RESEARCH ABSTRACT

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ENVIRONMENT

Title: Testing soybean peroxidase for swine manure treatment and mitigation of odorous VOCs, ammonia, hydrogen sulfide and greenhouse gas emissions – **NPB #12-108**

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Scientific Abstract:

The control of odor, odorous volatile organic compounds (VOCs), hydrogen sulfide (H_2S), ammonia (NH_3), and greenhouse gases (GHGs) emissions associated with commercial swine production is a critical need. Manure storage is the major source of gaseous emissions. This study aimed for the most comprehensive, to date, assessment of a manure additive for mitigation of gaseous emissions of all major compounds of interest from swine manure. This study tested *topical* application of manure additive treatment in controlled pilot and farm scales (soybean peroxidase (SBP); product code 516-IND; Bio-Research Products, Inc.). This research builds on the previous published study where SBP product was *mixed* into manure and resulted in significant mitigation of odorous VOCs in lab scale. In this research both pilot and farm scale testing of topical SBP treatment (and ~23.5:1 weight/weight mix of SBP:CaO_2 catalyst) was conducted over ~5 month and ~1.5 month, respectively. This work aimed at providing a comprehensive assessment of SBP treatment efficacy to mitigate emissions of odorous VOCs, odor, H_2S, NH_3, and GHGs, i.e., a set of target gases of concern to swine industry.

The soybean based additive was first tested in **pilot scale** (Objective 1). Effects of SBP dose and time were tested. The following topical doses (mass per manure surface area) with three replicates of each: 0, 2.28, 4.57, 22.8 and 45.7 kg/m^2 (equivalent of 0, 0.467, 0.936, 4.67 and 9.36 lbs/ft^2; and equivalent of 0, 2.5, 5.0, 25 and 50 g/L of swine manure) were evaluated. Emissions of VOCs, H_2S, NH_3, and GHGs were monitored over the course of 21 days pre-application and 136 days post SBP application. Pilot scale tests resulted in reduction of gaseous emissions for some compounds, while no difference or increase in emissions for others for the entire SBP testing period of 136 days. Specifically:

1. **Ammonia** emissions were reduced by 14.6% to 67.6% and were statistically significant except for the lowest SBP dose. The percent reduction was correlated with the SBP dose. The apparent effectiveness of SBP treatment was decreasing over time.
2. **H_2S** emissions were highly variable and not correlated with the SBP dose.
3. **GHGs** emissions were not significantly changed for nitrous oxide (N_2O). Methane (CH_4) and CO_2 emissions increased by 32.7% to 232% and 20.8% to 124%, respectively. The percent increase was statistically significant (except for CH_4 and the lowest dose) and was correlated with the SBP dose. The increase of CO_2 and CH_4 emissions may be inferred considering biochemical breakdown of VOCs as a result of SBP treatment.
4. **Sulfur VOC** emissions were generally reduced by 36.2% to 84.7% (DMDS) and 10.7% to 16.9% (DMTS). However, the only statistically significant reduction was for DMDS at the mid-range SBP doses.
5. **Volatile fatty acids** emissions were reduced by 8.5% to 19.5% (butyric acid), 79.2% to 88.5% (valeric acid) and 42.7% to 59.2% (isovaleric acid) except for the highest SBP dose for butyric and isovaleric acids. However, none of the reductions were statistically significant.
6. **Phenolics** emissions were reduced by 53.1% to 89.5% (*p*-cresol), 52.6% to 81.8% (indole, except for the highest SBP dose), and 63.2% to 92.5% (skatole) and were statistically significant for *p*-cresol and skatole. Indole emission's reductions were not statistically significant. The apparent effectiveness of SBP treatment on phenolics was decreasing over time.

The soybean based additive was then tested at **farm scale** (Objective 2). Effects of time were tested using one (the lowest) SBP dose selected from the pilot study. A topical dose of 2.28 kg/m^2 (equivalent of 0.467 lbs/ft^2, equivalent of 12 g/L of swine manure was used. VOCs, H_2S, NH_3, and GHGs emissions were monitored over the course of 42 days post SBP application. In general, mitigating effects of SBP treatment were similar at the farm and the pilot scales (especially, when the similar, 42 day treatment periods at the pilot and farm scales were compared). Overall, the SBP treatment was effective in mitigating major gases of concern on the farm scale. NH_3 showed a significant 22% overall reduction in emissions in the treated room compared to the untreated room. Hydrogen sulfide emissions in the treated room resulted in a significant 80% overall reduction compared to the untreated room. Greenhouse gas emissions in the treated room showed an insignificant reduction compared to the untreated room. Non sulfur VOCs emissions from the treated room showed an average reduction of 36% based on the average overall means. Specifically:

1. **Ammonia** emissions were reduced by 21.7% and were statistically significant. The reduction at the farm scale was slightly higher than that observed at the pilot scale (15.3%) over the same treatment time at the same SBP dose.
2. **H_2S** emissions were reduced by 79.7% and were statistically significant. However, it was only the 22.8 kg/m^2 SBP dose at pilot scale that resulted in H_2S emissions reduction (62.9%). Effects of other pilot scale doses were highly variable.
3. **GHGs** emissions were reduced for N_2O at 9.8%. However, the reduction was not statistically significant. Similarly, a statistically insignificant change was also observed at the pilot scale for N_2O (2.9% increase) at the same SBP dose. Both methane and CO_2 emissions were reduced by 6.2% and 3.0%, respectively. However, the reduction was not statistically significant. Significant increase in CO_2 (24.6%) was observed at the same SBP dose at the pilot scale. This apparent

discrepancy could be explained by contribution of exhaled CO_2 at the farm scale and its effect on significant increase in measured concentrations. Increased levels of CO_2 made it more challenging to measure the changes in CO_2 emissions from the manure. Methane also increased at the pilot scale for the same SBP dose (32.2%), however it was not significant.

4. **Sulfur VOC** emissions were significantly increased by 30.6% for DMDS. The pilot scale flux estimates resulted in a reduction of DMDS (65.1%) at the same SBP dose. DMTS was only present in high enough concentrations to be measured for one day in one room during the trial so the effect of the SBP could not be assessed.
5. **Volatile fatty acids** emissions were significantly reduced by 37.2% (butyric acid), 47.7% (valeric acid) and 39.3% (isovaleric acid). Similar reductions were observed (17.7%, 5.6% and 46.9%, respectively) at the pilot scale for the same SBP dose, however they were not significant.
6. **Phenolics** emissions were reduced by 14.4% (*p*-cresol), 31.2% (indole) and 43.5% (skatole) and were statistically significant for indole and skatole. The pilot scale resulted in reductions of 58.3% (*p*-cresol), 82.9% (indole) and 81.4% (skatole) at the same SBP dose, with significant reductions in *p*-cresol and skatole.

The estimated cost of treatment (additives only) was estimated at $1.45 per marketed pig and $2.62 per marketed pig when the cost of labor was added. Similarly, the estimated cost was $2.19/pig space/year of the (additives only) and $3.95 when the cost of labor was included (2014 price benchmarking). The cost estimate was at the lower range of comparable products tested for air quality mitigation ($0.01 to $18.2 per marketed pig). The SBP treatment with similar cost resulted in a more comprehensive mitigation of greater number of gases of concern for swine industry. It also may have a potential benefit to U.S. soybean farmers as the active ingredient is derived from soybean hulls, a low value by-product of soybean utilization.