

INTRODUCTION TO UV-OXIDATION FOR
ENVIRONMENTAL CONTAMINANT TREATMENT

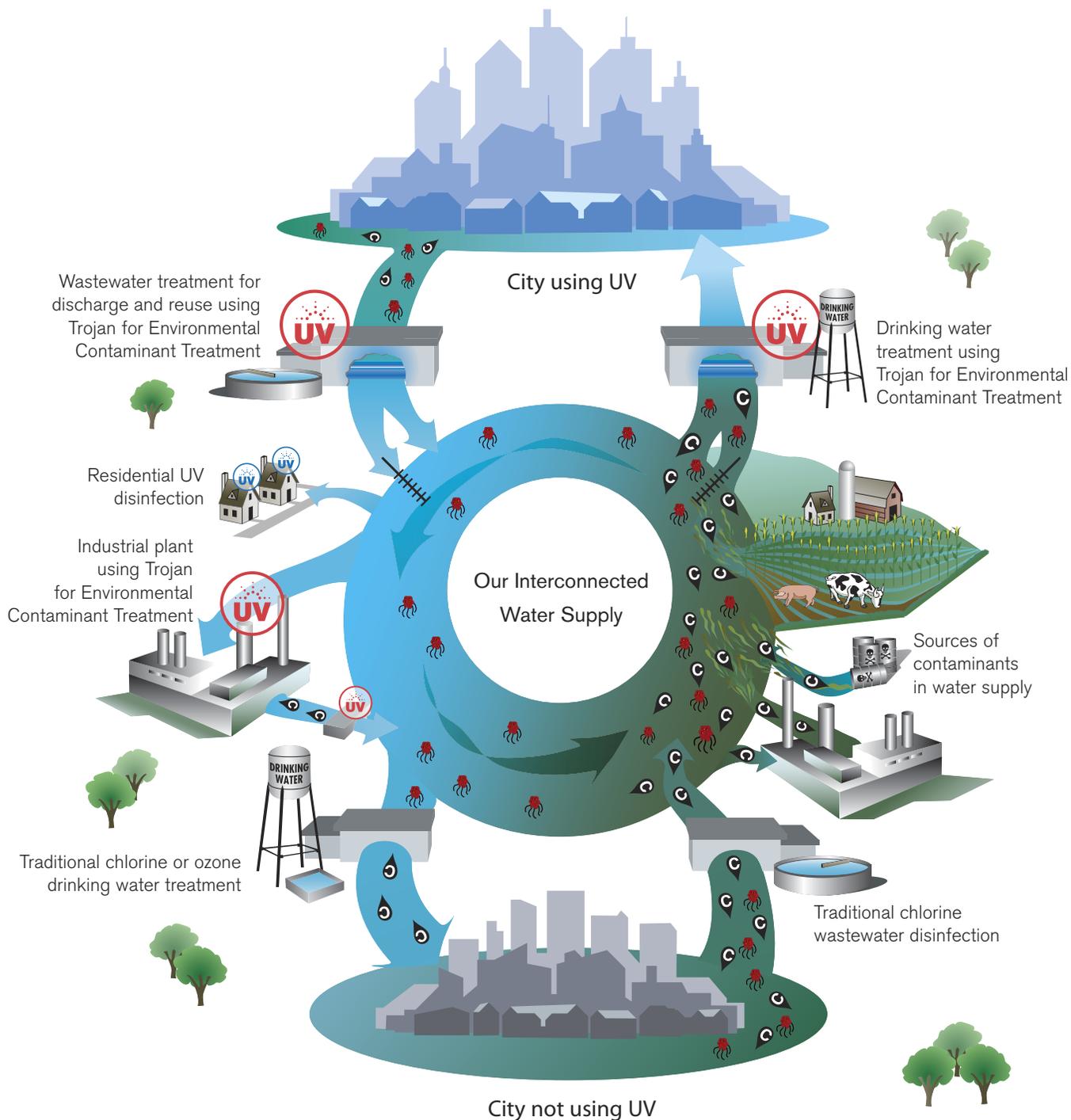


Trojan: Providing Water Confidence

Trojan has a solution to treat water at virtually every point in its cycle of use to give you confidence in the quality of your water supply. 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, Trojan provides 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 water supplies from microbial and chemical contamination.



What are Environmental Contaminants?

There is a growing awareness of chemicals in the world's water supply (see the water supply diagram on the opposing flap, right). Recent research has shown that a wide variety of such chemicals exist at trace concentrations in streams, lakes, rivers, and 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, and 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:

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

These compounds can be treated either by ultraviolet (UV) light alone or by UV light in conjunction with an oxidant such as 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 being applied to the large-scale environmental contaminant treatment (ECT).

