

Abstract

The project consisted of the application of phycoremediation to remove metal species from mine effluents under acidic conditions of 2.0-2.6 pH. The team cultivated *Chlorella vulgaris* algae to accomplish this removal. The experiment was required to remove 90% of the metal ions in a synthetic mine water solution. The full-scale process operates at a maximum of 10 gallons per minute of mine wastewater.

Metal Species	Aluminum	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Nickel	Zinc
Concentration (ppm)	25.3	0.819	0.869	3.88	341	1.18	189	0.065	189

Background

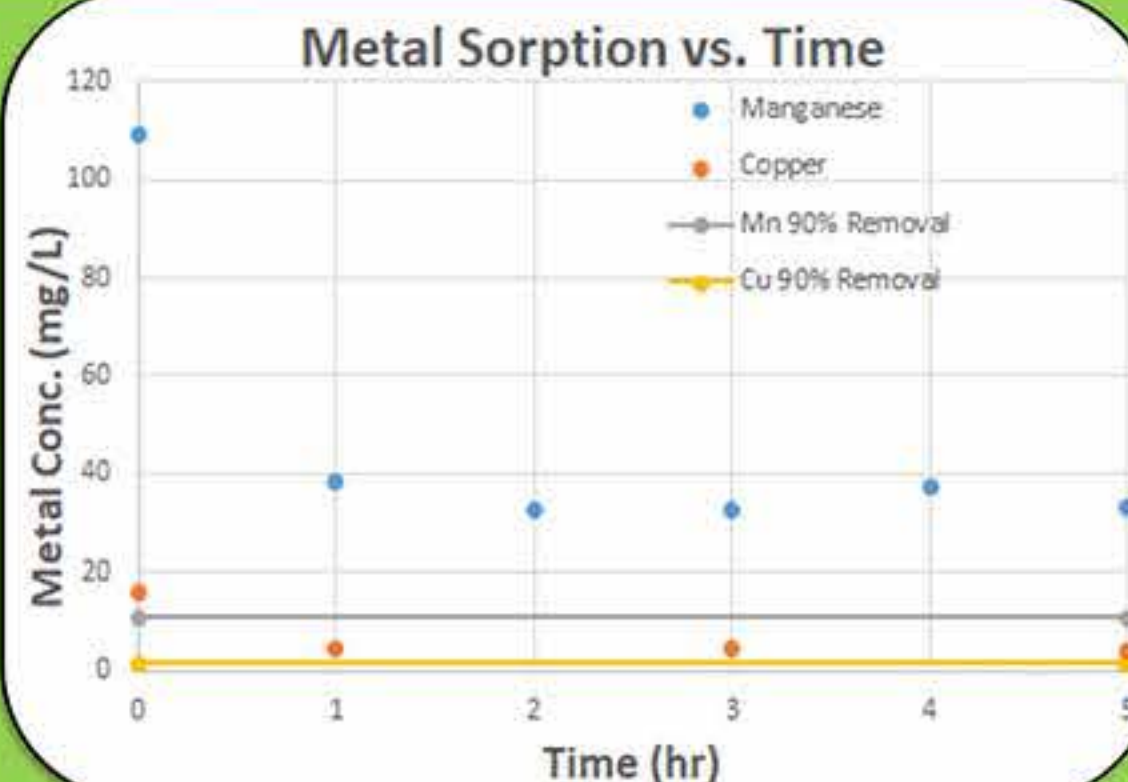
Phycoremediation is the application of a process relying on organisms, such as plants and microbes, to perform the remediation actions on impacted water and soils. Algae naturally separates metal ions in solution by binding unwanted metal species to the cell wall disallowing toxic buildup of heavy metal within the cell. Heavy metals from mining processes and metal leaching present an opportunity for phycoremediation. There are over 296 active metal mines across the United States which offer great opportunity for the application of this process.

