TROJAN UV

APPLICATION **ARTICLE**

# Mastering the Application of UV Advanced Oxidation using Chlorine in California

Advanced Oxidation Processes

## BACKGROUND

The Water Replenishment District of Southern California (WRD) is the largest groundwater agency in the State of California, managing and protecting local groundwater resources for over four million residents in South Los Angeles County. Because the demand for water exceeds nature's ability to replenish the groundwater basins, the WRD has historically performed artificial replenishment of the aquifers by using stormwater, recycled water, and water imported from Northern California and the Colorado River. However, they have now constructed a new water treatment facility that allows the region to be entirely self-sufficient in times of drought.

## THE ALBERT ROBLES CENTER FOR WATER RECYCLING AND ENVIRONMENTAL LEARNING

The Albert Robles Center (or ARC) can purify up to 14.9 million gallons of tertiary treated recycled water per day using an advanced treatment process consisting of ultrafiltration, reverse osmosis, and UV advanced oxidation (UV AOP). This advanced treated recycled water, which fully eliminates the demand for imported water, is delivered to nearby spreading grounds where it replenishes local groundwater supplies. The ARC facility is strategically located next to the San Gabriel River in the City of Pico Rivera, allowing it direct access to an existing recycled water pipeline that leads to the spreading grounds.

The Albert Robles Center for Water Recycling and Environmental Learning officially began producing advanced treated wastewater for groundwater recharge in Summer 2019.

Once the water is blended with tertiary treated recycled water and spread, it percolates and naturally filters through layers of sand and gravel before reaching the deeper drinking water aquifers.

## THE TROJAN SOLUTION

Trojan Technologies supplied the TrojanUVPhox™ for the UV AOP at ARC, arranged in two parallel trains. The system was designed to operate with sodium hypochlorite being injected into the treatment stream instead of more traditional hydrogen peroxide ($H_2O_2$). This is commonly referred to as a UV/chlorine or UV/$Cl_2$ approach to UV AOP. As described in more detail below, this critical difference in applied oxidants can allow for more efficient generation of the powerful radicals that break down chemical contaminants during the UV AOP process. ARC officially began producing advanced treated recycled water for groundwater recharge in Summer 2019 and has been permitted by the California State Water Resources Control Board to deliver advanced treated recycled water to the spreading grounds. As part of the permit, the TrojanUVPhox provides removal of both 1,4-dioxane and *N*-nitrosodimethylamine (NDMA). In addition, the UV system is credited with disinfecting 6-logs (99.9999%) of enteric viruses as part of the broader pathogen treatment requirements for potable reuse systems.

The TrojanUVPhox system in place at the Albert Robles Center uses a UV/$Cl_2$ approach to UV Advanced Oxidation instead of the more traditional UV/$H_2O_2$.

## WHY CAN THE UV/$CL_2$ AOP APPROACH BE MORE EFFECTIVE FOR ADVANCED WATER RECYCLING FACILITIES?

Preference to use UV/$Cl_2$ over the more commonly used UV/$H_2O_2$ AOP approach can be facilitated by treatment processes upstream of the UV AOP system as well as the intended use of the treated effluent. Reduced operating expenses and overall improved AOP efficiency using UV/$Cl_2$ AOP are possible if any of the following criteria are present at a site:

1. **Low (acidic) pH in Reverse Osmosis Permeate:** With many advanced water recycling facilities, a reverse osmosis (RO) system is installed upstream of the UV AOP system. Acid is added upstream of the RO membranes to prevent scaling resulting in the RO effluent having a pH in the 5 to 6 range, which is ideal for UV AOP using chlorine. When sodium hypochlorite is dosed into RO permeate, hypochlorous acid (HOCl) becomes the predominant free chlorine species at pH≤6 with its conjugate base, the hypochlorite ion (-OCl), being less prevalent. HOCl absorbs more UV light than -OCl or $H_2O_2$, producing more oxidizing radicals to break down chemical contaminants in the RO permeate water.

2. **Controlled Ammonia:** With most facilities using RO, chloramines are used to prevent membrane fouling. Chloramines are formed by dosing sodium hypochlorite and ammonia into the water ahead of RO membranes. Formed chloramine and its ammonia precursor are well rejected by RO membranes, but some passes through and if combined with the free chlorine used for the UV/$Cl_2$ AOP treatment step, further chloramines are produced. Chloramines can reduce the efficiency of UV AOP by lowering the UV transmittance of the water, and scavenging oxidizing radicals making them unavailable to break down chemical contaminants. Facilities using UV/$Cl_2$ AOP can overcome this by strictly monitoring and limiting residual ammonia after RO to concentrations which have minimal impact on UV AOP treatment.

3. **Free Chlorine for Distribution:** Advanced recycling facilities may require the presence of a free chlorine residual to avoid biological fouling during post-treatment distribution. This can be accomplished practically by using the same chlorine from the UV AOP system. UV AOP systems using UV/$H_2O_2$ would otherwise typically need a quenching step to remove residual $H_2O_2$ oxidant. This can be avoided with UV/$Cl_2$ AOP systems.

## UNDERSTANDING THE SCIENCE

Successful adoption of UV AOP, regardless of whether a plant is using chlorine or $H_2O_2$ as the oxidant, requires an understanding of complex photochemistry including the numerous light- and oxidation-driven reaction pathways. The UV/$Cl_2$ AOP in particular can be challenging to design and operate due to the dynamic chemistry, pH dependency, and chemical control requirements described here. UV/$Cl_2$ systems operating under these conditions require advanced control strategies that can rapidly adjust UV light and oxidant delivery in response to small changes in the water matrix. In addition, when using the UV/$Cl_2$ AOP, bromate formation is a documented concern. The presence of the precursor bromide in plant influent should therefore be considered to evaluate bromate formation potential. TrojanUV has over 20 years of experience researching and designing UV AOP systems for various contaminant treatment applications. Our experience ensures that advanced water recycling plant designers can make a confident decision on the most reliable and economical UV AOP approach.

## SUMMARY

The characteristics of an advanced water recycling facility as well as the water it treats strongly influence whether a suitable environment exists for a UV/$Cl_2$ AOP design. Evaluating these characteristics and whether they can contribute to a successful full-scale UV/$Cl_2$ AOP system without by-products like bromate should be carried out by experienced manufacturers with advanced knowledge of the embedded AOP science.

Overall, this will ensure the continued adoption of UV AOP in advanced water recycling systems as California works to sustain its water supplies through facilities like the ARC.


**Other Resources:**

Festger, A., and Bindner, S. "Chlorine improves UV-AOP efficiency in site-specific conditions." Water Reuse & Desalination, Autumn 2018, *https://www.trojanuv.com/about/news/when-does-uv-chlorine-advanced-oxidation-make-sense-1550*

Ortega, K., Knoell, T., Awad, J., Festger, A. and Royce, A. "WRD GRIP UV/Cl2 AOP for Indirect Potable Reuse." IUVA News, Quarter 3 2018, *https://iuvanews.com/stories/pdf/IUVANews_2018_Quarter3__links-Ortega.pdf* . Accessed February 21, 2020.



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