Water Quality Improvement with BioSwale® Technology

Project Location: Reynoldsburg, OH, USA

This case study demonstrates the ability of Elevated BioSwale® technology to improve stormwater runoff quality. Monitored parameters were ammonia, nitrate, total phosphorus (TP), orthophosphate (ortho-P) and *E. coli* bacteria. The BioSwale technology is protected by U.S. Patent No. 8,287,728. In this study, improvements were measured in four of the five water quality parameters monitored.

Overview

Field-scale tests were conducted at a city park in Reynoldsburg, OH. The project purpose was to test the ability of BioSwales (stream inserts/bioreactors) to improve the water quality of small, headwater streams, especially those affected by failing household sewage treatment systems. The watershed studied had an area of 0.12 square miles. The stream flow depends on rainfall throughout the year; surface flow often ceases during late summer. Attempts to measure the flow rate were unsuccessful.

This report covers measurements taken from January through November 2013 (prior to BioSwale installation) and November 2013 through April 2016 (after BioSwale installation). Five BioSwales ("stream inserts") were placed in series within an intermittent stream channel, largely fed by stormwater, at the upper end of a 350-ft study section.

BioSwales were up to ten feet wide, spanning the creek, and up to five feet long. Two of them were comprised of seven layers of 2-inch-thick BioHaven matrix for a total height of 14 inches. One was six layers high (12 inches), while two were six inches high and were installed below the water level in the deepest reaches of the creek. The three elevated BioSwales were placed approximately 50 feet apart. All the BioSwales were contained within an approximately 175-ft reach of the stream. One of the BioSwales is shown in Figure 1 and a close-up of the BioHaven matrix is shown in Figure 2. The matrix comprises non-woven, non-toxic durable fibers made from polyethylene terephthalate (PET).

Figure 1: Typical BioSwale

Figure 2: BioHaven Matrix

BioSwales were held in place with steel nail stakes at 2-ft spacing. A cable was strung through a hole in each nail stake and attached to a duck bill anchor. Plants can be added to BioSwales but were not added initially in this study. Later efforts to add plants were largely unsuccessful, although some volunteer plants established themselves on the BioSwales.

Water quality data collected in grab samples was quite variable. Data indicated that the BioSwales improved water quality for all but one of the parameters measured (Table 1). However, given the large variability in the concentrations measured during the study (Table 2), the differences were not statistically significant. Further statistical analysis indicated that bacteria counts were 2.5 times more likely to decrease more than 100 cfu/100 ml after the BioSwales were installed than they were before the installation, a statistically significant difference ($p<0.0005$).

TABLE 1: EFFECT OF BIOSWALES ON WATER QUALITY

Parameter	AverageDecrease After BioSwales[1]	Average Decrease Before BioSwales[1]	Improvement	Units
Ammonia	0.07	0.01	0.06	mg/L
Nitrate	0.28	0.31	-0.03	mg/L
TP	0.012	-0.003	0.015	mg/L
Ortho-P	0.011	0.002	0.009	mg/L
E. coli	185	-354	539	cfu/100 ml

1) Difference between sampling points above the inserts and 175 ft below the inserts

TABLE 2: EFFECT OF BIOSWALES ON WATER QUALITY VARIABILITY

Parameter	Minimum Value	Maximum Value	Average Value	Average Decrease After BioSwales	Average Decrease Before BioSwales[1]	Units
Ammonia	0	0.76	0.10	0.07	0.01	mg/L
Nitrate	0.6	4.83	2.48	0.28	0.31	mg/L
TP	0.02	0.32	0.056	0.012	-0.003	mg/L
Ortho-P	0.02	0.12	0.043	0.011	0.002	mg/L
E. coli	7.5	33000	1256	185	-354	cfu/100 ml

1) Difference between sampling points above the inserts and 175 ft below the inserts

Changes to the fish population and macroinvertebrate population were more marked than the changes in water quality. The number of fish in the stream went from one before BioSwale installation to 2-7 to 0-12* in the years following installation. The macroinvertebrate sampling yielded 0 EPT taxa (families of pollution-sensitive organisms) before BioSwale installation to 4 to 3-4** in the years following installation.

In addition, stream morphology changed. BioSwales raised the level of the streambed by one foot at the first two inserts during the first three years of the project, and the number of riffles and pools increased (Figures 3 and 4).

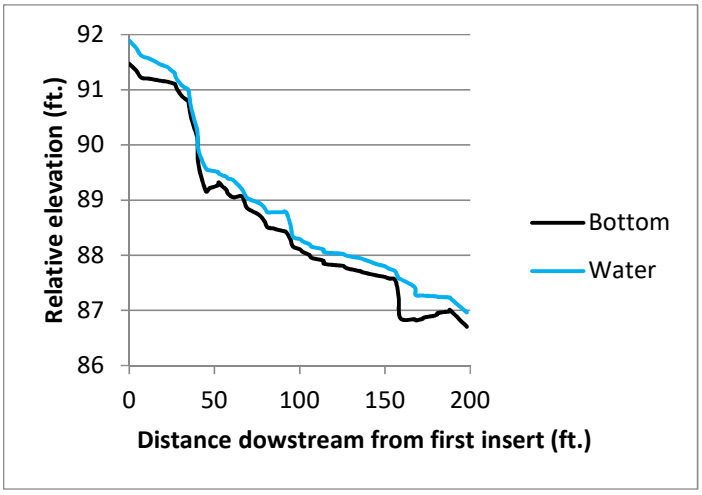

Figure 3:Stream Profile Before BioSwale Installation

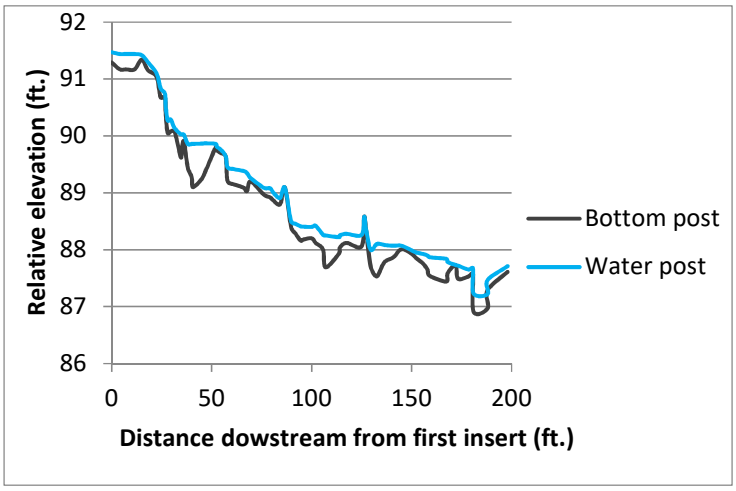

Figure 4: Stream Profile After BioSwale Installation

* - The stream bed had no surface flow when fish were sampled that year.
** - The stream had almost no flow when macroinvertebrates were sampled that year.

Conclusions

In this three-year study, data indicate that Elevated BioSwales (also called BioSwales or stream inserts) improved removal of ammonia, total phosphorus, orthophosphate and *E. coli* bacteria in an intermittent, highly urbanized stream that is impacted by stormwater runoff and failing discharging household sewage treatment systems. Increases in the fish population and in the number of pollution-sensitive macroinvertebrates were also noted during the study, as well as improvements in stream morphology.

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