A comparative study of lime doser treatment

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Extended Abstract Alkaline dosing is a common treatment strategy in rural areas affected by acidic waters from abandoned mine. The efficacy of these systems is dependent upon many natural and anthropogenic factors. Without a clear understanding of what will lead to either success or failure of a treatment system and what the ultimate goals of the treatment system are, system designs are hit or miss.

In southeastern Ohio, lime dosers have been selected to treat four mining impacted watersheds with varying results. The Carbondale Doser and Jobs Hollow Dosers were both installed in 2004 (NPS 2011), while the Thomas Fork Doser was installed in 2012 and the Pine Run Doser was installed in early 2013. Their siting was determined through a combination of sufficient treatment space, appropriate land ownership or availability, sufficient hydraulic head and consistent flow to drive the doser. The chemical and biological recovery varies between each stream, Carbondale has been the most effective, while Jobs has been a mixed success. So far, Thomas Fork has not been consistently effective. The physical and chemical characteristics of each stream (Monday Creek, Hewett Fork and Thomas Fork) were evaluated to determine what leads to success or failure of doser treatment. The stream flow and velocity to transfer the treatment waters, as well as additional acid sources and natural alkalinity sources along the flow path were considered. The lessons learned from this assessment have been used to create a conceptual model for successful treatment. The model has been applied to the newly constructed Pine Run system to assess its potential for success.

Several major factors affect success of treatment in the streams studied. Results suggest that, for successful doser treatment, acid sources must be close together, ensuring that the alkalinity from the doser is transported to the acid sources before secondary minerals are formed or is being consumed prematurely. Sufficient velocity is vital to carry unreacted lime downstream. In systems with insufficient velocity to carry material downstream, lime may build up within the stream channel and not be transported far enough to ameliorate downstream acid sources. A low velocity zone downstream of acid sources allows metal precipitates to settle. In some cases, natural alkalinity sources lead to further recovery and can add as much if not more alkalinity to the stream as a doser.

The Carbondale Doser in Raccoon Creek has been intensively studied (*e.g.* Kruse *et al.* 2012) and serves as the foundation for the conceptual model. Carbondale treats three key acid sources, Carbondale Mines, Carbondale Creek and Trace Run. They are clustered within two stream kilometers in the headwaters of Hewett Fork. The stream maintains sufficient power throughout the year to entrain alkaline material long enough to be consumed by the three major acid sources. Downstream of Trace Run, the alkalinity from the doser has been consumed. Further downstream, there are two key features that lead to effective watershed restoration: a low velocity depositional area for metal precipitates and large natural alkalinity sources from groundwater as

well as alkaline tributaries (Kruse *et al.* in review). The analysis presented in Fig. 1 further shows that at the beginning of the dry season in June, a critical time for biological impacts, there is little pH variability downstream of the doser, while in October, at the end of the dry season, large variations can be seen. These variations happen at a less critical time in the life of aquatic fauna that are evaluated during the summer biological sampling index period (K.S. Johnson 2013 personal communication).

Downstream of the Jobs Hollow Doser in the headwaters of the Monday Creek Watershed, there is a short zone of recovery, but large acid sources downstream limit recovery (NPS 2011). The watershed was extensively mined; most tributaries to the mainstem are acid sources. Only one, Little Monday Creek, is a significant alkalinity source and it is approximately 25 km downstream of the Jobs Hollow Doser (*e.g.* Pool *et al.* 2013). While sparse data is available, as shown in Fig. 1, the Jobs Doser maintains a near neutral pH in the stream channel at the end of the dry season, as the flow rate and velocity of the stream begin to increase. At the beginning of the dry season, however, low velocity leads to pH variability. This key early summer time period is particularly critical to aquatic life since it is at the beginning of the growing season. Multiple acid sources with few natural alkalinity sources alongside pH variability in early summer limit the effectiveness of the Jobs Doser. However, treatment of acid sources in the headwaters is an important strategy for watershed restoration.

