ASPECTS OF TREATMENT TRAIN DESIGN TO ENHANCE DISSOLVED METALS CAPTURE

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ABSTRACT

Engineering a Stormwater treatment train to effectively target dissolved metals requires a number of key design changes compared with targeting suspended solids, alone. There are a number of alternatives to sequester, adsorb or exchange the metal ions. Filtration devices with zeolite, metal oxide, peat or compost media are all capable of providing effective dissolved metals removal. To use them appropriately requires consideration of the kinetics of ion-exchange of each of the media and what contact time each requires in order to achieve the desired removal. As such, the choice of ion-exchanger dictates certain aspects of the design of treatment device in which it is used. The practicalities of using various media will be discussed. In addition, the impact of other devices in the treatment train will be addressed. Typically, ion-exchangers are used as the downstream device in a treatment train in order to minimise the impact of suspended solids on the exchange media. In fact, in certain situations, standing water upstream in the treatment train may significantly compromise the effects of downstream ion exchange. Indeed, catchpits, hydrodynamic separators and forebays may all be contraindicated where maximum dissolved metals capture is desired.

KEYWORDS

dissolved metals, stormwater, ion-exchange, treatment train, standing water

PRESENTER PROFILE

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1 INTRODUCTION

The most common metals in stormwater are copper and zinc from abrasion of tyres and brake pads, respectively. Both of these metals are readily soluble and typically 25% to 50% of the metal load is in dissolved form. The most obvious strategy for removing these dissolved metals is to use a reactive 'filtration' media, such as zeolite, peat, compost, or iron and steel making slags. In this case the 'filtration device' is more accurately termed a permeable reactive barrier. Each of these media has specific properties that influence the manner in which they may be effectively used.

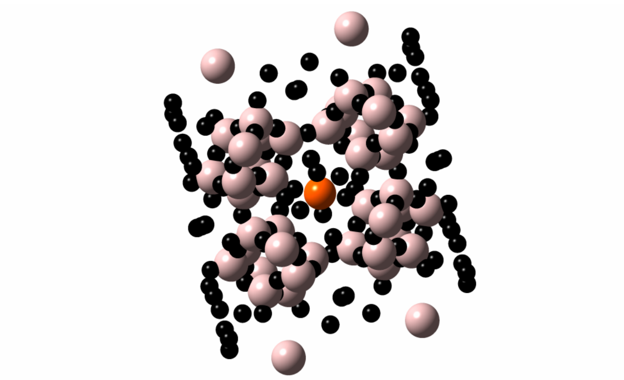
The effect of standing water in the treatment train should also be considered. In specific circumstances, when standing water is in contact with metal contaminated sediment, the influent dissolved metal concentrations may be significantly amplified, which may lead to first flush plumes of dissolved metals as the standing water is replaced. This can also tend to load the downstream ion-exchange media unnecessarily.

2 ION-EXCHANGERS AND OTHER REACTIVE MEDIA

2.1 ZEOLITES

Zeolites are a family of aluminosilicate minerals. They possess a crystalline structure which may be described as a lattice of cavities or cages, and are typically found with sodium, potassium or other (non-heavy) metal ions bound within the cages. Figure 1 shows the crystal structure of the naturally occurring zeolite, clinoptilolite. The orange sphere represents the metal ion bound within the aluminosilicate cage. It is free to exchange with a metal ion in solution, and this is the mechanism by which zeolites may remove dissolved heavy metals from solution.

Figure 1 Crystal structure of exchanged clinoptilolite, a naturally occurring zeolite.

