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COTTON GIN YARD AND ROAD DUST EMISSIONS AND THE RESULTING EFFECTS ON DOWNWIND SAMPLERS

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Abstract

The control of particulate matter emissions from cotton gins is a priority in many states. The air pollution regulatory process requires that concentrations measured off-property be less than the National Ambient Air Quality Standards. Two methods are commonly used to determine the concentrations on or beyond the property line: ambient sampling and dispersion modeling. In order to limit the emissions from a cotton gin, the State Air Pollution Regulatory Agencies require that the gin obtain a permit. This permit sets the Allowable Emission Rate for the primary criteria pollutant of concern, particulate matter with an aerodynamic equivalent diameter of ten microns or less. The Environmental Protection Agency (EPA) has established emission factors for the particulate emissions from cotton gins in its AP-42 document.

When using dispersion modeling or measuring ambient mass concentrations downwind of a cotton gin to determine if it is meeting its allowable emission rate, it is important to note that there are two sources of particulate matter. The exhaust systems from the machinery used to extract the cotton and bale is the source that is being permitted. The gin yard and roads also produce particulate matter. However, these sources are considered to be fugitive emissions, and are not regulated unless the source is considered to be a major source under the Title V operating permit program. There are no cotton gins that currently meet the threshold to be considered a Title V major source, so these emissions should not be regulated.

It was hypothesized by the authors that the gin yard and road emissions can contribute significantly to the downwind concentrations. This was demonstrated using the EPA-approved Gaussian-based model, Industrial Source Complex Short Term Version 3 (ISCST3). With this dispersion model, it was possible to distinguish between sources and the concentrations resulting from those sources. The emissions from the gin yard and roads were estimated using AP-42 emission factors, and applied using two processes that are described in detail in the methods section. The average contribution of the gin yard and road uncontrolled emissions was found to be as high as 35% based upon the processes and model assumptions. While this contribution is not precisely what is found on an actual gin yard, it does demonstrate the necessity of including the gin yard and road emissions when determining the concentrations off-property.

Introduction

The control of dust emissions from cotton gins is a priority in many states. The air pollution regulatory process requires that the concentrations off-property be less than the National Ambient Air Quality Standards (NAAQS). Two methods have been used to determine concentrations of regulated pollutants on or beyond the property line: (1) measurements using ambient samplers and (2) modeling. In order to limit emissions from cotton gins, State Air Pollution Regulatory Agencies (SAPRA) require them to acquire permits. The SAPRA air permit defines the air pollution abatement system and the associated Allowable Emission Rates (AER). The primary pollutant emitted by cotton gins is Particulate Matter (PM) with an Aerodynamic Equivalent Diameter (AED) of 10 micrometers AED (PM_{10}). EPA has published emission factors for emissions of total suspended particulate (TSP) and PM_{10} from cotton gins in a document referred to as AP-42 (USEPA, 1995).

There are several permitting programs that potentially affect agricultural operations in the United States. These programs are used to enforce emission limits based upon NAAQS. The AER is often dependent upon whether the operation is located in an attainment area or not. An attainment area is defined by the EPA as *an area considered to have air quality as good as or better than the national ambient air quality standards as defined in the Clean Air Act.* (USEPA, 1997) These permits include the New Source Review (NSR) and Title V operating permits. The NSR Permits include: the Prevention of Significant Deterioration (PSD) permit, non-attainment NSR permits, and minor source NSR permits. The threshold to require a PSD permit would be a source that either emits or has the potential to emit 250 tons per year of regulated pollutants. The PM_{10} thresholds to require Title V "major source" permits for cotton gins are emissions of 100 tons per year in an attainment area, and 70 tons per year in a non-attainment area. In order to be dubbed a major source for a Title V permit for PM_{10}, the facility has to either emit or have the potential to emit 100 tons per year in an attainment area or 70 tons per year in a non-attainment area.

The pollutant of concern for cotton gins is PM_{10} (USEPA, 1995). PM_{10} emissions from cotton gins are primarily a consequence of the use of pneumatic conveying of seed cotton, seed, lint and trash. The annual emissions of PM_{10} are unlikely to meet the threshold for Title V or PSD. The only permit applicable for cotton gins is the NSR minor source permit. A minor source is a source whose emissions do not meet Title V or PSD thresholds. The threshold for requiring minor source permits according to the EPA is dependent upon the SAPRA. In many states, all cotton gins are required to obtain NSR permits. Typically, these permits are acquired prior to construction. However, some gins obtained their NSR permits following modifications made to the gin that changed the emissions, i.e. modifying the pollution abatement systems. If a cotton gin possesses a NSR minor source permit, modifications can be made to the facility as long as the facility's PM_{10} emission rate or potential-to-emit does not increase.

