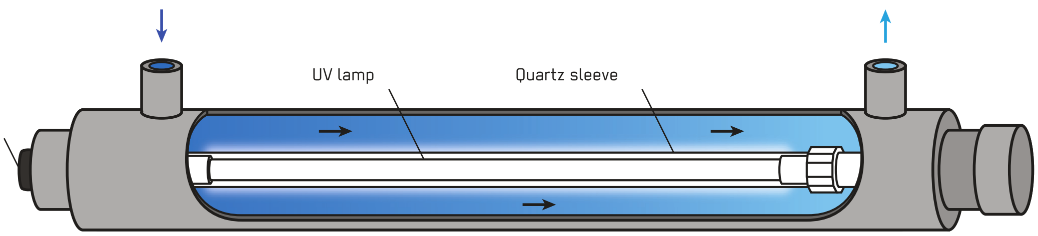
Ultraviolet (UV) Lamp

Response Phase	Application Level	Management Level	Objectives / Key Features
Acute Response * Stabilisation ** Recovery	** Household ** Neighbourhood City	** Household ** Shared Public	Point-of-use treatment, water disinfection
Local Availability	**Technical Complexity**	**Maturity Level**	
* Low	** Medium	** Medium	



A UV Lamp is a non-chemical means of disinfecting water at household level, effective against all classes of pathogens and requiring only seconds of contact time. It uses short-wavelength UV irradiation in the range of 200–300 nm generated from mercury lamps or from UV light-emitting diodes (LEDs).

UV disinfection is a physical process that inactivates microorganisms by damaging their nucleic acids and proteins, which absorb light in the 200–300 nm range. Some bacteria can repair DNA damage, especially when exposed to wavelengths present in sunlight and when the radiation dose is insufficient. For household drinking water treatment with UV irradiation, low pressure mercury vapour lamps are typically applied, which emit a single peak of UV radiation at 254 nm. UV-emitting LEDs are rapidly gaining popularity and can be designed for different emission outputs, though are typically used at 255 to 285 nm.

Design Considerations: Water flows across the lamps from one end of the UV system to the other and is disinfected in a matter of seconds. The hydraulic retention time is a key factor in the design of the system to ensure that the UV radiation exposure time, along with the lamp output intensity, provides the proper UV dose to inactivate all classes of pathogenic microorganisms. However, water quality influences the UV transmittance and efficiency of UV disinfection. For example, high turbidity or suspended solids can reduce the disinfection efficiency due to shielding the pathogenic targets. Inorganic constituents such as iron or manganese can also foul the lamp and reduce light transmission. Ideally, turbidity should be < 5 NTU and transmittance > 70 % at 254 nm over the 1 cm pathlength. Pre-treatment may be necessary when water quality parameters do not meet the limiting values.
A typical UV system includes a single UV Lamp encased in a quartz glass tube and submerged in a closed system made of stainless steel, UV-reflecting Teflon or plastic. UV Lamps can be also placed above the water surface.

Small, battery-driven, point-of-use devices, so called UV 'pens' can treat water directly in a polyethylene terephthalate (PET) bottle. When UV LEDs are used, typically an array of LEDs is encased in a reflective chamber behind a quartz plate, and water flows through the chamber as it is irradiated.

Materials: Water treatment devices based on UV Lamps or UV LEDs are usually ready to use systems. They can be connected inline in piped water supply and are usually fully automated. UV pens are small, and usually include a protective cover which needs to be removed before use, as well as an indicator showing the lifespan of batteries and lamp. UV Lamps require a continuous power supply either from conventional electricity or solar or mechanical means. Ideally, the intensity status and expected remaining lifetime should be monitored by a UV sensor and a lamp status on/off indicator. The UV 'pens' require rechargeable batteries. UV-light systems are often not locally available in many countries.

Applicability: UV disinfection is possible only when reliable power is available at the household level, which will most probably not be the case in an acute emergency. Therefore, the systems are more suitable for the stabilisation and recovery phases. UV 'pens' can be useful in the acute response when there is a possibility to recharge the batteries once every 5–10 days. Household-scale systems or small-scale systems for large households and water kiosks can be used. Usually, the operation is simple and can be completely automated. Users need to be well trained on the maintenance of the systems, or maintenance support must be available from local service providers. UV irradiation does not eliminate physical or chemical pollutants.

Operation and Maintenance: For small household systems, daily operation includes switching the lamp on and off when water needs to be treated. Fully automated inline systems are switched on and off automatically when water flow is detected. If an intensity sensor is present, the operating lamp intensity can be tracked to when it falls below a set-point for validated performance (~70 % or less from initial design value). Regular maintenance of the system should include flushing the container (reactor) from any debris that may build up and wiping the UV tube or quartz sleeve with a soft cloth to avoid scratching. Usually, after 8,000 hours of operation, the UV mercury lamp will reach their end of life and should be replaced to assure proper disinfection. The lifespan of LED lamps varies depending on the specifications of the LEDs and manufacturer. For all types of lamps, the inner surface of the reactor should be inspected and cleaned at least yearly.

Health and Safety: Typical UV treatment provides at least 3-log inactivation of bacteria and protozoa, including Cryptosporidium and Giardia at low doses (1–10 mJ/cm^2). UV disinfection does not protect against microbial recontamination and regrowth after treatment, so treated water should be stored safely. Only validated UV systems providing the designed dose under typical flow rates and UV transmittance values should be used. Direct exposure to UV radiation must be avoided, as UV radiation can burn the skin and damage the eyes. If a mercury lamp breaks, toxic mercury may be released, potentially causing health risks and harming the environment.

Costs: Currently, the cost of a UV–light-based household system varies between 55–220 USD, though can be higher. With LED systems entering the market, the prices are expected to decrease considerably. However, UV systems are often not locally available, and shipment and import costs need to be considered. Due to a small logistical footprint, though, shipping costs are comparably low.

Social and Environmental Considerations: The systems are well accepted and are perceived as modern and convenient. The availability of power is a must for UV treatment, but electric power generated by fossil fuels contributes to CO_2 emissions. The release of mercury from broken UV Lamps harms the environment and is a health risks to humans. UV Lamps containing mercury should be disposed of properly as toxic waste, which might be impossible in some locations. Non-mercury lamps (e.g. LEDs) should be preferred when proper management of toxic waste is impossible.

Strengths and Weaknesses:

(+) Operates simply, with no required supply of chemicals
(+) Causes no change in taste and odour of the water, and no formation of disinfection by-products
(+) Disinfects microorganisms with high chlorine-resistance (such as Cryptosporidium oocysts)

(−) Requires reliable electricity supply
(−) Requires occasional spare parts (mercury lamp)
(−) Has no residual disinfection, so safe storage must be otherwise assured
(−) Requires pre-treatment for turbid water

→ **References and further reading material for this technology can be found on page 223**