Evaluation of water quality during flood cycles with an ozone system

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Objective: To quantify whether the ozone system controls bacteria levels in subirrigation return tanks during periods of rapid flooding of bedding plant crops on concrete floors.

Research Methods:

- During spring bedding plant production, water quality data were collected from Lucas Greenhouses in New Jersey on the 9th and 10th of May 2012. Thank you very much to the team at Lucas Greenhouses for assisting with this research!
- Data represent the average over two days and two separate runs per day, with one cycle of 9 concrete bays flooded with a nutrient solution in a 26,760 gallon tank both with and without ozone each day.
- During each flood event, approx. 4,800 gallons was required per bay.
- No additional water was added during the flood supply and return cycles to top up the tanks. With "ozone off", water cycled through the same tank, Clearstream filter and pressurized glass-resin bead filtration as with "ozone on". The only difference was the injection of ozone in the line.
- Time between flood events was approx.30 min, and it required 15 min to flood a bay and return to tank.
- With a flow rate of approx. 9,600 gal/hour, it required 2.5 hours to completely cycle 24,000 gal through the filter and ozone system.

Results and Conclusions:

- Bacteria levels in the tanks were consistently lower when the ozone system was turned on (Fig. A).
- However, initial bacteria counts were higher before flooding occurred when the ozone system was turned off than when ozone was turned on. This difference occurred because the ozone system had run approx. 3 hours before the start of the "ozone on" treatment (Fig A). Figure B therefore shows change in bacteria counts standardized for a consistent amount of bacteria CFU/ml at the start of the flood cycles.
- Regardless of whether the ozone was on or off, CFU/ml decreased as increasing flood cycles occurred (Fig. A & B). This reduction may have occurred because conditions such as pressure changes and flow rates were not favorable for bacterial growth.
- After 9 flood events, CFU/ml was lower with the ozone on than off, on both an absolute and standardized basis (Fig. A & B).
- After 9 flood events, even with the ozone system turned on, CFU/ml in the tank were above a suggested target of 10,000 CFU/ml to avoid clogging of drip/mist irrigation, at an average 36,100 CFU/ml between

the 2 samples (Table 1). This threshold of 10,000 CFU/ml is not ideal for a flood floor (which lack small emitters), but provides a bench mark that is often used in describing high quality horticultural irrigation water.

- Bacteria counts after the injector with the ozone off showed no decline (Fig. C).

- However, with the ozone on, CFU/ml averaged 7% of the pre-injector (i.e., tank) CFU/ml (Fig. D). This meant that when the pre-injector CFU/ml (in the tank) started to decline after about 6 flood events, the post-injector CFU/ml with ozonation was below the threshold 10,000 CFU/ml level (Fig. C).

- Overall, it was interesting to see that the bacteria counts declined with increasing flood events even with ozone turned off, and that the ozone system further reduced bacteria counts.

- Given the high microbial load at the start of the day, it took time (2-4 hours, or 1-2 tank cycles) for bacteria counts to decline to below 10,000 CFU/ml post-injector. Bacteria counts remained above that threshold in the tank (pre-injector).

- So long as the microbial load and demand (from suspended solids, iron chelates, etc.) was not excessively high, the ozone system post-injector effectively sanitized the water. With a high microbial load and demand, then it would take more time for the ozone system to be able to achieve a high level of sanitation post-injector. It would longer still to achieve a high level of control in the tank, because the ozonated water is recontaminated when mixed back with the return water.

- Oxygen levels remained higher (above 10 mg/L) in the tanks when ozone was on, but declined to zero after nine flood events with ozone off (Table 1). At present, we do not have data on the effect of this oxygen level on plant health and pathogens.

- ORP in the tank (pre-injector) was approx 300 to 400 mV with ozone on, but stayed at 650 mV post-injector with ozone on (Table 1). ORP with the ozone off was near 240 to 300 mV in the tank, and 520 to 650 mV post-injector with ozone off.

- Total suspended solids in the tank remained fairly constant through the flood cycles, at around 7 mg/L (Fig. E). This is a moderate TSS level compared with recommended water quality guidelines (< 20 mg/L).

- TSS after the filter with the ozone injector off remained around 100% of the TSS before filtration (there was no reduction in suspended particles by the filter alone, Fig. G).

- However, TSS before and after the filter plus ozone injector resulted in about 77% lower TSS (Fig. G), indicating that the ozone was solubilizing the suspended solids.

- After the cleaned water (from filter plus ozone) was returned to the tank (Fig. E), there was no impact of ozone on TSS, presumably because of dilution with contaminated water.

- UV transmission averaged 72%, and was not affected by flood cycles or ozone (Table 1). This transmission level is borderline adequate for effective sanitation using UV radiation.

