ANALYSIS OF THE DISPERSION OF PARTICULATE MATERIAL FROM FIXED SOURCES IN A COLOMBIAN SUGARCANE MILL

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Abstract
In order to estimate the impact on air quality and the range of the atmospheric emissions generated by boilers using bagasse, the behaviour of the emissions from the chimneys of the Providencia Sugar Mill was studied by applying the dispersion model SCREEN 3. The results obtained corroborate the effect of modifying the combustion processes and the adoption of emissions-control systems on the reduction of the concentrations of particulate matter by approximately 98%.

Introduction
In order to predict the range of atmospheric emissions, different mathematical models of dispersion have been developed, from simple ones that can be processed manually to complex formulas of Gaussian-type modeling (Ajay, 1999). These models take as basic information the meteorological conditions (wind speed and direction, atmospheric stability, mixture height or thermal inversions), the topography, and the characteristics of the emissions to generate the concentrations of the contaminants present in the environment.

Materials and methods
In order to estimate the range of the emissions from the chimneys of the sugarcane factories in the geographic valley of the Cauca River, the Providencia Sugar Mill was taken as a pilot mill.

The dispersion model SCREEN 3 (EPA, 1995) was applied as a resource for determining the range of the emissions of particulate matter and evaluating their impact on air quality. The model provides a pollutant concentration estimation including maximum ground-level concentrations and the distance to the maximum, and determining plume rise for flare. The model incorporates the effects of simple elevated terrain on maximum concentrations and can also estimate 24 hour average concentrations due to plume impaction in complex terrain. The maximum range is 50 km, measured between the source and the receptor.

The historic data on the isokinetic samples of emissions from each of the three boilers of the Providencia sugar mill were compiled, corresponding to the period 1991–1999.

The years previous to 1996 correspond to the period before the adoption of technologies for controlling emissions of particulate matter and the improvement of combustion in the boilers. On the other hand, the years 1998–1999 correspond to the period after the modifications were made and reflect the current situation. The year 1997 was considered as a period of transition because, at this time, technologies were adopted for improving combustion and reducing emissions. For this reason, only 1996, 98 and 99 data were used for the analysis. The following technologies were introduced in all the boilers: improvements in the pneumatic distribution of bagasse, adjustment of the systems of tertiary air and air of combustion, multicyclone and an electrostatic precipitator in boiler 1, multicyclonal systems in boilers 2 and 3.

The dispersion model SCREEN 3 was applied for the particulate matter, taking in account aspects such as: topography, meteorology, bubble effect.

Topography
For the case study the area adjacent to the sugar mill was considered because it is relatively flat and the wind regime is stable.

Meteorology
In order to define the meteorological conditions of greater importance in the dispersion of the particulate matter, it was decided to use the data on the emissions from chimney 1 because of its greater technological infrastructure for controlling these emissions. Afterwards, the results were extended with data on emissions from chimneys 2 and 3.

The ‘bubble effect’
This considers the combined emissions from the three boilers when they use the same fuel and discharge the same pollutants. It is considered that the total emission is equal to the sum of the partial emissions and should be compared with the compulsory level.

Results
A graphical representation of the results offered a spatial distribution of the emissions as well as curves of equal concentration (isopleths) for 1996 and for 1998–99 as shown in Figure 1.

The results obtained from the SCREEN 3 Dispersion Model indicate that the distance from the chimney where the maximum concentration of particulate matter occurs tends to increase with increasing atmospheric stability. The foregoing trends were also observed for the emissions of chimneys 2 and 3.
Based on these data, the particulate matter dispersion was estimated, taking into account the bubble effect (sum of emissions from the three chimneys) for the two periods of interest: 1996 and (1998–1999). According to these results the following was observed:

The greater the wind speed, the smaller the distance at which the maximum concentration occurs, although the maximum concentration was reduced (Table 1).

The more unstable the atmosphere, the more maximum concentration of the particulate material occur further from the source.

The concentration on the surface tends to increase initially with increasing distance from the source of emission until a maximum value is reached. There is then a gradual decrease with increasing over distance (Figure 1).

The maximum concentrations of particulate matter were located over areas covered by sugarcane crop and not over the neighbouring populations, a fact that is favoured directly by the meteorological conditions of the zone. On the other hand, the levels were not great enough to be harmful to the health of the area’s residents.

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<td>Speed m/s</td>
<td>Maximum concentration ug/m³</td>
<td>Distance m</td>
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<td>934</td>
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<tr>
<td>Speed m/s</td>
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</tr>
<tr>
<td>1.9</td>
<td>1131</td>
<td>1851</td>
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*Stability B is more unstable than stability A.
Although the position where the maximum concentrations occur remained the same, the actual levels were reduced by approximately 98% when the boilers were changed to reduce emissions.

Conclusions

The particulate matter dispersion is affected by the meteorological conditions predominant in the zone. The greater the atmospheric stability, the greater is the distance where the maximum concentration of particulate matter occurs, although the concentration tends to decrease.

With the application of the dispersion model, it was possible to establish that the maximum levels of concentration of particulate matter generated after the change in the boilers were reduced by approximately 98% when the boilers were changed to reduce emissions. With the application of the dispersion model, it was possible to establish that the maximum levels of concentration of particulate matter generated after the change in the boilers were reduced by approximately 98% when the boilers were changed to reduce emissions.

REFERENCES


ANÁLISIS DE DISPERSIÓN DE PARTÍCULAS EN HUMO GENERADO EN UN MOLINO DE AZÚCAR COLOMBIANO

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Resumen

Para estimar el impacto en la calidad aérea y serie de emisiones atmosféricas generadas por calderas que usan el bagazo, el comportamiento de emisiones de las chimeneas del Molino Azucarero Providencia fueron estudiadas. Este estudio fue logrado aplicando un modelo de dispersión llamado ‘Screen3’. Los resultados obtenidos corroboraron el efecto de modificar el proceso de combustión y la adopción de un sistema de ‘emisión-control’ en la reducción de concentración de partículas en humo en aproximadamente 98%.