ASU SCHOOL of SUSTAINABILITY

ARIZONA STATE UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

Aura Ontiveros-Valencia

Will defend her prospectus

Ecological Interactions between Nitrate-, Perchlorate-, and Sulfate-reducing Bacteria in the Membrane Biofilm Reactor

Abstract

As a result of anthropogenic activities (e.g., agricultural run-off, improper disposal of industrial waste, and wastewater discharge), water pollution is a significant risk to the sustainability of our socio-ecological systems. Bioremediation processes (e.g., reduction of oxidized contaminants) rely on the intrinsic capacity of biological agents such as microorganisms to transform water pollutants into innocuous compounds. Among novel bioremediation-based technologies, the Membrane Biofilm Reactor (MBfR) has been successfully applied to treat a variety of oxidized water pollutants. In the MBfR, microorganisms grow as a biofilm community on the outer surface of gas-transfer membranes. Hydrogen gas (H_2) is delivered to the biofilm by its diffusion through the membrane wall, and the microorganisms oxidize the H_2 while reducing the oxidized contaminants in the water. My research focuses on the biological treatment of polluted water containing two oxidized contaminants by the MBfR -- nitrate (NO_3^-) (commonly applied in fertilizers) and perchlorate (ClO_4^-) (used in the production of rocket fuels and explosives) -- in the presence of a naturally occurring oxidized constituent, sulfate (SO_4^{2-}). The overarching research objective is to achieve a comprehensive understanding of ecological interactions among key microbial members in the MBfR when treating polluted water with NO_3^- and ClO_4^- in the presence of SO_4^{2-}. I first present results on the competitive and co-existence relationships between denitrifying bacteria (DB) and sulfate-reducing bacteria (SRB). Then, I assess the microbial community structure of biofilms mostly populated by DB and SRB and link this assessment to key reactor's operational parameters. When ClO_4- is introduced as a second oxidized contaminant, I first discover a detrimental effect from SRB on the performance of ClO_4^--reducing bacteria (PRB) when I target complete ClO_4^- destruction from a highly ClO_4^- −contaminated groundwater from an industrial site in Arizona. All of the work I

summarize so far is complete and published. In my future work, I will test a two-stage strategy to control SRB to achieve total ClO_4^- removal for the groundwater highly contaminated with ClO_4^-. Finally, I will evaluate the performance of a pilot-scale two-stage MBfR that treated polluted water with NO_3^- and ClO_4^-. In both cases, I will link the microbial community structure of the MBfRs with their performance. In summary, I propose that the microbial community structure in the MBfR can be used to explain successful or failed water biotreatment processes. Based on this understanding, I can develop means to manage the microbial community to achieve desired water-decontamination results. This proposal illustrates the benefits of looking "inside the box" of microbial communities and of translating the findings to "improving the box."

Monday, August, 26, 2013.
Time 10AM to noon
Biodesign Auditorium

Faculty, students, and the general public are invited.

Supervisory Committee:

Dr. Bruce E. Rittmann (Co-chair)
Dr. Rosa Krajmalnik-Brown (Co-chair)
Dr. Cesar I. Torres (Member)