Battling Beach Runoff Pollution

Rhode Island provides positive solution to runoff pollution at popular Scarborough Beach.

By J. I. Shane

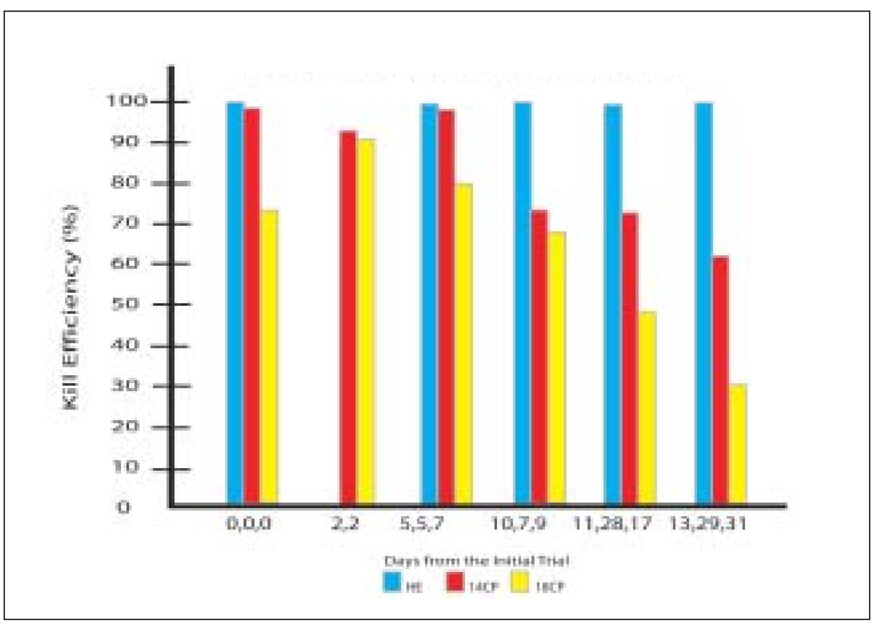
Impaired water quality caused by urban and stormwater runoff arguably poses one of the greatest threats to our nation's waterways, but fortunately many municipalities are finding innovative ways to fight the problem. Rhode Island's Scarborough State Park Beach in Narragansett—attracting over a half million people in the summer months—demonstrates one such example.

Three years ago, this popular beach was closed six times due to health-threatening levels of bacteria. However, the following year, the Natural Resources Defense Council's 2004 Annual Report identified it as one of the three top performers in the nation for protecting its beachgoers from contaminated water.

Edward Szymanski, Environmental Associate Chief Engineer, Rhode Island Department of Transportation (DOT), helped explain how this reversal came about. "In 2004, Governor Carcieri asked us to look into what was causing the problem and come up with a solution. Almost immediately, the state departments of Transportation [DOT], Environmental Management [DEM], and Health [DOH], began an expedient collective effort. Our goal was to implement a solution before the summer."

As Szymanski explained, the core of the solution involved diverting the flow of runoff from Scarborough's stormwater outfalls through a unique filtering system using Smart Sponge® Plus (Abtech Industries, www.abtechindustries.com), an antimicrobial filtration material, recommended by Cindy Baumann, Director of Engineering for Crossman Engineering, Inc. (www.crossmaneng.com) and the chief project consultant. "The DOT obtained the funding for the project under the Intermodal Surface Transportation Efficiency Act of 1991, which was set up to develop innovative methods for improvements of highway stormwater runoff," Szymanski added.

Baumann said that the project to date could be best explained in three stages. "In stage one, we identified the problem, designed a solution, and tested its effectiveness. In stage two, the University of Rhode Island conducted laboratory testing to provide data on increasing water flow rates and evaluating the removal efficiency of the antimicrobial material for two health-threatening bacteria. Stage three involved designing a retrofit to provide for greater efficiency."



