1-April-2016

HydroDyne Qualcomm Field Experiment 1 Part 1c (continue).

This report is a continuation to the first report submitted on 08-March-2016, and second report submitted on 9-March-2016. Sample descriptions and their assigned ID's are listed in **Table 1**. Water analysis methods were described in the previous reports. Analysis results for water sample MolEx01005 and MolEx01006 are included in this report (**Table 2**). The relative change of various parameters (of the water collected from the sampling port) over time are presented in **Figures 1 to 3**. The relative change is defined as $\frac{Value\ of\ Test\ Sample}{Value\ of\ MolEx01001} \times 100\%$; except for the Aluminum concentrations, for which the relative change is defined as $\frac{Value\ of\ Test\ Sample}{Value\ of\ MolEx01005} \times 100\%$; since the level of aluminum in MolEx01001 is below the reporting limit.

Table 1. Water samples received from Hydrodyne.

Assigned Sample ID	Information recorded on collection bottles					Sample delivered to Molecular Express on
	Label on Bottle	Collection Date	Collection Time	Ambient Temperature	Collected By	
MolEx01001	QP Towers	20.Feb.2016	9:34	70ºF	Will	22.Feb.2016
MolEx01002	Basin	20.Feb.2016	9:00	70ºF	Neil	22.Feb.2016
MolEx01003	QP Cogen	25.Feb.2016	11:34	62ºF	Will A	26.Feb.2016
MolEx01004	QP Cogen	27.Feb.2016	6:14	64ºF	Will A	1.Mar.2016
MolEx01005	QP Cogen Samp. Port	10.Mar.2016	19:35	70ºF	Will A	14.Mar.2016
MolEx01006	QP Cogen Basin	10.Mar.2016	19:30	70ºF	Will A	14.Mar.2016

The most notable change in the parameters measured is the depletion of iron after Day 7 (**Figure 2**). Iron is ferromagnetic and would be most susceptible to the magnet installed, amongst the metals measured in our assays. The depletion of iron may play an important role for bactericidal and/or bacteriostatic activity, since iron is an essential nutrient for bacteria, it influences cell composition, metabolism and many diverse functions in bacterial cells. The next most magnetic susceptible metal measured in our assay is manganese (χ_m=511x10^{-6}cm^{3}mol^{-1}), and it remained at a reduced level after day 5 (**Figure 2**). However, there is an emergence of detectable aluminum level in samples MolEx01005 (from sample port) and MolEx01006 (from basin), aluminum has a magnetic susceptibility value of 16.5x10^{-6}cm^{3}mol^{-1}, similar to magnesium and sodium, but the sharp increase is unique to aluminum. The cause of increased aluminum level in the latter samples remains to be determined.

Among the anions measured, chloride maintained a slight increasing trend over time (**Figure 1**). Increase in chloride could lead to increased solubility of metals. Therefore, it could contribute to the prevention of scale formation. In general, the total bacteria count (measured by 48 hours, 35ºC incubation) is below 10,000 CFU/mL, as recommended by the Cooling Technology Institute (**Figure 4**). The reason for the increase of bacteria count in the basin sample remains to be identified. This effect may be temporary and may be due to the collection of shed biofilm in the basin from the rest of the cooling system.

Future Studies

The goal of this field test is to generate supporting data for the effectiveness of the HydroDyne magnet, and to gain some information on the mechanism, by which the magnet works. While the most definite and direct proof of the effectiveness of the magnet is by observation of less scale on the system, the increased amount of precipitate collected at the filter, and the decreased amount of biofilm/slime at the test site and the quantitative water analysis data suggests that depletion of iron from the water is playing a role in the mechanism of action. The trend in the quantitative data suggest that the magnet may be preventing sessile bacteria formation by depleting an essential metal, iron, for survival. While this phenomenon might not affect the planktonic bacteria (as seen in the consistent planktonic bacteria count in our assay) existing in the water, it may be important in the control of biofilm formation. In order to confirm this hypothesis, a secondary controlled experiment should be conducted, where the viability of bacteria will be measured as a function of iron concentration.

