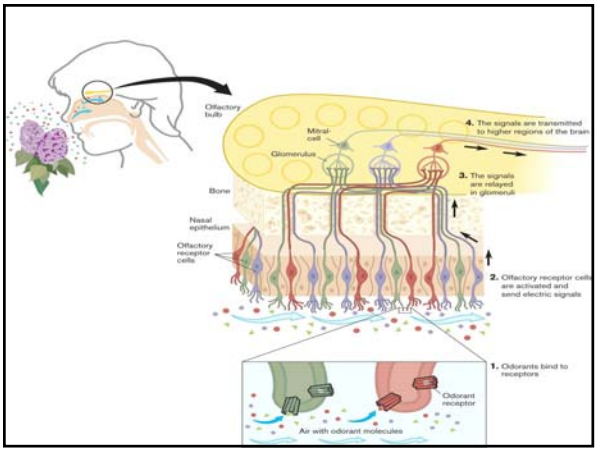
Odor Mitigation Techniques for Manure Storage

Overview

- What is odor?
- How can we deal with odor?

What is Odor?

- Stimulation of the olfactory system
  - Caused by volatilized chemical compounds perceived via receptors in the nose
  - Results in highly-variable physiological and psychological responses



What is Odor?

- Humans can recognize more than 10,000 different smells
- Molecules that are chemically similar can have distinctly different smells
- Mixtures of compounds can result in interference or masking of individual compounds

Agricultural Odor

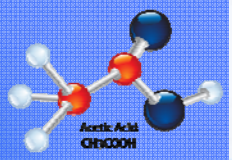
- Hundreds of different compounds have been identified with agricultural operations
- These can be generally classified as one of three types:
  - Volatile organic compounds (VOCs)
  - Odorous sulfur compounds
  - Ammonia

VOCs

- Carbon-based compounds
- Thousands of compounds are classified as VOCS
  - Not all are odorous

Agricultural VOCs

- Common odorous agricultural VOCs:
  - Volatile fatty acids (VFAs)
  - Indoles
  - Phenols
  - Aldehydes
  - Amides
  - Amines
  - Esters
  - Ethers
  - Ketones



VOC Formation

- All biological organisms emit VOCs naturally
- Intermediate products of decomposition, metabolization, and combustion
- Mainly formed by the breakdown of longer-chain carbon compounds

Odorous Sulfur Compounds

- Sulfur-based compounds
- Common agricultural odorous sulfur compounds:
  - Hydrogen sulfide (H_2S)
  - Dimethyl sulfide
  - Mercaptans
  - Methanethiol
  - Ethanethiol
  - Propanethiol

Sulfur Compound Formation

- Typically formed in anaerobic conditions
- Conversion of sulfur-containing compounds, such as proteins and amino acids

Ammonia

- Nitrogen-based compound
- Mainly produced as a by-product of urea and uric acid hydrolysis in recently-voided feces and urine
- Also generated by:
  - Deamination of undigested proteins
  - Ammonification of organic nitrogen
  - Conversion from ammonium and nitrite

Odor Management

- Odor is complex – should we expect an easy answer?
- Can we focus our efforts?
- How?

General Odor Management

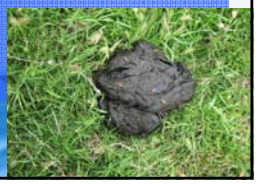
- Keep things simple
  - Prevent/clean up spills
  - Keep dry stuff dry and wet stuff wet

General Odor Management

- Feed management
  - What goes in has to come out
    - Manage N and S in feed, water, and additives
  - More efficient feed utilization means more in the animal and less in the manure

Manure Odor Management

- Beyond feed management, there are other "pressure points" where we can make an impact on odors
- 3 main processes we can influence
  - Formation/generation
  - Release/emission
  - Transport/dispersion



Formation/Generation

- Influenced by a number of physical, chemical, and biological properties
  - Amount of nutrient available
  - Temperature
  - pH
  - Moisture
  - Oxygen availability
  - Microbial activity
  - Etc.

Formation/Generation (cont.)

- Conditions conducive to forming:
  - VOCs
    - Higher temperatures
    - Moisture available
      - If too high, some VOCs will try to remain in solution
    - Inefficient microbial decomposition or combustion of carbon-based material

Formation/Generation (cont.)

- Conditions conducive to forming:
  - Odorous sulfur compounds
    - Anaerobic conditions
    - Lower pH
    - Higher temperatures

Formation/Generation (cont.)

- Conditions conducive to forming:
  - Ammonia
    - Higher pH
    - Higher temperatures
    - Moisture available
      - If too high, ammonia will try to remain in solution
    - Oxygen available

Formation/Generation (cont.)