Enterococci Kill Efficiency HE, 14CP and 18CP at 2.5 ft.

Stage One

During stage one, Baumann designed a system of 100-ft pipes running parallel to existing pipes that exit into the bay. The new drainage piping was filled with Smart Sponge Plus, which removes contaminants, destroys bacteria, and improves the water quality before it discharges into the bathing waters.

Baumann said that the decision to use the antimicrobial material was arrived at after the project team evaluated various Best Management Practices (BMPs) for treating bacteria within stormwater runoff. "We evaluated other BMPs such as storage and pumping to a waste water treatment facility, ultraviolet disinfection, chlorination and de-chlorination systems, infiltration systems, constructed wetlands, and rock filters. After eliminating these BMPs because of site constraints, costs, or resulting hazardous material requirements, we selected the anitmicrobial filter material," she said.

The antimicrobial filter material had not previously been used in this type of application, but it had proven effectiveness for removal and reduction of bacteria concentrations in stormwater runoff with the Ultra Urban Filter® Catch Basin Insert. These filtration systems encapsulate and remove harmful substances, including hydrocarbons, oil, grease, and other toxins, before they enter waterways.

The technology for Smart Sponge and Smart Sponge Plus ("Plus" means the antimicrobial agent is present.) was initially used for cleaning up oil spills, but is now being used more and more frequently to treat stormwater runoff in streets, parking lots, and other impervious surfaces in over half of the states in America.

The sponge-like material resembles popcorn, and it not only removes pollutants from the water but destroys bacteria. Rodolfo Manzone, Ph.D., AbTech's Executive Vice President and Chief Technology Officer, said, "The Smart Sponge Plus employs an antimicrobial agent, chemically bound to the polymer filtration material, which inactivates health-threatening microorganisms without releasing chemicals or leaching. Simply put, it acts by rupturing cell membranes—preventing potentially harmful microorganisms from functioning, developing, or reproducing."

Szymanski said that an important part of the project's initial stage was to assess the filter material's effectiveness for reducing and removing bacteria within stormwater runoff and to evaluate the amount of flow being treated by the filter system under various dry weather and wet weather conditions.

The samples taken were evaluated for two bacterial parameters—fecal coliform and enterococci. Fecal coliform is found in the feces of all warm-blooded animals. Historically, fecal coliform was used as an indicator of unsafe swimming conditions. In 1986, the EPA examined the relationship between swimming associated illnesses and the microbiological quality of the bathing waters. The EPA found that fecal coliform bacteria showed little correlation to swimming related illnesses in salt water environments.

On the other hand, enterococci showed a better correlation with swimming related illness. Enterococcus is a bacteria found in human feces as well as some animals and birds. Because it's more resistant than fecal coliform to saltwater, it serves as a better long term indicator of saltwater pollution. Over the 2004 beach season, the DOH adopted a posting limit for enterococci of 104 CFU/100mL and a geometric mean (five samples over 30 days) of 35 CFU/100mL, based on EPA requirements.

The sampling tests were conducted in dry weather and wet weather. Based on the results, the system was effective at reducing and removing bacteria from stormwater runoff for that portion of the flow that was diverted through the filter system.

"The Smart Sponge Plus has excellent removal rates," Szymanski said. "In both dry and wet weather sampling, the maximum removal rates for fecal coliform ranged from 89.4 to 99.8 percent. In the sampling process for enterococcus, the maximum removal rates ranged from 96.2 to 99.9 percent. The challenge for us was to increase the amount of water passing through the treatment pipes. We also needed to determine what the removal rates would be with various densities of the antimicrobial filtration material."