Simultaneous Disinfection

UV, as part of a multi-barrier system, can act to disinfect and destroy contaminants, simultaneously. This is accomplished without the formation of potentially hazardous disinfection by-products, such as the formation of THMs when using chlorine or the formation of bromate when using ozone.

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 also has the added 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 with chlorine or chloramine
- Printed circuit board manufacturing
- Rocket testing/manufacturing
- Pesticide manufacturing
- Rubber and tire manufacturing
- Meat curing



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 phosphorus and nitrogen loads on surface waters
- Causes water to taste and smell earthy and musty

Trojan – A Commitment to R&D

A strong commitment to R&D has fueled Trojan's leadership in the application of UV light to treat environmental contaminants. In addition to research in North America, Trojan has formed an international alliance with the PWN Water Supply Company North-Holland (the Netherlands). This research collaboration and the resulting state-of-the-art water treatment installation in Andijk has further developed the use of UV-oxidation as a drinking water treatment technology for simultaneous disinfection and destruction of contaminants.

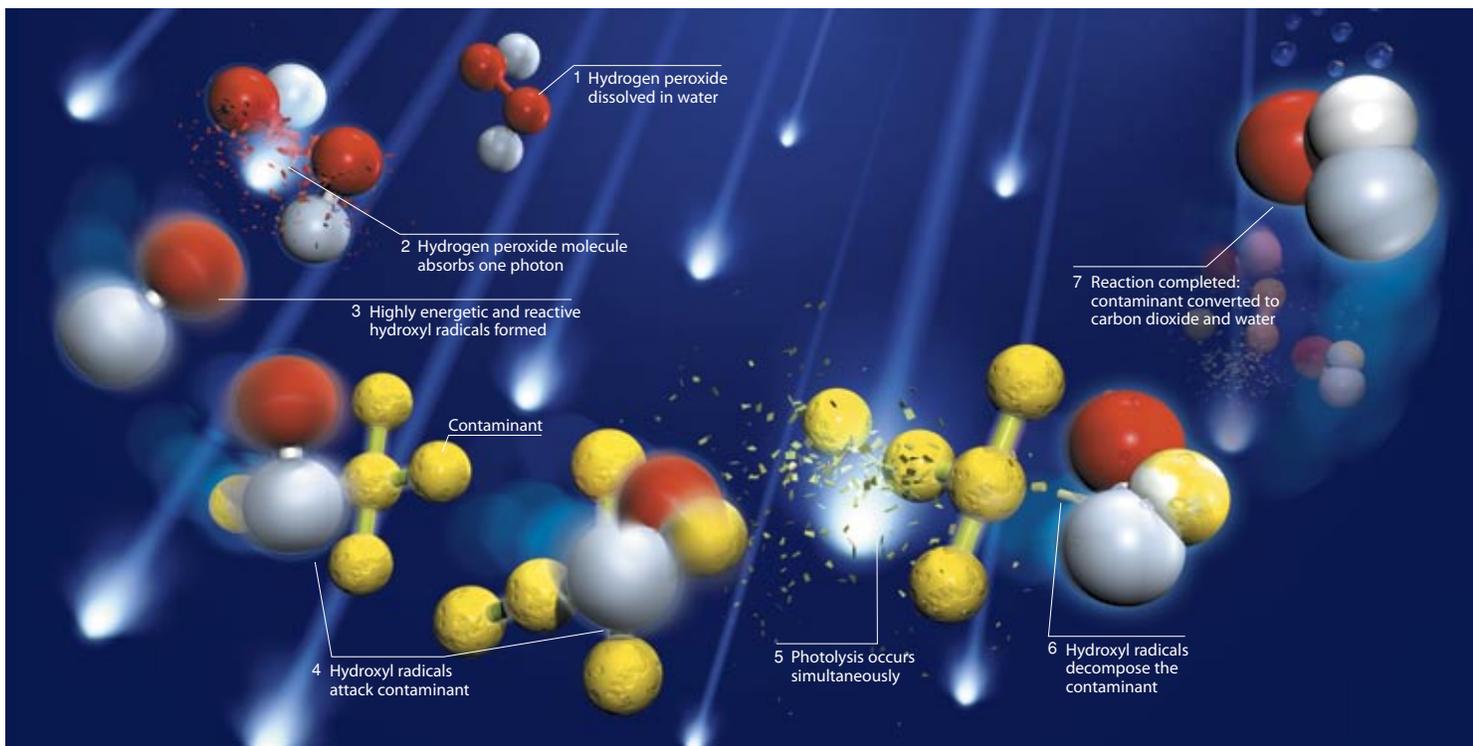
Our Solutions are Applicable in:

