

ADVANCED OXIDATION
PROCESSES

Environmental Contaminant Treatment

TROJAN  UV[®]

 Water
Confidence[®]

What are Environmental Contaminants?

There is a growing need to protect the world's water supply from chemicals. Recent research has shown that a wide variety of chemicals exist at trace concentrations in streams, lakes, rivers, and in groundwater throughout the world.

The term "environmental contaminants" refers to chemicals present in soil, in air, and in water. These compounds may come directly from human sources such as industrial manufacturing, agricultural run-off, or wastewater discharge, or they may originate from natural sources, such as the taste- and odor-causing chemicals in water generated by algae and bacteria blooms.

A Growing List of Environmental Contaminants:

- 1,4-Dioxane
- Taste- and odor-causing compounds (e.g., geosmin and MIB)
- *N*-nitrosodimethylamine (NDMA)
- Pharmaceuticals and personal care products (PPCPs)
- Pesticides and herbicides
- Fuels and fuel additives (e.g. MTBE and BTEX)
- Volatile Organic Compounds (VOCs) like PCE and TCE
- Endocrine disruptor chemicals (EDCs)
- Algal toxins (e.g. Microcystin)

These compounds can be treated either by ultraviolet (UV) light alone or by UV light combined with oxidizing radicals, referred to as the UV advanced oxidation process (UV AOP).

Why UV AOP for Environmental Contaminants?

UV has been used successfully over the last century to treat drinking water and wastewater. That same technology is now applied to perform environmental contaminant treatment on a large-scale.

Cost-Effective

For certain contaminants, UV AOP is the only economical method of treatment. For example, NDMA and 1,4-dioxane cannot be fully treated with membrane technologies (including reverse osmosis), carbon adsorption, or air stripping.

Eliminates Residuals

UV AOP has the advantage of being a technology that breaks down contaminants into their elemental components.

Other treatment technologies merely transfer the contaminant from one phase to another (e.g. air stripping: from water to air) – resulting in a potentially hazardous, contaminant-laden residual that requires further treatment or disposal.

Key Contaminants



• Photo courtesy of Bruce Macleod



NDMA: Potential Sources

- Treatment of drinking water and wastewater with chlorine or chloramines
- Printed circuit board manufacturing
- Rocket testing/manufacturing
- Pesticide manufacturing
- Rubber and tire manufacturing
- Meat curing
- Treatment of wastewater using ozone

Taste- and Odor-Causing Compounds

- MIB and geosmin
- Generated by algae and bacteria blooms in rivers, lakes and reservoirs
- A growing problem due to increasing temperatures and phosphorus/nitrogen loads on surface waters
- Causes water to taste and smell earthy and musty at low concentrations
- Often co-generated with algal toxins