- Think in terms of the type of manure management system
  - Liquid/slurry vs. solid
  - Aerobic vs. anaerobic
- Then, consider other parameters
  - Temperature, pH, etc.

Liquid/Slurry Systems

- Can be aerobic or anaerobic
- Carbon can volatilize as VOCs if not completely aerobic or completely anaerobic
  - Higher moisture content can keep most VOCs in solution

Liquid/Slurry Systems (cont.)

- Nitrogen can volatilize as ammonia
  - Higher moisture content can keep most ammonia in solution
- Sulfur will volatilize to odorous sulfur compounds in anaerobic systems or in anaerobic pockets

Solid Systems

- Typically aerobic
  - May have anaerobic pockets, if moisture content is too high
- Carbon can volatilize as VOCs if not completely aerobic

Solid Systems (cont.)

- Nitrogen can volatilize as ammonia, depending on other properties
- Sulfur will typically not volatilize
  - Some odorous sulfur formation in anaerobic pockets

Formation/Generation (cont.)

- Odor management techniques for formation/generation are often in conflict
  - High moisture content can keep VOCs and ammonia in solution, but promotes odorous sulfur compound formation
  - High pH will lower odorous sulfur compound formation potential, but increase ammonia formation potential

Practices/Activities for Formation/Generation

- Feed management (592)
- Solid/liquid waste separation facility (632)
- Anaerobic digester (365, 366)
- Waste treatment (629)
- Amendments for the treatment of agricultural waste (591)

Practices/Activities for Formation/Generation (cont.)

- Composting facility (317)
- Waste treatment lagoon (359)
- Waste storage facility (313)
- Waste utilization (633)
- Waste facility cover (367)

Release/Emission

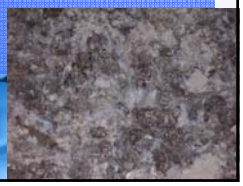
- Influenced by a number of physical and chemical properties
  - Concentration of generated pollutant(s)
  - Temperature
  - pH
  - Moisture
  - Air movement
  - Etc.

Release/Emission (cont.)

- Once formed, odorous compounds have different release mechanisms
  - VOCs and ammonia are more diffusive
    - Reduced surface area can have an impact
  - Odorous sulfur compounds rely more on "bubble" releases from liquid storages
    - Rely more on capture

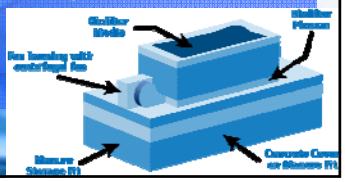
Practices/Activities for Release/Emission

- Waste facility cover (367)
- Waste treatment (629)
- Amendments for the treatment of agricultural waste (591)
- Waste transfer (634)



Practices/Activities for Release/Emission (cont.)

- Waste storage facility (313)
- Waste utilization (633)
- Waste storage lagoon (359)
- Also, add-on technologies:
  - Biofilters
  - Scrubbers
  - Flares



Transport/Dispersion

- Influenced by a number of physical and chemical properties
  - Pollutant reactivity
  - Airflow, turbulence, and deposition
  - Meteorology
  - Etc.

Transport/Emission (cont.)

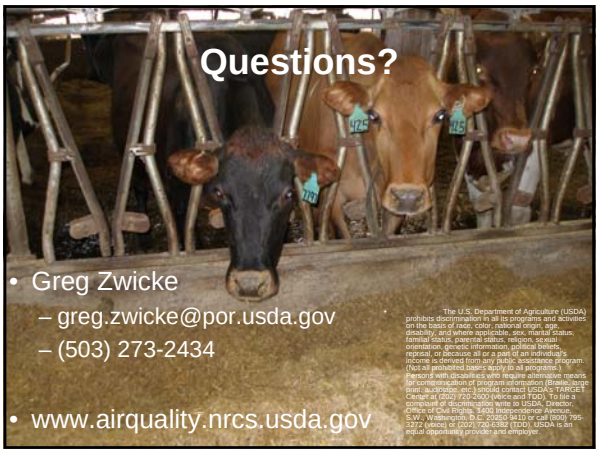
- Once released/emitted, pollutant concentrations can be influenced by:
  - Atmospheric dilution
  - Atmospheric chemical reactions
  - Filtration and deposition (i.e., windbreaks, precipitation, gravity)

Practices/Activities for Transport/Dispersion

- Windbreak/shelterbelt establishment (380)
- Windbreak/shelterbelt renovation (650)
- Also:
  - Siting
  - Air movement changes

Summary

- Odor is complex – dealing with odor is also complex
- Odor management is a process – many variables to consider
- We **can** make a difference



Questions?

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