When Dosers Turn Off: A Case Study in Raccoon Creek, Ohio

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Abstract Hewett Fork in Raccoon Creek, Ohio, was traditionally a large source of acid mine drainage to the main stem. To reduce this impact, the Carbondale doser was installed in the Hewett Fork subwatershed. From its installation in 2004, the doser has raised the pH of the mine discharge from about 3 to about 9 and has improved the biology in Hewett Fork and Raccoon Creek. During the summer of 2010, the doser was off-line for approximately one week. While the chemistry of Hewett Fork has rebounded well the fish and macroinvertebrate community suffered from this week of non-treatment.

Key Words calcium oxide, active treatment, doser, biological recovery

Introduction

Hewett Fork is a subwatershed in the headwaters of Raccoon Creek watershed in Southern Ohio (Figure 1). Three major sources of acid mine drainage (AMD) affect Hewett Fork, Carbondale East and West drifts (River Mile 11.0), Carbondale Creek (River Mile 10.8) and Trace Run (River Mile 10.35) (Figure 2). Before treatment, mine drainage from Hewett Fork caused fish kills in the mainstem of Raccoon Creek (Rice *et al.* 2002).

After previous wetland treatment did not meet acidity load reduction targets (NPS 2009), an Aquifix lime-doser (Figure 2) was installed in the Spring of 2004 using the discharge of Carbondale East drift to power the auger. Passive treatment systems were found to be either insufficient or cost prohibitive at this site. While the initial use of kiln dust caused bridging in the doser, subsequent dosing with calcium oxide has been effective in not only treating Carbondale East and West,

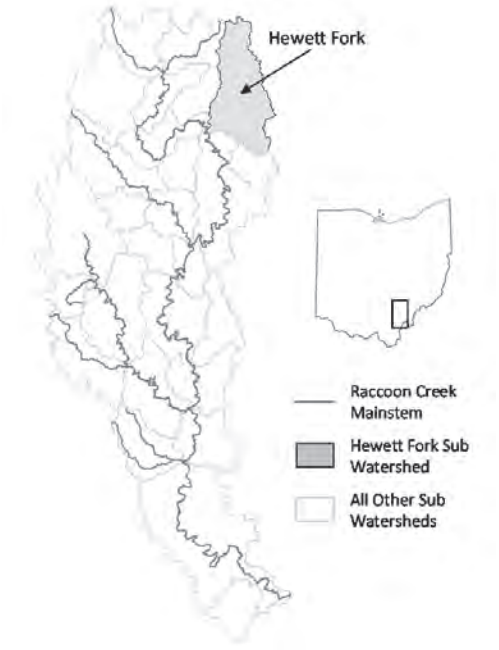

Figure 1 *Raccoon Creek Watershed with Hewett Fork subwatershed highlighted in darker grey.*

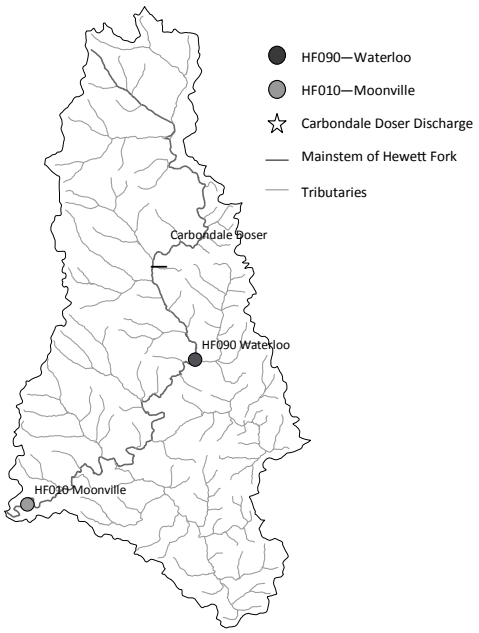

Figure 2 *Map of Sampling Points in the Hewett Fork subwatershed of Raccoon Creek.*

but also Carbondale Creek and Trace Run (NPS 2009). Initially, the goal of the Carbondale Doser was to reduce the impact that Hewett Fork had on the mainstem of Raccoon Creek, 11 miles downstream. While achieving warm water habitat use designation in Hewett Fork was never an articulated goal, monitoring since construction has shown that it is achievable.