SAPRA uses several different methods to determine whether a cotton gin is in compliance with their permit conditions. These methods very from state to state, but one of the most commonly used is dispersion modeling. Dispersion modeling allows the SAPRA to estimate downwind concentrations given emission rates and meteorological data. AP-42 emission factors for cotton gins along with ginning rates are used to determine emission rates. Historical meteorological data is used in the place of on-site data when the latter is unavailable. There are several dispersion models, but the one recommended by EPA and most commonly used is the Industrial Source Complex Short Term Version 3 (ISCST3). This is a Gaussian based model. ISCST3 is a useful tool for determining concentrations downwind and back-calculating emission rates from sources given measured mass concentrations downwind.

There are two PM_{10} emissions from a cotton gin site that should be considered when performing dispersion modeling. The first is the various point source emissions from the different process streams such as the lint cleaner exhaust, dryers, etc. The other PM_{10} emission that is often ignored is the ground-level area source (GLAS) referred to as "fugitive". Fugitive PM_{10} sources include the gin yard and roads that are in constant use whenever the gin is in operation. The PM_{10} is emitted as vehicles move across these sources. The pollution abatement strategies for cotton gin, point-source emissions have been studied and emission rates and factors documented in the AP-42 and other publications. The methods and procedures used to account for fugitive emissions from cotton gin sites and their respective contributions to the receptor concentrations are not well defined in the literature. Approximations of emission rates using unpaved road emission factors from AP-42 were used in this study.

The purpose of this study was to develop procedures to estimate impacts of fugitive emission on concentrations off – property as determined by ISCST3 modeling. It was hypothesized that a significant fraction of downwind concentrations would be a consequence of vehicle traffic on property during ginning. The following was accomplished and reported in this paper:

- Cotton gin emission factors were used in dispersion modeling (ISCST3) to obtain concentrations downwind relative to point source emissions.
- Fugitive emissions using unpaved road emission factors were used in ISCST3 to obtain concentrations downwind relative to GLAS emissions. (Two processes were developed to obtain estimates of emission fluxes (mass per unit area per unit time) from emission factors in units of mass per vehicle mile traveled for modeling purposes. These processes are described.)
- The relative contributions of point and fugitive emissions from cotton gin sources to concentrations downwind were analyzed.
- The model used by ISCST3 for determining downwind concentrations from ground level area sources is the line source algorithm. Results presented in this paper demonstrate that the 10-minute concentration obtained using the Gaussian model line source algorithm is identical to the 60-minute concentration from ISCST3. This finding demonstrates that ISCST3 will likely over-predict downwind concentrations from area sources.

Methods

In order to determine the concentrations off-property, the emission factors for a cotton gin had to be determined. Using AP-42 emission factors, the emissions for both the gin yard and stacks were approximated. Some assumptions had to be made in order to determine which emission factors were to be used, however. The gin abatement control system, components, and which particulate matter emission factor were an example of some of the assumptions that were made before an appropriate emission factor can be deduced. For the purposes of this publication, the abatement system was comprised of high-efficiency cyclones and the PM_{10} emission factor was the emission factor employed due to its role as a criteria pollutant. The AP-42 document lists two different cotton gin systems for which an overall emission factor was developed. Due to the assumption of the use of high efficiency cyclones, an emission factor of 0.817 pounds of PM_{10} per bale was the emission factor chosen for the overall cotton gin emissions. A listing of the components and their corresponding emission factors occurs in Table 1.

Table 1 - Components and corresponding emission factors for a cotton gin controlled with high efficiency cyclones. (USEPA 2004)

Component	PM_{10} Emission Factor (#/bale)
Unloading Fan	0.12
No. 1 Dryer and Cleaner	0.12
No. 2 Dryer and Cleaner	0.093
Overflow Fan	0.026
Lint Cleaners	0.24
Mote Fan	0.13
Battery Condenser	0.014
Master Trash Fan	0.074
Total	0.817

To utilize the emission factor in ISCST3, it was converted to the form of mass of emission per time. Another assumption was made to accomplish this. Because this publication is not dealing with a specific cotton gin, a production rate of 20 bales per hour was used. This was chosen because the average bales per hour produced by the United States are approximately 20. (TCGA, 2004) To calculate the emissions in grams per second, the following equation is used.

$$Q = GPR \times EF \times 0.126 \qquad \text{Equation 1}$$

Where Q = emission rate in grams per second

GPR = Gin Production Rate in bales per hour

EF = Emission factor in pounds per bale

0.126 = Conversion factor to change pounds/hour into grams/second

The resulting emission rate is used in ISCST3 to determine the concentration downwind due to the cotton gin point sources.

