Practical Considerations of Applying UV Technology for Reuse Water Disinfection

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INTRODUCTION

Water scarcity has become a growing issue globally. Many cities in the world are experiencing water stress, i.e., deterioration in water quality and growing shortage in water quantity. Reuse of treated municipal wastewater offers an attractive solution to the water stress problem. The treated wastewater can be reused for the purpose of irrigation, landscaping, toilet flushing, car washing or industrial use. In all these applications, reuse wastewater relieves the burden on existing municipal potable supplies. Since people are in direct or indirect contact with reuse wastewater, its proper disinfection is critical for protecting public health. Chlorine is used for disinfecting wastewater for reuse purposes, but there are two issues associated with chlorine disinfection. First, it has been well established in the literature that chlorine disinfection forms disinfection byproducts, such as THMs, HAAs and NDMA. These byproducts can cause both acute and long-term health efecto. Second, chlorine is ineffective in disinfecting *Cryptosporidium*. In many parts of the world, *Cryptosporidium* is commonly found in municipal wastewater even after conventional treatment [1]. A *Cryptosporidium* outbreak in Milwaukee, USA, in 1993 affected 403,000 people.

Ultraviolet (UV) disinfection is effective in controlling a broad spectrum of pathogens including chlorine-resistant *Cryptosporidium*. It is also environmentally friendly in that no harmful byproducts are formed. UV disinfection of wastewater for reuse purposes has been successfully applied for decades in large scale treatment plants in North America and recently on a global scale. Reuse water is wastewater that has been treated to high standards and can be used again for applications such as irrigation, landscaping, toilet flushing, car washing, industrial use and groundwater recharge. Wastewater reuse requires effective measures to protect public health and to ensure that the impact on the environment is sustainable. To prevent the transmission of waterborne diseases, disinfection of reclaimed water is controlled by stringent regulations. In North America, more than 22 states have adopted regulations pertaining to specific reuse applications. These regulations specify wastewater treatment processes, nutrient removal, final effluent quality and disinfection criteria based upon the specific reuse applications. As a rule, the resulting effluents have low turbidity - a cloudy condition in water stemming from suspended silt or organic matter - and suspended solids. For such results, ultraviolet (UV) technology can economically achieve the most stringent disinfection targets as required by the states of California and Florida for restricted and unrestricted reuse applications. Given the potential for public exposure with this water the disinfection and water quality standards for reuse water can be similar to drinking water standards. Hence, there are stringent equipment and sizing requirements.

Although the use of ultraviolet radiation for disinfection in reuse water is growing rapidly due to its economical and ecological advantages over chemical disinfection, there is still a vast array of UV reactors available ranging from different lamp types to open channel/closed vessel systems. Often, local legislation and site conditions (i.e. plant hydraulic profile) influences preliminary designs which are specified by the Consulting Engineers. For example, the National Water Research Institute (NWRI) and American Water Works Association Research Foundation (AWWRF) **now renamed the Water Research Foundation (WRF) --** "UV Disinfection Guidelines for Drinking Water and Water Reuse" presents a conservative basis for bioassay sizing for reuse projects involving UV. Although these Guidelines apply to reuse projects in the State of California, they are often referenced for guidelines in other states such as Florida and Arizona. Furthermore, regions such as Australia have designed their reuse projects based on the NWRI/AWWARF Guideline's requirements, including performance and monitoring. It should be noted that treated wastewater for reuse applications is also referred to as reclaimed or recycled water. Unrestricted or non-restricted water reuse is a term used by many States to describe a range of applications where human contact may occur. For these applications the highest quality effluent and most stringent disinfection are generally required. Restricted reuse refers to applications where the risk of human exposure is slight, as in the case of drip irrigation of tree plantations.

Filtration of suspended solids generally improves UV disinfection performance to achieve lower microorganism counts. The NWRI/AWWARF Guidelines define different minimum UV dose levels depending on the type of filtration technology used prior to UV treatment. While suspended solids affect UV performance in allowing or preventing the UV system to achieve a certain disinfection goal, the UV transmittance of the wastewater does not limit the system effect. However, the lower the UV transmittance, the more lamps (and hence, more energy) are required to apply the same UV dose. The determination of UV transmittance is therefore a critical step in UV disinfection design. To ensure a UV system is robust, it should be properly sized to respond accurately to water quality changes by, for example, increasing UV intensity at lower than design UV transmittance values.

