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Dust Emission from South Dakota Cattle Feedlots

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ABSTRACT

Dust and particle emissions (PM) from cattle feedlots is a concern for producers in order to maintain good relations with neighbors and also to comply with the EPA proposed $PM_{2.5}$ particulate emission rules. Dust at 2.5 microns, which cannot be seen by the naked eye, is a potential health hazard since it can be ingested into the lungs of humans. One of the proposed regulations of the Federal Clean Air Act is to apply the $PM_{2.5}$ standard to the agricultural sector. This research project examines the particulate matter dust emissions of various sizes in microns including 2.5, 10, and total particulate matter emitted from a typical cattle feedlot in eastern South Dakota. The particulate matter from ambient air on the feedlot was monitored for a period of four weeks in August 2005 to obtain a large sample and accurate results. The data was then analyzed and interpreted into micrograms per cubic meter for comparison with various EPA standards and tests. The results from the feedlot show that during optimum dust production conditions (high temperatures, low humidity, calm winds, and low precipitation) feedlots can produce significant levels of particulate matter at the 2.5 and 10 micron sizes. These levels are similar in significance to the National Ambient Air Quality Standards. The findings from the research may assist County Zoning Boards and Commissioners with information to assess dust and particulate matter potential from livestock operations. This data found may also help lawmakers effectively make decisions on the regulation of feedlot operations rather than blindly inhibiting their operation.

INTRODUCTION

This research project, the first of its kind in South Dakota, measures $PM_{2.5}$, PM_{10} and total particulate matter (PM_{TSP}) produced from a cattle feedlot in eastern South Dakota. Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air.(EPA Report, 34) Particulate matter includes both coarse (PM_{10}) and very fine dust particles ($PM_{2.5}$), which cannot be identified by the naked eye, can potentially cause health issues. Exposure to coarse particles is primarily associated with aggravation of respiratory systems such as asthma while exposure to fine particles is associated with decreased lung function, increased hospital visits, and increased respiratory symptoms and disease (Tomany, 21). The Environmental Protection Agency

(EPA) has proposed standards of 15 μg/m³ for $PM_{2.5}$ emissions and 50 μg/m³ for PM_{10} emissions (EPA Report, 35). The livestock industry has been identified as a potential producer of these emissions. The data collected in this research will be compared to the standards to determine the relationship between typical dust production levels from a feedlot and the proposed standard.

The livestock industry accounts for 1.6 billion dollars of annual revenue in South Dakota, 34% of the total farm receipts (ERS 2005). Increased livestock production provides competitive local grain markets, increased returns due to decreased basis levels, and more readily available manure for fertilizer applications. These all encourage and improve the economy in South Dakota.

This research study provides regulators with current dust emission data from cattle feedlots in South Dakota that may be used in preparing zoning regulations. Regulators and others will be able to assist cattle feedlot producers on properly citing feeding facilities to minimize emissions. It is imperative that County Zoning Boards and Commissioners have scientific information to assess dust and PM potential from livestock operations to permit the expansion of the state's top economy.

Feedlot producers will benefit from the results of this research since odors can possibly be linked the amount of dust emissions. As an ever increasing study on limiting livestock odors, further researchers may use the data to create relationships between odor and PM levels.

Materials and Methods

The research was conducted during August 2006 on an 800+ head cattle feedlot located in eastern South Dakota. Three dust collection mechanisms were installed in the center of the feedlot to obtain levels of PM in the air via paper filters (Figure 1).

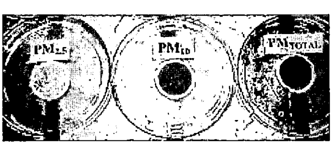


Figure 1. Sample picture of filters after testing.

The dust was collected at the $PM_{2.5}$, PM_{10} and PM_{Total} using Airmetrics model 4.2 air samplers (Figure 2).

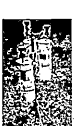


Figure 2. Dust Collection Mechanism Used (Airmetrics model 4.2).

