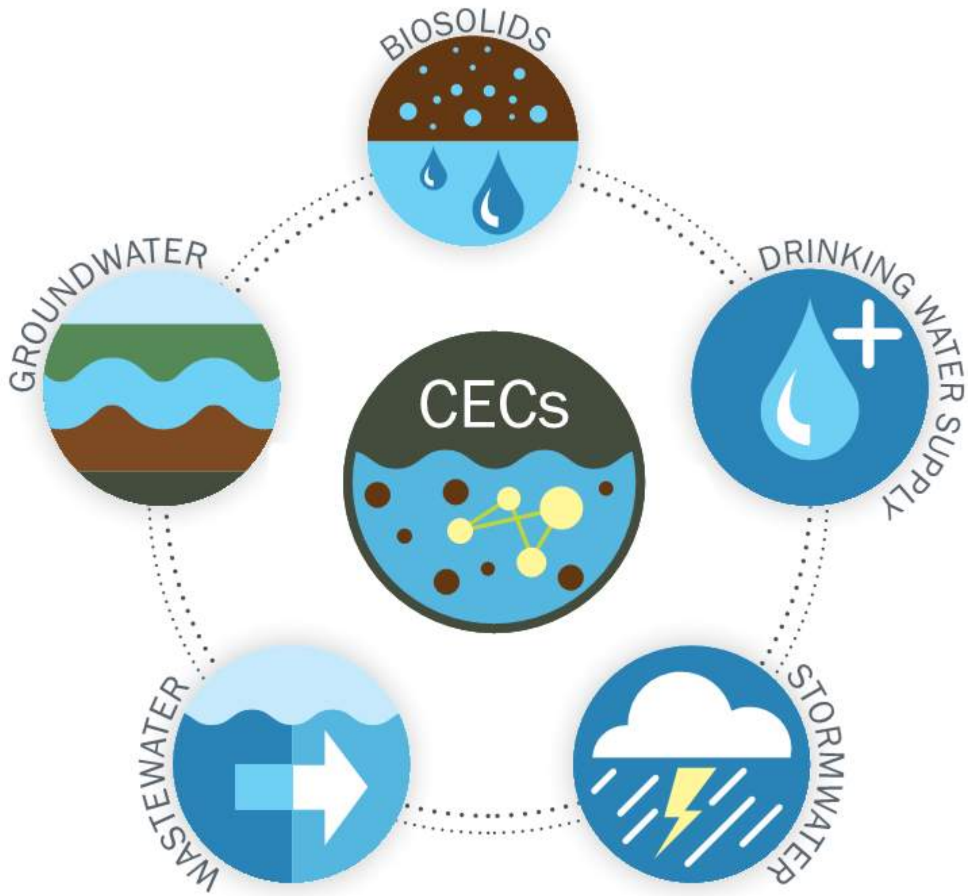
Agenda

1. CECs Definition
2. CECs Categories
3. Associated Health Effects
4. CECs in the Environment
5. Study of CECs
6. Q&A
7. Next Steps