Currently, all commercially available UV lamps operate based on vaporization of mercury within the lamp envelope. The two lamp technologies: low and medium-pressure lamps differ in the partial pressure of mercury and corresponding output spectrum. UV has been used for reuse disinfection since 1987. Presently, UV systems treat more than 500 MGD produced by over 100 reuse sites in over 12 states. The majority of the UV installations are based on conventional low-pressure lamp technology. The lamps are arranged horizontally in open channels. Larger plants have medium-pressure UV lamp systems. There has been a drastic rise in market share for "low pressure-high intensity" amalgam lamps in the past few years. This has been primarily driven by the need for higher electrically efficient lamps (thus lower electrical operating costs) and the growing awareness in using “green” technologies to reduce carbon footprint.

Both open channel and closed vessel systems are currently used in reuse applications. For example, open channel reactors are generally installed in existing chlorine contact chambers without the need for major civil work, thus reducing installation costs. Furthermore, the open channel configuration provides a complete disinfection system with minimal headloss, thus there is virtually no impact on the existing plant hydraulics. These open channel systems can treat reuse flows from as low as a few million gallons per day to several hundred millions gallons per day. As the UV energy destroys the water-borne pathogens, including E.coli, Giardia and Cryptosporidium, lamp cleaning technology supports maximum lamp output reducing operating, maintenance and labor costs.

With the rise of membrane bioreactors (MBR) replacing secondary treatment – often providing higher quality treated water for reuse applications - many plants are faced with a pressurized effluent which needs to be disinfected. Instead of “breaking head” and the need to re-pump, thus increasing pumping/operating costs, a better alternative would be to install a closed vessel UV system for disinfection. As shown in **Figure 1**, Trojan’s closed vessel UVFitTM reactors are optimized for reuse applications and are easy to install within existing pipework, so there is minimal disruption to plant operation. Day to day operation is simple and maintenance is minor. The only regular requirement is changing the UV lamps and wiper rings annually – a simple task that can be carried out by on-site personnel. Both the UV3000Plus™ and UVFit™ line of reactors are third-party validated in accordance with the NWRI/AWWARF Guidelines.

Figure 1: Five 32AL50 UVFitTM closed vessel reactors installed in parallel in Spain for disinfection of filtered secondary effluent. The reuse water was used for an irrigation application.

In the city of Roseville, California, the Dry Creek Wastewater Treatment Plant (18 mgd average dry-weather flow) and the Pleasant Grove Wastewater Treatment

Plant (12 mgd) had gone through a host of initiatives that has put reuse water to the best possible use, cut energy consumption and minimize chemical use. The plants’ effluent meets stringent California Water Recycling Criteria (Title 22).

Recycled water from both plants is used to irrigate golf courses, landscapes and commercial properties. Water from Pleasant Grove, which went on line in 2004, supplies the cooling water for the Roseville Energy Park (REP). The park, next to the Pleasant Grove plant, is operated by municipal owned Roseville Electric. Reuse water is used as cooling tower makeup, firewater, service water and process makeup. At Dry Creek, the plant’s five effluent channels are treated with a Trojan UV3000Plus™ disinfection system (**Figure 2**). Each channel, with four banks of low-pressure, high-intensity lamps, can treat up to 9 mgd, for a peak disinfection capacity of 45 mgd. The system began operation in May 2009. The system went through extensive testing with plant staff to ensure they were absolutely confident in using the system to produce reuse water in compliance with the stringent regulatory limits.

In North America, especially in the southern and western states, urban centers are experiencing decreasing ground water tables, land subsidence, saltwater intrusion and chemical pollution. Reuse of wastewater, now recognized as an ecological and economic necessity, is increasingly practiced not only in the United States, but globally as well in water scarce regions such as Australia, Italy, Spain and Portugal. For the past two decades, and more so today, ultraviolet radiation has been successfully used to disinfect reuse effluents. UV is a non-chemical disinfection technology for wastewater that can protect the public against pathogenic microorganisms including protozoa, bacteria and viruses. As an alternative to chemical disinfection, UV does not produce harmful by-products and is non-toxic to the environment.

Figure 2: The plant's five effluent channels are treated with a Trojan UV3000Plus™ disinfection system. Each channel has four banks of low-pressure, high intensity amalgam lamps.

REFERENCES

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