Prioritization of unregulated disinfection by-products in water distribution systems

Drinking water contamination has been recognized as a global challenge. Water contamination due to the regrowth of microorganisms, including harmful pathogens, has been recognized as a critical drinking water quality failure pathway. Disinfection is a common process to inactivate pathogens in drinking water. The commonly used chemical disinfectants, such as chlorine, chlorine dioxide, chloramine, and ozone, are oxidants; they react with natural organic matter if present in the water to form disinfection by-products (DBPs). DBPs have been in the spotlight since 1974 and plenty of studies have been conducted on them since then. To date, more than 700 species of DBPs have been identified in drinking water. The United States Environmental Protection Agency has imposed maximum contamination levels for a few DBPs, which are referred to as regulated DBPs.

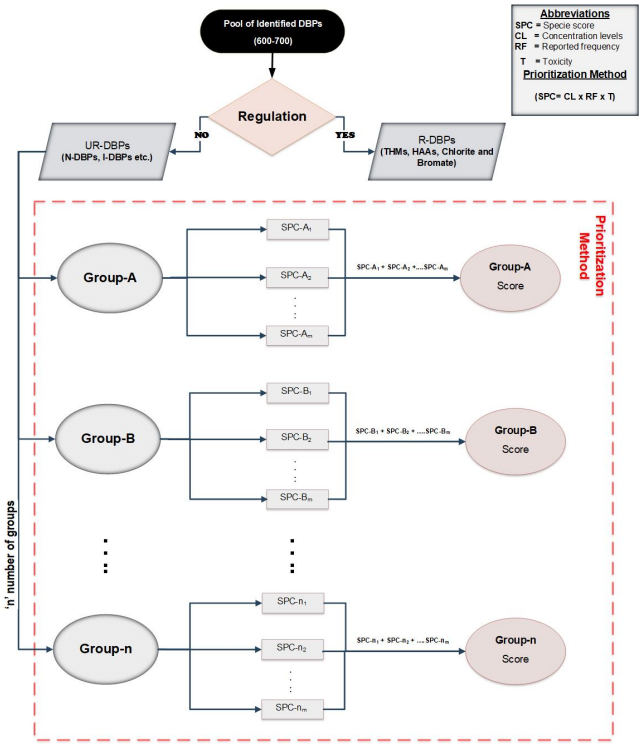

Fig. 1. An approach to prioritize UR-DBPs groups and species.

The regulated DBPs include the species of total trihalomethanes, haloacetic acid, bromate, and chlorite. More critically, some DBPs species have been found in drinking water but are not associated with any imposed threshold limits; those DBPs are referred to as unregulated DBPs. This summary is based on a critical review, which 1) identifies the commonly occurring unregulated DBPs in water distribution networks based on the existing literature; 2) prioritizes the commonly

occurring unregulated DBPs according to their species scores determined based on their concentration, occurrence frequency, and toxicity.

The commonly occurring unregulated DBP groups along with their reported concentration ranges are: 1) HANs (0.6-24 µg/L); 2) HNMs (0.16-1.5 µg/L); 3) HKs (1.23-8.6 µg/L); 4) HAMs (1.50-7 µg/L); 5) NAs (0.01-0.09 ng/L); 6) I-DBPs; and 7) CNX (4µg/L). The average concentration of AL is approximately 25 µg/L. Each unregulated DBP group consists of multiple species. Hence, in total 36 species of unregulated DBPs were selected. Figure 1 shows the prioritization method to classify the unregulated DBPs at both group and species levels.

Figure 2 shows the final species score and priority categorization of unregulated DBPs species.

