Ultraviolet Light

U.S. ARMY CORPS OF ENGINEERS **Building Strong®**

ANS Control: Ultraviolet (UV) Light

Targeted Species: Ultraviolet light can be used to effectively control a variety of microorganisms. The ANS of Concern – CAWS[1] that may be controlled by UV include bloody red shrimp (*Hemimysis anomala),* diatoms (*Cyclotella cryptic*, *C. pseudostelligera, Stephanodiscus binderanus*), European amphipod (*Echinogammarus ischnus),* fish-hook water flea (*Cercopagis pengoi),* grass kelp (*Entermorpha flexuosa),* harpacticoid copepod (*Schizopera borutzkyi),*.parasitic copepod *(Neoergasilus japonicas),* red macro-algae (*Bangia atropupurea),* scud (*Apocorophium lacustre),* spiny waterflea (*Bythotrephes longimanus),* testate amoebas (*Psammonobiotus* spp.*),* and water flea (*Daphnia galeata galeata).*


Source: Suffolk County Department of Public Works (New York)

Ultraviolet light is used in some wastewater treatment plants for disinfection. The process breaks down microorganisms, making them unable to reproduce.

Selectivity: Ultraviolet light treatment is designed to control microorganisms and is not selective.

Developer/Manufacturer/Researcher: There are numerous manufacturers of UV technology. A partial list is available on the International Ultraviolet Association website (www.iuva.org).[2]

Brief Description: Ultraviolet water purifiers destroy harmful microbes, including yeast, bacteria, algae, molds, virus and oocysts near the UV light. A UV filter is an enclosed chamber containing a series of UV-emitting light bulbs. As water flows through the chamber, UV light deactivates the DNA of bacteria, viruses and other pathogens, which destroys their ability to multiply and cause disease. As UV light penetrates through the cell wall and cytoplasmic membrane, it causes a molecular rearrangement of the microorganism's DNA, which prevents it from reproducing. Specifically, UV light causes damage to the nucleic acid of microorganisms by forming covalent bonds between certain adjacent bases in the DNA. The formation of such bonds prevents the DNA from being "unzipped" for replication, and the organism is unable to reproduce.

Ultraviolet treatment involves the conversion of electrical energy in a low-pressure mercury vapor "hard glass" quartz lamp. Electrons flow through the ionized mercury vapor between the electrodes of the lamp, creating UV light that penetrates through water flowing past the light (Yanong 2009). Ultraviolet light is electromagnetic radiation with a wavelength shorter than that of visible light. The spectrum consists of electromagnetic waves with frequencies higher than those that humans identify as the color violet.

[1] For a complete list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.
[2] Manufacturers and products mentioned are examples only. Nothing contained herein constitutes an endorsement of a non-Federal entity, event, product, service, or enterprise by the U.S. Army Corps of Engineers or its employees.

UV light affects spore germination and chloroplast function in several algae species (Agrawal 2009; Poppe et al. 2003; Cordi et al. 2001). Each organism may require a different exposure rate (or dose) to UV light in order to be killed.

Prior Applications: Ultraviolet is commonly used at fish hatcheries and water treatment facilities to prevent contamination. For many years, the medical industry has used UV light to sanitize rooms and equipment. Ultraviolet light is used for disinfection of drinking water, wastewater treatment, and disinfection of foods and beverages.

General Effectiveness: At certain wavelengths, UV is mutagenic to algae, bacteria, viruses, and other small organisms and microorganisms. Ultraviolet light is categorized by light spectrum ranges: short wave UV-C; medium wave UV-B; and long wave (black light) UV-A [US Environmental Protectin Agency (USEPA) 2006]. UV has not been specifically applied to the ANS of Concern – CAWS, but may be effective on a variety of small organisms.

Operating Constraints: Ultraviolet light is used to treat contained, flowing waters, but is ineffective in treating large, open, turbid systems, such as marshes and lakes. UV light treatment is most effective after sediment, suspended solids, iron, and manganese have been filtered from water, prior to disinfection. Suspended solids or particulate matter can cause a shielding problem in which a microbe may pass through the UV filter without receiving any direct UV penetration. Iron and manganese will cause staining on the quartz sleeve that houses the UV bulb, at levels as low as 0.3 parts per million (ppm) of iron and 0.05 ppm of manganese (USEPA 2006). Working best with filtered water that is treated at a constant flow rate, use of UV light disinfection may be limited to small-scale applications.

Cost Considerations:

Implementation: Implementation costs would include the construction of a piping system and UV treatment facility. Construction of a facility and piping system may have considerable costs, including facility, access, electricity, and equipment costs. Planning and design activities in the implementation phase may include research and development of this Control, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

Operations and Maintenance: Operations and maintenance costs would involve operating and maintaining a filtering and treatment system, regular inspections and repair of mechanical parts, and an effectiveness monitoring program.

Mitigation: Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

Citations:

Agrawal, S.C. 2009. Factors affecting spore germination in algae – review. *Folia Microbiologica*, vol. 54, pp. 273-302

Cordi, B., M.E. Donkin, J. Peloquin, D.N. Price, & M.H. Depledge. 2001. The influence of UV-B radiation on the reproductive cells of the intertidal macroalga, Enteromorpha intestinalis. *Aquatic Toxicology*, vol.56, pp. 1-11

Poppe, F., R.A.M. Schmidt, D. Hanelt, & C. Wiencke. 2003. Effect of UV radiation on the ultrastructure of several red algae. *Phycological Research*, vol. 51, pp. 11-19

US Environmental Protectin Agency. 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, Office of Water (4601), EPA 815-R-06-007, 1200 Pennsylvania Ave NW, Washington, DC 20460. Accessed November 22, 2011 http://www.epa.gov/safewater/disinfection/lt2/compliance.html

Yanong, Roy, P.E. 2009. Fish Health Management Considerations in Recirculating Aquaculture Systems – Part 2: Pathogens. University of Florida/Institute of Food and Agricultural Sciences Circular 121, Gainesville, FL. Accessed November 22, 2011 http://edis.ifas.ufl.edu/FA100