Even though monitoring the water properties while the magnet is in operation can provide valuable information, it may not paint a complete picture for the mechanism of action, since the water may be replenished constantly, and minor changes will be masked by the influx of fresh water. Futher analysis of any precipitate collected, and samples of water taken from a controlled source (e.g., water tower without magnet, and/or water directly from faucet) at the same time as the magnet treated water, would aid in the interpretation of the results.

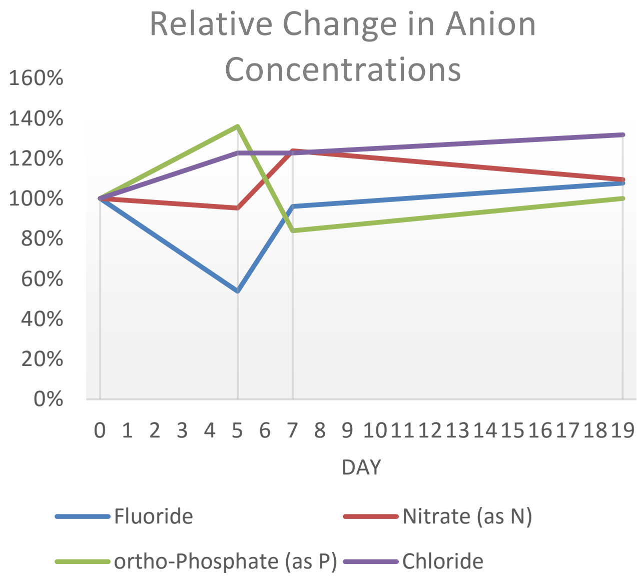

Figure 1. Relative change in anion concentrations over time in water collected from the sampling port.

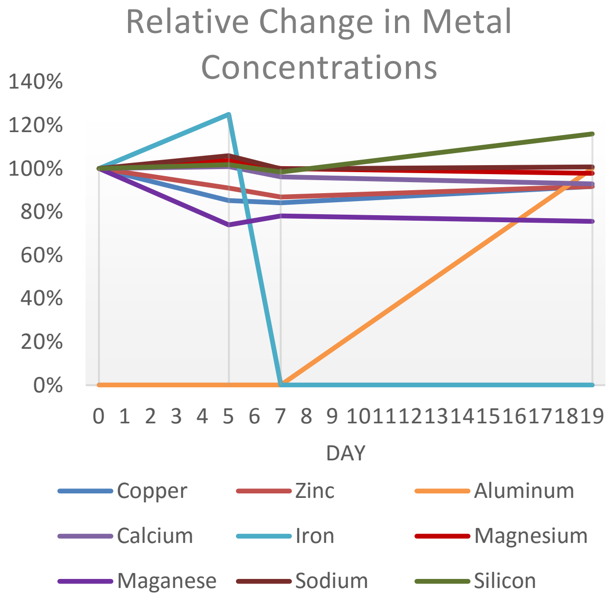

Figure 2. Relative change in metal concentrations over time in water collected from the sampling port.

