TROJAN UV

WATER CONFIDENCE™

INTRODUCTION TO UV-OXIDATION FOR ENVIRONMENTAL CONTAMINANT TREATMENT

What are Environmental Contaminants?

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

The term "environmental contaminants" refers to harmful 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:

- Taste and odor-causing compounds (e.g. geosmin and MIB)
- *N*-nitrosodimethylamine (NDMA)
- Pharmaceuticals and personal care products (PPCPs)
- Pesticides and herbicides
- 1,4-Dioxane
- Fuels and fuel additives (e.g. MTBE and BTEX)
- VOCs (e.g. 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 in conjunction with hydrogen peroxide.

Why UV for Environmental Contaminants?

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

Cost-Effective
For certain contaminants, UV 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 has the advantage of being a destructive technology that breaks down a variety of contaminants into their safe, 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

NDMA: Potential Sources

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

Photo courtesy of Bruce Macleod

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

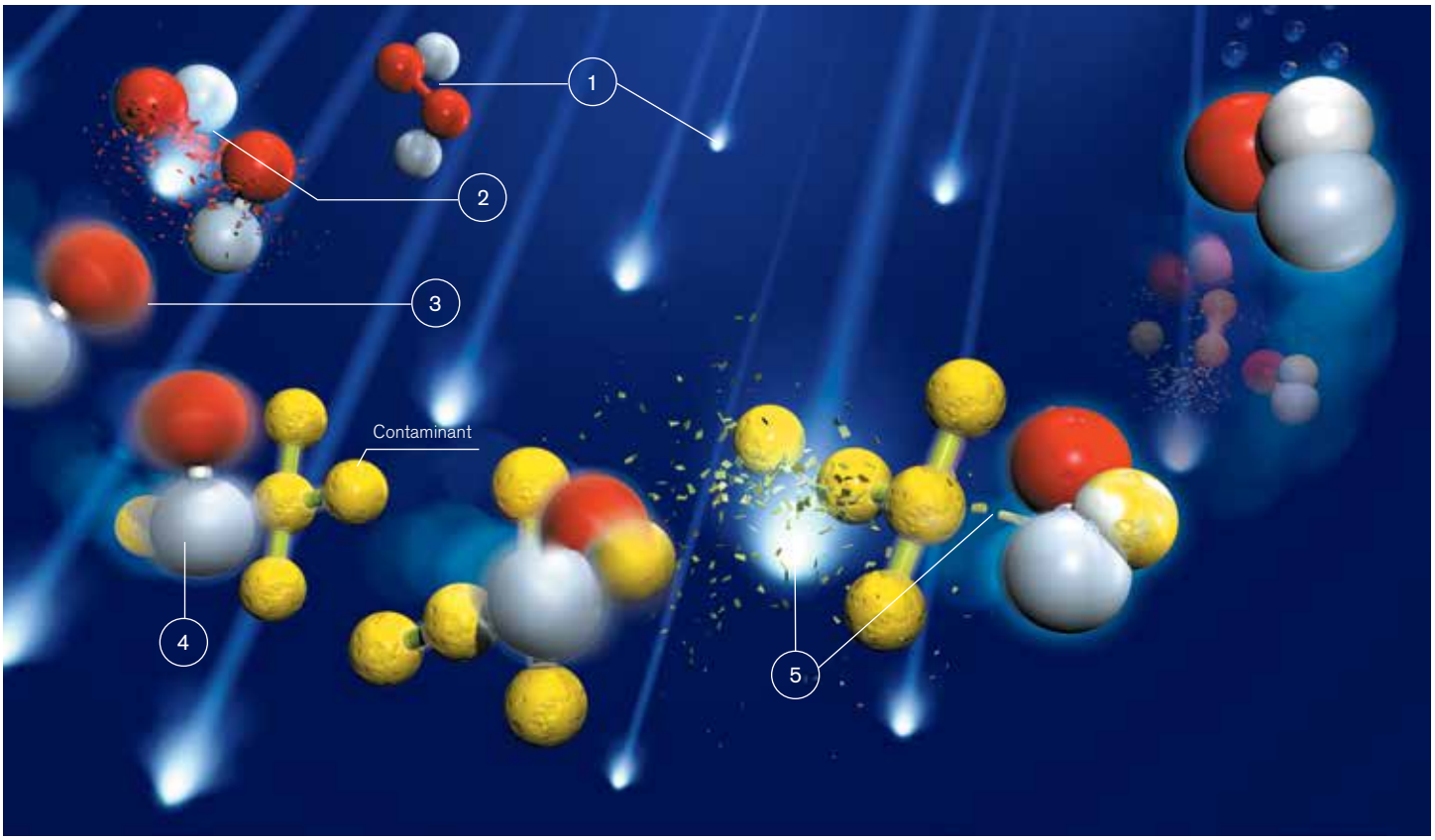
- 1,4-Dioxane, TCE and other cVOCs
- Improper disposal of chemicals
- Chemical spills from industrial accidents
- Spills can take years to reach groundwater supplies

