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Real-World Experiences With a Plant-Based Alternative to Chemical Treatment in Cooling Water Systems

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Companies adopting sustainable business practices understand that they are most successful when economic and environmental benefits align. Many companies are now positioning their business on a platform of sustainable development that visibly proclaims what they stand for and how they are contributing to their own and their customers' sustainability goals. To be successful in today's market, water treatment service companies will need to be able to offer greener alternatives to supplement or replace their conventional chemical treatment programs.

One such alternative is a treatment process that uses the leaves from a particular species of sphagnum moss that grows naturally in New Zealand and along the US–Canadian border. Water that flows from sphagnum moss bogs is among the most pure and pristine in nature due to the plant's ability to absorb contaminants, clarify the water, and, most importantly, suppress bacterial activity.

Sphagnum moss has had various uses for centuries. The Vikings used moss for water and food preservation on their voyages. It was used to make bandages in World War I (before penicillin) due to its greater ability to control infection and absorb fluids compared to cloth bandages. Human bodies 2,000 years old, often referred to as "bog bodies," which are perfectly preserved, have been found in moss bogs around the world. They were preserved due to sphagnum moss's unique ability to suppress bacterial activity that decomposes bodies. "As the sphagnum moss dies, it releases a carbohydrate polymer called sphagnan. It binds nitrogen, halting growth of bacteria and further mummifying the corpse."[1]

Minnesota-based Creative Water Solutions completed extensive research on sphagnum moss and found that the properties described above are derived from the leaves of the plant and are not dependent on the plant being alive. The company has developed a process for harvesting the leaves and packaging them for application in water systems.

The properties that make this significant in the water treatment industry are:

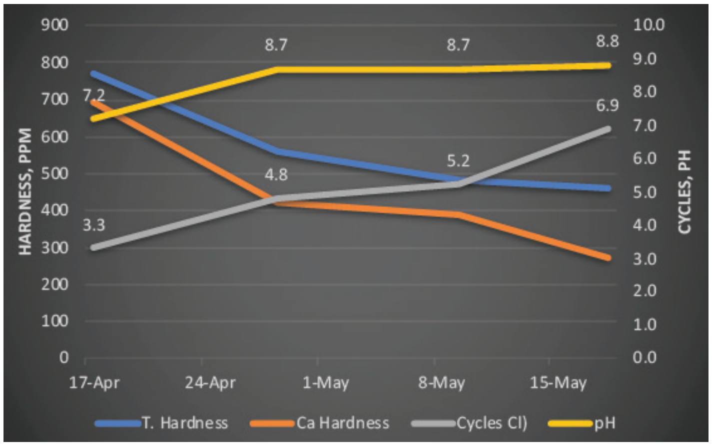
- Its ability to act as a natural water softener, removing impurities such as calcium, magnesium, iron, and other metals that can result in scaling and corrosion problems in water systems. The biomass of the living plant consists mainly of polysaccharides made up of glucose and galacturonic acid units. Galacturonic acid is rich in carboxylic acid groups that give sphagnum its high cation exchange capacity.[2] Hydrogen ions are released in the exchange process, effectively neutralizing alkalinity.
- Its ability to break down the organic "binders" that hold deposits together, resulting in cleanup and removal of deposits from system surfaces.
- Its ability to inhibit and remove organic contamination resulting from microbiological activity, which insulates heat transfer surfaces and causes corrosion in water systems. In

a lot of applications, this is proving to be a more efficient approach than chemical treatment, which relies on biocidal agents to kill bacteria that produce the contaminants. Over time, bacteria are able to adapt and protect themselves from these chemical agents but appear to have no immunity from conditions produced by sphagnum moss.

So, what are we seeing in systems where we have implemented moss treatment programs? In **evaporative cooling systems,** we have been able to:

- **Run higher cycles of concentration where hardness, alkalinity, and/or pH are limiting factors.** The following data is from a cooling tower system switched from chemical treatment to moss. Acid feed was being used to allow operation at 3.3 cycles under chemical treatment. Acid feed was discontinued along with the other chemicals with the start of the moss treatment program. Figure 1 shows hardness values and pH as cycles of concentration were increased. As the moss absorbs hardness ions, it displaces hydrogen ions, effectively neutralizing alkalinity.