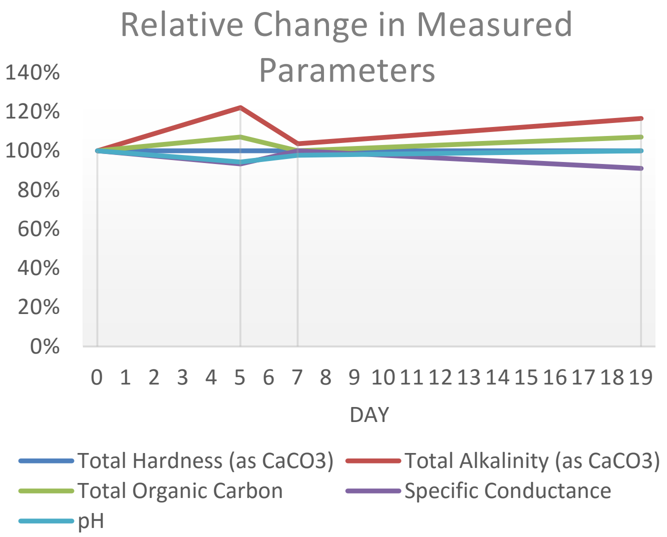

Figure 3. Relative change in parameters over time in water collected from the sampling port.

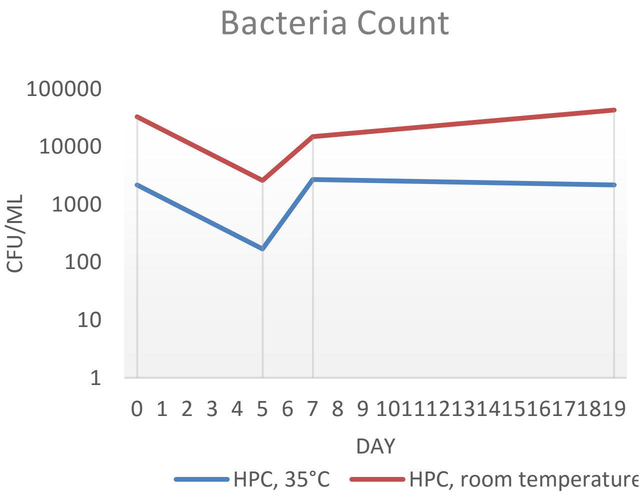

Figure 4. Change in bacteria count over time in water collected from the sampling port.

Table 2. Water analysis results.

	Sampling Port Samples				Basin Samples	
	MolEx01001	**MolEx01003**	**MolEx01004**	**MolEx01005**	**MolEx01002**	**MolEx01006**
Anions, mg/L						
Fluoride	2.6	1.4	2.5	2.8	2.7	2.9
Nitrite (as N)	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]	ND[1]
Nitrate (as N)	2.1	2.0	2.6	2.3	2.1	2.3
ortho-Phosphate (as P)	2.5	3.4	2.1	2.5	2.5	2.8
Chloride	440	540	540	580	450	600
Sulfate	1600	1700	1800	1700	1700	1700
Metals, mg/L						
Copper	0.0541	0.0461	0.0455	0.0496	0.0569	0.0475
Zinc	1.21	1.10	1.05	1.11	1.16	1.13
Aluminum	ND[2]	ND[2]	ND[2]	0.150	ND[2]	0.139
Calcium	335	338	322	311	353	305
Iron	0.200	0.250	ND[3]	ND[3]	0.174	ND[3]
Magnesium	136	141	136	133	147	132
Manganese	0.0124	0.00917	0.00969	0.00937	0.0128	0.00912
Sodium	526	557	525	530	559	522
Silicon	17.6	17.9	17.3	20.4	19.0	20.1
Total Hardness (as CaCO3), mg/L	1400	1400	1400	1400	NA	1400
Total Alkalinity (as CaCO3), mg/L	54.0	66.0	56.0	63.0	55.0	62.0
Total Organic Carbon, mg/L	14	15	14	15	14	15
Specific Conductance, µmhos/cm	4500	4200	4500	4100	4600	4200
pH	7.45	7.03	7.29	7.45	7.48	7.48
Heterotrophic Plate Count (CFU/mL)						
35ºC, 48 hours, R2A agar	2200	170	2700	2200	640	49000
Room temperature, 7 days, R2A agar	33000	2600	15000	45000	12000	116000

NA: not analyzed; ND[1]:level below reporting limit, <0.2 mg/L; ND[2]: level below reporting limit, <0.05 mg/L; ND[3]: level below reporting limit, <0.1 mg/L