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## Ultraviolet Water Disinfection

by James Dallan

Earlier this century, chlorine started to be used in municipal water treatment to combat waterborne infectious diseases. Now it has been discovered that using chlorine in water treatment is, in fact, a mixed blessing. On the one hand, chlorine keeps diseases under control and on the other hand, when it is mixed with naturally occurring organic chemicals, it creates hazardous chemicals such as trihalomethanes (THMs).

There are two main methods of disinfecting water: one is a chemical method and the other is a physical one.

Chemical disinfection involves the addition of chemicals like chlorine, iodine or bromine in the water. Whereas, physical disinfection consists of boiling water to kill germs, or micro filtration to physically remove germs from water, or using ultraviolet light (UV). This later method, adds nothing to the water nor does it take anything from it. It is a physical process that does not, in principal, change the chemistry of the water nor its taste.

### What is UV?

UV is an energy band within the electromagnetic energy spectrum. Its wavelength is between that of X-rays and visible light. At 254nm wavelength, UV reaches its near peak germicidal effectiveness against most microorganisms.

UV destroys germs by causing a molecular change in their DNA makeup. This prevents germs from multiplying and destroys the ability to spread disease. When germs cannot multiply, they are considered dead.

### UV dosage

Different germs can tolerate different amounts of UV light and therefore, require varying amounts of UV energy, to be destroyed. This energy level is called the dosage. By definition, dosage is the intensity of UV light multiplied by time (see Table 1).

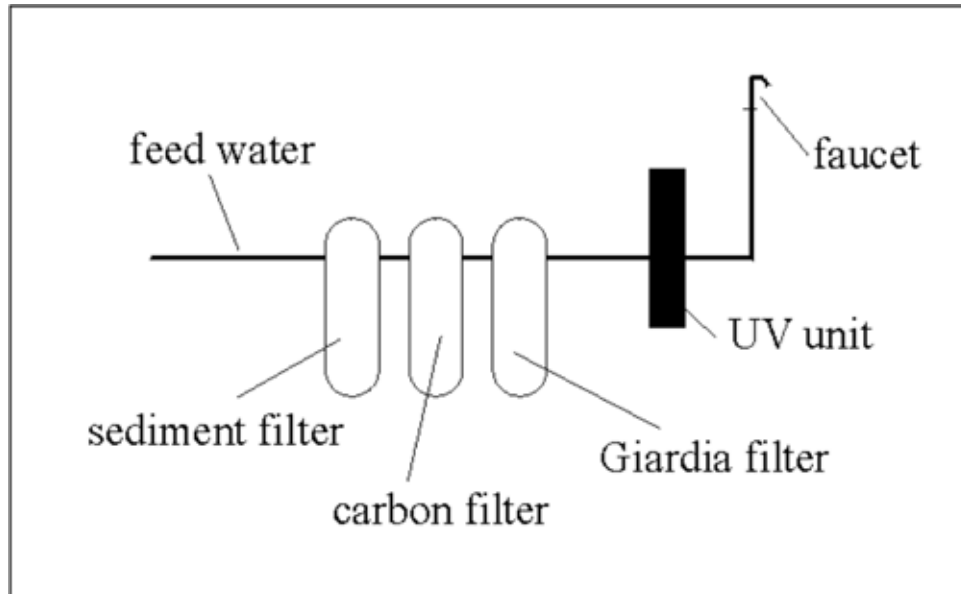
$$\begin{aligned}\text{Dosage} &= \text{intensity} \times \text{time} \\ &= (\text{microwatt per square centimetre}) \times \text{time} \\ &= \mu\text{Wsec/cm}^2\end{aligned}$$

**Table 1.** Dosage is the intensity of UV light multiplied by time

The intensity is the amount of UV energy, that the UV lamp produces at a certain distance from its surface per square centimetre of the lamp's surface area. The time is the period it actually takes water to travel inside the UV chamber.

### How is UV created?

UV is created when an electrical current flows between two electrodes inside a UV lamp shell containing mercury vapour. UV lamps are similar in design and construction to fluorescent lamps. The main differences are that fluorescent lamps use a coat of phosphorous on the inside surface to filter out UV light, whereas UV lamps use none and fluorescent lamps do not normally use hard glass which is commonly used in UV lamps to enhance UV light transmission.



**Figure 1.** Typical UV system with three filters for under-the-counter use

### Factors affecting UV

UV light can only be effective if it hits its target. If for example, UV light is prevented from reaching its mark due to suspended solids or other impurities in water, then UV will not be as effective as it can be. The following are the main obstacles that will reduce the effectiveness of UV disinfection:

- **Suspended solids.** These will act as an umbrella, 'protecting' germs from UV light. Suspended solids should be physically removed from water by pre-filtration before a UV unit.
- **Iron/manganese.** These will cause discolouration on the quartz sleeve that surrounds the UV lamp and reduces the transmission of UV light. They will also absorb UV energy. They should be removed from water by pretreatment or at least reduced to no more than 0.3 ppm for iron and no more than 0.05 ppm for manganese.
- **Hardness.** When water is hard, scale will eventually build up on the quartz sleeve around the UV lamp and will stop the UV light from passing through. A water softener should be used before a UV unit if the water is hard.
- **Dissolved substances.** Other organic and inorganic dissolved substances can also reduce the germicidal effectiveness of UV light and should be pre-treated before a UV unit.

### Limitations

- Excessive bacteria counts in water may require additional UV dosages or chemical treatment.
- Cysts, for example Giardia, are not affected by UV. If present in water, cysts should be physically removed by micron filtration.

Other factors such as water temperature, should also be considered. UV units are normally designed to operate best between two and 40°C. Freezing will cause damage to the UV unit and water temperatures higher than 40°C will cause a reduction in UV energy and therefore, a reduced germ kill ratio.

### Advantages of UV

UV has many advantages over other disinfection processes:

- UV is effective and quick. No need for holding tanks and reaction times. No need for storing chemicals.
- UV does not alter the taste of water, which makes it ideal for use in bottling plants and food processing applications.
- UV is safe. NO need to add or handle hazardous chemicals or risk polluting the environment.
- UV is compatible with all other water treatment processes. No need for de-chlorination if using RO systems. In fact, UV enhances the use of other water treatment systems by keeping them free from germs.
- UV is economical. Almost always, the cost of UV disinfection units is much less than the cost of chemical treatment systems. The cost of service and maintenance of UV units is very low. The electrical running cost of a UV unit in a house is about that of a regular light bulb.
- More effective against viruses than chlorine.
- Easy installation. UV units are very easy to install and require very little space.

### **UV applications**

The use of UV systems is found in residential, commercial and industrial applications, as well as in sewage treatment plants. UV can be used in: homes, cottages, hotels, motels, buildings, factories, rinse processes, bottling plants, food processing, cooling towers, breweries, hospitals, fisheries, farms, wineries, and the list goes on.

### **Installation guidelines**

UV units should be installed after any water pre-treatment process, just before the cold and hot branch lines. If in doubt about the size of a UV unit that is needed, always use a larger unit rather than a smaller unit. Normally an 8gpm UV unit will be adequate for an average size house. UV should be installed as close as possible to the dispensing point. All the pipes should be treated with chemical shock treatment and flushed thoroughly before a UV unit is commissioned and prior to its use.

UV disinfection is very quickly gaining ground on other conventional disinfection processes because it is effective, environmentally friendly and economical. UV does not change the taste of water nor does it add anything to it. It is the ideal choice for disinfecting water.

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