In situ sensor-based monitoring strategies for biogeochemical reactions in mine tailings environments

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Abstract

Natural resource extraction and ore processing have significant environmental impacts, such as the generation of wastewater, waste rock and tailings. These waste products are often detrimental to ecosystems, and negatively impact surface and groundwater bodies, often necessitating remediation treatments and long-term management of sites by operators, or, where operators have abandoned a contaminated site, by regulators and government agencies. Such cleanup and monitoring efforts regularly continue for decades after a site is closed.

Monitoring efforts usually serve two purposes: characterizing the long-term changes at a site once extraction and processing activities have ceased and evaluating the effectiveness of applied remediation treatments. Monitoring activities are usually mandated in the site's operating license and usually include frequent field sampling of surface water, groundwater, and soil or sediment, as well as ecological studies describing floral and faunal abundances. These samples are then analyzed to quantify the mobility and phase of contaminants (i.e., toxic heavy metals, hydrocarbons), fundamental water quality parameters (i.e., pH, TDS, alkalinity), and the makeup and function of the microbial community (i.e., culturing, microcosms, 'omics). The need for skilled workers and constant on-site personnel presence means that environmental monitoring is a high- cost activity for site operators and is a significant financial burden for government and regulatory agencies tasked with managing abandoned legacy mine sites.

Over the last decade, rapid developments in platforms for deploying remote scientific instrumentation, lower-cost environmental sensors, and data transmission from remote locations have brought about a renewal of interest in sensor-based environmental monitoring strategies. These approaches offer several advantages, such as lower cost, near real-time data access, and lower exposure risk to toxic and hazardous materials.

Here, we will present data collected from a suite of electrochemical sensors deployed in situ at a closed, managed mine site to monitor the effectiveness of remediation treatments in real-time. These results provide proof-of-concept for the effectiveness of sensor-based monitoring technology as part of safe, effective long-term remediation and management strategies.

Keywords

Acid mine drainage, Mine waste remediation, Sensor-based environmental monitoring.

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Conflicts of interest

The authors have declared that no competing interests exist.