Acid Mine Drainage Passive Bioremediation

Bench Test Proof of Concept: Abandoned Mine, Idaho

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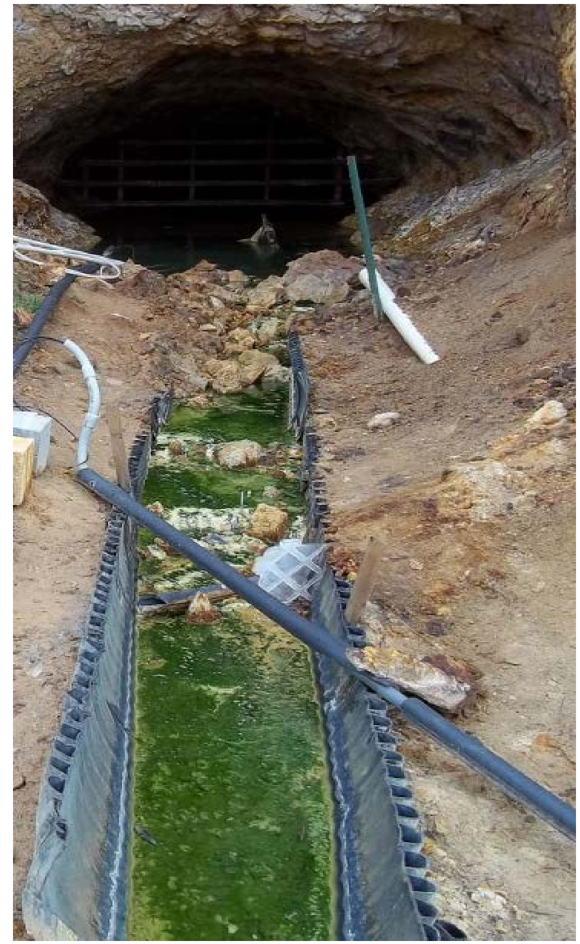
Introduction

- Abandoned mine site in Idaho discharging acid/metals to a local creek
- Investigate biological phenomenon with potential to bioremediate site at a fraction of expected cost
- Perform bench scale test to understand conditions necessary to engineer full-scale bioremediation

Site Location

Site Details



Environmental Conditions

Statistics	Flow (gpm)	pH (s.u.)	Al (mg/L)	Cu (mg/L)	Fe (mg/L)	Zn (mg/L)
Maximum	7.1	3.37	946	590	2460	134
Average	3.6	3.15	529	194	1321	83
Minimum	1.12	2.8	312	69	427	33
No. of Observations	32	25	39	44	44	44

Avoid costly active treatment via neutralization by "engineering" an apparent natural biological process

Iron and Aluminum Terrace (IAT)

Dynamic Trough Testing

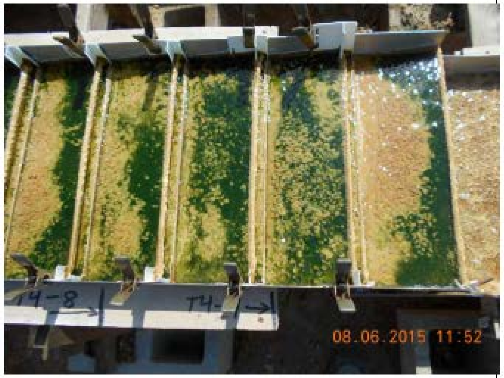
Trough 1: High organics
Trough 2: Non-organic biomat
Trough 3: Anoxic
Trough 4: Oxygenated

- Valuable field performance simulation
- Observe physical limitations
- Limited environmental variations

