SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS
BY MEANS OF GAUSSIAN PLUME MODEL

This chapter presents the spatial distribution of sulphur dioxide (SO$_2$) concentrations by means of multiple stack Gaussian plume model, by taking the actual emission inventory into consideration. The various possibilities of mitigating the pollutant levels are also discussed in addition to suggesting the optimum locations for new industries. A map of the city and neighbourhood showing various locations are presented in Fig. 8.1.

8.1 SPATIAL DISTRIBUTION OF SO$_2$ CONCENTRATION

The total emission of SO$_2$ from all the three sources is a little less than 10g$s^{-1}$. The isolines of the ground level concentrations of SO$_2$ are depicted in Figs. 8.2(a) to 8.2(l) for the months from January to December respectively.

January

The maximum sulphur dioxide concentrations (12$\mu$gm$^{-3}$) is observed over the Vettukadu area of the northeastern sector of the city. The values decrease away from the region in all directions over the city. Values less than 2$\mu$gm$^{-3}$ are observed over the southern, northeastern and northern portions of the city.
FIG. 8.1. MAP OF TRIVANDRUM CITY
FIG. 8.2(a). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR JANUARY (μg m⁻³)
FIG. 8.2(b). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR FEBRUARY ($\mu$gm$^{-3}$)
FIG. 8.2(c). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR MARCH ($\mu g m^{-3}$)
FIG. 8.2(d). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR APRIL (μg m⁻³)
FIG. 8.2(e). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR MAY (μgm⁻³)
FIG. 8.2(f). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR JUNE (µgm⁻³)
FIG. 8.2(g). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR JULY (μg/m³)
FIG. 8.2(h). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR AUGUST (μg m⁻³)
FIG. 8.2(i). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR SEPTEMBER ($\mu g m^{-3}$)
FIG. 8.2(j). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR OCTOBER ($\mu$gm$^{-3}$)
FIG. 8.2(k). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR NOVEMBER (μg m⁻³)
FIG. 8.2(1). SPATIAL DISTRIBUTION OF SULPHUR DIOXIDE CONCENTRATIONS FOR DECEMBER ($\mu$gm$^{-3}$)
February

The values near the first source in the Vettukadu region are much higher (20μg/m³) than in the previous month. The entire northwestern sector has values higher than 10μg/m³. In contrast over the rest of the city the values have decreased to very low values. Over more than half the city, the values are less than 1μg/m³. This is because most of the pollutants are carried westward over the sea from the source.

March

During this month too, the concentrations are very high near the source I. However, the concentrations show a substantial increase over the other areas of the city. The isopleths exhibit a slight northwest-southeast orientation, resulting in larger concentrations in the southern sector too.

April

The distribution in this month is similar to that of March except that in the extreme southern and eastern sectors, where the values are much lower now. The highest concentrations of 15-20μg/m³ continue to be near the Titanium factory. Most of the city has concentration around 5μg/m³.

May

The concentrations in May over the city are around
5\mu g/m^3. The values over the northwestern sector are higher in this month (20\mu g/m^3). The isopleths show a northwest-southeast orientation as in March.

June

The distribution is extremely different in this month. Two pockets of high concentrations are observed—one over the coastal area near Sankumukham (around 12\mu g/m^3) and the other in the northern parts of the city, covering Perurkada, Kowdiar and Nandankode areas. This second cell of high concentrations is due to the source III and is observed only during this month. The concentrations in the rest of the city area are low.

July

During this month too, the concentrations are high near the source I. The isopleths are oriented in southwest-northeast direction. The southern and eastern parts of the city have very low values.

August

Most of the city area is almost free from pollution, the values being around 1\mu g/m^3. Only the northwestern sector has values more than 4\mu g/m^3 with the coastal area near Vettukadu having a maximum of 12\mu g/m^3 near the source II. The
pollutants seem to be confined to the area close to the source.

September

The sulphur dioxide concentrations even near the source is much lower (around 5\( \mu \text{g/m}^3 \)) during this month. But there appears to be a considerable spread towards the southeastern regions of the city, since the winds are predominantly northwesterlies during the day time. In general, the concentrations are low over most of the city.

October

The maximum concentration in this month shoots up to 20\( \mu \text{g/m}^3 \) (the same values earlier observed in May) over the northwestern region. The northern region (Kowdiar, Perurkada) near Hindustan Latex Ltd experiences values of 8\( \mu \text{g/m}^3 \), while the neighbouring area north of Pattom has values around 4\( \mu \text{g/m}^3 \). During this month too, the southern and eastern portions show low sulphur dioxide concentrations.

