Category III: Water Quality

Influence of Bacterial Pathogen Condition on Cell Transport in Groundwater Environments: Implications of Extracellular Polymeric Substances (EPS) Production and Composition

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EXECUTIVE SUMMARY

Due to California's continuing population growth driving demand for an increased municipal water supply and political pressures for decreased reliance on Colorado River water, there is a vital need to ensure groundwater protection and quality. In the Santa Ana Regional Water Quality Control Board, a region of only approximately 2,800 square miles and a population approaching 6 million people, reclaimed wastewater is increasingly utilized for ground-water recharge (1). Additionally, non-point source pathogen pollution is a mounting problem due to sources such as dense dairy farming and urban run-off. For water quality professionals such as those in the Santa Ana Region and beyond, the capacity to determine the transport and source of bacterial pathogens is essential to safeguard drinking water supplies. Therefore, the ability to predict the fate of human pathogens in the environment is critical, and a mechanistic understanding of bacterial transport in the subsurface environment is imperative for assessing the environmental impact of groundwater contamination from sources including urban runoff, septic tank/leach field systems, and animal manure from agricultural operations. Additionally, such information is vital for effective design of water quality technologies including riverbank filtration, wastewater reclamation, and recharge into aquifers.

Objectives and Approach: A systematic and extensive examination of the physiological and environmental factors controlling bacterial adhesion and transport in subsurface environments is proposed. This research will investigate the role that extracellular polymeric substances (EPS) exuded by a model fecal coliform (*E. coli*) play in driving the adhesive nature of the cells – expressly analyzing the composition of the EPS and adhesion trends in a flowing environment as a coupled phenomenon. The hypotheses of this work are (1) the protein and polysaccharide content of the EPS exposed on the surface of a bacterium influences the extent of bacterial adhesion; (2) the relative protein content of the EPS controls the extent of adhesion onto collector surfaces; and (3) the dynamic nature of EPS will alter the adhesion kinetics of *E. coli*. To test these hypotheses, experiments will be conducted to determine the kinetics of bacterial adhesion utilizing a packed-bed column and batch adhesion tests in typical groundwater solution chemistry conditions for the model bacteria (*E. coli*) grown under a series of controlled metabolic and environmental stresses. Additionally, we will examine the EPS protein and

polysaccharide content using molecular biological and biochemical methods, systematically testing for cells exposed to the predetermined stresses (nutrient presence and temperature). Correlations between composition and characteristics of the EPS and the results of the deposition experiments will be investigated in an effort to delineate the role of EPS in the changing adhesive nature of the bacterium.

Anticipated Results and Benefits: The major outcome of this investigation will be determining the role of physiological and environmental factors controlling bacterial adhesion and transport in subsurface environments. In particular, the study should resolve the contribution of EPS on the outer membrane of gram-negative bacteria to the mechanisms involved in adhesion to mineral surfaces. This knowledge will allow for a greater fundamental understanding of the transport of bacteria and eventually improved predictive capacity – either for pathogens or bacterial species utilized in bioremediation practices. Indeed, through the application of interdisciplinary tools, this work should yield a new understanding of factors which control pathogen fate which are useful to professionals and experts in the field of water quality control and management.