- Municipal drinking water treatment
- Water recycling/reclamation/reuse
- Wastewater treatment
- Groundwater remediation (e.g. at U. S. Superfund and other contamination sites)
- Industrial discharge treatment
- Industrial process water treatment



Trojan's leadership is demonstrated by the patent-pending TrojanUVPhox™ that is being used to cost-effectively treat NDMA and other contaminants in drinking water and water reuse applications.

The UV-Oxidation Reaction



The Proven Leader in UV Solutions for ECT

Drinking Water Solution: Cornwall

The City of Cornwall draws its drinking water from the St. Lawrence River in northeastern Ontario, Canada. Frequently, in the late summer and early fall, the water has a musty/earthy taste and smell due to organic compounds produced by summer algae blooms. When the city looked to upgrade its disinfection system to comply with new disinfection rules, it took the opportunity to save taste and odor (T&O) treatment costs by using UV-oxidation versus its existing granular activated carbon (GAC) system. The TrojanUVSwift™ECT to be installed in 2005-2006 will use UV to disinfect year round, while treating MIB and geosmin during T&O events using UV in combination with hydrogen peroxide. This integrated system will economically provide the dual benefits of disinfection and taste and odor control in treating 22 million gallons of drinking water per day. Equally important, it will do so without forming the disinfection by-product, bromate.

Year-Round Objective	UV Disinfection
Seasonally-Treated Contaminants	MIB and geosmin
Contaminant Treatment Target	1-log Removal

Water Reuse Solution: Orange County

The Orange County Water District will construct the largest water reuse treatment facility in the world in 2005-2006, the Groundwater Replenishment System (GWRS). The GWRS will employ a highly advanced water treatment facility that will treat wastewater to standards beyond those required for drinking water. The project will treat an average of 70 million gallons per day (mgd) in its first phase, and will ultimately treat up to 130 mgd. The TrojanUVPhox™ will destroy NDMA and act as the main disinfection system.

Primary Contaminant	NDMA
Secondary Contaminant	other organics
Influent Concentration (NDMA)	150 ppt
Effluent Concentration (NDMA)	<10 ppt

Solutions for Emerging Needs

The patent-pending **TrojanUVPhox™** (UV-Photolysis and UV-Oxidation) is a groundbreaking, pressurized UV light reactor that utilizes Trojan's 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 UV treatment. Its unique design allows for the use of multiple reactors 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 reactor for use as part of a multi-barrier system in large, municipal applications (hundreds of millions of gallons per day). In such an application, the TrojanUVSwift™ECT destroys contaminants such as taste and odor-causing compounds while providing disinfection of microorganisms such as *Cryptosporidium* and *Giardia*.

How UV Works

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 (similar to steps 1 through 3 in illustration, left).

UV-Oxidation (illustrated at left) is also a photochemical reaction, but involves the irradiation of hydrogen peroxide with UV light. This creates strongly oxidizing hydroxyl radicals (steps 1 through 3) that oxidize the contaminant, breaking the bonds between the molecules, and reducing the potentially harmful chemical to its safe, elemental components (steps 4 through 7).



A TrojanUVSwift™ECT system installed at the PWN Water Supply Company in Andijk, the Netherlands.

Leading the Way from Science to Solutions

Trojan is the world leader in ultraviolet knowledge and technology, with over 100 patents granted and an additional 130 patents pending. We are a global company with over 350 employees worldwide.

Trojan has the largest installed base of municipal UV water disinfection systems and over a quarter century of experience dedicated to improving the quality of water with ultraviolet light. Our production is ISO9001 Certified – an internationally recognized standard of quality assurance in design, development, production, installation and service.

Trojan is committed to ongoing research. More than 80 leading scientists and engineers from various disciplines are actively engaged in our numerous on-site labs.

Trojan Industry Firsts

We are responsible for many of today's global innovations in UV technology, including:

- The first large scale, monochromatic lamp-based UV system for the treatment of NDMA
- The first application of UV technology to disinfect reclaimed wastewater to stringent limits
- The first incorporation of electronic ballasts into low-pressure UV lamp disinfection systems
- The first integrated chemical/mechanical cleaning system (ActiClean™)
- The industry's first facility for testing UV lamps in water



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Other patents pending.
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