Atmospheric Dispersion

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Stack (Chimney) and Plume (Emitted Smoke)

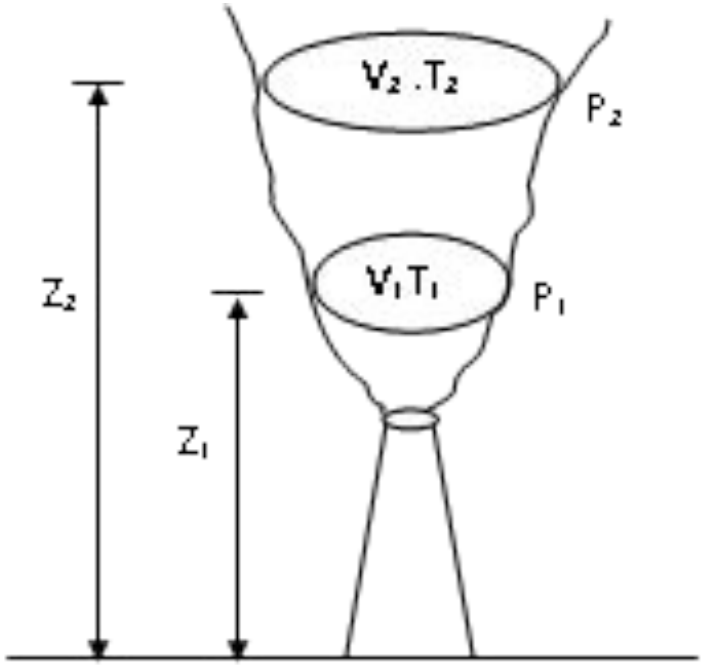

Fig: 3.10 Change of temperature of artificially heated air with increase of height

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Effective Stack Height

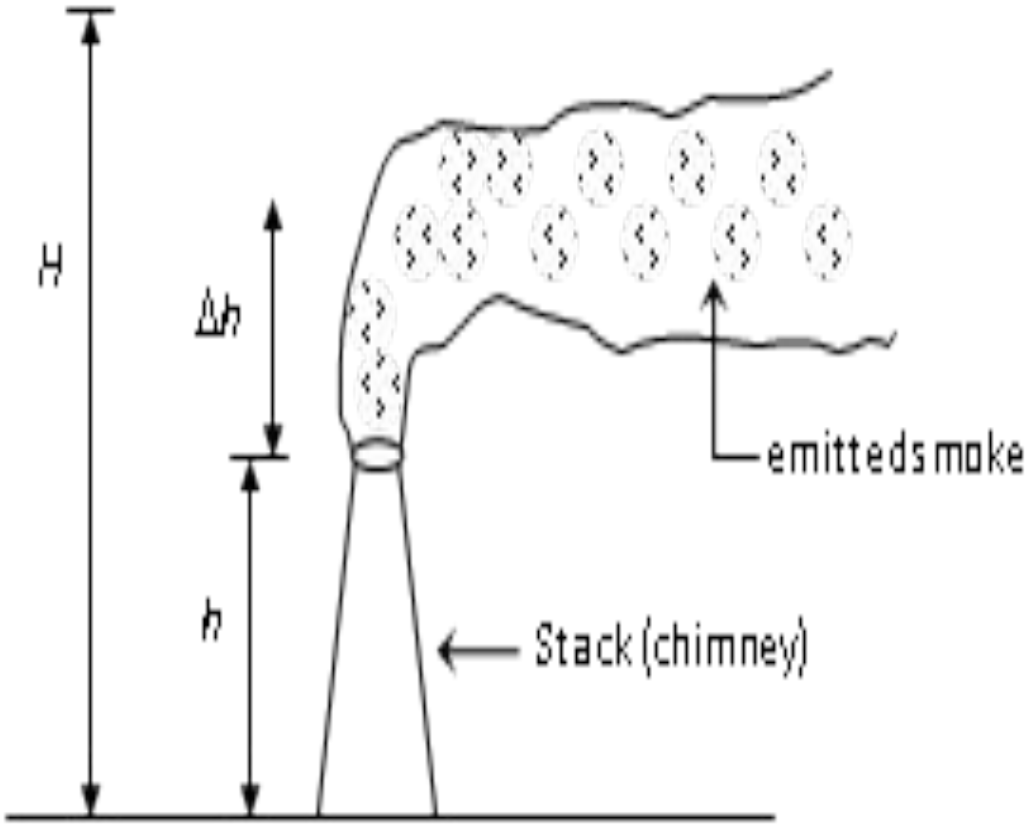

Fig: 3.18 Stack with plume

The Effective Stack Height (H) consists of Actual or Physical Height (h) and Plume rise (Δh).

