Evaluation of Odor Removal Via Electrostatic Particle Ionization and Geotextile Fence

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Purpose

Iowa Select Farms installed an electrostatic precipitator at the end of two tunnel ventilated swine finishing barns near Alden, Iowa. The objective was to quantify the performance of this system in regards to odor and dust control.

Location

Iowa Select Farms swine farm near Alden, Iowa. The site has two barns that were used in the study. The two barns are approximately 101 feet x 190 feet, with tunnel ventilation and have fans on the north wall. Both facilities are equipped with an electrostatic precipitator and geo-fabric fence.

The system was installed with two strands of corona wire 12 feet from the barn wall. The two corona wires were placed in the fan discharge cone; one strand in the upper 1/3 and one located in the lower 1/3. An air sample for odor and particulate was collected 4 feet from the fan discharge cone in the midpoint of the fan stream; this sample was approximately 4-foot upstream of the corona wires. The geotextile fence was located approximately 4 feet from the corona wires and was 10-foot-tall and extended down to the ground. The post-treatment sample was collected 8 feet from the geotextile fence again in the center of the fan discharge location (see figure 2 for sampling locations).

Key Measurements

Measurements were conducted every other week for a 4-month period with measurements being conducted one time with the fence on, the second with the fence off to evaluate the role the geotextile fence and the role the electrostatic precipitation fence had on odor and dust reduction.

1. Odor via sample collection in Tedlar bags and dilutions to threshold via forced tri-choice olfactometry.
2. Total suspended particulate (TSP), particulate matter less than 10 µm (PM10), and particulate matter less than 2.5 µm (PM2.5) quantifications before and after the electrostatic precipitator/geotextile fence were collected with MiniVols and measuring the mass of particulate collected on the filter.

Taken together, these parameters will provide Iowa Select Farms with the data required to understand the impact this system has on odor downwind of the facility. The olfactometry data can be used in the CAM (Community Assessment Model) to demonstrate how odor occurrence is modified as a result of using this treatment system. Particulate sampling for TSP, PM10, and PM2.5 will provide data on how the system is performing agglomerating particles together and keeping them onsite.

Figure 1. Installed electrostatic precipitator and geotextile fence system.

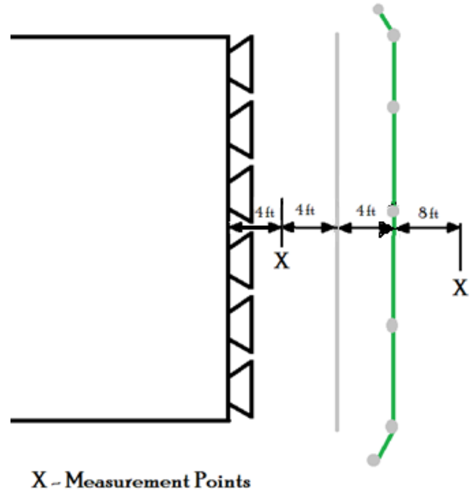

Figure 2. Measurement locations and system setup. The grey line represents the electrostatic precipitation fence and the green line the geo-fabric fence.

Methods

Swine barn description and sampling location

The study was conducted as an upwind/downwind paired sample study to evaluate the impact the electrostatic precipitation and geo-fabric fence had on odor and dust movement from the facility. There are two barns at this site, both of which had the treatment systems installed. To help evaluate the system performance, measurements were conducted with the electrostatic precipitator both off and on, alternating off and on each time the facility was sampled.

PM2.5 and PM10 concentrations

The MiniVol has an air sampling flow rate of 5 L/min and was equipped with size-selective inlets for PM 10 and 2.5. The MiniVol consists of a pre-separator assembly (a particle size impactor and a 47mm filter), a sampler (a pump and timer assembly), and a battery pack. The 47mm filters used for the samplers were VWR Flass Microfibre Filter, 691 (VWR European Cat. NO. 516-0074, UK).

TSP concentrations

Leland Legacy Sample Pump sampled air at 10 L/min for the duration of the 24-hour events. The Chemcomb contains a size-selective inlet with a PM2.5 or PM10 impactor inside of the single cartridge, a four-stage 47 mm filter pack and up to two honeycomb denuders for the collection of selected gases. TSP can be measured by removing the impactor. TSP will be collected on 47mm VWR Flass Microfibre Filter, 691 (VWR European Cat. NO. 516-0074, UK) filter, which were the same filter used for Minivol sampling. Each Chemcomb was labeled with the date, time, particles size, location, and filter start weight. All the components were assembled in the laboratory and enclosed in the samplers' container while transporting to the site.

