Strategies to Control Disinfection By-Products

**OVERVIEW**

Disinfection by-products (DBPs) are actively regulated around the world. In the United States, DBPs are regulated by the U.S. Environmental Protection Agency’s (EPA’s) Stage 1 and Stage 2 Disinfectants and Disinfection By-Products Rule (DBPR). In addition to setting maximum contaminant levels for four trihalomethanes (THMs), five haloacetic acids (HAAs), chlorite, and bromate, the EPA rule requires water treatment plants to remove DBP precursors through enhanced coagulation or enhanced softening.

DBP control strategies can be divided into three categories:
- Removal of DBP precursors
- Modification and optimization of treatment and disinfection practices to minimize DBP formation
- Removal of DBPs after formation

These strategies require balancing the need to disinfect and meet other water quality objectives with the risk of forming regulated and nonregulated DBPs as well as other potential unintended consequences.

**QUICK FACTS**

- The EPA currently regulates 11 DBPs
- DBPs are controlled using 3 types of strategies
  - Precursor removal
  - Modification of treatment practices to minimize DBP formation
  - DBP removal after formation
- Unregulated DBP control strategies are being researched
## THMs & HAAs

### Minimize formation through
- Eliminating prechlorination
- Switching to ozone or potassium permanganate as a preoxidant
- Chlorination later in the process
- Optimizing the chlorine dose
- Chlorimination

### Removal after formation through
- Biofiltration
- Granular Activated Carbon

## BROMATE

### Minimize formation through
- Adding ammonia
- Decreasing pH
- Reducing ozone dose by substituting other disinfectants
- Using chlorine dioxide as a preoxidant

### Removal after formation through
- Ferrous iron reduction
- Activated carbon
- Biological filtration
- UV irradiation

## CHLORITE AND CHLORATE

### Minimize formation through
- Diluting concentrated bleach immediately after delivery
- Lower bleach storage temperatures
- Storing bleach away from sunlight

### Removal after formation through
- Ozone
- Ferrous iron
- Sulfur dioxide
- Activated carbon

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**THMs AND HAAs**

THMs and HAAs are formed by the reaction of a chemical disinfectant on natural organic matter (NOM) and an inorganic precursor (e.g., bromide ion) during the water treatment process. One option to control these DBPs is to reduce NOM in the source water through watershed management or reservoir quality management (Kornegay, Kornegay, and Torres 2000). Other options for removing DBP precursors include enhanced coagulation, granular activated carbon filtration, nanofiltration (EPA 2006), and biological filtration (Price 1994; Lauderdale et al. 2011).

THMs and HAAs can also be controlled during the water treatment process. This can be achieved by eliminating prechlorination (Krasner et al. 2003), switching from chlorine as a preoxidant to alternatives such as ozone or potassium permanganate, moving the point of chlorination to later in the treatment process after NOM is removed (Schenkel et al. 2009), optimizing the chlorine dose, and converting to chloramination.

If THMs and HAAs are formed during the drinking water treatment process, they can be removed through biofiltration (Speitel et al. 2005) or with granular activated carbon (Xie et al. 2004).

**BROMATE**

Bromate typically forms during the ozonation process. Options to minimize bromate formation include adding ammonia (Amy and Siddiqui 1999), decreasing pH (Amy and Siddiqui 1999), reducing ozone dose by substituting other disinfectants, and using preoxidation with chlorine dioxide (Zhou and Neemann 2004).

If bromate is formed, options to remove it include ferrous iron reduction, activated carbon, biological filtration, or ultraviolet irradiation at very high doses (Amy and Siddiqui 1999).

**CHLORITE AND CHLORATE**

Chlorite and chlorate can be formed from hypochlorite (liquid bleach) or chlorine dioxide. Strategies to minimize chlorate or chlorite formation include diluting concentrated bleach immediately after delivery, using lower bleach storage temperatures, and avoiding sunlight during storage (Gordon, Adam, and Bubnis 1995). Options to remove chlorite include ozone, ferrous iron, sulfur dioxide, or activated carbon (Gates, Ziglio, and Ozekin 2009).
Different classes of nitrogenous DBPs form via different processes; unfortunately, strategies to control one class often result in increased formation of another class. One control option is to minimize introduction of precursors in the water (e.g., through reducing the polymer dose) (Valentine et al. 2006) or remove them (e.g., through coagulation or lime softening) (Mitch et al. 2009). Another option is prechlorination upstream of chloramination (Sacher et al. 2008).

However, prechlorination can also lead to the formation of regulated DBPs, such as THMs and HAAs. If prechlorination alone cannot be used, preozonation should be considered, as well as the sequential use of ozone and chlorine.

Iodinated DBPs

Though research on control strategies for iodinated DBPs (I-DBPs) is limited, it is known that I-DBPs are higher in water treatment plants that use chloramination. Therefore, the formation of I-DBPs typically can be reduced by adding chlorine well in advance of ammonia during the chloramination process.

REFERENCES


REFERENCES CONTINUED