Groundwater Contaminants

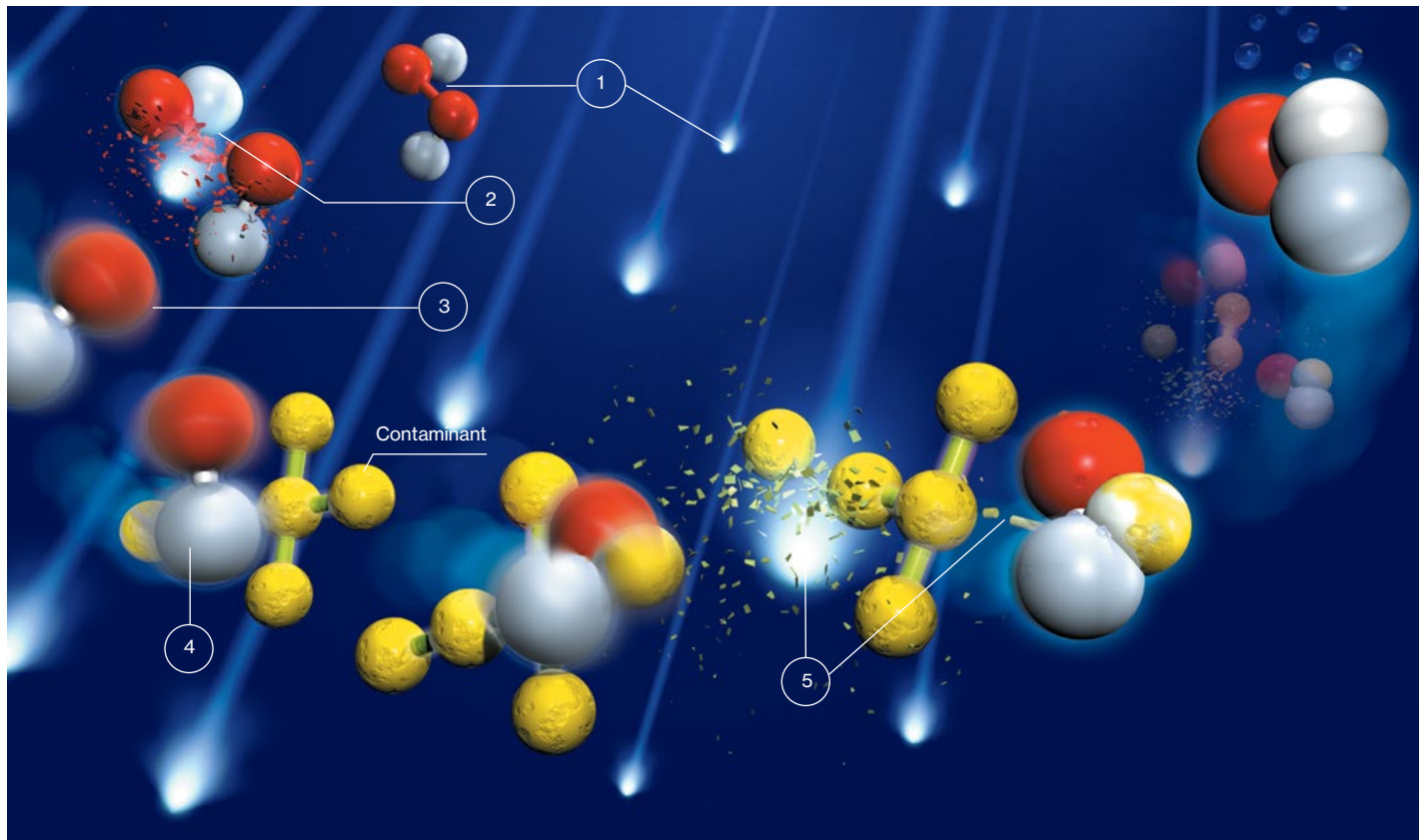
- 1,4-Dioxane, TCE and other VOCs
- Improper disposal of chemicals
- Chemical spills from industrial accidents
- Spills can take years to reach groundwater supplies

How UV AOP Treats Environmental Contaminants

UV-photolysis is a photochemical reaction that takes place when a contaminant molecule absorbs UV light. The photons break down chemical bonds of the molecule and reduce the chemical to its elemental components.

UV-oxidation is also a photochemical reaction, but involves the irradiation of an oxidant, such as hydrogen peroxide, with UV light. This creates strongly oxidizing hydroxyl radicals that oxidize the contaminant, breaking the bonds between the molecules, and reducing the chemical to its elemental components.

UV as part of a multi-barrier system, acts to simultaneously inactivate* microorganisms as well as break down contaminants. This is accomplished without the formation of by-products such as THMs or bromate.



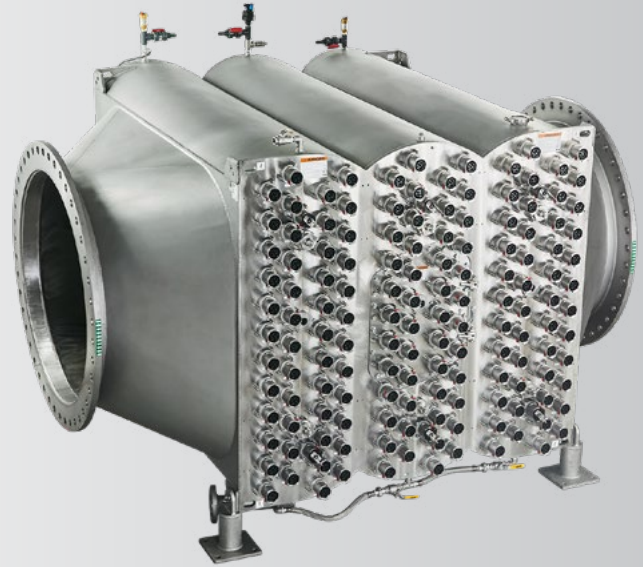
1. UV-oxidation requires two components: UV light and an oxidant such as hydrogen peroxide.
2. When UV light is introduced to the water, the dissolved hydrogen peroxide molecules absorb UV light.
3. Highly energetic and reactive hydroxyl radicals are then formed.
4. Hydroxyl radicals react indiscriminately with environmental contaminants in the water.
5. Working simultaneously with direct UV-photolysis (the photochemical process that inactivates microorganisms and breaks down contaminants using UV alone), these highly reactive radicals break down contaminants.

Most contaminants are treated with a combination of UV-photolysis and UV-oxidation. Some, like NDMA, require only UV-photolysis.

