JCWRE, Special issue on "Contaminants of Emerging Concern in Water Environments"

THE ASK

Contaminants of Emerging Concern (CECs) or simply Emerging Contaminants (ECs) have been in the wider lexicon of water research since the early 2000s. One of the earliest review articles on the topic was compiled by Petrovic et al. 2003 (*TrAC* 22(10) p.685) where they took time in their introduction to define the concept of an "emerging contaminant". Depending on the context of the term, CECs generally can be defined with five (5) characteristics that apply to nearly all constituents labeled with the term--

(1) Lack of regulatory controls or certainty
(2) Presence in water in low concentrations of µg/L or ng/L (ppb, ppt)
(3) Uncertainty concerning their human and ecotoxic risk according to known exposure routes
(4) Difficulty in removal through conventional primary and secondary wastewater treatment
(5) Diffuse and constant sourcing to the environment due to ubiquitous use in product and processes of modern life, frequently in urban settings

The thought of their concern as "emerging" is suggestive that there likely will be a concern for human health, ecotoxicity, or environmental persistence in the future, but it is not yet clear what the scope of that concern should be. This emerging nature is one reason why most of these contaminants, while they can now ***generally*** be measured, are not ***routinely*** measured. There is little to no regulatory framework which forces a drinking water utility, wastewater operator, landfill manager, crop farmer, hazardous waste treatment unit technician, hospital administrator, industrial product designer, or concentrated animal feeding operation (CAFO) operator to know anything about CECs or treat them in any way in their waste streams or products.

The fact that CECs span such a wide variety of classes, products, and sources makes them on the one hand interesting from a research perspective but also challenging to provide any type of comprehensive assessment of their generation, transport, fate, and impact. There is no single list of CEC classes which is definitive, but a common listing of CECs could be made according to broad classes including pharmaceuticals and personal care

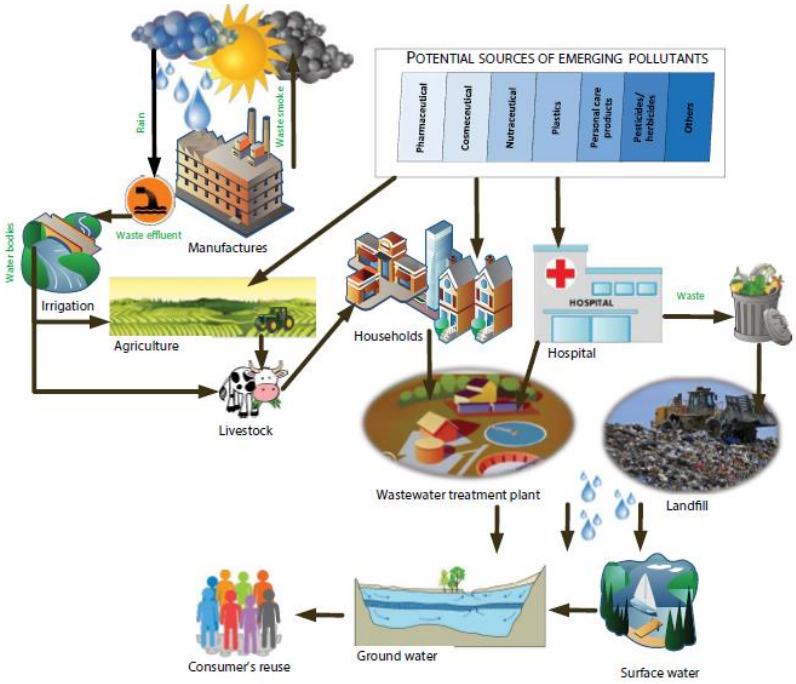

Figure 1. Potential routes for CEC introduction into anthropogenic and natural water systems. Taken from Neczaj 2020.[1]

products (PCPPs, antidepressants, illicit drugs, cosmetics, veterinary drugs), pesticides (in home insecticides, fungicides, herbicides), industrial products (PFAS, plasticizers, engineered nanomaterials), microplastics (plastic particles < 5 mm in size), and pathogens. Some define CECs more by what they ***are*** as in the case of personal care products or flame retardants while others are more concerned with what they ***do***. Are they environmentally persistent, generative of antibiotic resistant genes (ABR), or endocrine disrupting chemicals (EDCs)?

There is general consensus that one of the major routes to bring CECs into water systems is through municipal and industrial wastewater. Standard primary and secondary wastewater treatment was not designed for these low-level, highly diverse contaminants. To remove CECs in the wastewater stream and therefore before they are discharged to the environment seems a worthy goal. However, this is challenging because of the costs of monitoring required, the diversity of tertiary treatment technologies which a WWTP operator would need to examine for use, the cost of additional treatment which, due to the emerging concern criterion does not give regulatory backing for the expense, and uncertainty about residuals and degradation products that may be generated. The presence of CECs is therefore a complex challenge for wastewater utilities and thus even more complex to explain in any meaningful way to the public who might benefit from the additional focus on this threat.

A trend in water resources both now and growing into the future will be the reuse of wastewater for drinking water and agricultural irrigation through non-direct potable reuse (effluents to streams, lakes, managed aquifer recharge) and direct potable reuse. As water demand increases to enable a growing population to live in a modern fashion, the pressure to reuse water will only increase in proportion. Coupled with water reuse is the knowledge that a CEC that is “removed” from a stream of wastewater may have an in-process fate of residing in sewage biosolids. The desire to reuse the nutrients and organic material from these solids is laudable, but this is yet another route for CECs to enter the environment. Thus, through the food supply and through drinking water provision, the chance that human communities will be exposed to CECs of various kinds will only become more likely. The accompanying burden for CEC disbursal into environmental compartments of soil, sediment, surface water, groundwater, polar ice, and air particulates is also probable.

All of these issues help to define some important questions for research and education in the arena of CECs--

- How will we efficiently monitor CECs in complex matrices?
- What regulatory frameworks or other incentives will encourage us to address the potential risks from CECs?
- How might we prevent the generation of new CECs through green product design?
- What is a path forward on potential wastewater treatment options that are practical, affordable, and scalable?
- What efficient means might we find to evaluate human health and ecologic risks from CECs to prioritize the most important contaminants for us to eliminate or reduce?
- What communication strategies and educational initiatives might be required to aid the public understand the risk of CECs and their role as a source for these contaminants through their modern living?
- What is the role for technologies such as IoT, machine-learning, and novel sorbents in helping us address a problem that has been in the water and environmental researcher consciousness now for 20 years?

We invite you to submit articles fitting in classes of Original Research, Case Study, Review, Research Note, or Perspective Piece on these and other questions surrounding CECs in the *Journal of Contemporary Water Research and Education (JCWRE)*[1]. Please notify the guest editors below of your intent to submit an article along this theme. **Your article will then need to be submitted for peer-review by October 15, 2023** for potential subsequent publishing in the special issues in April 2024.

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[1] https://ucowr.org/journal/about-the-journal/