Warm Water Habitat: The Ohio EPA (OEPA) classifies streams based upon use designation recommendations that take into account a combination of biological, chemical and physical attributes (OEPA 1997). Raccoon Creek is considered a warm water stream since water temperatures are too high to support salmonids. The use designation categories used in Raccoon Creek are Exceptional Warm Water Habitat (EWH), Warmwater Habitat (WWH) and Limited Resource Water – Acid Mine Drainage (LRW-AMD). Attainment of each use designation is based upon several biocriteria as show in Table 1. While MAIS is not officially used for stream designation, it is used here because the MAIS (Macroinvertebrate Aggregate Index for Streams) dataset in Southern Ohio is richer than that for the official measure, ICI (Invertibrate Community Index). Hewett Fork was originally designated at LRW-AMD, suggesting that it has no near term prospect for reclamation, however, some sites in the lower reaches of Hewett Fork are in partial attainment (meeting some but not all of the biocriteria) of WWH.

This paper is a case study of the effects of the Carbondale Doser running out of calcium oxide for about a week during the summer of 2010.

Methods

Water chemistry was measured multiple times per year at the monitoring sites show in Figure 2 including monthly samples from HF090 to HF010 from July 2010 to June 2011. Biological quality was assessed at each site; what communities were assessed varied by year. These include habitat (Qualitative Habitat Evaluation Index or QHEI), fish (Index of Biotic Integrity or IBI) and macroinvertebrates (MAIS). This paper will focus on IBI and MAIS. This study focuses on the biological indices at HF090 (Waterloo) which is a site of transitional water quality 2.7 stream miles downstream from the doser and HF010 (Moonville) at the mouth of Hewett Fork and the chemistry at HF131 (Carbondale) which is the discharge from the Carbondale East and West drifts before April 2004 and the discharge from the doser after April 2004, Waterloo and Moonville.

Field data was measured with a sonde (equipment: Yellow Springs Institute 600 XLM datasonde) and included temperature (degrees Celsius), pH, specific conductivity (µS/cm), and dissolved oxygen (mg/L and percentage of saturation). Water flow was measured at each site with either a SonTek Flow Tracker Handheld-ADV, a pygmy flow meter, a Marsh-McBirney flow meter, or a Baski collapsible cutthroat flume. Filtered preserved, non-filtered preserved, and non-filtered non-preserved samples were gathered and sent to the Ohio Department of Natural Resources – Division of Mineral Resources Management Environmental Lab in Cambridge, Ohio for analysis of chemical water quality characteristics. Analysis was performed for acidity, alkalinity, pH, temperature, specific conductance, hardness, total dissolved solids, total suspended solids, dissolved oxygen, sulfate, calcium, magnesium, aluminum, iron and manganese using a Perkin Elmer Optima 2000 ICP, a Dionex ICS-2000 Ion Chromatography system and a Brinkmann Automated Titration system. All field data is catalogued on the Voinovich School's web-based watershed database (http://www.watersheddata.com).

Table 1 *Ohio EPA Biocriteria for Stream Use Designations (OEPA 2007).*

	EWH	WWH	LRW-AMD
QHEI	75	60	?
IBI	50	44	18
MAIS		12	

Note: MAIS is not officially used by OEPA as a biocriteria.

Index of Biotic Integrity (IBI)

The index of biotic integrity (IBI) is a multimetric index for fish populations (Karr 1981). It is used in Ohio to assess the attainment of water quality use designations for warm water streams (OEPA 2007). The IBI is calculated based upon 12 different factors; each factor is given a score of either 1, 3 or 5. The minimum score is 12 and the maximum is 60. A score of 44 is required to attain a warm water habitat use designation for wading sites. The factors that are included in this multimetric index for wading streams are total number of species, number of darter species, number of sunfish species, number of sucker species, number of intolerant species, percent tolerant species, percent omnivores, percent insectivore specie, percent top carnivores, number of individuals, percent simple lithophils and percent with Delt anomalies. The sites samples on Hewett Fork are all sampled using a 100 meter long line electrofishing unit to sample a 200 meter reach of stream from downstream to upstream.

