Expanding possibilities for the co treatment of mine drainage with municipal wastewater

William Strosnider[1], Benjamin Roman[2], Charles Spellman Jr. [3], Joseph Goodwill[4], Travis Tasker[5]

[1]Baruch Marine Field Laboratory – University of South Carolina, Georgetown, USA, bill@baruch.sc.edu ORCID 0000-0002-0839-4468

[2]Office of Surface Mining, Reclamation and Enforcement, Pittsburgh, USA, broman@osmre.gov ORCID 000-0003-3974-6961

[3]Narragansett Bay Commission, Providence, USA, cspellman@narrabay.com, ORCID 0000-0002-6242-3258

[4]University of Rhode Island, Providence, USA, goodwill@uri.edu, ORCID 0000-0002-7544-2925

[5]Saint Francis University, Loretto, USA, ttasker@francis.edu , ORCID 0000-0001-5040-7579

Extended Abstract

An increasing number of studies have noted a suite of fortuitous interactions between mine drainage and municipal wastewater in both controlled (engineered co-treatment) and uncontrolled (in-situ ambient environmental) settings. Benchtop studies with various configurations have noted high efficiencies in metals (>90%), phosphorus (>90%), and fecal indicator bacteria (>99%) removal. This approach could result in substantial fiscal savings, the repurposing of existing underutilized infrastructure, and the provisioning of treatment where it was once unaffordable (Spellman et al. 2022).

The co-treatment of mine drainage and municipal wastewater in its various forms may take advantage of the coagulating properties of Al and Fe, disinfection prompted by elevated metals and acidity, and availability of ferric or sulfate electron acceptors in mine drainage. Co-treatment also may leverage the availability of labile electron donors and substantial alkalinity of municipal wastewater. In addition, each water is generally relatively low in the concentration of pollutants that are high in the other, allowing for positive dilutive effects. Thus far, two co-treatment approaches have been primarily pursued, 1) in "passive" systems that center around elements such as treatment wetlands, settling ponds, and bioreactors (e.g., Strosnider et al. 2011; Younger and Henderson, 2014) and 2) in "active" systems emulative of conventional municipal wastewater treatment unit processes such as activated sludge and clarification basins (e.g., Hughes and Gray, 2013; Spellman et al. 2020).

As interest in co-treatment has grown over the last two decades, studies have demonstrated the efficient treatment of most constituents of concern in both waste streams (e.g., decreases in Al, As, Cd, Fe, Pb concentrations; production of net-alkaline circumneutral effluent; thorough removal of biochemical oxygen demand and phosphate; rapid reduction in fecal indicator bacteria). Approaches emulating conventional mine drainage passive treatment (i.e., setting ponds, anaerobic bioreactors, oxidation ponds/wetlands) as well as conventional municipal wastewater treatment (i.e., activated sludge plant aeration and settling) have firmly validated the mechanisms and performance potential of co-treatment. In addition, field studies documenting the in-stream uncontrolled mixing of mine drainage and municipal wastewater have reinforced our understanding of the mechanisms of water quality improvement in controlled settings.

While one full-scale passive co-treatment system exists (Lamesley, UK; Younger and Henderson, 2014) and has performed well for many years (i.e., removing >60%

of Fe and >30% of biochemical oxygen demand), it is the sole full-scale co-treatment system of any type in the world. At this juncture, most questions regarding key mechanisms and general removal rates have been answered. However, key questions remain regarding the nature of the solids produced (i.e., composition, structure, stability in various settings, and potential disposal avenues). The most pressing need is for field pilot studies to explore potential scaling issues and elucidate operational concerns (e.g., solids handling methods, system maintenance needs, mixing ratios and techniques, rainfall dilution and temperature effects) and most importantly, demonstrate to regulators, engineers, and other critical stakeholders the true co-treatment potential of these commonly coincident waste streams.

Keywords: Sewage, co-attenuation, sludge, circular economy

Acknowledgements

The authors thank all co-organisers for hosting the WFTF & IMWA 2024 Conference.

References

Hughes TA, Gray NF (2013) Co-treatment of acid mine drainage with municipal wastewater: performance evaluation. Environ. Sci. Pollut. Res. 20:7863-7877, doi:10.1007/s00356-012-1303-4

Spellman Jr. CD, Tasker TL, Strosnider WHJ, Goodwill JE (2020) Abatement of circumneutral mine drainage by Co-treatment with secondary municipal wastewater. J. Env. Manage. 271:110982, doi:10.1016/j.jenvman.2020.110982

Spellman Jr. CD, Smyntek PM, Cravotta III CA, Tasker TL, Strosnider WHJ (2022) Pollutant co-attenuation via in-stream interactions between mine drainage and municipal wastewater. Water Res. 214:118173, doi:10.1016/j.watres.2022.118173

Strosnider WHJ, Winfrey BK, Nairn RW (2011) Novel passive co-treatment of acid mine drainage and municipal wastewater. J. Environ. Qual.40:206-213, doi:10.2134/jeq2010.0176

Younger PL, Henderson R (2014) Synergistic wetland treatment of sewage and mine water: Pollutant removal performance of the first full-scale system. Water Res. 55:74-82. doi:10.1016/j.watres.2014.02.024