

Meteorology and Air Pollution

Factors influencing air Pollution.

When studying air quality, it is important to measure the following factors as they can help us understand the chemical reactions that occur in the atmosphere:

→ wind speed and direction.

→ temperature.

→ humidity

→ rainfall

→ Solar radiation.

wind speed and direction:-

When high pollutant concentrations occur at a monitoring station, wind data records can determine the general direction and area of the emissions. Identifying the sources means planning to reduce the impacts on air quality can take place.

Temperature:-

Measuring temperature supports air quality assessment, air quality modelling and forecasting activities.

Temperature and sunlight play an important role in the chemical reaction that occur in the atmosphere to form photochemical smog from other pollutants.

Humidity:-

Like temperature and solar radiation, water vapour

plays an important role in many thermal and photochemical reactions in atmosphere. As water molecules are small and highly polar, they can bind strongly to many substances.

### Rainfall:-

Rain has a 'scavenging' effect when it washes particulate matter out of the atmosphere and dissolves gaseous pollutants. Removing particles improves visibility. Where there is frequent high rainfall, air quality is generally better.

### Solar radiation:-

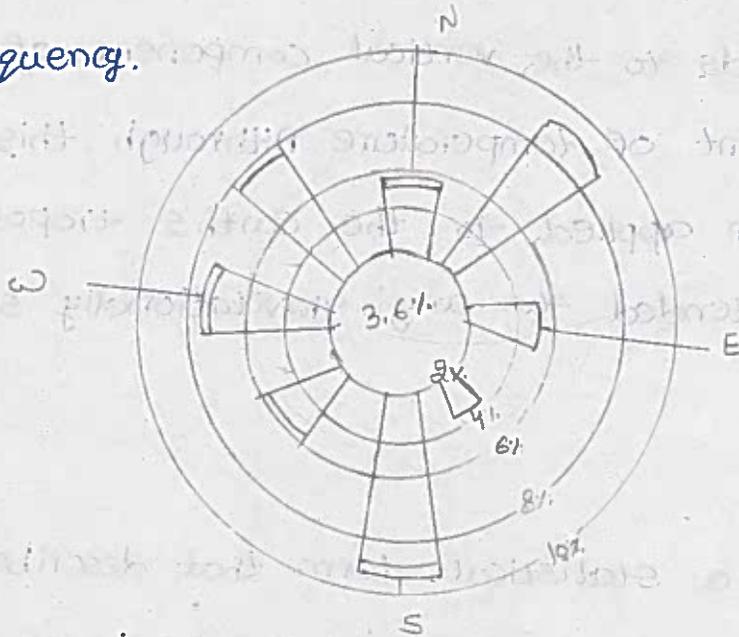
It is important to monitor solar radiation for use in modelling photochemical smog events, as the intensity of sunlight has an important influence on the rate of the chemical reactions that produce the smog. The cloudiness of the sky, time of day and geographic location all affect sunlight intensity.

### wind rose

A wind rose is a graphic tool used by meteorologists to give a succinct view of how wind speed and direction are typically distributed at a particular location. Historically, wind roses were predecessors of the compass rose, as there was no differentiation b/w a cardinal direction and the wind which b/w from such a direction.

→ using a polar coordinate system of gridding, the frequency of winds over a time period is

plotted by wind direction, with colour bands showing wind speed ranges. The direction of the longest spoke shows the wind direction with the greatest frequency.



### Mixing Depths

'mixing height' or 'mixing Depth' signifies the height above the surface throughout which a pollutant such as smoke can be dispersed. During times of surface temperature inversions, the mixing height goes to zero and smoke dispersion is minimal.

Typically this chart is used with afternoon ventilation rate values. Note that on nights with surface temperature inversions, the mixing height goes to zero and so does the ventilation rate. Situations to be avoided are successive days with afternoon category Day values 2 and below, as these scenarios can lead to "smoke-out" situations.