CECs Definition

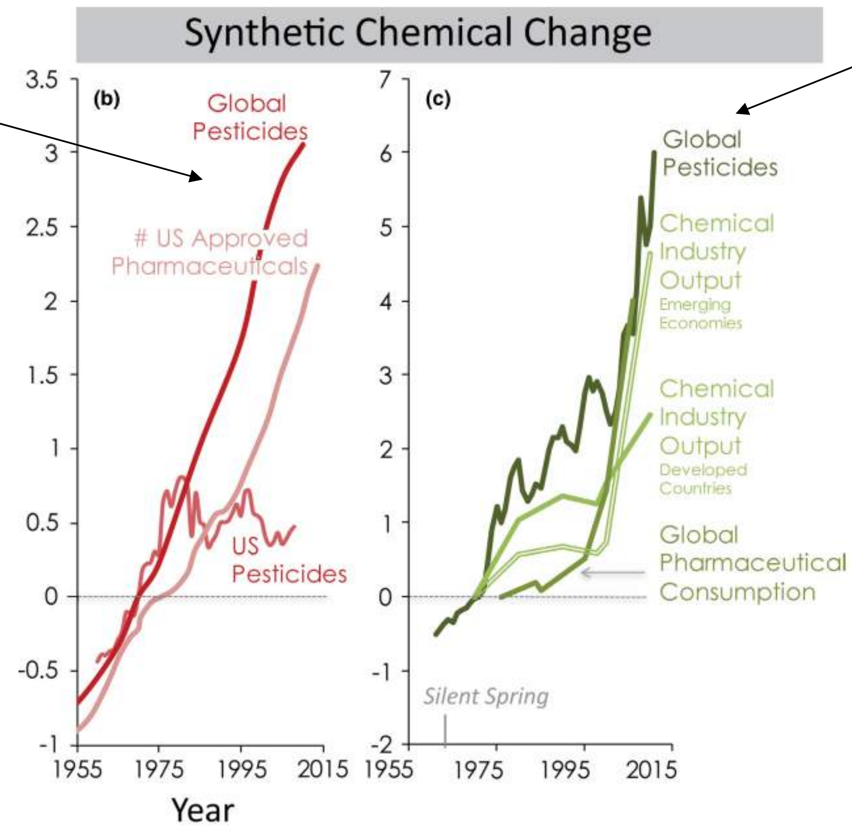
Fundamental traits

- Synthetic or naturally occurring chemical entering water sources but not commonly monitored
- Pose perceived or real threats to human health or the environment
- Health standards either don't exist or the standards are rapidly developing
- Substances may be new or may have been around for a long time but not recognized until analytical methods improved

Rise of Synthetic Chemicals

Diversity

- Increased diversity in synthetic chemicals

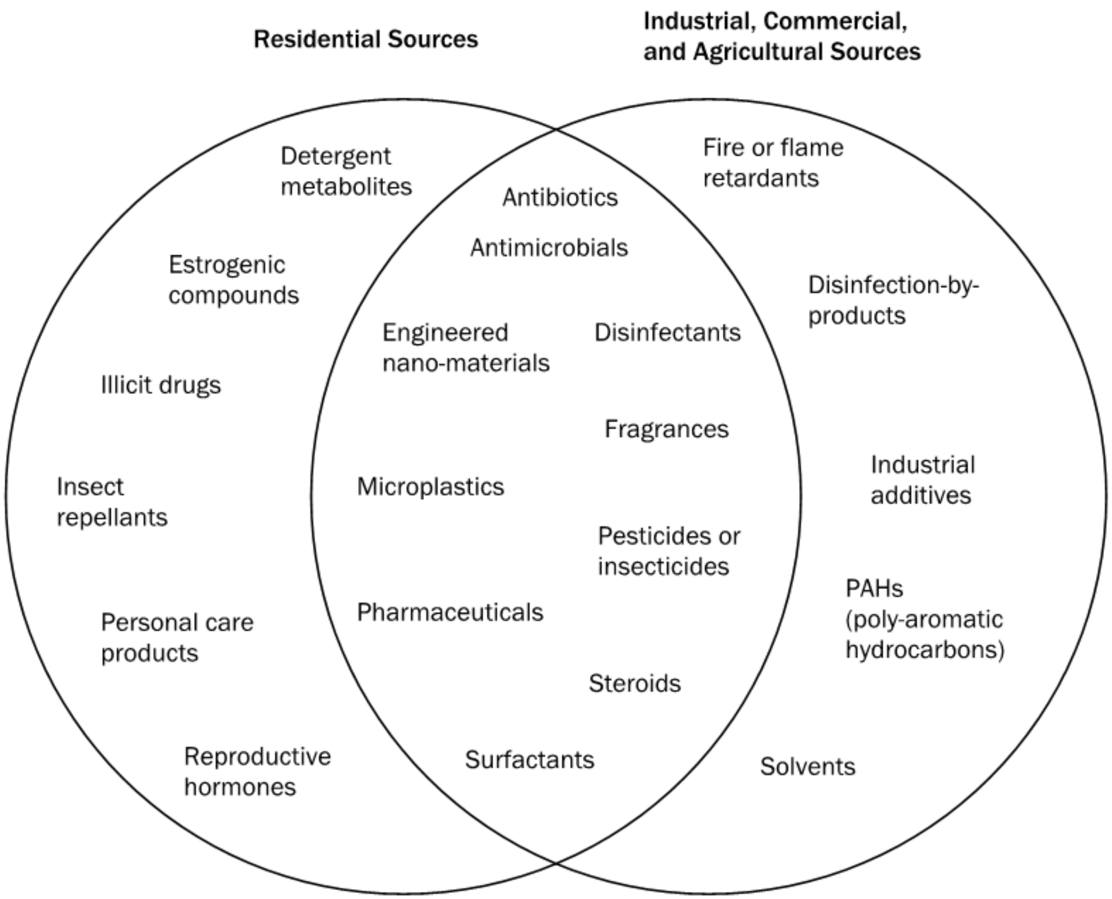


Production

- Projected mass of synthetic chemicals (based on trade value)

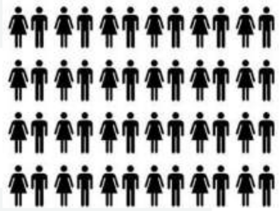
Bernhadt, Rosi, & Gessner, 2016

Common Classes of CECs



Example CECs

Associated Effects	CEC Categories
Antimicrobials	Triclosan, Triclocarban
Reproductive hormones	Estradiol
Surfactants	Nonylphenol
Fire or flame retardants	PFAS
Insect repellants	DEET



