FINAL PERFORMANCE REPORT

Report Abstract/Summary

Passive Soil Aeration for the Treatment of Food Processing Wastewater

Grant Number: 791N13000102

March 1, 2012

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This document represents a companion document to the Final Performance Report completed for the project. This document was completed in conformance with the Specialty Crop Block Grant Program guidance document for the completion and submittal of Final Performance Reports and readers of this report are encouraged to cite the full document text for a more detailed description of the work conducted and results of the Passive Soil Aeration for the Treatment of Food Processing Wastewater.

PROJECT SUMMARY

The Smeltzer Companies (Smeltzer), located in Joyfield Township, Benzie County, Michigan (Figure 1), received a Specialty Crop Block Grant (Grant number 791N13000102, Farm Bill 2010) to perform this study in November 2010 and contracted Lakeshore Environmental, Inc. (Lakeshore) of Grand Haven, Michigan to execute the work plan outlined in the grant.

Michigan's vegetable and fruit processing industry produces wastewater on a large scale with much of it treated and released to the ground surface through various means. This wastewater is very rich in organic material and often creates anaerobic soil conditions. These soil conditions cause naturally-occurring metals present in the soil to leach into groundwater at concentrations that may risk human health, as well as harm to the environment. As a result, the Michigan Department of Environmental Quality (MDEQ) has established conservative wastewater disposal standards. These regulations do not account for actual site conditions, specifically the amount of oxygen in the soils.

Soil aeration is a proven technology that provides oxygen to the soils regardless of site conditions. Active aeration technology is expensive due to the electricity requirements to operate blowers along with other operation and maintenance costs. Passive soil aeration was a proposed alternative to active soil aeration and is more economically feasible for large food processing applications.

The data generated during the study indicated that both soil aeration technologies were effective at augmenting the treatment of food processor wastewater. Active aeration, however, was consistently more effective than passive aeration, demonstrating a greater reduction of organic materials (as reflected by total organic carbon and chemical oxygen demand). Passive aeration was not as effective at preventing the mobilization of metals in the subsurface and the effective range of passive aeration appeared limited to two feet from the aeration piping

PROJECT APPROACH

Prior to the commencement of the study, it was theorized that active soil aeration was capable of enhancing the treatment of food processor wastewater in the subsurface and that passive aeration was also an effective alternative to active soil aeration. If demonstrated correct, the technology would improve the environment and reduce expenses when dealing with anaerobic soils due to wastewater application.

A one year study was conducted to monitor and measure the effectiveness of active and passive soil aeration under actual field conditions. Work to install the system commenced in December 2010 and discharge commenced on April 12, 2011, following the spring thaw. The system was operated continuously from that date until January 30, 2012. ~~, when the study concluded.~~ Due to temperate winter weather conditions, the study proceeded longer into the winter months providing valuable winter sub-surface irrigation information. The grant funded portion of this study was concluded on December 31, 2011 as scheduled. Information and data collected after that date was gathered through a privately funded continuation of the study's discharge and monitoring systems.

The system had five primary components, 1) wastewater drip irrigation system, 2) active subsurface aeration system, 3) passive aeration system, 4) soil moisture sampling lysimeters, and 5) subsurface environmental monitoring and logging system. Wastewater was filtered then

irrigated to the test plot via one gallon-per-hour drip irrigation emitters situated at two feet below grade.

Two irrigation fields were constructed, one field used an air compressor to inject air and the other used a passive venting system. Three data collecting stations were installed, one in each leach field and the third hydraulically upgradient (control). Data loggers and associated instruments recorded measurements every four hours. Influent wastewater was sampled once weekly, in accordance with the state discharge permit. "Treated" effluent wastewater was collected and analyzed monthly by sampling soil pore water using lysimeters.

Approximately 32,000 gallons was discharged over the period of April 12, 2011 to January 30, 2012. Maximum flow rates of 3.7 gallons per minute (GPM) were observed at the beginning of the discharge period but flow through the system decreased to 1.2 to 1.3 GPM near the conclusion of the study. This reduction in flow was likely caused by fouling of the drip emitters by sediment and organic growth on the interior of the drip tubing.

