RESEARCH REPORT
ENVIRONMENT

Title: Health Significance of Airborne Particles at Pork Production Facilities
NPB #99-116

Investigator: Robert W. Bottcher

Institution: North Carolina State University

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I. Abstract

This project was designed to measure several indicators of air pollutants in the exhaust air streams from swine building exhaust fans, and during sprayfield applications of lagoon effluent. The goal was to obtain sufficient information that the distribution of dust, odors, odorous compounds, ammonia, endotoxin, and bacteria close to the sources (fans and spray operations) could be used to predict levels further downwind. In particular, correlation of odors, odorous compounds, endotoxin, and bacteria concentrations with dust concentrations is desired, since positive correlation could allow us predict these pollutant levels by predicting dust levels using existing dispersion models.

Due to project delays involving dust instrumentation, personnel changes, difficulties in securing collaboration with a swine producer having a suitable site, and weather, data collection is still being conducted. Results obtained to date include: 1) establishment of a robust protocol for measuring the air pollutants in a grid of samplers downwind of the sources including tripods and generators for powering the samplers, 2) chemical analyses from air samples collected in Tedlar bags and absorbent tubes which show the levels of numerous odorous compounds, that the Tedlar bags absorb some compounds to an extent that will confound odor measurements, and substantially greater odorous compound levels within the plume near the fans than farther downwind, 3) comparison of 10, 20, and 30 second sampling periods for bacteria at the exhaust fans which suggest 10 to 20 second sampling is appropriate, and 4) development of a new method of measuring odorous compounds in air and dust using adsorbent tubes (small glass tubes filled with material to which odorous compounds adsorb) which will be employed in subsequent field trials. Additional data to be collected during mild and warm weather include the air pollutant levels at sampling locations when wind carries the fan airflow toward the lagoon (not vice versa), and correlation of the air pollutants with dust levels at the sampling locations.

II. Introduction

Emission of air pollutants from livestock operations can affect downwind neighbors and potentially exacerbate other air pollution effects. Dust, odorous compounds and gases including ammonia, endotoxin (cell-wall components of dead Gram-negative bacteria), and bacteria are typically present in livestock building exhaust fan airflow, and odorous liquid particles in sprayfield operations. Whether these emissions actually impact humans' health or ability to enjoy their property is determined by many factors including wind conditions, temperature, humidity, quality of management and sanitation of the operations, local topography, etc.

Odor and air pollution management for many producers will require some reductions in emission rates and/or determination that dispersion by wind is sufficient to avoid air pollution problems with neighbors. The airflows carrying the pollutants from the sources are known as plumes. In order to conduct meaningful dispersion modeling to predict when problems may occur due to these plumes, appropriate emission rates of the pollutants are needed. Measuring the variation of the important air pollutants with distance from the sources will assist in validating dispersion models for this purpose. Also, odors have been strongly correlated with dust levels; correlation of odorous compounds, bacteria, and endotoxin levels with dust levels may also show that these pollutants vary strongly with dust levels, so that prediction of dust dispersion will allow prediction of dispersion of the other pollutants. Although measurement of pollutant concentrations in the plumes over a large distance is desirable, current measurement techniques are limited in detecting the pollutants at large distances due to dilution. Hence, sampling and analyses for this project is confined to distances less than 20 m from the fans.

III. Objectives

The objectives of this research are to measure pathogen indicator organisms, endotoxins, odorants associated with the airborne dust particles emitted from swine production houses and associated with the aerosols created during spray irrigation of treated wastewater and determine variations in concentration with distances traveled in various environmental conditions. We will also develop relationships of pathogen indicator survival with distance over a range of environmental conditions (temperature, humidity, and prevailing wind velocity).

IV. Procedures

A protocol was developed for obtaining samples and measurements on a swine finishing farm in plumes from the building exhaust fans. Figure 1 shows the layout of the buildings, lagoon, and sampling locations. Samples are obtained upwind of the center building, at the exhaust fan outlet, and downwind locations along the fan centerline and in line with the building side wall (Fig. 2). Each data run (trial) lasts 30 minutes and includes dust sampling for dust mass concentration, endotoxin, and Clostridium perfringens spores, aspirated fabric swatch sampling and air sampling for odor measurements, viable sampling for total coliforms, and ammonia concentration using colorimetric detector tubes. Additional information recorded for each trial include number and type of exhaust fans operating, static pressure drop across exhaust fans, size and age of pigs, air temperature and humidity, and wind speed and direction. A set of 12 tripods, each 2 m tall, was constructed from steel pipe to enable placement of dust

and air sampling equipment at grid locations. At the beginning of each trial, wind direction is observed using smoke bombs to ensure compatibility with sampler locations. Figure 2 shows an inappropriate sampling situation with smoke flowing from a sampler tripod due to wind blowing from the lagoon toward the buildings. Such an arrangement could also be used for sampling odors and air pollutants from lagoons to allow comparison of building vs. lagoon emissions.

