Real-Time and In Situ Monitoring of Aquatic Environments Using Indigenous Microbial Community-Based Biosensors

Timothy M. Vogel (vogel@univ-lyon1.fr) and Megan Altizer (Enoveo USA, Berkeley, CA, USA)
Jean-Michel Monier and Olivier Sibourg (Enoveo France, Lyon, France)

Background/Objectives. Water pollution prevention and control measures are critical for ensuring aquatic environment quality and sustainability, complying with environmental regulations and reducing costly remediation and water treatment. Conventional monitoring strategies are expensive and time-consuming, often requiring individual spot sampling and ex situ analyses. Further, these traditional strategies may not detect localized, transient contamination events or describe dynamic changes in loading. Microbial biosensors populated by indigenous microbial communities are a novel, cost-effective alternative offering real-time event detection and monitoring. ENOVEO has developed such a microbial community based biosensor, NODE, and demonstrated its effectiveness in several water pollution scenarios including monitoring of bioremediation efficacy, detection of toxic compounds in industrial wastewater and measurement of organic compounds in groundwater. These field tests show indigenous microbial community-based biosensors are autonomous, sensitive and robust, offering new perspectives for on-line monitoring and acting as important decision support tools.

Approach/Activities. ENOVEO completed a field test of the NODE biosensor at a site contaminated with tetrachloroethylene and trichloroethylene where the remediation strategy focused on biostimulation via soybean oil injections. The biosensor was first inoculated in the laboratory with water from the site to capture the indigenous microbial community. After its functionalization and correlating changes in signal behavior to the pollutant of interests and calibrated against a known standard, the performance of the biosensor was validated in the laboratory. Subsequently, it was deployed at the site. Three units equipped with data loggers, geochemical probes and the biosensor itself were placed in line with the flow of the aquifer downgradient of the injection well to provide real-time, online monitoring.

Results/Lessons Learned. Functionalization of the biosensor showed increased electrochemical signal, 25-50 mV, associated with the biostimulant injection. The arrangement of the sensors was used to quantify the biostimulant transport in the aquifer at approximately 3 meters per day. A decrease in signal upon consumption of the biostimulant substrate showed total treatment time lasted 25-30 days. With just three biosensors, decision makers could answer the questions “how far?”, “how fast?” “where?” and “how long?”. The cost-effective decision support tool informed key personnel about the duration and extent of the biostimulation effort in real time. Future efforts will focus on correlating electrochemical signal with biodegradation activity by coupling biosensor data with traditional microbiological and chemical measurements.