The value of Δh can be calculated as-

$$\Delta h = \frac{V_s . D}{u}\left[1.5 + 2.68 \times 10^{-3}\ P.D.\left(\frac{T_s - T_a}{T_s}\right)\right]$$

Where,

Vs = Stack Velocity

D= Diameter of stack mouth

U= Wind Velocity

P= Pressure

Ts= Stack Temperature

Ta= Atmospheric Temperature

Stack Plume

The diffusion or dispersion of pollutants into the atmosphere is governed by the **Environmental Lapse Rate (ELR)** as well as **Adiabatic Lapse Rate (ALR)**. By comparing these two laps rates, it is possible to predict about the dispersion of emitted gases from the source. These are then known as **plume** and their source of origin as **stack**.

Looping Plume

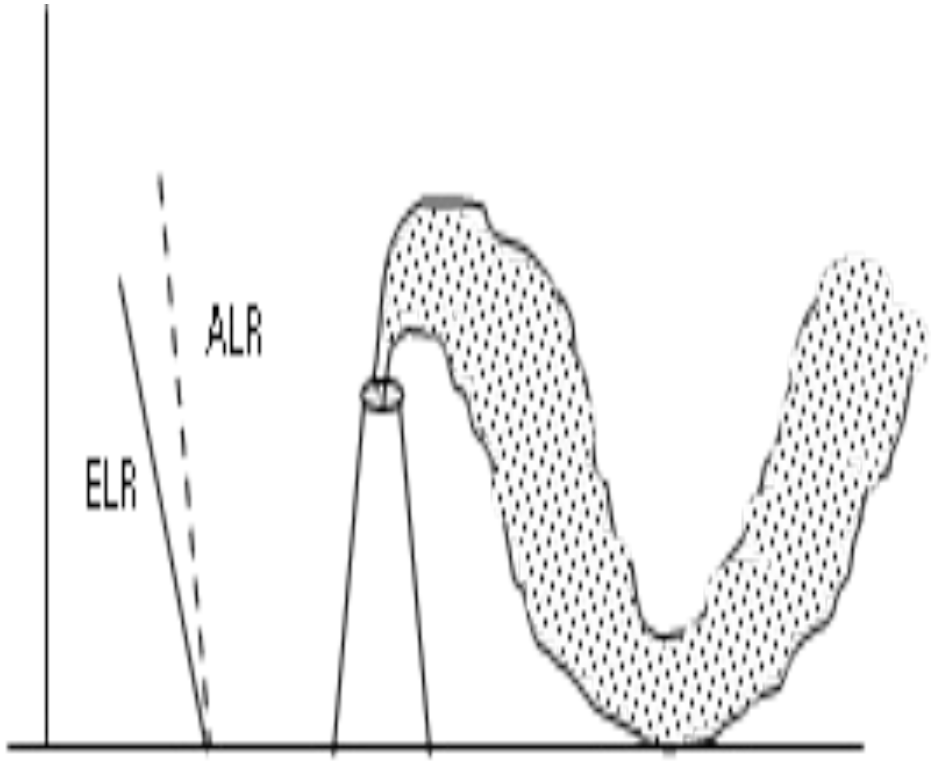

Fig: 3.19 Looping plume

Looping plume has a wavy character and occurs in **super adiabatic environment (**here, **ELR〉ALR)** which produces highly **unstable atmosphere**, because of rapid mixing. During the high degree of **turbulence**, the dispersion of plume would be rapid and as a result **high concentrations near the ground may** take place. To avoid this, it is suggested to design **high stack** where atmosphere is generally super adiabatic.