November

The sulphur dioxide concentrations register their highest values during this month. The entire western areas of the city have values more than 10\( \mu \text{g/m}^3 \). The maximum concentrations of 50\( \mu \text{g/m}^3 \) is noticed near Vettukadu region.
The values decrease away from this source and the minimum values are less than 1µg m\(^{-3}\) in the extreme southern parts of the city.

December

During this month, the concentrations are slightly lower than in November, but still very high. Although the maximum values observed (40µg m\(^{-3}\)) is lower than in November, the city shows generally higher values above 10µg m\(^{-3}\). Concentrations are greater than 1µg m\(^{-3}\) over the whole city area.

It is thus seen that the months December and November show the highest concentrations while the monsoonal months show the lowest. Higher values of mixing heights do not seem to have as much impact as the wind has on the concentration of pollutants. The months December to March show relatively higher mixing heights but the concentrations are not low. But in the monsoonal months, the strong winds are the main cause for the lower values. This may probably be explained as due to the direct inverse proportionality of wind to the concentration. The mixing height involvement in the model comes only after a certain distance from the source and as such the concentration will not be affected in the first few kilometres. But the wind has an increased involvement
throughout the distance up to which the concentration is calculated.

The very large concentration in November (highest in the year) may be due to the very low wind speeds coupled with lower mixing height. In any case one can notice that despite the strong unidirectionality of the wind in many cases the pollutant distribution does not follow that pattern. This is mainly because whenever the winds are unidirectional they are extremely strong as a result of which the concentration in the downwind direction is bound to be low compared to the case of low frequency but weak winds from any other direction. The latter, in view of its very low wind speed, results in higher concentration and the effect is seen for a considerable distance. Whether the weak winds are persistent enough to carry pollutants to such great distances is a debatable point. But the model does not take into account such persistence of the winds and as such the pattern discussed above appears.

It should also be noted that the monsoon brings in lot of rainfall resulting in a possible washout of pollutants leaving the concentration to be further low. The presence of huge amounts of moisture in the atmosphere cannot be left untouched because of a possible conversion of sulphur dioxide to sulphurous acid or sulphuric acid in which case also the
concentration of ground becomes further low. However, although the moisture and rain act as sinks of sulphur dioxide, this is not a matter over which one can be happy in view of the possible acid rain which has its own deleterious effects. In any case, from all counts monsoon season appears to be very safe in view of the low concentration.

These long term concentrations give some insight into choosing the appropriate locations for further industries. Except on a couple of occasions, it appears that most of the city area is relatively free from pollution. Especially, the southeastern and eastern sectors are free from pollution in most months. As such, the present location of industries are not inappropriate. However, one cannot think of a cluster of industries and hence other locations are to be chosen keeping the existing levels in view. The extreme northeastern parts appear to be very plausible for further industrial development since the contribution from the north side is not significant. One can see the rapid decrease of concentration towards south. This is the main point on which the northeastern locations is suggested. Although, the southeastern parts are free from pollution, it must be kept in mind that in most of the cases the spread is in the northwest-southeast direction and that would result in heavy doses of concentration in the central parts if southeastern parts are chosen for further industries. In any
case it depends upon the amount of emission also. To some extent the northwestern parts also seem to be appropriate for further industries. But it does result in rather high concentration in central northern parts. However, the city interior is not affected that much.

In addition to the location of the industries, one should also see the concentration variation diurnally. Although, not depicted here, the night-time concentrations are even higher, mainly because of low wind speeds. In certain months such as November and December the night-time concentration would be undoubtedly very high and hence one has to think of regulating the emissions. In fact if the night emissions are brought down, the effective concentration for day and night put together also would automatically come down. The emissions during night-time can be brought down with a corresponding increase during day time which then would also lead to lowering of effective concentrations. A fifty percent reduction in the night-time emission would lead to an almost fifty percent decrease in night-time concentration. However, fifty percent of additional emissions during day time would lead only to a marginal increase because of high wind speeds and hence the average concentration comes down considerably. In addition the effective stack height would also be raised but this does not
seem to have any considerable impact on the concentration of pollutants.

It must be noted that the concentrations are only due to the industries and the vehicular traffic is not included. This would mean that the present levels of pollutants reported here are underestimates.