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Emerging contaminant uncertainties and policy: The chicken or the egg conundrum

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HIGHLIGHTS

- Policies to manage emerging contaminants were identified and evaluated.
- Best practices revealed integration of science-policy and advocacy.
- Some key attributes of a management framework are identified.
- Recommends a global approach to collaboration to accelerate management actions.

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ABSTRACT

Best practice in regulating contaminants of emerging concern (CEC) must involve the integration of science and policy, be defensible and accepted by diverse stakeholders. Key elements of CEC frameworks include identification and prioritisation of emerging contaminants, evaluation of health and environmental impacts from key matrices such as soil, groundwater, surface waters and sediment, assessments of available data, methods and technologies (and limitations), and mechanisms to take cognisance of diverse interests. This paper discusses one of the few frameworks designed for emerging contaminants, the Minnesota Department of Health (MDH) Drinking Water Contaminants of Emerging Concern (CEC) program. Further review of mechanisms for CECs in other jurisdictions reveals that there is only a small number of regulatory and guidance regimes globally. There is also merit in a formal mechanism for the global exchange of knowledge and outcomes associated with CECs of global interest.

1. Overview of contaminants of emerging concern

Contaminants of emerging concern (CECs) or emerging contaminants differ from existing contaminants in that the sufficient knowledge has not been developed to ascertain adverse effects from the chemical which would assist in understanding the associated risks to public health and the environment. CECs broadly comprise pharmaceuticals, pesticides, 'lifestyle compounds' (such as caffeine, nicotine and sucralose), personal care compounds, industrial additives and by-products, food additives, water treatment by-products, flame or fire retardants, surfactants, hormones and steroids and ionic liquids (Stuart et al., 2012). These include chemicals that are new, or those that were not previously detected, and are therefore unregulated. Some of the reasons for detecting new contaminants include better methods for detecting low level concentrations of contaminants, some recognition that additional substances should be monitored, new chemicals are used and released, and there may be new ways of using existing substances (MDH, 2016). CECs can also refer to known contaminants for which there are new or emerging concerns.

Industrial and technology breakthroughs have outpaced the regulatory practice. For example, the Minnesota experience demonstrates that the pace of recovery of wildlife populations from contamination by CECs, including perfluorinated chemicals produced in the Upper Mississippi River basin since the 1950s is slow,

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and affected populations require decades to recover from adverse effects such as impaired reproduction (Wiener and Sandheinrich, 2010). Ecosystems as a whole require decades to centuries to recover from contamination (Wiener and Sandheinrich, 2010).

Even though a contaminant may have been discovered earlier, new concerns may arise when new pathways to humans or ecosystems become apparent, such as from a newly discovered understanding of adverse biological effects. For example, arsenic and perfluorinated chemicals are examples of CECs that have been known but the severity of adverse impacts were discovered after decades of exposure through commercial and industrial activity (Fromme et al., 2009; Mandal and Suzuki, 2002). Adverse impacts are considerable and not well understood. Halden (2015) found that CECs emerge from obscurity to height of concern over a period of 14 years driven by innovation such as novel scientific methods and scientific paradigm shifts. Some CECs such as nanomaterials and personal care products and microplastics can emerge due to the availability of associated consumer products in the market.

The cliché that the policy and regulation often lag behind the problem is also true in the case of CECs. Better legislation and policy in the past may or may not have prevented the proliferation of harmful CECs seen today given that the knowledge based has also improved over time. It is presently difficult to resolve the CEC problem all the same due to the ongoing nature of industrial and anthropogenic activities that continue to contribute the CEC problem. For example, new contaminants may be subject to one set of standards and existing contaminants to another of varying stringency (Huber, 2011). The distinction between new and existing contaminants means that new standards may need to be developed to address new or newly recognised contaminants. Development of ambitious yet feasible policies to address contaminants yet to be adequately studied, and addressing the ongoing use of existing contaminants, present scientific and political challenges (See Huber, 2011). Challenges also apply to emerging contaminants due to the need to deal with legacy contamination issues.

