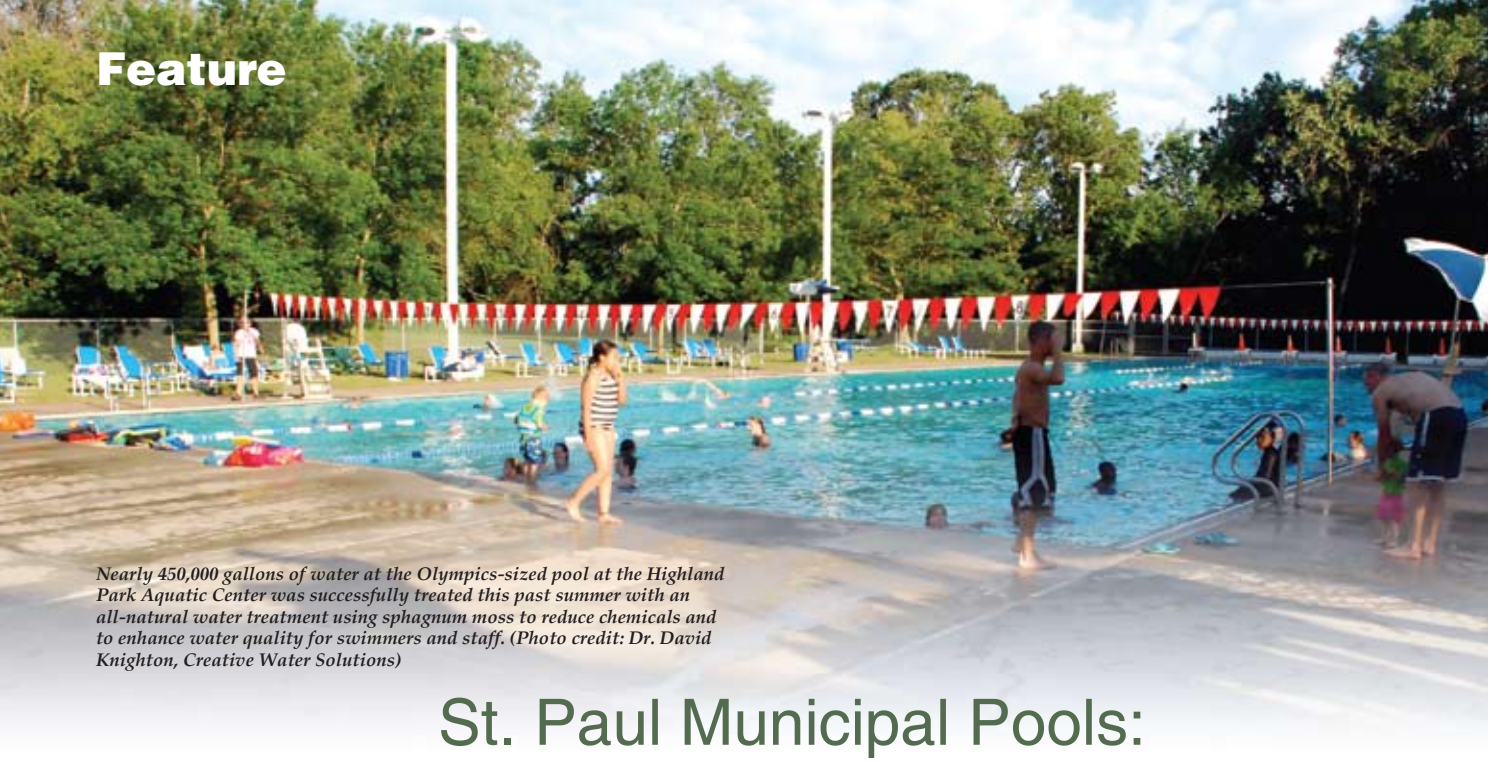

Nearly 450,000 gallons of water at the Olympics-sized pool at the Highland Park Aquatic Center was successfully treated this past summer with an all-natural water treatment using sphagnum moss to reduce chemicals and to enhance water quality for swimmers and staff. (Photo credit: Dr. David Knighton, Creative Water Solutions)

St. Paul Municipal Pools: Promising Results with Moss Water Treatment

By David R. Knighton, M.D.

