TROJANUV

TROJAN technologies

CASESTUDIES

Advanced Oxidation Processes

Advanced Treatment for 1,4-Dioxane – Tucson Breaks Down Volatile Organic Compounds Through UV AOP and Activated Carbon

PROJECT BACKGROUND

The Tucson Water Advanced Oxidation Site is located in the Tucson Basin in Pima County, Arizona. As early as 1942, metals, chemicals and other wastes were disposed of in the region, leading to aquifer contamination with volatile organic compounds (VOCs) including trichloroethylene (TCE) and 1,1-dichloroethene (1,1-DCE).

In 1981, the United States Environmental Protection Agency (USEPA) and the City of Tucson sampled the municipal water wells within the TIAA zone. Unsafe levels of TCE were identified, and a total of eleven drinking water wells were shut down. As a result of the contamination, the Tucson Airport Remediation Project (TARP) was established and a groundwater treatment system was commissioned in 1994. However, continued monitoring of the groundwater detected 1,4-dioxane, a contaminant not easily removed through the air-stripping treatment system used at the original treatment plant. As a result, a UV Advanced Oxidation Process (UV AOP) was installed to remove 1,4-dioxane.

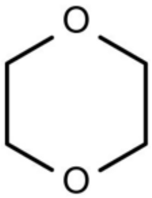
1,4-DIOXANE

1,4-Dioxane is a chemical stabilizer commonly added to chlorinated solvents including TCE and tetrachloroethylene (PCE) to prevent their acidification and breakdown.

Due to its high solubility and limited sorption to soils, natural degradation of 1,4-dioxane in water is limited and as a result, 1,4-dioxane will travel farther and remain in areas of groundwater contamination for longer periods of time than TCE and PCE, the solvents it originally was meant to stabilize.

Further, its low molecular size combined with its high solubility make it resistant to most forms of filtration including activated carbon and even reverse osmosis (**Figure 1a** and **1b** respectively). A low Henry's Law constant also makes 1,4-dioxane resistant to air stripping, a treatment method commonly used for the removal of other VOCs.

1,4-dioxane was included in the USEPA's third Unregulated Contaminant Monitoring Rule (UCMR3) and levels were monitored throughout the United Stated to evaluate whether federal regulations will be required to control concentrations in drinking water. Results released in 2017 suggested that over 20% of treatment plants tested had at least one sample measure above the minimum reporting limit of 0.07 ppb (µg/L) and over 7% of sites had at least one sample measure above 0.35 ppb, the USEPA's established 1 in 1,000,000 cancer risk concentration of 1,4-dioxane in water.



Chemical Name:	1,4-Dioxane
Chemical Formula:	$C_4H_8O_2$
USEPA Classification:	Probable Human Carcinogen

Plant Name: Tucson Water Advanced Oxidation Process Water Treatment Facility
Location: Tucson, Arizona
System: TrojanUVPhox®

TROJANUV

CASESTUDIES

SELECTING UV AOP TO TREAT 1,4-DIOXANE

Pilot studies were carried out to evaluate if UV AOP was a reliable remedy for 1,4-dioxane contamination. Specifically, evaluation was based on three criteria: treatment capabilities, by-product formation and residual hydrogen peroxide quenching.

Treatment Capabilities

1,4-Dioxane removal of greater than the targeted 2-log (99%) reduction was observed during pilot testing with the highest level of 1,4-dioxane reduction calculated to be approximately 2.8-log. In addition, VOCs including TCE and 1,1-DCE were simultaneously reduced to equal or greater levels than 1,4-dioxane (**Figure 1**).

By-Product Formation

A significant by-product of concern was bromate. However, effluent testing after UV AOP treatment showed no bromate formation. Equivalent pilot testing experiments carried out with ozone-hydrogen peroxide (O_3-H_2O_2) systems showed increases in bromate to over 50 µg/L, 5 times the regulated limit.

