A case study of long-term geochemical evolution of coal waste rock drainage and its remediation

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The site and the problem

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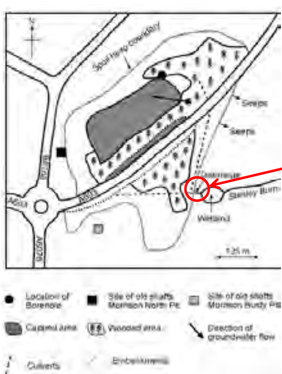


Main discharge point at outlet from culvert

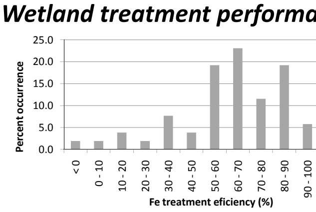
Discharge water quality

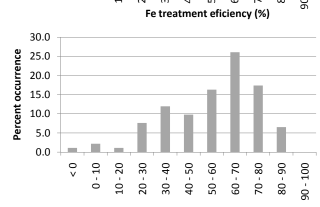
	Mean	Maximum	Minimum	n
pH	6.4	8.9	4.2	164
Conductivity (µS/cm)	6216	14030	280	147
Alkalinity (mg/L as $CaCO_3$)	59	136	0	149
Iron (mg/L)	5.0	20.5	0.5	182
Manganese(mg/L)	3.3	8.6	0.4	180
Aluminium (mg/L)	4.7	13.6	0.1	171
Zinc (mg/L)	1.2	4.1	0.1	123
Calcium (mg/L)	203	408	47	117
Magnesium (mg/L)	64	141	8	117
Sodium (mg/L)	1091	3251	140	117
Potassium (mg/L)	132	505	17	116
Sulphate (mg/L)	717	1541	106	174
Chloride (mg/L)	1788	4535	220	154

Wetland treatment system

- Discharge from waste rock pile caused discoloration of the local watercourse
- 500 m^2 compost treatment wetland system constructed in 1997
- Overall size of wetland constrained by land availability (a common issue in the UK)
- A charitable project
- Wetland system constructed in collaboration with the residents of the local village, Quaking Houses

Wetland treatment performance





Wetland treatment performance

1998

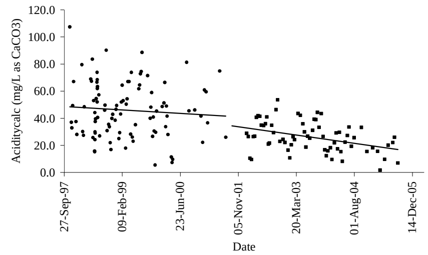
2001

2005

Deterioration in performance primarily driven by inundation of dead reed material within the system – clearly a maintenance issue

IMWA 2010, Nova Scotia, Canada

Long-term evolution of waste rock drainage



- Clear improvement in water quality over time
- Much quicker improvement than predicted by pyrite oxidation and dissolution modelling
- Result of partial capping of the heap in areas known to be acid-generating (and probably also natural re-vegetation of the heap)

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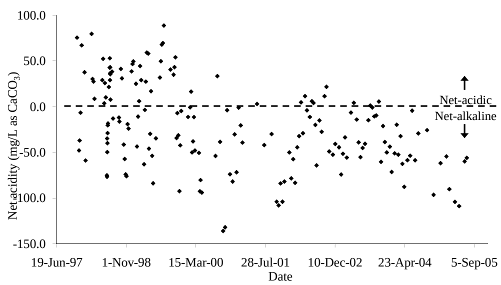
Long-term evolution of waste rock drainage



- Since around 2003 drainage net-alkaline
- Change in water quality influenced renovation of wetland system – primary objective removal of marginally elevated iron concentrations

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Wetland system renovation

Key issue during renovation was disposal of compost wetland substrate (above)

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Wetland system renovation

- British Standard (BS) leachability tests showed substrate could be disposed of as ‘inert’ waste (concentrations below Waste Acceptance Criteria (WAC) as inert waste).
- Note that iron and aluminium not required determinants for leaching tests (but Fe present at ~ 60 000 mg/kg)
- Disposal as inert waste significantly reduced overall costs of renovation

Period	L/S Ratio	Cl^-	SO_4^{2-}	Zn	As	Cd	Cr	Cu	Ni	Pb
6 hrs	A_2 (mg/kg dry matter)	694	1494	0.04						
18 hrs	A_8 (mg/kg dry matter)	661	2819	0.29	0.05	0.01	0.01	0.01	0.01	0.05
24 hrs	A_{10} (mg/kg dry matter)	455	1996	0.08	0.100	0.02	0.02	0.0	0.02	0.10
	WAC limit (mg/kg) L/S_{10}	**800**	**6000**	**4**	**0.5**	**0.04**	**0.5 (total)**	**2**	**0.4**	**0.5**

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Full life-cycle wetland costs

- Original wetland cost approximately £60 000 to construct (~ CAN $100 000)
- Renovation cost approximately £50 000
- Therefore over 8 years of operation cost was ~ £14 000 / annum
- No question that system would have performed for longer with basic maintenance programme in place e.g. reed clearance
- For other wetland systems costs may be significantly greater if other, potentially more eco-toxic, metals present in exhausted substrate

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Conclusions

- Modestly-sized compost wetland successfully attenuated acidity and metals in waste rock drainage
- Improved maintenance programme would likely have extended lifetime of original system
- Land availability always an issue in UK, and therefore such passive systems always likely to need renovation at some point – cannot ignore / overlook this requirement
- Presence of potentially eco-toxic metals might significantly increase costs of renovation
- Selective capping of waste rock appears to have resulted in improved drainage quality, which should extend lifetime of renovated system, further reducing future costs