Figure 1. Hardness values and pH as cycles of concentration increase.



In this case, the plant was able to double cycles of concentration, resulting in an over 60% reduction in tower bleed off to drain–over 5 million gallons of water per year on this system. The need for sulfuric acid feed was also eliminated as the system cycled to a stable pH between 8.7 and 8.8, under their discharge limit of 9.0.

- **Break down and remove existing deposits.** The following photos are from piping going into a plate and frame heat exchanger on an open air washer system. Years of deposits were removed after three months exposure to moss treated water.


Prior to Moss Treatment


3 Months into Moss Treatment

Sphagnum moss removes surface scale. It appears that the removal of scale is in part due to the resolubilizing of calcium. Removal of organic "binders" eliminates the "glue" that holds together and starts most mineral deposits.

- **Inhibit and remove organic contamination associated with microbiological activity in the system.** The following data and photos in Figures 2 through 6 are from a trial on a 1,300-ton HVAC cooling tower system. The condenser approach temperature along with the chiller load was logged for the duration of the trial. The approach trended downward, indicating an improvement in heat transfer.

Figure 2. Condenser approach vs. load.

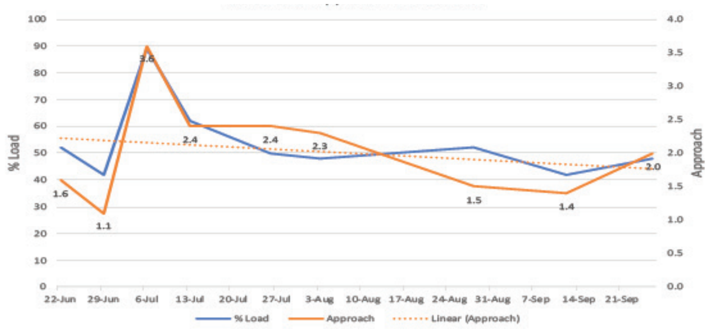
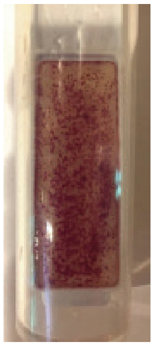


Figure 3 shows conditions at the start of moss treatment (under chemical treatment).

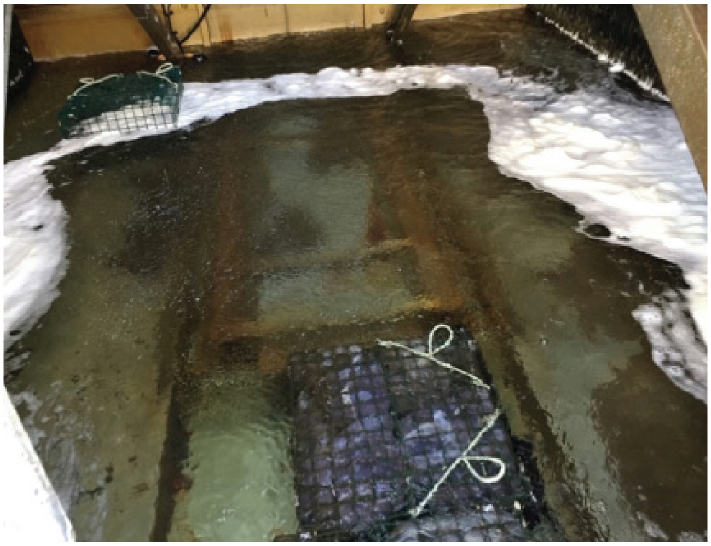
Figure 4 shows conditions two weeks into moss treatment. There were substantial decreases in ATP levels; total bacteria counts; and iron, copper, and turbidity levels.

Figure 3. Conditions at start of trial (chemical treatment).



Total Bacteria Count
10^7 CFU/ml
ATP–2,610 RLU's
Turbidity–28 NTU's
Iron–1.69 ppm
Copper–0.42

Figure 4. Conditions two weeks into moss treatment.



Total Bacteria Count
10^2 CFU/ml
ATP–126 RLU's
Turbidity–2 NTU's
Iron–0.02 ppm
Copper–0.29

Figures 5 and 6 depict total bacteria count data and iron and copper levels throughout the trial.

