The Finishing Touch

UV light disinfection gains favor as a simple, cost-effective finishing step for onsite wastewater treatment systems

By Dr. James E. Cruver

NSF Standard 40 listed onsite wastewater treatment units generally do a good job in removing suspended solids, BOD, and total nitrogen. But while they reduce the concentration of pathogenic bacteria, viruses, and parasites, additional disinfection is often required. Ultraviolet (UV) light can provide that finishing touch.

UV light is an increasingly popular water and wastewater disinfecting method. It has several inherent advantages over all other disinfecting techniques:

- No chemical consumption — eliminates storage, transportation and handling, and potential safety hazards.
- Low contact time — no contact basin is necessary, and space requirements are reduced.
- No harmful by-products are formed.
- Few moving parts, or none, thus high reliability.
- Low energy requirements.

UV disinfecting, therefore, solves environmental and safety problems, and is cost-effective as well.

How it works

Shortwave UV light — wavelength 254 nanometers (nm) — destroys microorganisms by causing molecular rearrangements in its DNA and RNA (genetic material). This blocks replication and the ability to form colonies. The peak region of germicidal effectiveness is the UV wavelength range of 240-260 nm. This is a much shorter wavelength than the UV light we receive from the sun, which cuts off at about 290 nm.

UV light sources are readily available. Low-pressure mercury lamps — the basis for a fluorescent lamp — efficiently generate more than 90 percent of their light at 253.7 nm, which is near the germicidal peak. These lamps are made in the same sizes as fluorescents and can be operated by the same ballasts.

Microorganisms vary in their resistance to UV light. The fraction killed depends on the product of UV light intensity and exposure time. This is known as the dose, and it is the single most important parameter for rating UV disinfecting equipment. UV destruction doses for non-spore-forming bacteria, common viruses, *Giardia lamblia* cysts, and *Cryptosporidium* oocysts are under 40 millijoules per cm^2. Spore-forming bacteria and mold spores require UV doses from 20 to 200 millijoules per cm^2.

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Key variables

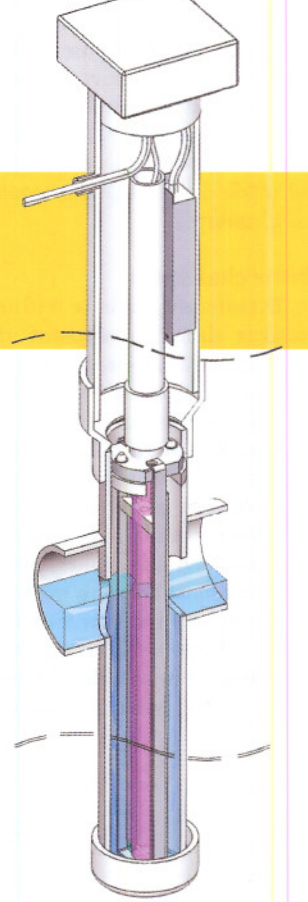
The most important process variables for UV disinfecting are UV light transmission and suspended solids. Compared to other substances, water is an excellent transmitter of UV light. Ultra-pure water transmits more than 99 percent of incident UV light per centimeter. Therefore, UV absorption in water is almost entirely caused by dissolved and suspended substances that are strong UV absorbers.

Among these are humic, fulvic, and tannic acids (derived by decayed vegetation and biological sewage treatment) and lignin sulfonic acids (derived from pulp and paper wastes). Iron is the strongest UV absorber of inorganic ions commonly found in water. Other ions normally present in water, such as sodium, chloride, calcium, magnesium, carbonate, sulfate and phosphate, absorb very little germicidal UV light.

Whether or not suspended particles interfere with disinfecting depends on their composition. For instance, suspensions of clay or silt in water up to 50 mg/liter have very little effect on microorganism destruction. On the other hand, a 50 mg/liter suspension of biological debris that contains microorganisms could severely limit disinfecting.

The reason is that microorganisms buried with the debris particles are shielded from UV light by the strong UV-absorbing organic matter that surrounds them. In general, the effect of suspended particles is no greater on UV disinfection than on chemical disinfection.

The operating temperature of the UV lamp, line voltage, and lamp aging rate are other important UV system variables.



Design approaches

There are two basic UV system design approaches currently in use:

- Shellside flow.
- Teflon tubeside flow.

In the shellside design, water flows over one or more quartz sleeves (similar to flow on the shell side of a shell-and-tube heat exchanger). Inside each quartz sleeve is a germicidal UV lamp. The outer shell is usually constructed of stainless steel or polyvinyl chloride.

The quartz sleeves penetrate bulkheads at both ends of the outer shell and are sealed with UV-resistant O-rings. Electrical connections to the lamps are at either end of the unit, but the ballasts are placed in a separate enclosure outside the disinfecting chamber. For gravity-flow effluent disinfecting, several sleeved germicidal lamps are placed on a removable vertical rack suspended in an open flow channel.

In the Teflon tubeside design, water flows inside one or more UVtransmitting fluoropolymer tubes. They can be connected in parallel to large diameter headers for high flow capacities. Germicidal lamps placed outside and between the flow tubes evenly expose fluid to UV light. In larger units, the lamps are sometimes mounted on sliding aluminum racks for easy replacement. The principal advantage of the Teflon design is that it requires less cleaning.

Onsite challenges

Disinfecting onsite effluent presents design constraints that standard shellside or tubeside UV units cannot easily satisfy. They are:

- Aerobic onsite systems are usually installed at or below grade, which places the effluent pipe as low as 24 inches below grade. Therefore, to maintain gravity flow, the UV unit must be below grade and have very low flow resistance.
- Underground UV components must be accessible for service.
- The UV system's fluid-carrying chambers are permanently installed in the ground or in a pump tank.
- Sensitive components must be protected from flooding and high humidity.
- Cleaning or other maintenance occurs every six months or longer.

A newly designed UV disinfection system for onsite effluent follows these criteria. The subassemblies are housed in a UV-resistant plastic disinfection chamber that is permanently installed below grade.

The UV light is housed in a subassembly accessed through the riser for periodic servicing. The subassembly mounts in the center of an anodized aluminum frame that divides the chamber in half and seals it to prevent flow bypass. Two locating pins lock the subassembly in place near the top of the chamber. Effluent flows down from one side of the unit, makes a 180-degree turn, then flows up and out the other side, assuring the proper fluid exposure time.

When the chamber is full, the UV light operates continuously at a temperature range of 105 to 120 degrees F for optimal disinfection, whether or not water is flowing in the chamber. Should the light operate improperly, an external alarm warns the homeowner. The alarm relay circuit is compatible with many commercial alarms and can operate in closed or open modes. The disinfection subassembly is watertight and extends above grade to protect the electrical connections from fluid backups.

Electrical components are another subassembly. A NEMA 4X electrical junction box houses the alarm board and terminal blocks for electrical connections. The ballast and lamp power cable are pre-connected. A green LED indicator on the outside of the box glows when the UV lamp is producing germicidal light at a safe level.

Specifications

The system can be installed within 30 minutes. It requires an annual inspection and cleaning, and replacement of the UV light every two years. The unit is rated for 4,320 gpd with TSS less than 30 mg/l and BOD5 less than 30 mg/l. If TSS and BOD are less than 10 mg/l, maximum flow increases to 8,640 gpd. In both cases, fecal coliform is reduced by 99.9 percent. Third-party testing by NSF and other facilities has been successfully completed or is still ongoing to meet State of Washington 2007 regulations.

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