Figure 1. Summary results

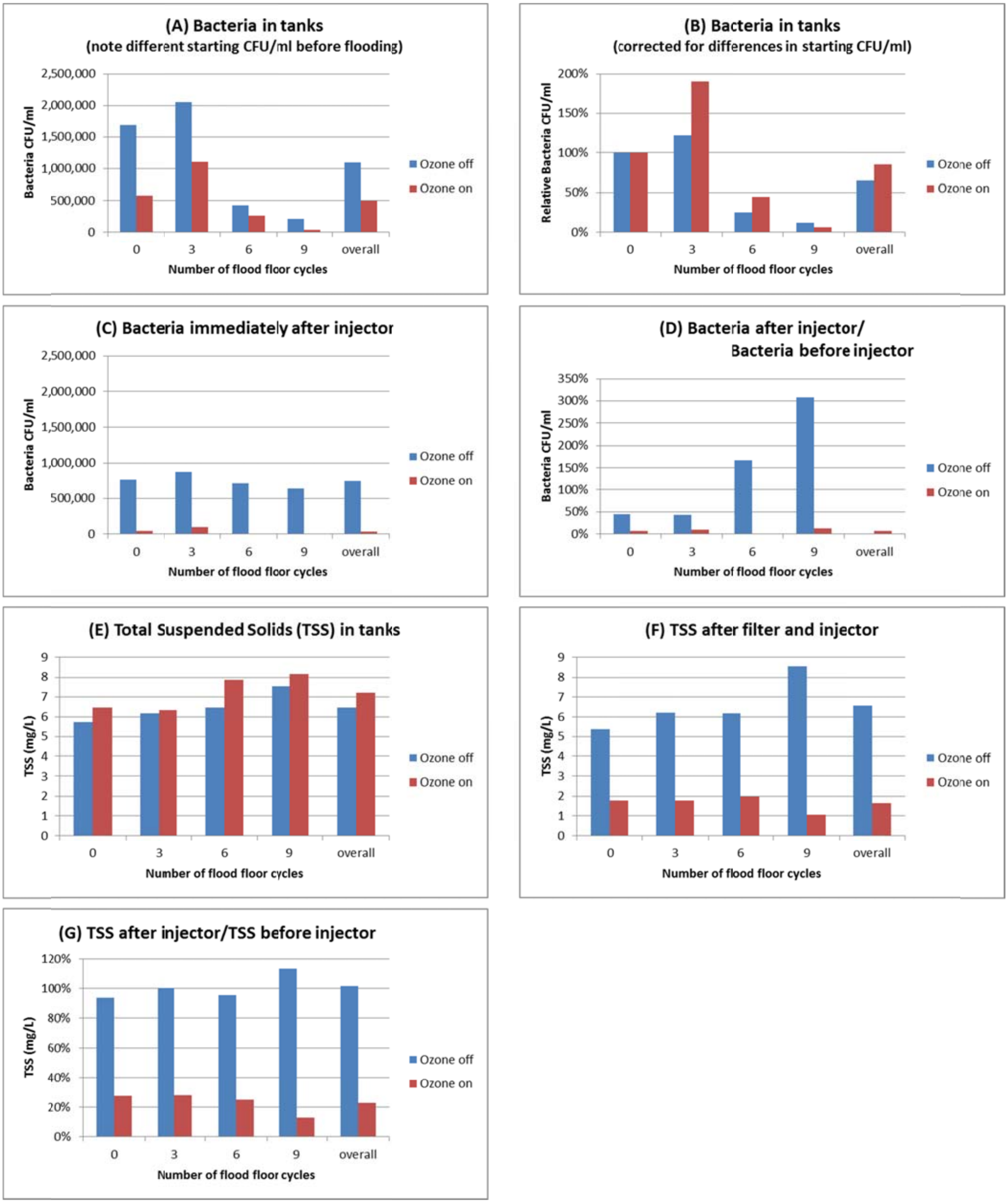

Table 1. Raw data with ozone injector turned off (top) or turned on (bottom). Average of data from 2 days, with two sets of 9 flood cycles per day with ozone either on or off.

Ozone Off

	Bacteria, CFU·mL^{-1}		ORP, mV		TSS, mg·L^{-1}		UV Trans., %		Dissolved Oxygen in tank, mg·L^{-1}	pH in tank	EC in tank, µS/cm	Temp. in tank, °C
Flood(s)	Pre	Post	Pre	Post	Pre	Post	Pre	Post				
0	1,690,000	745,000	304	636	5.2	5.9	72	73	15	4	1,595	23
3	2,052,500	555,000	280	633	5.7	5.7	71	72	12	4	1,605	23
6	422,500	635,000	262	605	6.4	6.7	71	72	7	4	1,600	24
9	207,500	535,000	258	582	7.4	7.7	71	71	3	4	1,615	23

Ozone On

	Bacteria, CFU·mL^{-1}		ORP, mV		TSS, mg·L^{-1}		UV Trans., %		Dissolved Oxygen in tank, mg·L^{-1}	pH in tank	EC in tank, µS/cm	Temp. in tank, °C
Flood(s)	Pre	Post	Pre	Post	Pre	Post	Pre	Post				
0	580,000	10,300	374	636	6.3	3.0	72	75	30	4	1,655	23
3	1,102,500	15,250	368	637	5.5	1.9	72	75	25	4	1,645	23
6	257,500	2,400	344	637	9.2	2.3	71	74	17	4	1,655	23
9	36,100	4,900	337	637	7.6	1.7	72	74	12	4	1,595	23