UV Disinfection for Wastewater Treatment

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Course Author: Mathew Holstrom

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Section 1

INTRODUCTION

Effluent from municipal wastewater treatment plants (WWTPs) using the activated sludge process is typically disinfected to protect water supplies, beaches, and aquatic organisms. Chlorine has been the preferred disinfectant used, but concerns about worker and public safety and the potential for chlorinated WWTP effluent to be toxic to aquatic life have called its use into question. As a result, regulatory agencies are adopting stringent chlorine residual effluent limitations and require risk management plans for bulk storage of chlorine gas, as well as stringent storage and handling requirements for sodium hypochlorite. The New York State Department of Environmental Conservation (NYSDEC) has, and is expected to continue reducing chlorine residual limits in WWTP discharges, which will require implementation of dechlorination or an alternative disinfection technology.

Although chlorine, which sometimes is followed by dechlorination, continues to be used at most municipal WWTPs, use of other disinfection means is increasing. Maintaining high quality WWTP effluent discharges while minimizing energy usage and costs requires the use of innovative technologies, one such technology being ultraviolet radiation (UV). This technology is capable of providing effective disinfection of WWTP effluent while reducing safety and environmental toxicity issues.

The design and operation of disinfection systems requires great care to ensure that the facilities are safe, reliable and economical. Municipal wastewaters in New York State vary significantly depending upon the type of community served and the type of treatment employed. Although there are many potential benefits of using UV for WWTP effluent disinfection, there are also potential disadvantages associated with cost, lamp fouling and photoreactivation of target microorganisms. Therefore, wastewater treatment professionals are understandably careful regarding the implementation of new processes and require independently obtained treatability data and pilot-scale evaluations before changes in treatment processes will be considered. These professionals require information on the benefits, efficacy, capital and operating costs, energy use and potential impacts to water quality on a long-term basis.

To evaluate the costs and benefits of using UV instead of chlorine for disinfection of WWTP effluent, the New York State Energy Research and Development Authority (NYSERDA), National Grid and the Erie County Department of Environment and Planning (ECDEP) sponsored a pilot-scale demonstration at the Erie County Southtowns WWTP. The demonstration included the pilot-scale evaluation of three different UV lamp types: low pressure-low intensity (lp-li), low pressure-high intensity (lp-hi), and medium pressure-high intensity (mp-hi). URS Corporation (URS), the University at Buffalo (UB) and StanTec, Inc. (StanTec), performed the demonstration jointly.

This report summarizes the results of the pilot-scale demonstration and evaluation of the benefits and costs associated with the three different UV lamp types. Included are a comparison of long-term performance, benefits, energy use, costs and environmental impacts associated with three lamp types with respect to chlorination/dechlorination. A comparison of UV disinfection performance on treating filtered and unfiltered (secondary clarifier effluent) wastewater also is presented. In addition, the report includes a summary of equipment and operating and maintenance costs using UV disinfection at various sized municipal WWTPs.

Section 2

BACKGROUND

CHLORINE AND UV DISINFECTION

Chlorine Disinfection Issues

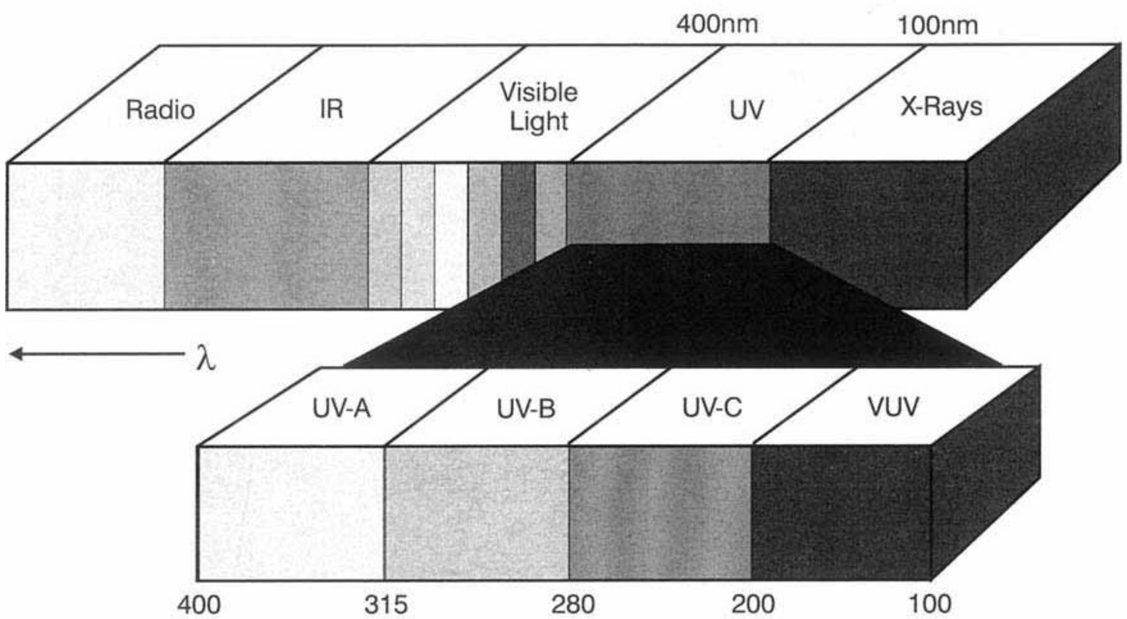
As noted in the introduction, chlorine disinfection is the most common form of wastewater disinfection today. Chlorination is a well established technology and an effective disinfectant. However, the use of chlorine for disinfection is being reevaluated because of several key concerns. First, chlorine poses a risk to the health and safety of WWTP personnel and the surrounding community. Accidental release of chlorine can occur through volatilization from chlorine contact facilities or through leaks in the storage cylinders or feed lines. Inhalation of chlorine damages the upper and lower respiratory tracts and causes severe skin irritation upon physical contact, and can be lethal to humans. Because of this danger, larger water and wastewater facilities are required to maintain risk management plans that address chlorine use and storage.

Second, chlorine can adversely impact receiving streams and can adversely impact biota. The residual chlorine and chloramines from the disinfection process are toxic to many aquatic organisms, including fish, oysters and copepods (Johnson and Jensen, 1986). Residual concentrations as low as 0.002 milligrams per liter (mg/L) have reportedly induced toxic effects in aquatic organisms (TFWD, 1986). Vegetation also can be affected by residual chlorine.

Third, chlorine reacts with organic material in the environment to form disinfection byproducts (DBPs) that have potentially adverse impacts to human health. The key DBPs of concern are the formation of trihalomethanes (THMs), such as chloroform and haloacetic acids (HAAs).

Ultraviolet (UV) Radiation Disinfection

UV light was discovered as part of the electromagnetic spectrum by John Ritter in 1801 (Fleishman, 1996). UV light refers to radiation with wavelengths between 30 and 400 nanometers (nm), which are shorter than visible light. UV light commonly is referred to as black light because it cannot be seen by the human eye. The UV spectrum is divided into three parts: UV-A (315 – 400 nm), UV-B (280 – 315 nm) and UV-C (30 – 280) (Thampi, 1988). UV light produced by the sun causes the human skin to tan or burn. However, the more harmful effects of the sun (e.g., skin cancer and eye cataracts) are specifically from the UV-C part (Fleishman, 1996). Figure 2-1 presents a schematic of the UV light spectrum.



ELECTROMAGNETIC LIGHT SPECTRUM

FIGURE 2-1