Bench Scale



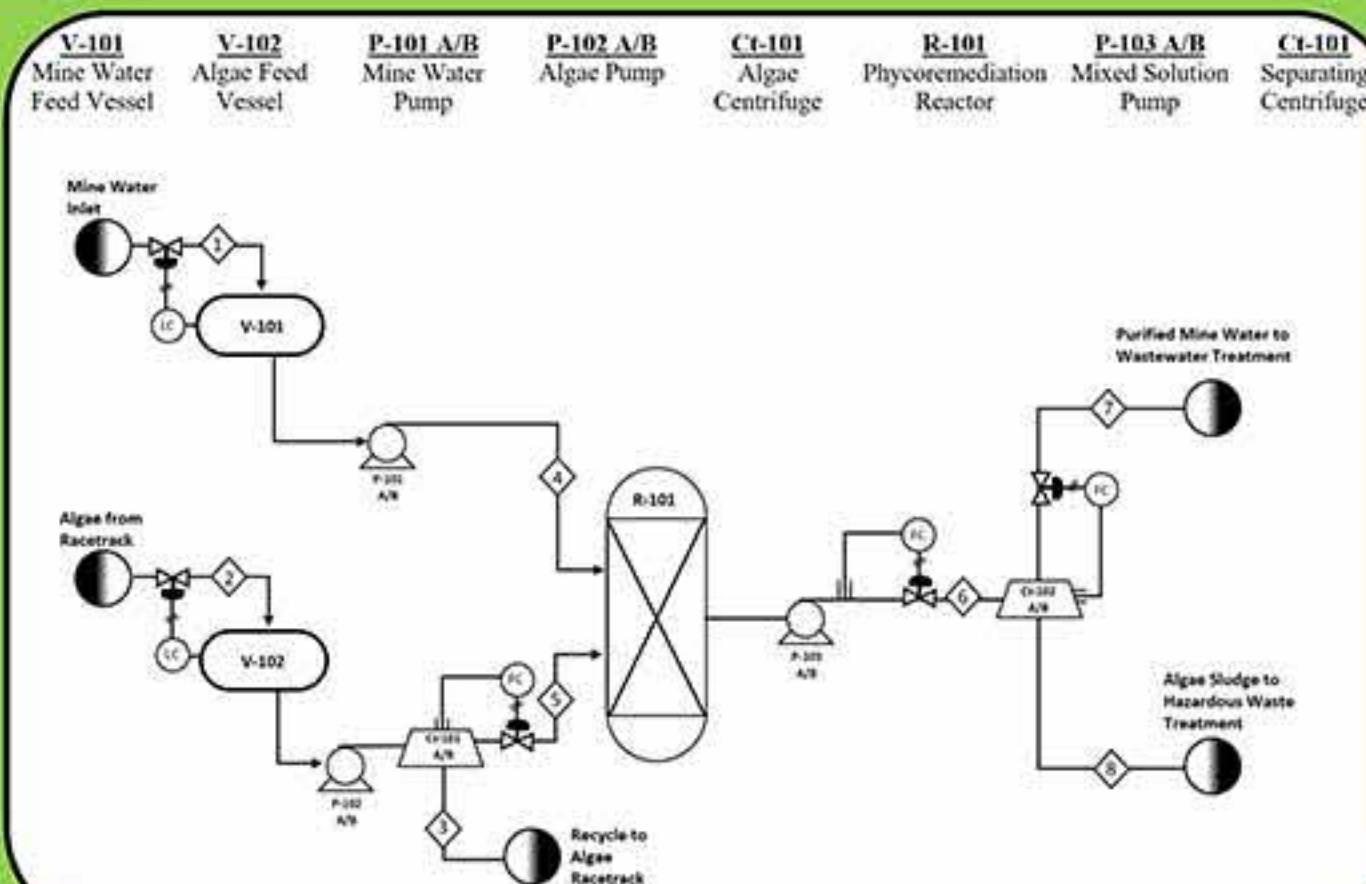
The bench scale design was done as a batch system, where 100 mL of algae was used and the concentration of the metal is mixed in as a metal salt. Samples were taken every hour to observe the changes in metal concentration.

Results



Manganese and copper salts were tested in algae solution and the concentrations were measured over time using HACH test kits. From the collected data a removal capacity of 138 mg of metal/g of algae for manganese and 21.5 mg of metal/g of algae for copper was determined. From the experiment shown the total algae requirement for removal was found to be 0.24 lb/min.

Full Scale Design



Acknowledgements

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Annual Production

Production		
Product	Wastewater (ton/year)	Hazardous Waste (ton/year)
Metal Ions	0.53	4.78
Chlorella Vulgaris	-	61.73
Water	2188.78	44.67

These values were used to estimate the cost of waste treatment.

Cost of Waste Treatment

Without Removal Process	With Removal Process
\$ 4,062,000	\$202,572

Economic Analysis

Capital Investment		Annual Cash Flow	
Fixed Capital Investment	\$811,491	Savings	\$3,859,473
Working Capital	\$196,000	Annual Operating Costs	\$1,358,247
Total Capital Investment	\$1,007,491	Pay Back Period	1.3 years

Conclusion

- The proposed process can meet the desired industrial requirements.
- Due to the COVID-19 pandemic, testing was unable to be performed using the synthetic mine water solution.
- Future tests should be conducted with the unused metal species to ensure similar sorption characteristics.
- The economic analysis shows strong evidence that the process is feasible and marketable to the client.
- We strongly recommend implementing this system as it will save the client millions of dollars annually.
- This process represents an environmentally friendly solution for mine wastewater treatment while significantly reducing their hazardous waste treatment costs.