Quenching

Quenching residual hydrogen peroxide (H_2O_2) with granular activated carbon (GAC) was favored over other established methods of quenching due to the high efficiency of GAC and its ability to remove H_2O_2 with both high loading rates and minimal empty bed contact time (EBCT). This limited concerns associated with head loss and additional pumping requirements.

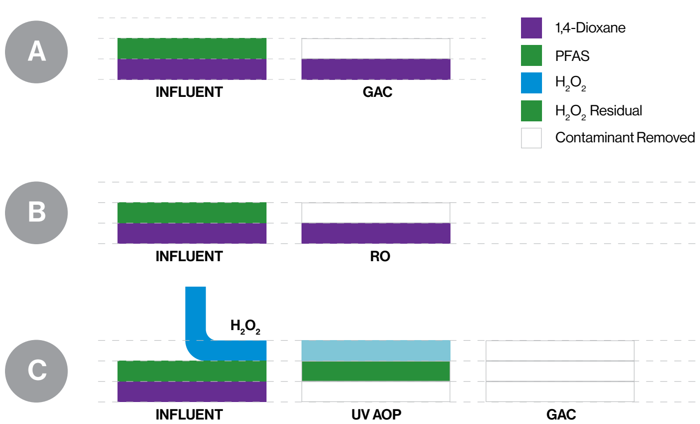


Figure 1. Common filtration methods including GAC (**A**) and RO (**B**) treat PFAS molecules but have little effect on 1,4-dioxane which is treated most efficiently through oxidation-based methods like UV AOP (**C**). GAC has a dual ability to quench residual H_2O_2 in a UV AOP system and treat PFAS.

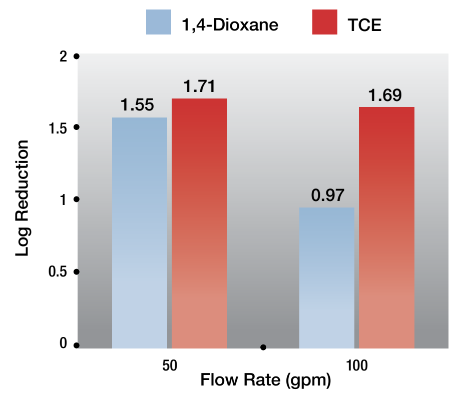


Figure 2. Results of pilot testing low-pressure UV-oxidation for treatment of indicated contaminants. Log reduction of contaminants treatment with UV-oxidation. H_2O_2 concentration = 15 ppm.

THE TROJANUV SOLUTION

TrojanUV supplied 6 TrojanUVPhox® D72AL75 UV units organized in three treatment trains with each train containing two UV units. Each unit contains 144 low-pressure high-output (LPHO) UV lamps designed for high efficiency UV output with minimum energy requirements. Along with an advanced H_2O_2 dosing system and control program, the UV AOP installation is capable of removing 1.6-log (>97%) 1,4-dioxane and treating a maximum capacity of 5,800 gallons per minute (gpm).

Simultaneous PFAS Removal with GAC Quenching

Perfluoroalkyl substances (PFAS) are a group of resilient contaminants of concern that cannot be oxidized through UV AOP or ozone-based methods like O_3-H_2O_2. On the other hand, GAC is considered a preferred solution for PFAS removal (**Figure 2a**). Tucson Water decided to use the combination of UV AOP and GAC to remove both contaminants of concern, 1,4-dioxane and PFAS simultaneously at the facility (**Figure 2b**).

The original UV AOP installation was commissioned in 2014. The purified water from the combined UV AOP and GAC processes is sent to the nearby Santa Cruz River. However, continuing developments will eventually allow the water to instead be added to the Tucson Water Recycled Water System which will use the water for various non-potable purposes including golf course and park irrigation.

Expanding the System

Tucson Water recently added an additional three treatment trains to the existing UV AOP facility and now has the capacity to remove 1,4-dioxane from over 18.7 million gallons of groundwater a day. This expansion also included additional GAC filters to ensure continued quenching of residual H_2O_2 and removal of the PFAS contaminant.

To learn more about the brands and affiliates of Trojan Technologies, please visit www.trojantechnologies.com

TROJAN technologies