Knowledge gaps and inadequate regulation of CECs combine to form the 'chicken or the egg' causality dilemma. Lack of knowledge impedes regulatory decision-making efficacies and vice versa. For example, policy and legislation requiring regular environmental assessments may not specifically require data on many CECs leading to the chicken or the egg causality dilemma. Large uncertainties about the presence, frequency of occurrence, source, persistence, fate and transport of CECs in the environment will exist for CECs in the medium to long term (US EPA, 2014; Stuart et al., 2012; Lapworth et al., 2012). This information is needed to understand risks and develop monitoring and mitigation strategies. However, practitioners and regulators should also have some guidance on dealing with CECs in the shorter term as well. Policy approaches, unlike legislative instruments, are adaptive, collaborative and can be reviewed regularly making it ideal for managing CECs given the associated uncertainties and also the rapid evolution of knowledge. Policy approaches tend to enable an efficient decision-making process on important matters supported by available technical evidence, even if the scientific knowledge is incomplete and evolving.

The objective of this paper is to identify best practice policy for CECs. In the first instance, this paper provides a scan of international jurisdictions to identify and describe existing policy framework for CECs. The scan indicated that very few jurisdictions have implemented mechanisms to address emerging contaminants. The Minnesota Department of Health Drinking Water Contaminants of Emerging Concern (CEC) program is selected as a key case-study because CECs have specifically been addressed. Best practice from other jurisdictions with programs addressing CECs will also be discussed. The evaluation of the jurisdictional case studies and literature is used to distil some of the key considerations for a best practice policy for CECs.

2. Science-policy framework for emerging contaminants

The complexities in managing CECs stems from the magnitude of the problem, that is, the rapid proliferation of CECs over time and its wide distribution in the environment. There is much research on CECs that has become available in recent years which can assist regulators. A survey of research papers published on CECs on the Web of Science database (accessed 5 January 2016) indicates that 2800 papers have been published on the topics 'emerging contaminant' and 'contaminants of emerging concern', with publication frequency increasing exponentially from 1990 to 2015. Approximately 70 percent of the research papers were published in the period between 2010 and 2015, mainly in the areas of environmental science and ecology (45%), chemistry (24%), engineering (24%), water resources (13%), toxicology (9%), biochemistry (8%), biotechnology (5%), marine freshwater biology (4%), food science (3%) and public environmental occupational health (3%).

A particularly interesting area of research has been on the collective screening, characterising and monitoring of CECs. The research findings provide a way forward in terms of the identification of localised vulnerable areas, sources and model future trends to enable the prediction of potential risks as precautionary measures. For example, Lapworth et al. (2015) studied CECs in the Chalk aquifer of Northern Europe given its significance as an internationally important source of drinking water and baseflow for surface water ecosystems. The study provided insight on the occurrence of CECs in relation to vulnerable groundwater settings. Sorensen et al. (2015) characterised CECs in urban groundwater in Kabwe, Zambia and found that emerging contaminants were most prevalent in shallow wells situated in poor socio-economic housing areas. Onset of rainfall events substantially increased the concentration of the very mobile CECs (eg DEET) indicating that aquifers are more vulnerable than previously considered. Lopez et al. (2015) screened French groundwater for regulated and emerging contaminants and, among other things, indicated those that are most prevalent and should be considered for inclusion in environmental and health regulations and policies. Altenburger et al. (2015) provides adaptive tools to deal with mixtures of pollutants in water resource management.

The generation of increased publications in recent years is indicative that substantial research currently exists to accelerate science-policy based decision making. At the same time, policy frameworks must also enable a focussed strategy at the local, regional and global scales not only to translate the science into policy frameworks, but allocate resources to conduct research on CECs. Ideally, such CEC programs would proactively aim to prevent further contamination rather than rely solely on reactive mechanisms such as the management of contaminants (see Wiener and Sandheinrich, 2010).

3. International best practice

In this section, jurisdictional case studies are used as examples to provide insight into the current best practice in managing CECs. This section is followed by a discussion of the case studies together with current literature to identify some of the common elements of a best practice policy for CECs.

3.1. Minnesota Department of Health (MDH)

The Minnesota Department of Health (MDH) established a Drinking Water Contaminants of Emerging Concern (CEC) program