

ADSORBIT/AM

Surface Bonded Antimicrobial Fabric Test Data Showing 100% Removal of Fecal Coliforms

INTRODUCTION

Water runoff frequently contains significant hazardous contaminants including microbial pathogens and indicator organisms such as fecal coliform. Such contaminants pose threats to humans directly during recreational uses of surface waters and seafood consumption; and to aquatic life through chronic and acute exposure to bacterial pathogens. During stagnant or low flow conditions, the microorganisms flourish exponentially in environments rich in organic and inorganic nutrients. Treatment with water-soluble antimicrobials or disinfectants is not acceptable, as they would have an adverse effect on aquatic life when drained into the streams and surface waters. Also, water-soluble antimicrobials will dilute to sub-lethal levels allowing resistant bacterial populations to persist. Any antimicrobial media used to successfully control bacteria in stagnant or low flow conditions must not leach or dissolve into water, nor be consumed by the exponential bacteria growth, and also provide adequate surface area contact.

The ADSORBIT/AM fabric has an antimicrobial nano-structure covalently bonded to its fibers which 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 ADSORBIT Filtration Fabric which allows the flow of water and bacteria to pass freely in all directions.

OBJECTIVE

Presently, little if any information is available on the efficiency of surface-bonded antimicrobial fabrics in removing microorganisms in stagnant or low flow water conditions. The objective was to conduct a timed bacterial efficacy study on the ADSORBIT Filtration Fabric, covalently bonded to an antimicrobial nano-structure. This initial study is intended to provide the percent microbial removal over time, and specify the surface area of the fabric per volume of inoculated water used.

METHOD

Contaminated Water

Fecal coliform bacteria were 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 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 for fecal coliform bacteria. The laboratory determined that the contaminated water contained approximately 4,000cfu/100ml of fecal coliforms.

Test Container

Two containers measuring 18 inches long, 12 inches wide and 12 inches deep were used for the test. 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 ADSORBIT/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. This design allows 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 also constructed using untreated ADSORBIT fabric as the control for comparison.

PROCEDURE

The incubation containers were filled with 40 liters (10.6 Gals) of the synthetic contaminated water and allowed to equilibrate for 30 minutes. Initial samples were taken in sterile bacteria sample bottles. The antimicrobial 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 the lab within 24 hours of sampling. The samples were analyzed by Method SM9222D for Fecal Coliform MF; the results are as follows:

RESULTS

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

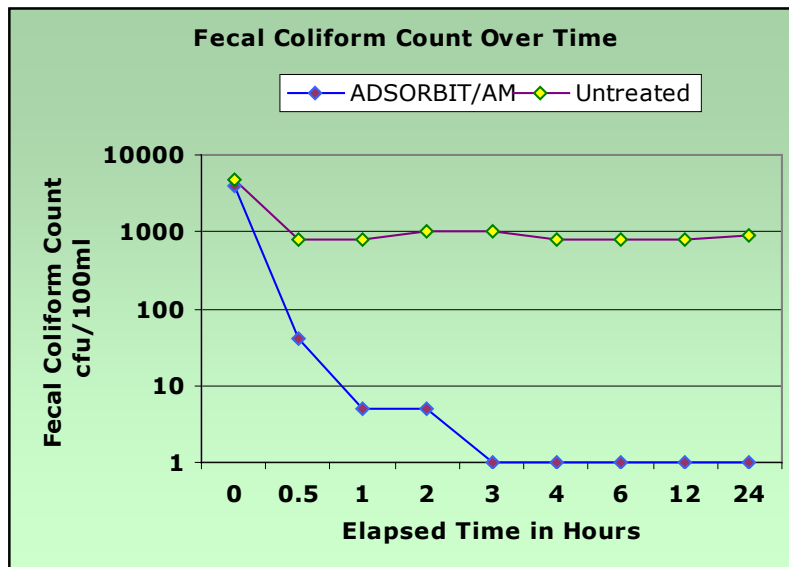
* Note: The surface area of the ADSORBIT filtration fabric is far greater than its outside physical measurements. It has vast interstitial spaces between the fibers from its proprietary manufacturing process and the recycled fibers have surface area enhancement greatly increasing available surface area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

Table I

Sample Times	Result ADSORBIT/AM cfu/100ml	Result ADSORBIT Control cfu/100ml	Percent Removal Compared to Control
Initial 0 min.	4000	4700	n/a
30 min.	40	800	95%
1 hour	5	800	99.40%
2 hours	5	1000	99.50%
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 was 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 if the covalently bonded antimicrobial 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 ADSORBIT/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 antimicrobial 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:

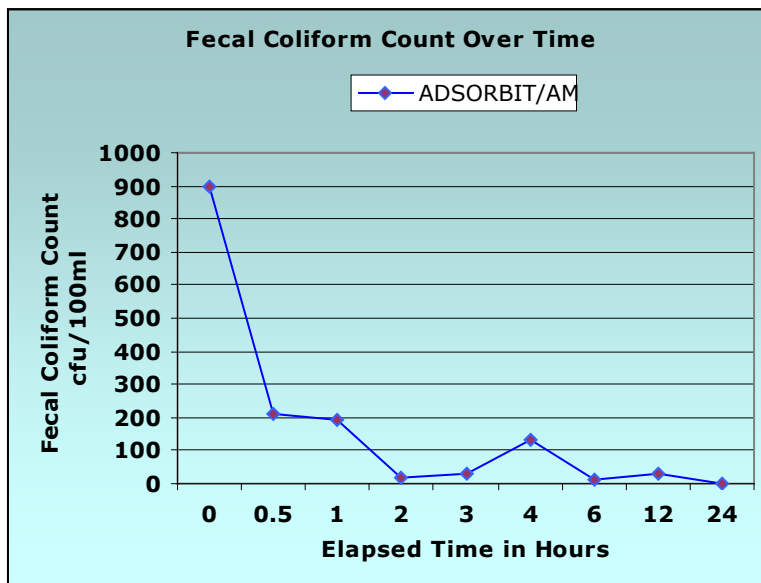
RESULTS

Table II

Sample Times	Result ADSORBIT/AM cfu/100ml	Percent Removal Compared to Initial
Initial 0 min.	900	n/a
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 at the 4-hour sampling event.

Graph II



DISCUSSION

The ADSORBIT 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 min. 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 contaminated water. Both the treated fabric and the untreated control experience a severe drop from the initial bacteria levels. This as noted may be caused by bacterial up take 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, endangering water to resistant bacterial populations. The ADSORBIT/AM tested in this study was designed to overcome these problems by using an immobilized surface-bonded antimicrobial which kills bacteria by molecular penetration and electrocution. Since the antimicrobial is covalently bonded to the fabric, it can't dilute to sub-lethal levels, and the physical kill mechanism is not consumed by repeat bacteria contact.