EPA Science Forum 2003
Partnering to Protect Human Health and the Environment

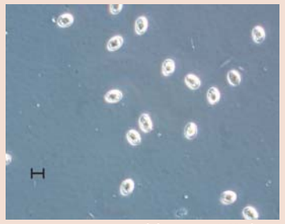
Inactivation of *Giardia muris* by Low Pressure Ultraviolet Light

MW Ware[1], FW Schaefer III[1], SL Hayes[2], and EW Rice[2]
[1]USEPA, Office of Research and Development, National Exposure Research Laboratory [2] USEPA, Office of Research and Development, National Risk Management Research Laboratory

Year of Water: Thirty Years of Progress Through Partnering

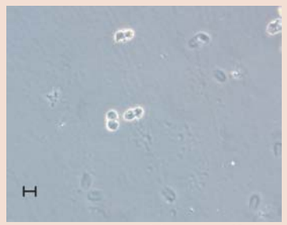
Giardia, a Waterborne Problem

Giardia is a parasite of humans and is a cause of waterborne diarrheal disease worldwide. In the U.S., the parasites *Giardia* and *Cryptosporidium* have been associated with approximately one third of the waterborne outbreaks illness that occurred between 1990 and 2000. To assure safe drinking water, there must be adequate disinfection practices for these microorganisms. Concern over the disinfection byproducts associated with chlorination has led to increasing interest in the application of ultraviolet (UV) light for drinking water disinfection. However, the UV dose required for inactivation of *G. lamblia* cysts is not known. Early studies suggested that cysts may be highly resistant to UV. But these studies were done using *in vitro* excystation to determine viability, and work with other parasites has suggested that *in vitro* excystation does not correlate with animal infectivity. The goal of the research effort presented here was to develop a complete UV inactivation curve for *Giardia* that accurately reflects the true disinfection of the microorganism.



scale bar represents 10 microns

Figure 1: Intact *Giardia muris* cysts

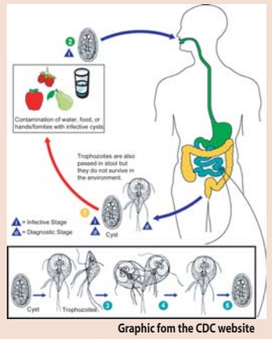


scale bar represents 10 microns

Figure 2: Excysted *Giardia muris* cysts: Empty cyst walls and trophozoites

Life Cycle

Giardia has a two stage life cycle composed of an environmentally stable cyst, and the trophozoite. When an infectious cyst is ingested, stomach acid triggers excystation - the release of two trophozoites. The trophozoites multiply in the small intestines and cause gastrointestinal symptoms. Some trophozoites form cysts that will subsequently shed in the feces thus completing the life cycle.



Graphic fom the CDC website

Figure 3: Life cycle of *Giardia*

A Two-fold Approach

The biocidal potential of various UV doses was assayed using both animal infectivity and *in vitro* excystation. *G. muris* was used in this study. Although not a pathogen of humans, *G. muris* has been used as a conservative surrogate for *G. lamblia* for evaluating other disinfectants. The *in vitro* excystation occurred after cysts were exposed to acid, heat, and bile salts. The percent of cysts that excysted was determined by microscopy. Excysted cysts were considered viable. Animal infectivity was determined by comparing the cyst dose at which half of a cohort of mice became infected. Mice groups were exposed to various doses of cysts and infection was determined by the detection of cysts in the feces.

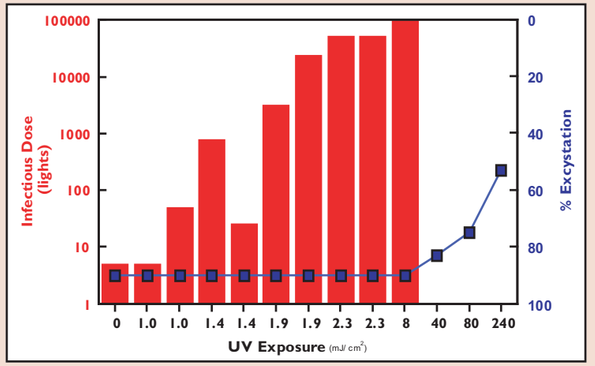


Figure 4: UV inactivation curves of *G. muris* cysts by animal infectivity (highly inactivated at 2.3 mJ/cm^2) and *in vitro* excystation (no effect until greater than 8.0 mJ/cm^2)

Impact of Research

This data represents the only complete inactivation curve for *G. muris*. This curve demonstrates that *G. muris* cysts exposed to low levels of UV light are not infectious to mice. *In vitro* excystation indicates that *G. muris* cysts are resistant to UV light, and thus *in vitro* excystation is not an acceptable surrogate for evaluating disinfection by UV light. This study demonstrates that low UV exposure could be an effective barrier in preventing transmission of infective *Giardia* cysts in drinking water.

Partnering to Protect Human Health and the Environment