Chemical & Environmental Engineering

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Nancy Love

Professor

Department of Civil and Environmental Engineering

University of Michigan

Toward Understanding Dynamic Microbiological Responses to Chemical Stress: Chemical Stressors and Antibiotic Resistance

Bacteria have an arsenal of responses that are rapidly activated in response to a range of stressful conditions. Whether remedial or protective, these molecular-scale responses can have a significant impact at other scales. Ecologically, responses can change the community composition and function. At the bioreactor scale, responses can manifest into performance anomalies that interfere with meeting effluent guidelines. Our work has focused on understanding how chemical perturbations result in the expression of stress responses that are the true causal mechanisms of deleterious microbiological effects seen in engineered or natural systems. This presentation will start with a discussion of how our lab has identified selected stress biomarkers that may serve as indicators and/or mediators of large-scale performance problems in biological treatment reactors. This historical overview will provide a background for the rest of the talk, which will focus on more recent studies that have linked chemical perturbations with multidrug efflux pump expression and an enhanced antibiotic resistance phenotype in *Pseudomonas aeruginosa*.

Pseudomonas aeruginosa is an opportunistic pathogen capable of causing acute and prolonged infections. It is ubiquitous in the environment, including in wastewater treatment systems and drinking water pipe biofilms. A suite of complex strategies enables it to colonize and proliferate in diverse environments. Its defense arsenal includes several intricately regulated broad spectrum efflux pumps such as MexAB-OprM. This efflux pump is constitutively expressed and protects *P. aeruginosa* from a variety of harmful antibiotics. We recently found that MexAB-OprM was hyperexpressed in *P. aeruginosa* in the presence of environmentally relevant concentrations of chlorinated phenols, particularly pentachlorophenol (PCP), and we plan to evaluate it in the presence of disinfection byproducts. In the presence of these chlorinated phenols, it establishes an antibiotic resistant phenotype. We have been pursuing the mechanism of this response by evaluating how efflux pump gene regulation systems respond to PCP and oxidative stressors. This work has relevance to pathogen disinfection in drinking water and water reuse systems. In the course of our investigation into the mechanism of PCP-mediated upregulation of MexAB-OprM, we observed 2-4 fold reductions in minimum inhibitory concentrations of various antibiotics when grown in the presence of antioxidants, including L-ascorbic acid (vitamin C). We are currently looking into the implications of this phenomenon and its potential therapeutic benefits, and will provide a brief overview of this work.

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