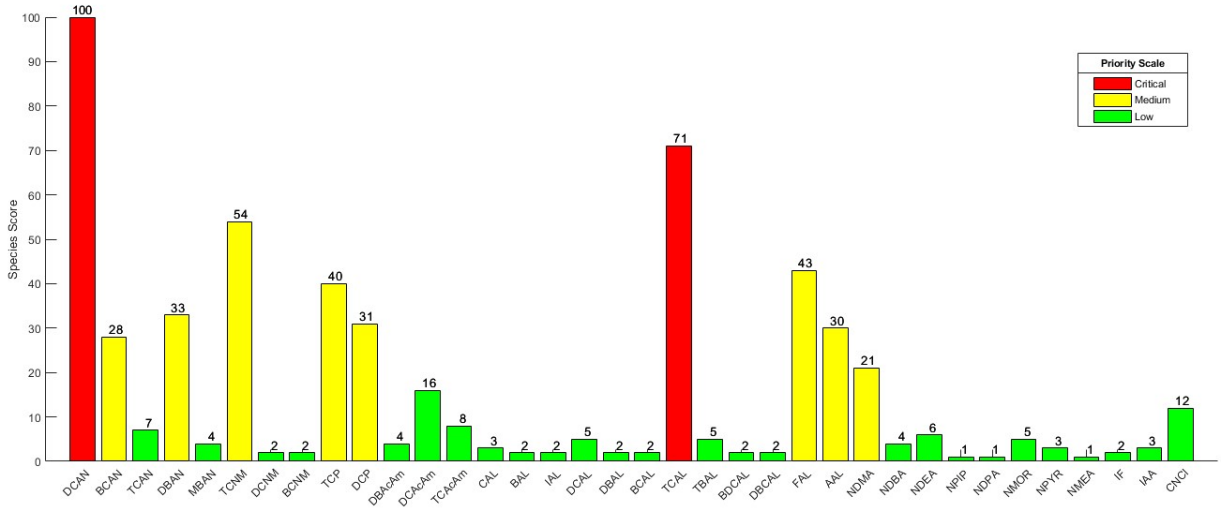

Fig. 2. Prioritization of UR-DBPs based on species scores calculated by considering concentration level, reported frequency, and toxicity.

At the species level, DCAN and TCAL were identified with critical priority; BCAN, DBAN, TCNM, TCP, DCP, FAL, AAL, NDMA were determined with medium priority; where the rest were identified with low priority. Unregulated DBPs scores at the group level were calculated by aggregating the scores of species within each group and were ranked as HANs (score = 172) > ALs (score = 169) > HKs (score = 71) > HNMs (score = 58) > NAs (score = 42) > HAMs (score = 28) > CNX (score = 12) > I-DBP (score = 5). The prioritization can facilitate water regulators in identifying critical unregulated DBPs in drinking water for developing potential guidelines or concentration threshold limits. The results can also help water utilities select disinfection alternatives to minimize the occurrence of unregulated DBPs and allocate resources to monitor their occurrence.

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Abbreviations:

Unregulated DBPs species
Dichloroacetonitrile (DCAN); Bromochloroacetonitrile (BCAN); Trichloroacetonitrile (TCAN); Dibromoacetonitrile (DBAN); Bromoacetonitrile (MBAN); Trichloronitromethane (TCNM); Dichloronitromethane (DCNM); Bromochloronitromethane (BCNM); Trichloropropanone (TCP); Dichloropropanone (DCP); Dibromoacetamide (DBAcAm); Dichloroacetamide (DCAcAm); Trichloromoacetamide (TCAcAm); Chloroacetaldehyde(CAL); Bromoacetaldehyde (BAL); Iodoacetaldehyde (IAL); Dichloroacetaldehyde (DCAL); Dibromoacetaldehyde (DBAL); Bromochloroacetaldehyde (BCAL); Trichloroacetaldehyde (TCAL); Tribromoacetaldehyde (TBAL); Bromodichloroacetaldehyde (BDCAL); Dibromochloroacetaldehyde (DBCAL); Formaldehyde (FAL); Acetaldehyde (AAL); N-nitrosodimethylamine (NDMA); N-nitroso-di-n-butylamine (NDBA); N-nitrosodiethylamine (NDEA); N-nitrosopiperidine (NPIP); N-nitrosodipropylamine (NDPA); N-nitrosomorpholine (NMOR); N-nitrosopyrrolidine (NPYR); N-nitrosomethylethylamine (NMEA); Iodoform (IF); Iodoacetic acid (IAA); Cyanogen chloride (CNCL)

Unregulated DBPs groups
Halo acetonitrile (HANs); Halo nitromethanes (HNMs); Halo ketones (HKs); Halo acetamide (HAMs); Aldehyde (ALs); N-Nitrosamines (NAs); Iodinated DBPs(I-DBP); Cyanide (CNX)

Publication

Prioritization of unregulated disinfection by-products in drinking water distribution systems for human health risk mitigation: A critical review
Mian HR, Hu G, Hewage K, Rodriguez MJ, Sadiq R.
Water Res. 2018 Dec 15