Trough 1

Trough 2

Trough 3



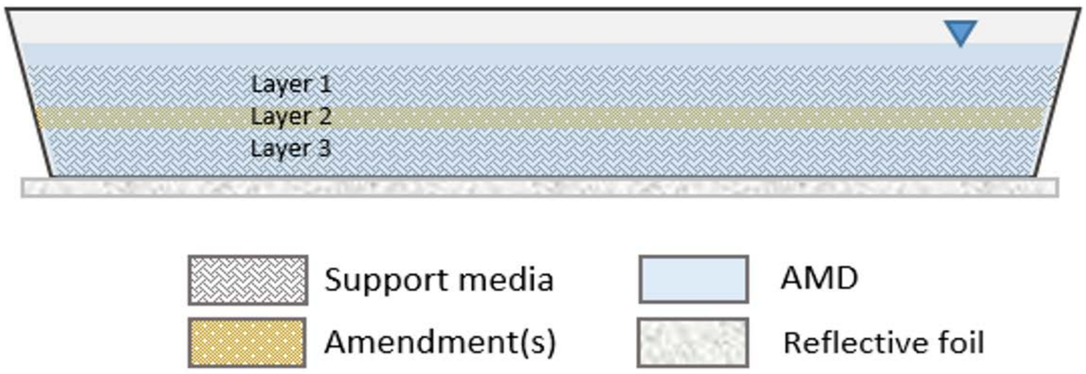
Trough 4

Static Bench Test Objectives

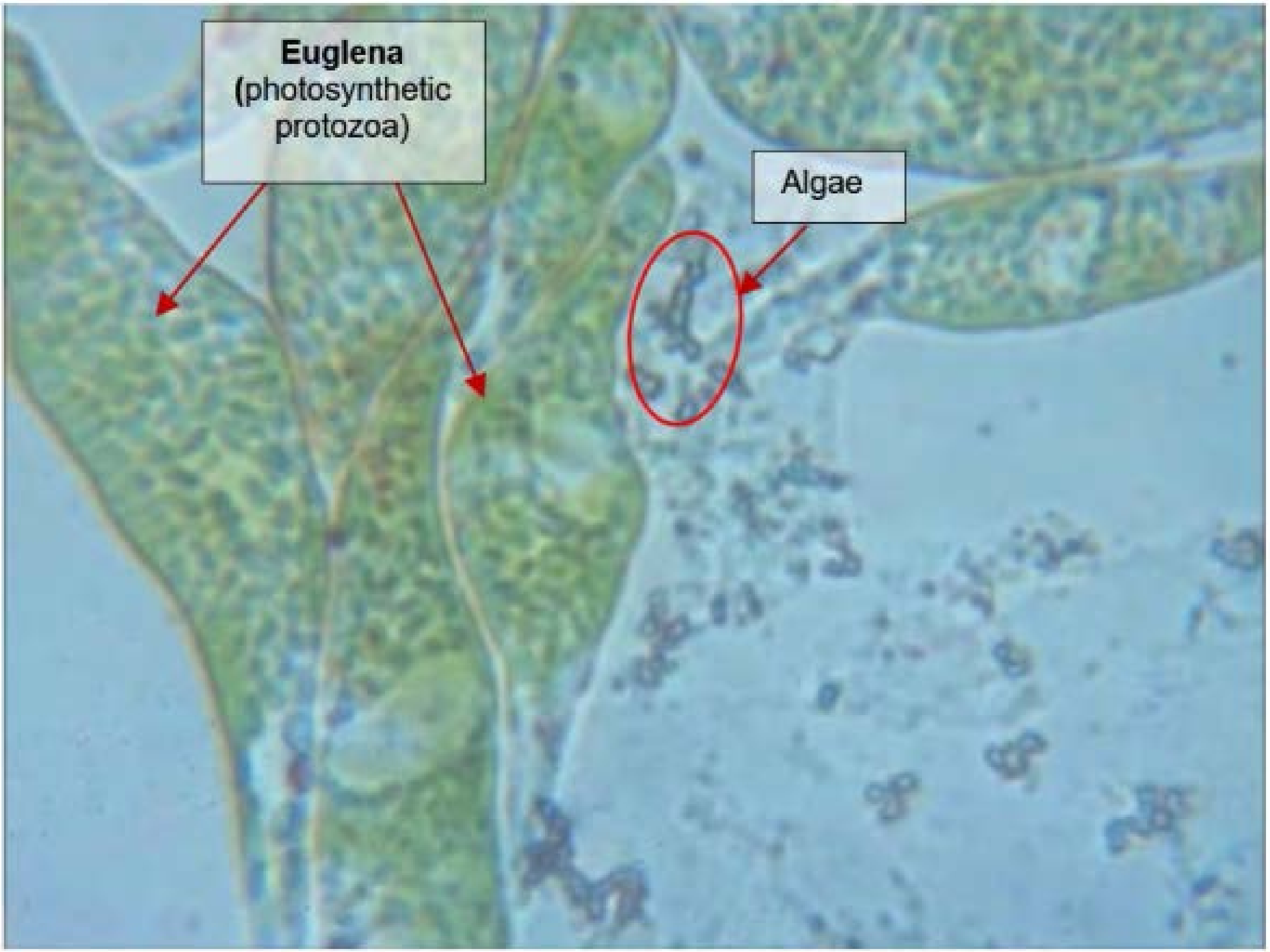
1) The effect of metals removal and Δrate versus retention time;
2) The effect of readily available soluble carbon on algae growth and metals removal rate;
3) The impact of daylight exposure on metals removal rate;
4) The impact of temperature on metals removal rate.