Solutions for Emerging Needs

Utilizing revolutionary Solo Lamp® Technology, the TrojanUVFlex®AOP provides high-intensity treatment in an extremely compact footprint. This revolutionary system offers a cutting-edge control strategy for advanced oxidation processes to reliably deliver treatment objectives while minimizing operating costs and facilitating regulatory reporting.

The TrojanUVFlexAOP has been validated through microbial testing. Through this testing, performance data has been generated for UV dose delivery to inactivate *Cryptosporidium*, *Giardia*, and *Adenovirus*.



The TrojanUVSwift®ECT employs medium-pressure lamps and sophisticated controls to optimize treatment. Its ultra-compact footprint and large flow capacity makes it an excellent chamber for use as part of a multi-barrier system in large, municipal applications (hundreds of millions of gallons per day). In such applications, the TrojanUVSwiftECT breaks down taste and odor-causing compounds MIB and geosmin.

The TrojanUVSwiftECT has been validated through microbial testing. Through this testing, performance data has been generated for UV dose delivery to inactivate *Cryptosporidium*, *Giardia*, and *Adenovirus*.

The Proven Leader in Solutions for UV AOP



Groundwater Remediation Solution: San Gabriel Valley, CA

Volatile organic compounds (VOCs) including trichloroethylene (TCE), perchloroethylene (PCE) and 1,4-dioxane have been detected in a plume of contaminated groundwater under the San Gabriel Valley as far back as 1979. 1,4-Dioxane in particular, is not well treated by alternative methods of contaminant removal including carbon adsorption, filtration or air stripping. The hydroxyl radicals produced through UV AOP effectively break down 1,4-dioxane. As a result, UV AOP was selected as the best technology to cost-effectively meet 1,4-dioxane treatment needs of the San Gabriel Valley and the cities located there. To date, we have supplied UV AOP systems, including our TrojanUVFlexAOP and TrojanUVPhox, to four groundwater extraction facilities in the San Gabriel Valley. These systems provide 1,4-dioxane treatment for nearly 40 MGD capacity of contaminated groundwater with the goal of protecting the drinking water supply of over 1,000,000 people.

Primary Contaminant	1,4-Dioxane
Secondary Contaminant	TCE and PCE



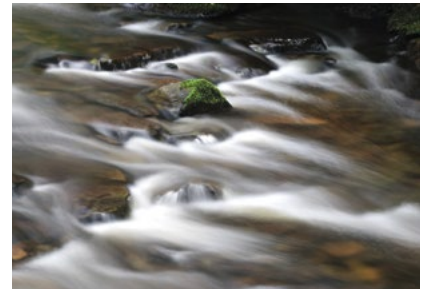
Water Reuse Solution: Orange County, CA Expansion

The Orange County Water District operates the largest indirect potable reuse treatment facility of its kind in the world, the Groundwater Replenishment System (GWRS). The GWRS employs a cutting-edge water treatment train which treats wastewater to advanced standards in preparation for injection back into the potable groundwater supply.

The GWRS will have a final output capacity of 130 MGD of advanced treated recycled wastewater.

The UV AOP system installed here is designed to treat NDMA and 1,4-dioxane as well as pharmaceutical and endocrine disrupting compounds that may be left untreated by the membrane systems.

Primary Contaminant	NDMA
Secondary Contaminant	1,4-Dioxane



Drinking Water Solution: Neshaminy Creek and Shenango Valley, PA

Both of these facilities are owned and operated by Aqua Pennsylvania and serve multiple small municipalities in the state of Pennsylvania. The combined flow rate of these facilities is 31 MGD and both experience extended taste and odor events brought on by algal blooms in the fall months. Our solution for each facility was to provide two TrojanUVSwiftECT 16L30 systems equipped with hydrogen peroxide dosing to treat MIB and geosmin. In addition, this validated UV system was designed to provide inactivation of *Cryptosporidium* and *Giardia*. Dual systems like these economically provide inactivation and taste and odor control and do so with a low carbon footprint and without the formation of by-products such as THMs or bromate.