Neutral Plume

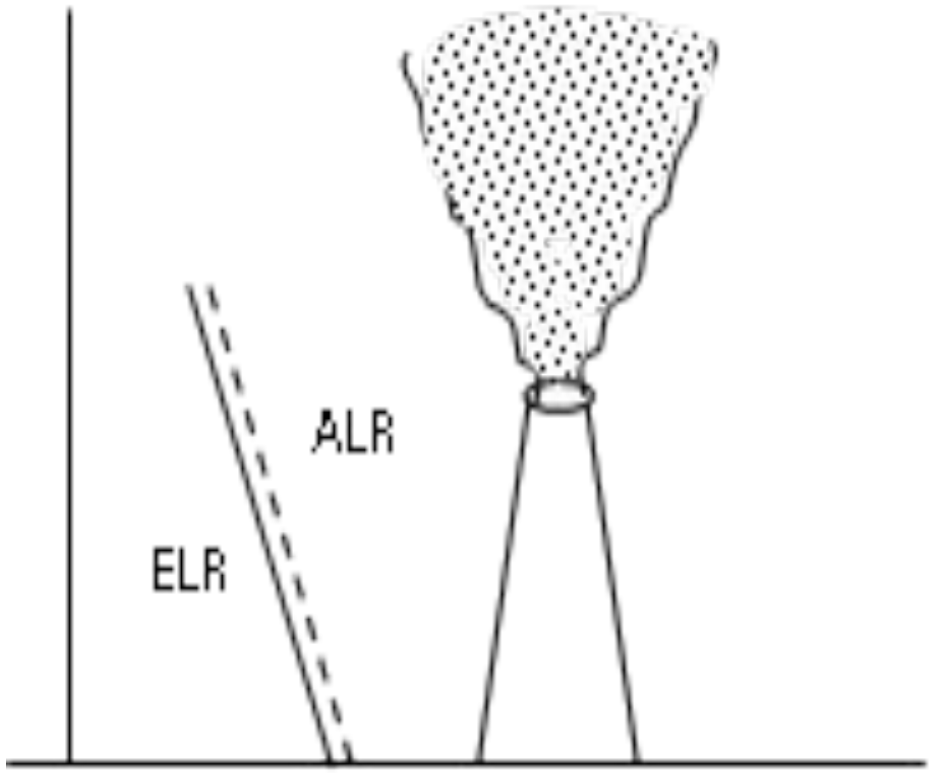

Fig: 3.20 Neutral plume

Neutral plume is available in the **neutral atmospheric condition** (i.e., ELR = ALR). This type of plume rises vertically in upward direction. This upward lifting of the plume will continue till it reaches at the height where density and temperature of surrounding air equal to it.