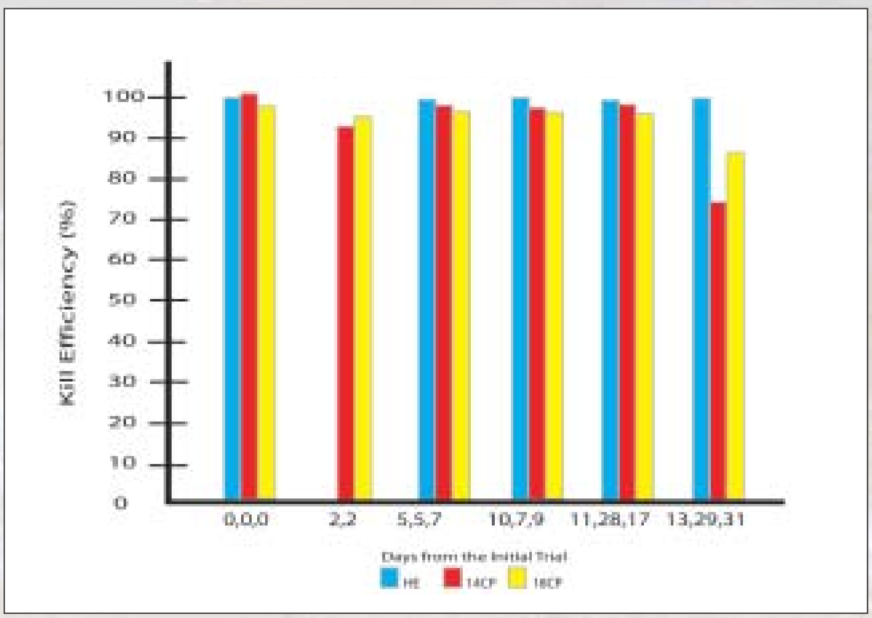
Stage Two

Thus began the second stage of the project. Szymanski said that the University of Rhode Island's Civil Engineering Department (Raymond Wright, Ph.D. and George Veyera, Ph.D.) and Crossman Engineering were asked to conduct laboratory testing to determine flow rates through the antimicrobial material for various densities and physical characteristics. The findings of this study were then used to provide the needed data for investigating the treatment efficiency of the material—a process that followed the laboratory testing.

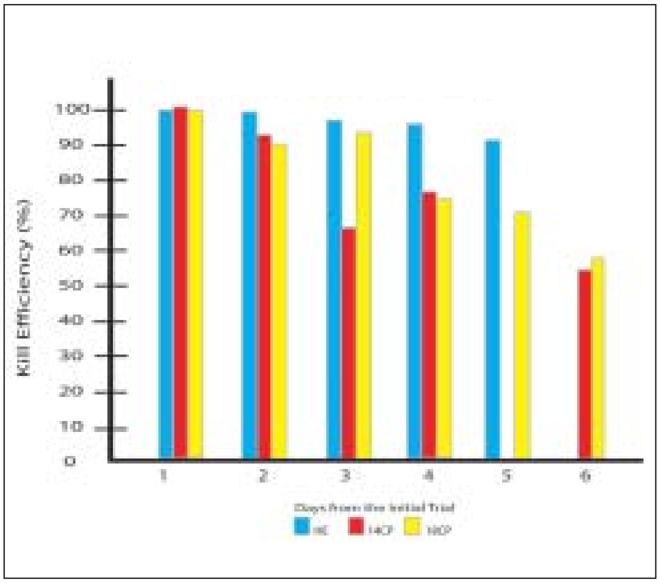
The hydraulic evaluation was designed, constructed, and tested under a variety of carefully controlled conditions. Baumann said that their primary objective was to determine flow rates through the antimicrobial material using various pipe diameters, hydraulic heads, pipe slopes, and densities.

Here are some general conclusions derived from the laboratory testing:

- The highest outflows occurred for the lowest density in the antimicrobial filter material.
- The process used to pack the antimicrobial material in the pipes impacted the outflow. Cold pack (CP) is simple gravity packing. Hot extruded (HE) pipes are filled in the factory before shipping.
- Empirical equations were developed



Enterococci Kill Efficiency HE, 14CP and 18CP at 5.0 ft.



