Chloraminated Drinking Water Distribution System Nitrification: Batch and Biofilm Inactivation Studies, Model Nitrifying Biofilm Investigations, and Evaluation of Operational Responses to Nitrification Episodes

Impact Statement

The purpose of this research is for the U.S. Environmental Protection Agency (EPA) to address knowledge gaps in our understanding of nitrification in drinking water distribution systems. Through increased understanding of nitrifying biofilm, new methods to prevent and control nitrification will be elucidated, which will support EPA's goal for clean and safe water to protect public health.

Background:

Nitrification in drinking water distribution systems is undesirable and may result in degradation of water quality and subsequent non-compliance with existing regulations. Thus, nitrification control is a major issue in practice and likely to become increasingly important as chloramine use increases. Unfortunately, our understanding of distribution system nitrification and its control is incomplete, which has made this a topic of considerable ongoing research. Many proposed strategies for nitrification control and nitrification modeling require knowledge of both the in-situ growth and inactivation kinetics of nitrifiers inhabiting the distribution system. Inactivation kinetics are only available for suspended nitrifier cultures, but it is well established that suspended cultures are less resistant to disinfectants than biofilm cultures present in distribution systems. The determination of both the inactivation and degradation kinetics of ammonia oxidizing bacteria (AOB) that are likely present in chloraminated drinking water represents a significant knowledge gap in our understanding of nitrification episodes.

Description:

Studies are currently underway to help fill knowledge gaps that exist in the general understanding of nitrification episodes. One of these gaps includes the need for growth and inactivation kinetic parameters for nitrifiers representative of those inhabiting distribution systems to be used in modeling nitrification processes. In order to fill this gap, new molecular genetics techniques are being used to study both the growth and inactivation kinetics of pure and mixed culture nitrifiers.

Another major gap in our understanding of nitrification events is the relative contribution from suspended culture nitrifiers compared with nitrifiers growing in biofilm. Nitrifying biofilm research is ongoing with new microelectrodes capable of probing the full depth of a model distribution system biofilm, determining the profile of the relevant water quality parameters and enabling calculations of the relative contribution of biofilm nitrification. For development and application of the microelectrodes, EPA's National Risk Management Research Laboratory researchers are collaborating with The University of Cincinnati to develop, validate, and utilize a total chlorine microelectrode to measure disinfectant profiles within a nitrifying biofilm. In addition to the microelectrode investigations, biofilm annular reactors enriched for AOB biofilm growth are being used to assess the temporal changes to nitrifying biofilm community structure after receiving periodic increases in chloramines. The results of these annular reactor experiments may help elucidate which AOB species are most resistant to chloramines. In the future, current operational responses to nitrification episodes will be evaluated with respect to their effect on the biofilm.

EPA GOAL: Goal #2 - Clean & Safe Water; Objective 2.1.1 - *Water Safe to Drink*
ORD MULTI YEAR PLAN: (DW) Long Term Goal - DW-2 *Control, Manage, and Mitigate Health Risks*

RESEARCH PARTNERS:
Collaborators: University of Cincinnati
Contractors: Pegasus Technical Services, Inc.

Expected Outcomes and Impacts:

Based on the results of this research, a better understanding of the interaction of monochloramine with nitrifiers in chloraminated distribution system biofilm is anticipated. This will allow better prevention and control of nitrification episodes, which will result in safer drinking water.

Outputs:

Current and expected outputs consist of published papers and a peer-reviewed journal article:

- David G. Wahman, Karen A. Wulfeck-Kleier, and Jonathan G. Pressman. *Monochloramine Disinfection Kinetics of Nitrosomonas europaea by Propidium Monoazide Quantitative PCR and Live/Dead BacLight Methods*. Applied and Environmental Microbiology, September 2009, p. 5555-5562, Vol. 75, No. 17 http://aem.asm.org/cgi/content/abstract/75/17/5555

- Characterization of a Chlorine Microelectrode for Measuring Monochloramine within a Drinking Water Distribution System Biofilm: (Submitted to Sensors and Actuators B)

Resources:

NRMRL Treatment Technology Evaluation Branch: http://www.epa.gov/ORD/NRMRL/wswrd/tteb.htm

David G. Wahman, Karen A. Wulfeck-Kleier, and Jonathan G. Pressman. *Monochloramine Disinfection Kinetics of Nitrosomonas europaea by Propidium Monoazide Quantitative PCR and Live/Dead BacLight Methods*. Applied and Environmental Microbiology, September 2009, p. 5555-5562, Vol. 75, No. 17 http://aem.asm.org/cgi/content/abstract/75/17/5555

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