

Date: 7/17/2015

Subject: performance chart and efficacy test for EcoWasherPro (7H-ECO-01)

Performance test:

The EcoWasherPro model 7H-ECO-01 was received and installed according to the device guideline. A water flow meter was installed to measure inlet water flow rate. An aqueous ozone analyzer, UV-106W was installed in the device outlet to measure generated ozone concentration [1]. The analyzer has accuracy of 0.05 ppm which enables very accurate measurement of aqueous ozone. pH was measured with VersaStar meter. Figure 1 depicts schematic of the experimental rig.



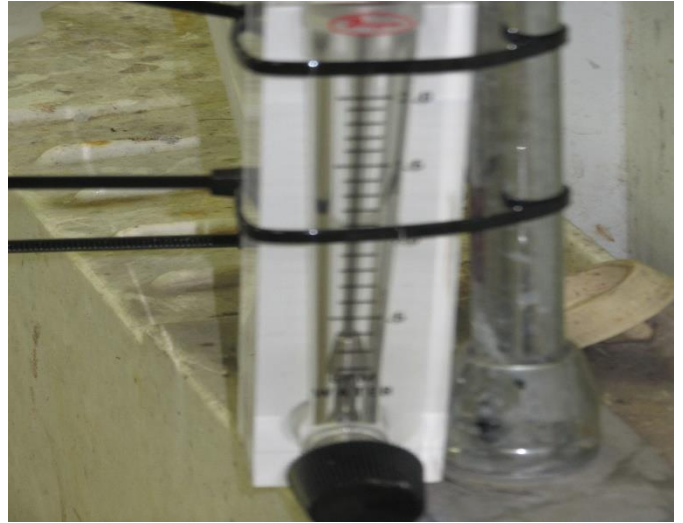


Fig.1- Schematic of ozone experimentation.

VersaStar pH meter was calibrated before the test to increase accuracy in reading the pH level.



Fig.2- VersaStar pH calibration.



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It was noticed that ozone generator starts working at 0.7 gpm flow rate and at flows below 0.7 gpm the generator is not working. The first set of the test results have been documented in Table 1.

Table-1. Experimental with fully functioning system.

Water flow rate(gpm)	Ozone ppm	pH	Conductivity
0.7	0.91	7.51	935
0.8	0.83	7.57	955
0.9	1.08	7.63	962
1	1.116	7.7	964

Based on the obtained results the device is capable of generating ozone between 0.9-1.1 ppm which is more than what has been claimed in the product manual (0.5-1 ppm). The ozone level is based on the following water quality analysis:

Component	Concentration(ppm)
Iron	0.007
Mn	0
Chlorine	0.144
Sulfate	0.015

It is obvious fact that the chemicals in the water can consume ozone, so it is possible to reach less ozone or more ozone ppm's in different places.

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In this experiment, the objective was to check effect of PCO and O₃ generator on pH. Water pH was measured as 7.92 at room temperature (72 °F). Then ozone was removed from the injection system. The effluent stream pH with only PCO was 7.47. There was 7.92-7.47=0.5 unit reduction of pH with only PCO. Then PCO unit was removed from the injection loop and only ozone was in the loop. The pH with only ozone was 7.61 which indicates 0.31 unit pH reduction. The pH with whole unit working was 7.61.

It seems the PCO does not affect whole system pH. The higher reduction in pH with PCO was investigated in another experiments with simultaneous ozone and pH measurement. Table 2 depicts these experiments.

Table-2 experimental with fully functioning system(tap water pH=7.8)

Test module	Water flow rate(gpm)	Ozone ppm	pH	conductivity
With PCO only	1	0.66	7.34	936
With O₃ only				
	1	1.12	7.5	958
Whole system				
	1	1.13	7.63	957

From these experiments it seems that both PCO and ozone system generate ozone. Again from this experiment it seems that PCO does not affect generated ozone from whole system.



