

TROJAN^{UV} CASE STUDIES

Environmental Contaminant Treatment

Treatment of Groundwater Contaminated with 1,4-Dioxane



Advanced Oxidation Process Water Treatment Facility - TUCSON, Arizona

PROJECT BACKGROUND

The Tucson International Airport Area (TIAA) Superfund Site is located in the Tucson Basin in Pima County, Arizona and includes the Tucson International Airport as well as residential areas of the city of Tucson. As early as 1942, metals, chemicals and other wastes were disposed of in the region, leading to aquifer contamination. Volatile organic compounds (VOCs) including trichloroethylene (TCE) and 1,1-dichloroethene (1,1-DCE) have been detected at this site, along with 1,4-dioxane, a chemical stabilizer commonly used in solvents.

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

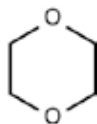
1,4-dioxane, a contaminant not easily removed through the air-stripping treatment system used at the original treatment plant. As a result, UV-oxidation was incorporated in the Advanced Oxidation Process Water Treatment Facility immediately adjacent to the TARP to remove 1,4-dioxane.

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. In the United States, approximately 10 million pounds of 1,4-dioxane are produced each year.

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 Henry's Law constant 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 States to evaluate whether federal regulations will be required to control concentrations in drinking water. Results released in 2013 suggested that 1,4-dioxane was present in over 12% of samples at concentrations greater than the minimum reporting limit of 0.07 ppb ($\mu\text{g/L}$) and in nearly 4% of samples at concentrations higher than 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:	$\text{C}_4\text{H}_8\text{O}_2$
USEPA Classification:	Probable Human Carcinogen

CASE STUDIES

TREATING 1,4-DIOXANE AT TARP

Pilot studies were carried out in 2010 to evaluate UV-oxidation as a possible remedy for 1,4-dioxane contamination. Specifically, evaluation was based on three independent criteria: treatment capabilities, by-product formation and residual hydrogen peroxide quenching.

Treatment Capabilities

1,4-Dioxane removal of greater than the targeted 2-log 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-oxidation 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 $\mu\text{g/L}$, 5 times the regulated limit (Figure 2).

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. This limited concerns associated with head loss and additional pumping requirements.

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, the UV-oxidation installation is capable of removing 1.6-log (>97%) 1,4-dioxane and treating a maximum capacity of 5,800 gallons per minute (gpm). GAC is applied after UV-oxidation treatment to remove residual H_2O_2 exiting the UV reactors.

CONCLUSION

Commissioned in January 2014, the UV-oxidation installation at the Advanced Oxidation Process Water Treatment Facility treats 1,4-dioxane and produces water that is blended and then treated at the neighboring TARP facility. This purified water is supplied to nearly 50,000 end-users in the Tucson area.

FULL SCALE SYSTEM

SYSTEM DESIGN PARAMETERS

- **PEAK FLOW CAPACITY:** 5,800 gpm (1317 m^3/hr)
- **PRIMARY CONTAMINANT:** 1,4-Dioxane
- **SECONDARY CONTAMINANTS:** TCE, 1,1-DCE
- **DESIGN TREATMENT REQUIREMENT:** 1.6-Log 1,4-Dioxane Removal

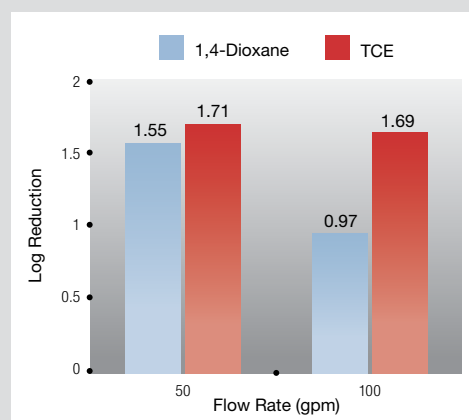


Figure 1. Results of pilot testing low-pressure UV-oxidation for treatment of indicated contaminants. Log reduction of contaminants treatment with UV-oxidation. H_2O_2 concentration = 15 ppm

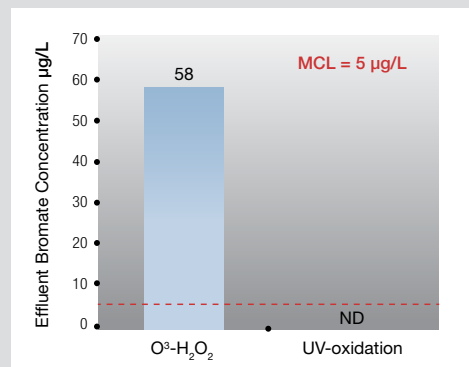


Figure 2. Maximum concentration of bromate detected in post-treatment effluent during pilot testing of indicated AOP technologies

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