Coning Plume

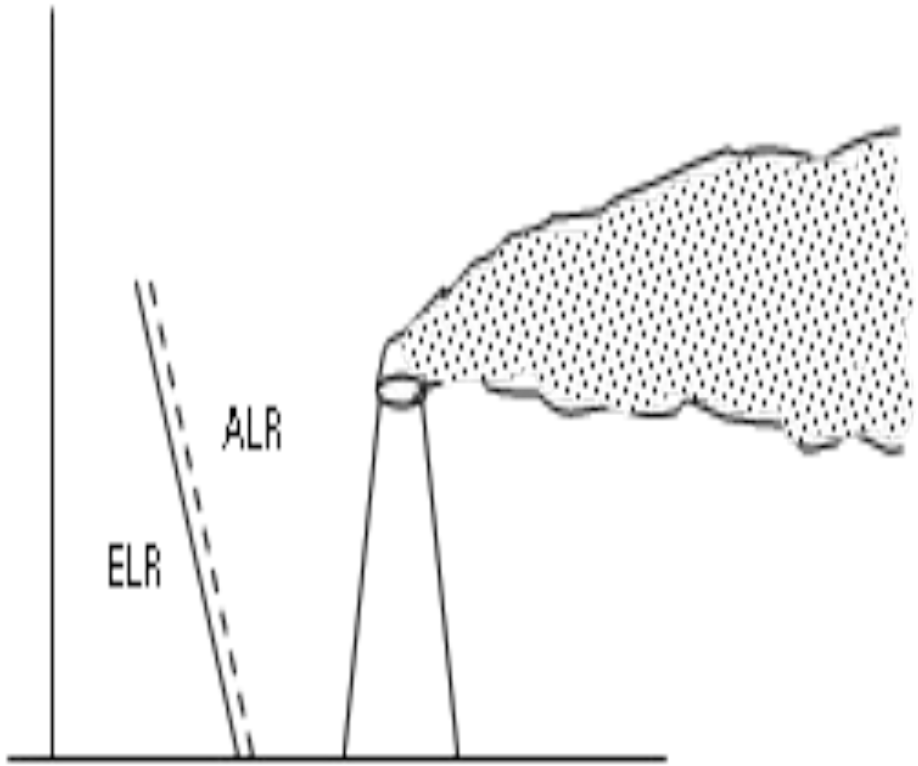

Fig: 3.21 Coning plume

The neutral plume tends to form **cone** like structure, when the horizontal wind velocity is greater than 32 km/hr and when cloud cover blocks the solar radiation by day and terrestrial radiation by night

Fanning Plume

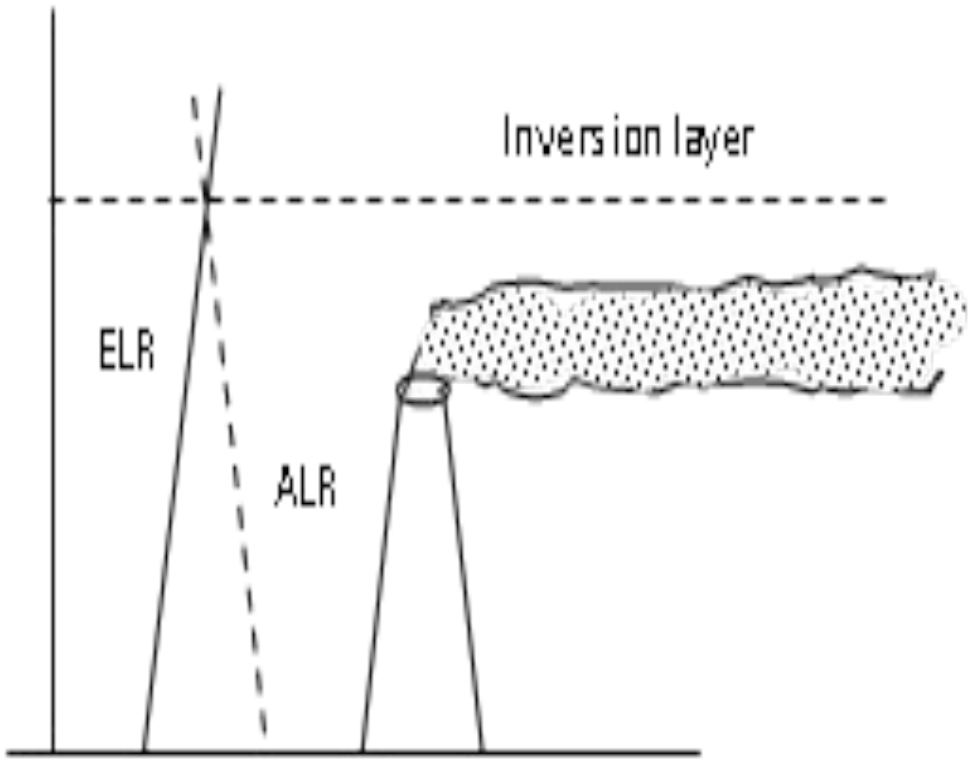

Fig: 3.22 Fanning plume

The fanning plume is available under the extreme **inversion condition** (due to negative lapse rate). This inversion condition leads to stable environmental condition just above the stack. As a result, the smoke emitted from the stack does not move in upward direction but moves horizontally.

