X-Tex-AM®

A NEW SURFACE BONDED ANTIMICROBIAL FABRIC

Introduction

Storm water runoff from impervious surfaces in urban areas contains significant hazardous contaminants, including indicator organisms such as fecal coliform. Such contaminants pose threats to humans directly during recreational uses of surface waters and through seafood consumption, and to aquatic life through chronic and acute exposure to bacteria. Increasing evidence indicates that storm water control systems, catch basins and storm water pipes may be enhancing microbial contamination. These structures act as biological incubators in stagnant or low flow conditions, allowing the microorganisms to flourish exponentially in environments rich in organic and inorganic nutrients. Treating these festering areas with water-soluble antimicrobials or disinfectants is not acceptable, as they would have an adverse effect on aquatic life by contaminating the streams and surface waters they drain into. Also, water-soluble antimicrobials dilute to sub-lethal levels, allowing the development of resistant bacterial populations. Any antimicrobial media used to safely and successfully control bacteria in stagnant or low flow storm water conditions must not leach or dissolve into water or be consumed by the exponential bacteria growth, and must also provide adequate surface area contact.

UltraTech International, Inc. has developed a hybrid filtration fabric merging two patented technologies that meet these criteria for bacterial reduction in storm waters. The X-Tex-AM fabric has an antimicrobial nano-structure covalently bonded to its fibers that will not leach or dilute from the fabric, even with repeated washings. The patented antimicrobial kills microorganisms by molecular physical penetration, electrostatic attraction and electrocution. This physical, rather than chemical, mode of action does not lose strength with use and does not promote adaptive organisms (super bugs). The antimicrobial spectrum is specific to single cell organisms such as bacteria, fungi, yeast and algae. The antimicrobial is bonded to the patented oil removal fabric X-Tex, which provides vast lipophilic interstitial spaces with an open fiber

design. This design allows the flow of water and bacteria to pass freely in all directions in a unique wicking action. The synergy of these patented technologies is illustrated in the time efficacy study that follows.

OBJECTIVE

Presently, little if any information is available on the efficiency of surface bonded anti-microbial fabrics in removing microorganisms in stagnant or low flow storm water conditions. This study was conducted to provide critical information on this emerging technology in the storm water industry. The objective was to conduct a timed bacterial efficacy study on the patented X-Tex filtration fabric, covalently bonded to an anti-microbial nano-structure. This initial study is intended to provide the percent microbial removal over time and to specify the surface area of the fabric per volume of inoculated storm water used. It is anticipated that this information will be useful to storm water professionals in applications of this unique product in new or existing BMP systems and devices.

METHOD

Simulated Contaminated Storm Water

A fecal coliform bacterium was used as the indicator species in this study. The bacterial seed mixture used was obtained from the clarifier at a local sewer treatment plant. A working standard of 40,000 cfu/100 ml was prepared from the seed mixture by adding 20 ml of the seed inoculum into eight liters of BOD phosphate buffered dilution water at pH of 7.2 and kept under aeration for 24 hours. The contaminated storm water was produced by adding 8 liters of the working standard to a plastic drum containing 80 liters of buffered distilled water at pH 7.2 and 10 grams of glucose as an organic substrate. This water was then aerated for 24 hours and analyzed by Spectra Laboratories in Tacoma, Washington for fecal coliform bacteria. The laboratory determined that the simulated storm water contained approximately 4,000cfu/100ml of fecal coliforms.

