

March and April 2014 HPC tests with plastic tubing

Test Description:

On March 7, 2014, two 10-gallon tanks were filled with 5 gallons of local potable water. The water was circulated with an aquarium pump to allow residual chlorine to evaporate for 5 days. On March 12, 2014, 500 mL of pond water was added to each tank, 100-watt aquarium heaters were turned on and set to maintain the water temperature at 88 F in each tank. On March 14, 2014, water in each tank was then mixed with each other to create homogeneity and samples were taken for HPC. Magnetic treatment was then initiated in one tank by wrapping a 4-link halbach magnet bracelet around the 3/8" ID pvc tubing in one tank while the other tank was left untreated. Identical aquarium pumps pumped water through the pvc tubing at 82 mL/s. Water in each tank was monitored for temperature and conductivity for the duration of the test, which concluded on April 9, 2014. The final HPC sample was taken on April 9, 2014. The results are presented in Figures 1 and 2.

Figure 1. Heterotrophic plate count of tap water spiked with local pond water. The initial count was equal for both tanks. After 26 days, the magnetically treated water experienced a 43% reduction in HPC, whereas the untreated water experienced a 23% increase in HPC.

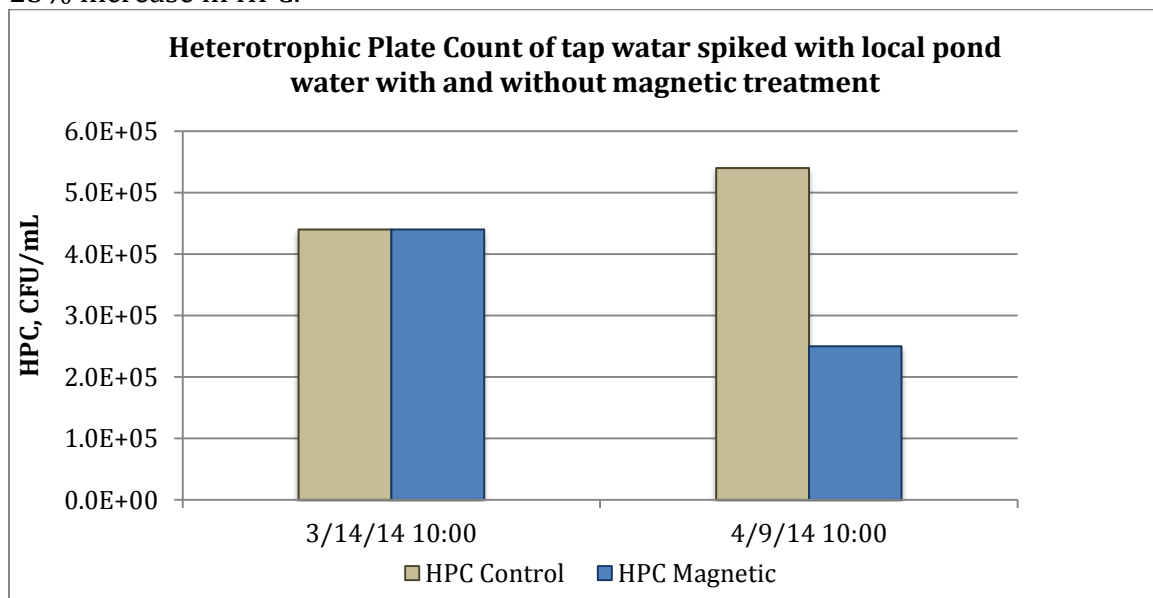


Figure 2. Raw data from HPC testing between 3/14/15 and 4/9/15

Date	HPC, CFU/mL		Temperature, F		Conductivity, uS/cm	
	Control	Magnetic	Control	Magnetic	Control	Magnetic
3/14/14 10:00	4.4e5	4.4e5	-	-	-	-
3/23/14 12:00	-	-	87.8	85	-	-
3/30/14 10:00	-	-	88.2	86.6	541	458
4/6/14 12:00	-	-	88.3	86.7	575	465
4/9/14 10:00	5.4e5	2.5e5	89.1	86.9	613	439

Figure 3. Photo of HPC testing set up. The tank is on the left houses circulating untreated water. The tank on the right houses water passing through a 4-link halbach magnet bracelet placed on top of the tank lid.



Figure 4. Close-up photo showing aquarium heater, pump, pvc tubing, and halbach magnet.



May and June 2014 HPC Testing with all plastic tubing in a water bath

Test Description

To build upon the previous month's test, a similar experiment was constructed. Instead of using separate heaters to maintain the water temperature in each tank, the tanks were placed in a galvanized steel trough that served as an isothermal water bath. On May 16, 2014 two 10-gallon tanks were filled with local potable water, 5-gallons in each tank. The water was circulated for 2 days to remove residual chlorine. Each tank was spiked with 500 mL of pond water. Water was then mixed between tanks to ensure homogeneity. The two tanks then sat in a water bath heated by (2) 100-watt aquarium heaters. A fan circulated the water in the bath to equally distribute heat between the two tanks. Water in the tanks was monitored for temperature, pH, conductivity, and HPC. The results are presented in Figures 5 and 6 below.