With a new pool season approaching across the country, some important results from a pilot program in St. Paul, MN are in, using a species of sphagnum moss to condition the water of several municipal pools. After treating two of the four pools at Highland Park in St. Paul for the 2009 summer season, beginning in late May, the St. Paul Parks and Recreation Department and the company contracted to carry out the research, have presented Beta I results for use of all-natural sphagnum moss as a clean technology agent to improve water quality, as defined by water clarity measurements using a turbidity meter. The meter showed that the moss-treated pool consistently achieved less than 0.04 NTU throughout the summer (pools are traditionally considered clear at 3 NTU), while also significantly reducing chemical loads and costs, Beta II tests will continue into 2010.

Sphagnum moss from New Zealand in its natural state before its leaves are hand-harvested, sterilized and compressed for all-natural water treatment in pools and spas. (Photo credit: Vance Fiegel, Creative Water Solutions)

Aquatic center configuration

Two pools were treated at Highland Park Aquatic Center (HPAC), the Olympic-sized 440,000-gallon (1,665,581-liter) main pool, and the 22,500-gallon (85,171-liter) children's activity pool. The City of St. Paul and its partners selected the Highland pools because they provided two control pools that were not treated with the moss and two that were.

This was an ideal setting to conduct a controlled, real-world experiment—with measurement and survey support—to see if the pools' chemical loads, especially chlorine, could be lowered for cost savings, more natural water conditions, and less harmful impacts to swimmers' bodies, suits and pool hardware. It also allowed for a safe, but healthier, swimming environment that met all of the standards required by the City of St. Paul, in accordance with the *Minnesota Pool Code, Minnesota Rules (Parts 4717.0150* through *4717.3975)*.

All previous water treatment was left in place at the four pools. The larger Highland Park lap pool sits opposite the diving pool (one of two pools not receiving treatment). Specially processed sphagnum moss was used in customized strainer bags enclosed in crates and tethered within the lap pool's underground surge tank.

The smaller children's activity pool relied on the sphagnum moss treatment in an arrangement more similar to a residential pool system, with off-line tanks housing the necessary sphagnum moss dosage. A nearby splash deck was not treated.

The setup was cleared with the Minnesota State Health Department before the system was installed. The staff was informed of the experiment, but the change was kept a secret from all swimmers until August. Throughout the summer, the pool chemistry, water management, client satisfaction and bather loads were monitored, using measurements against data from 2008. Using previously acquired research with the moss in the residential settings, the test in the big public pools was launched, armed again with an all-natural water solution.

Positive outcome mirrored nature

Sphagnum moss and biofilm research was extensively

covered in "Sphagnum Moss, Bacterial Biofilm and Water Quality" (see *WC&P*, November 2008). To recap briefly, recent research shows that almost all types of bacteria form colonies (microscopic neighborhoods) on any surface that is in contact with water. These colonies constitute what we now know as biofilm.

The pools acted as a laboratory setting that yielded positive results, similar to what sphagnum moss does in northern Minnesota lakes. For eons, the sphagnum moss bogs of northern Minnesota—and other bogs throughout the world—have acted as natural filters and water conditioners that stabilize and clarify water.

Imagine a coral reef, a colony of billions of tiny sea creatures that make their home by secreting a material that hardens into a rock-like structure. Take this coral reef and make it microscopic, replacing the coral animals with bacteria and you have biofilm. Whenever bacteria, water and a surface are combined, bacteria migrate to the surface and set up housekeeping. These colonies are quite complex in design. The first bacteria that adhere to the surface produce and secrete a sticky matrix of complex sugar molecules that also incorporates proteins, nucleic acids and other compounds from the immediate environment. Just like coral, this substance protects bacteria from attack by chemicals or other agents that can destroy them. Sheltered by this biofilm, they divide and increase their colony size as long as they have sufficient nutrients and enough fluid flow to remove their waste products.

Wet sphagnum moss pulled from the surge tank for the Olympic-sized pool. The moss significantly reduced chlorine loads, pool maintenance and impacts to swimmer's eyes, skin, hair and swimsuits. (Photo credit: Laurel Edwards, City of Saint Paul Parks and Recreation)

As bacteria grow, the biofilm colony expands. Eventually, it develops a complex array of channels (functionally similar to our blood vessels) that bring nutrients closer to the cells and more efficiently remove waste products. Biofilm colonies also share information among their members to enhance survival in the event of attack, reduced nutrient levels or desiccation of their fluid environment. Small pieces of biofilm sometimes break off and float away to begin a new colony. Individual bacteria can also break free and establish new biofilm neighborhoods on other surfaces.