Bench Test Setup

Microcosm Unit	Amendment	Temperature	Sunlight	Support Media	Sampling Events
Tray 1	Organics	Optimum	Yes	Yes	1, 3, 7, 20 days
Tray 2	Glucose/ Organics	Optimum	Yes	Yes	1, 3, 7, 20 days
Tray 3	Organics	Optimum	No	Yes	1, 3, 7, 20 days
Tray 4	Organics	Chilled	No	Yes	1, 3, 7, 20 days



Site Microbiology @ 1000x



Conditions vs. Removal Rate

$$C_f = C_0 e^{-kt}$$

$$k = \frac{-ln\left(\frac{c_{f\,tray}}{c_{0\,tray}}\right)}{t}$$

Where,

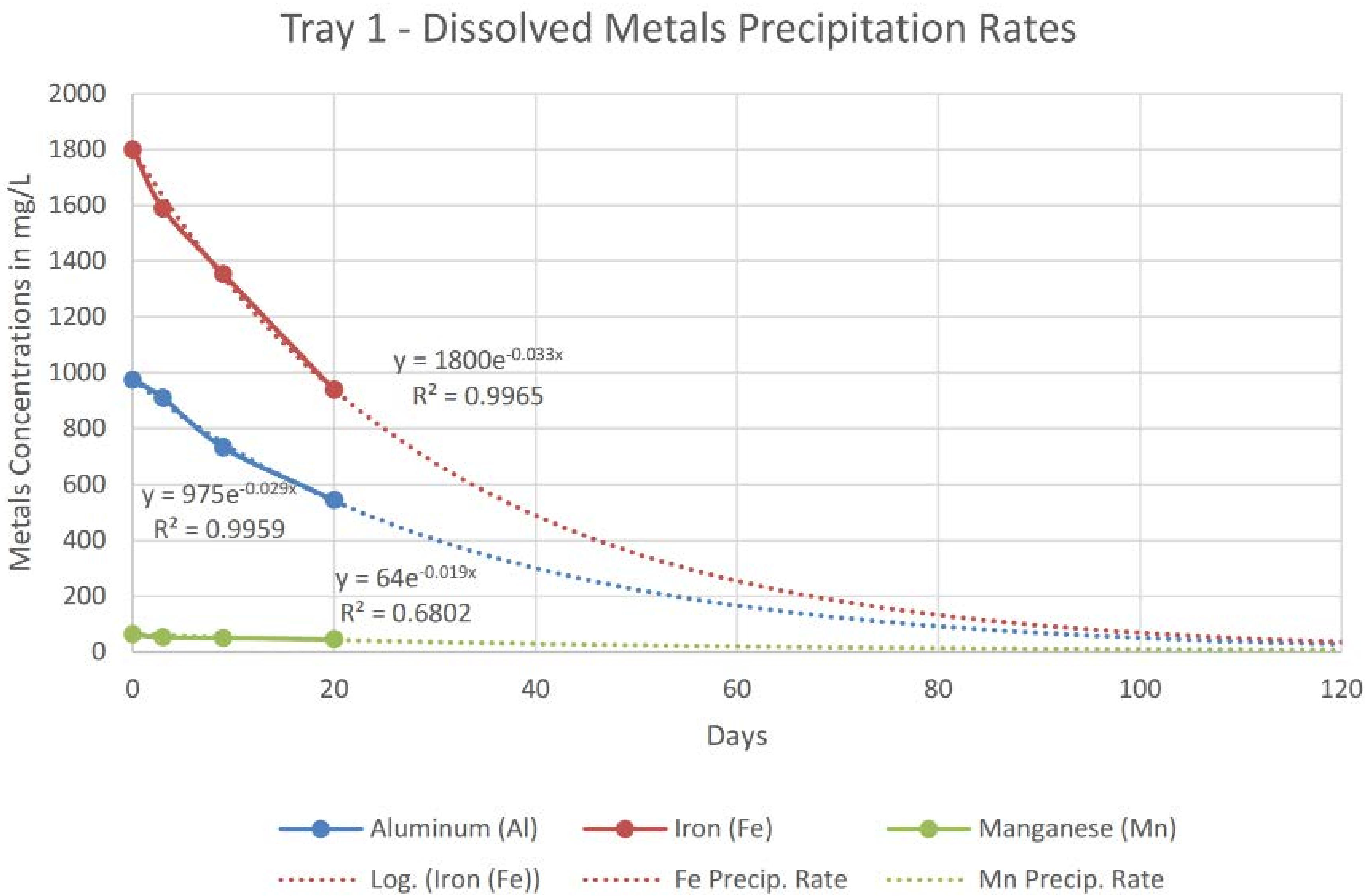
t = time in the tray

C_0 = starting concentration