This instrument intermittently passes air at a known fixed flow rate through a paper filter to collect particulate matter. Grey particle size separators, as seen in Figure 2, mounted on top of the samplers limit PM particles of either $PM_{2.5}$ or PM_{10} from reaching the paper filter to obtain desired particle size. The instruments are equipped with run timers which allow for calculating the total volume of air sampled. The equation to determine total volume is explained below.

Volume m^3 = Flowrate (L/min) * (60 min/1 hour) * Time of Operation (hours)

The instruments were powered by rechargeable batteries which had a life of approximately six days. The paper filters were replaced along with a new battery every six days. Feedlot emissions were analyzed for a total of four consecutive sampling periods, each six days long.

The paper filters were weighed before and after sampling to obtain the mass of PM emissions collected during the sampling time. The filters and scale were contained in a humidity controlled environment to equilibrate before and after collection. The constant humidity level inside the chamber prevented distortions due to water weight from changes in humidity. The filters were weighed using a Sartorius model CP2P-F balance (Figure 3) that has accuracy to one microgram (0.000001g). The scale is placed on a large marble table to deaden or eliminate any vibrations that may distort the mass reading.

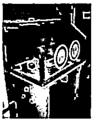


Figure 3. Sartorius scale used for weighing samples inside humidity controlled chamber.

The equation below explains how the mass of the PM collected was analyzed to produce a desired microgram (μg) value.

Mass (μg) = (M1 – M2)*1000

M1 = Mass of filter before sampling
M2 = Mass of filter after sampling
1000 = conversion factor (mg → μg)

Results and Discussion

Results from the four sampling periods are illustrated in charts directly comparing them with the national standards and also with other PM collection sites in the region. Figure 4 below displays the results of the $PM_{2.5}$ compared with the 15μg/m^3 standard.

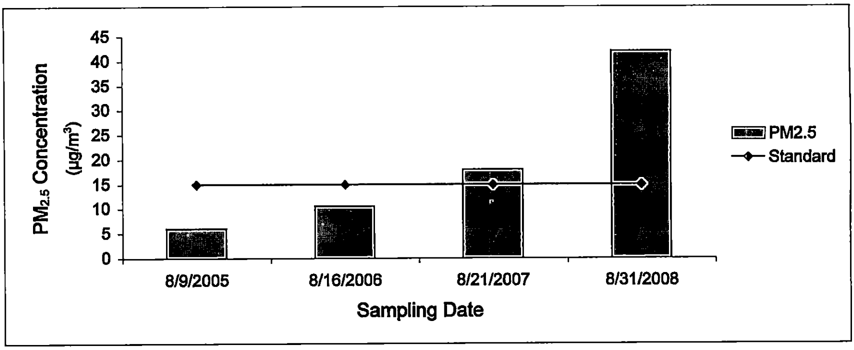


Figure 4. Experimental PM2.5 and Standard PM2.5.

Figure 4 shows a definite increase in emissions occurred over the four sampling periods. Ideally the experimental data should be lower than the standard line. The last collection of August 31, 2005 displays large amounts of $PM_{2.5}$ emissions. This exponential increase in production may be linked to various weather effects including: extreme temperatures, wind conditions, precipitation, and humidity. Weather data (Appendix A) from the region in the last week of August showed high average high temperatures (91.5°F), low relative humidity (46%) combined with moderate wind speeds (11.6 mph), all optimum conditions for dust production (Climate, 2005).

Figure 5 displays the results obtained from the PM_{10} emissions sampling.