Smeltzer played a key role in the project by providing the land for the study, supplying electricity for the pumps and blower, performing routine system checks, operation and maintenance activities, and collecting wastewater (influent) samples throughout the project. Furthermore, discharge of wastewater was permitted through the use of Smeltzer's previously-issued MDEQ Groundwater Discharge Permit.

GOALS AND OUTCOMES ACHIEVED

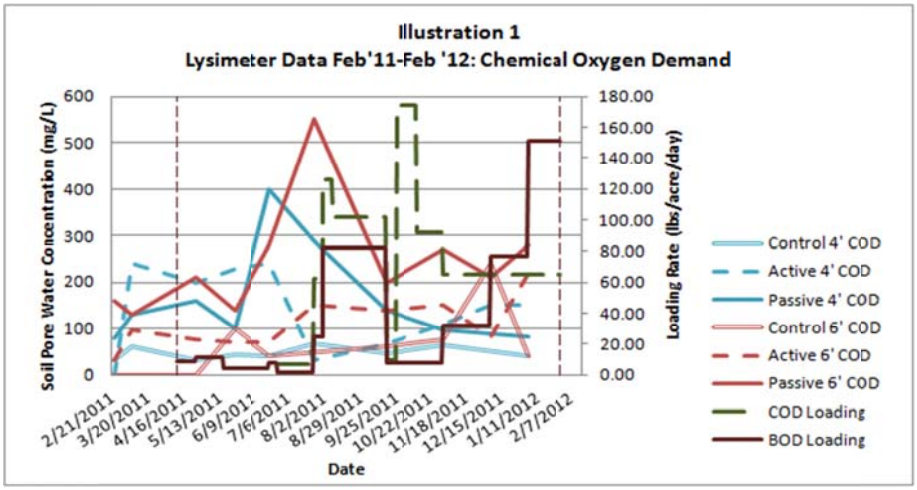
The goals of this study were:

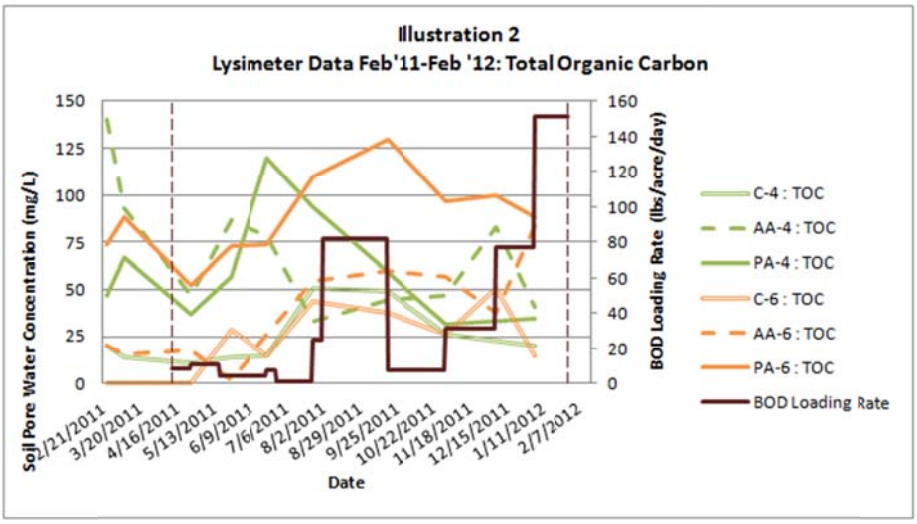
1. ***Demonstrate that soil aeration is effective in the treatment of fruit processing wastewater.***
    a. GOAL ACHIEVED: The data summarized below demonstrates that soil aeration is effective at reducing the concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and total inorganic nitrogen (TIN) that is present in the wastewater stream.
    b. Aeration was also effective at reducing the concentrations of mobile metals found in soil pore water which would have the effect of improved groundwater quality at a food processing facility.
2. ***To reduce wastewater management costs for processors of specialty crops in Michigan by demonstrating that passive aeration is a feasible alternative to active soil aeration.***
    a. GOAL ACHIEVED: This study demonstrated that both active (forced air) and passive (convective) aeration methods provided supplemental oxygen and augmented wastewater treatment in the subsurface.
    b. Though not as effective as active aeration, passive aeration provided treatment (reduction) of up to 90% of key wastewater analytes as demonstrated by soil pore water sampling.
    c. Both systems were strained at elevated hydraulic, BOD, and COD loading rates.
    d. Passive aeration was not as effective at preventing metals mobilization in the subsurface.

