American Lung Association.

Can Ultraviolet Lights Improve Indoor Air Quality

The COVID-19 pandemic brought a renewed interest in improving indoor air quality and reducing airborne pathogens such as viruses and bacteria. Many homes, businesses, and schools began using indoor portable HEPA (high-efficiency particulate air) air cleaners to clean the air. Air cleaners can do a remarkable job of capturing allergens, irritants, and particulate matter. If the mechanical air cleaner includes a carbon filter, it will also deactivate many chemicals from the air. However, HEPA air cleaners do not necessarily purify the air from biological pathogens.

One way to reduce pathogens in the air is through ventilation - allowing clean outdoor air to come inside. This is also called "clean air exchange". A clean air exchange can reduce the indoor pathogens by more than 60% in one hour. Currently, there is not a US standard for clean air exchanges, but the Centers for Disease Control and Prevention (CDC) recommends five per hour. Other organizations factor in the size of the room and the number of people in the room into their clean air exchange recommendations.

How to calculate the clean air exchange or "Air Change per Hour" (ACH)

1. Determine (or measure) the airflow through the HVAC system in cubic feet per minute (cfm). You can find this in your HVAC owner's manual.
2. Measure the volume of the room in feet (width x depth x height).
3. Calculate ACH:
   Air Change per Hour (ACH) =

$$\frac{\text{cfm} \times 60 \text{ minutes}}{\text{Volume of room in feet (width x depth x height)}}$$

Another proven way to purify the air and kill the airborne and surface pathogens is using Ultraviolet Germicidal Irradiation (UVGI). Simply put, UVGI uses ultraviolet light (UVL) to kill viruses and bacteria. A well-designed UVGI system that is properly installed and maintained can effectively kill the virus that causes COVID-19 and help protect people from viruses indoors.

How does UVGI kill pathogens?

UVL are wavelengths shorter than that of visible light. Wavelengths between 222 nm (nanometers) and 254 nm kill viruses and bacteria. UVL acts as a germicide by damaging the DNA and RNA of a germ. When the ultraviolet wavelength hits the DNA or RNA, it causes a mutation to form. With this mutation to its DNA or RNA, the germ is unable to replicate, thus preventing its spread.

UVL lamps are high voltage lamps that excite the krepton cloride (KrCl) gas within the lamp bulb. This begins the process of photon emissions that kills pathogens in the air and on surfaces within the "disinfection zone". The disinfection zone is where the UVL light rays reach. UVL will not kill pathogens where the UVL wavelengths cannot reach (for example, the underside of tables, in the shade of a chair, etc.) or near someone emitting the pathogen (for example someone coughing within 2-3 feet of another person).

How well does UVGI disinfect the air and surfaces in my classroom?

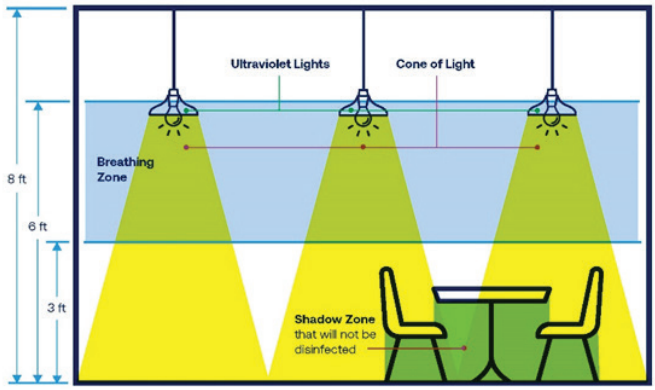
UVGI has been used in healthcare facilities for over 70 years. The first use of this technology was to disinfect tuberculosis bacteria. More recently, UVGI has been considered for home and school use. If used in the home or school, the recommendation is to use an UVGI for 30 minutes after the last occupant/guest leaves the room. This is enough time to kill the pathogens in the disinfection zone. For example, 90% of the COVID-19 virus is killed within 55 seconds of UVL lamp use, while 90% of the influenza virus is killed in just 30 seconds. This is because the COVID-19 virus is about 11 times more difficult to kill than the influenza virus.

Who should use UVGI lamps to disinfect the air and surfaces?

UVGI is an effective way to kill pathogens. Since viruses are the leading trigger for asthma and COPD exacerbations, individuals with these lung diseases may benefit from UVGI disinfecting. In addition, individuals with lung cancer or individuals who are immunocompromised may also benefit from UVGI disinfecting.

Where do I place the UVGI lamp?

1. Since the typical UVL lamp will disinfect 200 square feet of space, measure the space you want to disinfect, such as a classroom.
2. Do not overlap the lamp "cones" of light or place too closely together. See image for more information.
3. Place the UVL lamp away from any air vents.
4. Watch for the "shadow zone", where light cannot reach. UVL is only effective where the light waves reach.
5. Place the UVL lamp within the "breathing zone", where a person's nose and mouth are when standing or sitting. This is typically between 3 and 6 feet from the floor.
6. Finally, a UVL lamp can be used when the room is occupied; however, see below for the drawbacks of this technology.



What are the drawbacks of using UVGI to disinfect?

1. The accurate height and placement of the UVL lamps and appropriate use are key.
2. While research shows that 222 nm wavelengths are safe for human exposure, it is best to limit the number of people and length of time that individuals are exposed to the UVL for protection of the skin and eyes. To be most conservative, run the lamp when the room is not occupied.
3. Ozone will be created by any UVL with wavelengths under 240 nm. Ensure the UVGI lamp has a high-quality filter to capture the ozone.
4. Note, when running an UVGI lamp, there is a byproduct smell. This smell is not harmful to humans or animals, and it does not irritate the lungs. However, it is always a good idea to ensure good ventilation when your UVL light is running.

There are several factors to consider when selecting a UVGI:

1. Quality is important. The type and quality of the glass in the UVL lamp can vary the efficiency of the lamp. Look for a UVL lamp with quartz glass.
2. Wattage is also important. The power of UVL lamp varies between 2 watts and 500 watts. The higher the watts, the more powerful and effective the lamp.
3. Ensure the UVL lamp has reflectors to direct the light downward.
4. Most UV lamps have a short life. These lamps are most effective in their first 100 hours of use but can be effective for up to 3000 hours of use. Lamps last longer with reflectors.
5. **Proper and complete cooling of the lamp is needed.** Most manufacturers recommend six to 10 minutes of cooling time.
6. Any ultraviolet light under 240 nm does produce ozone. Ozone is a known lung irritant. Therefore, a high-quality, synthetic filter is needed to capture the ozone.
7. While you can purchase a UV lightbulb at your hardware store for $12, a UVGI system is different and expensive. You can expect to pay between $700-$2,000 per UVL lamp. The rule of thumb is that one UVL lamp will service about 200 square feet of space. Be sure to read the label regarding the number of square feet that specific UVL lamp will disinfect.
8. A low-cost alternative is increasing the daily ventilation (clean air exchange) in your home or school by opening doors and windows. Remember, a clean air change can reduce the indoor pathogens by more than 60% in one hour.