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A Direct Comparison of Two Commercially Available Storm & Surface Water Filtration Media for Denitrification

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Abstract

The performance of two commonly used, commercially available filter media for storm and surface water filtration are compared for nitrate removal. The excessive release and accumulation of bionutrients in stormwater, wastewater and surface water is the single most important factor contributing to toxic algal blooms and eutrophication in estuaries, lakes and rivers around the world. Nitrate is an important bionutrient that is immediately available for uptake by cyano-bacteria and algae. NutriGone™ patented media (designated Media-NG) is a proprietary mixture of an inorganic carbon, organic carbon source and ion adsorption mineral. Wanielista patented media (designated Media-BG) is a mixture of 68% sand, 25% tire crumb and 7% sawdust by volume. These media are primarily used to assist in meeting environmental regulations involving removal of bionutrients from stormwater prior to discharge, intercepting ground water near surface water interfaces and filtering surface water from ponds and swales. The rates of nitrate removal in 5-gallon pail recirculating filters are observed and recorded for each media. pH is also recorded. Media-NG demonstrates rapid nitrate removal compared to Media-BG. Nitrate level in Media-NG was reduced from 40mg/L to 10mg/L within 30-minutes and to non-detect within 60-minutes. Nitrate level in Media-BG was reduced from 40mg/L to 30mg/L within 30-minutes and to 20mg/L within 60-minutes. pH in Media-BG increased from 6.8 in the nitrate solution, to 7.6 in the filter bed within 30-minutes. pH in the Media-NG increased from 6.8 nitrate solution to 7.0 in the filter bed within 60-minutes. pH in the control increased from 6.8 to 7.0 within 120-minutes.

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Introduction

Nitrate is an important bionutrient that is immediately available for uptake by cyano-bacteria and algae. Excessive nitrate, especially in marine estuaries is a major factor leading to algal blooms, depleted oxygen and eutrophication. Biological filtration systems for removal of nitrate via denitrification are becoming a popular means to help meet state and local surface water quality regulations and standards. It is important to assess performance of commercially available media systems designed to facilitate rapid denitrification.

EcoSense International (ESI) (Burden) developed a media formulation (NutriGone™) intended to maximize biological denitrification and nutrient removal. ESI markets and sells NutriGone™. Wanielista developed a media formulation which is patented and is marketed in the state of Florida and elsewhere. In order to illustrate that NutriGone™ has a marked advantage over the Wanielista media, ESI performed a simple, direct comparison study where equal volumes of each media filtered identical nitrate fortified drainage ditch water.

Material and Methods

Item	Quantity	Purpose
5-gallon pail	5	Filter and control vessels / media storage
12-gallon pail	1	Media mixing and water storage
NG Component BioChar	1-gallon	Media-NG component
NG component Organic	1-gallon	Media-NG component
NG component Mineral	1-gallon	Media-NG component
Rubber crumb	0.75 gallon	Media-BG component
All-purpose sand	2.04-gallon*	Media-BG component
Mixed wood sawdust	0.21-gallon*	Media-BG component
600 µ filter bag	1	Raw water coarse filter
100 µ filter bag	1	Raw water fine filter
Nitrate of soda, 16-0-0	23g	Nitrate source
Aquarium circulation pump	2	Circulation pump for filters
2” ϕ x 13.5” pvc pipe	2	Filter infiltration / collection pipe
Vinyl tubing ¾” ϕ x 10”	2	Pump intake tube
Vinyl tubing ½” ϕ x 18”	2	Pump discharge tube
¾”-1/2” barbed fitting	2	Pump intake tube closure
½” pvc threaded cap	2	Pump intake tube restrictor
Polyester wadding	2	Pump discharge tube closure plug
Funnel	1	Water transfer
Miscellaneous containers		Water transfer, measuring, mixing
Stormwater ditch water	11.5-gallon*	Sample water source

*Approximate measure

Media: The 3-components of Media-BG, 2.04-gallon all-purpose sand (68%), 0.75 gallons rubber crumb (25%) and 0.21 gallons mixed wood sawdust (7%) were mixed in a 12-gallon plastic pail and transferred to a 5-gallon pail temporarily. The 3-components of Media-NG were similarly mixed and transferred.