How UV 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 potentially harmful chemical to its safe, elemental components.

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

Simultaneous Disinfection. UV, as part of a multi-barrier system, acts to simultaneously inactivate pathogens as well as destroy contaminants. This is accomplished without the formation of potentially hazardous disinfection by-products, including THMs (formed when using chlorine) or bromate (formed when using ozone).



1. UV-oxidation requires two components: UV light and 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 disinfects 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

TrojanUVPhox™ is a ground-breaking, pressurized UV light chamber that utilizes our low-pressure high-output, amalgam UV lamps. Through the extensive use of computational fluid dynamics modeling and other computer simulation tools, it has been optically and hydraulically optimized to provide extremely efficient and cost-effective treatment year-round. Its unique design allows for the use of multiple chambers in series, giving the TrojanUVPhox an extremely compact footprint.

The **TrojanUVSwift™ECT** employs medium-pressure lamps and sophisticated controls to optimize the treatment of environmental contaminants. 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 destroys contaminants such as taste and odor-causing compounds while providing disinfection of microorganisms such as *Cryptosporidium* and *Giardia*.

Utilizing UV light alone or in conjunction with hydrogen peroxide, the **TrojanUVTorrent™ECT** (with TrojanUV Solo Lamp™ Technology) is designed to provide a high efficiency, low maintenance solution for environmental contaminant treatment. The result is a system that combines the advantages of low-pressure high-output and medium-pressure lamp technologies, using fewer lamps with significantly lower energy requirements.

The Proven Leader in UV Solutions for ECT

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 disinfection throughout the year in order to inactivate pathogenic microorganisms, such as *Cryptosporidium,* in accordance with the United States Environmental Protection Agency (USEPA) regulations. Dual systems like these economically provide disinfection and taste and odor control and do so with a low carbon footprint and without forming bromate or other regulated disinfection by-products.

Seasonally-Treated Contaminants	MIB and geosmin
Contaminant Treatment Target	1-log Removal

Water Reuse Solution:
Orange County, CA Expansion

The Orange County Water District operates the largest indirect potable reuse treatment facility 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 has been expanded to increase the output capacity from 70 MGD to 100 MGD. For this expansion, we supplied an additional twelve TrojanUVPhox chambers to the twenty-seven initially installed. Similar to the original installation, the expansion equipment has been designed to treat chemical contaminants such as NDMA and 1,4-dioxane as well as pharmaceutical and endocrine disrupting compounds that may be left untreated by the membrane systems. The UV equipment will also continue to function as an additional disinfection barrier.

Primary Contaminant	NDMA
Secondary Contaminant	1,4-Dioxane
Influent Concentration (NDMA)	150 ppt
Effluent Concentration (NDMA)	<10 ppt

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-oxidation effectively destroy 1,4-dioxane. As a result, UV-oxidation was selected as the best technology to cost-effectively meet 1,4-dioxane treatment needs of the San Gabriel Valley Water Supply Co. and the cities located there. For this project, we supplied four TrojanUVPhox chambers that provide 1.9-log (~98%) removal of 1,4-dioxane and treat 2.5 MGD of contaminated groundwater with the goal of protecting the drinking water supply of over 1,000,000 people.