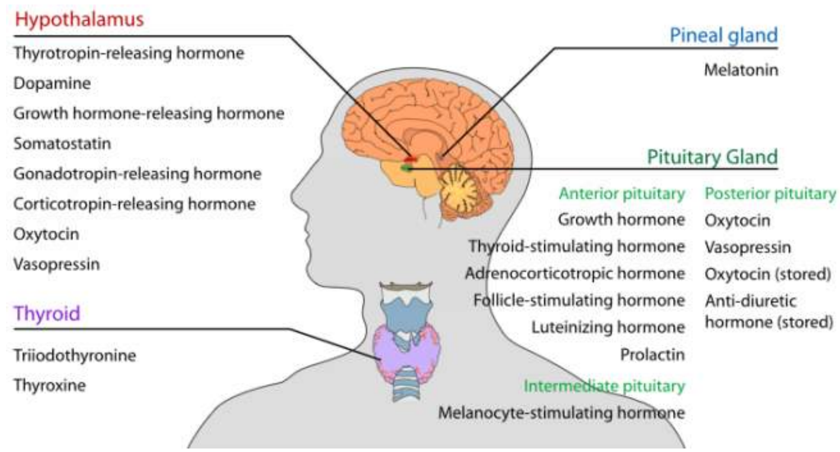
Suspected Effects from Environmental Exposure
(Often at High Levels)

Associated Effects	**CEC Categories**
Antibiotic resistance	Antibiotics, Antimicrobials, Personal care products
Carcinogenicity or increased risk of cancer	Fire retardants, Prescription drugs
Endocrine disruption	Personal care products, pesticides, plasticizers, reproductive hormones, solvents, steroids
General toxicity (incl. geno-, cytotoxicity)	Disinfectants, Industrial additives
Negative effect on animal reproductive activity	Life-style products (Caffeine, Nicotine)
Organ damage	Prescription drugs

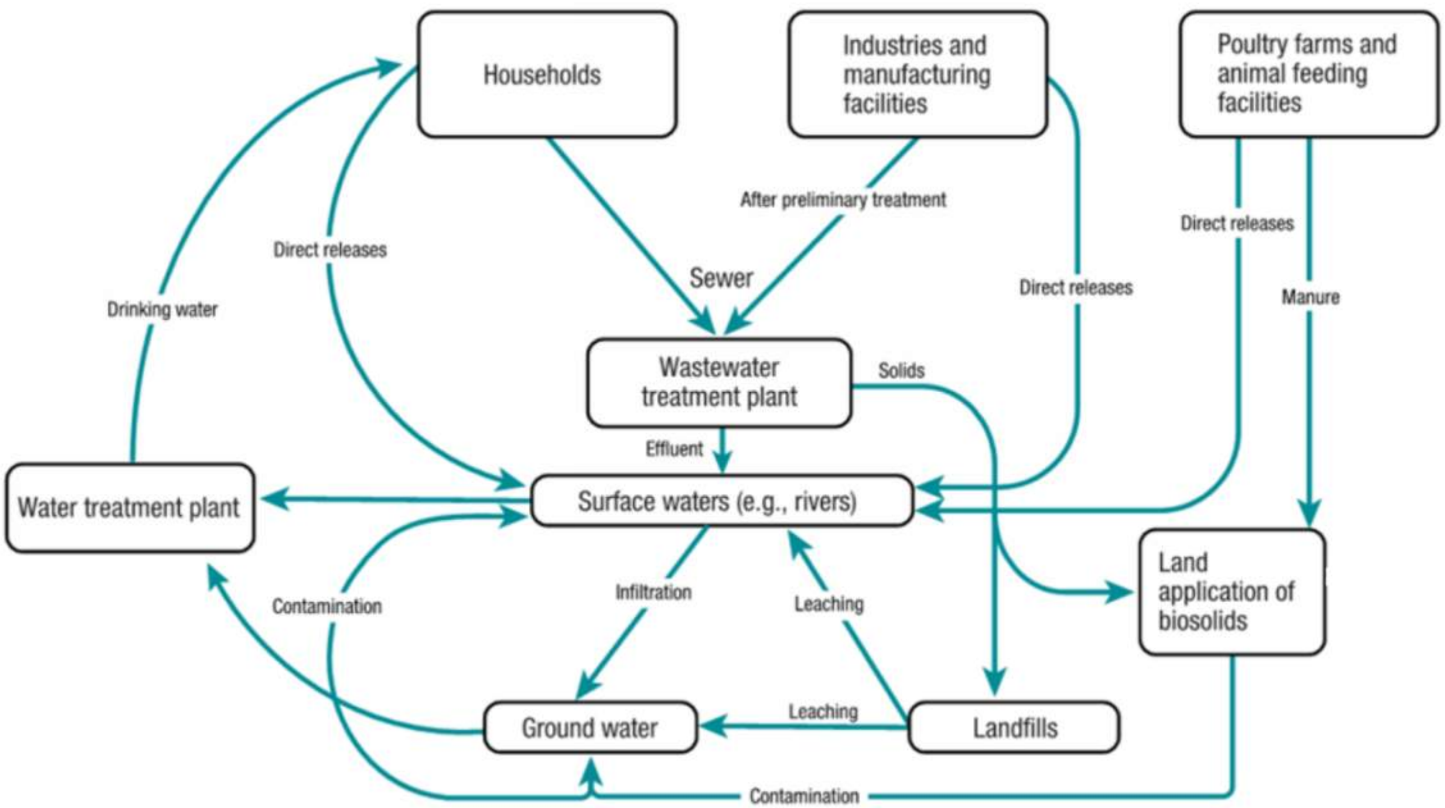
Modified from Rahgav, Eden, Mitchell, & Witte 2013