Macroinvertibrate Aggregated Index for Streams (MAIS)

The Macroinvertibrate Aggregated Index for Streams (MAIS) is a family level rapid bioassessment method for macroinvertebrates (Smith and Voshell 1997) accepted by the Ohio EPA as a level

2 (rapid) bioassessment method for assessment of mine impacted streams in the Western Allegheny Plateau ecoregion, including Raccoon Creek (Johnson 2009). MAIS scores are calculated based on nine factors and can range from 0 to 18. The factors used to calculate MAIS scores are number of caddisfly, stonefly and mayfly families, number of mayfly families, percent abundance of mayflies, percent of population made up by the five most dominant taxa combined, Simpson Diversity Index (integrates richness and evenness), Modified Hilsenhoff Biotic Index (taxa are weighted by pollution tolerance), number of intolerant taxa, percent of the sample that are scrapers (macros that feed on periphyton) and percent of that sample that are haptobenthos (macros that require clean, coarse, firm substrates) (Johnson 2009). The sites on Hewett Fork are all sampled using standard methods. Within a 150 meter reach, three riffles are sampled using kick nets and all other available habitats are sampled with 20 jabs of a dip net. All individuals are picked from each net in the field and preserved for later idenfication and quantification.

The Summer of 2010

While the Carbondale Doser had improved the chemical and biological quality of Hewett Fork, during late June 2010, the doser was inadverantly left empty for approximately a week. Prior to June 2010, the last IBI measurement was in 2008 with a score of 24 (up from the pre-treatment value of 12); the last MAIS measurement was in 2009 with a score of 6 (no pre-treatment data exists). In the week prior to the doser being off-line (on June 23, 2011), an electrofishing demonstration (not a full survey) was performed at Waterloo (HF090) by the authors. During this demonstration, in addition to many pollution tolerant species, several longear sunfish, brook lamprey and redfin shiners were found indicating water quality and habitat improvements. Redfin shiner and brook lamprey were new species at this site.

While the empty doser was discovered within a few days, material ordering and shipping times led to a down-time of nearly one week. In addition to the empty doser, the concrete channel downstream of the doser that channels dosed mine water to Hewett Fork was emptied of excess calcium oxide precipitates by vaccuum truck during Spring 2010, so any residual buffering capacity was removed.

All 2010 bioassessments were performed after the doser was offline and subsequently refilled. Macroinvertibrate surveys were performed during July 2010, most sites were sampled within two to three weeks after the doser was refilled. Fish surveys were collected from August 3rd – 6th, 2010 with a second survey on September 20, 2010 at key sites. The results presented here show the response to a week of non-treatment both chemically and biologically.

Results

While sparse data is available prior to construction of the doser, Carbondale East and West (site HF131) contributed over 700 lbs/day of acid into Hewett Fork. Before June 2010 when the doser was off-line (see Figure 4), all three of the monitoring sites presented here were net alkaline. Since the doser was refilled, the dosing rate has been adjusted several times. This, along with low flow effects have contributed to the variability of net alkalinity at both Waterloo and Carbondale. The net alkalinity at Moonville, however, has remained consistently positive both before and after the doser was off-line. This reasonably quick chemical recovery is expected, but does not demonstrate full recovery since the biological communities will be slower to recover.

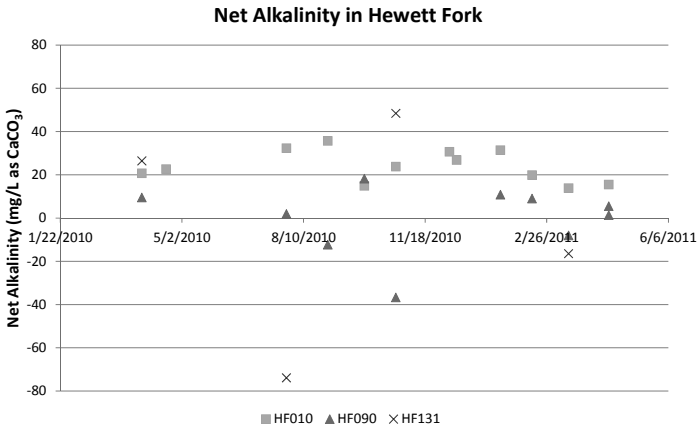

Figure 3 *Net alkalinity measurements at HF 010 (Moonville), HF090 (Waterloo) and HF131 (Carbondale) focussing on the period of non-treatment.*

