IMPACT OF ODOR WHEN CONSIDERING LOCAL CODE FOR CONFINED FEEDING OPERATIONS (CFOs)

1-19-18

Introduction of Interesting Observations from Literature Review

- Odor showed up as the most frequent complaint and/or concern regarding CFOs
- Odor is surprisingly much more complicated than one would think
- There is little consensus yet on the impact of odor or the best way to measure to satisfy everyone
- Understanding odor generally prior to considering odor as a component of concern in CFOs is helpful in sorting out discrepancies in studies
- Odor cannot be considered without consideration to quality of life but final determinations must be based on the absolutes known rather than anecdotal reporting due to the individualization of odor perception.

Looking at Odor

What is odor?

- Odor is a perceived or detected smell via olfaction
- Odor is produced by chemicals in a gas phase
- Odor is caused by volatized chemical compounds usually at very low concentrations (volatized means the tendency of a substance to vaporize or enter a gaseous state from original to liquid or solid form). Volatile compounds have a low boiling point so they have a larger number of molecules to evaporate and enter the atmosphere.
- Compounds are pungent in high concentration
- Many are detected by chemesthesis by trigeminal nerve stimulation that are strong nasal, ocular and throat irritants.
- Unlike light and sound which travel *through* the air, smell is found in the compounds that make up the air around us so we must keep this difference in mind when thinking about measuring and detecting odors.

What are Thresholds?

- Odor concentration is measured by olfactometor and expressed as a dilution factor (ratio).
- Odor Threshold (OT) is the lowest concentration perceived by human sense of smell (usually by 50% of test panel)
- Threshold of a chemical compound is determined in part by share, polarity, partial charges, and molecular mass
- The measurement is based on the dilution of an odor sample to the odor threshold. The number is the dilution factor necessary to reach odor threshold. Generally the unit is expressed as the European Odour Unit (OUe). (an example is if I can detect something at 25 mL and it was diluted to 200mL, the threshold is 200 divided by 25 or 8.
- Detection Threshold is the lowest level where an odor is noticed.
- Recognition Threshold is the lowest level when an odor is recognized.
- Differential Threshold is level at which a change in the stimulus can be detected.
- Terminal Threshold is the level beyond which a stimulus is no longer detected.

What creates odor?

- Most odorous molecules are organic compounds (carbon based). Our olfactory system reacts to all various odorous stimuli all mixed together.
    - Human activity
    - Animals
    - Nature
    - Vehicles
    - Industry

What are the types of odor?

- Seven basic odors seem to be listed with varying descriptive terms from article to article:
    - Musky/woody
    - Putrid
    - Pungent/vinegar
    - Camphoraceous/mothballs
    - Ethereal/chemical
    - Floral/Sweet
    - Minty

How is odor measured?

- **Intensity/Concentrations:**
    - Odors are usually made up of various chemicals or compounds and each one of those has its own odor and detection threshold. Therefore, all odors will vary in intensity and level of pleasantness.
    - Measuring intensity alone is insufficient to assess human perception of odor.
- *Methods*

- Air Sampling and Gas Chromatagraphic Analysis - analytical chemistry where they separate and analyze compounds that can be vaporized without decomposing
- Electronic Noses – these detect volatile chemicals or categories and predict sensory-like responses
- Human Panelists – opinion of personal experience
- Dynamic Dilution Olfactometry (DDO) - This looks at the dilution threshold of a gas by sampling continuing multiple components. Gives an indication of overall strength of the odor regarding how much must be present to detect it and gives "numbers" for comparison. It does not identify individual odors or tell good/bad smell information but it does use human noses.
- Dynamic Dilution Factor - Measures intensity as a function of concentration but there is no instrument available to quickly measure the concentration of odors consisting of many compounds such as in a barn. It is a best estimate threshold.
- Ambient Air Limits - This is for individual compounds (ie hydrogen sulfite) Measures parts per billion by volume. Take the number of days in a set period – number of times per year
- Off-site annoyance with general regular language - These are Likert type scales by field inspectors. Use Scentometer Readings
- Off-site Limits- based on levels predicted by dispersion modeling and DO
- BACT - Best available control technology that equals level of odor treatment
- American Society of Agricultural Engineering Practice Document – Recommended setbacks based on annoyance threshold dispersion modeling.
  - 0.4 to 0.8 km from neighbors (.25 mile to .50 mile)
  - 1.6 km from residential development (1 mile)
- Forced –Choice Ascending Concentration – Uses an Olfactometor to measure a series of limits