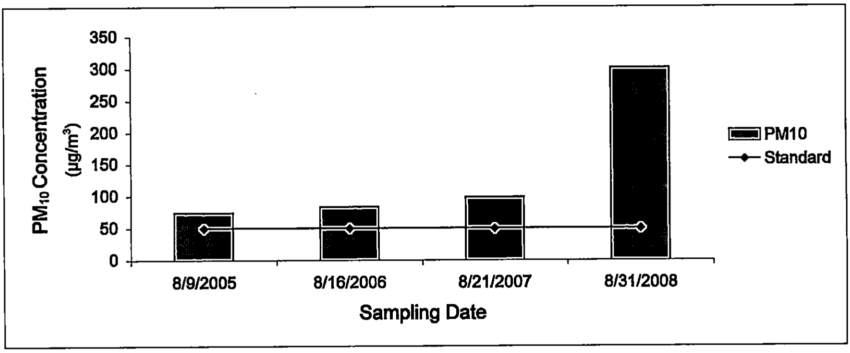


Figure 5. Experimental PM_{10} and Standard PM_{10}.

Figure 5 above examines the PM_{10} compared to the standard of 50 µg/m³. The same increasing trend as seen in $PM_{2.5}$ data in Figure 4 is seen in the PM_{10} emission data. These two charts are very similar, giving validity to each of the tests. The similarity in both charts reassures the data collected that the tests were accurate. This exponential increase towards the later dates is more than likely related to the optimum weather conditions as explained before. It is very interesting to examine how the weather can play a major role in PM emissions.

A final stock chart (Figure 6) was created to give an average value of PM emissions with the ranges collected shown as high and lows for each PM size.

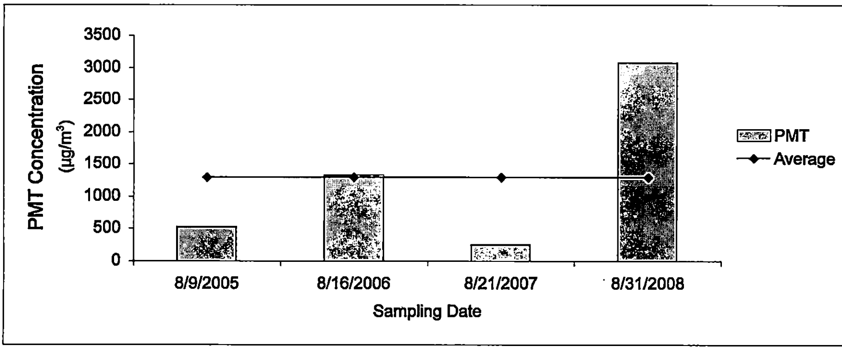
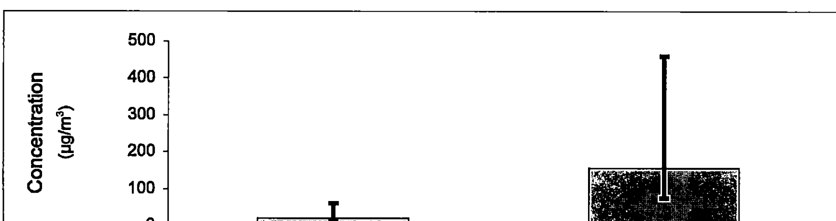


Figure 6. Stock Chart displaying high and lows along with the average emission for the month of August.

Total suspended PM (PM_{TSP}) was also monitored. The results shown in Figure 7 give an indication of how much large PM along with small PM were present in the air. Currently no standards exist on PM larger than 10 microns.



	PM2.5	PM10
Average	19	155.8
High	42.3	304
Low	6.2	80

Figure 7. Experimental PM_{TSP} and Their Average.

PM emissions are monitored at various locations across the state. These stations are typically located in towns which are not directly exposed to PM emissions as this research project was. As a base to compare the experimental data found during the instruments, the two figures below give an idea of typical PM emissions data found in eastern South Dakota.