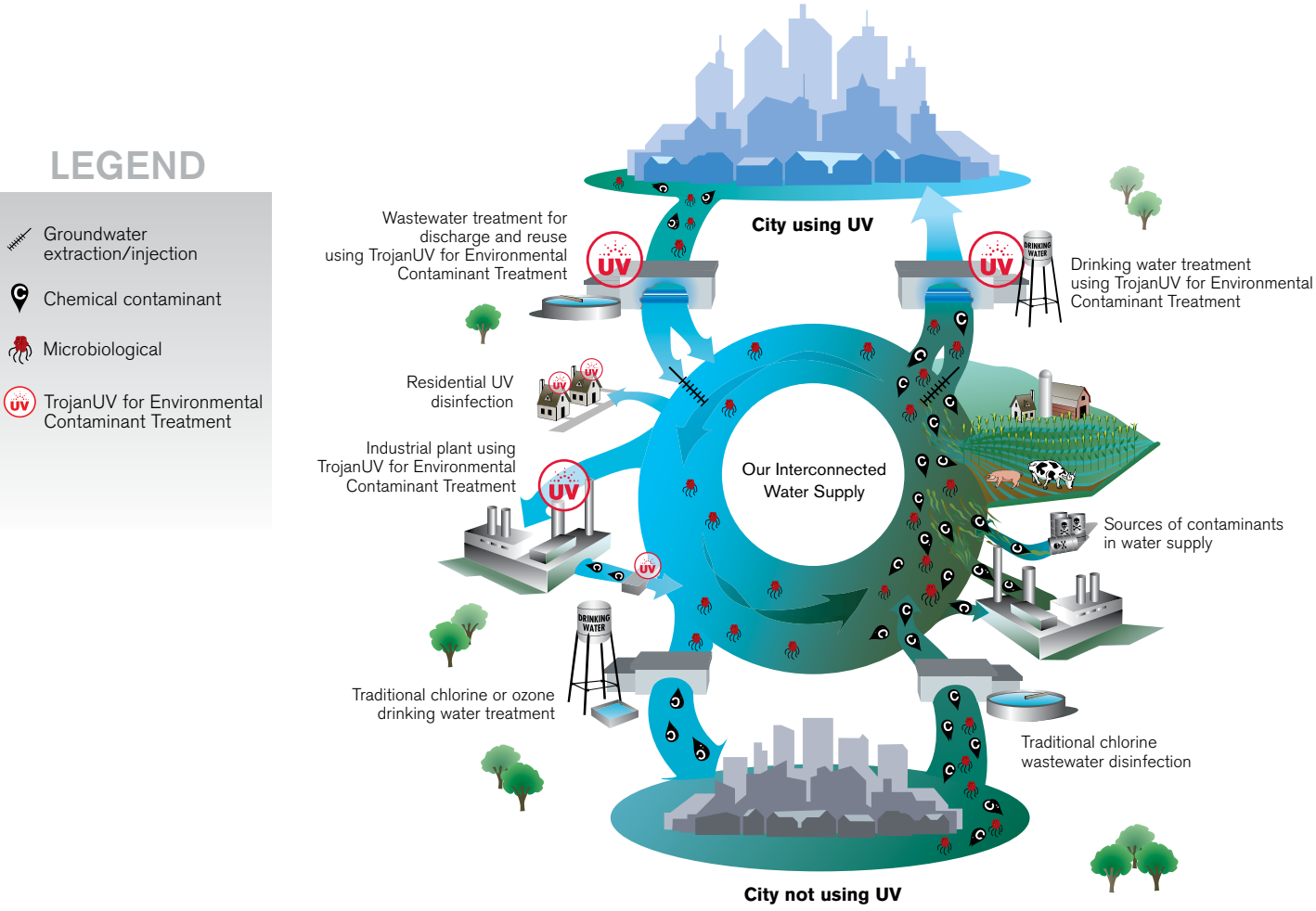
Primary Contaminant	1,4-Dioxane
Secondary Contaminant	TCE and PCE
Influent Concentration (1,4-Dioxane)	40 ppb
Effluent Concentration (1,4-Dioxane)	<0.5 ppb

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 protect from microbial and chemical contamination.

With the largest installed base of UV systems in the world and hundreds of patents, we are recognized as the leader in advanced UV 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-oxidation for simultaneous disinfection 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)



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