- **Density**
  - The molecules of a single chemical have to be counted within a set space. This is not extremely useful measure due to the fact that generally speaking odors are a combination of several compounds.
  - Density differences between cold and warm air generates air currents (convection). Aeration (movement) causes air currents. Man influences this but cannot control this entirely.
- **Dispersion**
  - Smell travels through air via air particles. It is dispersed by diffusion – the movement of the molecules from high to low concentration. There are many factors that impact dispersion as listed below.
  - Odor molecules will keep diffusing until equilibrium is reached meaning all molecules are evenly spread out in air. Even before this, the concentration drops below minimum threshold for detection.
  - To determine how far an odor will travel one would need to consider physics, chemistry, and a meteorological foundations such as wind distributions and patterns and topography of the land.
  - Smells have been known to be detected 5 to 6 miles away dependent on weather, whereas 3 miles can be common with certain wind patterns and certain topographies
- **Velocity**
  - There is no way to actually measure the speed at which an odor will travel. Graham's Law of Effusion gives a close approximation in terms of comparisons (speed at which gases flow through a hole without collisions of molecules). Effusion rate of a gas is inversely proportional to the square root of the mass. (over-simplified. A lot of math but what I found out was the odor of a rose, Gerianol, is 8% slower than that of the smell of a fart, skatole. LOL)
- **Duration**
  - Basically, duration is impossible to measure beyond in the moment due to constantly changing factors in the environment and diffusion of the compounds themselves.
  - If a smell is constant, the brain will acclimate to that smell, ignore and no longer be able to detect it as a salient change from the background.
  - For purpose of regulation a better way to look at this may be to consider the when it happens within given periods and frequency

What factors impact measurement of odor?

- Composition
- Concentration
- Frequency
- Duration
- Volatile compounds
- Number of olfactory receptors to bind them
- Degree at which the compounds become solvent for binding
- Temperature

- Humidity
- Air movement
- Topography of land

How odor is interpreted

Perception

- First there are various levels of perception of odor
    - Detection (there is a smell, something is different)
    - Recognition (discriminate what that smell is)
    - Annoyance (I like it or I don't like it)
    - Intolerance (Something must be done)
    - Perceived Irritation (that must be bad for me)
    - Somatic Irritation (that odor is causing anxiety, nausea, headache . . .)
    - Toxicity (harmful bodily responses to the chemical compounds of the odor)

Neurological

- Human noses can detect odor at extremely low levels of concentration.
- Let's talk brain stuff! The two primary nerves that provide us the modality to interpret information from the olfactory nodes are the olfactory nerve (sense of olfaction-sweet earthy floral, fecal, urine, etc.) and the trigeminal nerve (sense of irritation- pungency, burning, stinging, etc. There are others but these are the main ones that are the neurological to inform us of the chemical quality of air.
- The brain sends noses information via nerve filters to higher brain areas (cortexes where higher order thinking occurs such as consciousness, discrimination as well as perception of odors) AND to the more primitive areas (where emotions -such as fear, loathing, and pleasure-and memory/ associations are held). Thus personal history with odor is individualized.
- One interesting thing about the brain is that if a stimuli is constant over time, the brain will interpret this as something to be ignored. The key is the constancy.

Action Stages of Odor for Consideration

What constitutes odor as at annoyance level?

- Annoyance defined is when the odor is noticed but is below irritation levels, the dose is not poisonous. Odor Thresholds can be first detected around the 0.8 ppm. We normally detect about 10,000 smesll but some research suggests capabilities of up to 1 trillion.
- Air quality has improved over the last 50 years according to the EPA but tolerance to odor has decreased regarding odor. I found two theories about why this is so. One is Signal Detection which indicates that due to education and regulations causing the background air to be cleaner, our sensitivity to low level odors is heightened. The other theory is the Misma Theory. This theory takes into account that until the middle of the 19th century people correlated odors and vapors to illness. Once they could actually see germs, this fell away but some people today think about chemical odors in this way. They perceive odor and associate it with health effects which may or may not be accurate.
- Studies show threshold for annoyance (more complaints are evoked) is approximately around 5 times Detection Threshold

When is odor considered at irritation level?

- Irritation occurs **at** the true chemical sensory level.
- There may be some health reactions at this level.
- For ammonia the Irritation threshold is around 4-8 ppm.

When is odor considered at toxicity level?

- Toxicity with a co-pollutant (endotoxin) is where serious health problems occur.
- We smell odors at low levels before they are harmful. An example is Hydrogen Sulfide (H2S). The Odor Threshold for H2S is somewhere between 0.3 and 30 parts per billion. Irritation Threshold is somewhere between 10-20 parts per million. Loss of consciousness, is somewhere between 750-1000 parts per million, just to show contrast.