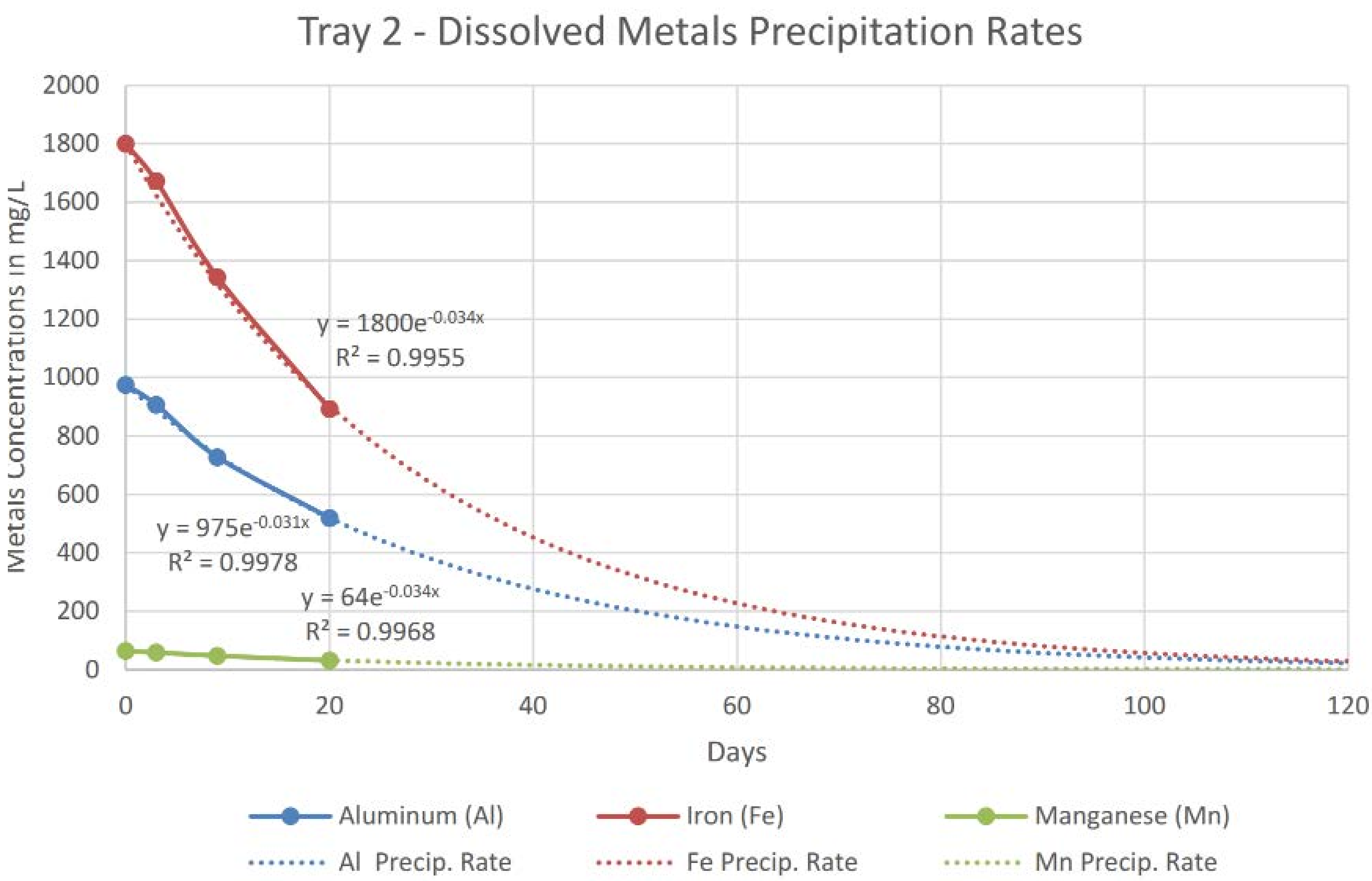
C_f = concentration at time t

k = precipitation (removal) rate constant

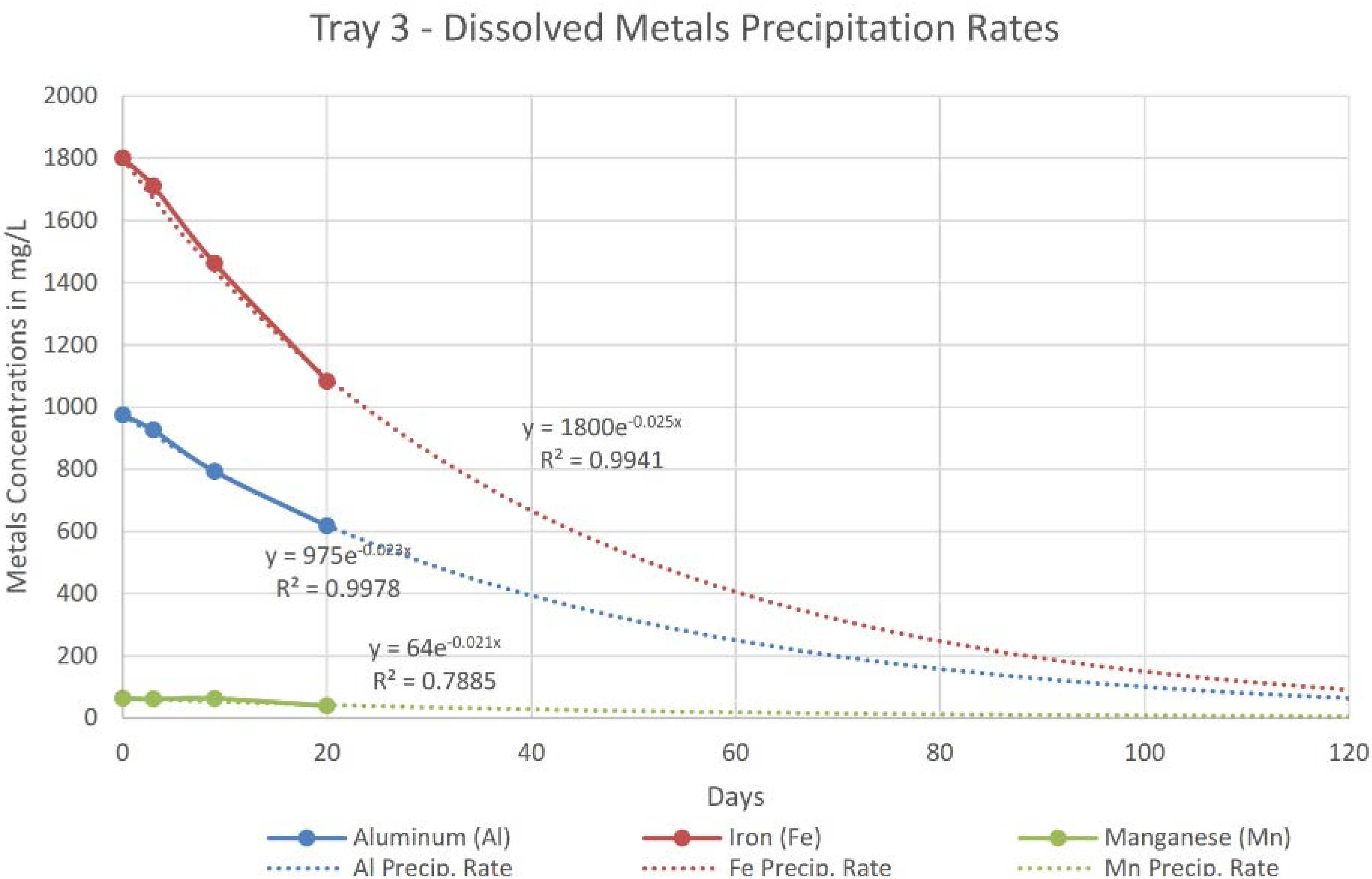
Organics/Sunlight



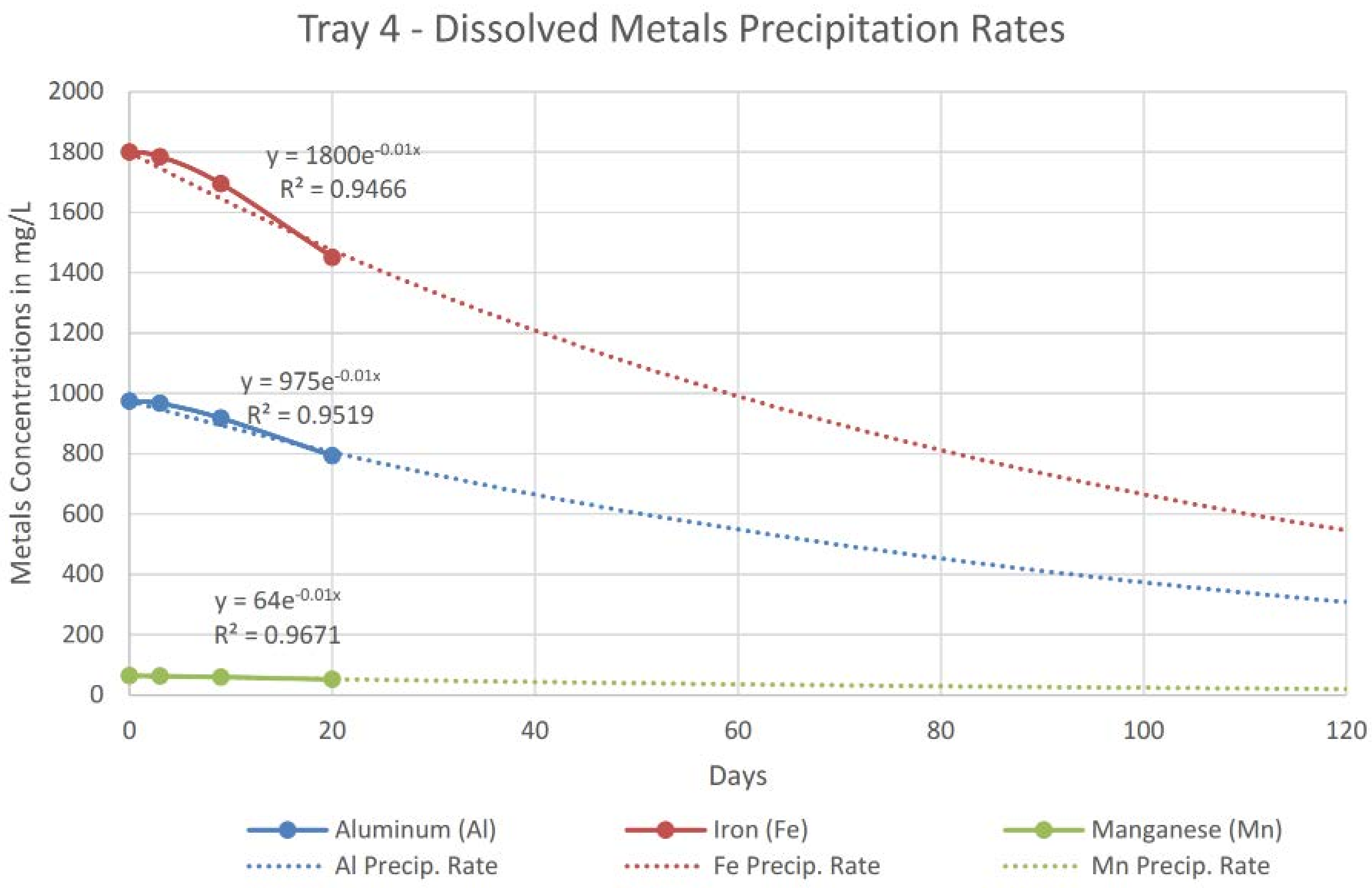
Glucose/Organics/Sunlight



Organics/Darkness



Organics/Darkness/Chilled



Tray 2: Organics/Glucose Before and After

Performance Summary

Metals Concentration vs Time (corrected for evaporation)						k Value $C_o e^{-kt}$	Comments
Tray	Metal	Days of PBR Exposure					
		0	3	9	20		
Tray 1 Organics only with sunlight	Al	975	910	733	545	0.0294	Second highest performer