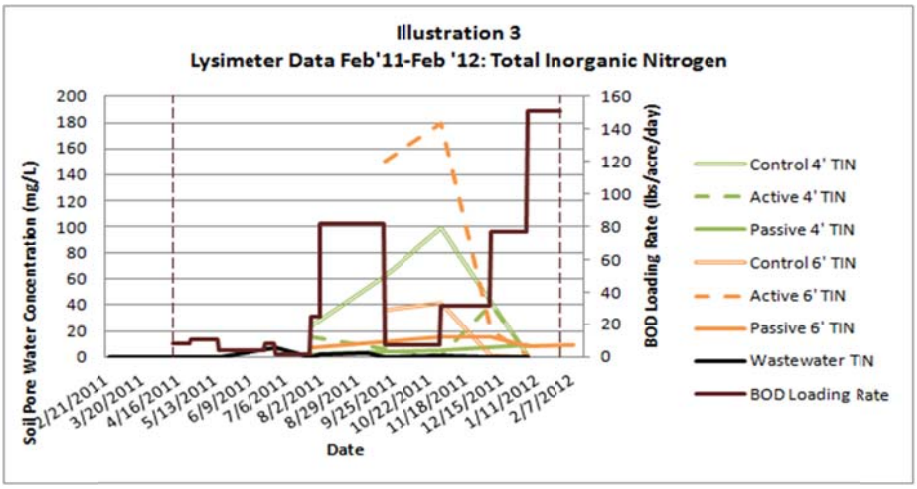
<u>PERFORMANCE MONITORING: WASTEWATER/LYSIMETER SAMPLING</u>

BOD, COD, TOC, TIN:

As detailed in the main Final Performance Report document, this study confirmed that soil aeration is an effective means of the in-situ treatment of food processing wastewater since it provides additional oxygen to the subsurface where it is needed the most. Illustrations 1 through 3, below, compare wastewater influent concentrations of COD, TOC and TIN to their respective concentrations in system effluent as measured in soil pore water collected from lysimeters installed in the study area. Additionally, these illustrations depict the BOD and COD loading rates applied during the study to monitor the effectiveness of the treatment method at various BOD/COD loading rates.







Overall, passive aeration was able to reduce COD by 80% at a minimum, often times reducing near to 90%. Active aeration reduced COD concentrations by 95% or more.

Passive aeration appeared to reduce TOC levels to a relatively stable concentration of 100 mg/L. Again, active aeration was more consistent in treating the wastewater, maintaining a TOC concentration in the effluent of around 50 mg/L regardless of influent concentrations; with an increase of soil pore water TOC concentrations to over 80 mg/L when BOD/COD loading rates exceeded 50 pounds per acre per day. Active aeration was significantly more effective than passive aeration during the first half of the study when BOD/COD loading was lower but both aeration methods were strained by BOD/COD loading rates in excess of 50 pounds per acre per day. Active aeration maintained 90% reduction levels throughout the study.