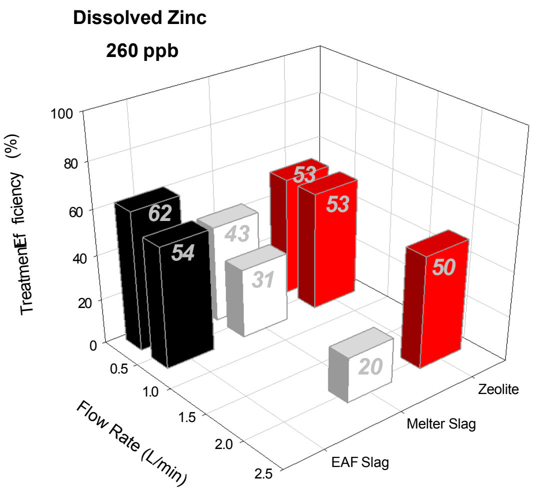


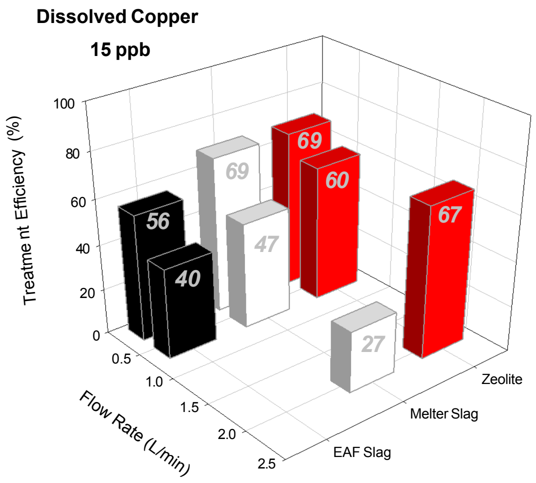
New Zealand zeolites perform very well across a range of concentrations and flow rates for the removal of dissolved copper and zinc.

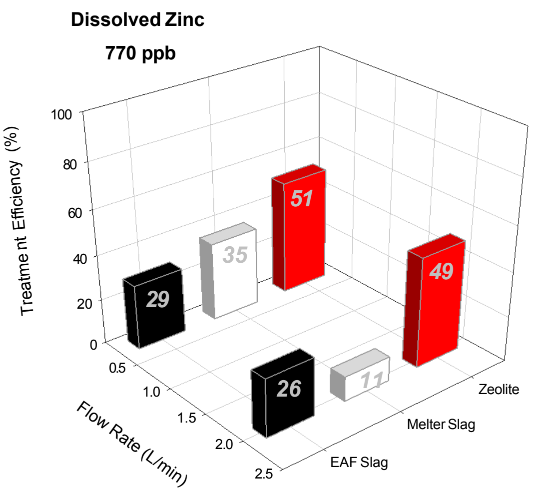
2.2 IRON AND STEEL MAKING SLAGS

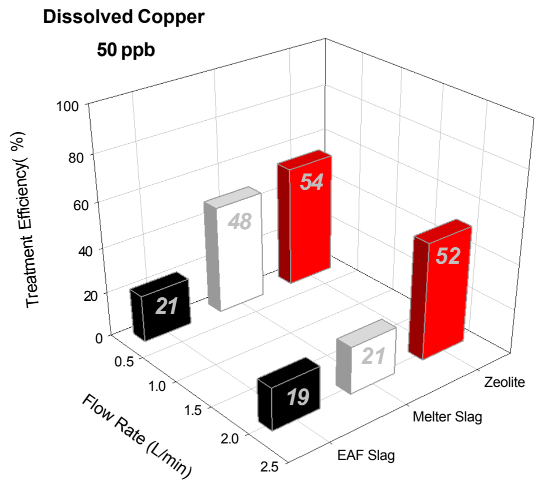
Iron and steel making slags have also shown some potential to remove dissolved heavy metals. These byproducts of the iron and steel making industry are mixtures of metal oxides. They typically have a high surface area, and the surface is capable of adsorbing dissolved metal ions from solution. We have performed initial investigations using melter slag and electric arc furnace slag from the Glenbrook Steel Mill. The former is an iron-making slag, the latter a steel-making slag.

When used with similar media particle sizes NZ iron and steelmaking slags give comparable results to zeolite at low flow rates. However in highly elevated metals concentrations and at high flow rates the New Zealand zeolite's performance is currently superior.









