DEVELOPMENT OF A DYNAMIC OLFACTOMETER LAB

by

R. E. Nicolai
Research Fellow

C. J. Clanton
Assoc. Professor

P. R. Goodrich
Assoc. Professor

L. D. Jacobson
Assoc. Professor / Ext. Eng.

K. A. Janni
Professor / Ext. Eng.

V. J. Johnson

E. Lees
Sr. Lab Tech

D. R. Schmidt
Asst. Extension Engineer

Biosystems and Agricultural Engineering Dept.
University of Minnesota
St. Paul, Minnesota, USA

Written for presentation at the
1997 ASAE Annual International Meeting
Sponsored by ASAE

Minneapolis Convention Center
Minneapolis, Minnesota
August 10-14, 1997

Summary:

Odor measurement is a requirement for science based improvement in controlling odor emissions from livestock facilities. The Biosystems and Agricultural Engineering Department at the University of Minnesota developed an olfactometer laboratory to measure odor threshold and intensity. Laboratory layout and odor panelist selection and training are important for obtaining reliable results. Procedures used in the new lab are described.

Keywords:

Odor, Olfactometer, Manure, Livestock, Odorants.
Development of a Dynamic Olfactometer Lab

Biosystems and Agricultural Engineering Department
University of Minnesota, St. Paul, MN

Introduction

Odor from livestock production facilities, in the past, was assumed to be part of the business. However, with the trend towards larger and more concentrated production sites, odor is rapidly becoming an important issue for the livestock industry. The economic importance of this industry to Minnesota made it essential to find adequate solutions to the problem.

Before progress can be made on the reduction of odor from livestock facilities, a reliable method is needed for quantifying odor emissions. Of the five general dimensions, threshold, intensity, persistence, hedonic tone, and character descriptor for quantifying odor emissions, only two have ASTM standards (ASTM, 1991; ASTM, 1988); threshold and intensity. These two standards, along with several European standards serve as the basis for establishing an odor emission lab. The dynamic triangular forced-choice olfactometer approach to odor threshold measurement using panels of eight people is gaining acceptance (Sweeten, 1995).

For odor control research to continue at the University of Minnesota a laboratory was needed which could measure odor intensity and threshold, with a dynamic triangular forced-choice olfactometer. This paper describes the laboratory layout, panelist selection, training instructions, and laboratory operating procedures used at the olfactometer laboratory in the Biosystems and Agricultural Engineering Department at the University of Minnesota.

Laboratory Layout

Since most odor measurement uses the human nose as a sensor, the environment in which people doing the sensing can effect the results (Koster, 1986). Factors affecting the environment include room ambient air quality, drinking water, resting area, and human - machine interface of the olfactometer.

At the University of Minnesota two rooms are designated for odor evaluation; one is used for storage and sample preparation and the other is for odor evaluation with the olfactometer. The evaluation room is pressurized with a heating - air conditioning unit. Air from the unit passes through a carbon filter, which removes background odors before entering the room. A rest area in the evaluation room is provided for panelist during the time between sniffing. This area consists of a lounge bench, tables and chairs. Bottled drinking water is provided for panelists.
Since the olfactometer has only one sniffing port, only one panelist is evaluating the sample at a time. As the panelist approaches the olfactometer, they insert their breathing mask onto the port and place the nose about one inch from the mask. Each panelists has their own mask. The mask directs the air sample to the nose and yet allows for normal breathing.

Panel Selection

People’s sensitivity to odors vary widely. It is not uncommon to have a factor of 100 between thresholds measurement from different panelist (Koster, 1986). The general population’s olfactory sensitivity follows a typical bell curve (Figure 1). The panel should represent the general population and at the same time be as homogeneous as possible (Harssema, 1990). People who exhibit any of the following tendency should be automatically excluded: smokers, drug dependency, pregnancy, serious allergies, or frequent colds. (EPA600/R-92/047. 1992)

![Figure 1. Distribution of olfactory sensitivity](image-url)
Hangartner (1985) reports that the olfactory sensitivity of an individual varies from odorant to odorant. Selection to a single standard odorant may not always be representative of the general population. He recommends that panelists be evaluated using the sensitivity distribution of a large panel ($> 25$), based on the actual odor to be tested, and screening of panelists according to their position in the distribution.

At the University of Minnesota a data base was compiled which relates production livestock odor to type of operation, management practices, and odor control technologies. (Jacobson, et al. 1997) As a result of this database of a total of 5183 panelist evaluation, a sensitivity distribution of each panelist to livestock odors was developed. Figure 2 illustrates a typical panelist deviation history from the sample norm for each sample analyzed. This panelist average deviation from the norm is -0.24. The deviation is shown as the $\log_{10}$ of the odor units (volumetric concentration). From average deviation for each panelist, the standard deviation for the total pool of 33 panelist is determined to be 0.3. Based on this data base, panelists are continually evaluated for deviation from the norm. N-Butanol is used as a calibrating gas at every session for each panelist. N-butanol deviation history is also analyzed for each panelist. Figure 3 shows the deviation for the same panelist as shown in figure 2, but only for N-butanol. The panelist average deviation for this calibration gas is -0.01. The standard deviation for all panelist for N-butanol is also 0.3.

![Figure 2. A panelist deviation history of livestock odor from the sample norm.](image-url)
Panel Training

Although panels can never be standardized to the same extent as the olfactometer hardware, proper training of the panelist can improve the reproducibility of the results (Wihnen, 1986). The following is an outline of the training each person receives prior to becoming a panelist.

1. **Overview** - New panelists are given a tour of the laboratory and a brief overview of what is expected of them.