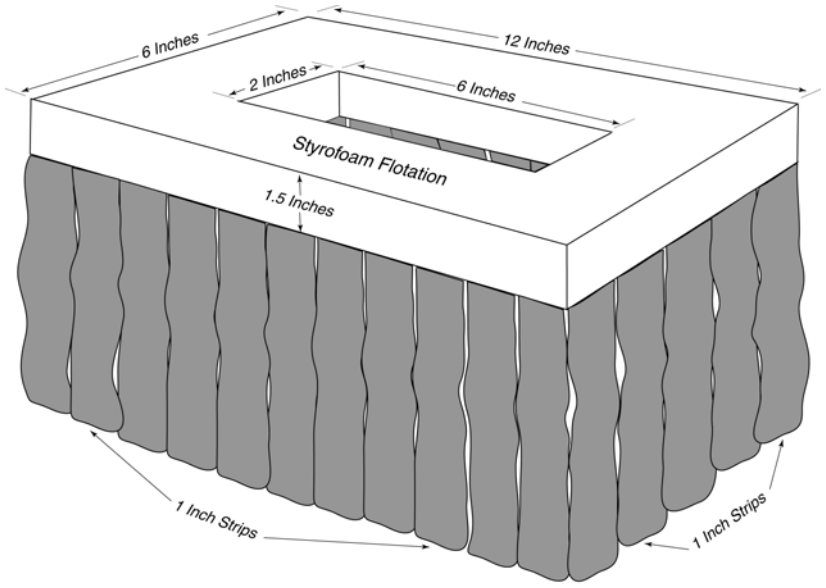
Test Basin Container

Two containers were designed to approximate small urban storm drain basins measuring 18 inches long, 12 inches wide and 12 inches deep. Each had a lid, which was kept closed except for sampling. The containers were insulated to maintain constant temperature for the duration of the experiment.

Antimicrobial Fabric Flotation Apparatus

A three-foot by one-foot strip of the Treated X-Tex-AM fabric was cut from a manufactured roll. The fabric was hot-glued around the perimeter of a Styrofoam frame, with a center cutout used for sampling. The material hanging below the frame was cut into one-inch strips, ending at the Styrofoam frame. The assembled flotation apparatus is illustrated below in Figure 1, showing the dimensions. This design provides three-dimensional contact with the water, as the fabric strips have a density greater than water and hang down from the Styrofoam float. A second apparatus was constructed using untreated X-Tex fabric as the control for comparison.

Fig.1



FABRIC FLOTATION APPARATUS

PROCEDURE

The incubation containers were filled with 40 liters (10.6 Gals) of the synthetic contaminated storm water and allowed to equilibrate for 30 minutes. Initial samples were taken in sterile bacteria sample bottles. The anti-microbial flotation apparatus and the control flotation apparatus were positioned into each of the containers and the timed sampling sequence began. Water samples were taken using a 20 ml sterile glass tube. Four samples were taken from each corner of the container and two from the center; these were combined into sterile bacteria bottles for each timed sample event submitted for testing. The timed sequence of sampling progressed from minutes to hours. The samples were maintained at 4C, and submitted to Spectra Laboratories in Tacoma, Washington within 24 hours of sampling. The samples were analyzed by Method SM9222D for Fecal Coliform MF; the results are as follows:

RESULTS

Constants	X-Tex-AM	X-Tex Control
pH	7.2	7.2
Fabric surface area*	3.0 sq/ft	3.0 sq/ft
Volume water gal	40 liters/10.6 gal	40 liters/10.6
Water temperature	70F	70F
Fabric weight grams	4 oz/124 grams	4 oz/124
Ratio fabric/water	1 / 322	1 / 322

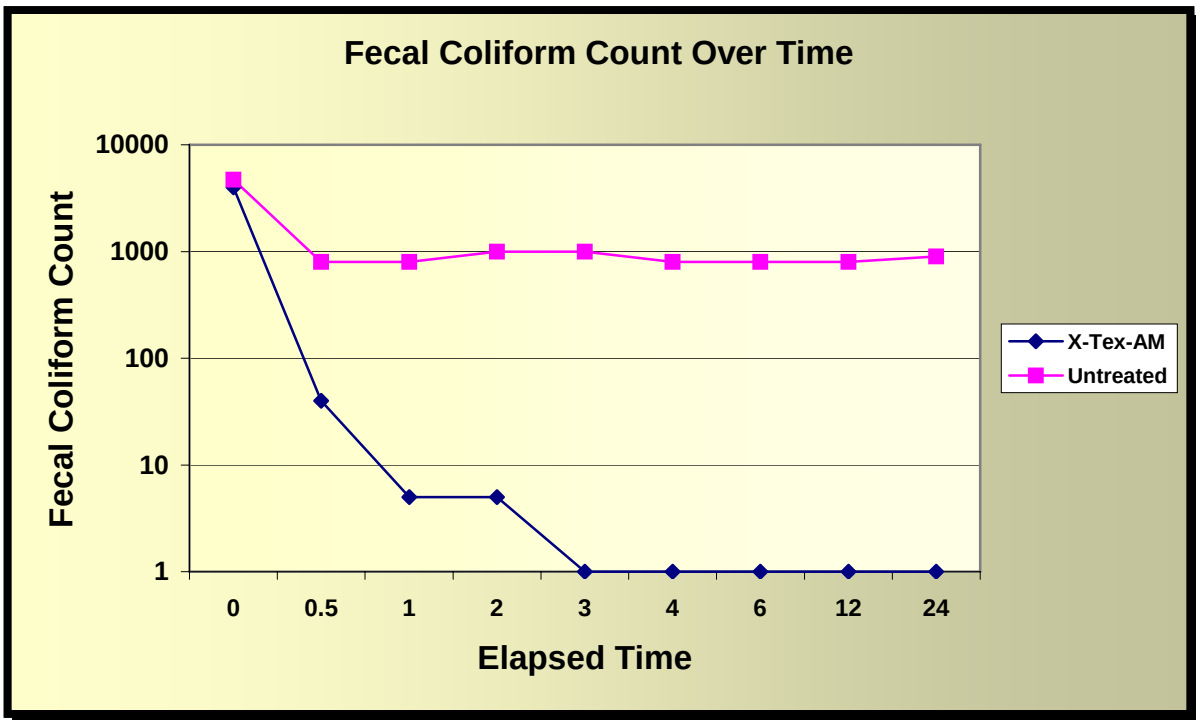
* Note: The surface area of the X-Tex filtration fabric is far greater than its outside physical measurements. It has vast interstitial spaces between the fibers from its proprietary manufacturing process and the recycled fibers have surface area enhancement greatly increasing available surface area compared to virgin fibers.