Dynamic Dilution Olfactometry

Samples of air for measuring odor concentration were drawn into Tedlar bags (SKC, Inc., PA) with date, site, location, and client name labeled in a Vac-U-Chamber (SKC-West, Inc., Fullerton, CA), a rigid air sample box designed for filling SKC sampler bags using negative pressure provided by an air sampler pump (Universal PCXR4 Sampler Pump, SKC, Inc., PA). These bags were taken for determining their odor concentrations using forced tri-choice olfactometry, which was performed using an olfactometer (AC'SCENT Laboratory Olfactometer, St. Croix Sensory, Inc) with a tri-forced-choice method of sampling presentation to a panel of four assessors. Samples at different dilutions were presented to odor panelists for sniffing and their responses were recorded. In this forced-choice method, single sniffing port was used. There are 14 levels in our system and the dilution is different at each level. Diluted samples were twice presented to the panelists. This olfactometer had one sniffing port that delivering the diluted air sample. For each presentation, panelists indicated, via a keyboard consisting of G (guess) or D (determined), the port that delivered the scheduled diluted odor. The collected results were received from the olfactometer and processed by DataSense Olfactometry Software Application (AC'SCENT Laboratory Olfactometer, St. Croix Sensory, Inc) to automatically compute the sample results in terms of dilution to a threshold.

Statistical Analysis

Statistical analysis on chemical concentrations were performed using JMP Pro 14 (SAS Institute Inc. Cary, NC, USA) software. Data were analyzed for each field day using the experimental unit with each measured substance as follows:

1. Paired to test procedure to determine significant differences in Odor and PM concentrations (i.e., PM2.5, PM10 and TSP) between upstream and downstream was conducted using an ANOVA procedure with factors of date (random blocking variable to pair upstream and downstream samples), barn (random blocking variable to hand site-to-site differences, sampling location (upstream/downstream) (fixed effect), electrostatic fence setting (on or off) (fixed effect to handle when the fence was running, and the interaction of when the electrostatic fence setting and sampling location. The statistical significance was set at $\alpha = 0.05$.

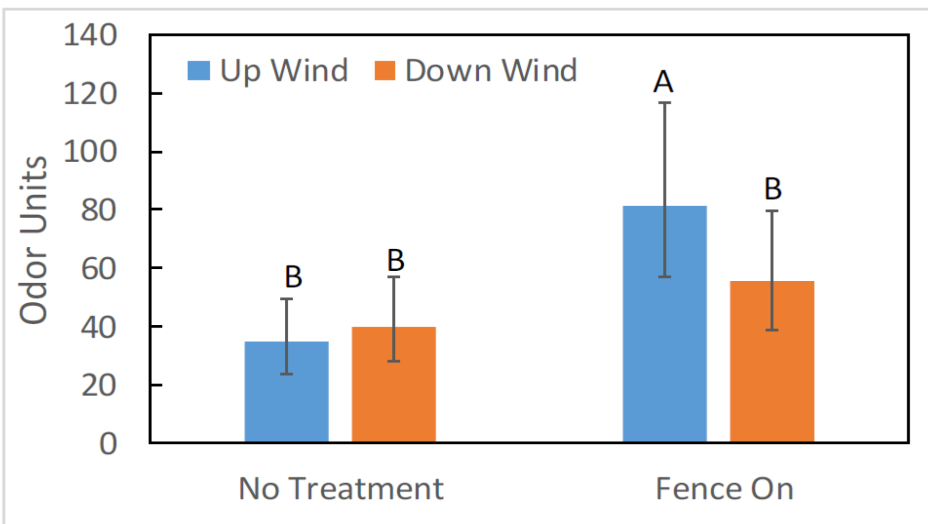

Figure 3. Odor units emitted both during treatment and without treatment. Concentrations shown with different letters/numbers were statistically significant at $\alpha < 0.05$. Error bars represent the standard deviation of days sampled.

Results

Odor

We saw no statistical difference in odor concentration before and after the fabric fence when the electrostatic fence was off; we saw a statistical difference ($p = 0.0024$) when the fence was on with the average reduction in odor being **31%.** Overall, this shows the electrostatic fence was causing an odor reduction and it was due, at least in part, to the electrical discharge impact on odor (figure 3). The results were generally consistent, with no individual sampling event showing a difference in odor concentrations between the upstream and downstream sampling points the electrostatic precipitation system turned off causing a significant change in odor concentration. When the electrostatic precipitation system was on, performance ranged from no reduction to 40% reduction on any individual sampling date.

One interesting aspect of this data, when the fence was on, we saw a statistically higher odor at the outlet of the fan, than on the days the system was turned off. This was random and due mostly to several days early in the study when ventilation rates impacted the number of fans that were running, and as a result, the odor concentration in the exhaust air tended to be high and was related neither to the barn sampled from or any other variable evaluated in this study.

