Ultraviolet Disinfection

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Fact Sheet

What is disinfection?

Human exposure to wastewater discharged into the environment has increased in the last 15 to 20 years with the rise in population and the greater demand for water resources for recreation and other purposes. Wastewater is disinfected to prevent the transmission of infectious diseases and to ensure that water is safe for human contact and the environment. There is no perfect disinfectant. However, there are certain characteristics to look for when choosing the most suitable disinfectant:

- ability to penetrate and destroy infectious agents under normal operating conditions;
- lack of characteristics that could be harmful to people and the environment;
- safe and easy handling, shipping, and storage;
- absence of toxic residuals, such as cancer-causing compounds, after disinfection; and
- affordable capital and operation and maintenance (O&M) costs.

What is UV disinfection?

One way to disinfect wastewater is through ultraviolet (UV) radiation, which inactivates disease-causing bacteria by electromagnetic radiation. Wastewater flows through or around a tube with UV light penetrating it from all directions. Radiation is transferred to the cell walls of the bacteria, rendering the organisms sterile.

A UV disinfection system consists of mercury arc lamps, a reactor, and ballasts. The lamps are the source of UV radiation, the ballasts provide power to the system, and wastewater flows through tubes in the reactor. Two types of mercury lamps can be used: low pressure or medium pressure.

There are two types of UV disinfection reactor configurations: contact and noncontact. In both of these types, wastewater can flow either perpendicular or parallel to the lamps. Figure 1 (see page 2) shows two UV contact reactors with submerged lamps placed parallel and perpendicular to the direction of the wastewater flow. In the noncontact reactor, the UV lamps are suspended outside of a clear conduit. Flap gates or weirs are used to control the level of the wastewater.

What are the advantages and disadvantages of using UV disinfection?

Advantages

- UV disinfection is effective at inactivating most viruses, spores, and cysts.
- UV disinfection is a physical process rather than a chemical disinfectant; thus eliminating the need to generate, handle, transport, or store toxic/hazardous or corrosive chemicals.
- There are no toxic residuals that could be harmful to humans or aquatic life.
- UV is user-friendly for operators.
- The wastewater needs to be in contact with UV light for only a short time to be adequately disinfected (approximately 20 to 30 seconds with low-pressure lamps).
- UV disinfection equipment requires less space than other methods.

Disadvantages

- Low dosages may not effectively inactivate some viruses, spores, and cysts.
- Organisms can sometimes repair themselves and "undo" the effects of UV disinfection. This phenomenon is known as *photoreactivation*.
- The tubes used to carry the wastewater can develop a buildup of slime, or fouling, which may require regular cleaning for preventive maintenance.
- It is more difficult to penetrate microorganisms in wastewater that is not clear (containing high amount of solids in suspension).
- In some cases, UV can be more expensive than other disinfection methods.
- There is no measurable residual to indicate the effectiveness of UV disinfection.

What determines the performance of UV disinfection systems?

A UV disinfection system must be designed to reach the most bacteria with the strongest UV dose for the longest time possible. The success of UV disinfection depends

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A General Overview

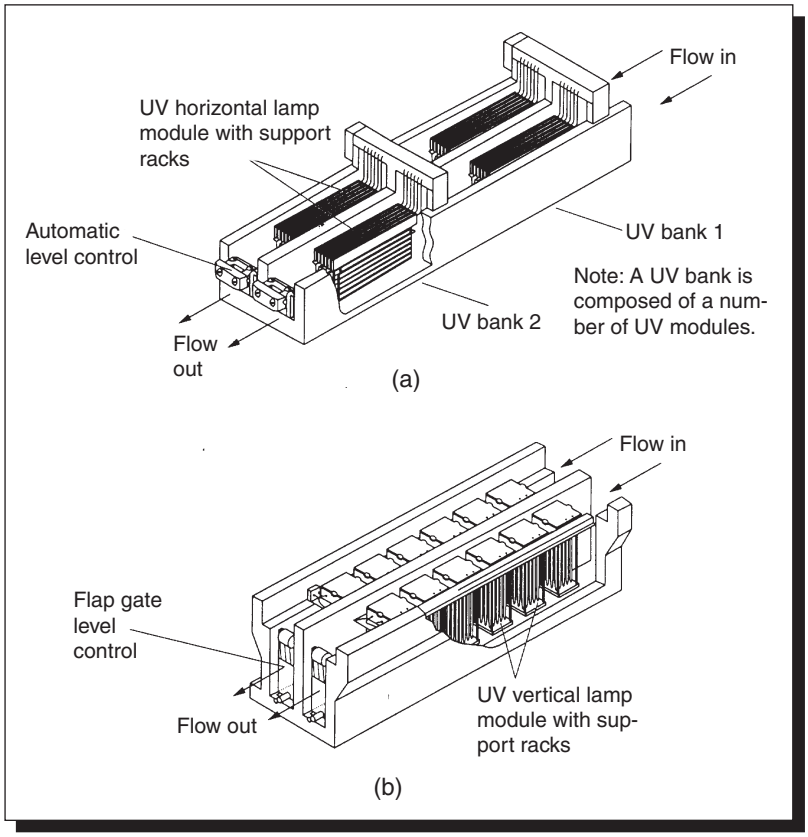

Figure 1:
Isometric cut-away views of typical UV disinfection systems with cover grating removed: (a) horizontal lamp system parallel to flow (adapted from Trojan Technologies, Inc.) and (b) vertical lamp system perpendicular to flow (adapted from Infilco Degremont, Inc.)

Source: Crites and Tchobanoglous (1998), used with permission from The McGraw-Hill Companies

on the amount of time the wastewater is exposed to UV radiation, the intensity of UV radiation, and the characteristics of the particular wastewater at the time of disinfection. The amount and type of microorganisms vary with different wastewater. The concentration of total suspended solids and of particle-associated microorganisms determines how much UV radiation ultimately reaches the target organisms. The higher these concentrations are, the lower the UV radiation absorbed by the organisms, and thus, the less effective disinfection can be.

Are UV disinfection systems easy to operate and maintain?

Proper O&M is needed to keep a UV system functioning at maximum performance. This requires that all surfaces between the UV radiation and the target organisms be kept clean—mainly the tubes, lamps, and reactor. Inadequate cleaning is one of the most common causes for a UV system's failure to perform.

O&M also involves replacing the tubes, lamps, or quartz sleeves regularly, according to manufacturer's instructions. Lamps are generally replaced after 12,000 hours of use, quartz sleeves after 5 to 8 years, and ballasts every 10 to 15 years.

What is the cost of UV disinfection?

The cost of UV disinfection systems depends on the manufacturer, the site, the capacity of the plant, and the characteristics of the wastewater to be disinfected. The main operating costs are power consumption, equipment replacement and repairs, cleaning supplies, and personnel costs.

Typical (total) O&M costs per year for each low-pressure lamp range from $85 to $98, which includes these items: power; replacement of lamps, ballasts, and sleeves; cleaning chemicals and supplies; staffing requirements; and miscellaneous equipment repairs.

How do I stay informed about UV technology?

For more information on UV disinfection contact the National Environmental Services Center (NESC) at West Virginia University. Phone: (304) 293-4191. Web site: *http://www.nesc.wvu.edu*.

References

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