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Efficacy of the EcoWasherPro (7H-ECO-01) Against *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimurium*, *Streptococcus pyogenes*, *Candida albicans* and *Aspergillus brasiliensis*

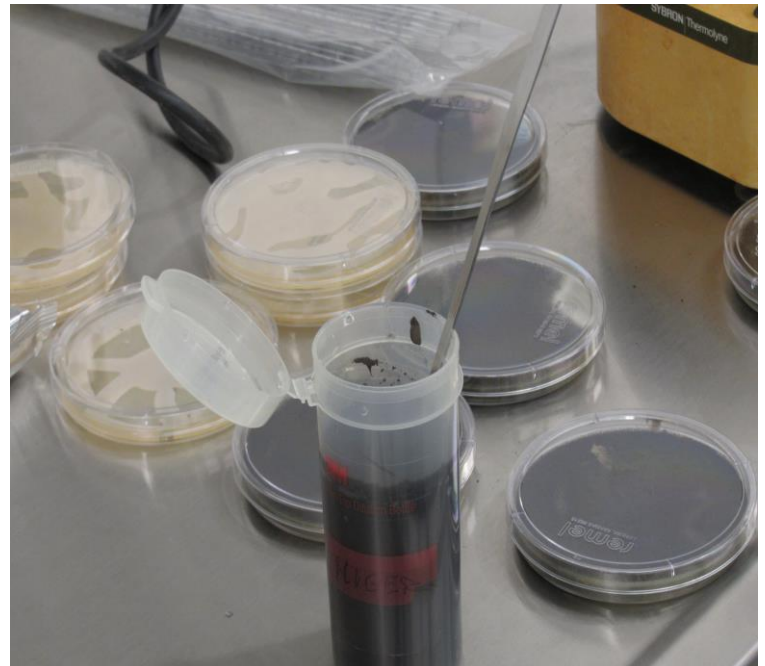
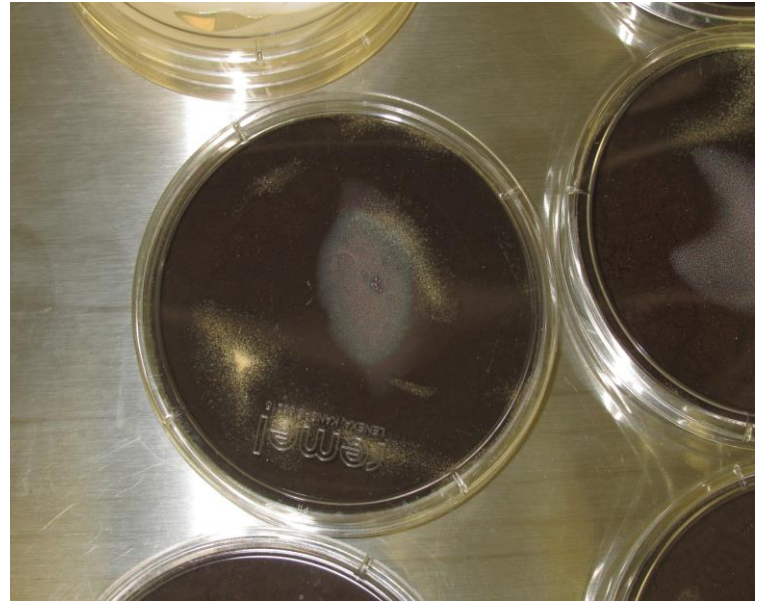
Materials and Methods: Pure cultures of *Escherichia coli* (ATCC#25922), *Staphylococcus aureus* (ATCC#25923), *Salmonella typhimurium/enterolytica* (ATCC#13311), and *Streptococcus pyogenes* (ATCC#19615) were grown in TSB and pure cultures of *Candida albicans* (ATCC#14053) and *Aspergillus brasiliensis* (ATCC#16404) were grown on potato dextrose agar. Each bacterial pure culture was grown to a concentration of 5 to 6 logs/ml. The molds were grown on 5 individual plates for each of the organism and after 3 days significant plate growth for each had been achieved. The mold colonies were then picked from the plates and suspended in buffer to a concentration of approximately 6 logs/ml. Two stainless steel containers approximately 2 to 3 L in volume were used for the study; Container #1 would contain a known volume of municipal water (control) and Container #2 would contain the same volume of ozonated water generated by the EcoWasherPro (7H-ECO-01). The concentration of ozone from this equipment was measured to range from 0.87 ppm to 0.95 ppm. After filling the containers a known volume of test organism inoculum from one of the pure cultures was added to each container, stirred, and a timer was set for 5 minutes. At 5 minutes, 1 ml was drawn from Container #1 and plated on selective media and 1 ml was drawn from Container #2 and plated on selective media. This occurred for each of the organisms and 3 to 4 trials were performed (depending on the organism) for each. The bacterial plates were incubated at 36°C±1 for 48 hours and the mold plates were incubated at 28°C±1 for 3 days. After their incubation periods, the TPC of each plate was determined and calculations were made to achieve results in cfu/ml in Container #1 and cfu/ml in Container #2. The average of the results from each of the trials for each of the organisms was recorded and can be seen in the Table 3 below. The percent reductions when