Recent research from the Center for Biofilm Engineering at Montana State University (www.erc.montana.edu/) showed that the biofilm matrix *absorbs* chlorine, bromine and other reactive ions into the sticky molecular matrix that covers the living bacteria. The ions may kill the bacteria closest to the surface, but billions of bacteria remain unharmed in the depths of the biofilm. These bacteria also quickly divide to replace the ones killed by the chemicals.

The problem then is that conventional sanitizing chemicals in pools don't deeply penetrate the biofilm—or kill most of the bacteria. But nature has created an effective way to penetrate biofilm and reduce bacterial proliferation. These natural antibacterial properties are currently being studied in the laboratory. Certain species of sphagnum moss (a plant that grows in bogs as a carpet of floating vegetation)can inhibit the formation of biofilm in laboratory tests.

Initial research on sphagnum moss and bacteria looked at the proliferation of bacteria in idealized liquid cultures with and without the moss. It looked at many different types of bacteria, algae, fungus and mold and found that the correct species of moss inhibited the proliferation of bacteria without killing them. If the moss was removed, then the bacteria would continue to grow (see US Patents 7,497,947 and 7,625,486 and 7,625,489).

Additional laboratory studies using standard biofilm methods, under controlled conditions, allowed the company to measure a significant decrease in biofilm formation compared to controls using a *Psuedomonas* biofilm, and the correct species and dose of moss. How the moss actually inhibits biofilm formation is still being investigated.

Sphagnum moss is a soft, leafy plant with small leaves and stems almost a foot long. It can be easily harvested and spontaneously re-grows in three to five years, depending on the climate. It's found in the higher latitudes of both the northern and southern hemispheres. The lakes in the Boundary Waters—and, more generally, in northern Minnesota, Wisconsin, Michigan and southern Ontario, Canada—all receive their water from huge expanses of bog that contain many species of sphagnum moss.

The correlation between the presence of this moss and the purity and healthfulness of the surrounding water did not escape the long-time inhabitants of these areas. In fact, several Native American tribes have long considered sphagnum moss sacred because of its healing properties. For centuries they used it to pack wounds to aid in healing. They also used it as a natural diaper for babies.

Later, explorers from northern Europe used this moss to keep food from spoiling and to keep drinking water fresh. In fact, sphagnum moss is what allowed the Vikings to travel to Iceland, Greenland and North America by preserving their food and water during long ocean voyages. Once antibiotics, refrigerants and other modern forms of healing and preservation were discovered, however, the remarkable effects of sphagnum moss were largely forgotten until more recently when the company began testing it early in the 21st century.

There are hundreds of species of sphagnum moss. Yet not all types possess this property. After years of testing, the company was able to identify two species with the highest water conditioning activity. The value of sphagnum moss for pool and spa owners has been very positive, and anecdotally recorded that the moss helps keep the water clear and clean; there is no foaming, no discoloration, no smell and no taste. The moss also keeps water pH stable at 7.4. Further, water treated with moss typically requires only 20 to 30 percent of the chlorine or bromine it would otherwise need to maintain the state-regulated level of sanitizer. As a result, spa and pool owners would not need to change the water as often.

Work in residential pools over the past several years provided solid data that the moss was an effective clean green technology. But would it work in an Olympic-sized pool with more variables, including fluctuating bather loads and a couple of wild-card situations?

Water management, bather loads and cotton seed

Conceptually, the surge tank of the Highland lap pool was converted to an artificial moss bog as swimmers began the pool season. Summer 2009 in Minnesota was not one of the best for attendance. It started off sunny and warm in June and early July and was cool in August. Compared to the 2008 summer season (sunny and hot for three months), HPAC still surpassed 2008 attendance by the end of June, and ultimately set a record for

both attendance and revenues.

St. Paul pools are managed by an experienced team of professionally trained CPO-certified employees. They received additional training before installation of the all-natural system, and were told to treat the water in accordance with State of Minnesota standards.

