

August 12, 2019

Project to Beta-Test and Validate the Anzai Nano-Bubble Oxygen/Ozone Technology's Ability to Remediate Blue-Green Algae in Ponds and Lakes

Project Goals

Improve the biological balance on a pond at a prominent golf course near Orlando, Florida to include removal of the Blue-Green Algae, infusion of dissolved oxygen into the water column, and better transparency of the water. Further, this test was a beta-test to prove the ability of the Nano-Bubble Ozone Technology ("NBOT") system to deliver the oxygen/ozone infused nano-bubbles efficiently and effectively at a flow rate of 400 gpm.

Background

The pond being remediated is approximately .78 acres, contains between 550,000 and 600,000 gallons of water, and a water depth no more than 4 feet at its deepest point. The pond is adjacent to a larger pond and connected via an underground pipe and is located in a fairly large drainage area that gathers runoff from the golf course. The pond has been subjected to many years of clay flocculants and other chemicals being poured into it to essentially sink the problems to the bottom of the pond.





The NBOT system was deployed on the east side of the pond and operated using a diesel-powered 3-Phase generator consuming approximately 21 kWh for the 67.5 hours it was operated during this period.



The NBOT system inlet suction hose was connected to a skid resting close to the bottom of the pond. This skid has been specially designed to keep debris and aquatic species from being suctioned into the water treatment system. This was the first time this suction inlet system was deployed, and it worked very well. Also, on the outlet side of the NBOT system, a new design was tested that consisted of a 4-hose manifold allowing broader and even distribution of the oxygen/ozone nano-bubbles throughout the pond. These two specific designs required more work in the setup phase, however observations proved that these applications worked very well.





Operational Testing

The Blue Nano NBOT system is the first of its kind in the US based on oxygen/ozone infused nano-bubbles being generated through a fixed device with nano-scale pores at a flowrate of 400 gallons per minute (gpm). This flow rate is approximately 3.3 times more than the next highest known NBOT system on the market. The Blue Nano NBOT system commenced operation on Tuesday, July 23rd at 11:20am, and was turned off Friday, 9:00am, July 26th, operating 67.5 hours during that period. The entire system was being “tuned” during the first several days while it ramped up water flow rates and oxygen/ozone gas volume. At approximately 8:00pm on Thursday, July 25th, the NBOT system began operating at 100% oxygen/ozone gas flow production (26 liters/min) at the appropriate delivery pressures thus operating at full capacity for about 13 hours. The remaining time the NBOT was operating and generating nano-bubbles, however the level of oxygen/ozone infusion was far less than optimal so that Blue Nano could observe reactions to the water treatment prior to full-scale operations.

During the treatment, we observed that an adjacent pond back flowed into the pond being treated during two storm events. We believe that this caused new inflow into the target pond which required additional treatment time.

Water Quality Results

Water samples were gathered prior to the start-up, midway and at prior to demobilizing the NBOT system. The following table sets for the sample results for the pre- and post-tests.

POND TEST RESULTS SUMMARY					
	Pre 1	Post 1		Delta Pre to Post	
LAB PARAMETER	Result	Result	Units	Result	% Change
Total Nitrogen (as N)	6.49	6.19		-0.30	-4.62%
Nitrate (as N)	0.2	0.742	mg/L	0.54	271.00%
Nitrite (as N)	0.2	0.2	mg/L	0.00	0.00%
Chlorophyll-a	131	69.8	ug/L	-61.20	-46.72%
BOD - 5 Day	8.84	11.9	mg/L	3.06	34.62%
TSS	45	17	mg/L	-28.00	-62.22%
TKN (as N)	6.49	5.45	mg/L	-1.04	-16.02%
Chemical Oxygen Demand (COD)	48.1	69.8	mg/L	21.70	45.11%
Ammonia (as N)	0.0641	0.959	mg/L	0.89	1396.10%
Phycocyanin (Blue Green Algae)	158.1	132.5	ug/L	-25.60	-16.19%
FIELD DATA					
pH	9.39	7.14		-2.25	-23.96%
ORP	16	300	mv	284.00	1775.00%
DO	5.3	14.4	mg/L	9.10	171.70%

Water Quality Analysis

The pre-test water samples reflected conditions of a pond that is not biologically balanced and that contained possible unreleased cyanobacteria toxins. The initial dissolved oxygen (“DO”) of the water in the pond prior to any treatment was 5.3 mg/l (ppm) and the oxygen reduction potential (“ORP”) was +16 milli-volts. Just after the NBOT system startup, we observed disturbance of the bottom “silt” in the pond which resulted in an ORP reading dropping below zero. This is not unusual as there are typically organic constituents laying on the bottom of a water body that once disturbed enter the water column above and require oxidation to remove them. The measured Chlorophyll-a began at 131 µg/l (ppb) and the total suspended solids began at 45 mg/l (ppm). Further, the pond contained 158 µg/l (ppb) of Phycocyanin (Freshwater Blue Green Algae). This is noteworthy since blue-green algae of this type could possibly contain harmful toxins that could be released into the water at any time.

As discussed, the pond was not biologically balanced based on the pretreatment indicative readings of multiple constituents (pH, ORP, DO). At the end of the water treatment, the water quality improvement was noticeable for some constituents and for others the improvement process was trending in the right direction however we believe more time for delivery of the oxygen/ozone infused nano-bubbles was needed.



Total Suspended Solids (TSS), TKN (Total Kjeldahl Nitrogen), Phycocyanin, and Chlorophyll-a all improved a good amount. Nitrates increased, but that is the natural process in water and to be expected.

It is difficult to understand why Ammonia reacted as it did. However, one possibility is that some of the nitrates present in the soil, silt, and sludge may be going through denitrification which creates nitrogen gas. Conversely think "nitrification" where the ammonium ion is converted to nitrate or nitrite. Again, with more time on site, the Ammonia that is released from the lower layer silts would be reduced. The change in lower pH in the water column also releases bound Ammonia and ammonium ions.

The pH and DO improved significantly. All aquatic animals need DO to breathe. Low levels of oxygen (hypoxia) or no oxygen levels (anoxia) can occur when excess organic materials, such as large algal blooms, are decomposed by microorganisms.

Metals were largely unchanged as would be expected with the type of oxidizing treatment.

Regarding the clarity of the pond, the algae load in the water was significantly reduced creating greater clarity in the water as shown in the beaker tests below. Also, attached are graphs showing the field data which reflect improvement in DO and ORP during the pond remediation.

T= 0 hours to T= 24 hours of treatment:



T = 0 hours to T = 72 hours of treatment:



One week following the NBOT treatment, samples were taken from the pond in four locations and DO readings were observed to be at 10 mg/L (ppm) which was still almost twice the original level prior to the NBOT treatment. Two weeks following the tests the water clarity was still greatly improved.

Summary

The data shows that the Blue Nano NBOT system improved the biological balance and clarity of the pond from a poor state at the start to a much-improved state at the end. Continued observation indicates the improvement in DO and clarity has lasted for at least two weeks following the initial NBOT treatment. Due to cautious tuning and testing of the Blue Nano NBOT system during the first few days of operation, the system did not begin optimal performance until about 8:00pm on Thursday, July 25th. This resulted in approximately 13 hours of the 67.5 hours that the system operated at optimal performance. Had the NBOT system stayed on the pond possibly 12 to 24 hours longer, we believe we would have observed more dramatic results.

Blue Nano Management

T = 0 Hours



T = 0 hours to T = 14 days after treatment:



T = 0 hours to T = 19 days after treatment:

Visible golf balls – close-up view.



T = 0 hours to T = 19 days after treatment:

Visible golf balls – far away view.