The determination of the gin yard and road PM_{10} emission factors was accomplished using the AP-42 emission factor guide for unpaved road emissions. The gin yard is used as extensively as the roads by the various equipment in use by the gin; consequently the unpaved road emission factor may be utilized for the gin yard as well as the roads. There are two equations used by the AP-42 unpaved road emission factors, one for industrial road emissions and another for public road emissions. These are differentiated because unpaved industrial roads in general have heavier traffic and vehicles using the roads, while the publicly accessible roads are dominated by light duty vehicles. Because the cotton gin is predominantly used by heavy duty vehicles, the industrial emission factor is the more appropriate of the two emission factors; consequently, it was the emission factor used in this study. The industrial unpaved road emission factor equation is as follows:

$$EF = k(s/12)^a (W/3)^b \qquad \text{Equation 2}$$

Where EF = size specific emission factor in pounds per vehicle mile traveled

s = surface material silt content in percentage form

W = mean vehicle weight in tons

k, a, and b are empirical constants that are determined by which particulate matter emission factor it is

This equation used the surface material silt content percentage to calculate the respective emission factor. Silt content is defined by the AP-42 as *particles smaller than 75 micrometers in diameter*. (USEPA 2003) The fraction is calculated by "measuring the proportion of loose dry surface dust that passes a 200 mesh screen, using the ASTM-C-136 method." (USEPA 2003) The silt content that was used for this publication was determined from samples provided by the USDA ARS laboratory in Lubbock, Texas. These samples were taken at 3 different cotton gins, and at least 5 samples taken at each site. The average silt content from all 3 sites was 8.5 %. This is fairly representative, considering agricultural soil silt content is usually in the range from 5 to 15%.

When the emission factor for the unpaved road dust was calculated, it was necessary to change it to a form that ISCST3 could use. Because the gin yard is considered to be an area source, it is necessary to convert to mass per unit area per time. There were two different methods developed to determine an area flux. Some assumptions were made in order to facilitate this conversion. The assumptions for the first method were as follows:

- The gin yard was assumed to be 150 meters by 150 meters.
- The truck width was chosen to be 3 meters.
- Average speed for the trucks was considered to be 5 miles per hour.
- 1 truck traveled the entire yard to produce a conservative estimate.
- The wind direction was from the south.
- The wind speed was 3 meters/second.
- The stability class was C.

To obtain the emission flux to be placed into the area source, the total vehicle miles traveled was calculated. The equation to calculate the total miles traveled by a single truck over the entire yard is:

$$VMT_{total} = \frac{W_{yard}}{W_{truck}} \times L_{yard} \times 0.0006215 \qquad \text{Equation 3}$$

Where VMT_{total} = total vehicle miles traveled

W_{yard} = width of the yard in meters

W_{truck} = width of the truck in meters

L_{yard} = length of the yard in meters

0.0006215 = factor to convert meters to miles

It was necessary to determine the amount of time necessary for one truck to make a complete pass over the entire gin yard. This was calculated using the next equation:

$$t_{truck} = \frac{VMT_{total}}{S} \times 3600 \qquad \text{Equation 4}$$

Where t_{truck} = time it takes for truck to make one pass over the gin yard in seconds

S = speed of the truck in miles per hour

3600 is factor to convert hours to seconds

To obtain the area flux in mass per unit area per unit time, it was necessary to use the following equation:

$$Area\,Flux_1 = \frac{EF \times VMT_{total} \times 454}{Area_{yard} \times t_{truck}} \qquad \text{Equation 5}$$

Where Area $flux_1$ = amount of PM_{10} the truck produces per unit area in grams per meters^2 per second using the first method

EF = AP-42 emission factor for unpaved roads in pounds per vehicle mile traveled

454 is the factor to convert pounds to grams

The second method to obtain the area flux also used the industrial emission factor. For a 20 bale per hour cotton gin, it is assumed that each module produces 10 bales. Therefore, it is necessary to move two modules an hour to meet the production rate. Each module truck must travel a certain distance in order to obtain and return a module to the gin. There are also module trucks bringing in modules to be ginned, so it is assumed that there are two being brought in every hour to meet the production rate. The paths that are taken and the distances assumed for an example gin are shown in Figure1. To determine the area flux emission rate in grams per meters squared per second that is produced by this different method, it is necessary to use the following equation:

$$Area\,Flux_2 = \frac{L_{rate} \times EF \times 0.0000784}{L_{distance} \times W_{truck}} \qquad \text{Equation 6}$$

Where Area $Flux_2$ = amount of PM_{10} the truck produces in grams per meters^2 per second using the second method