Sampling Methods:

In developing the sampling protocol, several problems were encountered and modifications to approaches were adopted based on measurements. The optical (laser) particle counters initially intended to provide most of the dust data were found to be subject to considerable variability, which led to a decision to use high volume dust samplers for total dust at the sampling points, instead. Several such dust samplers were procured to conduct this and other work. Three electric generators were also purchased to power the 1 kW sampler motors on site; the devices consume too much power to use batteries. Battery powered dust sampling devices do not provide dust samples sufficiently large for lab analyses (e.g. for odors).

Sampling methods for gas chromatograph (GC) analyses of odorous constituents in air and dust were also evaluated. A small amount (1 mL) of a stock solution of a mixture of odorous compounds was added to a Tedlar bag filled with nitrogen gas, the odorous compounds in the mixture were detected by GC, and the process was repeated with the same bag. The same amount of the mixture was also added to an adsorbent tube and detected by GC. Comparison of odorous compound levels obtained from the Tedlar bag and adsorbent tube showed that the levels of several compounds were much higher from the bag than the tube, indicating that the compounds first adsorb to the bag material and then desorb. This indicates that adsorbent traps are more reliable for odor sampling than Tedlar bags, which others have also reported. A new method using adsorbent traps (tubes) designed to collect odorous compounds for later desorption (delivery) to the GC was therefore developed and applied to measurements at and downwind of the exhaust fans. Also, bioaerosol sampling was conducted at the exhaust fans using the Andersen single stage bioaerosol impactor, at 10, 20, and 30 seconds, and the agar plates were later incubated at 35 C, to determine appropriate sampling periods at the fan locations.

Due to poor weather (wet conditions affecting access to the farm, cold weather limiting fan operation to minimum ventilation, and wind from the wrong directions) after the project site was prepared, data collection needed to accomplish the project objectives is still underway.

V. Results

Results obtained to date have established that the protocol for building fan plume measurements is realistic. The smoke bombs quickly show wind direction and stability (see Fig. 2), tripods hold high volume dust samplers and bioaerosol samplers at sampling locations, odor sampling using air bags, aspirated swatches, and absorbent traps at the sampling locations is simultaneous with total dust and bioaerosol sampling, and laboratories for measuring endotoxin and bacteria counts are prepared to conduct their measurements. Sufficiently warm, dry weather with stable winds in appropriate directions (southwest to northwest winds, see Fig. 1) is needed to finish data collection and analyses.

Bioaerosol sampling at fans:

Duplicate bacteria samples were obtained on agar plates in the bioaerosol sampler at the exhaust fan, at 10, 20, and 30 second sampling intervals, and cultured at 35C. The concern is that a sampling period appropriate for downwind bacteria sampling may be too long for sampling at the source (fans) and saturate the plates with bacterial colonies. Inspection of the plates showed more and larger colonies at 20 than 10 sec, and a sampling period of 10 to 20 sec., e.g. 15 sec., should provide sufficient bacteria loading at the exhaust fans.

Adsorbent tube measurements:

The adsorbent tube (or trap) method of odorous compound sampling was conducted at the exhaust fan of the test building (Fig. 1) and approximately 10 m downwind, 30 cm above the ground. The chromatographs (graphs of levels of chemical compounds detected by the GC) showed that more compounds occurred at the fan, and at higher levels, than at the downwind location. The total peak area under the odorous compound peaks on these graphs is an indicator of the total odor compound presence; the total peak area of the sample at the fan was approximately 7 times the total peak area at the downwind location. This result is consistent with the amount of dilution that would be expected as fan air plumes enlarge and mix with ambient air. Hence, the adsorbent tube approach will provide a simple, robust way of measuring odorous compounds simultaneous with odor measurements at the sampling locations.

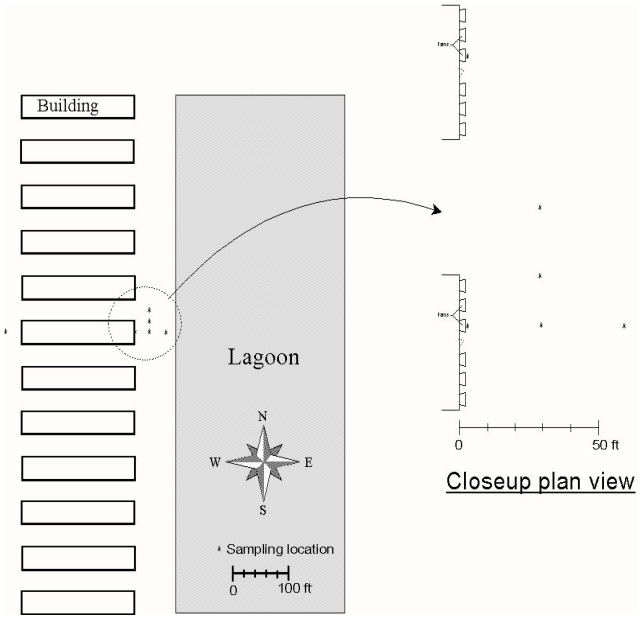

Figure 1. Layout of swine finishing buildings, lagoon, and sampler locations.

Figure 2. Smoke bomb shows wind blowing from lagoon to buildings.