

# **Improved, GC-Olfactometry Based, Malodor Assessment of Swine CAFOs Utilizing Novel Air Sampling Technologies**

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## **ABSTRACT**

**Odor profiling efforts were directed at applying to high-density swine CAFOs, some of the experience gained through recent GC-Olfactometry based odorant prioritization studies relative to high-density cattle CAFOs. Preliminary GC-O odor profile work indicates that with increasing distance from either high-density cattle or swine feeder operations the residual odor is increasingly defined by a limited number of high priority odorants. These ‘character defining’ odorants appear to be dominated by compounds of relatively low volatility and high polarity. This work suggests that, as previously shown for cattle CAFOs, p-cresol alone appears to carry much of the overall odor impact. This is particularly true for the case of increasing distance from the swine CAFO source. If confirmed, such prioritization questions the validity of air sampling protocols which are based on plastic sample bags. Several studies have shown that p-cresol and other high-impact semi-volatile odorants are rapidly lost from the captured air samples through ‘scalping’ effects; resulting from adsorption onto and absorption into the wall of the bag.**

**Keywords:** malodor analysis, agricultural odor analysis, farm odor, GC-Olfactometry, GC-O, solid phase microextraction, SPME, multidimensional gas chromatography, livestock housing

## **INTRODUCTION**

A large body of excellent analytical work has been reported during the past three decades relative to the volatile compounds emitted by high density livestock operations. A variety of concentrating and analytical techniques (3,6,7,8) have been utilized in the identification of scores, if not hundreds, of volatile compounds in these environments. Included among these volatiles are a large number of compounds which are known to be potent individual odorants. The challenge relative to the CAFO odor issue is to extract from this large field of 'potential' odorants, the compounds which carry primary responsibility for the downwind odor complaints relative to these operations.

There is a popular ‘school of thought’ which states that there are no odorants emitted by CAFO environments which are sufficiently dominant to be utilized as quantitative odor markers. As a result, much of the odor assessment work to date has been restricted to qualitative assessment utilizing ‘human’ detectors in conjunction with techniques such as dynamic dilution olfactometry. Past and recent (9) GC-Olfactometry work which has been carried out by these authors, as well as others, suggests that CAFO odor assessment

should, in fact, be translatable to objective, instrument based protocols. This GC-O based work suggests that the key odorants relative to distance separation from high density CAFOs are dominated by just a few compounds and these are characterized by relatively low volatility, high polarity and extreme odor potency (i.e. p-cresol, p-ethyl phenol, isovaleric acid, 2-amino acetophenone, indole and skatol)(9).

The prioritization of individual odorants relative to odor impact can be an extremely important consideration in the development of odor assessment sampling and analysis protocols. It is impossible to overstate the importance of sampling quality to the overall validity of an analytical procedure. There is absolute truth to the old adage that ‘the analysis is only as good as the sample to which it is applied’. This consideration is especially pertinent to the question of environmental odor assessment in general and CAFO odor assessment in particular. For example, much of the odor monitoring work to date has been carried out utilizing sampling protocols which are based upon Tedlar™ (i.e. or alternate plastic) bags. Unfortunately, the propensity for plastic films to rapidly adsorb semi-volatile compounds from contained gas samples has been well documented (4,5). This ‘scalping’ effect coupled with past and recent GC-O based odorant prioritization results combine to bring into question the validity of plastic bags for odor sampling relative to these environments. That is, if the odorant prioritization results presented herein are even close to correct, a sampling protocol which accepts 70% to 100% (4,5) loss of top priority odorants (i.e. within the first few minutes or hours after collection) should be viewed with skepticism.

It appears that three major challenges confront on-going efforts to develop objective and quantitative instrument based odor assessment protocols for CAFO environments. The first of these is to confirm or disprove the validity of the concept of odorant prioritization for these environments. If the concept of odorant prioritization is proven to be valid, the second challenge is to refine and expand the initial prioritizations (i.e. such as proposed herein). The third challenge is the development of sampling and analytical protocols which more closely reflect the ‘consensus’ prioritizations which emerge from successfully addressing the first two challenges.

Focusing on the first of the three challenges, the goal of this current project was to perform a similar GC-O based odor prioritization study for swine CAFOs as was reported previously for high density cattle feedlots (9). As summarized below, the resulting odorant priority rankings were found to be very similar relative to the top two or three priority odorants. As previously reported, the top priority was dominated by p-cresol, a semivolatile odorant of particular adsorption sensitivity. This result serves as added impetus for critical review of the current odor assessment sampling and analysis protocols for the CAFO odor application. Presented in the sections which follow are the authors’ progress, to date, relative to addressing the three challenges defined above.

## MATERIALS and METHODS

### **Multidimensional Gas Chromatography-Olfactometry-Mass Spectrometry**

MDGC-O-MS is an integrated approach combining olfactometry and multidimensional GC separation techniques with conventional GCMS instrumentation. A commercial integrated AromaTrax™ system from Microanalytics (a MOCON Company) of Round Rock, Texas was used for the GC-olfactometry profiling work as presented below. Details regarding hardware and operational parameters have been described in detail in past publications (9) and will not be restated here.

