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Microbial and Source Zone Reduction Sensors for Managing Contaminated Sites

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Background/Objectives. A microbial sensor was developed for the characterization of contaminated sites in terms of microbial activity and source zone reduction. The primary objective is to support ongoing development of natural source zone depletion (NSZD) strategies by examining the dynamics of carbon dioxide and methane evolution and the relation to mass loss. Other collateral measurements such as redox potential, with certain unique sensitivities, are integrated into that same system. Then, some derivative applications include the use of the sensors as sentinels for plume expansion management and the evaluation of bioavailability in sediments in concert with monitored natural recovery (MNR) activities.

Approach/Activities. The sensor is functionally related to microbial fuel cell technologies, but with some critical differences. The design of the sensor allows for deployment in many types of natural environments including soils, sediments, aquifers and natural waters. The sensor and associated electronic board allows for three data collection modalities, each having a distinct and, in some cases, complementary applications. They are as follows.

- Microbial Amperometric Sensor (MAS)
- Microbial Potentiometric Sensor (MPS)
- Microbial Kinetic Sensor (MKS)

The sensor, and the accompanying electronics, is actually a single unit capable of making all three distinct types of measurements as noted, individually or collectively.

Results/Lessons Learned. All of these analytical results have been obtained with extremely high reproducibility and that data will be presented. In MAS mode, the sensor measures electrical current as the metric to determine substrate concentration and/or the turn-over rate in the subsurface. While this is somewhat conventional, when combined with the MPS measurement which employs open circuit voltage (OCS), a heretofore unrecognized process, it is possible to also obtain redox measurements. Finally, the MKS mode, one can measure substrate/turnover rates less than 10^{-6}M. All of the sensor processes are designed to be linked up via telemetry and to the Cloud such that numerous data management and reporting functions can be part of the process.

Since the sensor is sensitive to microbial activity it can detect an uptick in electron flow as a function of a change in substrate availability. This would manifest when, for example, a dissolved phase hydrocarbon plume impacts the sensor supporting its use as a sentinel. Conversely, a lack of electron flow in the subsurface, which can be easily monitored, could indicate a lack of bioavailability. This then relates to the MNR application whereby, in effect, if a contaminant is unavailable a case can be made for limited if any impact on human health and the environment.