Endocrine Disruption

- Concern most frequently mentioned (e.g. endocrine-disrupting compounds or EDCs)
- Endocrine system is a system of glands and organs that secrete and regulate hormones
- Controls body functions such as growth, metabolism, and reproduction
- Gained public awareness in 50s and 60s with DDT
- Discovery of aquatic organisms with disrupted sexual development near WWTP outfalls drew attention to CECs



Environmental Sources and Pathways for CECs

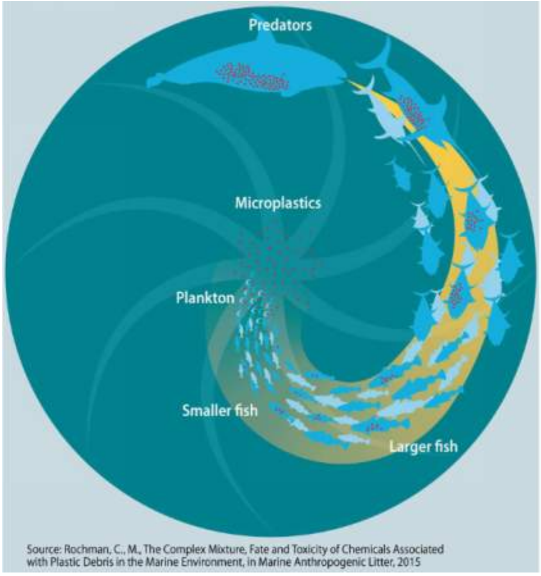


Environmental transformation processes: biodegradation, chemical redox, hydrolysis, and photolysis

Rahgav, Eden, Mitchell, & Witte, 2013; originally modified from Petrovic, Barcelo, Perez, 2013

Ecosystem Risk Considerations for CECs

- Aquatic (and potentially terrestrial) organisms submitted to perpetual, multigenerational exposure wherever humans are located
- Subtle, undetected effects could accumulate over time, causing irreversible ecosystem change
- Concern that numerous CECs sharing same mode of action or associated effect could lead to additive or synergistic exposures



Study of CECs

- Key priories identified early in the study of CECs by the USEPA ORD (Daughton and Ternes, 1999) include:

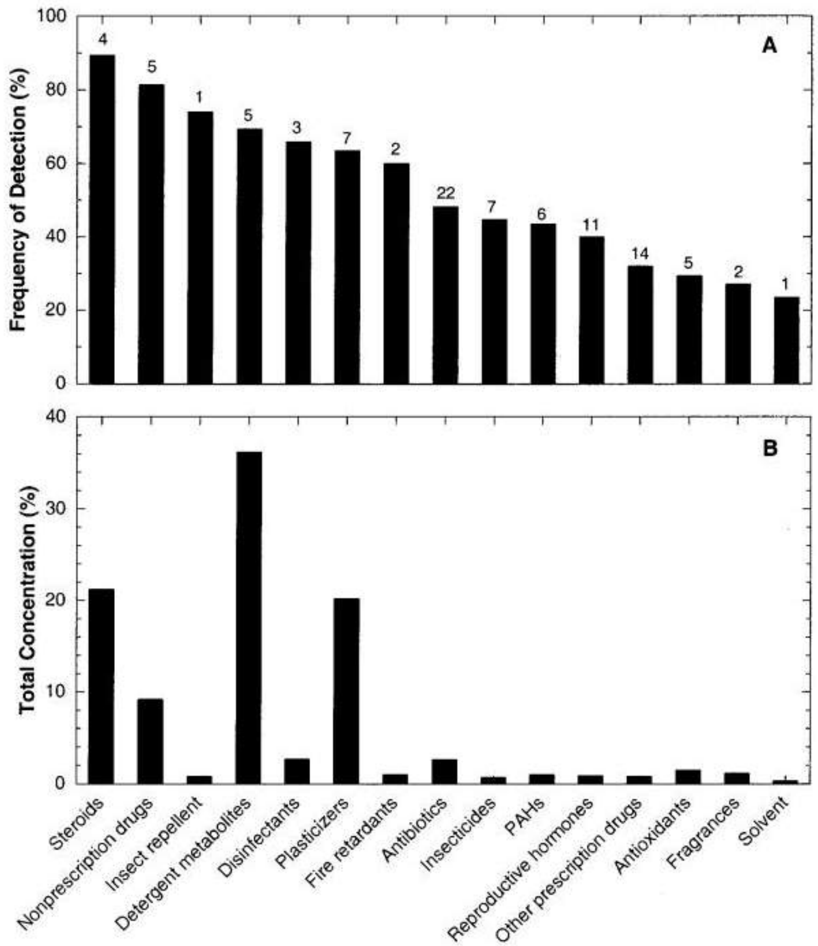
Surveys of WRRF effluents (and solids products), surface waters/groundwaters, and potable water for the presence of CECs