### Lapse rates and dispersion

The lapse rate is the rate at which an atmospheric variable, normally temperature in earth's atmosphere falls with altitude.

→ Lapse rate arises from the word lapse, in the sense of a gradual fall. In dry air, the adiabatic lapse rate is  $9.8^{\circ}\text{C}/\text{km}$ .

→ It corresponds to the vertical component of the spatial gradient of temperature. Although this concept is most often applied to the earth's troposphere, it can be extended to any gravitationally supported parcel of.

### Dispersion:-

Dispersion is a statistical term that describes the size of the distribution of values expected for a particular variable and can be measured by several different statistics, such as range, variance, and standard deviation.

### Atmospheric stability

Atmospheric stability is a measure of the atmosphere's tendency to discourage or deter vertical motion, and vertical motion is directly correlated to different types of weather systems and their severity.

In unstable conditions, a lifted thing, such as a parcel of air will be warmer than the surrounding air at altitude. Because it is warmer, it is less dense and is prone to further ascent.

1. Strongly unstable
2. Moderately unstable
3. Slightly unstable
4. Natural stable

5. slightly stable.

### 1. Strongly unstable:-

To be unstable is to lack stability, meaning things could change without warning, like an unstable bookshelf that is likely to fall down.

If you are unstable emotionally, you might be ecstatically happy one minute and horribly depressed and angry the next. The adjective unstable means the opposite of stable.

### 2. Atmospheric stability:-

Air is considered unstable, in the lowest layers of an air mass when the air is warmer and or more humid than the surrounding air.

When this occurs the air will rise, as that air parcel is warmer than the air surrounding it.

### plume behaviour

→ plume refers to the path and extent in the atmosphere of the gaseous effluents released from

a. source, usually a stack

→ The behavior of a plume emitted from any stack depends on localized air stability. The Geometric forms of stack plumes are a function of the vertical temperature and wind profiles, vice versa, by looking at the plume one can state stability condition and dispersive capacity of atmosphere.

→ Six types of plume behavior are shown in the figure below.

### 1. Looping:-

It is a type of plume which has a wavy character.

It occurs in a highly unstable atmosphere because of rapid mixing.

### 2. Coning:-

It is a type of plume which is shaped like a cone. This takes place in a near neutral atmosphere, when the wind velocity is greater than 32 km/hr.

### 3. Fanning:-

It is a type of plume emitted under extreme inversion conditions. The plume under these conditions will spread horizontally, but little or not at all vertically.

### 4. Lofting:-

Lofting occurs when there is a strong lapse rate above a surface inversion. Under this condition, diffusion is rapid upwards, but downward diffusion does not penetrate the inversion layer. Under these conditions, emission will not reach surface.

### 5. Fumigation:-

It is a phenomenon in which pollutants that are emitted into the atmosphere are brought rapidly to the ground level when the air destabilizes.