Figure 5. Heterotrophic plate count of water spiked with local pond water with and without magnetic treatment. At 21 days, the magnetic bracelet was removed from the experimental tank and placed on the control tank. Between days 21 and 29, water within the control tank was magnetically treated and water within the experimental tank was untreated.

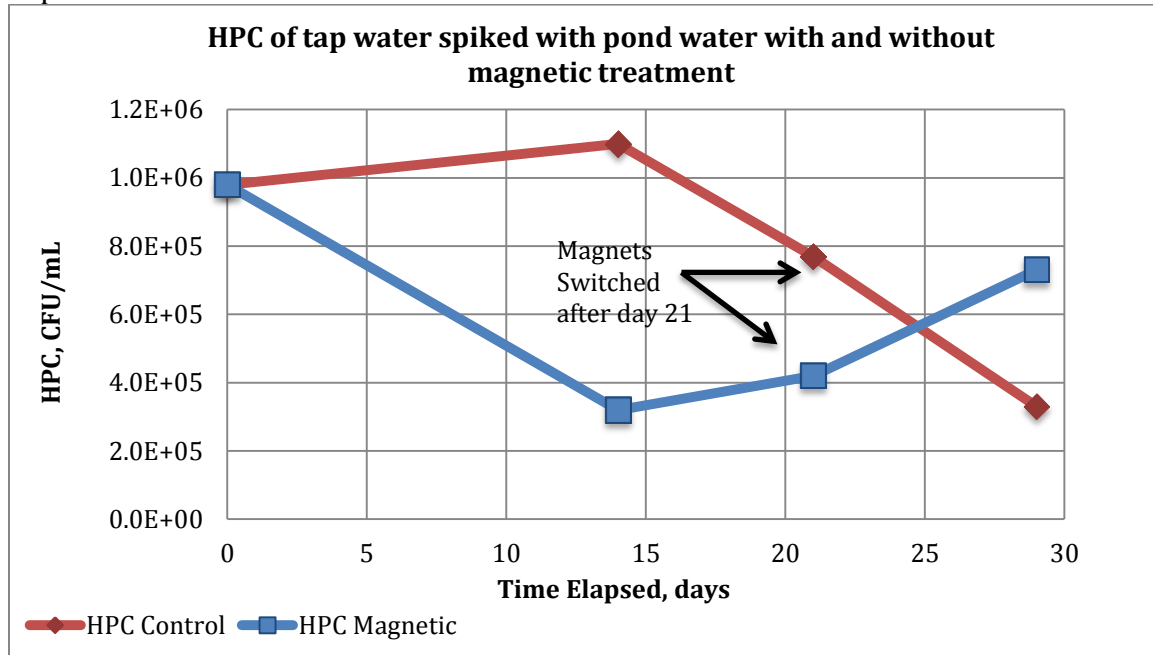


Figure 6. Results of HPC testing between May 18- June 18

Time	HPC, CFU/mL		pH		Temperature, F		Conductivity, uS/cm	
	Control	Magnetic	Control	Magnetic	Control	Magnetic	Control	Magnetic
5/18/15 11:00	-	-	8.25	8.24	82.3	82.2	618	620
5/20/15 11:00	9.8e5	9.8e5	8.23	8.24	84.6	84.7	626	623
6/3/15 11:00	1.1e6	3.2e5	8.46	8.47	85	84.9	631	614
6/10/15 11:00	7.7e5	4.2e5	8.50	8.48	86.6	86.8	640	641
6/18/15 11:00	3.3e5	7.3e5	8.53	8.48	86.6	86.3	637	650

Figure 7. Two 10-gallon tanks sit in a water bath. The tank with magnetic treatment is on the left. The one on the right has no treatment.



July 2014 HPC Testing with 304 SS piping in a water bath

Building upon the previous two tests, the parameters were slightly tweaked to create more uniformity in the testing conditions. 304 SS was added to each tank to introduce material more consistent with that of commercial evaporative cooling systems. The (2) 100-watt aquarium heaters were replaced with (5) 125-watt immersion for more consistent heating. On July 9, 2014, two 10-gallon tanks were filled with 5 gallons of city potable water and recirculated for 5 days to allow for dechlorination. On July 14, water in each tank was spiked with 500 mL of pond water. Water from each tank was then transferred to the other tank and mixed back-and-forth to ensure homogeneity. The two tanks were immersed in a water bath where the temperature was set to maintain 94F. A fan was placed in the water bath to distribute the heat equally across the two tanks.

Water within each tank was circulated using a pump at a flowrate of x . The pipe materials used were $\frac{1}{2}$ " 304 SS and $\frac{1}{2}$ " flexible plastic tubing. Given the $\frac{1}{2}$ " diameter of the piping, the velocity through the pipe was ft/s. All else being equal, a magnetic bracelet with four links treated the water in one tank and the other tank was left untreated. Water was monitored for temperature, conductivity, pH, and HPC; the results are presented in Figures 8 and 9.

