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Stability of Function and Microbial Community Structure in a Denitrifying Fluidized Bed Reactor

Overview

Engineered microbial communities are used to solve a variety of environmental problems ranging from treatment of industrial and municipal wastewaters to the remediation of contaminated sites. This resesarch project seeks to understand of the relationship between function and microbial community dynamics, an essential component of improving the design, monitoring, and operation of biological treatment systems.

Experimental Objective

To examine the function and microbial community dynamics in a pilot-scale denitrifying fluidized bed reactor during periods of constant operating conditions and in response to disturbances typically experienced in the field

Experimental Approach

Figure 1: Denitrifying FBR

- **A pilot-scale denitrifying fluidized bed reactor** (FBR) fed nitrate, lactate, and ethanol was used as the model system in this study.
- **370 days of operation** included periods of constant operation interspersed with several disturbances including a shutodown period, two mechanical disturbances, and a step increase in concentration of nitrate in the feed (also called increase in loading rate).

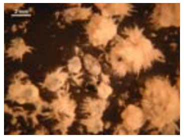

Figure 2: Biofilms grown on carrier particles.

- **Function** was measured by monitoring concentrations of nitrate and nitrite in the effluent

•**Microbial Community Structure and Dynamics** were examined by clone library construction and terminal restriction fragment length polymorphism (T-RFLP) of SSU rRNA.

Experimental Results

Functional Performance

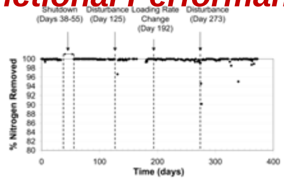

Figure 3 (left): Functional performance of the denitrifying fluidized bed reactor. Nitrogen removal is the ratio of the sum of nitrate and nitrite concentrations in the effluent to nitrate concentration in the influent, expressed as a percentage.

Microbial Community Dynamics

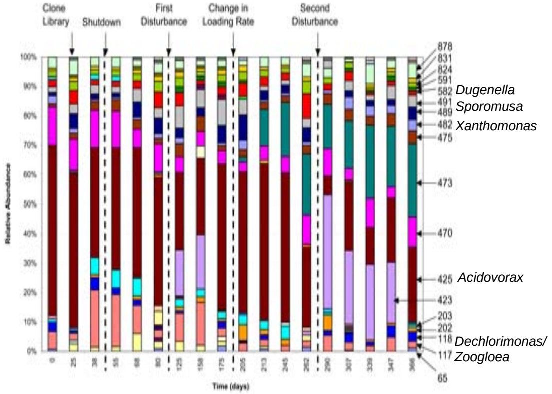

Figure 4: Histogram of operational taxonomic unit (OTU) relative abundances in T-RFLP profiles of biofilm samples collected from the FBR over time. Relative abundance is the ratio of the peak height of a given OTU in a given sample to the sum of all OTUs in that sample, expressed as a percentage. Arrows indicate the size in basepairs of the restriction framents for most OTUs.

•Function and community structure were relatively stable during periods of constant operating conditions.

•Community structure was not affected by the shutdown period.

•The most significant changes iqn community structure correlated with the change in loading rate and disturbances.

Response to Mechanical Disturbances

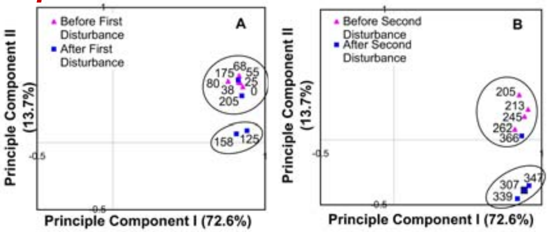

Figure 5: Principle components analysis of all T-RFLP profiles based on OTU relative abundance. Panel A- samples before, during and after the first disturbance. Panel B- samples before, during, and after the second disturbance. 72.6% and 13.7% of the total variability were accounted for by the first and second principle components, respectively.

•Duplicated response to mechanical disturbance was characterized by:

>Faster recovery of function than community structure

>Deviation from and return to original community structure, due largely to the transient appearance of a previously undetected OTU

Impact

•The characterization of community dynamics in this functionally stable system establishes of a baseline for monitoring and control.

•The repeated response to disturbance indicates a general response pattern, also useful for monitoring and control.

•The comparison of community dynamics between functionally stable and unstable systems will yield insights into designing systems with improved efficiency and stability

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