RECOMMENDATION ON 1,4-DIOXANE TREATMENT OPTIONS FOR DRINKING WATER

Treatment Subcommittee

New Jersey
Drinking Water Quality Institute
September 30, 2020

DWQI
TREATMENT SUBCOMMITTEE

Members
Anthony Matarazzo
Patricia Gardner
Norman Nelson

NJDEP Support
Lee Lippincott, PhD
Kristin Tedesco
Filina Poonolly
Tyler Rowe
Sabrina Hill
Kelly Hullen

DWQI
TREATMENT SUBCOMMITTEE

In December 2018, DWQI moved forward with developing a recommended Maximum Contaminant Level (MCL) for 1,4-dioxane.

The Treatment Subcommittee is responsible for evaluating best available treatment technologies or methods, for removal of the hazardous contaminants from drinking water.

1,4-DIOXANE

- Synthetic organic chemical used as a solvent and in manufacturing of organic chemicals.
- Used as a stabilizer in chlorinated solvents, such as TCA.
  - Often seen in the environment alongside this VOC.
- Fully miscible in water and highly mobile.
  - Travels readily from soil down to ground waters.
  - Found in both surface and ground waters.
- 1,4-dioxane's hydrophilic nature and other physical and chemical properties pose treatment challenges.

1,4-DIOXANE

- Monitored under UCMR3 at all public water systems serving >10,000 people.
- In NJ, reported concentrations ranged from 0.08 µg/L to 5.83 µg/L.

Range of Concentrations of 1,4-Dioxane	Number of NJ Systems in Range
6 – 3 µg/L	4
3 – 2 µg/L	3
2 – 1 µg/L	5
1 – 0.5 µg/L	9
0.5 – 0.4 µg/L	8
0.4 µg/L	3

DWQI
TREATMENT SUBCOMMITTEE

The subcommittee has met several times to discuss and investigate the best available treatment options for 1,4-dioxane.

To do this, the Treatment Subcommittee did the following:

- Gathered and reviewed data from a wide variety of sources.
- Identified widely-accepted and well-performing strategies for removal of 1,4-dioxane.
- Reviewed available treatment technologies to ensure that the methods could achieve the draft health-based MCL of 0.33 µg/L.

TREATMENT DESIGN

- Some treatment methods are more effective for treatment of 1,4-dioxane than others. Selection of the most effective treatment requires evaluation.
- Considerations include initial concentration of 1,4-dioxane, the background organic and inorganic compounds concentration, and other site-specific conditions.
- Additional considerations include cost, the ability to address more than one contaminant with one treatment option, and waste disposal.
- Selection of the most cost-effective treatment process requires evaluation using both bench and pilot-scale studies and may result in the use of more than one of the identified options in a treatment train.

TREATMENT RECOMMENDATIONS

Advanced Oxidation:

- A review of the literature and several case studies indicated Advanced Oxidation Processes (AOPs) were found to successfully remove 1,4-dioxane from drinking water.
- Removal ratios vary depending on several factors (e.g. initial concentration and presence of other contaminants) but can exceed 99% removal.
- AOPs break down organic contaminants into carbon dioxide, water, and residual chloride. This limits waste stream considerations.
- The Treatment Subcommittee evaluated several forms of AOPs including:
  - UV and hydrogen peroxide, ozone and hydrogen peroxide, UV and ozone, and UV and chlorine/chloramines.

TREATMENT RECOMMENDATIONS

Advanced Oxidation:

New Jersey American Water – Hummocks Wellfield

- A full-scale UV/ H_2O_2 system installed as part of treatment train that includes air stripping for VOC removal.
- Raw water concentrations of 1,4-dioxane between 1.4 µg/L and 0.4 µg/L.
- Post-UV/H_2O_2 treatment showed levels of 0.15 µg/L on average.
- EPA Method 522.

TREATMENT RECOMMENDATIONS

Advanced Oxidation:

Tucson Water, Arizona

- A full-scale UV/ H_2O_2 system was installed followed by GAC contactors for quenching H_2O_2.
- Raw water concentrations of 1,4-dioxane of 1.5 μg/L.
- Post-UV/H_2O_2 treatment was non-detect, with a detection limit of 0.1 μg/L.

TREATMENT RECOMMENDATIONS

Membrane Separation:

- Membrane separation, specifically nanofiltration/reverse osmosis, was also evaluated and found to have varying effectiveness. RO in combination with other filtration methods yields a more effective result rather than using a solitary RO treatment.
- Unlike AOPs, membrane separation does not break down 1,4-dioxane and waste streams must be managed.

TREATMENT RECOMMENDATIONS

Granular Activated Carbon:

- Due to its high miscibility and hydrophilic nature, 1,4-dioxane is prone to pass through GAC, making GAC a relatively ineffective treatment for removal (Kegel et al, 2010).
- A study performed by Kegel et al. (2010) found that GAC only removed 18% of the contaminant in tests.
- Waste stream is a consideration as GAC filters require regeneration or replacement.

TREATMENT RECOMMENDATIONS

<u>Synthetic Media</u>

- Dow - AMBERSORB™ 560
  - The Dow Chemical Company markets a proprietary synthetic carbon-based absorbent material AMBERSORB™ 560.
  - Size and distribution of pores in media can be controlled to be selective for specific compounds, such as 1,4-dioxane.
  - 1,4-dioxane is not broken down and management of waste streams must be considered.
- Other synthetic medias under development.

CONCLUSION

- The Treatment Subcommittee concludes that it has been demonstrated that 1,4-dioxane can be reliably and feasibly removed by carefully designed AOP treatment to below the recommended health-based MCL of 0.33 µg/L.