2.3 PEAT AND COMPOST BASED MEDIA

Peat and compost based media act as organic ligands that bind dissolved metals to the solid phase substrate. Their ability to capture dissolved metals is generally better than zeolite or iron and steel slags, as can be seen below. Their major limitation is their lack of hydraulic permeability, especially as the media swells with moisture. In addition, particularly in the case of compost, breakdown of the media may release nutrients downstream.

Filtration Medium	Flow Rate (StormFilter full scale equivalent*) L/s	Influent Dissolved Zinc Concentration mg/L	Effluent Dissolved Zinc Concentration** mg/L	Dissolved Zinc Removal %	Influent pH	Effluent pH
1 NZ Zeolite	0.48 L/s	0.880	**0.059**	93%	6.7	6.7
		0.730	**0.036**	95%	-	-
	0.24 L/s	0.880	**0.045**	95%	6.7	6.7
		0.730	**0.018**	98%	-	-
2 Australian Zeolite	0.48 L/s	0.880	0.092	90%	6.7	6.7
		0.730	0.078	89%	-	-
	0.24 L/s	0.880	0.080	91%	6.7	6.7
		0.730	**0.060**	92%	-	-
3 Peat Perlite Mixture	0.48 L/s	0.880	**0.045**	95%	6.7	5.8
	0.32 L/s†	0.730	**0.028**	96%	-	-
	0.24 L/s	0.880	**0.042**	95%	6.7	5.6
		0.730	**0.024**	97%	-	-

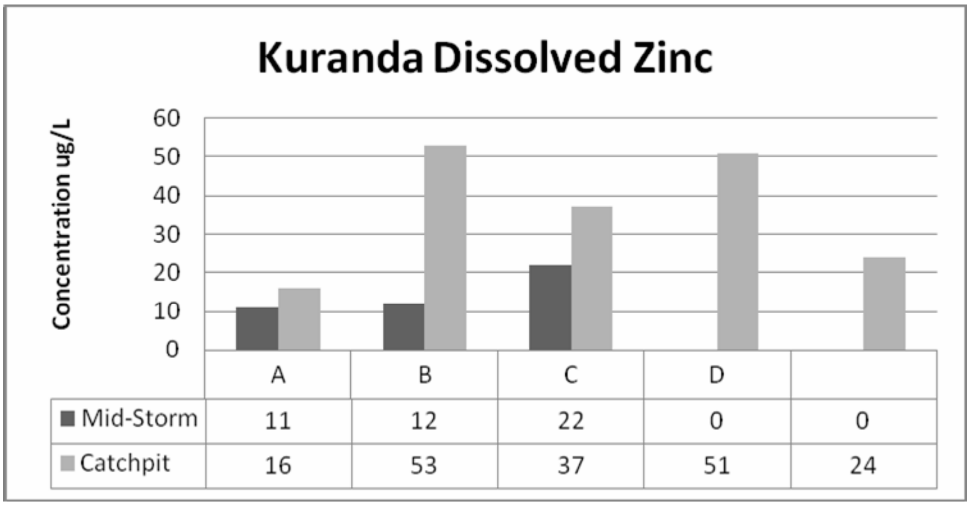
* Full scale StormFilter equivalent flow rate is 24x HFC flow rate

** Bold values represent effluent concentrations below 5x ANZECC dissolved zinc trigger values (95% protection level, salt water; 0.015 mg/L)

† Swelling of the peat/perlite mix caused reduced hydraulic conductivity and limited flow rate of this run to max. 0.32 L/s, rather than the intended 0.48 L/s

3 INCREASED LEVELS OF DISSOLVED METALS IN STANDING WATER

It is our experience that standing water may increase the levels of dissolved zinc, in particular. We note that the issue is most associated with warm climates and with high dissolved organic carbon concentrations. In these situations it may be preferable to remove all standing water from the system, otherwise the effect of the downstream ion-exchange media is negated.



4 CONCLUSIONS

Where dissolved metal removal is the critical aspect of a treatment train it may be advisable to remove or minimize all standing water. The choice of ion-exchange media should be made, dependent upon the influent concentrations, effluent requirements and filter design constraints.