Figure 5. Total bacteria counts.

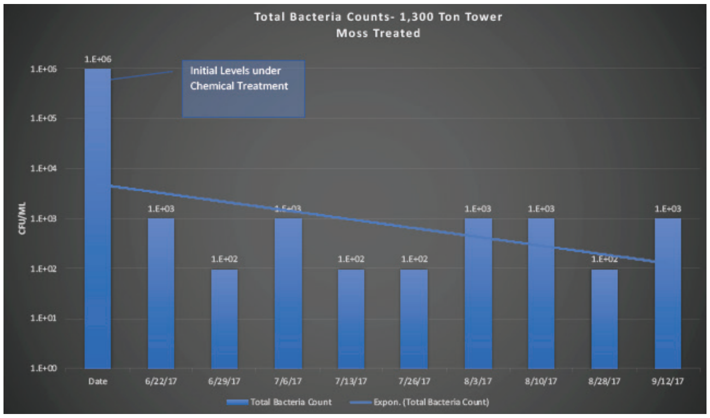
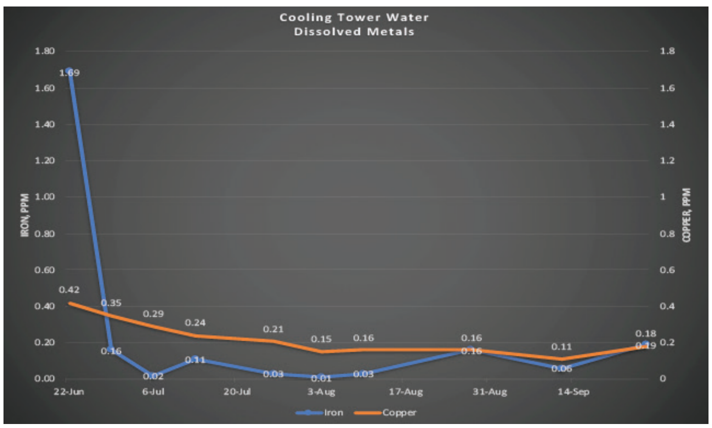


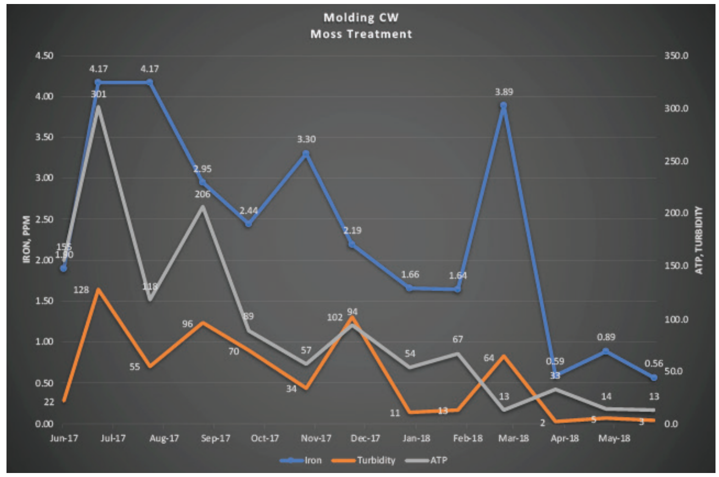
Figure 6. Iron and copper levels.



In **closed process water systems,** we have been able to:

- Remove corrosion byproducts (iron, copper, zinc) as well as absorb oil. Figure 7 shows iron, turbidity, and ATP test data from a chilled water system that was originally treated with a molybdate-based inhibitor system and a microbiocide. This system has an open sump and routinely experiences water loss and oil contamination from the process. The system was converted to moss treatment in June 2017.

Figure 7. Test data from a chilled water system.



Using moss to absorb and remove corrosion byproducts from closed water systems has significant advantages over chemical approaches requiring cleaning, flushing, and re-treating. Moss can also absorb up to 10 times its weight in oil. Moss can be applied using existing bypass feeders or by installing bypass feeders specifically engineered for moss. In open sump systems, specially designed cages can be used.