Infiltration/collection pipe: 2”-pvc pipe was cut and drilled as shown in Figure 1. Each pipe was then sleeved with 600µ nylon mesh to keep media particles from entering the pipe (not shown).

Pump & Tubing Assembly: The two ¾” ϕ vinyl intake tubes were cut and one end of each was fitted with barbed fitting and caps. Two 5/32” ϕ holes were drilled in each cap to allow restricted water flow to each pump. The tubes were then connected to each of the pump’s intake fittings (Figure 2).

Figure 1. Infiltration tubes

The two ½” ϕ vinyl discharge tubes were cut, perforated with 13-1/8” ϕ holes each Then one end of each plugged with polyester wadding and connected to each of the pump’s discharge fittings. Restricted flow rate for the pumps was estimated to be 0.75 gpm (Figure 2).

Filter Assembly: Mesh sleeved infiltration pipes were placed upright in the center of each of the two filter pails. Filter media was then poured in around the pipes to support and maintain their position in the center of the pails. The pump and tubing assemblies were placed so the intake tubes extended to the bottom of the infiltration pipes and the pumps could draw filtered, water (Figure 3). The pump discharges water to the top of the filter bed.

Figure 2. Pump Assembly

Figure 3. Filters set up. Media-BG on left.

Water Source and Collection: Stormwater was collected from a roadside drainage ditch adjacent to ESI offices. This water is a mixture of runoff and groundwater. The ditch bottom is sandy muck and there are a variety of aquatic plants growing in it.

Approximately 11.5-gallons of water were collected with a 5-gallon pail. The water was screened to remove coarse debris using a 600µ nylon mesh while transferring to the 12-gallon pail. A shovel was used to collect about ½ liter of ditch bottom muck. This muck was also screened and added to the water sample. (It is known from previous studies that the muck contains viable denitrifying bacteria.)

Sampled water was returned to ESI lab where it was transferred to two 6.5-gallon containers. The water was filtered through a 100µ nylon filter bag and transferred back to the 12-gallon pail.

Start up Operation: Approximately 6.5 liters of the ditch water sample was transferred from the 12-gallon pail to each filter bed by funneling it in the top of the infiltration pipes. The pumps were primed, started and allowed to run, recirculating the water through the filter beds for 64-hours. This was done to ensure full saturation of the media and to allow establishment of a microbial population in each filter bed.

Inoculation of ditch water with Nitrate: A target concentration of 40mg/L NO_3 (nitrate) was chosen for testing. This concentration was chosen so nitrate concentrations would not be a limiting factor for denitrification and give easily observed removal efficiency.

23g nitrate of soda 16-0-0 was dissolved into 1-liter distilled water. 220ml of this solution was added incrementally to 30 liters of ditch water. After each addition, the ditch water was stirred and allowed to sit for 30-minutes. Nitrate concentration was measured after each addition until the final concentration was 40mg/L-NO_3.

Each of the filter beds were pumped out until dry. Filter bed water was allowed to seep and collect in the infiltration pipes for 30-minutes, then pumped dry again.

8-liters of the 40mg/L-NO_3 ditch water was transferred to each filter, funneled into the infiltration pipes. The pumps were primed and allowed to run. Samples were drawn from each filter for analysis. Samples were taken at 30-minutes, 60-minutes, 120-minutes, 240-minutes and overnight after 16 hours. The control (approx. 14 liters) was also sampled and analyzed. Nitrate and pH were measured at each sampling interval.

Results

Results of analysis are presented in table 1. NO_3 given in mg/L (ND=non-detect)

Table 1: Results of Comparison Study

Media	Sample Times, Nitrate and pH Analysis											
	Start 1:45 p		2:15 p		2:45 p		3:45 p		4:45 p		7:45 a	
	NO_3	pH	NO_3	pH	NO_3	pH	NO_3	pH	NO_3	pH	NO_3	pH
NG	40	6.8	10	6.8	ND	7.0	ND	7.0	ND	7.0	ND	6.8
BG	40	6.8	30	6.8	20	7.6	20	7.6	20	7.6	ND	7.6
Control	40	7.0	40	7.0	40	7.0	40	6.8	40	7.0	ND	7.6