SUPPRESSING FUGITIVE DUST EMISSIONS FROM CATTLE FEEDYARDS

Auvermann, Brent W.

ABSTRACT

Controlling dust and odor is an essential component of environmental management plans for cattle feedyards, particularly for those feedyards adjacent to public roadways, businesses or homesteads. Recent interpretations of the National Ambient Air Quality Standards (NAAQS) as property-line limits for airborne pollutants such as PM_{10} and $PM_{2.5}$ underscore the importance of conscientious management of the feedyard surface. The moisture content of the feedyard surface is the principal predictor of dust and odor emissions. Although conventional wisdom suggests that dust and odor emissions are inversely related to one another (i.e., dust and odor emissions respond oppositely to changes in the moisture content of the feedyard surface), the quantitative relationship between the two is sufficiently ambiguous to warrant consistent attention to each.

DEFINITIONS AND REGULATORY BACKGROUND

Even though protecting air quality has implications for cattle health and performance as well as overall feedyard profitability, the language of dust and odor derives principally from environmental regulations designed to protect public health and the use and enjoyment of private property. Public health concerns relating to gases and aerosols (and, to a modest extent, their associated odors) are expressed in ambient air quality standards, emissions permits and nuisance legislation.

National Ambient Air Quality Standards (NAAQS). The NAAQS are a set of health-based limits on the ambient concentrations of certain aerosols known or suspected to cause health problems in humans. At present, six airborne contaminants are listed as "regulated pollutants," as they are commonly known: ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), lead (Pb) and particulate matter (PM). Within the PM designation, the USEPA has listed two fractions of concern, PM_{10} and $PM_{2.5}$. The subscripts refer to discrete subsets of the particle-size continuum comprising PM. For example, PM_{10} refers to that fraction of the particulate matter suspended in the air that has an aerodynamic equivalent diameter (AED) of 10 micrometers (μ) and less.

The NAAQS actually embody two principal considerations based on health effects. Humans' physiological responses to airborne pollutants may be characterized by acute (typically short-term, high concentrations) and chronic (longer-duration, somewhat lower concentrations) effects that may be expressed in widely disparate pathologies and degrees of severity. Thus, several of the regulated pollutants have at least two different ambient standards, a 24-hour average concentration and an annual average concentration. Ozone, carbon monoxide and sulfur dioxide also have shorter-term standards (e.g., one-hour and three-hour) reflecting the rapidity with which those compounds can affect human health as compared to particulate matter and lead.

Finally, the NAAQS also include specifications for how often the numerical standards must be exceeded before the area is designated a *nonattainment area*. When an area is so designated, the responsible state agency, or SAPRA (state air pollution regulatory authority), must implement a plan to reduce emissions of the pollutant in question so that ambient concentrations are reduced below the NAAQS that has been violated. For example, the San Joaquin Valley, CA, has been designated as a serious nonattainment area for PM_{10}, and California's SAPRA is attempting to identify the main sources of PM_{10} that could reasonably be reduced by abatement systems or improved industrial management practices. As of the date of this publication, the NAAQS for the six regulated pollutants are as shown in Table 1 (USEPA, 1997)

In addition to their use in conjunction with continuous ambient monitoring programs to determine regional compliance status, the NAAQS are also used in the permitting process for new emissions sources of the regulated pollutants. Using a site-specific simulation process known as *dispersion modeling*, permit reviewers estimate the worst-case concentrations expected to occur downwind of a proposed emissions source. If the concentrations predicted at the property line of the proposed source exceed the NAAQS, the SAPRA may require additional abatement measures before the permit is granted. Shaw et al. (1996) have criticized this use of the NAAQS on the basis that property-line concentrations do not represent truly "ambient" conditions, especially in rural settings, but engineers are currently providing guidance for agricultural sources in New Mexico whose permits have recently been denied in this way.

Table 1. Current Numerical Values for the National Ambient Air Quality Standards.

	Regulated Pollutant	Short-Term	Long-Term
1.	Particulate Matter		
	PM_{10}	150 μg/m^3 (24-hr)	65 μg/m^3 (annual)
	$PM_{2.5}$	50 μg/m^3 (24-hr)	15 μg/m^3 (annual)
2.	Lead	n/a	1.5 μg/m^3 (quarterly)
3.	Ozone	0.08 ppm (8-hr)	n/a
4.	Carbon monoxide	35 ppm (1-hr)	9 ppm (8-hr)
5.	Nitrogen dioxide	n/a	100 μg/m^3 (annual)
6.	Sulfur dioxide	365 μg/m^3 (24-hr)	80 μg/m^3 (annual)

*Note: As of the date of submittal, a Federal court has remanded the NAAQS for PM_{10}, $PM_{2.5}$ and Ozone to EPA to clarify the scientific justification for those standards. Enforcement of the standards has been temporarily suspended.

