Improving Remediation Strategies for Legacy Mines: Case Study of Mt. Morgan Gold and Copper Mine, Queensland, Australia

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Due to their geological traits, various mine sites worldwide are affected by Acidic Metalliferous Drainage (AMD). AMD is generated when sulfide minerals are exposed to water, air, and iron- and sulfur-oxidizing bacteria. Once initiated, it is challenging to stop AMD generation since it is a spontaneous reaction that continues if all four components are present in an environment. Characteristically, AMD is low in pH and contains elevated concentrations of dissolved metals. These conditions pose serious concerns given their potential detrimental effects on surrounding ecosystem, wildlife, and human health. The concerns are more acute at legacy mines, where financial and human resources for remediation are drastically more limited than at active mine sites.

This study presents an integrated assessment on AMD impacts across multiple environmental systems at the historic Mt. Morgan gold and copper mine in Central Queensland, Australia. Although mining activity that started in 1882 ceased in early 1990s, AMD issues from the site persist until today.

A combination of chemical and mineralogical analyses, and 16S rRNA gene sequencing on field samples revealed potential pathways for metals transportation, transformation, and persistence across water, soil, and plant systems. Chemical assays of water, soil, and plant samples indicated low pH conditions (2.5-3.9) and elevated metal concentrations i.e. arsenic, lead, and copper. Investigation of mineralized biofilms using SEM-EDS showed biologically induced formation of jarosite and gypsum. Further synchrotron-based XFM analysis highlighted the presence of Fe-Mn-oxide associated with the base metals, with Fe concentration reaching up to ~ 20% by mass. The gene sequencing data showed dominant presence of acid-tolerant iron-oxidizing and sulfate-reducing bacteria and algae. Overall, geochemical, mineralogical, and microbial insights from the Mt. Morgan site highlighted the potential for harnessing native microbial communities in developing targeted and sustainable AMD remediation strategies.