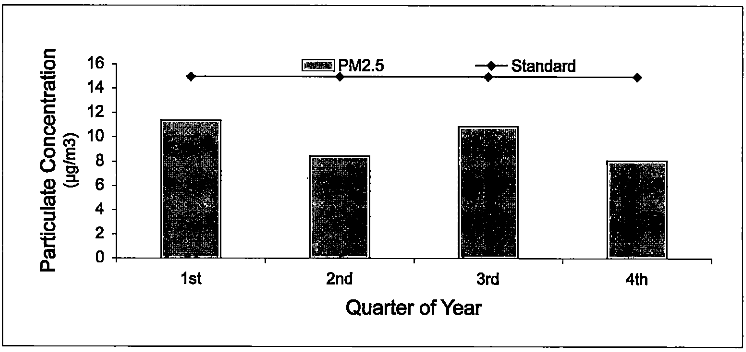


Figure 8. Experimental $PM_{2.5}$ and Standard $PM_{2.5}$ in the town of Brookings, SD. (Courtesy of SDDENR)

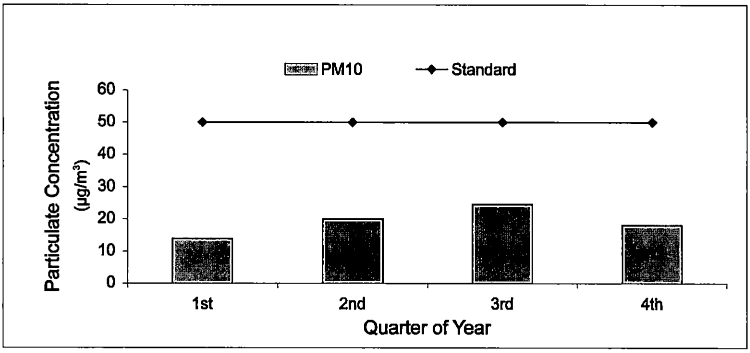


Figure 9. Experimental PM_{10} and Standard PM_{10} in the town of Brookings, SD. (Courtesy of SDDENR)

Figures 8 and 9 are comparable to the data collected at the feedlot. Obviously the emissions data for Brookings (pop. 17000) will be less than that of the feedlot. But in direct comparison of the $PM_{2.5}$ emissions, the feedlot produces only about twice as much $PM_{2.5}$ emissions as compared to typical air in Brookings, South Dakota. (19 $\mu g/m^3$ @ feedlot vs.10 $\mu g/m^3$ @ Brookings). The PM_{10} emissions are approximately eight times higher for the feedlot compared to that in Brookings. These two locations of study may have error in comparison due to different weather patterns because of the time when the samples were taken. Without other feedlot research to compare with, this provides a medium to compare to.

CONCLUSIONS

After completing this research, many conclusions can be made on the emissions from cattle feedlots. The sampling occurred during August (3rd Quarter) which typically results in the highest PM emission data, as seen in other reports. The increased PM emissions could be contributed to the weather. The weather can play a major role on PM emission. For example, during the last week of August, PM emissions were at their highest. This is related to the hot temperatures, dry soil conditions, low humidity, and the low wind conditions that occurred. Also, this summer was hot and dry which could have potentially favored PM emissions in August. The best possible solution to these certain weather circumstances would be to sample the feedlot for a period of three years. This would allow for extremes and would produce a more typical average value.

When comparing the feedlot results found in August to those in the city limits of Brookings, $PM_{2.5}$ and PM_{10} emissions from the feedlot were higher as expected, although the $PM_{2.5}$ emissions were not largely different. These are the emissions that the EPA is most sensitive about due to their health hazards. Since the feedlot's $PM_{2.5}$ emissions are slightly higher than the EPA standard for the worst possible conditions, it is apparent that cattle feedlots will not pose a health hazard and their averages would likely comply with the 15 $\mu g/m^3$ standard for $PM_{2.5}$ emissions. PM_{10} emissions seem to have more variability and response to weather compared to that of $PM_{2.5}$ emissions. More research is needed to accurately compare the PM_{10} emissions with the EPA standard of 50 $\mu g/m^3$.

FURTHER WORK

This research was conducted for only one month out of a year. To achieve the most accurate results a more in depth study should be conducted on a feedlot for a period of three years. This longer period will provide a better understanding and a concrete average value of PM emissions. Installation of a weather station should also be considered in continuation of this research.

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