Emissions inventories, emissions factors and Title V. Title V of the federal Clean Air Act Amendments (CAAA) provides for the issuance of federal operating permits and the assessment of emissions fees for so-called *major sources*, defined as those operations that have the *potential to emit* more than 100 short tons per year of regulated pollutants. A facility's potential to emit is determined by adding together the *source strengths* all of the sources on its *emissions inventory*. In turn, the source strengths (or emission rates) of the individual sources are described by *emissions factors*, which relate emissions rates to the rates of throughput of production units in the facility.

For example, the PM_{10} emissions inventory for a feedyard might include: (a) fugitive dust from the feedyard surface, (b) dust from the grain unloading process, (c) dust from the feed loading process and (d) dust from the cyclones on the steam-flaking system. Emissions factors for those processes might take the form of lb/day per 1000 head of one-time capacity for the open lots; and lb/ton of grain unloaded, processed and reloaded as feed. (Incidentally, these same emissions factors are often used to compute source strengths for the dispersion modeling process in the review of permit applications.)

SAPRAs have some flexibility in identifying those processes that contribute to the potential to emit. Currently, in Texas, fugitive emissions from the feedyard surface are not included in the emissions inventory for cattle feedyards. As Lesikar et al. (1996) observed, if fugitive dust had been included in the inventory for total suspended particulate (TSP, no longer a regulated pollutant), feedyards as small as 2,000 head one-time capacity would have been considered major sources. As such, even those small yards might have been subjected to annual emissions fees exceeding $1.25 per head of capacity. (The major-source capacity threshold for PM_{10} would be approximately 8,000 head; PM_{10} emissions fees would exceed $0.30 per head of capacity.) In the event the EPA finds cause to list PM as a hazardous air pollutant (HAP), the major-source threshold may be reduced.

Odors and nuisance litigation. In part because of the relatively circumstantial evidence linking odors to public health effects, the CAAA did not explicitly authorize USEPA (or, by extension, the SAPRAs) to regulate odors in the same way that aerosol constituents are regulated. By virtue of their highly subjective nature, odors are not as easily or objectively quantifiable as are the regulated pollutants. Furthermore, complex interactions (antagonistic or synergistic) of odorous gases make the establishment of numerical odor standards a difficult and frustrating affair. Consequently, regulation of odors usually occurs within the context of *nuisance*, defined in Texas (Sweeten, 1991) as any condition that "interferes with the normal use and enjoyment of property."

In a typical scenario, individuals perceiving a nuisance condition resulting from activities upwind of their property will call the local office of the TNRCC, who will then dispatch an inspector to the site in an attempt to verify and document the complaint. The eventual disposition of such complaints defies generalization (Sweeten and Miner, 1979; Vukina et al., 1996), but evidence suggests that nuisance conditions are difficult to document and even more difficult to litigate successfully except in the most severe and persistent cases.

THE SCIENCE AND MANAGEMENT OF FEEDYARD DUST

Ambient particulate matter consists of suspended particles having a wide range of characteristic diameters. The aerodynamic composition of particulate matter from a given source (i.e., a description of how the particulate matter is expected to behave in air) is often communicated in the form of a particle-size distribution, or PSD. The PSD is essentially a probability distribution, representing the likelihood that a randomly selected particle from within a sample will have an AED smaller than a given value.

Figure 1 shows a cumulative PSD of synthetic particulate matter generated from dried, ground and sieved feedyard manure. For this dust sample, the mass median diameter (AED_{50}) is approximately 23 micrometers; the sample contains approximately 26% PM_{10} and 3% $PM_{2.5}$.