Turbidity was measured with a portable turbidity meter. Using the NTU units, spa and pool water previously exposed to the moss attained 0.04 NTU. This same test was conducted with the St. Paul pools with similar results in both. And that's when one of the 'wild cards' entered the picture. The Twin Cities had one of the most intense cottonwood seed-dropping periods in recent memory. It often looked as if it was snowing during June.

Turbidity started to increase above 1.0 NTU. This increase, while well below that accepted for clarity for pools of three NTU, required investigation of the system. The strainers were about 60-percent plugged with cotton seeds. After the strainers were cleaned, turbidity returned to levels below 0.05 NTU. Throughout the summer, turbidity measurements provided warning of problems with filtering and water management systems before they caused a change in water safety.

Dr. David Knighton, who 'discovered' the water treatment and conditioning properties of sphagnum moss, examines a moss refill that helps control biofilm formation in the children's activity pool at the Highland Park Aquatic Center. (Photo credit: Laurel Edwards, City of Saint Paul Parks and Recreation)

Another wild card, related to the cottonseed problem, occurred just two weeks after sphagnum moss was introduced when a filtration pump automatically shut off in response to unusually high amounts of cottonwood seeds causing backpressure. The pump shut down and went unnoticed overnight, and the lack of filtration significantly clouded the lap pool. The pool recovered within one day, however, without pool closure and without the use of chemicals, whereas water clarity previously took up to four days under the older, conventional water treatment system.

Water chemistry and chlorine protected by cyanuric acid

The contractor, based on four years of previous experience with residential pools, had a roadmap to follow when monitoring water chemistry of the two public pools. Like residential pools, there was an immediate increase in free chlorine. At one point, it was eight ppm with no combined chlorine.

Pool engineers were reticent to decrease ORP, fearing the free chlorine would plummet; however, ORP was decreased by increments of 10 mV when free chlorine was greater than four ppm. As the season progressed, ORP settled at 650 mV with free chlorine levels of two to three ppm, with no recorded combined chlorine.

The next change involved cyanuric acid. Cyanuric acid is commonly used in outdoor pools to protect chlorine from degradation by UV light, and it is commonly added to stabilize chlorine under the names dichlor and trichlor. In 2008, the effect of cyanuric acid on chlorine oxidation in spas and pools in Arizona, New Mexico and southern California was explored. The company's scientists documented that cyanuric acid is denser than water, so it sinks and starts to affect hypochlorus acid oxidation at levels above 30 ppm. Most importantly, no scientific articles documenting the chemistry of how cyanuric acid protects chlorine from UV degradation were found.

Since cyanuric acid sinks, the levels can be very high at the bottom of the pool, possibly explaining why algae blooms usually occur in the deep end of the pools. Cyanuric acid levels at the bottom, mid- and surface-levels at the deep end of the Olympic-sized pool were different: at the bottom, they were above 100 ppm, 50 ppm at mid-level and 20 ppm at the surface.

After conferring with St. Paul's traditional water management consultant, the contractor started a gradual decrease in cyanuric acid delivery by 10 ppm each week. By the end of July, no more cyanuric acid was added to the pool, and levels gradually decreased to zero at the surface and 10 ppm at the bottom.

Pool engineers, concerned there would be no free chlorine in the pool with the decrease in cyanuric acid delivery, were ready to add it by hand if the free chlorine decreased to one ppm. Throughout the remainder of the summer, however, free chlorine levels remained at two to four ppm with no cyanuric acid.

Hardness, pH and alkalinity were stable throughout the study period. Even with the 1,000-plus bather days and hot weather, the pH required almost no adjustment beyond the controller—in contrast to the previous year, when frequent additions of bicarbonate were needed. Hardness stayed at 500 throughout the summer.

Promising results

Chemical use

Based on the results, decrease of chemical use was confirmed. By mid-summer, chlorine use dropped by half and even further by the end of the season. Cyanuric acid was discontinued. Bicarbonate and acid use also fell to half the levels of the year before.

Maintenance

Prior to using sphagnum moss in the public pool, the play features in the kid's pool were faded and some were almost white. The paint on the features was fading in the sun, even with lifeguards cleaning the water lines and features weekly. The common wisdom is that the whitish discoloration is calcium carbonate that precipitates on the surface of the play feature or water edge. The company hypothesized that this discoloration is a biofilm-based matrix, which incorporates precipitated ions such as calcium carbonate. It also hypothesized that inhibition of biofilm formation removes the matrix so precipitation doesn't occur. Based on previous experience, after moss conditioner is added to a pool, two to three weeks later, the precipitated calcium carbonate is found as a powder on the bottom of the pool. After vacuum removal of the powder it does not re-accumulate in the pool.

