Quantifying and treating contaminant discharges from the James Mine on New Zealand's West Coast

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Abstract

New Zealand's West Coast is home to numerous unmitigated legacy mining complexes and galleries that regularly release acid mine drainage (AMD) into the downstream environment. In a typical setting, standard *in situ* passive treatment technologies would be highly recommendable. However, a comparative examination between conventional technologies such as RAPs, SAPs or ALDs illustrate the inherent short-comings they exhibit when treating highly contaminated mine waters. The James Mine is a legacy coal mine that exhibits AMD with high acidity and metal loads. Furthermore, the mine's topography and local high precipitation rates result in varying flow-rates representing significant challenges to treatment technologies.

The present research sought to identify and test an effective method to treat the James Mine effluent at its source and was based upon laboratory research and field experiments. Specifically, this study investigated the premise that in sites such as the James Mine, conventional treatment solutions would not function properly due to early clogging leading to a loss of porosity and a loss of reactivity as the armouring of the reactive media takes place. This research investigated the Dispersed Alkaline Substrate (DAS) technology as a solution to these problems. The DAS system works on the foundation of applying a fine-grained reactive substrate mixed with a coarse inert substrate. The fine-grained alkaline reagent retards passivation due to it dissolving almost entirely before the process can occur while also providing a significant reactive surface. The mixed media as a whole provides not only a means of dispersion for nuclei allowing for precipitates to form on the inert material but also provides for a large reactive surface from the fine-grained alkaline reagent.

Laboratory and field experiments demonstrated that the DAS was able to abate AMD consisting of high metal concentrations with pH ≈ 2.54 and a net acidity of 1349 mg/L as $CaCO_3$. Peak performance of the field experiments showed a metal removal rate of 99 % (Fe, Al and Cu), 40 % (Mn), and 91 % (Zn and Ni) while increasing pH levels to >6.40. Depth profiles provided chemical data that was used to create reactive transport models while hydraulic parameters were calculated during the experimental phase to determine hydraulic residence times (HRT). Each aspect assisted in identifying the evolution of the AMD allowing for a more comprehensive analysis. It should be noted that the size of the DAS implemented was big enough to treat 2150 L/day of AMD effectively; however, the high acid load of the AMD quickly exhausted the neutralising capacity of the reactive substrate.

Overall, this study demonstrated that if the DAS was to be up-scaled to a full-scale system it could not only prove to be an effective means of treating heavily influenced trivalent mine waters but also divalent affected mine waters. Additionally, it illustrates the difficulty of obtaining an optimal HRT in balancing the need to meet effluent quality standards while maintaining reasonable treatment times.

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BACKGROUND

The James Mine is located on New Zealand's West Coast and regularly releases acid mine drainage (AMD) with high acidity and metal loads (Figure 2) into the downstream environment (Figure 1). This study investigated Dispersed Alkaline Substrate (DAS) technology as a solution. Associated with this study were three central questions:

1) How does the treatment effectiveness change with time;
2) How does the treatment work through the whole system; and
3) In which forms are the metals retained in the substrates mixtures (what are the metal removal mechanisms taking place)?

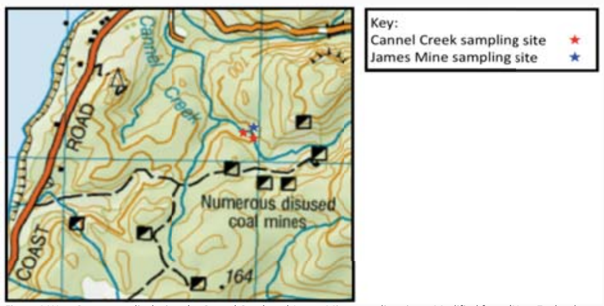

Figure 1 West Coast map displaying the Cannel Creek and James Mine sampling sites - Modified from (New Zealand Topographic Maps, n.d.)

SITE GEOCHEMISTRY

The severity of the site is illustrated below as the primary metals of concern are all above thresholds limits for freshwater.

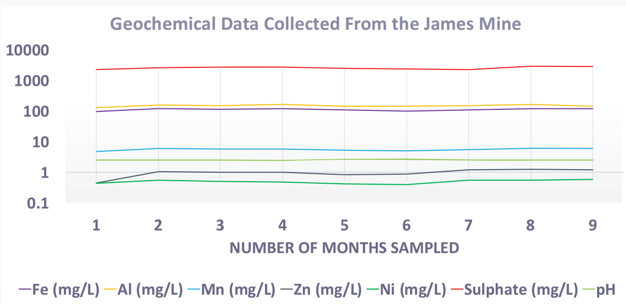

Figure 2 Raw total metal, sulphate and pH concentration from the James Mine AMD

DISPERSED ALKALINE SUBSTRATE

- A fine-grained reactive substrate mixed with a coarse inert substrate
- A multistep treatment solution to target specific metals
- A smaller grain size provides a large reactive surface and retards passivation
- Provides a means of dispersion for nuclei allowing for precipitates to form on the inert material.

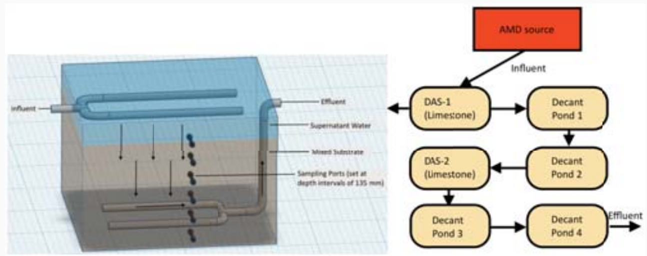

Figure 3 *The schematic of the DAS set-up used in at the James Mine*

RESULTS OF TREATMENT

- Establishment of a high targeted pH levels
- Metal concentrations lowered to below established trigger values
- Metal removal trends differed between metals
- Total metal removal fluctuated but generally decreased over time indicating that the metal removal processes also changed over time.

Table 1 Total metal removal percentages for the primary metals of concern throughout the DAS' lifespan

Treatment period	Al	Fe	Mn	Zn	Ni
Weeks 1 – 4	99.65 %	99.74 %	41.03 %	90.91 %	91.48 %
Weeks 5 – 8	93.59 %	98.44 %	39.31 %	87.96 %	54.42 %
Weeks 9 - 12	47.33 %	77.02 %	15.37 %	57.74 %	25.27 %

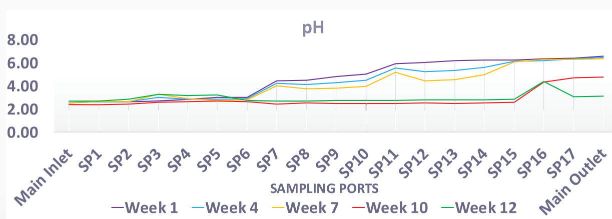

Figure 4 pH levels observed throughout the DAS during the treatment period

Figure 6 Medium metal removal values during the months of treatment (mg/L)

CONCLUSIONS

- Treatment was successful before the reactive material reached its neutralising capacity
- The multi-step nature allowed for precise metal removal by targeting specific pH levels within each reactor
- The DAS offers an inexpensive, alternative and appealing solution to AMD treatment for highly contaminated sites with either high trivalent or divalent metal concentrations

ACKNOWLEDGEMENTS

This research was financed Ministry for Business, Innovation and Employment. Access to the mine site was provided by MBD Contracting and Solid Energy New Zealand.