Wastewater influent concentrations of TIN were consistently very low and well within effluent limitations set by the MDEQ. Samples taken from the control plot on November 1, 2011 showed a spike in TIN at 4' BGS. On the same date, the active plot was sampled and analysis of soil pore water showed a maximum TIN concentration of 180 mg/L. This was preceded in the active aeration plot by a concentration of 150 mg/L on September 19, 2011. These high values of TIN come from a higher than expected concentration of nitrates in the plot areas as demonstrated by soil pore water samples collected at the control. This is most likely due to a period of consistent rain that occurred from October 13 through October 31, 2011. The passive aeration plot did not show a correlating increase in TIN concentration, and remained consistent throughout the study at both 4' and 6' BGS with concentrations of 5 mg/L and 11 mg/L, respectively (average). These results clearly demonstrate that active aeration is better suited to handle a rapid influx of nitrogen from both natural and manmade sources.

Metals

The concentration of key metals iron, manganese, and arsenic was also monitored throughout the course of this study. These metals are typically associated with reducing soil conditions related to the presence of organic material in the subsurface wastewater and anaerobic soil and groundwater conditions. Soil pore water samples collected from the Control Plot were compared to pore water samples collected at two depths below the Active and Passive Aeration Plots. The Control Plot did not contain detectable concentrations of iron at either the 4 or 6 foot interval, manganese was present at detectable concentrations at both intervals with elevated concentrations at 6 feet BGS. Arsenic was not detected in any sample collected from soil pore water in the Control Plot.

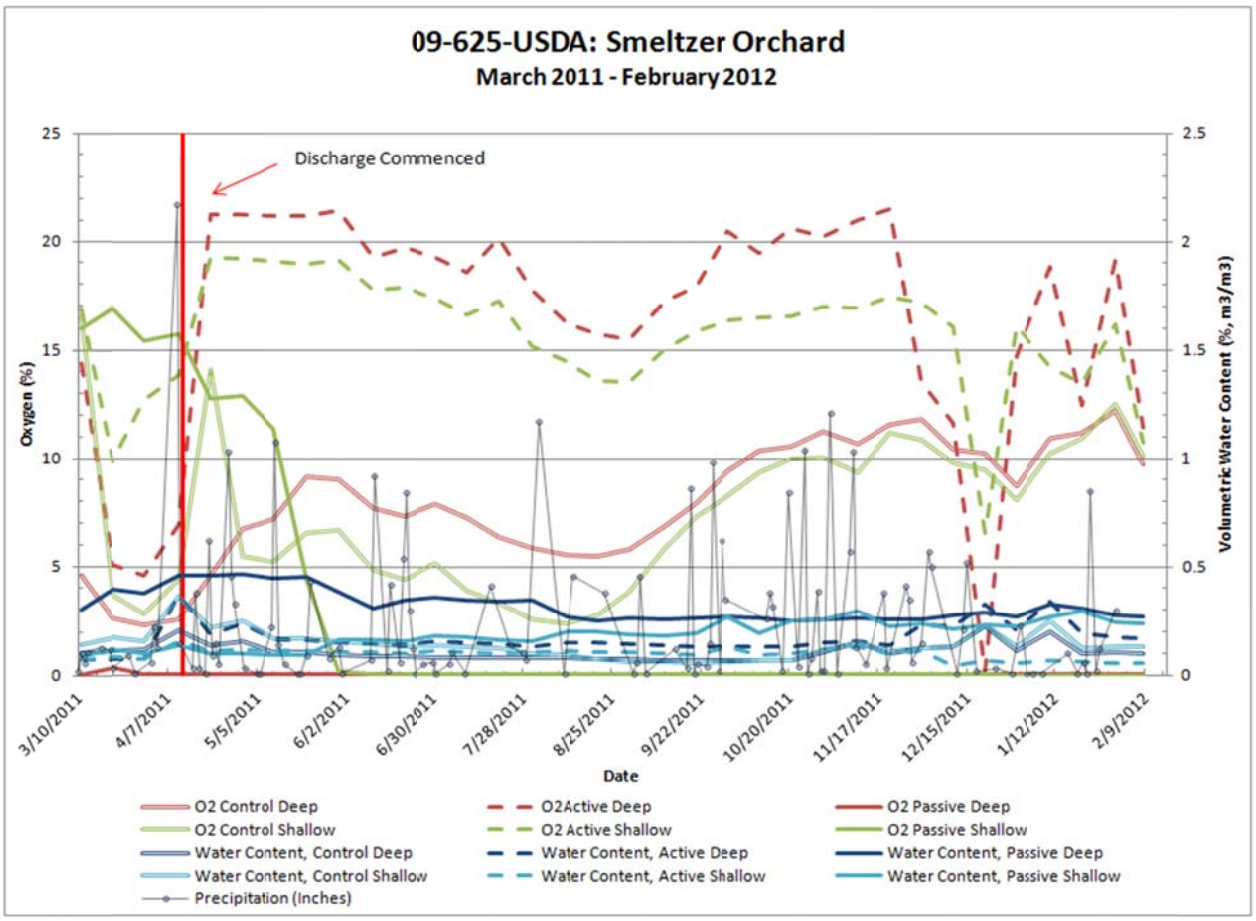
Soil pore water collected from the 4 foot BGS lysimeter in the Active Aeration Plot contained lower concentrations of manganese than found in the Control Plot but had elevated concentrations of iron at that same depth. Conversely, the lysimeter set at 6 feet BGS generally showed a reduction of all metals in soil pore water at this depth. This meant that active aeration not only treated the wastewater influent but improved the quality of naturally-occurring soil pore water at the 6 foot BGS interval.