CFO odor impact

General Statements to Consider

- Odors are the #1 complaint
    - Studies taken together are reported to have shown little consensus regarding emissions and health impact. The largest study was with a sampling greater than 100,000 individuals in a high dense CFO area versus a sampling of just under 8000 individuals in a low dense CFO area. Conclusion was that the high rate of reported concerns were likely related more to annoyance and individual characterizations rather than actual harm.
- Primary odors of concern
    - Ammonia – product of the metabolism of proteins - urine
    - Hydrogen Sulfide – rotten eggs
    - Sodium Hypochlorite

    - Skatole – fecal
    - Methane – odorless but toxic
    - Particulate matter
    - Nitrous Oxide
    - Phenols
    - Short chain fatty acids
    - Alcohols
- We have to remember that we smell odors at very low concentrations much lower than Irritation or Toxicity levels
- For example: Ammonia. OT for ammonia is 0.04 ppm to 57ppm. The Detection Threshold can be 0.04 to 20ppm. OSHA set OT is between 5 to 50ppm. The TLV for ammonia for a worker at 8 hours per day/ 40 hours per day is 25ppm set by the American Industrial Hygienists.

Psychological

- Odor sensitivity and response is individualized until the levels of irritation and toxicity are met
- Odor worry appears to be a synergistic determinant of symptom reporting (me too)
- The more a person focuses on the odor the greater the increase in stress, anxiety, and hypervigilance.
- Responses vary by extremes of age, genetics, gender differences, medical history, lifestyle, social habits, and coping skills
- Areas report of concern: changes in mood, energy, and motivation

Biological

- Subjective Symptoms:
    - These are symptoms/reactions that occur in concentration below bodily effect expected.
    - They are reported but not clinically attested as measurable or seen.
    - Often doctors will tie these to emotional issues: worry that increases Blood Pressure or Blood sugar levels, reactions that may be more psychological than toxin-mediated irritations.
    - For the person experiencing these symptoms, these are not made up but are experienced as real symptoms.
    - The basis of their experience, however, is quite individualistic.
    - The symptom may or may not have a specific medical test that can conclusively state the condition exists but the person does experience the symptoms (sub-clinical symptoms)
    - These would be difficult to ascertain the cause/effect aspects of odor due to impacts of genetics, individual history with odor, perceived unpleasantness both genetic and learned, beliefs about safety and emotional states.
- Objective Symptoms:
    - Reported symptoms that are clinically measurable by a test of some sort and can be see.
    - They are in concentration at bodily effect that would be expected.
    - Respiratory Ailments (can be measured by lung capacity and blood indicators) There are conflicting studies on this. Some state there is increased inflammation in neighbors and others claim there is not). I think the key would be that the person would have to eliminate all other possible causes and that would be very difficult.
- Toxicity with a co-pollutant that causes health problems is what needs to be measured as this would impact the majority of people.

<u>Some management techniques of odor</u>

- Performance Standards:
    - (Clean Air Act -6 criteria with 188 emission's standards)
    - Be sensitive to the expense and difficulty or performance standards
    - Reasonable measurements and remember most of these seem to be approximates/know the purpose of the measurement
    - Determining frequency of clean outs of manure
    - Setting guidelines of when clean outs occur (odors linger more and are more concentrated early morning and evening due to vaporization and decreased air movement)
- Mandates:
    - Be sensitive that quantifying odor on a farm is tough because it is a mixture of free and particle bound compounds.
    - Set backs
    - Covers or enclosed staging/storage facilities
    - Biofilters
    - Diets
- Educate:
    - Accessible records of manure applications
    - Forums to let people know how things work and are regulated
    - Build neighbor understanding and good will

    - Grass roots audits farmer to farmer with peer pressure to keep the county name strong
    - Form collaboration between Ag/Environmental/Health providers (medical and behavioral) for educational purposes and to give feedback of trends observed within the community to county officials
- Watch for Demographic Trends: what is the constitution of our county and match apples to apples, don't try to be what we are not
- Laws related to CFOs (2016)
    - There are federal regulations for operation but none specifically for odor which is appropriate due to the diversity of factors that impact this aspect of concern
    - There are permits required at the federal and state levels for CFOs
    - 4 states require Odor Management Plans and Measures
    - 2 states require odor considerations in their Nutrient Management Plans
    - 2 states require consideration of odor in the Compulsory Waste Management Plans
    - 2 states include odor in Pollution Prevention Plans
    - 1 state imposes air quality permits
    - 1 state makes reference to potential nuisance actions giving residents an avenue to lodge complaints
    - 2 states have location laws as related to odor buffers or setbacks with prevailing wind considerations
    - Indiana (1997) legislation to define by law that CFOs were required to have 1 mile setbacks was defeated.