UV LIGHTS FOR WATER TREATMENT

Drinking water is a necessity of life. Unfortunately, not all sources of drinking water are safe. Surface water from lakes, rivers, streams and springs are often contaminated with germs, which, if consumed, can cause illness. Ground water supplies, particularly those very close to the surface, such as a dug well, can also become contaminated. For surface water and some dug wells a treatment device is required to make the water safe for drinking. A type of water treatment device that is becoming very popular is the UV light.

What is UV light?

Ultraviolet light, better known as UV light, is an energy region of the electromagnetic spectrum. In this spectrum, the shorter the wavelength of the light, the greater the energy. Wavelengths of light are measured in units called nanometres (nm) (1 nanometre = 10^{-9} metres). UV light lies in a region located between visible light and x-rays. It occupies the space of the spectrum between approximately 100 nm and 400 nm. UV light has less energy than the x-ray region but more than visible light. UV light below 300 nm is the most effective at killing germs that may be in water.

How does UV light kill germs?

Most of the germs we find in drinking water are single celled microbes. They make up the groups of microbes known as viruses, bacteria, fungi, algae and protozoa. When UV light passes into these cells it is absorbed by the genetic material in the cell called nucleic acid (i.e. DNA and RNA). This absorption of UV light by the nucleic acid causes a rearrangement of the cell's genetic material. The cell's ability to multiply stops. When the cell can no longer multiply, it is considered dead.

How much UV light is needed to kill germs?

UV light is measured in microwatt seconds (MWs). The amount of UV light needed to kill a microbe depends on the type of microbe. For instance, more UV light is required to kill viruses than bacteria. The minimum recommended dosage considered acceptable for an ultraviolet light water treatment device is 16,000 MWs/cm^2 at a wavelength of 253.7 nanometres (nm) at maximum flow.

How do UV lights work?

Ultraviolet lights use a physical method of microbe destruction instead of the more common chemical methods (i.e. chlorination). The key elements of UV light systems are a ballast and lamp combination, a teflon or quartz sleeve to protect the lamp and a properly designed reactor chamber. The ballast is the controlling device that drives the lamp at the desired electrical conditions. UV lights work best when voltage or cycle variations do not exceed manufacturer's specifications. The lamp is very similar in design to a florescent light. UV light is emitted when an electrical current passes through mercury vapour located between two electrodes that are at opposite ends of a tube-like lamp. With a UV light, the lamp is constructed with quartz which allows for 93% of the lamp's UV light to pass to the outside. With florescent lights the lamps are lined with a coating of phosphor which lets very little UV light escape to the outside. Water enters through the bottom part of the ultraviolet light reactor chamber, swirls around the ultraviolet lamp with its protective tube and comes out the top. Exposure of the water to the UV light in the reactor chamber kills the microbes in the water.

Does raw water quality have an affect on UV lights?

The quality of the raw water to be treated has an effect on all water treatment devices, including UV lights. The four major concerns with raw water affecting UV light performance are as follows:

i. The number of germs present in the raw water;
ii. The amount of suspended solids in the water;
iii. The amount of soluble molecules in the water; and
iv. The mineral content of the water.

UV lights that are designed to treat water for drinking purposes are not very effective if the raw water contains high numbers of microbes. These devices should not be used for treating water which contains more than 1,000 total coliforms per 100 mL, or more than 100 faecal coliforms per 100 mL. As the concentration of the microbes increases, the possibility of some of them not receiving a lethal dose of UV light also increases (some of the microbes may block the UV light from reaching others). Also the presence of large amounts of suspended solids in raw water can create shadows that prevent UV light from reaching the microbes. Reactor chambers are usually designed to create turbulent flow patterns that help to bring germs out of shadowed areas and into the UV light. However, if germs are trapped inside suspended particles the UV light will not penetrate far enough into the particle to kill them. To prevent this, a good quality sediment filter should always be installed on the raw water side of the UV light. This filter will remove any suspended solids increasing the efficiency of the UV lights operation.

Some molecules commonly found in drinking water, such as humic acids, tannins, and iron, are capable of absorbing UV rays. If high amounts of these molecules are present in the raw water they can reduce the amount of UV energy available in the water to kill microbes.

Minerals such as manganese and iron, as well as calcium and magnesium which relate to water hardness can, over a period of time, precipitate on the protective sleeve of the UV lamp. Eventually this slow build-up will reduce the intensity of the UV light reaching the Water. As a result, raw water which contained high quantities of these minerals must be pre-treated to lower the mineral concentration before UV treatment. Even at centrations meeting current potable water standards, the lamp's protective sleeve occasionally has to be removed and carefully cleaned with a mild acid solution to remove mineral deposits. With some devices, gloves must be worn during cleaning procedures to prevent oil and grease on the fingertips from etching the lamps sleeve. Always refer to the manufacturer's recommended cleaning procedure before attempting to clean any lamp or protective sleeve.

Before installing a UV light, it is advisable to have the raw water which is to be treated, tested. This will help you to determine what pretreatment equipment, if any, is needed. Water should be tested for bacterial quality, total iron, hydrogen sulphide, suspended solids, manganese and hardness.

How often do the lamps have to be replaced?

The output of UV lamps gradually decreases over the period of time used. Most manufacturers claim that the lamps will have an effective life ranging from between 6,000 and 12,000 hours. As previously discussed, a number of operating problems can lead to premature failure. However, under normal household operating procedures, lamps will commonly last about a year.

How do you know if the UV light is working?

The best way to tell if a UV light is doing its job is to periodically submit a sample of the treated water for bacteriological analysis. Contact your local Health Unit for sampling information.

How do you know when to change the lamp?

Proper installation of UV lights requires the connection of the light to a safety feature that can monitor UV intensity through the maximum depth of water in the chamber. If UV intensity drops to a level no longer sufficient to kill germs, the monitoring or sensing devise should trigger an alarm. The alarm could be visual or audible, or both, and/or it can be directly wired to the water pump so that it will immediately stop the water flow. Visual alarm systems are usually equipped with a series of LED indicators. These must be inspected regularly and appropriate action taken when necessary.

What the UV light will not do?

UV lights will not kill some parasitic microbes such as worms or cysts. To remove these organisms from the water a filter of 5 microns or less must be used in conjunction with the light (a 3 micron filter is required to remove a parasite called Cryptosporidium from water).

Another disadvantage of UV light water treatment is that it will not leave a chemical residue in the water to protect against post treatment contamination. This can be a problem since some germs may be reactivated when exposed to oxygen. In some cases, particularly those premises with long distribution systems, it may be necessary to use an additional treatment device, such as chlorinator, that will leave a chemical residue.

More questions?

If you have any questions regarding UV lights, please contact the Public Health Unit at (519) 376-9420 or 1-800-263-3456.