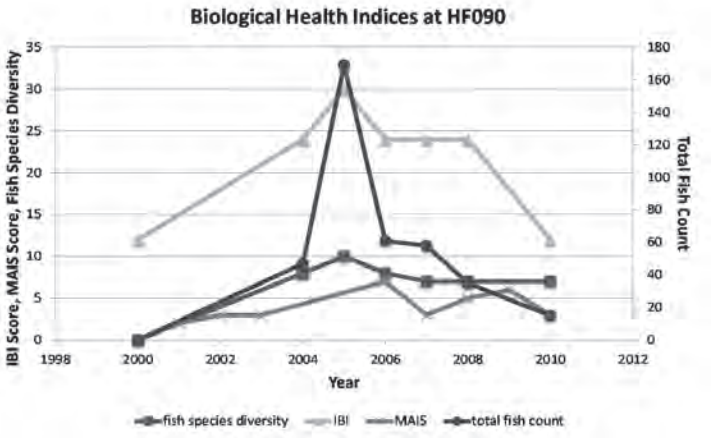

Figure 4 *Biological Quality at HF090 (Waterloo) from 2000 – 2010.*

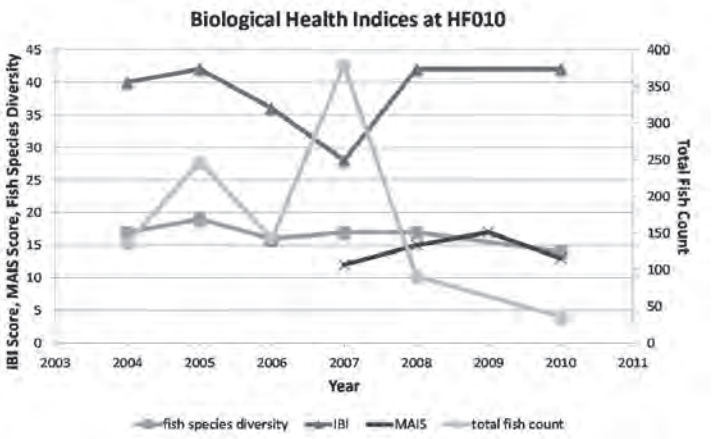

Figure 5 *Biological Quality at HF010 (Moonville) from 2004 – 2010.*

Since the construction of the doser, biological health has improved throughout the Hewett Fork subwatershed, as seen in Figures 4 and 5. The IBI at Waterloo pre-treatment was 12, the lowest possible score. During the next few years, the IBI improved to a maximum of 30, and consistently achieved a score of 24. In the 2010 sampling season, fish were surveyed twice at Waterloo; both surveys resulted in a score of 12. In addition, the MAIS score in 2010 returned to the pretreatment level of 3. The 2007 MAIS survey also had a low score, reflecting another, shorter, period of non-treatment that was buffered by in-stream and in-channel calcium oxide. Additionally, the 2010 fish survey at Waterloo had the lowest number of fish collected since treatment began. Although there is hope that biological assessments during 2011 will show improvement, an electrofishing demonstration on June 9, 2011, at Waterloo yielded only one pollution tolerant fish (a yellow bullhead).

While consistent biological recovery at Waterloo is not necessarily a realistic expectation in Hewett Fork, recovery at Moonville, 11 miles downstream from the doser may be a realistic expectation. As seen in Figure 5, since treatment, the IBI score has been consistently high. During the 2010 fish survey at Moonville, less than half the number of fish were collected when compared to the 2008 survey, although this did not affect the IBI score. The fish catch may have decreased due to gradual deepening of the sample site which makes sample collection more difficult. Additionally, the 2010 MAIS score dropped by four points from the 2009 survey.

Conclusions

While alkaline addition treatment can be extremely effective at minimizing the impacts of AMD and improving biological communities, equipment failures, human error and lack of maintenance can lead to treatment shutdown. A seemingly insignificant mistake can take its toll on the health of a watershed for years to come. Hewett Fork did not have the resilience to quickly bounce back from a week of non-treatment. While this system has allowed biological communities

to return to Hewett Fork and the headwaters of Raccoon Creek, it is not sustainable improvement withouth consistent and continued treatment of AMD at Carbondale.

Acknowledgements

This work was supported by a foundation grant from American Electric Power and by the Ohio Department of Natural Resources Division of Mineral Resources Managment.

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