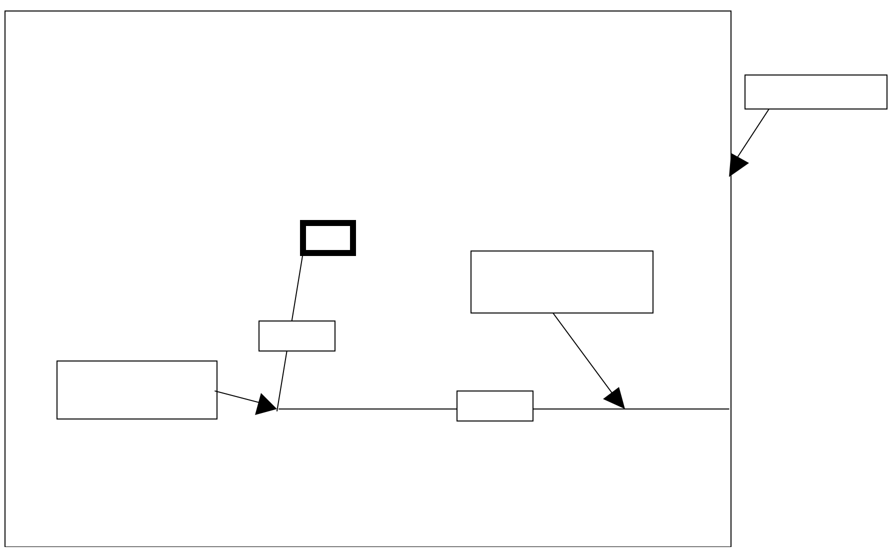
ER = total emission rate in grams per second coming off of the road surface

L_{rate} = rate that the trucks travel in meter per hour

$L_{distance}$ = length that the trucks travel in meters

W_{truck} = width of the truck in meters

0.0000784 is factor to convert pounds to grams, miles to meters, and hours to seconds



The area fluxes that were obtained by Equation 6 and 7 are not related, in that they were obtained using different methods. They are however approximately equal, so it was then assumed that a 20 bale per hour plant's fugitive emissions could be approximated using a 150 meter by 150 meter yard. For larger gins, the second method might need to contain longer roads and more trucks, thereby increasing the emissions coming from the yard and roads. It must then be postulated that the yard size that would approximate the fugitive emissions from a larger gin would be appropriately larger as well. The average area flux from both methods was then used by both ISCST3 and the infinite line source algorithm to calculate the PM_{10} concentrations downwind. The use of the infinite line source algorithm was an attempt to understand how ISCST3 calculates mass concentrations downwind of an area source. There are several ways to calculate an area source by hand using Gaussian-based methods. One of them is to divide the source into "lines" and then use the infinite line source algorithm to obtain the concentrations downwind. The infinite line source equation is:

$$C_{10} = \frac{2Q_L 10^6}{\sqrt{2\pi}\,(\sigma_z u)} e^{\left(-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right)} \qquad \text{Equation 7}$$

Where C_{10} = 10 minute concentration at some distance downwind in micrograms per cubic meter

Q_L = line emission rate in g/m

σ_z = vertical dispersion parameter in meters

u = wind speed in meters per second

H = effective emission height in meters

The σ_z component was calculated for the above equation by using the following:

$$\sigma_z = aX^b \qquad \text{Equation 8}$$

Where X = downwind distance to the sampler in kilometers

a and b are constants that are dependent upon stability class (Turner 1994)

To determine Q_L, a simple equation was used:

$$Q_L = \frac{Area\,Flux \times A_{yard}}{P_{truck} \times L_{yard}} \qquad \text{Equation 9}$$

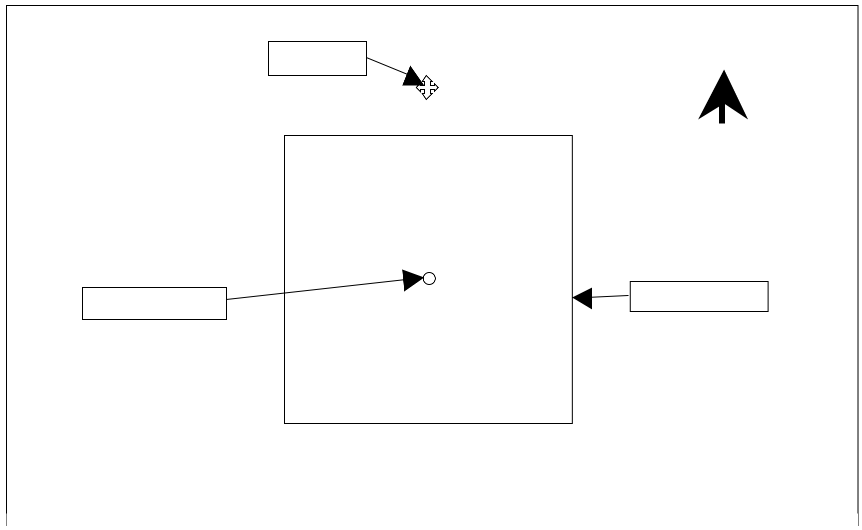
Where A_{yard} = area of the yard in square meters

P_{truck} = number of passes made by the truck

The mass concentrations at certain distances from the line source model were compared to the results from the ISCST3 model. The gin yard used for both was a simple 150 meter by 150 meter square as was mentioned above. A table of mass concentration values from both models appears in the Results section.