Lofting Plume

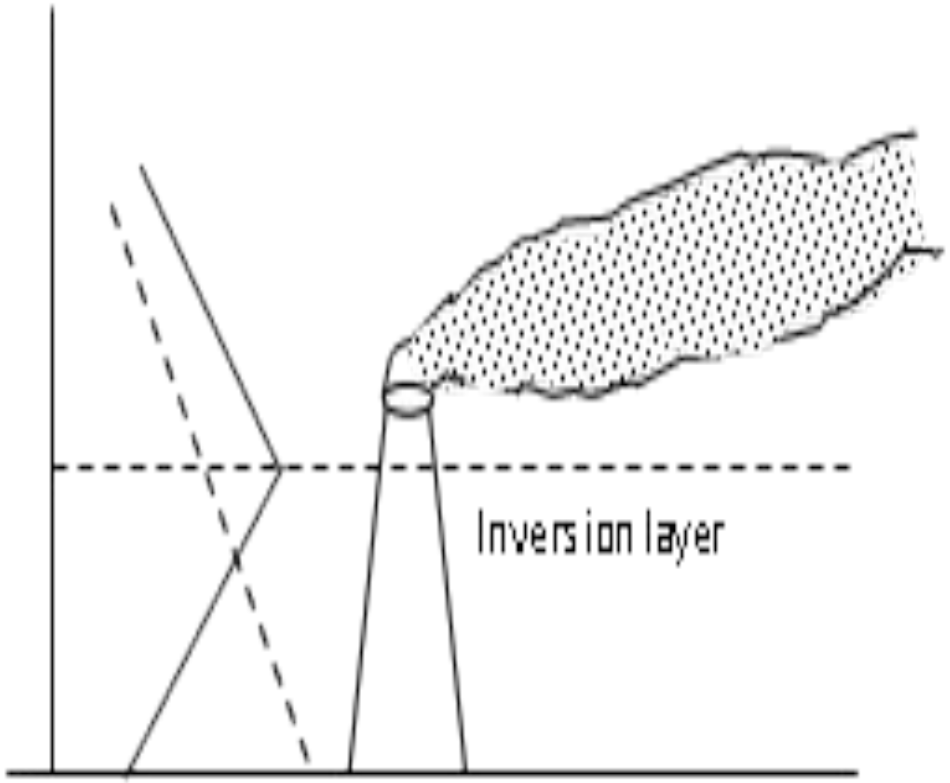

Fig: 3.23 Lofting plume

This type of plume is available when there is a strong **super adiabatic** lapse rate just **above** the stack and **negative lapse rate** (inversion) just **below** the **opening of stack**. Such a plume has minimum downward mixing, as its downward motion is prevented by inversion, but the upward mixing will be quite turbulent and rapid. The dispersion of pollutant will therefore, be rapid, and no pollutants will touch the ground. Hence, this would be the most ideal case for dispersion of air pollutants.