Identification of CEC sources

Evaluation of potential physiological effects (on nontarget species and human health)

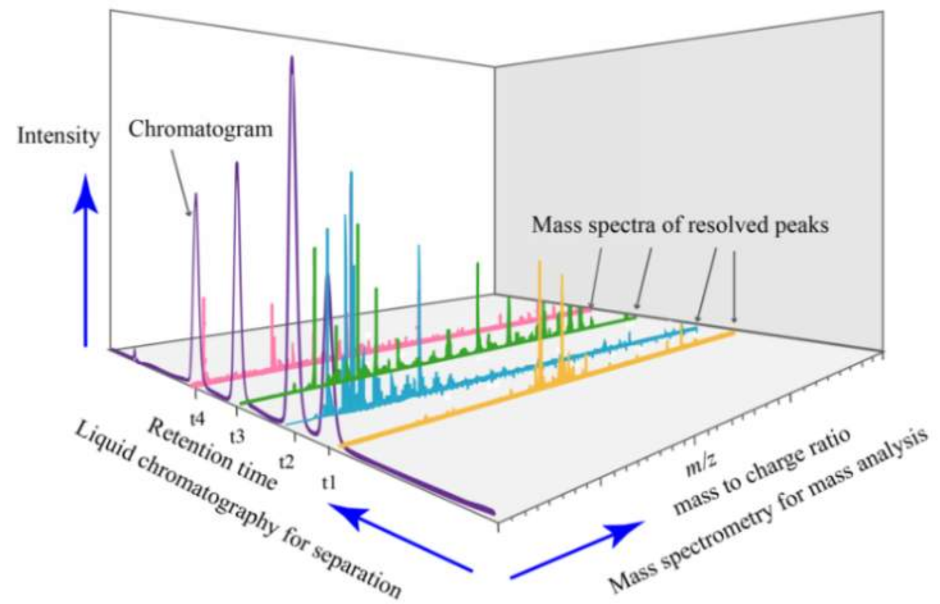
Discussion on the relative importance of this issues

Study of CECs: Occurrence in US Water Sources



Study of CECs: Analytical Methods

- Ability to survey CECs tightly linked to advancements in analytical instrumentation
- USGS study was made possible by introduction of liquid chromatography with mass spectrometry or LC/MS (capable of detecting polar and water-soluble compounds).
- LC/MS continues to improve, but is reliant on comparison of samples to standards and searchable libraries



Study of CECs: Analytical Methods

- Next frontier: Identification of unknown and nontarget compounds (e.g. metabolites and transformation products) using:
  - High resolution MS (HR-MS) analyzers (e.g. time-of-flight, ion trap, and Orbitrap)
  - Nuclear magnetic resonance (NMR) spectroscopy

