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Update on Emerging Contaminants: 1,4-Dioxane

Advanced Oxidation Processes

1,4-Dioxane is a semi-volatile, colorless liquid with a mild ethereal odor, also known as diethylene dioxide, dioxane, or p-dioxane.

It is miscible with water, oils and most chlorinated solvents. It is also flammable and, during storage, may form explosive peroxides.

SOURCES OF 1,4-DIOXANE

1,4-Dioxane is primarily used as a stabilizer in chlorinated solvents. At one time, approximately 90% of the 1,4-dioxane produced went into the production of 1,1,1-trichloroethane (TCA). This application has now been phased out due to TCA's destructive effects on atmospheric ozone. Industries or processes in which 1,4-dioxane is used, or is associated, include:

- Chlorinated solvents manufacturing (as a stabilizer)
- Organic chemical manufacturing
- Textile processing
- Paper manufacturing
- Varnish stripper and paint production
- Pesticide production

When released into the air, 1,4-dioxane degrades relatively quickly through reactions with photochemically-produced hydroxyl radicals. However, degradation in water and soil is slow. For this reason, 1,4-dioxane is persistent in the environment, and will remain present in areas of groundwater contamination. Due to the ubiquitous nature of 1,4-dioxane, contamination can be found in many parts of the U.S.

A PROBABLE CARCINOGEN

The United States Environmental Protection Agency's (USEPA) Integrated Risk Information System (IRIS) released a toxicological review of the contaminant to include a cancer assessment. IRIS designated 1,4-dioxane as "likely to be carcinogenic to humans". In addition, the IRIS system indicated that 1,4-dioxane concentrations of 0.35 ppb (ug/L) or higher in drinking water would result in 1 in 1,000,000 people developing cancer. In animal testing, 1,4-dioxane increased the incidence of cancer in the liver, lungs, gall bladder, and on the skin.

Non-carcinogenic side effects of 1,4-dioxane include liver and kidney toxicity. The primary routes of human exposure to 1,4-dioxane are inhalation, ingestion, and dermal contact.

OCCURRENCE IN THE U.S.

The USEPA included 1,4-dioxane on its third Unregulated Contaminant Monitoring Rule (UCMR3) for drinking water contaminants. Levels of 1,4-dioxane were monitored at 800 water treatment plants across the U.S. between 2013 and 2015.

CHEMICAL NAME:	1,4-DIOXANE
CHEMICAL FORMULA:	$C_4H_8O_2$
MOLECULAR WEIGHT:	88.12
WATER SOLUBILITY:	HIGHLY SOLUBLE
DENSITY:	1.033 G/ML
VOLATILITY:	SEMI-VOLATILE

Results of the UCMR3 initiative shows that over 20% of treatment plants tested had at least one sample measure above the USEPA established reporting limit concentration of 0.07 ppb. In addition, over 7% of sites had at least one sample measure above the 0.35 ppb 1 in 1,000,000 cancer risk limit.

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Figure 1 provides a detailed heat map showing the occurrence of 1,4-dioxane samples testing above the 0.07 ppb reporting limit across the U.S. The data shows expectedly high concentrations in highly industrialized regions.

ULTRAVIOLET (UV) LIGHT KEY TO TREATMENT PROCESS

1,4-Dioxane's low vapor pressure and high solubility render air stripping, carbon adsorption and reverse osmosis ineffective for its removal.

However, UV-oxidation using UV light and hydrogen peroxide is effective at breaking down 1,4-dioxane. The irradiation of hydrogen peroxide by UV light generates hydroxyl radicals. These radicals effectively oxidize 1,4-dioxane, breaking it down into non-toxic molecular components.

EXTENSIVE UV INSTALLATIONS

Trojan Technologies has conducted numerous pilot studies to verify the efficacy of 1,4-dioxane reduction using UV light and hydrogen peroxide. Currently, Trojan has dozens of surface and groundwater UV-oxidation installations designed for its removal. Collectively, these installations treat over 380 million gallons of water each day.

TREATING MULTIPLE CONTAMINANTS WITH ONE UV SYSTEM

As an added benefit to 1,4-dioxane treatment, TrojanUV® UV-oxidation systems also provide up to 6-log removal of microorganisms including Cryptosporidium, Giardia, and microbes including adenovirus and treat for other chemical contaminants including N-nitrosodimethylamine (NDMA), endocrine disruptor compounds, pesticides, volatile organic compounds (VOCs), and taste and odor causing compounds such as MIB and geosmin.

For more information regarding the treatment of multiple contaminants using TrojanUV UV-oxidation solutions, including 1,4-dioxane treatment, please contact Trojan Technologies.

Figure 1: Heat Map Showing 1,4-Dioxane Occurrence from UCMR3. Reporting Limit = 0.07 ppb.

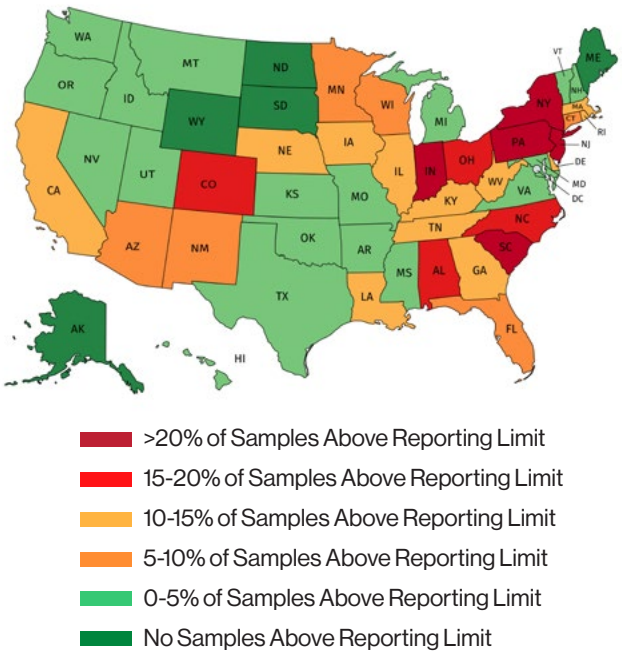

Figure 2. TrojanUVPhox® system treating 1,4-dioxane

References: National Toxicology Program: 12th Report on Carcinogens, 2011; EPA Toxic Release Inventory, 2009; EPA Integrated Risk Information System (IRIS); USEPA Unregulated Contaminant Monitoring Rule 3 Occurrence Data, 2017

We hope this fact sheet has answered some of the questions you might have related to 1,4-dioxane treatment. Don't hesitate to reach out if you have any other questions, feedback or suggestions.

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