Fumigating Plume

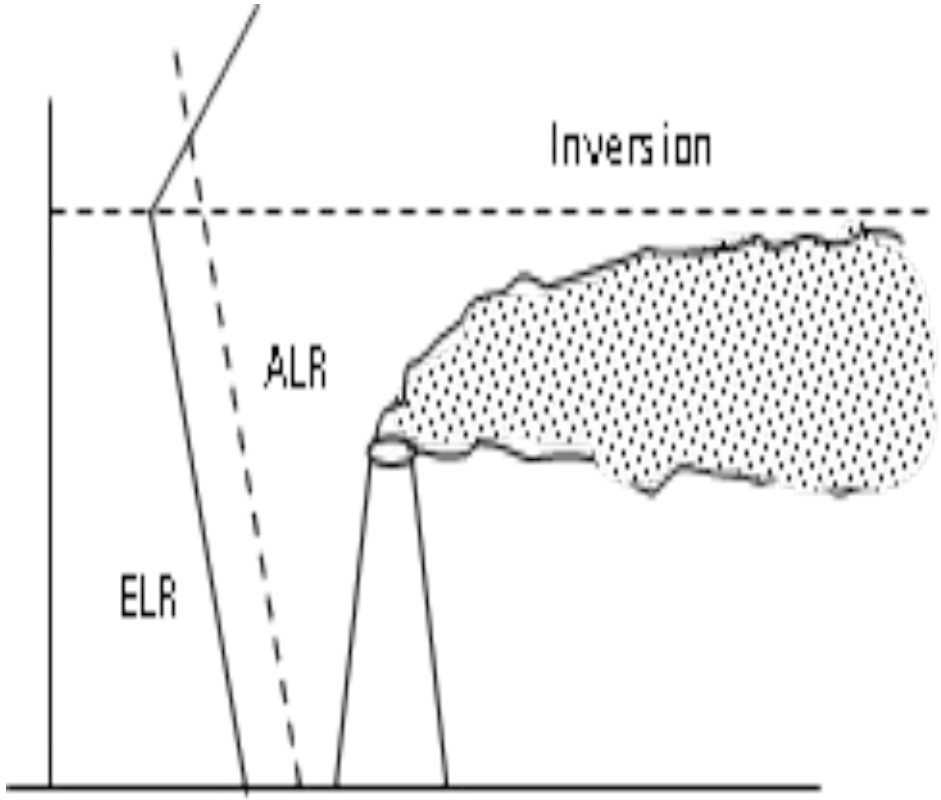

Fig: 3.24 Fumigating plume

This type of plume is just **opposite to lofting plume**. When **inversion layer** occurs at a short distance **above the top of the stack** and **super adiabatic conditions** prevail **below the stack**, then the plum is said to be **fumigating**. In such a case, the pollutants can not **escape above the top of stack** because of inversion layer and will be **brought down near the ground** due to turbulence in the region above the ground and below the inversion. This represents **quite a bad case** of atmospheric conditions for dispersion.

Trapping Plume

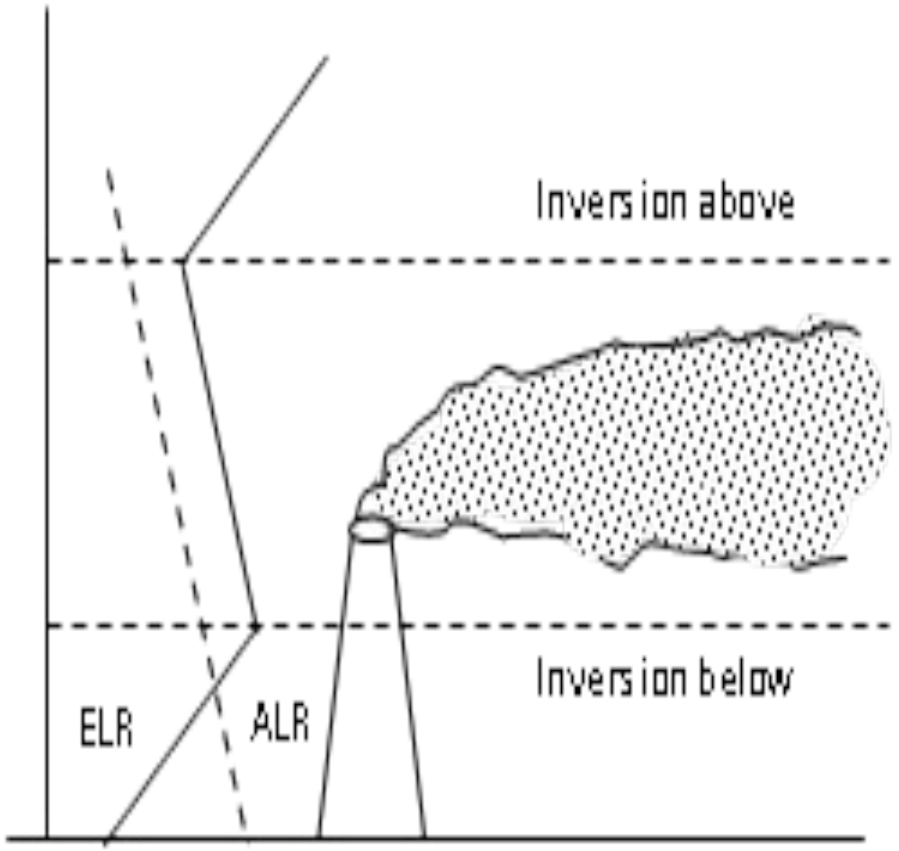

Fig: 3.25 Trapping plume

When the inversion layer exist above the emission source, as well as below the source, then the plume emitted from the stack is known as **trapping plume**. Here, the plume will neither go up nor will go down and would remain **confined** or **trapped** between these two inversion layers. This plume is also considered as a **bad condition for dispersion**, as the dispersion can not go above a certain height.