To determine the effect that the gin yard and road dust have when compared to the gin stack emissions, the EPA-approved ISCST3 was used. This Gaussian based model was developed as an attempt to predict downwind concentration from stationary sources. When performing the basic gin analysis for this publication, a simplified model of a cotton gin was used. Although this model is too simple to represent an actual gin in full production, it does provide an understanding of just what effect the gin yard and roads can have on samplers that are located downwind. The setup in ISCST3 is shown in Figure 2.

The emissions from the cotton gin stacks were combined into one source to simplify the model and to also create a conservative estimate of the gin yards effect. With all of the point sources emissions combined into one point source, and with no deviation in the wind direction, the point source will be given a notably higher effect upon the samplers than if there were 20 point sources spread out around the gin. The AP-42 emission factor for PM_{10} from a cotton gin was used as the point source emission rate. The area source emission rate was discussed above. There was more than one sampler than is depicted in the diagram. There was a sampler at 10 meters from the North edge of the feedyard and then samplers from 25 to 500 meters at 25 meter intervals directly downwind.



The concentrations that are the result of each source can be determined in ISCST3 easily, which was one of the primary reasons for its use in this publication. ISCST3 determines the total concentrations at a specific location by summing the contributions from individual sources at that location. The individual contribution from a specific source at a specific location was found by setting all of the other sources emissions equal to zero. The concentration found was then divided by the total concentration to find the percentage of the concentration contributed by that specific source at that location. Tables listing the concentrations and percentages are found in the following section.

Results

The industrial emission factor was calculated using the AP-42 emission factor parameters. The parameters varied by which particulate matter size for which the emission factor was being calculated. The parameters used for this publication are listed in Table 2. The other various parameters necessary to calculate the emission factor were listed in the Methods section.

Table 2 - Parameters used to calculate the industrial emission factor.

k =	1.5
a =	0.9
b =	0.45

The result of the industrial emission factor calculation was 2.58 pounds per vehicle mile traveled. Using the equation to convert the emission factor to an area flux in grams per square meter per second, the emission factor using the first method was 72.4 micrograms per square meter per second. Using the second method for calculating an area flux, the result was calculated to be 67.4 micrograms per square meter per second. Because these area fluxes are very close, the average was used in the line source algorithm and ISCST3 to calculate the downwind mass concentration at various distances. The cotton gin stack emission factor conversion produced emission rate of 2.06 grams per second. This emission factor was used in the ISCST3 point source emission rate to provide the comparison between the contribution made by the gin yard and that made by the gin stack.

The comparison between the line source algorithm and ISCST3 was an attempt to understand ISCST3 as well as provide an alternative with which to compute downwind mass concentrations from an area source. Using the meteorological conditions mentioned in the assumptions and the emission factor calculated above, the resulting mass concentrations from both the line source algorithm and the ISCST3 modeling program are presented in Table 3. The concentrations are approximately equal until the distance increases enough to show the difference between the infinite line source algorithm and the area source algorithm used by ISCST3. The infinite line source is utilized mainly for roads and highways where the samplers are close enough that the road could be considered an infinite source. The same could be said for the use of the infinite line source to approximate the area source. Up to certain distances, the length of the gin yard could be considered to be much larger than the distance from the edge of the gin yard to the sampler. Once the distance from the edge of the gin yard to the sampler becomes approximately equal to the length of the edge of the feedyard, however, the length of the feedyard can not be considered to be an infinite line source any longer. ISCST3 then must use a modified version of the line source algorithm to approximate an area source, one that incorporates the finite length of the edge of the yard and the "edge effects" that produces. Figure 3 clearly demonstrates this with the line for the industrial emission factor, with a separation beginning at roughly 150 meters and continuing to increase until the end at 500 meters.

Table 3 - Mass Concentration in micrograms per cubic meter for both ISCST3 and the line source algorithm using the Industrial road emission factor, with the corresponding distance downwind from the edge of the gin yard.