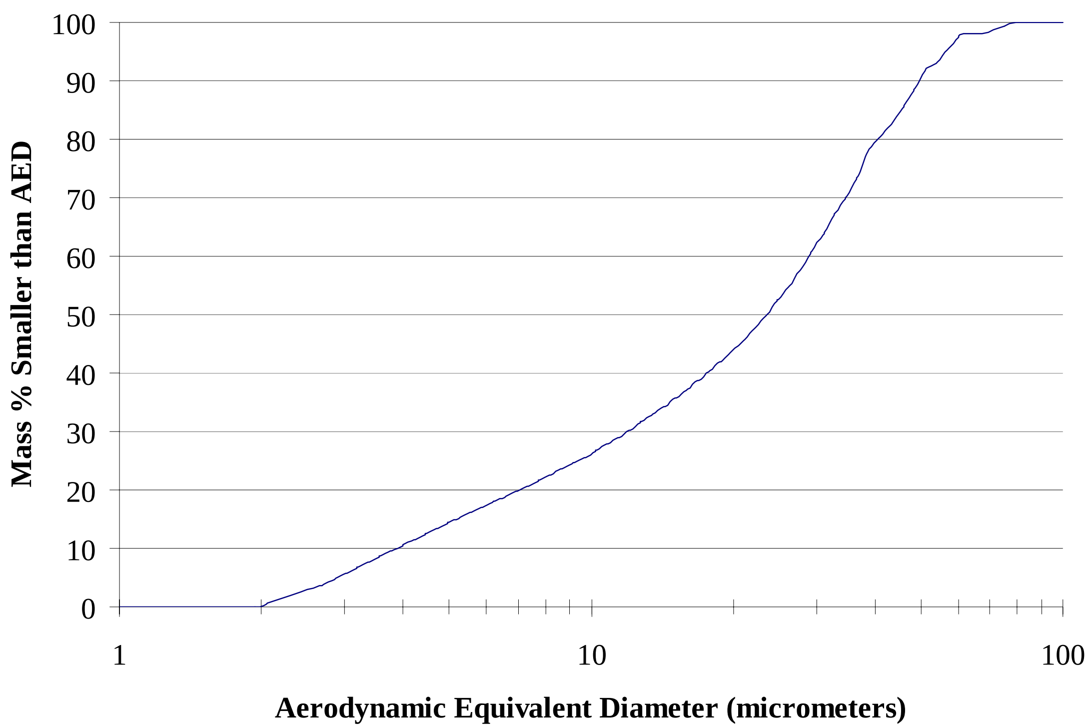

Figure 1. Cumulative particle-size distribution (PSD) for a sample of synthetic feedyard dust. Note that 100% of the sample mass has an AED of 80 micrometers or less.

Controlling the emissions of particulate matter from the feedyard surface can be achieved in several ways (Sweeten and Lott, 1994). Among the simplest methods is the frequent harvesting of loose, dry manure from the pens. In this way, hoof action will act on a moist, compacted manure pad instead of a dry, friable layer prone to pulverization and resuspension in air.

A second method of dust control involves the active application of water to the feedyard surface during dry conditions. In semi-arid climates, application rates up to ¼ inch per day have been shown to improve dust conditions substantially. For those feedyards equipped to monitor the moisture status, a target value of 25-35% in the upper inch of manure will help to reduce dust without materially increasing odor intensities. A study by Elam et al. (1971) indicated that when sprinkler use ceased for 7 days, dust concentrations in the corrals increased by nearly 800%.

Increasing the stocking density in corrals is a passive method of improving the moisture balance on the feedyard surface during dry weather. With an increased stocking density, the water contained in feces and urine is distributed over a smaller area, reducing the daily loss of moisture from the feedyard surface. During the hottest time of the year in semi-arid and arid regions, stocking density manipulation is unlikely to have a significant impact on dust emissions by itself, but it may be a tool to improve the efficiency of active methods of water application.

Paving feed pens with concrete or fly ash can facilitate the maintenance of smooth, firm pen surfaces and precision manure collection. In most cases, fly ash surfaces will be the less expensive method, but neither method is cheap. A recent study by Kantor (1995) was unable to prove statistically significant dust reductions from pens paved with fly ash.

Other, more costly methods of dust suppression include the application of resins and/or oils to pen surfaces and roads, but the long-term efficacy and economic implications of those methods have not been established conclusively. A study by Gillies et al. (1999) tracked the effectiveness of road-dust suppressants over 14 months and showed that some compounds were able to achieve 98-100% reductions in PM_{10} emissions from road surfaces. Reductions of that magnitude may be significant for feed alleys and working alleys where new material subject to pulverization (e. g., manure) is not being continually deposited on the surface. However, at a cost of $0.69 per square meter per year, using the best of the compounds tested on the feed alleys alone would cost about the same as a major-source assessment. For a feedyard having a design bunk spacing of 12" per head, applying the suppressant would cost $0.29 per head per year; for 8" of bunk space per head, the cost would be $0.20 per head per year. Those expenditures would not address the dominant emissions, however, and thus would contribute only modestly to total dust emissions from cattle feedyards.

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Brent W. Auvermann, Ph. D.
Assistant Professor and Extension Agricultural Engineer/Environmental Systems
6500 Amarillo Blvd. West
Amarillo, TX 79106
Phone: 806.359.5401
FAX: 806.358.9718
E-mail: b-auvermann@tamu.edu