### **Sampling:**

Solid Phase Microextraction (i.e. SPME) (1,2) utilizing a 1 cm Carboxen modified PDMS - 85 µm fiber was the headspace sampling technique which was utilized for this odor profiling study. SPME collections were carried out by direct fiber exposure of the target swine barn environment – utilizing variations in downwind distance for cross-comparison purposes. All SPME collections were carried out under ambient conditions. Samples were collected simultaneously at the “Near” and “Far” locations for 20 min.

### **Animal Feeding Facilities:**

Field air sampling was conducted at a 5,400-head capacity swine finisher site with an on-site lagoon. The site was located approximately 160 km from the Texas A&M Agricultural Research and Extension Center in Amarillo, Texas. The site consisted of five, mechanically-ventilated barns (72.1 m x 12.6 m). Feces and urine are collected in the shallow pit with a pull plug discharging to an on-site lagoon every 7 days. The “Near” site was the southernmost barn exhaust fan, i.e., a belted 1.22 m dia. (AirStream 48) fan, on the east sidewall. The “Far” site was located approx. 200 m downwind from the “Near” site.

## RESULTS and DISCUSSION

The odor issues relative to CAFOs will be very different; depending on the distance of downwind separation from the source facility (9). Results to date, suggests that p-cresol represents the preponderance of the odor problem relative to at-distance separation from cattle CAFO sources. As expected, locations at or near these source facilities appear to be characterized by greater odor complexity; with a greater number and variety of individual odorants rising above their individual odor thresholds. The natural dilution effect associated with increasing distance from these sources has the effect of simplifying the resulting odor profiles; reducing both the number of individual odorants detected and the relative intensities of those odorants that are detected. This natural dilution effect relative to one representative swine CAFO is demonstrated in the following series of aromagrams (i.e. odorant profile generated by GC-O utilizing a human odor ‘detector’). Figures 1 and 2 reflect the odor profiles which were generated near-source and at-distance relative to the targeted swine barn facility.

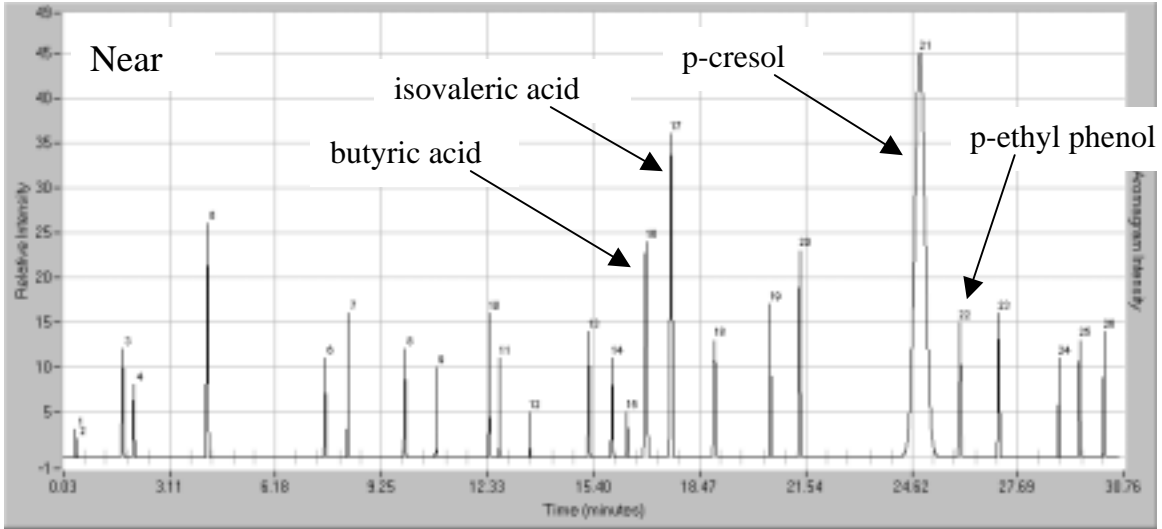


Figure 1. Aromagram for 20 min SPME fiber collection at 20 m downwind (“near” site) from research swine CAFO.