Distance Downwind	Conc. - Line Source	Conc. – ISCST3	Distance Downwind	Conc. - Line Source	Conc. – ISCST3
10	642.25	643.97	275	120.96	114.06
25	470.35	470.81	300	113.36	105.02
50	346.98	346.98	325	106.70	96.96
75	281.14	281.03	350	100.83	89.74
100	238.42	238.11	375	95.59	83.24
125	207.96	207.29	400	90.90	77.39
150	184.92	183.72	425	86.67	72.08
175	166.81	164.81	450	82.84	67.28
200	152.13	149.15	475	79.35	62.93
225	139.98	135.80	500	76.15	58.96
250	129.73	124.22			

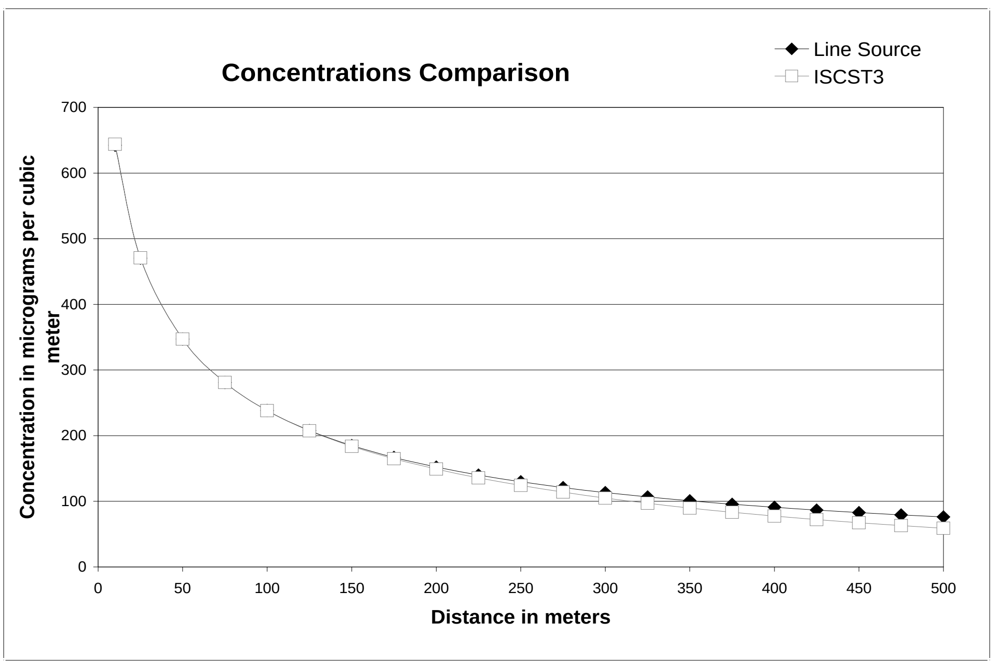


Figure 3 - Graph depicting comparison of concentrations derived from the Line Source Algorithm with the concentrations derived using ISCST3 and the industrial emission factor.

It must also be noted that the line source algorithm produces concentrations that are 10 minute estimates. The Pasquill-Gifford parameters used to estimate the dispersion of the plume are based upon 10 minute averages, and are used widely today (Cooper, 2002). ISCST3 predicts concentrations that are hourly averages. These same concentrations were used to compare to the line source algorithm. As can be seen, there was little to no difference except with an increase in distance. This presents a quandary, one that needs resolving. A 60 minute concentration is, by its very definition, always lower than the 10 minute average, due to wind shifts and meteorological changes that occur throughout the hour. A 10 minute average is short enough so that the shifts and changes do not create an overwhelming dissonance in the concentrations predicted versus the concentrations measured. In 60 minutes, however, this change can and does cause a notable difference in the concentrations measured versus predicted.

To predict the effect of the gin yard as compared to the gin stack emissions, ISCST3 was used to predict the downwind concentrations at various distances downwind. The public and industrial emission factors were used for the gin yard, and to incorporate the effect that watering the yards would produce, the emission factor for the gin yard was used at 100%, 75%, 50%, and 25% of its full value for both the public and industrial emission factors. Table 5 provides data that was produced by ISCST3 for both the modeled gin stack and yard emission factors.

Table 4 - Mass Concentrations in micrograms per cubic meter differentiated by the various sources and distances from the edge of the feedyard. The yard is considered to be emitting 100% as is the stack.

	Industrial Emission Factor			
	Concentrations by Source			
Distance Downwind	Total	Stack	Yard	Percent Contribution by the Yard
10	1336.94	692.97	643.97	48.17
25	1228.34	757.53	470.81	38.33
50	1080.51	733.52	346.98	32.11
75	930.79	649.76	281.03	30.19
100	797.34	559.23	238.11	29.86
125	685.53	478.24	207.29	30.24
150	593.73	410.01	183.72	30.94
175	518.47	353.65	164.81	31.79
200	456.42	307.27	149.15	32.68
225	404.78	268.98	135.80	33.55
250	361.40	237.18	124.22	34.37
275	324.63	210.57	114.06	35.13
300	293.15	188.13	105.02	35.82
325	266.03	169.07	96.96	36.45
350	242.49	152.75	89.74	37.01
375	221.93	138.69	83.24	37.51
400	203.88	126.49	77.39	37.96
425	187.93	115.84	72.08	38.36
450	173.78	106.50	67.28	38.72
475	161.18	98.25	62.93	39.04
500	149.90	90.94	58.96	39.33

