Passive treatment using drainable limestone beds: Lessons from 14 years of design and maintenance

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Extended Abstract

Oxic limestone beds provide a reliable and low-cost treatment option for acidic mine waters with Al, Fe, and Mn. Early designs suffered from poor performance due largely to the accumulation of metals solids that plugged aggregate pore spaces and inhibited water contact with the aggregate surface. At the 2010 IMWA conference, Wolfe et al. (2010) described experiments with oxic limestone beds that received mine water containing Al, Fe, and Mn and were drained until empty on a daily to weekly basis. The beds discharged good quality water and the draining removed solids and sustained treatment performance longer than without draining. The development of solar-powered computer-controlled gate valves has made the technology feasible on remote sites where regular manual draining is not feasible.

Since 2010, dozens of Drainable Limestone Beds (DLBs) have been installed in the eastern USA for the treatment of acidic waters containing Al, Fe, and Mn. Treated water from DLBs can be discharged directly to streams and flush water is directed to a settling pond. Table 1 shows the characteristics and performance of six DLBs installed in Pennsylvania. All DLBs remove Fe, Al, and Mn and discharge good quality water. The Greene DLB is subject to an NPDES discharge permit and the Lotus DLB feeds a fish pond in a botanical garden.

The long-term effectiveness of the systems depends partly on the management of the solids formed in the beds. Studies of the effectiveness of draining events have found removal of 25–70% of the Al solids, depending on the chemistry and plumbing design. This solids management is suitable to preserve the bed permeability and reactivity for many years.

Table 1 Characteristics and performance of Drainable Limestone Beds (DLBs) installed in Pennsylvania. TRT: average theoretical retention time. Median size: approximate median limestone aggregate size

Site	Year installed	Limestone	Median size	Flow	Avg TRT	Data	pH	Net Acidity	Fe	Al	Mn	Cleaned
		t	mm	L/min	Hr				mg/L			
Scootac	2010	907	19.1	40–379	20	In	3.6	93	<0.1	9.3	17.3	2011, 2016,
						Out	7.3	-179	<0.1	<0.1	<0.02	2023
Lotus	2013	408	38.1	8–42	48	In	3.3	155	0.7	19.7	0.8	never
						Out	6.6	-193	<0.1	<0.1	0.1	
Sterrett	2015	3,193	38.1	120–990	30	In	3.6	96	3.0	9.4	14.5	2017, 2020,
						Out	6.9	-110	0.2	0.7	1.1	2022
Greene	2015	4,082	19.1	40–1140	54	In	3.4	127	5.6	4.0	40.0	2019
						Out	7.2	-90	0.2	0.1	0.1	
Kentucky	2019	1,361	38.1	42–1100	20	In	3.6	90	0.9	9.9	0.8	2023
						Out	7.6	-143	0.1	<0.1	<0.1	
Cherry	2020	7,165	19.1	830–1190	30	In	4.9	27	0.6	2.4	0.2	never
						Out	7.8	-44	<0.1	0.1	<0.1	

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Eventually, the beds accumulate enough solids that cannot be removed through draining that maintenance is required to sustain satisfactory treatment performance. Maintenance typically involves rehabilitation or replacement of the limestone at variable frequencies (See "Cleaned" in Table 1). Rehabilitation is increasingly preferred over limestone replacement. The limestone aggregate in the beds is mechanically mixed using excavation equipment and rinsed with water to remove accumulated metals solids which increases porosity and reactivity at a fraction of the cost of aggregate replacement.

Solids produced by draining and cleaning are captured in settling ponds. Ultimately, these solids must be removed from the settling ponds and disposed of. This has not yet occurred at any of the sites discussed here. Development of solids disposal methods is a reasonable next step in the evolution of this treatment technique.

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References

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