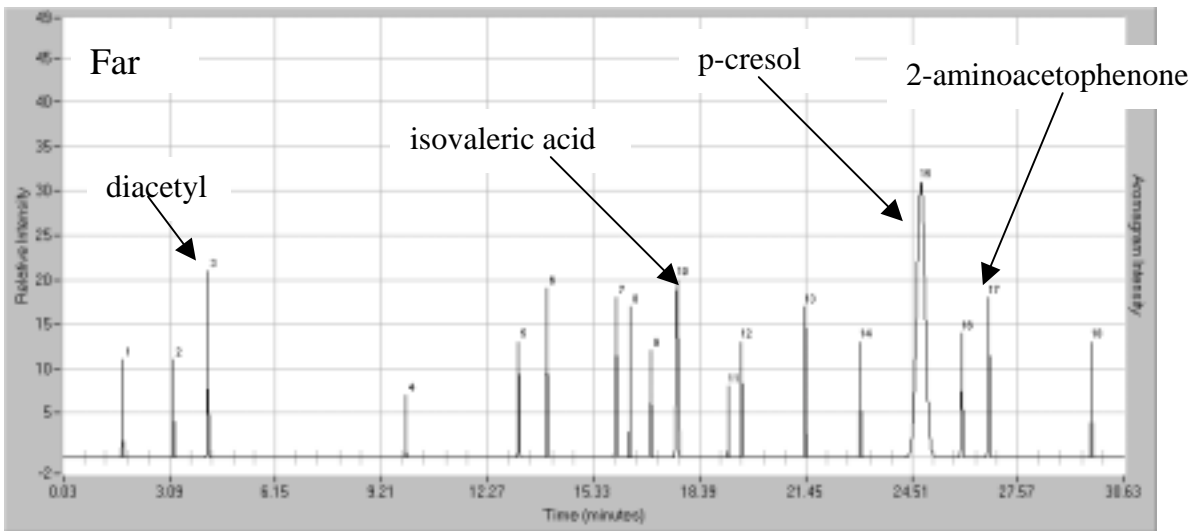


Figure 2. Aromagram for 20 min SPME fiber collection at 200 m downwind (“at-distant” site) from research swine CAFO.

The reduced sample loading resulting from sampling at increasing distance from the source is clearly reflected in this aromagram series. Key observations which can be extracted from these comparative profiles are the following:

- Increasing distance from the source results in a significant reduction in the total number of detectable odors as well as corresponding reductions in odor impact intensities for those odors that are detectable.
- Clearly, p-cresol represented the dominant odorant relative to both near-source and at-distance downwind sampling points. This dominance was reflected in responses by the GC-O investigator to both perceived odorant intensity as well as perceived odor

character. This priority ranking of p-cresol relative to at-distance separation from the swine CAFO source is in agreement with earlier profiles developed for cattle CAFOs.

- Relative to the near-site collection, only the dimethyl trisulfide homolog of the sulfide series presented with a significant individual odor response (i.e. distinct 'fecal'). There were no significant odor responses for H<sub>2</sub>S or the lower MW organic homologs (i.e. under the selected sampling parameters).
- The profile of odorants which were secondary to p-cresol in odor impact ranking were found to be in good agreement with those previously shown for cattle CAFOs. These included; isovaleric acid, 2-aminoacetophenone, p-ethyl phenol, butyric acid and diacetyl.
- Surprisingly, in contrast to previous swine CAFO odor profile efforts, skatol and indole were not shown to be significant secondary odorants relative to this current series. It is assumed, at this point, that this absence results from the extremely short exposure times (i.e. 20 minutes) used for these SPME fiber collections. Short exposure time bias relative to increasing molecular weight volatiles is a well established characteristic of the SPME sampling technique. [2]

These odor profile results were shown to be consistent with those previously reported by these authors for cattle CAFOs. Comparative odorant priority rankings relative to these two environments are summarized in Tables 1 and 2 below.

Table 1. Approximate odor impact priority rankings for a commercial cattle CAFO.

Odor Priority Ranking	Near Source	Distance From Source
1	trimethylamine	para-cresol
2	para-cresol	isovaleric acid
3	butyric acid	para-ethyl phenol

Table 2. Approximate odor impact priority rankings for a research swine CAFO.

Odor Priority Ranking	Near Source	Distance From Source
1	para-cresol	para-cresol
2	isovaleric acid	isovaleric acid
3	2-aminoacetophenone	guaiacol
4	butyric acid	dimethyl trisulfide

Although considerable similarity is shown in these comparative odor profiles, there were also points of significant difference. Particularly noteworthy was an apparent reduction in the odor impact significance for trimethylamine for the swine CAFO in comparison to the previous cattle CAFO results. As stated previously, this apparent difference may be accounted for by the unusually short sample collection time (i.e. 20 minutes) relative to that of the previous cattle CAFO series (i.e. 1 hour and 4 hour). Perhaps, of greater importance, is the similarity in the top priority odor impact rankings when these comparisons are made. These similarities serve as additional reinforcement of the indictment of para-cresol as the odorant of greatest individual odor impact relative to either cattle or swine CAFOs. The observations presented above do not purport to

represent a definitive qualitative assessment of the complex field of CAFO odor. However, these assessments are believed to be sufficiently compelling and consistent to warrant a more comprehensive GC-O based odorant prioritization study.

## CONCLUSIONS

Based upon past and current GC-O based odor profile efforts, para-cresol appears to be the key 'character defining' odorant relative to downwind, distance separation from high density cattle and swine CAFOs. If these preliminary priority rankings can be proven consistent across a broader sampling of similar environments and analytical parameters, there will be increasing impetus for critical review of current sampling, analytical and odor abatement strategies. Particular attention appears to be warranted for para-cresol and other high priority semi-volatile odorants due to their apparent odor impact prominence and their well documented sensitivity to adsorption driven loss to the walls of plastic sample containers. Success in identifying this minimal critical odorant set from CAFOs simplifies the challenge of translating current, subjective, human 'detector' based odor assessment protocols to objective, instrument based alternatives.

## ACKNOWLEDGEMENTS

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