2. **Laboratory Rules** - Each panelist must consent to the following rules:
   - Must be free of colds or other physical conditions affecting the sense of smell.
   - Must not smoke or use smokeless tobacco.
   - Must not chew gum, eat, or consume coffee, tea, or beverages for at least one hour prior to odor panel work.
   - Must not eat spicy foods for at least six hours prior to odor panel work.
   - Must not consume alcohol for at least six hours prior to panel work.
   - Must be “fragrance-free” by not using perfume, cologne, deodorant, or scented aftershave, shampoo, hand lotion the day of odor panel work.
   - May drink only bottled water during odor panel work.
   - Must not discuss their odor selections and answers with other panel members or public.
   - Must attend a training session and recertification each year.
   - Must demonstrate “professional behavior” at all times.

3. **Odor Dimensions** - An introduction is given of the five odor measurement dimensions: threshold, intensity, persistence, hedonic tone, character descriptors. Since persistence is a calculated value based upon intensity measurement, the panelist are only informed of its purpose. Hedonic tone and character descriptors are currently not being used thus the panelist are only informed that they exist.

Figure 3. Same panelist as figure 2 deviation history from the sample norm for N-butanol.
4. **Threshold** - There are two types of odor threshold; detection and recognition. Detection threshold is defined as the lowest concentration of an odorant in clean air and the odor of the mixture is detectable. It is the awareness of the presence of an added substance. Recognition threshold is defined as the lowest concentration of an odorant in clean air and the odor of the mixture can be recognized. It is the recognition of a characteristic of a specific odor quality. To understand this concept an analogy is made using other senses. The threshold in sound is demonstrated by increasing the volume of a radio until a sound can be heard (detection threshold). The volume is continued to be increased until speech is understood (recognition threshold). From the sense of sight the detection threshold is demonstrated by increasing the voltage to a light bulb until it begins to glow.

5. **Intensity** - Intensity of an odor occurs in the super threshold concentration region in which the odor is experienced. Intensity increases as the amount of odorous air in the sample mixture increases. To illustrate this concept the analogy of sight and sound is again used. As the volume of the radio is increased above the recognition threshold the sound becomes louder (intensity increases). As the voltage to the light bulb is increased the bulb becomes brighter (intensity increases).

Intensity measurement involves the referencing the odor intensity to a series of concentrations of 1-butanol (n-butanol) in water (ASTM, 1988). The panelist must become familiar with a referencing scale and match one of the concentration of 1-butanol to the sample. To teach this concept the analogy of variation between shades of a paint chip color is used. A series of different shades of the same color represent different odor intensities. The panelist arrange the series in ascending order, then memorizes the order (scale). Next, the panelist removes a chip from an envelope one at a time and places it in the correct position relative to each other in increasing intensity. A similar exercise is done with the sense of touch using sand paper.

### Sampling Procedures

Odor samples have been collected from both manure storages and exhaust fans from livestock buildings. Samples are collected in 10 liter tedlar bags. These bags are filled by drawing a sample from either a flux chamber located immediately above the manure storage or from tubing placed directly in the fan exhaust. Samples are drawn over a six minute period at a flow rate of one liter per minute. Samples are brought back to the lab and analyzed within 48 hours.

### Evaluation of Samples

**Panel size**

The preferred number of panelists is eight with an acceptable minimum of six (Hangartner, 1985). Evaluation is done one at a time behind a divider in order to minimize distractions. The order of panelists is kept consistent throughout the session. The panelists are asked not to discuss evaluations. A panel leader supervises the activity and records data during the session.

**Triangular force choice method**

Odor threshold is determined by using a venturi olfactometer designed by St. Croix Sensory, Inc. and tested at the University of Minnesota (Nicolai, et al. 1997). The panelist is given three stimulus presentations (air streams) one at a time in random order. One of the three
presentations contains the diluted sample. The panelist is required to identify or guess which stimulus presentation contains the odorous air. If the panelist is unable to discriminate between the presentations, he/she responds with a guess and the panel leader increases the dilution by one increment. If the odor is sensed, the panelist selects the presentation containing the odor and indicates detection. The forced choice method helps to control response preservation and other anticipation factors.

Length of time for evaluation
The duration of the stimulus presentation is three seconds. The exposure time of the stimulus presentation is limited because of the adaptation processes by the panelists. The panelist determines the amount of time between each stimulus presentation and may choose to repeat a presentation. The panel leader observes the interval between the stimulus presentations.

Resting time
Each panelist has from ten to fifteen minutes to rest between samples depending upon the number panelist for that session. A session consists of 10-12 samples.

Recording data
The panelist evaluates one or two lower dilution levels before reaching the detection threshold. The panel leader determines the starting dilution level based on the panelist’s sensitivity and the strength of the odor. The odor samples are presented in ascending concentrations to minimize odor fatigue and desensitization. For each dilution level evaluated, the panel leader records the response as either a guess or detection and whether it is wrong or correct. The panel leader ends the evaluation when it is certain the odorous air is detected or when the panelist completes evaluation of the relevant levels.

Determination of the detection threshold
The detection level for each panelist is recorded half a step below the level in which the odor is detected. One increased dilution level doubles the concentration of the odorous air. It is assumed that the detection threshold is between the level of detection and level prior to this. The geometric mean of the concentration of the detection level and the concentration of the last guess is the best estimate of the threshold concentration. The sample threshold is determined by using the geometric mean of the thresholds of all panelists.

Conclusions
The dynamic forced-choice olfactometer method of odor measurement is gaining acceptance. At the University of Minnesota an olfactometer lab was developed to evaluate odor threshold and intensity. A triangular force choice olfactometer is used to determine odor threshold. Odor panelist selection and training is critical to reduce threshold data variation. Further research is suggested on the variability between panelists, samples, and the olfactometer.
References