Corrosion Data

Our experience with corrosion control in moss-treated systems has led us to conclude that corrosion control is comparable to chemically treated systems. Although we can often achieve lower *general* corrosion rates with chemical inhibitor systems, we have fewer issues with microbiologically induced corrosion (MIC) in moss-treated systems. As all water treaters know, MIC is much more destructive to systems than general corrosion. Figure 8 shows data from two cooling tower systems that are representative of the corrosion rates we are measuring with mild steel and copper corrosion coupons.

Figure 8. Data from two cooling tower systems.

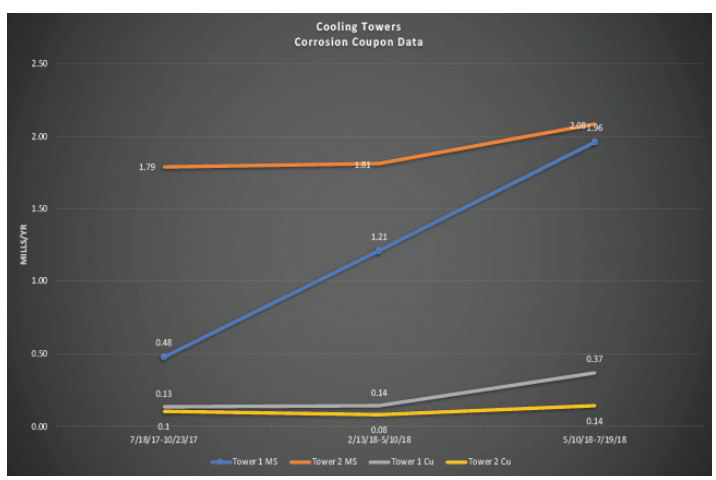
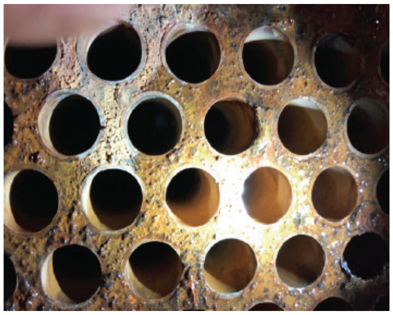


Figure 9 shows a typical water analysis for these cooling tower systems. We operate at an LSI around 1.5.

Figure 9. Typical water analysis for cooling tower systems.

System Sample ▸ / TEST ▼	Makeup	TOWER 1
pH	7.62	8.66
Total Hardness, ppm $CaCO_3$	22	290
Ca-Hardness, ppm $CaCO_3$	10	220
Total Alkalinity, ppm $CaCO_3$	12	215
P-Alkalinity, ppm $CaCO_3$		
Iron, ppm Fe	0.02	0.12
Copper, ppm Cu	0.22	0.01
Biological Counts		500
Silica, ppm	5.0	68.0
LSI		1.5
Cycles of Concentration (silica)		13.6
Conductivity Set point		1,800
Conductivity, µmhos	132	1,513
Cycles of Concentration (cond.)		11.5



Our inspections of condenser tube sheets on moss treated systems show results similar to or better than chemical treatment. In systems that have tube sheet corrosion tubercles, we have seen those being broken down and removed.

So, what does this mean to the end users who are deploying this program in their water systems?

- Removing cations that limit cycling in evaporative systems translates to water conservation.
- More efficient inhibition of organic contaminants in water systems results in better heat transfer, which lowers energy costs and mitigates MIC.
- Removal of old deposits leads to improved reliability and efficiency and often extends equipment life.
- Perhaps most significant to users with high sustainability goals, discharged water no longer contains chemicals that are potentially damaging to the environment. This opens up more possibilities for reuse of blowdown water in other processes.

Southeastern Laboratories began working with moss as an alternative to their conventional chemical treatment programs in October 2016. To date we have over 50 clients using moss in their systems. Our goal has been to introduce moss to a variety of water systems allowing us to evaluate and document performance under a wide range of operating conditions. In other words, we have been "testing the limits" of the program.

References

[1] Europe's Famed Bog Bodies Are Starting to Reveal Their Secrets, *Smithsonian Magazine,* March 2017.

[2] Spearing, A. M., 1972. Cation-exchange capacity and galacturonic acid content of several species of Sphagnum in Sandy Ridge bog, central New York state. *Bryologist,* 75: 154-158.