Odor strength is often quantified in odor units. To measure odor sensation, an odor is diluted to a point where it can just be detected. The numerical value of the odor concentration is equal to the dilution fac-

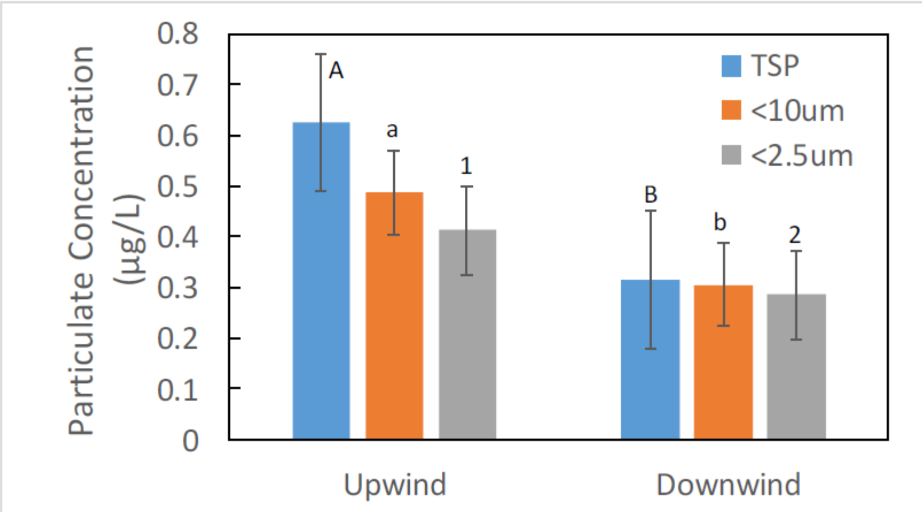

Figure 4. Summary of particulate matter concentrations for total suspended particulate (TSP), particulate matter less than 10 microns, and particulate matter less than 2.5 microns. Concentrations shown with different letters/numbers were statistically significant at $\alpha < 0.05$.

tor that is necessary to reach the odor threshold. Thus in the study the odor unit was calculated as the geometric average dilution level at which panelist could first correctly identify which sample was the one that contained the odor, and which where the blanks.

Particulate Matter

We did not see a statistical difference in dust reduction when the electrostatic precipitation fence was on or off, but dust between the fan outlet and the measurement point was statistically reduced in all cases. Since no statistical difference was found between when the electrostatic fence was on or off, all data was summarized together to increase statistical power. This is not directly dust removal due to the treatment system as some of the dust would have settled anyway due to the distance from the fan. Several tests were run without the geo-fabric fence present to quantify the effect measurement distance from the fan had on dust concentration. This was performed by taking several samples without the fence in place and will be discussed after the initial results.

The results indicated statistically significant reductions ($p<0.0001$) for all three sizes of particular mater (total suspended particular, particulate less than 10 µm. and particulate less than 2.5 µm). Reductions were 50% for TSP, 37% PM10, and 31% for PM2.5. Results are summarized in figure 4. This does indicate that reductions were slightly higher for larger particles, but the removal of all particles was relatively similar.

Three sampling events were conducted without either the electrostatic precipitation system turned on or the geotextile in place, during these sampling events we saw a 14% reduction in TSP, an 8% reduction in PM10, and a 6% reduction in PM2.5. These results would set a standard for the impact we would expect to see from just sampling distance alone, essentially dilution due to dispersion and settling. Using this as a baseline we suggest the electrostatic precipitation fence system and geotextile fence reduced the dust by 42% for TSP, 29% for PM10, and 25% for PM2.5

Summary

Overall, the electrostatic precipitation-geotextile fence system performed well, reducing odors by 31% and dust of various sizes by 31-50%. These levels are similar to or slightly better than those previously reported in literature for an in-barn system. Original estimates of odor reduction were 12% reported for in-barn system. The higher reduction here could be a result of several factors, including fence distances from the fan, how it interacts with the air, as well as the inclusion of the geo-fabric fence system, which may have increased turbulence and mixing. Dust removal efficiencies were similar, with reductions of 39-65% being reported in literature as compared to the 31-50% reductions found in this study. In this case, the difference may be primarily due to the sampling location as dust measurements in-barn tend to be higher than those emitted by barn fans, which make higher reductions likely. Based on observation, the period rain events seemed frequent enough to wash the dust from the fence and rejuvenate its capture potential and overall, the system worked well.

Additionally, based on the ISU AMPAT tool, you may see an additional benefit of 5-15% reduction in odor from a vegetative buffer around the facility. Similarly, this buffer will further remove any dust coming through the electrostatic system, with reductions of up to another 50% obtainable.

Additionally, given you are not running your pit fans during higher ventilation this can serve as an additional odor reduction during the summer, and based on previous research has the potential to reduce odor from the facility by another 10-20% .

Combining all these practices, it is possible these facilities are in the neighborhood of a 50% reduction in odor, as compared to more conventional swine production facilities.

System	Odor	TSP	PM10	PM2.5
Electrostatic + Fence	31%	50%	37%	31%
Fence	0%	50%	37%	31%
Nothing	0%	14%	8%	6%

Table 1. Summary of Results