Table 5 is an example of how ISCST3 can discriminate between the concentrations that each source produces downwind. It also shows the percentage that the yard contributes at each distance downwind. As can be seen, the yard contributes significantly. The contribution is higher than one-third of the total mass concentration measurements at each of the distances out to 500 meters. This is a significant contribution that must be understood and compensated for when calculating the concentrations downwind. If these measurements were taken with gravimetric sampling equipment, there would be no precise method to discriminate between the sources and the concentrations that result from the sources.

Some gins, understanding the impact that the yard can have on downwind concentration measurements, have endeavored to mitigate those emissions by applying water to the yard surface. This management practice is effective in that it does alleviate some of the particulate matter emissions from the yard for a period of time. The yard and roads, because of their constant use, dry up in a matter of minutes or hours and continue to produce emissions. Also, the watering methods are not equivalent to a significant rain event, which prohibits dust emissions for a day or days. Thus, this measure cannot be considered to be 100% efficient, and must be compensated for in the calculations of downwind emissions. The following table (Table 5) and graphs (Figures 4 and 5) represent different efficiencies of the watering methods and the resulting average concentrations and contributions downwind. It must also be noted that some SAPRA limit the maximum efficiency of the watering methods from 50% to 70% for the unpaved roads. (Rodriguez, 2005)

Table 5 - Average concentrations and contributions of PM_{10} from the gin yard over a distance of 500 meters from the edge of the gin yard as a function of the gin yard emitting at various percentages. The calculations were performed with ISCST3.

Percentof Yard Total that is Emitting	Industrial Emission Factor Average Conc. by Source			Percent Contribution by the Yard
	Total	Stack	Yard	
100	505.67	325.98	179.69	35.54
75	460.75	325.98	134.77	29.25
50	415.83	325.98	89.85	21.61
25	370.90	325.98	44.92	12.11

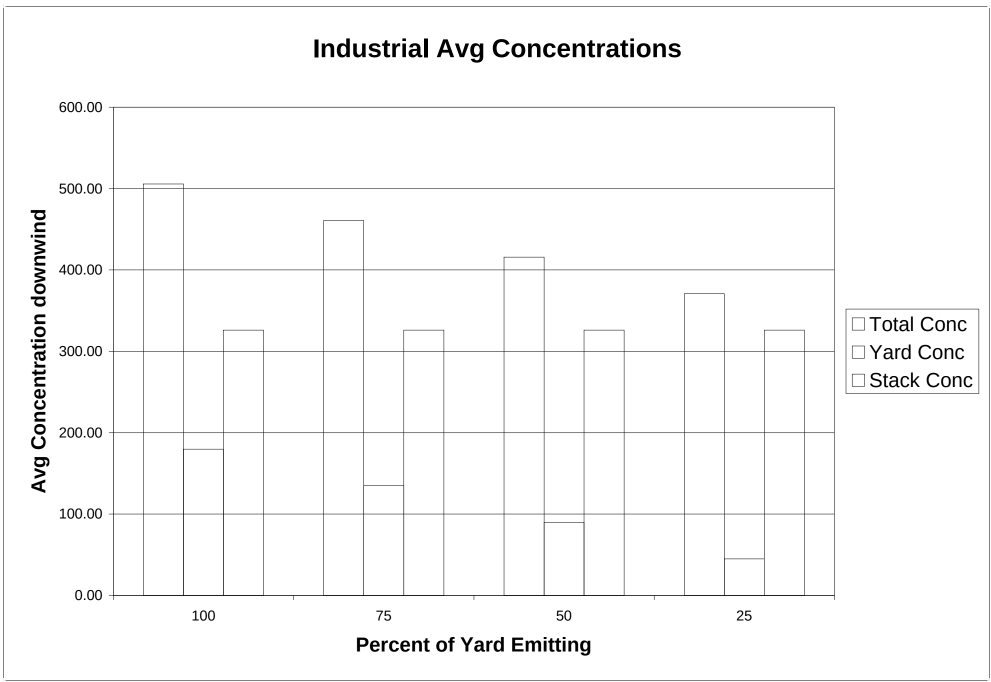


Figure 4 - Average concentrations downwind of the cotton gin model for various sources using the Industrial Emission Factor. The concentrations are plotted as a function of the percent of the yard emitting.

