**UV Technology Continues to March On for Municipal Wastewater Disinfection in the Americas**

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**Introduction**

In the past decade, UV technology has received increasing attention in the Americas for a variety of applications. For municipal drinking water, the recent discovery that UV readily inactivates Cryptosporidium oocysts and Giardia cysts has transformed the technology from a small niche groundwater disinfection market technology to the most promising technology for surface water systems faced with concerns over Cryptosporidium/Giardia and/or disinfection by-products (DBPs). Also for municipal drinking water, the use of UV for advanced oxidation processes (AOPs) is currently receiving ample interest for the destruction of “emerging” contaminants such as N-nitrosodimethylamine (NDMA), methyl-tert-butyl-ether (MTBE), endocrine disruptors and chlorinated solvents. The use of UV light has also become more prevalent for air treatment, including HVAC systems. Many industry leaders consider air treatment as the single largest application for UV in the coming decades. The use of UV light also is growing steadily for residential Point-Of-Entry (POE) and Point-Of-Use (POU) applications, as well as for bottled water applications. The advantages of ultraviolet light have been clearly demonstrated for curing applications. And the list of applications keeps growing with ultrapure water, process applications, etc.

With all the interest generated for the above applications, we have almost forgotten that the largest application of UV worldwide remains by far the disinfection of municipal wastewater.

**Municipal Wastewater Applications and Markets – Old and New**

In North America, the most common application of UV for municipal wastewater is as an alternative to chlorination-dechlorination for the disinfection of secondary effluents before discharge to the natural environment. For this application, UV continues to emerge as the preferred technology over chlorination primarily due to 1) requirements for dechlorination subsequent to the chlorination step (to eliminate the toxicity to aquatic species associated with residual chlorine), and 2) concerns associated with handling, transport and storage of chlorine. For this application, the target organism generally is fecal coliforms in the U.S. and E. coli in Canada, with treatment objectives ranging from 200 – 1000 cfu (or MPN) /100 mL.

Characterized by low UV transmittances and high TSS levels, primary effluents, Combined Sewer Overflows (CSO) and Sanitary Sewer Overflows (SSO) represent new challenges for UV technologies.

Over the last five years, due to increasing concerns over water shortages, and led by California Title 22 and Florida in the US, UV technology has become very popular for water reuse applications. For a given peak flow rate, these applications require significantly larger UV systems than conventional municipal secondary wastewater discharge applications, as the treatment objective is as stringent as nondetect in total coliforms (Title 22 stipulates 2.2 cfu/100 mL of total coliforms based on a 7-day median value).

Latin America, aggressively led by Brazil and Chile, represents an emerging market for municipal wastewater UV disinfection. Several large systems recently have been installed in the State of Sao Paulo (Brazil) and near Santiago (Chile). In the past two years only, over 20 wastewater treatment plants in Brazil and 15 in Chile have either installed or are currently evaluating proposals for a UV system. In these countries, the treatment objective usually is less stringent than in North America (e.g., 1,000 cfu/100 mL for total coliforms).

**Lower Overall Costs**

Capital costs of UV systems continue to decrease as a result of fierce competition. Table 1 shows capital equipment costs for recently awarded projects. These recent UV equipment costs are similar to the costs of conventional low-pressure, low-output (LP-LO) published in the mid-1990’s (1, 2). However, improvements in technology efficiency are leading to significantly lower life cycle costs. First, capital costs other than the cost of the UV equipment itself are lower due to, for example, smaller system footprints.

Second, and more important, improvements in lamp technology, automatic cleaning mechanisms, dose pacing capabilities, and reactor design (see next Section) have led to significantly lower power consumption and labor costs, and consequently lower O&M costs.
Continuous Evolution of the Technology

As discussed at the recent 2002 WEFTEC Conference (3), low-pressure, high-output W lamp (LP-HO) technology may be the “wave of the future” according to one presenter.

Except for very small systems, low-pressure, low-output (LP-LO) W systems no longer are the technology of choice primarily due to 1) the very high number of lamps required, 2) the high maintenance cost associated with manual lamp cleaning and lamp change-out, and 3) the lack of dose pacing capabilities.

Cost of W System

<table>
<thead>
<tr>
<th>State</th>
<th>Design Peak Flow (MGD)</th>
<th>UV System Type</th>
<th>Cost of UV System (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvania</td>
<td>3.5</td>
<td>LP-HO</td>
<td>80,000</td>
</tr>
<tr>
<td>Iowa</td>
<td>6</td>
<td>LP-HO</td>
<td>140,000</td>
</tr>
<tr>
<td>Nebraska</td>
<td>8.5</td>
<td>LP-HO</td>
<td>125,000</td>
</tr>
<tr>
<td>Montana</td>
<td>14</td>
<td>LP-HO</td>
<td>270,000</td>
</tr>
<tr>
<td>Ohio</td>
<td>22</td>
<td>MP</td>
<td>410,000</td>
</tr>
</tbody>
</table>

All projects in Table 1 were for discharge applications awarded in 2002, and for a design percentage transmittance of 65%. LP-HO: Low-pressure, high-output system; MP: Medium-pressure system.

Due to the disadvantages of LP-LO systems listed above, medium-pressure (MP) W systems gained a considerable momentum in the last decade. However, as projects are more and more evaluated based on a life cycle cost analysis, the lower germicidal efficiency (and consequently higher power consumption cost) of the MP lamp makes the technology less competitive with LP-HO systems. This can be easily quantified by considering that 1) the power consumption cost of a MP system will be three to four times greater than the power consumption cost of a LP-HO system, and 2) the power consumption cost is the most important parameter of the Operations and Maintenance (O&M) cost, representing between 50 and 70% of the total O&M cost.

MP systems retain an advantage for large systems for which footprint considerations become a critical factor. Significant innovative developments are further strengthening the competitiveness of LP-HO lamps. For the same length of lamp, mercury-indium amalgam LP-HO UV lamps have a higher output than liquid mercury lamps, and their efficiency is significantly less dependent on water temperature fluctuations. Double-folded LP-HO UV lamps have a UVC output 4 to 10 times greater than conventional LP-HO lamps, and 20 to 35 times greater than LP-LO lamps (4).

The optimal performance of UV systems is highly dependent on hydraulics. Designs are being optimized with the application of Computational Fluid Dynamics (CFD) and the use of mixers. However, with the exception of one commercial system based on an innovative single lamp reactor design for optimized hydraulics (2), major commercial systems continue to rely on banks of lamps submerged in open channels.

Looking Ahead

UV technology has a bright future for wastewater applications. However, issues remain and will need to be addressed. The image of the industry must continue to improve by, among others, decreasing the number of full-scale systems not performing according to manufacturer’s claims and/or project performance.
specifications. Also, comparison between commercially available UV systems is difficult due to the fact that systems vary in proprietary lamp technology, reactor designs, etc., must be performed on a more uniform basis.

To tackle these issues, stricter standards are required. Among others, improvements in standards for defining the measurement of parameters such as system performance (e.g., bioassay), lamp life, and hydraulic parameters (e.g., head loss) are necessary. This will be one of the major objectives of the recently formed IWA Topical Group on Wastewater Disinfection.

References