Soil pore water samples collected at both the 4 and 6 foot BGS intervals in the Passive Aeration Plot demonstrated elevated concentrations of iron, manganese and arsenic over the course of this study. Iron was not detected in soil pore water collected from the lysimeter installed at 6 feet BGS in the Control Plot but was detected at concentrations that exceeded the states default residential drinking water standards in soil pore water collected from the lysimeter placed at 6 foot BGS in the Passive Aeration Plot.

Soil pore water samples demonstrated that active aeration is more effective at preventing the mobilization of metals in the subsurface than passive aeration methods, furthermore, passive aeration methods do not appear to be as effective at providing wastewater treatment over 2 feet away from the aeration source.

PERFORMANCE MONITORING: SOIL ENVIRONMENTAL LOGGING

The study made use of buried temperature, oxygen, and moisture sensors connected to a centrally-located data logger. This information was tabulated along with meteorological information available for the area and plotted against time for interpretation on the chart below:



In summary, as is clearly evident on the above chart, active aeration was more effective at providing oxygen to the subsurface than passive aeration following the commencement of irrigation activities. Periods of increased precipitation were correlated with an increase in soil oxygen in the Control Plot as a result of the influx of fresh, oxygenated precipitation to the subsurface. The initialization of the aeration pump was evident by a spike in subsurface oxygen following system start-up. Concurrently, subsurface oxygen in the passive aeration plot plummeted to nearly zero within two months of system start-up. As discussed below, the Passive Aeration Plot was installed on an area of previously-disturbed soils that had poor compaction. Despite an effort to remove, test, relocate and replace the oxygen sensors in the Passive Aeration Plot, we suspect that water accumulated in the sensor producing very low soil oxygen readings.

Volumetric water content represents soil moisture for subsurface soils in the study. As demonstrated in the chart, soil moisture is responsive to natural precipitation that occurred at the study site throughout the project. Elevated soil moisture readings were recorded for both the 4 foot and 6 foot BGS sensors installed in the Passive Aeration plot while soil moisture content in the Active Aeration Plot was only slightly higher or consistent with soil moisture readings collected from the Control Plot. Again, this anomaly is less-likely related to the aeration method than the soil types encountered in the Passive Aeration Plot.

BENEFICIARIES

Currently, Michigan's food processing and agribusiness is a $37 billion industry, making it the state's second largest industry (MDEQ, Food Processing E2-P2 website, 6/22/09). Furthermore, according to the Michigan Department of Agriculture, food processing and agribusiness is the fastest growing industry in the State. The operating costs associated with environmental compliance for Michigan processors are significant. Annual costs associated with wastewater treatment, discharge, and discharge compliance can range from approximately $50,000 to $1,000,000 for a single processor.