Figure 8. Heterotrophic plate count of tap water spike with pond water, with and without magnetic treatment. After the first day of operation there was a 59% decrease in HPC in the tank with magnetic treatment while the control tank experienced a 50% increase in HPC. Subsequent counts fluctuate in both tanks.

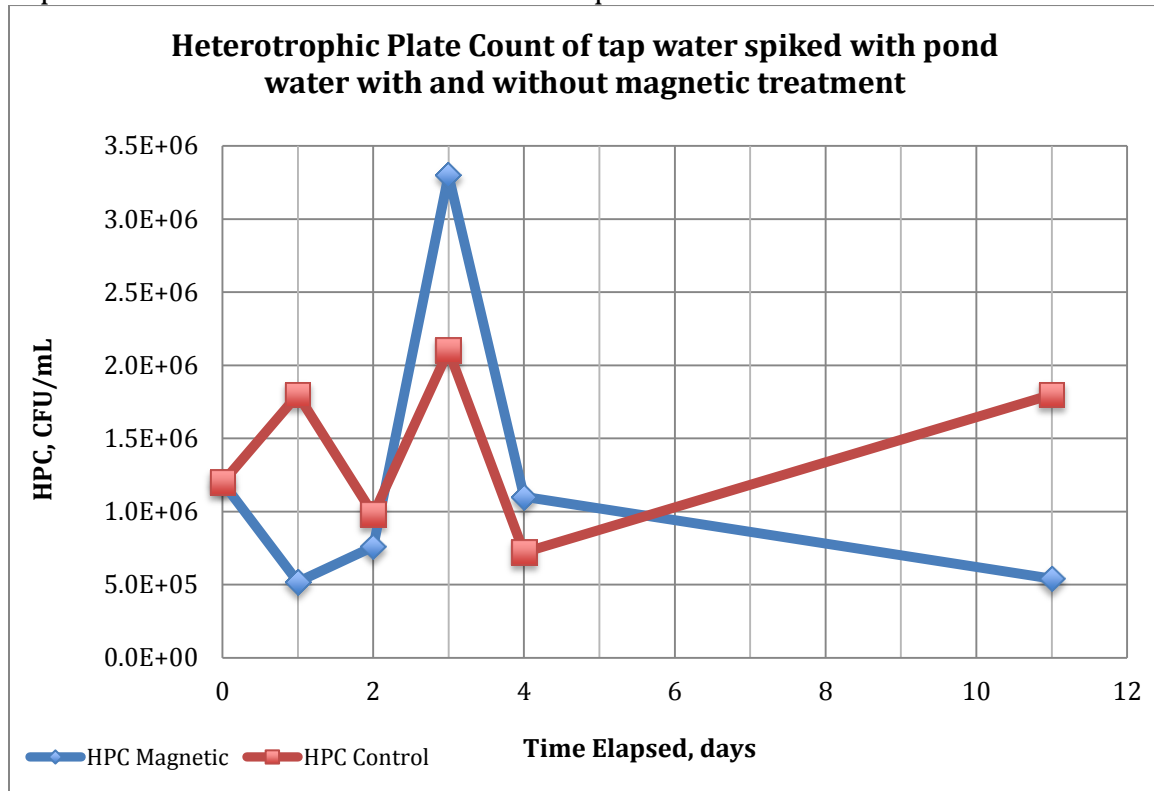


Figure 8. Results from July 2014 Heterotrophic Plate Count (HPC) sampling in the control and experiment tank.

Time	HPC, CFU/mL		pH		Temperature, F		Conductivity, uS/cm	
	Control	Magnetic	Control	Magnetic	Control	Magnetic	Control	Magnetic
7/14/15 11:00	1.2e6	1.2e6	8.45	8.41	92	92	455	461
7/15/15 11:00	1.8e6	5.2e5	8.44	8.39	81	81	454	458
7/16/15 11:00	9.8e5	7.6e5	8.45	8.40	94	94	0.458	0.464
7/17/15 11:00	2.1e6	3.3e6	8.47	8.4	94	94	0.462	0.460
7/18/15 11:00	7.2e5	1.1e6	8.43	8.42	94	94	0.459	0.466
7/25/15 11:00	1.8e6	5.4e5	8.52	8.47	94	94	0.467	0.461

Figure 10. Two tanks both spiked with pond water sit in a water bath held around 94F. The tank on the left circulates water through a 4-link halbach magnet bracelet. The tank on the right has no treatment.



In every HPC experiment that was conducted, magnetic treatment yielded a short-term decrease in HPC of about 50%, whereas the control HPC always increased over the same duration. Over longer periods of time, HPC levels fluctuate, possibly due to environmental contamination. To remedy the problem, an independent laboratory, Molecular Express Inc., was employed to run these experiments under a laminar flow hood. Results of testing from Molecular Express Inc. are pending.