	Fe	1800	1588	1354	939	0.0326	
	Mn	64	54	51	46	0.0187	
Tray 2 Organics & glucose with sunlight	Al	975	906	728	520	0.0315	Highest performer
	Fe	1800	1672	1343	892	0.0345	
	Mn	64	59	48	32	0.0344	
Tray 3 No sunlight	Al	975	926	793	618	0.0228	Third highest performer
	Fe	1800	1710	1463	1083	0.0248	
	Mn	64	61	63	39	0.0213	
Tray 4 Chilled/ No sunlight	Al	975	967	918	793	0.0096	Poorest performer
	Fe	1800	1785	1695	1451	0.0100	
	Mn	64	63	60	52	0.0100	

Estimating IAT Retention Time

$$T_{IAT} = \frac{-ln\left(\frac{c_{f_{IAT}}}{c_{0_{IAT}}}\right)}{k}$$

C_{IAT} = intial concetration into the IAT

C_{IAT} = design effluent concetration from the IAT

Performance vs. Retention

$$D_{IAT} \times A_{IAT} = T_{IAT} \times f_a$$

D_{IAT} = Depth of the IAT required to achieve $C_{f_{IAT}}$

A_{IAT} = Area of the IAT required to achieve $C_{f_{IAT}}$

f_a = flowrate at the adit

Estimating IAT Area

$$A_{IAT} = ln\left[\frac{\left(\frac{c_{f_{IAT}}}{c_{0_{IAT}}}\right)}{\left(\frac{c_{f_{tray}}}{c_{0_{tray}}}\right)}\right] \times t \times f_a$$

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Impact of Environmental Conditions

$$C_f = C_0 e^{-\varphi k t}$$

Where $\varphi =$ estimated corrected removal efficiency

Conclusions

- The bench scale test indicated viability of passive bioremediation of metals-impacted AMD
- Temperature change was the most impactful environmental design condition; the other parameters were relatively modest
- Detailed design information on passive bioremediation of AMD can be gathered from an inexpensive bench test (<$5,000)

Questions

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