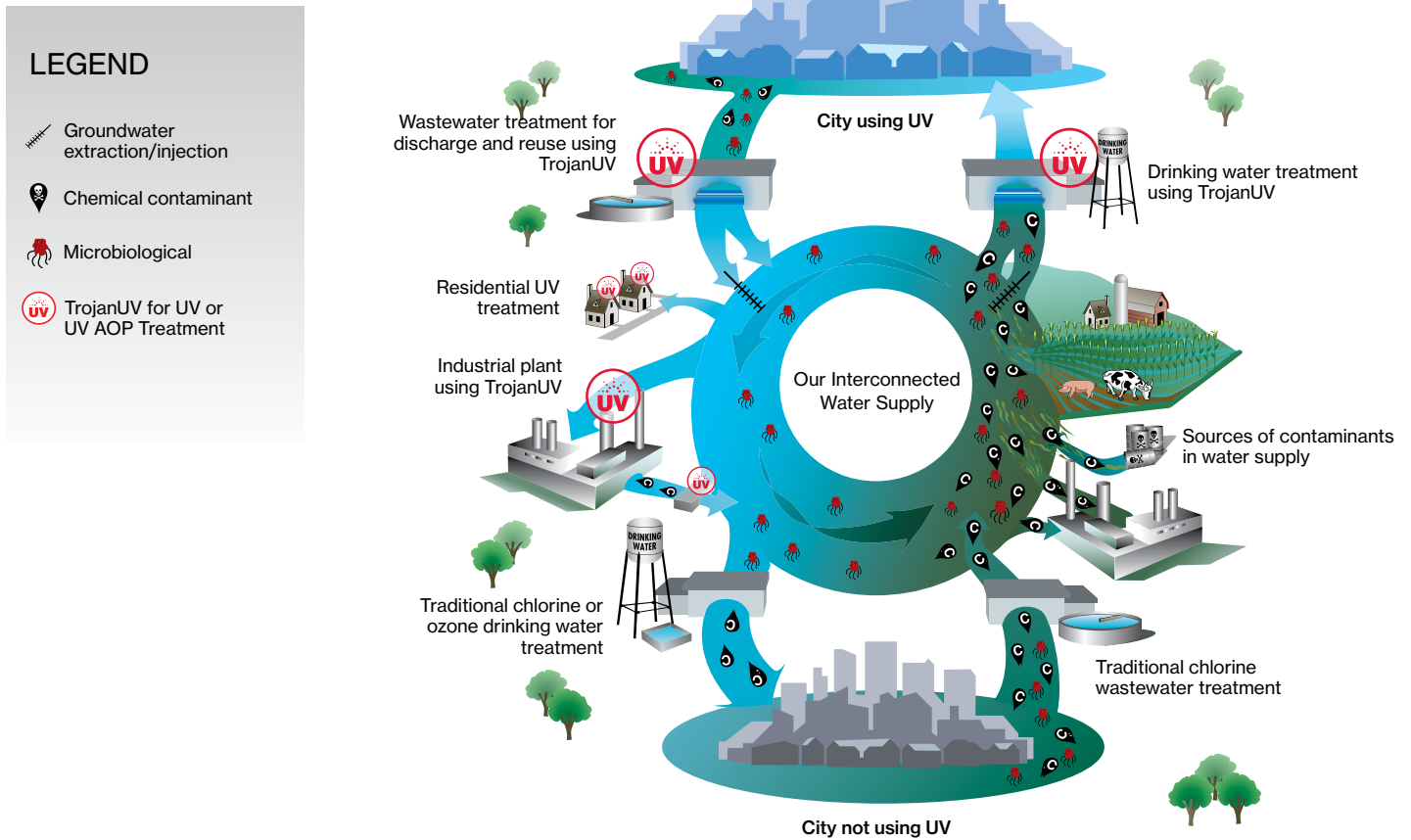
Seasonally-Treated Contaminants	MIB and geosmin
Year-Round Microorganism Targets	Cryptosporidium and Giardia
Secondary Contaminant	Algal Toxins

Leading the Way from Science to Solutions

We have a solution to treat water at virtually every point in its cycle. From the moment it is pumped from the ground or drawn from a reservoir, through its various stages of use, to its discharge into our rivers, lakes and oceans, we can provide a treatment solution. Our technology is a natural part of a multi-barrier treatment strategy, and offers communities a proven and cost-effective way to treat microbial and chemical contamination.

With the largest installed base of UV systems in the world and hundreds of patents, we are recognized as a leader in advanced UV AOP water treatment technology. Our scientists and engineers have introduced many of today's global UV innovations, including:

- The first large-scale UV system for the treatment of NDMA
- The first installation of UV AOP for simultaneous treatment and control of taste and odor-causing compounds in municipal drinking water
- The first integrated chemical/ mechanical cleaning system (ActiClean®)
- The first lamp to offer the advantages of both medium-pressure and low-pressure lamp technology (TrojanUV Solo Lamp Technology)



*Specific UV systems manufactured by Trojan Technologies have been validated through microbial testing. Through this testing, performance data has been generated for UV dose delivery to inactivate *Escherichia coli* (*E. coli*), fecal coliform, Poliovirus, *Cryptosporidium*, *Giardia*, and *Adenovirus*. For a detailed list of UV systems and target organisms, visit www.trojantechnologies.com/en/support/treatment-claims

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



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