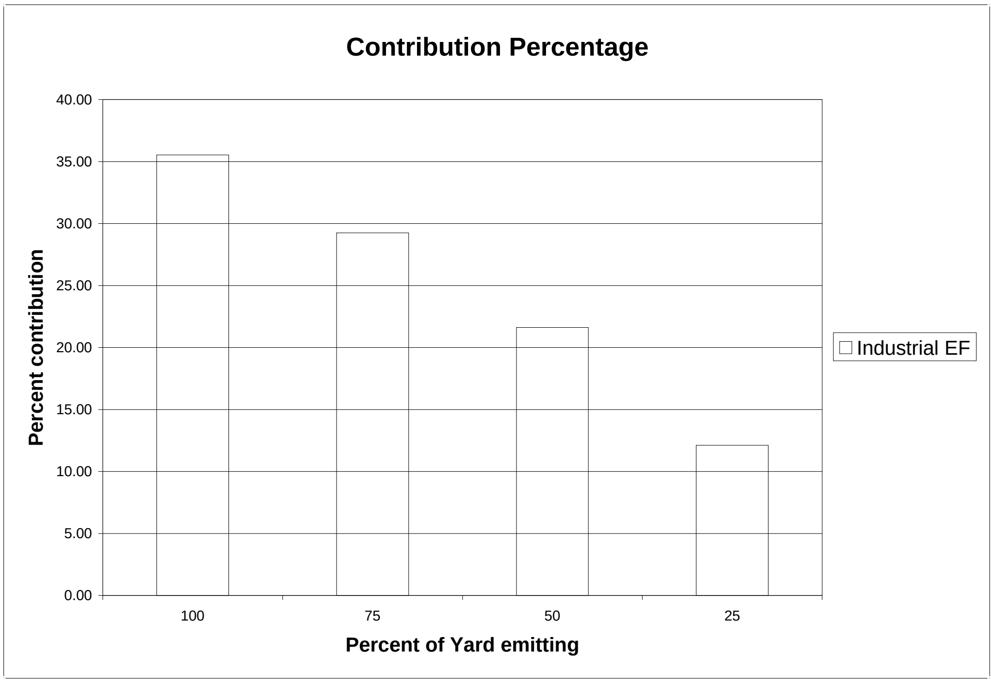


Figure 5 - The average percentage that the gin yard contributes to the downwind concentrations plotted as a function of the emission factors and the percent of the yard that is emitting.

As can be expected, the lower the percentage that the yard emits, the lower its average contribution downwind. Even with the yard emitting at only 25%, the average contribution from 0 to 500 meters is approximately 12%. It can be concluded, based on the results of this study, that the gin yard has an impact on the downwind samplers, and in some cases, is the dominating emission source for the entire cotton gin.

Conclusions

With the various objectives complete, an informed look can be made at what type of impact that the PM_{10} emanating from the cotton gin yard will make upon samplers placed at various locations directly downwind. Because of the various permitting programs used by the EPA and the various SAPRAs, it is necessary to have an accurate emission factor for all of the sources that exist upon a cotton gin yard. Many cotton gins consider the gin yard to be a lesser part of the emissions, especially after watering has taken place. As is demonstrated in the results section, the yard can still have a major impact upon the samplers downwind, from an average of 12% to over 35% depending on the efficiency of the watering. Because some SAPRA's limit the effectiveness of watering, cotton gins are prevented from eliminating the gin yard from its emissions inventory entirely because of watering.

The ISCST3 modeling program area source was demonstrated to be virtually identical to the Infinite Line Source algorithm. This was especially important as ISCST3 predicts hourly concentration measurements, and the line source algorithm predicts 10 minute parameters. It can therefore be concluded that the model predicts concentrations from an area source to be the same at one hour as at ten minutes, an issue that needs careful consideration by state agencies.

It should be noted that there were two methods used to develop an area flux based upon the AP-42 emission factor. Although the calculated area flux is not considered by the authors to be the flux from a normal gin yard, it is important to note the impact that the uncontrolled emissions from the yard had on mass concentration. The area flux from an actual gin yard might be higher, creating a greater impact on the concentrations downwind. And the opposite is true as well. And although the gin setup can be considered simple, it is still relevant. For the first method, the emissions were calculated using only a single truck to produce all of the emissions. Although some of the yard does not produce fugitive emissions, other areas produce higher concentrations because of higher traffic flow. An average emission rate over the entire area would perhaps be similar to the ones predicted by the two methods in this publication.

Further work is recommended on this subject by the authors. A more extensive look at the particulate matter emissions from a cotton gin yard is necessary to get a complete and accurate picture. Further research would need to choose several gins from across the country, gather soil samples, gin yard and stack measurements, and place all of the data into one of the dispersion models currently accepted by the EPA. This research would then be appropriate for determining precisely the effect of the gin yard emissions on the downwind samplers, and could then be used to improve the measures already being taken to reduce the yard emissions.

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