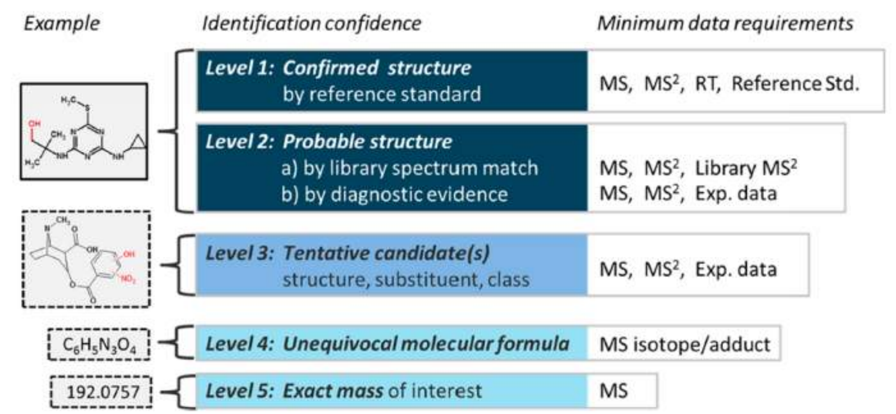
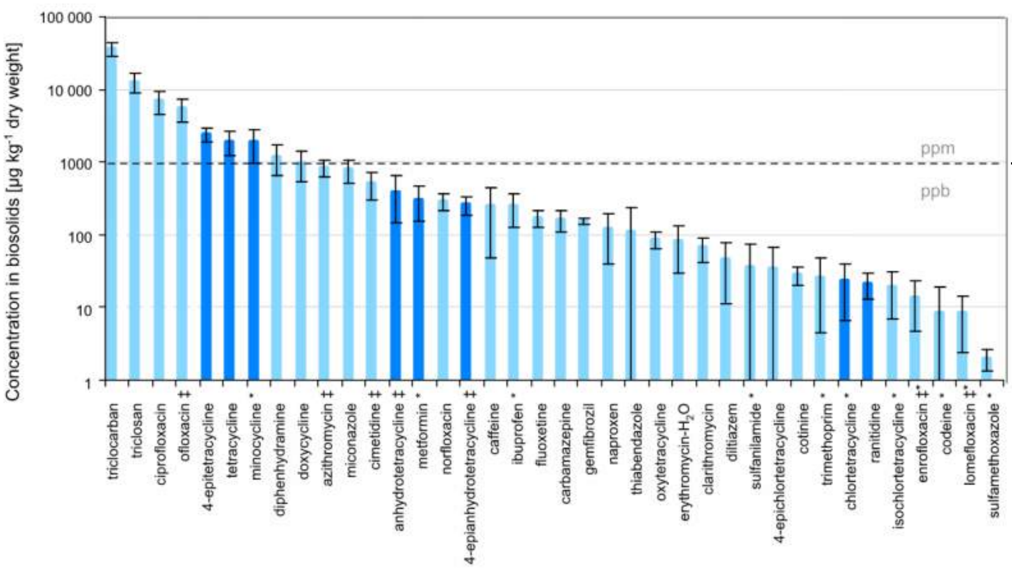


Figure 1. Proposed identification confidence levels in high resolution mass spectrometric analysis. Note: MS^2 is intended to also represent any form of MS fragmentation (e.g., MS^e, MS^n).

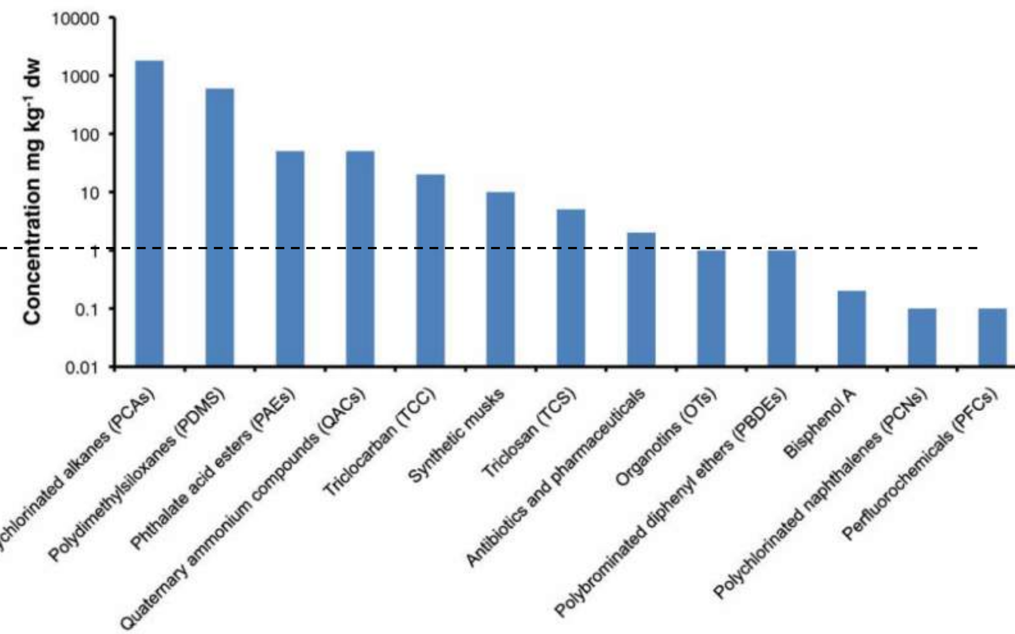
Schymanski et al., 2002 (USGS)

Study of CECs: Occurrence in Wastewater Solids

- Many CECs have hydrophobic properties and transfer to wastewater solids
- Critical surveys published in 2010-2011 for US and Europe