Table I

Sample Times	Result X-Tex-Am cfu/100ml	Result X-Tex control cfu/100ml	Percent Removal Compared to Control
Initial 0 min.	4,000	4700 *	--
30 min	40	800	95.0
1 Hour	5	800	99.4
2 Hours	5	1000	99.5
3 Hours	0	1000	100
4 Hours	0	800	100
6 Hours	0	800	100
12 Hours	0	800	100
24 Hours	0	900	100

Note* Since the initial untreated control showed a reduction from 4700 to 800 in the first 30 min. one could assume that the fecal coliform were sensitive to some component of the untreated fabric, or were trapped within the vast interstitial spaces of the fabric and therefore, not recovered.

Graph I



DURABILITY AND PERFORMANCE STUDY

To verify that the covalently bonded anti-microbial treatment will retain its efficacy and not leach off the filtration fabric after repeated washing and drying, the following test was performed.

PROCEDURE

The first procedure was repeated using X-Tex-AM that was washed 10 times with warm water and rung dry between washings. The treated fabric was allowed to hang dry overnight. This was done to ensure that any silanequat not covalently bonded to the fabric's fiber would be washed off along with any other component within the fabric that could be chemically detrimental to the fecal coliform. The washed fabric was attached to the flotation apparatus and placed within the incubation container. The conditions of the first procedure were duplicated; the results are as follows:

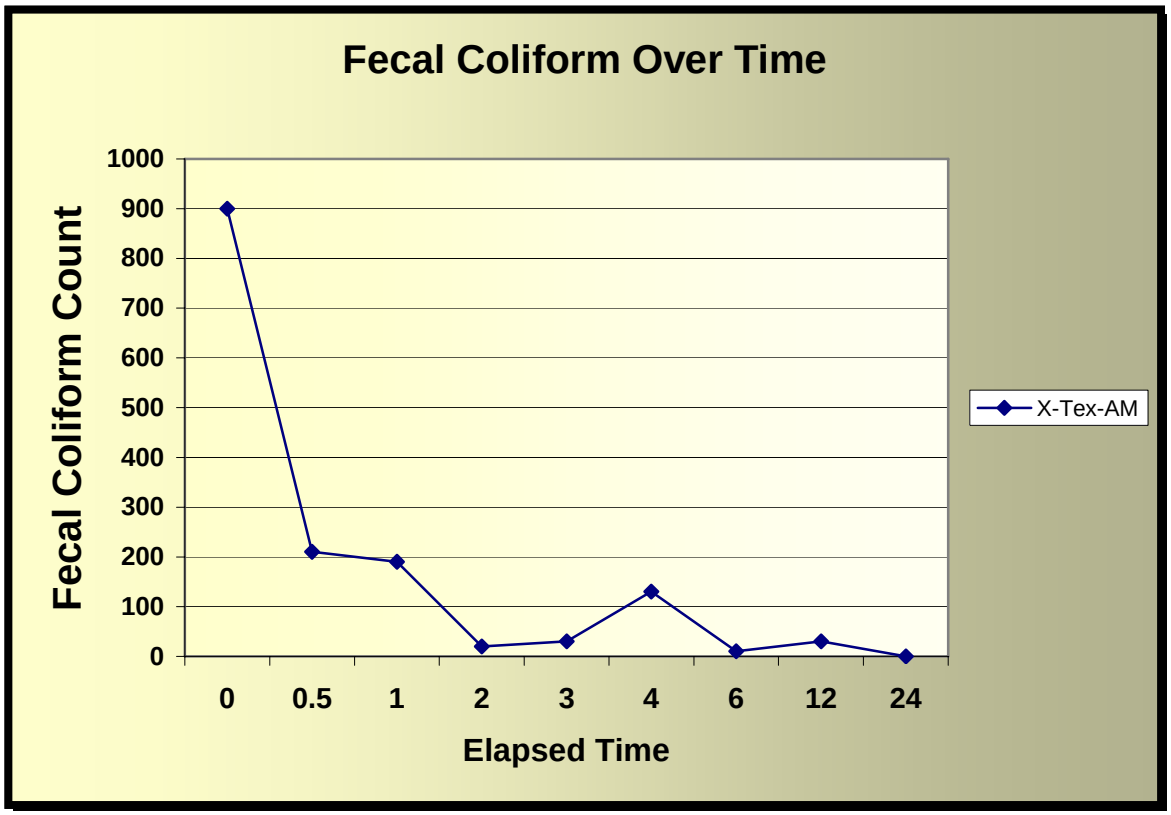
RESULTS

TABLE II

Sample Times	Result X-Tex-AM cfu/100ml	Percent Removal Compared to Initial
Initial 0 min	900	---
30 min	210	76.6
1 Hour	190	78.8
2 Hours	20	97.8
3 Hours	30	96.6
4 Hours	130 *	85.5
6 Hours	10	98.8
12 Hours	30	96.6
24 Hours	0	100

* Note: Possible sampling contamination error

Graph II



Discussion

The X-Tex fabric surface bonded antimicrobial compared to the untreated control fabric removed 95 percent of the population of fecal coliforms in the first 30 minutes of contact, and 100 percent within a three hour period in the control study. The efficacy of the washed fabric removed over 76 percent of the fecal coliforms within the first 30 minutes of contact, and 96.6 percent within three hours. Both stagnant water tests using the treated fabric and the washed fabric maintained 100 percent removal after 24 hours. It should be noted that this study was only monitoring the efficacy for fecal coliform bacteria. Other gram(+) and gram(-) bacteria, mycelial fungi, yeast and algae were also being killed in the simulated storm water. Both the treated fabric and the untreated control experienced a severe drop from the initial bacteria levels. This, as noted, may be caused by bacterial uptake into the fiber matrix, shock to the bacteria being transferred into a new environment, or some component leaching off the unwashed fabric that is detrimental to the bacteria. The fecal coliform population stabilized to 800-1000 cfu/100ml in the untreated control, but dropped to non-detectable levels with the treated fabric. The washed fabric illustrated similar efficiency; however the initial fecal coliform count was 900 at the start of the test. This may be due to the longer stabilization time allowed before taking the initial sample.

Conclusion

Unlike a chemical pollutant, bacterial contamination is dynamic and grows exponentially from one bacterium into billions within 24 hours under optimal conditions. Bacteria will also adapt and mutate to develop resistant populations when water-soluble antimicrobial agents or disinfectants are used. This is because they dilute out to sub-lethal levels, allowing adapting resistant forms to persist and endangering storm water to resistant bacterial populations. The X-Tex-AM tested in this study was designed to overcome these problems by using an immobilized surface bonded silanequat that kills bacteria by molecular penetration and electrocution. Since the antimicrobial is covalently bonded to the fabric, it will not dilute to sub-lethal levels and the physical kill mechanism will not be consumed by repeat bacteria contact.

The unique X-Tex fabric was designed as an oil filtration fabric with vast interstitial spaces and enhanced fiber surface area. The fabric's open design allows the free flow of water in every direction and has great wicking ability. When coupled with a surface immobilized antimicrobial nano-structure, the resulting fabric becomes a powerful delivery system for bacterial removal in our nation's storm water systems.

The applications are immense as the fabric can be cut, formed or molded for use in any new or existing BMP system or design and it is cost effective, durable and resistant to bio-fouling. Areas of applications would include cisterns, pipes, drain basins, culverts, cooling towers and any other stagnant water areas contaminated with bacteria or oil.

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