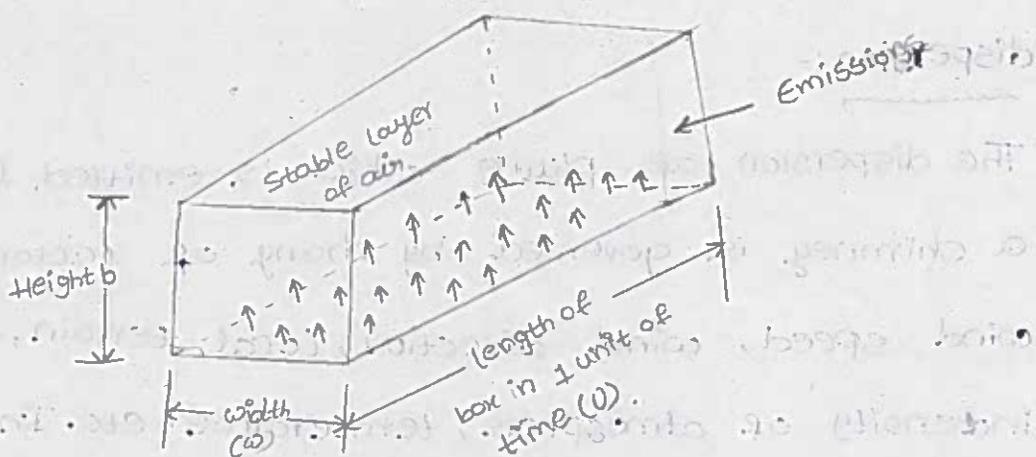
### 6. Trapping:-

This refers to conditions where the plume is caught between inversions and can only diffuse within a limited vertical height.

## Box model

→ A simple atmospheric model called a box model can be used to calculate ground level concentrations of specific air pollution pollutants of consideration from the project activity.

→ A box model is based on assumption that pollutant emitted to the atmosphere are uniformly mixed in a volume are box.



## Gaussian model

The assumption that pollutant follows normal statistical distribution, different types of modeling plumes based on the callous.

$$x = \frac{Q}{2\pi U \sigma_y \sigma_z} \left[ \exp\left(-0.5 \left(\frac{y}{\sigma_y}\right)^2\right) \right] \left[ \exp\left(-0.5 \left(\frac{z}{\sigma_z}\right)^2\right) \right]$$

$x$  = hourly concentration at down wind distance

$U$  = mean wind speed at pollutant release height

$\sigma_x, \sigma_y$  = stability coefficient

$Q$  = pollutant coefficient

$H$  = pollutant release

$y$  = cross wind distance from the well.

## plume rise and dispersion

### Plume rise :-

The plume rise is an important parameter in the overall air pollution control mechanism which directly interferes the dispersion of pollutant over a period of time and space, the more is the plume rise, the better would be the dispersion of air pollutants resulting into less ground level concentration of air pollutants.

### dispersion :-

The dispersion of plume which is emitted from a chimney is governed by many of factors: wind speed, wind direction, local terrain, turbulence intensity of atmosphere, temperature, etc. In this study, we numerically investigate the plume dispersions for various altitudinal temperature variations.

### Prediction of air quality

Predicting air quality, therefore, not only involves the difficulties of weather forecasting, it also requires data on and knowledge of: local pollutant concentrations and emissions, pollutant concentrations and emissions from distant locations, movements and possible transformations of pollutants.

If air pollution is not controlled, by 2030 the air will become so poisonous that it will be necessary to use an oxygen kit to breathe easily. Rising air pollution will also lead to premature aging.

## Dispersion Coefficient

The coefficient of dispersion (COD) is the average difference a group of numbers has from the median. The value is reported as a percentage of the median. In ratio analysis, the coefficient of dispersion is reported as an average percentage difference from the median ratio.

The dispersion number represents the overall extent of axial dispersion in the system under consideration and is the reciprocal of the Peclet number

( $Pe = uL/D_a$ ). In the dispersion number expression,  $D_a$  is the axial dispersion coefficient,  $u$  is the mean velocity and  $L$  is the length between the two measurement points.

## Application of tall chimney for pollutant dispersion

A chimney is an architecture ventilation structure made of masonry, clay or metal that isolates hot toxic exhaust gases or smoke produced by a boiler, stove, furnace, incinerator or fireplace from human living areas. Chimneys are typically vertical or as near as possible to vertical, to ensure that the gases flow smoothly, drawing air into the combustion in what is known as the stack, or chimney effect. The space inside a chimney is called the flue. Chimneys are adjacent to large industrial refineries, fossil

fuel combustion facilities or part of buildings, steam locomotives and ships.

→ In the United States, the term smokestack industry refers to the environmental impacts of burning fossil fuels by industrial society including the electric industry during its earliest history.

→ The term smokestack is also used when referring to locomotive chimneys or ship chimneys, and the term funnel can also be used.