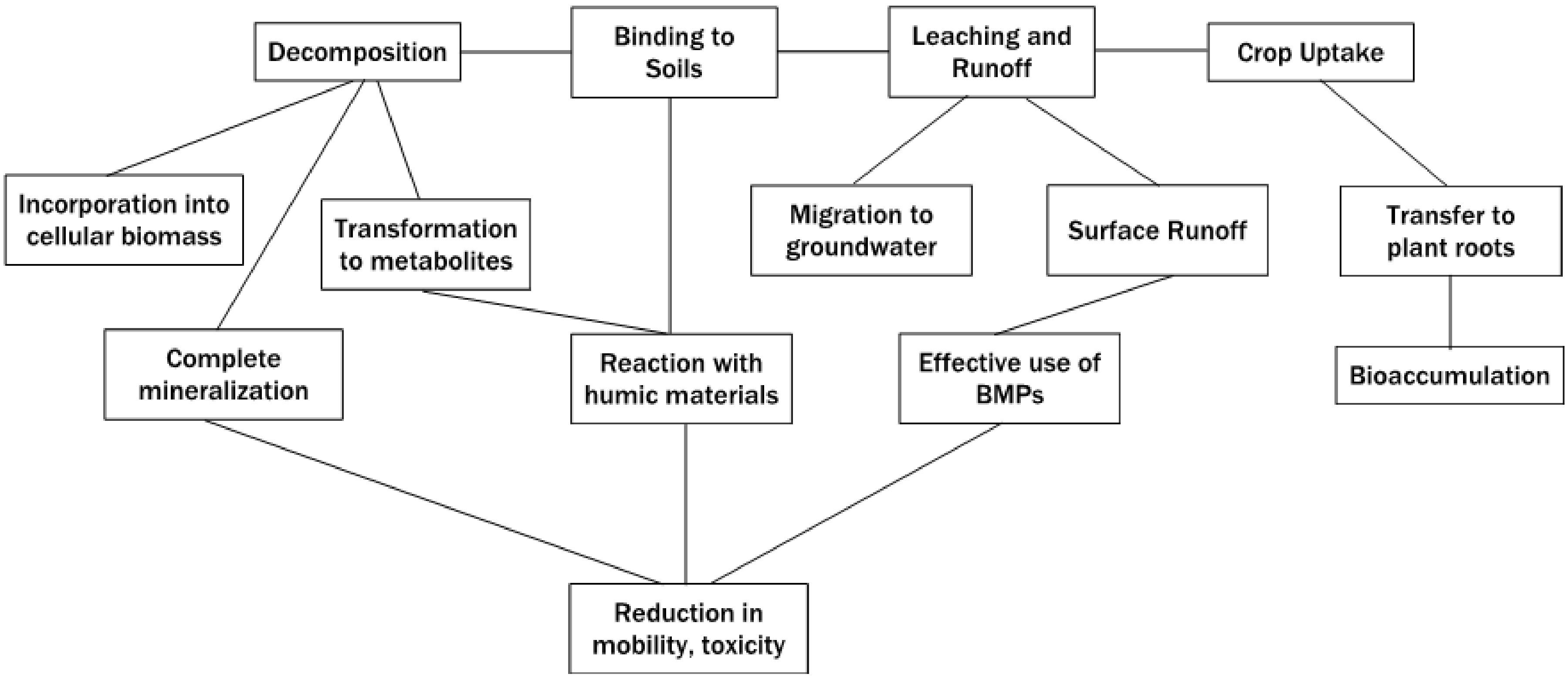


McClellan and Halden, 2010



Clarke and Smith, 2011

Study of CECs: Pathways in Land



Overcash, Sims, Sims, & Nieman, 2005

Study of CECs: Occurrence in Wastewater Solids

Table 4
Assessment matrix to determine research priorities for selected 'emerging' organic contaminants in sewage sludge with respect to their potential significance for agricultural utilisation.

Emerging organic contaminant	Persistent in soil (>6 months) 2 – yes 1 – uncertain 0 – no	Human food chain 2 – possible 1 – uncertain 0 – no	Ecological bioaccumulation 2 – yes 1 – possible 0 – no	Soil ecotoxicity 2 – yes 1 – uncertain 0 – no	Research quality 3 – lack of empirical data 2 – few reported studies 1 – a number of consistent studies 0 – many consistent studies	Score (/11)
Antibiotics and pharmaceuticals[a]	0	2	0	1	2	5
Benzothiazoles	1	1	0	1	3	6
Bisphenol A	0	0	0	0	2	2
Organotins	1	1	2	1	2	7
Phthalate acid esters (PAEs)	0	0	0	0	1	1
Polybrominated diphenyl ethers (PBDEs)	2	2	2	1	0	7
Polychlorinated alkanes (PCAs)	2	2	1	1	3	9
Polychlorinated naphthalenes (PCNs)	2	2	1	1	3	9
Polydimethylsiloxanes (PDMSs)	0	0	0	0	1	1
Perfluorochemicals (PFCs)	2	2	2	1	3	10
Quaternary ammonium compounds (QACs)	0	0	0	0	2	2
Steroids	0	0	0	0	2	2
Synthetic musks	1	0	1	0	1	3
Triclosan	1	0	2	2	2	7
Triclocarban	1	0	2	2	2	7

