

M/ProbE™: Recent Test Results for a (Bio)Electrochemical Sensor System for Continuous Redox Surrogate Monitoring

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Background/Objectives. Activity of electrons (Eh) is an important descriptor of reduction-oxidation (redox) potential. Eh information is useful for understanding thermodynamic potential of a solution relative to the theoretical standard hydrogen electrode. Practical measurement involves ORP instrumentation where a more readily usable reference is used (e.g., silver/silver chloride). ORP meters are used in laboratories and field settings to characterize and monitoring redox state associated with a wide range of processes including natural environmental and industrial processes including environmental remediation for designing, monitoring and optimizing treatment processes. Numerous factors influence Eh and ORP meter operation and measurement results can be difficult to interpret. For example, multiple redox couples are often active within a non-equilibrium setting. At minimum, ORP meters must be frequently calibrated and generally are not compatible with continuous monitoring even in highly accessible setting, not to mention remote setting. Burge Environmental has developed its patent pending M/ProbE™ system as a (bio)electrochemical sensor system for low cost continuous and remote monitoring of general redox conditions over long periods. One motivation for recent testing is to further establish baseline operational conditions for a range of redox environments, including specific abiotic and biotic conditions.

Approach/Activities. The M/ProbE™ is an electrochemical sensor first and foremost and when placed within a biologically active environment becomes a bioelectrochemical sensor. The system includes at least one stable anode and atmospheric oxygen referenced cathode pair embedded in electrolyte (groundwater, wastewater, surface water, saturated and unsaturated sediment) that allows for electron accumulation and ion migration depending on circuit condition. A scalable printed circuit board with on-board intelligence augmented by software control is used to monitor voltage under normally open condition and intentional closed condition. Thermistor and other instruments can be readily integrated. Voltage readings are stored locally and can be wirelessly transmitted further data processing and reporting. Open circuit voltage is of most interest but shunting allows for remote check on sensor operation and in some cases insight into kinetics of bio-accumulation of electrons potentially related to metabolism of electron donor such as acetate often present in environment. InfraSUR has collaborated with Burge over two years on field and laboratory testing under a range of test conditions including large and small microcosms and flowing columns.

Results/Lessons Learned. To date, M/ProbE has generated continuously measured potentials similar in magnitude (but of opposite sign) to periodic calibrated ORP meter readings. Oxidation to reduction (and vice versa) trends are similar and match expectations. In microcosm and column environments simulating the groundwater treatment technology BiRD (where sulfate reduction occurs) maximum M/ProbE readings are on order of +500 mv with full recovery documented after circuit close and open cycles. Corresponding maximum ORP readings are approximately -400 mv. Calculation of charge in coulombs allows for assessment of kinetics with respect to expected biogeochemical reactions. Results indicate M/ProbE has strong potential for use in continuous monitoring of general redox state for characterization and process control within aqueous, slurry, and porous media environments.