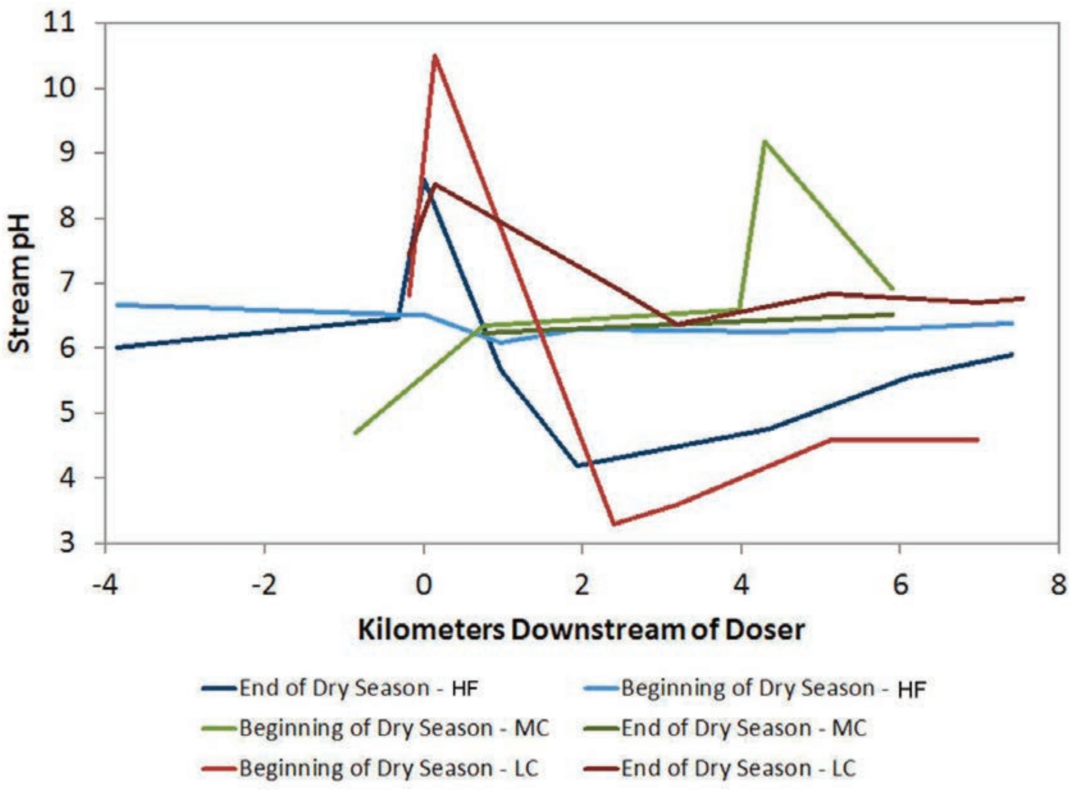

Fig. 1 *pH profiles downstream of the Carbondale Doser in Hewett Fork (HF), the Jobs Hollow Doser in Monday Creek (MC) and the Thomas Fork Doser in Leading Creek (LC) for the beginning and end of the dry season. The seasonal variability in pH can limit biological recovery, especially when low pH occurs during key times in the lifecycle of aquatic fauna.*

The Thomas Fork Doser in the Leading Creek Watershed is plagued by low velocity which does not allow unreacted lime to travel downstream far enough to treat acid sources further downstream. As shown in Fig. 1, when there is insufficient flow at the beginning of the dry season, large pH variability is seen during the critical time period, while at the end of the dry season, there is sufficient stream power to carry the alkaline material downstream and buffer acidity in the Thomas Fork. Beyond the lack of velocity during the dry season, there are several other large acid sources along Thomas Fork that may limit the dosers effectiveness, despite the natural buffering capacity added to the stream by the East Branch of Thomas Fork.

This analysis suggests a conceptual model for success includes: acid sources located close to the doser, sufficient velocity to carry alkaline material, a depositional area downstream of acidity sources to collect metal precipitates and additional alkalinity sources.

The Pine Run Doser, in the West Branch of Sunday Creek, that was installed in early 2013 may not be effective based on the conceptual model developed here. The site is plagued by insufficient flow which is unlikely to carry lime downstream to treat the multiple acid sources located downstream in Pine Run making the stated goal of treatment ambitious (Shaw 2011). The buffering capacity added to the system by the doser may, however, accrue positive results many kilometers downstream due to additional treatment systems in the West Branch of Sunday Creek.

This study has allowed for better understanding of additional factors that ought to be considered when siting a doser. The conceptual model can be applied to siting and design of treatment to maximize recovery.

References

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