[a] The chemical properties of antibiotics and pharmaceuticals and subsequent behaviour in the environment can vary greatly. The scores are considered generally for antibiotics and pharmaceuticals, certain exceptions such as carbamazepine may exhibit longer soil persistence.

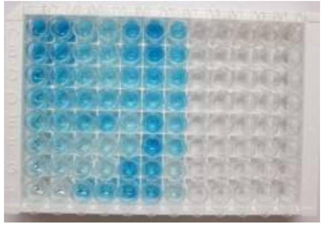
Clarke and Smith, 2011

Study of CECs: Identifying Risk to Ecosystems

- CECs present a wide spectrum of (often unknown) physiological impacts and existing toxicity data is lacking
- Fundamental questions:
  - Can we use species-defined, laboratory toxicity data to predict ecological impacts from mixture of CECs?
  - Do we need to understand all physiological effects or modes of action of CECs before looking for and assigning causation for population level changes?

Study of CECs: Identifying Risk to Ecosystems

- One strategy is use of ecotoxicological assays for variety of endpoints
- Examples include:
  - Bacterial growth inhibition for antibiotics
  - Aquatic vertebrate and invertebrate population level response
  - *In vitro* estrogen receptor and androgen receptor binding and transcriptional assays



Colorado.edu

Study of CECs: Identifying Risk to Ecosystems

- Combining chemical analysis and bioassays (mixture-toxicity modelling) is a developing science
  - Recent study in Danube River could attribute 80% of estrogen receptor activity to known biological effects of detected compounds, but only 0.2% of pregnane X receptor activity

Study of CECs: Continuing and Interagency Initiatives

- USGS
  - Continues to conduct CEC surveys and fate studies in US water ways
- USEPA
  - 1985 *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Life and Their Uses*
  - Contaminant Candidate List under Safe Drinking Water Act
  - Endocrine Disruptor Screening Program
- US States
  - Advisory panels and work groups
  - Survey and screening efforts

Thank you.

Questions?

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Upcoming Presentations

Webinar 2: CECs—Where are we now?

Thursday, August 27, 2020 • Noon – 1:00 PM

In this second part of our webinar series on CECs, we will highlight the current state of research on CEC treatment and removal by Water Resource Recovery Facilities (WRRFs). WRRFs are the receivers of many CECs, however they are not currently designed and regulated for the removal of these compounds. In this webinar we will discuss the existing capacity and mechanisms for removal by WRRFs. By understanding the efficiencies of existing systems and processes, we can better prepare for potential future regulations that may require costly retrofitting or upgrades.

Presenter: Amy Hunter, AECOM, Chelmsford, MA

Webinar 3: Addressing CECs with innovation

Thursday, September 24, 2020 • Noon – 1:00 PM

Join us for an interactive panel session where technology innovators advancing liquid and biosolid treatment and management processes will discuss new commercially ready technologies to address CECs. These innovative solutions are working to improve performance, cost, and operating challenges of existing technologies. Attendees will learn about which types of innovative technologies can address CECs, what advantages they have, where they fit in the process lifecycle, and how to partner to remove CECs in the environment.

Presenter: Julie Bliss Mullen, Aclarity Water, Hadley, MA

Webinar 4: Cost impacts & considerations for innovative CEC removal technologies

Thursday, October 29, 2020 • Noon – 1:00 PM

Getting CECs out of the water cycle is the job of every water professional. But what does it cost and what needs to be considered in evaluating and selecting innovative CEC removal technologies? The cost of the technology is not the entire picture. This webinar will cover the various life-cycle costs associated with CEC removal technologies and discuss other considerations such as maintenance,sustainability/energy usage, and managing residuals.

Webinar 5: Communicating with stakeholders about CECs

Thursday, November 12, 2020 • Noon – 1:00 PM

Customers, elected officials, regulators and the general public need to hear about CECs from the perspective of the clean water professional. Communication is typically not a strength of water quality experts and communicating about a subject as complex as CECs in the environment can seem daunting. But when a CEC removal technology is implemented, it will require rate changes to pay for it and we need to be able to communicate those impacts to all our stakeholders. This webinar will introduce various NEWEA communication tools designed to help you start a conversation about CECs with just about anyone.