A number of processors have expressed the need to expand to meet market demand, but the current concentration and loading limits for wastewater prohibit such endeavors. Many specialty crop processors cannot expand their businesses, and thus the State's revenues, without dedicating a rapidly increasing amount of capital to meet wastewater discharge standards. Development of this technology for the treatment of wastewater may significantly reduce costs for the State's food processors, while protecting the State's water resources.

LESSONS LEARNED

Issues:

1. Filtration: Due to the nature of the wastewater stream, Lakeshore and Smeltzer quickly identified that the filtration methods initially implemented in the system were not adequate to provide filtration to 100 microns AND longevity. The original system design included the use of dual disc filters to achieve the water quality required for the buried drip irrigation system. As reported in the First Quarter 2011 report, one of the disc filters was removed and replaced with a bag-style filter module. The filter media used was a 100 micron felt media that functioned to specification during the first day of application then fouled quickly with a slimy film that prevented water movement. After some research, Lakeshore upgraded the bag filter media from polyethylene felt to nylon mesh of similar pore size. This revision to the system occurred in August 2011 and provided

for more consistent flow rates over the course of application and required weekly filter media changes.

2. Drip Irrigation: The effectiveness of the drip irrigation system decreased over time. This was likely due to emitter fouling as a result of either excess solids passing through the filtration system or, more likely, the accumulation of organic "sludge" within the piping system. Future attempts at this type of irrigation with wastewater will require regular treatment of the drip system to remove and prevent emitter fouling.
3. Installation Method: Drip irrigation tubing was placed in trenches directly beside active/passive aeration tubing. Since the open spaces in the aeration tubing provide perfect specific hydraulic storage when compared to compacted soils, it is likely that wastewater accumulated in the passive aeration vent tubing thereby prohibiting or limiting the free movement of atmospheric air through the aeration piping. Future installations should have drip tubing at the bottom of the trench surrounded by clean native backfill above with a space of greater than three inches before the placement of the aeration piping. This will allow moisture to infiltrate the soil but decrease the likelihood of water accumulation in the aeration piping.
4. Weather: Winter weather conditions present at the commencement of the study prohibited the start-up of the system despite efforts to winterize the pipes and distribution system. Furthermore, in February 2012, soil pore samples analytical results were limited to only Passive Aeration because the other lysimeters could not produce water for a sample. This was most likely due to water frozen in the tubes, which created a block when the pressure was applied to the lysimeter.
5. Plot Selection: Successful application of passive aeration techniques and in-situ soil monitoring with electronic environmental sensors is achieved in native, undisturbed soils or soils that are properly compacted and free of organic debris (crushed cherry pits).

Achievements:

1. This study demonstrated that soil aeration is effective at reducing the concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and total inorganic nitrogen (TIN) that is present in the wastewater stream.
2. This study demonstrated that aeration was also effective at reducing the concentrations of mobile metals found in soil pore water which would have the effect of improved groundwater quality at a food processing facility.
3. This study demonstrated that both active (forced air) and passive (convective) aeration methods provided supplemental oxygen and augmented wastewater treatment in the subsurface.
4. Though not as effective as active aeration, this study demonstrated that passive aeration provided treatment (reduction) of up to 90% of key wastewater analytes as demonstrated by soil pore water sampling.
5. This study demonstrated that both systems were strained to treat wastewater when discharged at elevated hydraulic, BOD, and COD loading rates.
6. This study demonstrated that, passive aeration was not as effective at preventing metals mobilization in the subsurface.

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ADDITIONAL INFORMATION

Readers of this report are encouraged to review the full Final Performance Report on file with the Michigan Department of Agriculture, Michigan Food Processors Association, Smeltzer Orchards Company, and Lakeshore Environmental, Inc. Additional information can also be obtained by viewing the Lakeshore Environmental, Inc. website at www.lakeshoreenvironmental.com/SCBGProjects available after March 22, 2012.