ABSTRACT

Busse, Margaret M. M.S.E., Purdue University, May 2016. Characterization of a Continuous-Flow Reactor for Solar UV Water Disinfection. Major Professor: Ernest R. Blatchley III.

Lack of access to safe water is a common problem in many developing countries (UNICEF/WHO, 2011). Fortunately, solar ultraviolet (UV) radiation is abundantly available in many of these same areas, and it has been used to accomplish disinfection of drinking water by processes that involve no electrical power, such as solar water disinfection (SODIS). However, conventional SODIS systems are limited by batch processing and exclusion of UVB radiation, which is the most germicidally-active portion of the UV spectrum (Coohill and Sagripanti, 2008). To address these limitations, a continuous-flow solar UV disinfection system was developed to amplify ambient solar UV radiation, while including the UVB portion of the spectrum. With knowledge of the inactivation characteristics of target microbes and ambient spectral irradiance, community-scale, continuous-flow solar UV disinfection systems can be designed. This same information will inform the design of process control devices for these systems that will ensure adequate disinfection.

To address these needs, dose-response experiments were conducted in the UVB range to develop action spectra for two bacteria (*Salmonella typhimurium* LT2, *Vibrio harveyi*)

and a protozoan parasite, *Cryptosporidium parvum*. The bacteria were selected as surrogates for the organisms that cause typhoid fever and cholera, respectively. *C. parvum* was studied because it is known to cause cryptosporidiosis, which together with the two selected bacteria, account for a large fraction of waterborne disease outbreaks in developing countries (GEMS, 2013). UV dose-response experiments were carried out between 254 nm to 330 nm using three different collimated beam sources. The range of wavelengths used for these experiments was selected to allow overlap with previously published work for each of these microbes, while at the same time extending measured action spectra across the entire UVB spectrum.

Measurements of UVB spectral irradiance from the USDA UVB Monitoring Network were compared with simulations of UVB spectral irradiance using the Tropospheric Ultraviolet and Visible Radiation Model (TUV) for West Lafayette, Indiana. The TUV model was used to simulate incident, ambient solar spectral irradiance at locations corresponding to planned implementation of the CPC reactor, including Eldoret, Kenya and Port-Au-Prince, Haiti. Integration of measured action spectra with simulated spectral irradiance indicated that peak antimicrobial effectiveness occurs around 320 nm – 330 nm for all three target microbes. This suggests that process control should be based on real-time measurements of UV radiation in this wavelength range.

A raytracing program (Photopia, LTI Optics) was then used to simulate amplification of solar spectral irradiance within the CPC system using the results of TUV simulations as input. Output from the raytracing simulation illustrated the fluence rate distribution throughout the inner tube of the CPC, based on amplification of the input power within the reactor. Integration of these

results with computational fluid dynamics (CFD) will allow for future simulations of the inactivation responses of all three microbes in the CPC system at any given location.