At the beginning of the season, the surge tank for the

Olympic pool was coated with slime and was growing miniature cottonwood trees; the smell was foul. As the season progressed, the play features gradually lost their white coating and, by the end of the year, they looked like new. The lifeguards never had to clean the water line. And by the end of the outdoor swimming year, the surge tank was sweet smelling, the water was crystal clear, and the walls and floors were completely free of slime. When the pools were drained for the winter, they required no cleaning at all. In fact, they appeared as if they had been power-washed with strong acid.

Client survey results

Three interns working for the St. Paul Parks and Recreation Department randomly but regularly surveyed clients at the Aquatic Center. One week after the introduction of the moss-based system, clients started to comment on the difference in the character of the water. It was softer, less harsh, did not cause eye irritation, skin itching or typical, pungent chlorine odor. As the summer progressed, clients continued to report positive experience with the water.

The year before, the Director of Aquatics would spend every Monday answering complaints about the pools. After the natural treatment system was installed, she received primarily positive comments and kudos about the changed water. By the end of the summer, parents, clients and swim-team members reported soft skin, no chlorine smell after swimming, no change in hair color and no degradation of their swim suits.

A very consistent comment was made by parents of children with asthma and adults with asthma, or reactive airway disease. They did not have to use their medicated inhalers while swimming at these pools, but they did when they visited other pools without the moss.

The most common comment was, "We don't know what you are doing, just keep doing it." Clients were even more impressed when they learned that this change in the water was provided by a totally natural technology and green product. Since the public pool experiment, the contractor has received hundreds of calls and letters from grateful patrons of the St. Paul Highland Park Aquatic Center. Recently, a woman who was a competitive swimmer in her youth noted how she gradually developed severe asthma and had to give up swimming.

After hearing about the St. Paul pool experience, for the first time in 20 years, she was able to swim again without any broncho-constriction and without using an inhaler. She now swims daily at the indoor facility (Great River Aquatic Center, where the moss is now being employed and tested).

Cost savings and revenue increases

The installation of the sphagnum moss system was made public by St. Paul's Mayor Chris Coleman in mid-August, 2009, at a press conference. Local media coverage (followed by international coverage) and strong word-of-mouth publicity attracted many more swimmers to the pool in the final weeks of the outdoor swim season that ended on Labor Day. Attendance continued to increase even during the atypically cool month of August.

By the end of the season, the HPAC increased revenue significantly over the previous year. Numbers just released by the City of St. Paul indicate the city saved $36,000 in chemical costs over the previous year ($78,000) and $40,000 in overtime costs, realizing a $100,000 increase in revenues.

Previously, the pool maintenance crew accumulated many hours of overtime dealing with the daily problems. Overtime savings resulted because there were no pool closings due to water issues, no need to hyperchlorinate and less demand for backwashing the filters.

The main problem—and another wild card in the experiment—was convincing crews to do less work and administer only the chemicals required by the water measurements. In addition, they had to be convinced that backwashing did not need to be done three times a week as done previously, and the pool only needed to be backwashed by pressure differential. By the end of the season, backwashing was being done once every other week, another cost-savings on the city's water bill.

Summary

Testing of the all-natural water conditioning system was an impressive success. Results from the 2010 summer season are anticipated to be even better because the process will be started with an impeccably clean facility, and last year's knowledge and experience. Continued improvements in water treatment, chemistry, maintenance, cost and revenue changes are anticipated in the future.

With the positive results in the outdoor pools at HPAC, St. Paul requested that the moss-based system be installed at their indoor facility, Great River Water Park. When the outdoor HPAC facility closed on Labor Day, attendance at the indoor facility immediately began to increase. To date, that pool is now setting another record.

About the author

♦ *David Knighton is a co-founder of Creative Water Solutions based in the Twin Cities and its President and CEO. Read more about him, the company's new commercial entity, Recreational Aquatic Solutions (www.RASnaturally.com), the company's three-patented residential products, PoolNaturally® and SpaNaturally,® and about sphagnum moss and biofilm at the CWS website www.cwsnaturally.com*