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The element of success. comparing Container #2 to Container #1 can be seen in Table 4 below. Figure 4 shows some pictures from microbial testing.



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Fig.3- ozone efficacy test.

Results: After 5 minutes the counts in the ozonated water were lower than in the plain water for each of the test organisms, although this was most dramatic for the *Escherichia coli* and *Candida albicans* which both had a one to two log reduction. There was less than a one log reduction for all other test organisms.

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Table 3: The following table shows the average bacterial count in Container #1 and Container #2 for each of the test organisms.

Test Organism	Estimated Count of Inoculum	Average Count in Container #1 After 5 Minutes	Average Count in Container #2 after 5 minutes
<i>Escherichia coli</i>	5 logs/ml	3.2 x 10 ² cfu/ml	BLD
<i>Streptococcus pyogenes</i>	6 logs/ml	3.3 x 10 ³ cfu/ml	1.5 x 10 ³ cfu/ml
<i>Salmonella typhimurium</i>	6 logs/ml	6.3 x 10 ³ cfu/ml	3.4 x 10 ³ cfu/ml
<i>Staphylococcus aureus</i>	6 logs/ml	5.8 x 10 ³ cfu/ml	3.8 x 10 ³ cfu/ml
<i>Candida albicans</i>	6 logs/ml	3.4 x 10 ⁴ cfu/ml	1.8 x 10 ² cfu/ml
<i>Aspergillus brasiliensis</i>	6 logs/ml	7.1 x 10 ³ cfu/ml	2.4 x 10 ³ cfu/ml

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Table 4: The following table shows the percent reductions for each test organism that the ozonated water achieved (Container #1) when compared to plain water (Container #2).

Test Organism	Percent Reduction
<i>Escherichia coli</i>	100
<i>Streptococcus pyogenes</i>	54
<i>Salmonella typhimurium</i>	46
<i>Staphylococcus aureus</i>	34
<i>Candida albicans</i>	94
<i>Aspergillus brasiliensis</i>	66

Discussion: The concentration of ozone in container #2 ranged from 0.87 to 0.95 ppm depending on the heat and humidity in the room as the EcoWasherPro (7H-ECO-01) draws from ambient air. Parameters such as heat, humidity, flow rate, etc. will all effect what the concentration of ozone in the water will be. While it is clear that each organism in the study was reduced by the ozone, two of them had prominent reductions while the other four had much less reductions at 0.87 to 0.95 ppm ozone.

Test Performed by: Dr Gholamreza Zahedi, Dr George Kraft

Reference

[1]. <http://www.ozonesolutions.com/products/Ozone-Monitors/Dissolved-Ozone/UV-106W-Dissolved-Ozone-Analyzer>).

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