Average Last Three Runs (HE-3, 4, 5 and CP-6, 7, 8).

to allow for estimating the outflow for any antimicrobial filter material packed density.

- Empirical equations were developed to allow for estimating outflows at pipe diameters greater than 12 in.

Baumann said that the specific results of the laboratory tests provided guidance for developing the field testing program—also conducted by the University of Rhode Island's Civil Engineering Department. After determining the basic hydraulic behavior of the antimicrobial filter material over a range of parameters, the next objective was to provide information about the effectiveness of the antimicrobial filter in the treatment of diluted wastewater (equivalent to stormwater concentrations) for the elimination of fecal coliform and enterococci bacteria.

"The field tests were designed to set up a situation that simulated stormwater flow," Szymanski said. "We needed to find out the impact of different hydraulic heads, various filter densities, and types of packing in a controlled field experiment. We also needed to evaluate the length of treatment pipe required to meet our goals for removing bacteria."

Here are some of the conclusions derived from the field testing report:

- All three densities of antimicrobial material that were used provided significant removal of enterococci and fecal coliform. HE provided the highest efficiency in the shortest length of pipe. The HE pipe provided 97 percent removal of enterococci by the first sample point at 2.5 ft. The HE pipe provided the fastest and most consistent removal of fecal coliform starting out at 80 percent by ten ft and reaching 90 percent between 30 to 40 ft.
- The CP densities (14 CP and 18 CP) did well in providing acceptable kill efficiencies of enterococci and fecal coliform. Data suggests that the CP prepared pipes will require longer exposure to the material (longer pipes) and may result in a slightly lower kill efficiency in the case of fecal coliform. However, the cold pack process provides several advantages over the hot extruded process. CP pipes can be prepared on site and can be easily customized to fit any design in the field. In addition, the flow rate through CP pipes is superior to the flow rate through HE pipes.
- The process of bacteria removal does not impact the flow rate.
- The flow rates through any densities need to be improved while maintaining kill efficiency. The packing methods and/or containment system needs to be further examined.
- The removal efficiency rate of the filter material does decrease over time and the system needs to be maintained at regular intervals.
- There were no measurable differences with respect to enterococci kill efficiency between the high and low head. This indicates that removal efficiency is not dependent on flow (or velocity) and allows the designer to focus on increasing the energy grade line to improve flow rate without concern for a reduction in kill efficiency.

Stage Three

Baumann explained that the information gained from the two stages of testing has been significant in designing a retrofit. "We learned that we didn't need a 100-ft pipe to achieve a high bacteria removal rate. We need only about five ft for enterococci and about 20 to 30 ft for fecal coliform. We've modified the original design and installed a filtration system within the outfall pipes with three to five ft of Smart Sponge Plus at three outfalls. We also realized that we can remove the filtration material during the winter months and put it back in place at the start of the summer when the beach is used recreationally."

Baumann said that the project team was pleased with the testing program and the results and will continue to improve on the project. As technology continues to develop, the project team is ready to take advantage of it. For example, at the project's inception, the second generation of the antimicrobial material was used. By the time the testing began, a fourth generation was available that is currently being used.

Szymanski concluded, "Pollution of our waterways has evolved over many decades and isn't a problem we're going to solve overnight. The important thing is to continue our commitment to finding scientific solutions to the problem—along with educating people on how their actions affect the environment. We have a cutting edge project in place. Although the Smart Sponge Plus can be used in multiple applications, we were the first in the nation to use it in a pipe application. After extensive testing, we have complete confidence in the Smart Sponge Plus's antimicrobial capabilities. Now it's simply a matter of fine tuning to increase efficiency in the hydraulic effect and to maximize contact between contaminants and the antimicrobial material. Our goal is always to protect our beaches and keep the water quality safe for all our citizens." GE

Ms. Shane is a lecturer in the Civil and Environmental Engineering Department at the University of California at Los Angeles.